ICDSST 2023

9th International Conference on Decision Support System Technology – ICDSST 2023

on

Decision Support System in an Uncertain World: the Contribution of Digital Twins

30 May – 01 June 2023, Albi, France

IMT Mines Albi, France – Industrial Engineering Center, Albi

Editors:

Daouda KAMISSOKO, Franck FONTANILI,
Eva PETITDEMANGE, Didier GOURC, Xavier LORCA,
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Editors

Ass. Prof. Daouda KAMISSOKO
IMT Mines Albi, University of Toulouse
daouda.kamissoko@mines-albi.fr

Ass. Prof. Franck FONTANILI

IMT Mines Albi, University of Toulouse
franck.fontanili@mines-albi.fr

Ass. Prof. Eva PETITDEMANGE
IMT Mines Albi, University of Toulouse
eva.petitdemange@mines-albi.fr

Prof. Didier GOURC
IMT Mines Albi, University of Toulouse
didier.gourc@mines-albi.fr

Prof. Xavier LORCA
IMT Mines Albi, University of Toulouse
xavier.lorca@mines-albi.fr

Prof. Matthieu LAURAS
IMT Mines Albi, University of Toulouse
matthieu.lauras@mines-albi.fr

Chenhui YE
IMT Mines Albi, University of Toulouse
chenhui.ye@irit.fr

Organization

Conference General Chair

Ass. Prof. Daouda KAMISSOKO
IMT Mines Albi, University of Toulouse
daouda.kamissoko@mines-albi.fr

Prof. Isabelle LINDEN
University of Namur, Belgium
isabelle.linden@unamur.be

Conference Program Chair

Prof. Shaofeng LIU
University of Plymouth, UK
shaofeng.liu@plymouth.ac.uk

Prof. Pascale ZARATE
University of Toulouse, FR
pascale.zarate@irit.fr

Local Program Chair

Ass. Prof. Franck FONTANILI
IMT Mines Albi, University of Toulouse
franck.fontanili@mines-albi.fr

Local Organisers

Prof. Xavier LORCA
IMT Mines Albi, University of Toulouse
xavier.lorca@mines-albi.fr

Prof. Matthieu LAURAS
IMT Mines Albi, University of Toulouse
matthieu.lauras@mines-albi.fr

Prof. Frederick BENABEN
IMT Mines Albi, University of Toulouse
frederick.benaben@mines-albi.fr

Chenhui YE
IMT Mines Albi, University of Toulouse
chenhui.ye@irit.fr

Prof. Didier GOURC
IMT Mines Albi, University of Toulouse
didier.gourc@mines-albi.fr

Ass. Prof. Eva PETITDEMANGE
IMT Mines Albi, University of Toulouse
eva.petitdemange@mines-albi.fr

Ass. Prof. Sergio Pedro DUARTE
University of Porto
spduarte@fe.up.pt

EWG-DSS Coordination Board (CB)

Prof. Shaofeng Liu
University of Plymouth, UK
shaofeng.liu@plymouth.ac.uk

Prof. Boris Delibasic
University of Belgrade, Serbia
delibasicboris@gmail.com

Prof. Isabelle Linden
University of Namur, Belgium
isabelle.linden@unamur.be

Prof. Jason Papathanasiou
University of Macedonia, Thessaloniki, Greece
jason.papathanasiou@gmail.com

Prof. Pavlos Delias
International Hellenic University, Greece
pdelias@af.ihu.gr

Prof. Ana Paula Cabral Seixas Costa
Universidade Federal de Pernambuco, Brasil
apcabral@cdsid.org.br

EWG-DSS Advisory Board (AB)

AB-Chair

Prof. Pascale Zaraté
Toulouse University / IRIT, France
zarate@irit.fr

AB-Members

Dr. Fatima C.C. Dargam
SimTech Simulation Technology, Austria
f.dargam@simtechnology.com

Prof. José Maria Moreno
University of Zaragoza, Spain
moreno@posta.unizar.es

Prof. Alexis Tsoukias
CNRS-LAMSADE, France
Alexis.Tsoukias@dauphine.fr

Prof. Marko Bohanec
Jožef Stefan Institute, Slovenia
marko.bohanec@ijs.si e-mail

Prof. Jorge Hernández
University of Liverpool, UK
Hernandez@liverpool.ac.uk

Prof. Philip Powell
Birkbeck, University of London, UK
beidean@bbk.ac.uk

Prof. D. Marc Kilgour
Wilfrid Laurier University, Canada
mkilgour@wlu.ca

Prof. Jorge Freire de Souza
University of Porto, Portugal
jfsousa@fe.up.pt

Prof. Adiel Teixeira de Almeida
Federal University of Pernambuco, Brazil
almeida@cdsid.org.br

EWG-DSS Board of Assistants (BA)

Dr. Daouda Kamissoko
Ecoles des Mines d'Albi Carmaux
Albi, Midi-Pyrénées, France
daouda.kamissoko@mines-albi.fr

Dr. Femi Olan
Northumbria University, UK
femi.olan@northumbria.ac.uk

Mr. Sandro Radovanovic
University of Belgrade, Serbia
sandro.radovanovic@fon.bg.ac.rs

Ms. Panagiota Digkoglou
University of Macedonia, Greece
giotadigkoglou@outlook.com

Dr. Uchitha Jayawickrama
Loughborough University, UK
U.Jayawickrama@lboro.ac.uk

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http://www.euro-online.org/

EWG-DSS EURO Working Group on Decision Support Systems
https://ewgdss.wordpress.com

Institut Mines -Telecom
https://www.imt.fr

About the EWG-DSS

The EWG-DSS is a Working Group on Decision Support Systems within EURO, the Association of the European Operational Research Societies. The EWG-DSS was founded during a memorable EURO Summer Institute on DSS that took place at Madeira, Portugal, in May 1989. Most of the participants of the EURO Summer Institute on DSS in Madeira in 1989 still continue nowadays to pursue their goals, working actively in their research areas related to OR and Decision Support Systems.

The EWG-DSS was born with 24 founding-members. Since then, the number of members has substantially grown along the years. Now we are over 300 registered members coming from various nationalities. There has also been established quite a few well-qualified research co- operations within the group members, which have generated valuable contributions to the DSS field.

Since its creation, the EWG-DSS has held annual Meetings in various European countries, has taken active part in the EURO Conferences on decision-making related subjects; and has organized several workshops and conferences on different topics around Decision Support Systems. The main purpose of the EWG-DSS is to establish a platform for encouraging state-of-the art high quality research and collaboration work within the DSS community. Other aims of the EWG-DSS are to:

- Encourage the exchange of information and knowledge among practitioners, end-users, and researchers in the area of Decision Systems.
- Enforce the networking among the DSS communities and facilitate activities that are essential for the start-up of international collaborative research and projects.
- Create professional, academic and industrial opportunities for its members.
- Inspire the development of innovative models, methods and tools in the field Decision Support and related areas.
- Actively promote the interests on Decision Systems in the scientific community by organizing dedicated workshops, seminars, mini-conferences, and conference streams in major conferences, as well as editing special and contributed issues in relevant scientific journals.

The process-loop shown next translates the main activities of the EWG-DSS envisaging the dissemination of DSS Information (1) and Research (2), in order to encourage DSS Development (3) and Collaboration (4) among the DSS researchers and professionals. Consequently, Publication (5) opportunities to document the research & development processes and the end results are promoted within the EWG-DSS editions.

Specifically, to accomplish the main objectives listed above, the EWG-DSS promotes the following key activities:

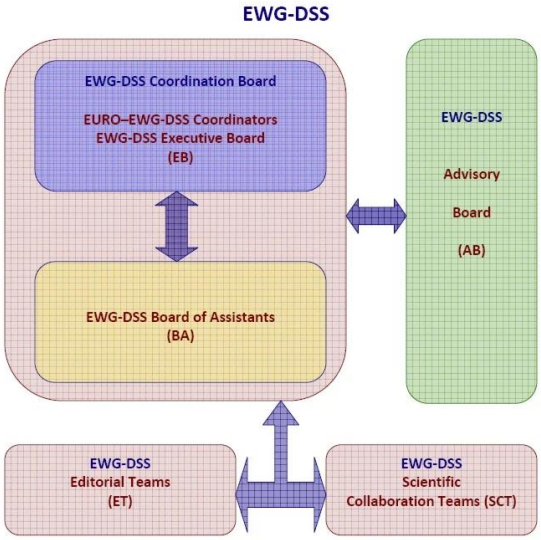
- Annual ICDSST Conference and other Conference-Streams organization related to Decision Support Systems topics.
- Annual Journal Special Issues publications, in support of the annual EWG-DSS organized Conferences, providing publication opportunities in the DSS Community.

- Annual EWG-DSS Newsletter publication, promoting the events and the research achievements of the EWG-DSS members and of the DSS Community as a whole.
- Annual EWG-DSS Award: a motivating research initiative for young researchers to submit and present their work in one of the EWG-DSS organized events during the year.
- Collaboration projects among the group members. Check about the EWG-DSS research project Collab-Net Project, as well as the R&D competences of some member-institutions listed for collaboration in European projects.

Since 2007 the EWG-DSS has been managed by a Coordination Board. One of the aims of this Coordination Board is to promote joint work among the group members and to encourage more participation of the whole group in DSS related projects and events, the best way possible. The Current EWG-DSS Coordination Board counts with the assistance of a board of six members, namely: Professor Shaofeng Liu, Professor Boris Delibasic, Professor Isabelle Linden, Dr Jason Papathanasiou Dr Pavlos Delias and Dr Ana Paula Cabral Seixas Costa.

EWG-DSS Management Structure

Since May 2015, the EWG-DSS has updated its Management Structure in order to incorporate into the Coordination Board (CB) with an Advisory Board (AB), which is composed of senior members of the EWG-DSS group and of the international DSS community, including the Professor Pascale Zarate and Dr Fatima Dargam who moved onto the Advisory Board from the Coordination Board. The Advisory Board is chaired by Professor Pascale Zaraté.



The Board of Assistants (BA) is formed by young researchers linked to the Coordination Board (CB) members, in order to assist them with the EWG- DSS annual tasks. Board and Team members can be in more than one of the groups of the EWG- DSS new defined Management Structure. However, the members of the Coordination Board are not supposed to be members of the Advisory Board and vice-versa. The new Management Structure also distinguishes different teams, namely: the Scientific Collaboration Team (SCT) and the Editorial Team (ET), amongthe EWG-DSS Members who collaborate with EWG-DSS projects and joint–Editions, respectively, as illustrated in the Figure.

The EWG-DSS Editorial Team (ET) is a dynamic group of researchers composed of EWG-DSS Members that have guest-edited Journal Special Issues and Springer Books with the EWG-DSS. The Scientific Collaboration Team (SCT) includes the researchers who are involved with EWG-DSS research projects and initiatives, for instance the Collab-NetProject. For more details about the EWG-DSS organized events and publications, check the homepage: http://ewgdss.wordpress.com/

Joining the EWG-DSS

The EWG-DSS membership does not cost you anything. If you wish to join the EURO-Working Group on Decision Support Systems, all you have to do is to send an e-mail to our group at:

ewg- dss@fon.bg.ac.rs with the following information:

Name; Affiliation; Mailing Address; Phone; e-mail; and Homepage link.

Alternatively, you can also join the EWG-DSS via our LinkedIn Group at: https://www.linkedin.com/groups/1961459/

Thanks for your interest!

The EWG-DSS Coordination Board

Preface

This thirteenth edition of the EWG-DSS Decision Support Systems published in this proceedings presents a selection of high-quality papers from the 9th International Conference on Decision Support System Technology (ICDSST 2023), held in Albi, France, during May 30 – June 1, 2023, with the main theme "Decision Support Systems in An Uncertain World: The Contribution of Digital Twins". This event was organized by the Euro Working Group on Decision Support Systems (EWG-DSS) in collaboration with the University of Toulouse – IMT Mines Albi.

The EWG-DSS series of International Conferences on Decision Support System Technology (ICDSST), starting with ICDSST 2015 in Belgrade, were planned to consolidate the tradition of annual events organized by the EWG-DSS in offering a platform for European and international DSS communities, comprising the academic and industrial sectors, to present state-of-the-art DSS research and developments, to discuss current challenges that surround decision-making processes, to exchange ideas about realistic and innovative solutions, and to co-develop potential business opportunities.

- The scientific topic areas of ICDSST 2023 include:
- Decision Support Systems: Advances and Future Trends
- Multi-Attribute and Multi-Criteria Decision Making
- Knowledge Management, Acquisition, Extraction, Visualisation, and Decision Making
- Multi-Actor Decision Making: Group and Negotiated Decision Making
- Collaborative Decision Making and Decision
- Discursive and Collaborative Decision Support Systems
- Mobile and Cloud Decision Support Systems
- GIS and Spatial Decision Support Systems
- Data Science, Data Mining, Text Mining, Sentiment Analysis, and Process Mining
- Big Data Analytics
- Imaging Science (Image Processing, Computer Vision, and Pattern Recognition)
- Human-Computer Interaction
- Internet of Things
- Social Network Analysis for Decision Making
- Simulation Models and Systems, Regional Planning, Logistics, and SCM
- Business Intelligence, Enterprise Systems, and Quantum Economy
- Machine Learning, Natural Language Processing, Artificial Intelligence
- Virtual and Augmented Reality
- New Methods and Technologies for Global Crisis Management
- Analytics for Mitigating the Impact of Pandemics
- Intelligent DSS for Crisis Prevention
- Innovative Decision Making during Global Crises
- New DSS Approaches for Post-Crisis Recovery of Economy
- Decision Making in Modern Education
- viii Preface
- Decision Support Systems for Sports
- Immersive Analytics for Decision Making
- Digital Twins for Decision Making
- General DSS Case Studies

This wide range of topics allowed us to present various solutions regarding the decision-making process and decision support in a great number of domains, and to highlight the main trends and research evolution. This EWG-DSS proceedings includes contributions selected via a double-blind evaluation process, maintaining the society's high-quality profile. Each selected paper was reviewed by at least two internationally known experts from the ICDSST 2023 Program Committee. The selected papers are representative of the current and recent DSS research and application advancements. The papers are topically organized in nine topics: (1) AI Technics, (2) Multi-actor or AHP Decision Making, (3) DSS Case studies, (4) Decision Making technics, (5) DSS Analysis, (6) Digital Twins, (7) DSS and Green projects, (8) DSS procedures and, (9) ML and DSS

We would like to thank many people who greatly helped the success of this proceedings. First of all, we would like to thank the board of the EWG – DSS for giving us the opportunity to edit, and we especially wish to express our sincere gratitude to the staff of the "Centre Génie Industriel" of IMT Mines Albi who have provided us with timely professional guidance and advice during the volume editing process. Secondly, we need to thank all the authors for submitting their state-of-the-art work to be considered for the proceedings. All selected papers are of high quality. It was a hard decision for the guest editors to select the best ones. Thirdly, we wish to express our gratitude to all reviewers, who volunteered to help with the selection and improvement of the papers.

We believe that this proceeding has selected a collection of high-quality and interesting research papers addressing the conference's main theme and related topics. We hope the readers will enjoy the publication!

May 2023

The Editors

Daouda KAMISSOKO

Franck FONTANILI

Eva PETITDEMANGE

Didier GOURC

Xavier LORCA

Frederick BENABEN

Matthieu LAURAS

Chenhui YE

Keynotes

Pr Greg (Gregory) Zacharewicz, IMT Mines Alès, France " Digital Twins support in decision-making processes"

This keynote speech discusses the potential benefits of using Digital Twins in decision-making processes. Digital Twins are virtual models of physical systems that can be used to simulate and analyze real-world scenarios. In this speech, we will explore how Digital Twins can support decision-making in various industries, such as manufacturing, supply chain management, and product design. By simulating different scenarios and identifying potential issues, Digital Twins can provide decision-makers with valuable insights to make more informed decisions. Specifically, we will examine how Digital Twins can be used for predictive maintenance, performance optimization, risk management, product design, and supply chain optimization. We will also discuss the challenges and limitations of using Digital Twins and the importance of integrating them with other technologies, such as artificial intelligence and machine learning. Ultimately, this presentation argues that Digital Twins have the potential to revolutionize decision-making processes and transform various industries.

Pr Greg (Gregory) Zacharewicz is Full Professor at IMT – Mines Ales (National Institute of Mines and Telecommunications) in Alès, France. He joined in 2018 the LSR lab to develop simulation driven research works. This lab works on the relationship between humans and the complex systems while keeping their roots in the field of Information Science and Technology. He was previously Associate Professor at the University of Bordeaux (2007-2018) where he focused his research for more than 10 years on Enterprise and Social Organization Modelling, Interoperability and Simulation.More generally, his research interests include Discrete Event Modelling (e.g. DEVS, G-DEVS), Distributed Simulation, Distributed Synchronization Algorithms, HLA, FEDEP, MDA, Short lived Ontologies, ERP, BPMN, and Workflow.He recently co-wrote with a worldwide team of authors the prospective chapter "Model-based approaches for interoperability of next generation enterprise information systems: state of the art and future challenges".In the domain of Healthcare methodologies and technologies, he co-wrote in 2018 with Bernard P. Zeigler, Mamadou K. Traore and Raphaël Duboz the book "Value-based Learning Healthcare Systems: Integrative modeling and simulation".He has been the program chair of Springsim 2016 in Pasadena, vice-general chair of SpringSim 2017 in Virginia Beach and the general chair of SpringSim 2018 in Baltimore. He is member of editorial board of Sage Simulation Journal, JSimE, Journal of King Saud University - Computer and Information Sciences, Science Progress and SNE journals.

Pr Antonio De Nicola, ENEA CR Casaccia, Italy "Decision Making for Resilience Engineering in Cyber-Socio-Technical Systems"

Resilience engineering aims to enable the continuity of operations and activities for service delivery under both expected and unexpected conditions. Decision making for resilience engineering in cyber-socio-technical systems requires a deep understanding of the inherent processes, which is difficult to achieve due to several factors, including misinterpretations and the complexity of technologies and human relationships. In this context, this presentation will explore how to support process comprehension by shedding light on the different varieties of work knowledge, such as the Work-As-Imagined held by blunt-end operators and the Work-As-Done by sharp-end operators. Next, it will discuss how these different perspectives on real processes are converted between agents within a cyber-socio-technical system, such as an industry. Finally, it will reflect on how awareness of this multifaceted reality can be harnessed by semantic technologies to make cyber-socio-technical systems more resilience.

Pr Antonio De Nicola serves as a research scientist at ENEA, the Italian national agency for new technologies, energy and sustainable economic development, where he is member of the Laboratory for the Analysis and Protection of Critical Infrastructures. He holds a master's degree in physics from Sapienza University of Rome and a PhD in Computer Science from University of Rome Tor Vergata. His principal areas of research activity concern semantic technologies and their applications to smart cities, energy systems, and industrial contexts. His work experience includes more than 20 research projects related to the above-mentioned topics. He has authored about 70 scientific papers published in international peer reviewed journals, such as Information Systems, Communications of the ACM, Safety Science, and the Journal of Contingencies and Crisis Management, and conference proceedings. He has acted as expert reviewer for Horizon projects, the Cost EU programme, and several scientific journals. Recently, he was the project coordinator of the International SAF€RA project H(CS)2I (2019-2022), focusing on human-centred safety indicators in enterprises. Currently, he is the Principal Investigator of the ENEA unit of the Horizon Europe project gEneSys (2023-2026), focusing on proposing targeted interventions to address the inequalities that are intertwined with the energy transition process at the economic, political, social, and technological levels, with a focus on gender inequalities.

Pr Tina Comes, Delft University of Technology, The Netherlands "The use of information technologies and digital twins for crisis management"

Our world is increasingly uncertain. Resilience has rapidly risen to the top of the research and policy agenda to foster sustainable development and combat the impacts of climate change. As the world is confronted with a range of crises and risks - from Covid19 to the war in Ukraine - this trend is expected to continue. With the turn to digitalization, increasingly smart cities and infrastructures, new opportunities to improve resilience arise. However, better information and information technology does not automatically lead to better decision-making. Further, interconnectedness increases complexity and thereby creates new pitfalls. Major challenges remain in (rapidly) identifying and analysing data and from there develop ans share meaningful and actionable information. Through case studies ranging from Covid19 to urban planning, I will outline key resilience principles and related research traditions, and highlight how information technologies (and digital twins) can be used to improve both the rapid response to disasters and longer-term adaptation. Further, I will discuss the intersection of methods and problems in resilience and will highlight potential avenues for future work.

Prof. Tina Comes is a Professor in Decision Theory & ICT for Resilience at the TU Delft and the University of Maastricht (NL). Since her PhD, she has been determined to better understand decision-making of individuals and groups in the context of risk and crises. The uniqueness of her work is the combination of behavioural insights from the field with computational models and simulations, especially at the interface of information and decision-making. At the TU Delft, she leads the Resilience Lab and heads the disaster resilience theme for the Delft Global Initiative. She serves as the Scientific director for the 4TU.Centre for Resilience Engineering, a collaboration of the 4 technical universities of the Netherlands. She has led the Science Advice for Policy-Makers by European Academies - SAPEA Working Group on the Evidence Review Report on Strategic Crisis Management in the EU. She is a member of the Norwegian Academy of Technological Sciences and the Academia Europaea, and she serves as Editorial Board Member for Nature Scientific Reports.

Program

Day 1	Tuesday, May 30th 2023
09 :00 - 09 :30	ICDSST 2023 - Conference Opening – *Room 1A22* *Daouda KAMISSOKO* Welcome by the EWG-DSS Coordination Board *Shaofeng Liu* Welcome from Program Chair *Franck Fontanili* Conference logistics and announcements *Daouda Kamissoko*
09:30 - 11:00	Session 1 – Paper Presentations – *p. 34-38* "AI Technics" Chair: Christer Carlsson – *Room 1A22*
	S1.1: A tool to support the decisions for the trace clustering problem with a non-compensatory approach Authors: Nikolaos Zapoglou and Pavlos Delias
	S1.2: BPR Assessment Framework: Staging Business Processes for Redesign using Cluster Analysis Authors: George Tsakalidis, Nikolaos Nousias and Kostas Vergidis
	S1.3: A Digital Distance Learning Critical Success Factors Model for Conducting Learning Analytics Research Authors: Sean Eom
	S1.4: Young Elderly DSS Users - Some Reasons for Successful Adoption Authors: Christer Carlsson and Pirkko Walden
11:00 - 11:30	*Coffee Break – Room 1A26*
11:30 - 12:30	Keynote #1 – *Room 1A22* Professor Gregory Zacharewicz IMT Mines Alès, France "Digital Twins support in decision-making processes" Chair: Pascale Zaraté
12 :30 - 14 :00	*Lunch - Restaurant*
14 :00 - 15 :30	Session 2 – Paper Presentations – *p. 39-43* "Multi-actor or AHP Decision Making" Chair: Boris Delibasic – *Room 1A22*
	S2.1: MAMCABM: A data-driven stakeholder-based decision-support system that considers uncertainties Authors: He Huang, Shiqi Sun, Lina Liu, Koen Mommens and Cathy Macharis
	S2.2: Multi-actor VIKOR method for highway selection in Montenegro Authors: Boris Delibašić, Draženko Glavić, Sandro Radovanović, Andrija Petrović, Marina Milenković and Milija Suknović
	S2.3: AHP METHOD APPLIED TO THE EVALUATION OF COSTS AND POLLUTION EMITTED BY COMBINED MEANS OF TRANSPORT, CASE OF SMMC PORT TOAMASINA Authors: Jean Baptiste Rakotoarivelo
	S2.4: Exploring Proportional Representation to Synthesise Multiple Analytic Hierarchical Process Matrices for Human Well-being in a Water User Community in an Upstream Agricultural Sub-catchment in Mediterranean South Africa Authors: Sinetemba Xoxo, Jane Tanner, Sukhmani Mantel, David Gwapedza, Bruce Paxton, Olivier Barreteau and Denis Hughes

15:30 - 16:00	*Coffee Break – Room 1A26*
16:00 - 17:00	Session 3 – Poster session – p. 44-49 Chair: Franck Fontanili – *Room 1A24*
	S3.1: Simulating Compatibility Scenarios in a local AHP-GDM context Authors: María Teresa Escobar, Juan Aguaron and José María Moreno-Jiménez
	S3.2: Air Traffic Management Decision Support System to Control the Spread of Pandemics Authors: Alfonso Mateos, Antonio Jiménez-Martín, Arminda Moreno-Diaz, Andy Rafael Domínguez and María Jesús Rufo
	S3.3: Leadership and emotional valence: Analysis of sentiments of the network leaders' tweets and their followers through machine learning Authors: Alberto Turón, Juan Aguarón, José María Moreno-Jiménez and Jorge Navarro
	S3.4: Enhancing Decision Support Systems Information Quality through NLP-based Spell Checking Authors: Zineb Touati Hamad and Mohamed Ridda Laouar
	S3.5: SENTIMENT ANALYSIS OF TWEETS AND SOCIAL NETWORK LEADERS DURING THE COVID-19 VACCINATION PROCESS IN SPAIN Authors: Jorge Navarro, Juan Aguaron, Alfredo Altuzarra, José María Moreno-Jiménez and Alberto Turón
17:00 - 17:30	EWG Steering committee meeting – *Room 1A24*
17:30 - 18:00	EWG Board meeting – *Room 1A24*

Day 2	Wednesday, May 31st 2023	
9 :00 - 10 :40	Session 4 – Paper Presentations – *p.50-55* DSS Case studies Chair: Ciara Heavin – *Room 1A22*	
	S4.1: Time-aware Optimisation Models for Hospital Logistics Authors: Herwig Zeiner	
	S4.2: Evaluate the potential of the Physical Internet for last mile delivery in developing countries Authors: Eva Petitdemange, Sam Ban, Matthieu Lauras and Srang Sarot	
	S4.3: Integrating Existing Knowledge to Accelerate Buildings Renovation Rates in Europe Authors: Charikleia Karakosta, Zoi Mylona, Jason Papathanasiou and John Psarras	
	S4.4: Prevention and Detection of Network Attacks: A Comprehensive Study Authors: Tauheed Khan Mohd, Paul Addai, Ryan Freas, Elnatan Mesfin Tesfa and Max Sellers	
	S4.5: Building Risk Prediction Models For Diabetes Decision Support System Authors: Sarra Samet and Ridda Laouar	
10:40 - 11:00	*Coffee Break – Room 1A26*	
11:00 - 12:00	Keynote #2 – *Room 1A22* Professor Tina Comes "The use of information technologies and digital twins for crisis management" Chair: Shoafeng Liu	
12:00 - 13:00	Session 5a – Paper Presentations – *p.56-76* DSS Case studies Chair: Ana Paula Costa Cabral – *Room 1A22*	Session 5b– Paper Presentations – *p.82-101* Decision Making technics Chair: Marko Bohanec – *Room 1A24*
	S5a.1: Parallel screening of teachers and schoolkids to highlight the potential for the production of podcasts on climate change as teaching and digital community engagement tool Authors: José Castro, Fatima Dargam, Panagiota Digkoglou, Lucia Fanini, Rosário Ferreira, Carla Machado, Anamaria Magri Pantea, António Martins, Krasimira Miteva, Kiki Mousafiri, Zhaklyn Neycheva, Jason Papathanasiou, Maurizio Pinna, Tatyana Shurelova and Katina Mladenova	S5b.1: DEXi Suite: Renewing Qualitative Multi-Criteria Decision Modeling Software Authors: Marko Bohanec
	S5a.2: Adoption of Blockchain Technology for Sustainable Food Security: Drivers, Barriers and Potential Solutions for Agri-food Supply Chain in Nigeria Authors: Ruth Goma, Shaofeng Liu, Charles Thornton and Huilan Chen	S5b.2: Data-driven classification of negotiation processes Authors: Rudolf Vetschera
	S5a.3: Supply Chain Network Design for a New Circular Business: a Case Study in Electric Conversion of ICE Vehicles Authors: Ziqing Wu, Victor Estavoyer, Mathieu Windenberger and Raphaël Oger	S5b.3: The common-sense knowledge about artificial intelligence across groups of drivers: A social representation approach Authors: Luciano Moreira, Bruno Cardoso, Ana Carolina Mora, Sérgio Pedro Duarte, Sara Ferreira and Antonio Lobo
	S5a.4: Designing Discrete Envelopment Simulations of Single Units for Socially Inclusive Banking Services Authors: Thyago C. Nepomuceno, Naialy Patrícia Rodrigues, Jonas Ferreira da Silva and Flávia Barbosa	S5b.4: Revolutionizing Decision Making in Education: Leveraging Deep Learning for Arabic Spoken Digit Recognition to Assess Adult Learners' Speech Therapy Progress Authors: Zineb Touati Hamad and Mohamed Ridda Laouar

13:00 - 14:30	*Lunch - Restaurant*	
14:30 - 16:00	Session 6 – Paper Presentations – *p. 107-111* DSS Analysis Chair: Peter Keenan – *Room 1A22*	
	S6.1: Scientific Authorship in DSS Research: Past Trends and Future Opportunities Authors: Peter Keenan and Ciara Heavin	
	S6.2: Towards an integrative assessment model for port sus-tainability decisions: A systematic review Authors: Xiaofang Wu, Shaofeng Liu, Shaoqing Hong and Huilan Chen	
	S6.3: Behavioral studies for the use of visualization in holistic evaluation for multicriteria decision problems decision Authors: Evanielle Barbosa Ferreira, Tarsila Rani Soares de Vasconcelos, Lucia Reis Peixoto Roselli and Adiel Teixeira de Almeida	
	S6.4: An investigation on Cloud ERP adoption using Technology-Organisation- Environment (TOE) and Diffusion of Innovation (DOI) theories: a systematic review Authors: Sin Ting Cheung, Uchitha Jayawickrama, Femi Olan and Maduka Subasinghage	
16:00 - 16:30	*Coffee Break - Room 1A26*	
16:30 - 17:30	Session 7a – Paper Presentations – *p.112-125* Digital Twins Chair: Uchitha Jayawickrama – *Room 1A22*	Session 7b – Paper Presentations – *p.131-140* Case Studies Chair: Daouda Kamissoko – *Room 1A24*
	S7a.1: Mitigating Business Process Debt with Digital Process Twins Authors: Nikolaos Nousias, George Nedos, George Tsakalidis and Kostas Vergidis	S7b.1: The Application of Digital Technologies in the Agri-Food Supply Chain of China: Enablers Identification and Prioritization Authors: Guoqing Zhao, Xiaoning Chen, Shaofeng Liu and Xiaotian Xie
	S7a.2: An Introduction to a Methodology for Decision Making based on Digital Twins Authors: Daouda Kamissoko, Matthieu Allon and Blazho Nastov	S7b.2: Quantifying the House of Quality components Authors: Sanaz Azarnoosh, João Carlos Lourenço and Isabel Maria João
	S7a.3: Multi-criteria decision-making techniques and tools for sustainability assessment in nanomaterials manufacturing Authors: Maria-Paraskevi Belioka, Jason Papathanasiou and Georgios Aretoulis	
18:00 - 22:00	*Social Event & Gala Dinner* *18:00 Bus Transfer (IMT Gymnasium)* *18:30 – 20:00 Visit* *20:00 - 21:30 Gala Dinner* *22:00 Back to Albi (IMT Gymnasium)*	

Day 3	Thursday, June 1st 2023	
09 :00 - 10 :30	Session 8 – Paper Presentations – *p. 147-151* DSS and Green projects Chair: Shaofeng Liu – *Room 1A22*	
	S8.1: Attracting financing for green energy projects: A City Readiness Index Authors: Aikaterini Papapostolou, Charikleia Karakosta, Filippos Dimitrios Mexis and John Psarras	
	S8.2: An Asset-Based Causal Loop Model to Improve Corporate Value Authors: Romain Ben Taleb, Matthieu Lauras, Mathieu Dahan, Aurelie Montarnal and Romain Miclo	
	S8.3: Impact of Industry 4.0 on OEE improvement Authors: Emna Masmoudi, Laurent Piétrac and Séverine Durieux	
	S8.4: A Lean Knowledge Management Processes Framework for Improving the Performance of Manufacturing Supply Chain Decisions in an Uncertain World Authors: Jiang Pan, Shaofeng Liu, Sarah Tuck and Aira Ong	
10:30 - 11:00	*Coffee Break - 1A26*	
11:00 - 12:00	Keynote #3 – *Room 1A22* Professor Antonio De Nicola ENEA CR Casaccia, Italy "Decision Making for Resilience Engineering in Cyber-Socio-Technical Systems" Chair: Daouda Kamissoko	
12:00 - 13:00	Session 9a – Paper Presentations – *p. 152-176* DSS procedures Chair: Sergio Duarte – *Room 1A22*	Session 9b– Paper Presentations – *p. 185-206* ML and DSS Chair: Ana Paula Cabral – *Room 1A24*
	S9a.1: Understanding interdependencies of success factors for truck platooning implementation: a facilitators' perspective Authors: Sérgio Pedro Duarte, Liliana Cunha, Sara Ferreira and António Lobo	S9bs.1: Prediction of Sentiment Using Machine Learning and Deep Learning Approaches for Restaurant Reviews Authors: Adrija Majumdar, Jayant Choudhary and Trisha Pravin Sarwade
	S9a.2: Sharing Economy: How to support users in selecting the right transaction partner? Authors: Pascale Zaraté, Aysegul Engin and Rudolf Vetschera	S9b.2: A dynamic model for planning and management resources and maintenance activities Authors: Gabrielle Ribeiro and Ana Paula Costa
	S9b.3: Are the Internet Connections at Augustana College Good Enough for Student Productivity? Authors: Tauheed Khan Mohd, Kashav Piya, Jon Cathcart, Minh Nguyen and Jacob Speirer	S9b.3: Why did you fail? An interpretability system for NLP models Authors: Mohsen Rahimi, Giulia De Poli, Andrea Masella and Matteo Bregonzio
	S9a.4: Enhancing Privacy when Accessing Public WiFi with Raspberry Pi Authors: Tauheed Khan Mohd, Christopher Le, Kidus Getachew and Estephanos Jebessa	S9a.4: Decision Support Procedure for Maturity Assessment in Asset Management Authors: Gabriel Herminio de Andrade Lima and Ana Paula Cabral de Seixas Costa
13:00 - 14:30	*Lunch - Restaurant*	
14:30 - 15:30	Closing session – *Room 1A22* Chair: Daouda Kamissoko Presentation of ICDSST2024 by Sergio Duarte	

Papers

Day 1	**Tuesday, May 30th 2023**	Room 1A22

Session 1

AI Technics

9:30 – 11:00

Chair: Christer Carlsson

Room 1A22

#1	*A tool to support the decisions for the trace clustering problem with a non-compensatory approach*	Nikolaos Zapoglou and Pavlos Delias
#2	*BPR Assessment Framework: Staging Business Processes for Redesign using Cluster Analysis*	George Tsakalidis, Nikolaos Nousias and Kostas Vergidis
#3	*A Digital Distance Learning Critical Success Factors Model for Conducting Learning Analytics Research*	Sean Eom
#4	*Young Elderly DSS Users - Some Reasons for Successful Adoption*	Christer Carlsson and Pirkko Walden

A tool to support the decisions for the trace clustering problem with a non-compensatory approach

Nikolaos Zapoglou[1][0000-0002-2918-5235] and Pavlos Delias[2][0000-0002-3722-2307]

[1] Dept. of Computer Science, International Hellenic University, Kavala, Greece
xizapog@cs.ihu.gr
[2] Dept. of Accounting and Finance, International Hellenic University, Kavala, Greece
pdelias@af.ihu.gr

ABSTRACT

Process Discovery and Trace Clustering are used to extract business process related knowledge from event logs and create models of processes. A non-compensatory approach, involving concordance and discordance settings, can be used to assess trace similarity and form groups. Previous research demonstrated the effectiveness of that approach, but it is time-consuming and requires a deep understanding of technique's parameters and desired outcomes. To make the process more efficient, we developed a software tool to assist with parameter definition and analysis of results. The tool provides a user-friendly interface, visual aids and ability to adjust parameters to ensure the solution reflects user preferences, allowing users to make more informed decisions. The publicly available tool combines the power and versatility of the R language with the friendly interfaces implemented using the Shiny libraries.

Keywords: Trace Clustering, Shiny applications, Non-compensatory, Process Mining.

BPR Assessment Framework: Staging Business Processes for Redesign using Cluster Analysis

George Tsakalidis[1][0000-0002-0889-7946] Nikolaos Nousias[1][0000-0002-6598-2098] and Kostas Vergidis[1][0000-0002-2755-499X]

[1]Department of Applied Informatics, University of Macedonia, Thessaloniki, Greece.

{g.tsakalidis, nnousias, kvergidis}@uom.edu.gr

ABSTRACT

In response to increasingly competing environments, organizations are examining how their core business processes (BPs) may be redesigned to improve performance and responsiveness. However, there is a lack of approaches for evaluating BPR at design time and systematically applying BPR in the case of eligible models. The aim of this research is to demonstrate in practice how the BPR Assessment Framework evaluates the redesign capacity of BP models prior to implementation. From the two discrete operation modes of the framework, the paper focuses on the Staging Mode that accounts for the classification of sets of organizational processes. The staging is supported with a clearly defined methodology that is based on partitional clustering and is demonstrated by using a BP model repository from literature, initially containing 1000 process models. Based on the findings, the models have varying BPR capacity and the results are consistent to the rational claim that a rising structural complexity denotes a low capacity for BPR. The framework proved to be a convenient and straightforward method for classifying the BP models of the repository to categories of low, moderate, and high plasticity and external quality. The contribution of the approach lies to the fact that it can be readily used by practitioners in the course of BPR decision making.

Keywords: Business Process Redesign, Business Process Measurement, Cluster Analysis, Business Process Analytics.

Young Elderly DSS Users – Some Reasons for Successful Adoption

Christer Carlsson and Pirkko Walden

IAMSR, Åbo Akademi University, Åhuset, 20500 Turku Finland
Christer.carlsson@abo.fi, pirkko.walden@abo.fi

ABSTRACT

There is consensus in health studies that regular physical activities of sufficient intensity and duration contribute to better health both in the short and long term. We have worked on getting young elderly, the 60-75 years age group, to adopt and include physical activities as part of their daily routines. One reason for addressing young elderly is large numbers – they are now 18-22% of the population in most EU countries (80-100 million citizens). A second reason is that regular health-enhancing physical activities (HEPA) can serve as preventive health care, which will improve and sustain quality of life and save health-care costs for the ageing population. We have learned that the adoption of digital services, which are modern implementations of DSS technology, can be instrumental for building sustainable HEPA programs. We also found out – a bit surprisingly – that digital applications on mobile phones are readily accepted and adopted by the young elderly ("no problems with understanding and learning to use the application") when they are tailored to meaningful purposes and a context that is relevant for the young elderly.

Keywords: Young elderly users, Adoption of DSS, Self-efficacy.

A Digital Distance Learning Critical Success Factors Model for Conducting Learning Analytics Research

Sean Eom

Southeast Missouri State University, Cape Girardeau, MO 63701, USA

sbeom@semo.edu

ABSTRACT

A recent EDUCAUSE horizon report describes that learning analytics is one of the leading technologies and practices that will impact the future of teaching and learning. The growing presence of online delivery modes has accelerated the advancement of learning analytics (LA) and the use of data in education. Despite huge volumes of LA research publications, a systematic literature review reveals that LA research faces several challenges, including a lack of good pedagogical models that will further advance theoretical development in understanding relationships between the effectiveness and learning outcomes and the complexity of learning processes. Recently, Guzmán-Valenzuela et al. claimed that LA tends to underplay the complexity of Learning processes. Their bibliometric analysis of recent literature identified several critical concerns of LA research, including oversimplification of the learning process and lack of good pedagogical models to illuminate students' learning processes and outcomes. This paper aims to tackle these critical concerns. The complexities of teaching and learning processes are due to multiple interdependent factors that affect learning outcomes directly and indirectly. This paper aims to provide an integrated, foundational pedagogical model that is complete and parsimonious for further advancing e-learning analytics research.

Keywords: Learning Analytics, Learning Outcomes, Learning Processes, Systems View, Distance Learning, Critical Success Model

Day 1	**Tuesday, May 30th 2023**	Room 1A22

Session 2

Multi-actor or AHP Decision Making

14:00 – 15:30*

Chair: Boris Delibasic

Room 1A22

#1	*MAMCABM: A data-driven stakeholder-based decision-support system that considers uncertainties*	He Huang, Shiqi Sun, Lina Liu, Koen Mommens and Cathy Macharis
#2	*Multi-actor VIKOR method for highway selection in Montenegro*	Boris Delibašić, Draženko Glavić, Sandro Radovanović, Andrija Petrović, Marina Milenković and Milija Suknović
#3	*AHP Method Applied to the Evaluation of Costs and Pollution Emitted by Combined Means of Transport, Case of SMMC Port Toamasina*	Jean Baptiste Rakotoarivelo
#4	*Exploring Proportional Representation to Synthesise Multiple Analytic Hierarchical Process Matrices for Human Well-being in a Water User Community in an Upstream Agricultural Sub-catchment in Mediterranean South Africa*	Sinetemba Xoxo, Jane Tanner, Sukhmani Mantel, David Gwapedza, Bruce Paxton, Olivier Barreteau and Denis Hughes

* 20 minutes/presentation + Q&A

MAMCABM: A data-driven stakeholder-based decision-support system that considers uncertainties

He Huang[1], Shiqi Sun[1]
[1]Vrije Universiteit Brussel
Pleinlaan 2, 1050 Ixelles, Belgium
He.Huang@vub.be, Shiqi.Sun@vub.be

Lina Liu[2], Koen Mommens[1], Cathy Macharis[1]
[1]Vrije Universiteit Brussel, [2]Nanjing University
[1]Pleinlaan 2, 1050 Ixelles, Belgium
[2]Xianlin Road 163, 210023, Nanjing, PR China
liulina@smail.nju.edu.cn, Koen.Mommens@vub.be , Cathy.Macharis@vub.be

ABSTRACT

In recent years, decision-making in mobility has increasingly relied on data support and consideration of uncertainty. However, conventional decision-making methods such as Multi-Criteria Decision Making (MCDM) and Multi-Criteria Group Decision Making (MCGDM) have limitations in accounting for the complexity and dynamics of real-world mobility situations. This has led to an interest in Agent-Based Modeling (ABM), which can capture the heterogeneity and interactions of individuals in a system. On the other hand, MCDM remains a legitimate method that allows for the consideration of conflicting interests simultaneously. Moreover, it is still valuable to involve stakeholders in the decision-making process, as they can provide important insights and perspectives that may not be captured by purely analytical methods.

This paper presents a novel decision-support system (DSS) that combines Multi-Attribute Multi-Criteria Analysis (MAMCA) and ABM to support mobility decision-making under conditions of uncertainty, called MAMCABM. The DSS provide stakeholders with a comprehensive decision making tool to assess and compare alternative scenarios based on different criteria, where ABM provides rich data support. Furthermore, MAMCABM also accounts for uncertainties that are generated in different steps. MAMCABM is demonstrated on a real-world case study of a road adjacent to a university campus, where different types of vehicles, bikers and pedestrians interact in complex ways. The results of the MAMCABM analysis highlight the importance of considering multiple criteria and uncertainty in mobility decision-making, and provide valuable insights for improving the road situation by taking into account the preferences of different stakeholders.

Keywords: Group decision-making, MCDM, ABM, uncertainty, data-driven

Multi-actor VIKOR method for highway selection in Montenegro

Boris Delibašić[1][0000-0002-6153-5119], Draženko Glavić[2][0000-0002-0069-2153], Sandro Radovanović[1][0000-0002-9975-8844], Andrija Petrović[1][0000-0003-4516-495X], Marina Milenković[2][0000-0001-7931-0586], and Milija Suknović[1]

[1] University of Belgrade, Faculty of Organizational Sciences, Jove Ilića 154, Belgrade, Serbia

[2] University of Belgrade, Faculty of Transport and Traffic Engineering, Vojvode Stepe 305, Belgrade, Serbia

ABSTRACT

Nowadays, decision-making systems in modern infrastructural planning greatly impact everyday life. This paper proposes a novel modification of the multi-criteria decision analysis (MCDA) method VIKOR that can be successfully applied to infrastructural decision-making systems. Our contributions are twofold: We first solve a highway section selection on the Montenegro A1 highway. Secondly, we modify the VIKOR method for the multi-actor (MA) setting. Although the original VIKOR method recognized multi-actor preferences through the selection of the value of the compromise parameter v, it did not explicitly include multiple actors in the decision-making process. Moreover, we show how the multi-actor (MA) VIKOR method can serve as a decision support system for making important infra-structural decision problems, improve the transparency of the decision-making process with the rising need to include citizens in the decision-making process, and how it successfully solves the distortion in social choice problem.

Keywords: MCDA · VIKOR · highway selection · multi-actor.

AHP Method Applied to the Evaluation of Costs and Pollution Emitted by Combined Means of Transport, Case of SMMC Port Toamasina

Jean Baptiste Rakotoarivelo,

IUGM, University of Mahajanga, Georges V Street, Building Kakal Mahajanga be, BP 652 401 Mahajanga Madagascar rjbravelo@yahoo.fr

ABSTRACT

This article is based on the application of multicriteria support methods to decision-making. Within the Conventional Goods Handling Company, we encourage decision-makers in society to adopt assessment methods and available techniques based on strong assumptions in line with today's reality, to take sufficient account of the objectives of integrated development. Indeed, this aimed at all aspects of development, and to integrate into the analysis of many projects different aspects and their impact on the national economy. The problems presented call for the development of new instruments more appropriate to the particular context of combined transport in the case of the SMMC[*]. The purpose of this work is to model a transport system within society. Modelling could be seen as a generalization of the system so that it is standard and applicable to similar systems, taking into account three criteria : ecological, economic and traffic We have estimated the performance of the following five alternatives : pollution, energy, noise, time and damage in which we can estimate the costs of expenditure and the amount of pollution emitted during the transport journey from the port to the final destination of the goods. This makes it possible to consider collective points of view and plan integral resources in a decision support system concerning port activities through the Hierarchical Analytical Decision-Making Process (AHP[†]) method.

Keywords: Pollution - energy – noise – time and damage.

[*] SMMC : Conventional Goods Handling Company
[†] AHP : Analytical Hierarchy Process

Exploring Proportional Representation to Synthesise Multiple Analytic Hierarchical Process Matrices for Human Well-being in a Water User Community in an Upstream Agricultural Subcatchment in Mediterranean South Africa

Sinetemba Xoxo [a*], Jane Tanner [a], Sukhmani Mantel [a], David Gwapedza [a], Bruce Paxton [b], Olivier Barreteau [c], Denis Hughes [a]

[a] Institute for Water Research, Rhodes University, Makhanda, Eastern Cape, South Africa

[b] Freshwater Research Centre, Cape Town, Western Cape, South Africa

[c] G-EAU, University Montpellier, AgroParisTech, CIRAD, IRD, INRAE, Montpellier SupAgro, Montpellier, France

* Correspondence: g13x2945@campus.ru.ac.za

ABSTRACT

Managing water resources and preventing water-related disasters requires an investment in tools that aid knowledge-based group decision-making at local levels. This study focuses on Water User Associations in South Africa, providing assessment techniques to promote cooperative and sustainable governance. Here, adopting the Droop Quota system is proposed as an alternative mathematical procedure for synthesising individual preferences from the Analytic Hierarchical Process (AHP) judgement matrices to form a community weighting index representing supply priority. The preference for water supply in the Twee area is for multipurpose use, with equal importance on economic efficiency and environmental protection, followed by domestic use and tourism. This ranking is justified by the high endemism on the rivers draining the Twee, the socio-economic importance of farmers, the constitutional protection of the domestic water user, and the tourism sector's importance. Tourism/weekenders are expected to operate profitably if the environmental flows are met in the dry season. The results indicate that this approach can facilitate knowledge exchange and social learning, which should benefit collaborative management. In the future, the results will be combined with hydrological and environmental flow estimates to determine the risk of water deficits.

Keywords: AHP Application; Community sensitivity; Decision-Support Systems; Human wellbeing; Koue Bokkeveld; Social-hydrological dynamics.

Day 1	**Tuesday, May 30th 2023**	Room 1A24

Session 3

Posters

16:00 – 17:00

Chair: Franck Fontanili

Room 1A24

#1	*Simulating Compatibility Scenarios in a local AHP-GDM context*	María Teresa Escobar, Juan Aguaron and José María Moreno-Jiménez
#2	*Air Traffic Management Decision Support System to Control the Spread of Pandemics*	Alfonso Mateos, Antonio Jiménez-Martín, Arminda Moreno-Diaz, Andy Rafael Domínguez and María Jesús Rufo
#3	*Leadership and emotional valence: Analysis of sentiments of the network leaders' tweets and their followers through machine learning*	Alberto Turón, Juan Aguarón, José María Moreno-Jiménez and Jorge Navarro
#4	*Enhancing Decision Support Systems Information Quality through NLP-based Spell Checking*	Zineb Touati Hamad and Mohamed Ridda Laouar
#5	*Sentiment Analysis of Tweets and Social Network Leaders During the COVID-19 Vaccination Process in Spain*	Jorge Navarro, Juan Aguaron, Alfredo Altuzarra, José María Moreno-Jiménez and Alberto Turón Moreno-Jiménez and Jorge Navarro

Simulating Compatibility Scenarios in a local AHP-GDM context

María Teresa Escobar, Juan Aguarón, José María Moreno-Jiménez
Grupo Decisión Multicriterio Zaragoza (GDMZ), Universidad de Zaragoza, Spain
mescobar@unizar.es, aguaron@unizar.es, moreno@unizar.es
web-page: http://gdmz.unizar.es

Abstract: The authors have developed a semi-automatic procedure, called AEM-COM, for reducing incompatibility between the actors and the collective position in a local Analytic Hierarchy Process-Group Decision Making (AHP-GDM) context. AEM-COM requires the individual pairwise comparison matrices, the decision maker weights, the permissibilities, and a collective matrix. With this input information, the algorithm is able to provide an updated collective matrix with a lower level of incompatibility. Regarding the degree of actors' participation, we consider that automatic procedures are not appropriate in GDM, unless they are used to simulate and explore scenarios. In order to facilitate informed decisions and negotiation processes between the actors involved in the resolution of AHP-GDM problems, this paper accounts for the simulation of different scenarios for compatibility analysis using the AEM-COM tool. These scenarios are obtained by considering different permissibility values and some possible variants of the procedure. The analysis of these scenarios will provide decision makers with relevant information about the critical points and the decision opportunities of the resolution process.

INTRODUCTION

- **AEM-COM procedure (Aguarón et al., 2023)**
  - Procedure for reducing incompatibility between DMs pairwise comparison matrices and the collective priority vector
  - Modifying judgements of the collective matrix up to a permissibility level provided by DMs (ρ)
  - Incompatibility measured by the Geometric Compatibility Index (**GCOMPI**):

$$GCOMPI(A^{(k)}, w^{(G)}) = \frac{1}{(n-1)(n-2)} \sum_{i,j} log^2 (a_{ij}^{(k)} \frac{w_j^{(G)}}{w_i^{(G)}})$$

$$GCOMPI(w^{(G)}) = \sum_k \alpha_k GCOMPI(A^{(k)}, w^{(G)}), \sum_k \alpha_k = 1$$

$$\text{Efficiency}_i = \frac{\text{GCOMPI}_0 - \text{GCOMPI}_i}{\text{GCOMPI}_0 - \text{GCOMPI}_{min}}$$

OBJECTIVES

- **Simulate scenarios for compatibility analysis**
  - Consider different permissibility values
  - Consider other variants: limiting to the [1/9,9] scale, repeating judgements,....
- **Facilitate informed decisions and negotiation processes between the actors involved in the resolution of AHP-GDM problems**

CASE STUDY

Dong et al. (2010)

- 5 decision makers (DMs) and 4 alternatives
- DMs weights: $\alpha_1 = 1$; $\alpha_2 = 3$; $\alpha_3 = 1$; $\alpha_4 = 2$; $\alpha_5 = 3$

Simulation of Scenarios

- Permissibility from 5% to 50% and with no permissibility
- Limited/Not limited to the scale [1/9,9]

Individual pairwise comparison matrices $A^{(k)}=(a^{(k)}_{ij})$

DM 1	A	B	C	D
A	1	4	6	7
B	1/4	1	3	4
C	1/6	1/3	1	2
D	1/7	1/4	1/2	1

DM 2	A	B	C	D
A	1	5	7	9
B	1/5	1	4	6
C	1/7	1/4	1	2
D	1/9	1/6	1/2	1

DM 3	A	B	C	D
A	1	3	5	8
B	1/3	1	4	5
C	1/5	1/4	1	2
D	1/8	1/5	0,5	1

DM 4	A	B	C	D
A	1	4	5	6
B	1/4	1	3	3
C	1/5	1/3	1	2
D	1/6	1/3	1/2	1

DM 5	A	B	C	D
A	1	1/2	1	2
B	2	1	1/2	3
C	1	2	1	4
D	1/2	1/3	1/4	1

Consensus matrix (Dong et al., 2010)

CM Dong	A	B	C	D
A	1	2.9095	4.6539	6.8707
B	0.3437	1	2.5719	4.0951
C	0.2149	0.3888	1	2.0720
D	0.1455	0.2442	0.4826	1

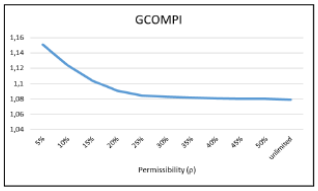
GCOMPI (CM Dong) = 1.1871

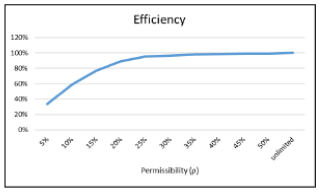
Min GCOMPI = 1.0790

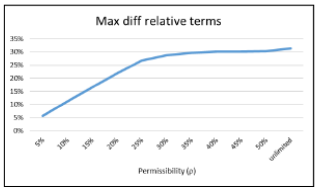
Output

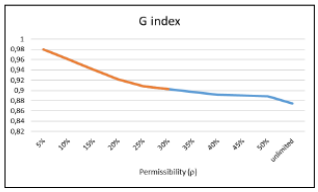
- Final GCOMPI and associated efficiency
- Comparison of initial and final priority vectors using the maximum and the average differences in relative terms and the G index (Garuti, 2007) $G = \sum_i \frac{\min(x_i, y_i)}{\max(x_i, y_i)} \frac{x_i + y_i}{2}$

rho	GCI	GCOMPI	Efficiency	Max Rel	Avg Rel	G index
5%	0.0568	1.1509	33.5%	5.7%	2.8%	0.9799
10%	0.0558	1.1236	58.7%	11.2%	5.5%	0.9605
15%	0.0566	1.1039	77.0%	16.6%	8.0%	0.9405
20%	0.0579	1.0906	89.3%	21.9%	10.4%	0.9216
25%	0.0637	1.0843	95.1%	26.8%	12.3%	0.9083
30%	0.0851	1.0828	96.5%	28.8%	13.1%	0.9027
35%	0.1115	1.0815	97.7%	29.7%	13.8%	0.8970
40%	0.1339	1.0804	98.7%	30.1%	14.4%	0.8915
45%	0.1295	1.0802	98.9%	30.2%	14.6%	0.8902
50%	0.1268	1.0800	99.1%	30.3%	14.7%	0.8889
unlimited	0.2017	1.0790	100.0%	31.3%	16.4%	0.8742









RESULTS

- Results do not vary if judgements are limited or not to the scale [1/9,9]
- All the final matrices have an acceptable inconsistency (GCI < 0.34)
- Efficiency of more than 90% are achieved from ρ ≥ 25%
- Up to 30% of permissibility, the initial and final priority vectors are highly compatible (G> 0.9)

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Air Traffic Management Decision Support System to Control the Spread of Pandemics

Mateos[1], A.; Jiménez-Martín[1], A.; Moreno-Díaz[1], A. ; Domínguez[1], A.R.; Rufo[2], M.J.
[1]Decision Analysis and Statistics Group, ETSI Informáticos, Universidad Politécnica de Madrid
[2]Decision and Inference Bayesian Group, Universidad de Extremadura

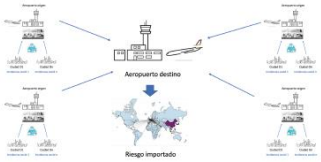
Abstract. The COVID-19 pandemic spread rapidly around the world through international air passenger traffic. This renewed interest in studying what measures can be taken with respect to air traffic to prevent the spread of pandemics. One possible course of action is the selective closure of part of the air traffic, where the economic, social and political consequences conflict with the epidemiological. From an epidemiological point of view, there are mathematical models that make it possible to predict the risk of importing a pandemic via an airport on the basis of the risk of importation through individual flights arriving daily. From an economic point of view, the closure of part of the air traffic entails economic losses for both the airlines and the airports and regions where they are located. Finally, from a socio-political point of view, the cancellation or closure of airspace will affect the population as a whole and restrict mobility, also affecting the connectivity of the air transport network.
To solve this binary problem, we propose a multi-objective perspective where several alternative metaheuristics (attractors-based sticky binary particle swam optimization and NSGA-III) are used to approximate the Pareto front, alongside techniques to quantify decision-makers' preferences in order to reach satisfactory solutions.

Acknowledgements: This paper was supported by the Ministry of Science and Innovation Project PID2021-122209OB-C31.

Epidemiological impact

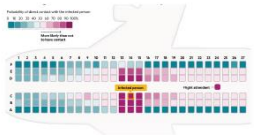
Imported pandemic risk at an **airport** → risk of importation thorugh individual flights of arriving flights:

- incidence of the pandemic in the area of influence of the airport of departure.
  Incidence rates + travel to airport (inland transport)



- risk of passengers becoming infected at:
  - airports of departure and arrival
    computer vision and deep learning (contact and mask detection)

  - during the flight en route
    virus propagation models (SIR and variants: SEIRS, SIS or ASIRS)



Economic impacts

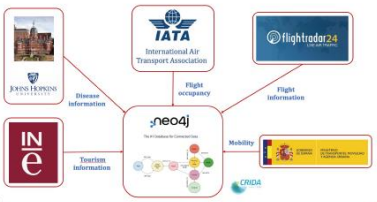
Economic losses for :

- **airlines** (loss of passengers)
  data on operated flights
- **airports** (airport taxes, catering and retail)
  AENA estimates for each airport-port

- **regions** in which the airport is located (loss of tourism, conventions...)
  INE data on tourism (stays and expenditure).

The economic impact should be homogeneous across the stakeholders (airlines, airports and regions).

Available information



Problem instance

Opening/closing of connections to Europe from 36 major Spanish airports

596 international connections

Social impacts

Air transport network connectivity.
IATA connectivity measures.

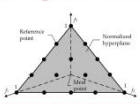
Political restrictions on air traffic could restrict the solution space, (e.g. connections to major European or world capitals must be maintained).

Air Traffic Management Decision Support System to control the spread of pandemics

Metaheuristics

Attractors-based Sticky Binary Particle Swarm Optimization (**ASBPSO**)

Non-dominated Sorting Genetic Algorithm III (***NSGA-III***)



VARIANTS OF THE PROBLEM WITH THE POSSIBILITY OF INTRODUCING PROBLEM-SOLVING DIMENSIONS AND/OR TARGETS.

Quantification of experts' preferences

ENAIRE
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LEADERSHIP AND EMOTIONAL VALENCE: ANALYSIS OF SENTIMENTS OF THE NETWORK LEADERS' TWEETS AND THEIR FOLLOWERS THROUGH MACHINE LEARNING

Alberto Turón, Juan Aguarón, José María Moreno , Jorge Navarro

Grupo Decisión Multicriterio Zaragoza (GDMZ), Universidad de Zaragoza, Spain

turon@unizar.es, aguaron@unizar.es, moreno@unizar.es , jnavarrol@unizar.es

web-page: *http://gdmz.unizar.es*

Abstract: In accordance with the cognitive orientation (Moreno-Jiménez and Vargas, 2019) contemplated in the resolution of complex problems raised in public decision-making through social networks, this work analyzes the influence of network leaders on the state of mind of society. Using sentiment and emotion analysis as research techniques and Twitter as a representative social network, the tweets and retweets published in Spanish about Covid-19 in the environment of the main Spanish political parties during the last five months of 2021 are considered. The study shows that the centrality indicators provided by social network analysis (mainly centrality and prestige) are insufficient for characterizing the influence of leaders on their followers' mood. The emotional valence is a new emotion-driven indicator that allows to extract the arguments that support the different positions and decisions of network users from the analysis of tweets issued exclusively by social leaders.

INTRODUCTION

The main current psychological and neurophysiological theories about emotions highlight the importance of polarity in decision-making and in the development of arguments for or against different alternatives. In this way, the evaluation of polarity is fundamental in affective contexts.

In social networks, the creation of opinion states is attributed to leaders or influencers. We have developed an indicator, emotional valence (Navarro et al.), that strongly relates the moods of leaders to those of their followers. Compared to the classic measures of social network analysis, this indicator incorporates the analysis of sentiments extracted from the text of the messages published and retweeted.

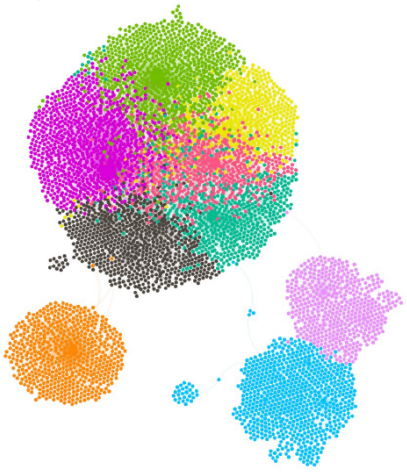

Figure 1: Main clusters of the retweets network.

OBJECTIVES

1. Identify the opinion groups and their leaders through the connectivity between members.
2. Identify the social network leaders by means of the emotional valence.
3. Test the association between the leaders' and the followers' emotional valence.

METHODS

The proposed procedure consists in four stages:

1. **Tweets Extraction:** 48,868 tweets between August and December 2021, written in Spanish and related to the COVID pandemic.
2. **Social Network Analysis:** A retweet network was built, from which nine large clusters were identified (see Fig. 1).
3. **Sentiment Analysis:** The sentiment of each tweet was evaluated with a Spanish lexicon (Turón et al.).
4. **Leaders identification:** The most outstanding authors (leaders) by community, were ranked from highest to lowest according to their emotional valence (Navarro et al.)

RESULTS

Leaders can be selected on the basis of their emotional valence or any of the classical indicators. The correlation between the input degree (measure of power) of the leaders and the emotional valence of their followers is not significant. The same can be said of leaders' centrality (measure of prestige). But when leaders are selected on the basis of emotional valence, the correlation between their emotional valence and that of their followers is highly significant (see Table 1).

Table 1: Correlation between emotional valence and the main social network indicators.

Pearson's r	indegree	eigencentrality	leader e.v.	group e.v.
indegree	1,000	-0,106 0,786	-0,086 0,825	-0,119 0,759
eigencentrality		1,000	0,154 0,693	0,052 0,895
leader e.v.			1,000	0,962 ** 0,000
group e.v.				1,000

CONCLUSIONS

- Sentiment and emotion analysis techniques allows the identification of Social network leaders through their emotional valence.
- The state of mind of the society can be identified through the state of mind of network leaders.
- The corpus of messages to study in order to extract the arguments is considerably reduced.

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Enhancing Decision Support Systems Information Quality through NLP-based Spell Checking

Zineb TOUATI-HAMAD ,Mohamed Ridda LAOUAR
Laboratory of mathematics, informatics and systems (LAMIS),
Echahid Cheikh Larbi Tebessi University, Tebessa, 12002, Algeria
zineb.touatihamad@univ-tebessa.dz,ridda.laouar@univ-tebessa.dz

Abstract: The quality of decision support systems (DSS) information is vital in ensuring accurate and effective decision-making. In this paper, we propose a spell checker based on deep learning and natural language processing (NLP) technology to improve the quality of DSS information. The holy Qur'an ,as the most sensitive text, is used as a case study to demonstrate the effectiveness of our approach. The system can be used by Qur'an scholars and researchers to ensure the accuracy and authenticity of the written version of the Qur'an. Additionally, the system can aid in making decisions about the interpretation of Qur'anic verses based on their contextual placement.

Keywords: Decision Support Systems, Spell Checker, Deep Learning , BiLSTM, NLP , Word Embeddings .

INTRODUCTION

DSS are computer-based systems that provide decision-makers with information and analytical tools to support their decision-making processes. The accuracy and quality of information provided by DSS are critical in ensuring effective decision-making. However, information can be compromised by errors, such as spelling mistakes, which can lead to incorrect decisions. Therefore, there is a need for effective spell checking systems to improve the quality of DSS information. In this paper, we propose a spell checker based on long short-term memory (LSTM) network and Word Embeddings technology to improve the quality of DSS information. We focus on the Arabic Holy Qur'an, which is the most sensitive texts in the world, and present a case study to demonstrate the effectiveness of our approach.

MOTIVATIONS

Spell checking is a well-studied problem in natural language processing. Many existing systems utilize rule-based or statistical approaches to identify spelling errors and suggest corrections. However, these systems can have limitations, such as not accounting for context or being computationally expensive. Recently, deep learning models, such as bidirectional LSTM, and the word embeddings technique have shown promising results in spell checking. These models can capture the context and patterns in text, making them more accurate and efficient than traditional approaches.

METHODS

The BiLSTM based spell checker framework for DSS is composed of three main parts: text to vector representation, model architecture, and text classification. In the text to vector representation part, a vocabulary is created, and the words in a text are replaced with their corresponding index value. Variable-length sequences are transformed into fixed-length sequences using the pad sequence method, with an optimal sequence length of 129 (the longest verse in the Qur'an) chosen to reduce computational cost. The model architecture includes three major blocks: embedding layer, BiLSTM layer, and classification layer. The BiLSTM layer is used to capture contextual information from previous and next words, and the classification layer generates the expected output based on the previous states of the input. The proposed framework effectively addresses spell checking in DSS, with the use of BiLSTM and Word2vec embedding technique enabling the model to capture contextual information and extract features from text data.

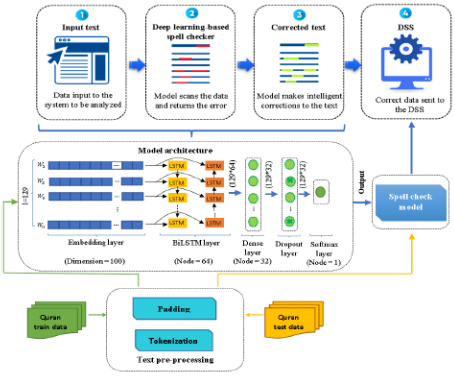

Figure 1: DSS steps based spelling checker

EVALUATION & RESULTS

Using the Qur'an dataset from [1] and applying the K-fold cross-validation technique with a value of K = 10, the proposed decision support system (DSS) Quranic spelling checker achieved an accuracy rate of 94.2%.The study results demonstrated that the proposed system based on the Bi-LSTM model is highly effective in identifying misspellings and suggesting correct spellings of the Quranic text.

CONCLUSIONS

The proposed BiLSTM and word embedding model effectively develops a spelling checker for the Arabic Qur'an dataset, enhancing the quality of decision support systems with an acceptable accuracy rate. Future research will aim to add diacritics for a more comprehensive model. Overall, this model has the potential to significantly improve the accuracy and validity of information in DSS for studying and analyzing the Qur'an. Additionally, it can enhance the accuracy of interpretation in healthcare, finance, and other fields, leading to informed decision-making processes in line with the teachings of the Qur'an. The proposed model has the potential to revolutionize the study and interpretation of the Qur'an in various fields.

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SENTIMENT ANALYSIS OF TWEETS AND SOCIAL NETWORK LEADERS DURING THE COVID-19 VACCINATION PROCESS IN SPAIN

Jorge Navarro, Juan Aguarón, Alfredo Altuzarra, José María Moreno, Alberto Turón

Grupo Decisión Multicriterio Zaragoza (GDMZ), Universidad de Zaragoza, Spain

jnavarrol@unizar.es, aguaron@unizar.es, altuzarr@unizar.es, moreno@unizar.es, turon@unizar.es

web-page: *http://gdmz.unizar.es*

Abstract: Following the cognitive orientation in the resolution of complex problems for public decision-making using social networks, this work studies the possibility of identifying the predominant social mood through the state of mind of network leaders. It is based on the analysis of 98,197 tweets about the COVID vaccination process in Spain (and in Spanish language), from February 2020 to December 2021. This sentiment analysis or "opinion mining" procedure allows us the quantitative analysis of these tweets by extracting subjective information from the examination of emotions (anger, fear, anticipation, trust, surprise, sadness, joy and disgust) and polarity, i.e. the positive or negative connotation of the language used.

INTRODUCTION

COVID-19 is one of the greatest global threats to humans in recent history. So far there has been no sign of remission, and there is no proven effective cure—except, partially, vaccination.

Vaccination is therefore the main preventive health measure against coronavirus. However, the prejudices or sentiments of the general public and the political class, reflected in social media, can have a significant impact on the progression towards achieving herd immunity. The vaccination process in Spain has been officially divided into 4 Phases: Phase O (Development, licensing and evaluation), Phase 1 (First doses available), Phase 2 (More doses available) and Phase 3 (Vaccine widely available).

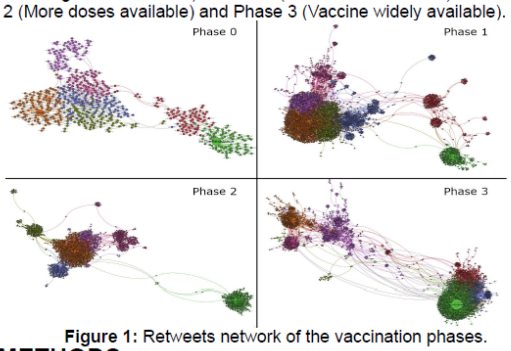

Figure 1: Retweets network of the vaccination phases.

METHODS

The proposed procedure consists in three stages:

1. Tweets Extraction:

- 98,197 tweets between February 2020 and December 2021, written in Spanish related to the COVID vaccination process.
- It has been possible to identify the geographical location of the users. All tweets and retweets published during each of the periods by geolocated authors in Spain were selected.

2. Social Netwok Analysis and Leaders Identification:

- A network was built consisting of a digraph in which the nodes represented the users of the network, and an arc is directed from node A to another node B if user A is geolocated in Spain and has retweeted a message of user B.
- Applying the community detection algorithm of Blondel et al. (2008), seven large clusters were identified, each one represented by a different color. The nodes were distributed using the Force Atlas 2 algorithm of Jacomy et al. (2014).
- The most outstanding authors (leaders) by community, were ranked from highest to lowest according to their influence.

3. Sentiment Analysis:

- The sentiment of each tweet was evaluated with a list of Spanish words and their associations with eight basic emotions (anger, fear, anticipation, trust, surprise, sadness, joy, and disgust) and two valences (negative and positive).
- In order to elucidate how the narrative was structured throughout the tweets we obtained a trajectory graph, i.e., a representation of narrative time (tweets date) versus emotional valence.

RESULTS

The results obtained suggest the impact of the different policies and news during and the influence of leaders in the vaccination process in Spain:

- Figure 1 shows two clearly differentiated clusters: on the left, groups linked to the official sources of the Government/health administrations, journalists and media; on the right, accounts disseminating denialist and anti-vaccine messages. The composition and size of both groups appear clearly related to variations in social mood.
- Table 1 shows the most outstanding authors, coloured by community, ranked from highest to lowest according to their influence, measured by the number of retweets. These eight authors constitute the group of leaders of the discussion, as they are the most valued according to both indicators (influence and valence).

Author	Influence	Valence	Tweets	Sign
ImTheResistance	10,407	1,555	1,299	neg
sanidadgob	10,403	3,800	241	pos
SaludPublicaEs	2,391	230	269	neg
desdelamoncloa	2,381	786	108	pos
salvadorilla	1,892	372	27	pos
sanchezcastejon	1,458	350	10	pos
Covidiota8M	1,238	191	182	neg
HuhConH	907	298	9	neg

Table 1: Influence and emotional valence of the 8 most influential leaders.

- Figure 2 shows the Fourier plot trajectory, which represents emotional valence versus percentage of tweets (date). In the upper side, the positive sentiments, and in the lower side the negative ones. It can be observed how the mental state or social mood of Spanish people has been changing along the different phases of the vaccination process. Finally, local hotspots (green circles) were marked by analyzing the content of these tweets and relating them to relevant news and political decisions.

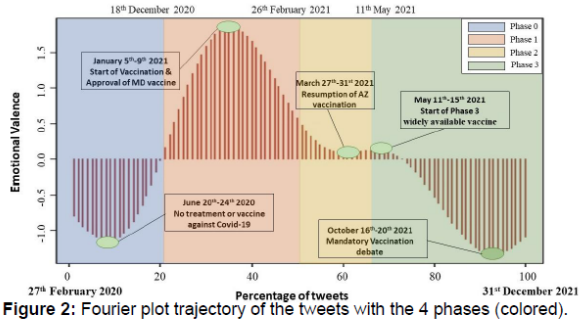

Figure 2: Fourier plot trajectory of the tweets with the 4 phases (colored).

CONCLUSIONS

- This approach evaluates in different time scales the social mood of citizens, gauging predominant states of mind and social support to policies.
- The public mood during the pandemic has strongly oscillated from negative to positive, and again to negative, due to the different measures and news during the vaccination process and leader's position.

Day 2 **Wednesday, May 31st 2023** Room 1A22

Session 4

DSS Case studies

9:00 – 10:40

Chair: Ciara Heavin

Room 1A22

#1	*Time-aware Optimisation Models for Hospital Logistics*	Herwig Zeiner
#2	*Evaluate the potential of the Physical Internet for last mile delivery in developing countries*	Eva Petitdemange, Sam Ban, Matthieu Lauras and Srang Sarot
#3	*Integrating Existing Knowledge to Accelerate Buildings Renovation Rates in Europe*	Charikleia Karakosta, Zoi Mylona, Jason Papathanasiou and John Psarras
#4	*Prevention and Detection of Network Attacks: A Comprehensive Study*	Tauheed Khan Mohd, Paul Addai, Ryan Freas, Elnatan Mesfin Tesfa and Max Sellers
#5	*Building Risk Prediction Models For Diabetes Decision Support System*	Sarra Samet and Ridda Laouar

Time-aware Optimisation Models for Hospital Logistics

Herwig Zeiner

JOANNEUM RESEARCH Forschungsgesellschaft mbH, Steyrergasse 17, 8010 Graz, Austria http://www.joanneum.at
{herwig.zeiner}@joanneum.at

ABSTRACT

Our health system must become more efficient! Cost reduction in the medical sector usually also lowers the quality of patient care and is therefore socially unacceptable. Therefore, other areas of the health care system must be found where cost reductions can be achieved without decreasing the time for patient care. Considerable potential for savings lies in hospital logistics, whereby there are still far-reaching possibilities for optimisation, especially in the planning and implementation of patient transport. The systems currently used for planning transport operations are mostly partially automated and provide useful solutions for simple standard situations. However, such systems are not capable of exploiting the optimisation potential of complex logistics problems or of reacting independently to emergencies and combining patient transports in the optimal way. These disadvantages result in poor utilisation of existing transport capacities (vehicles, personnel) and delays in the handling of transports, which in turn disrupt the transport logistics resources. In this paper, we present a scale-able, novel scheduling algorithm for patient transport in healthcare facilities and hospitals. We consider the time-aware aspects (e.g. short lead times in planning and opening hours of the stations).

Keywords: transport scheduling · time-awareness · robust implementation

Evaluate the potential of the Physical Internet for last mile delivery in developing countries

Eva Petitdemange[1], Sam Ban[1,2], Matthieu Lauras[1], and Sarot Srang[2]

[1] Industrial Engineering Center, University of Toulouse - IMT Mines Albi, Campus Jarlard, 81013 Albi CT Cedex 09, France

[2] Industrial and Mechanical Engineering Department, Institute of Technology of Cambodia, Russian Federation Blvd, P.O. Box 86, Tuol Kouk, Phnom Penh, Cambodia srangsarot@itc.edu.kh

{eva.petitdemange,sam.ban,matthieu.lauras}mines-albi.fr

ABSTRACT

Last mile delivery is a crucial component of the supply chain process, particularly in developing countries. However, traditional delivery methods are often characterized by inefficiencies, such as high costs, long delivery times, and poor delivery accuracy. The rise of e-commerce and the growth of online retail have added further pressure to last mile delivery in these countries. To address these challenges, Physical Internet (PI) has emerged as a promising solution. PI is a new paradigm for logistics and supply chain management that aims to increase the efficiency, sustainability, and resilience of the supply chain. This study aims to assess the impact of PI on last mile delivery in developing countries, using a digital model-based approach. By analyzing the potential benefits and limitations of PI, this study will contribute to the literature and provide insights and recommandations into the implementation of PI-based scenarios in last mile delivery in developing countries.

Keywords: Physical Internet · Last Mile Delivery · Developing Countries · Digital Model.

Integrating Existing Knowledge to Accelerate Buildings Renovation Rates in Europe

Charikleia Karakosta
Decision Support Systems Laboratory, School of Electrical and Computer Engineering,
National Technical University of Athens
9, Iroon Polytechniou str., 15780, Zografou, Athens, Greece chkara@epu.ntua.gr
Zoi Mylona
HOLISTIC IKE
507, Mesogion Av.Ag. Paraskevi, 15343 Athens, Greece zmylona@holisticsa.gr
Jason Papathanasiou
Department of Business Administration, University of Macedonia 156, Egnatia Street, 54636, Thessaloniki, Greece jasonp@uom.edu.gr
John Psarras
Decision Support Systems Laboratory, School of Electrical and Computer Engineering,
National Technical University of Athens
9, Iroon Polytechniou str., 15780, Zografou, Athens, Greece john@epu.ntua.gr

ABSTRACT

Nowadays, boosting the implementation of energy efficiency measures in buildings and subsequently, mainstreaming energy efficiency financing is of paramount importance for the European Union towards achieving its goal of carbon-neutrality by 2050. Unfortunately, statistics have shown that a lot of effort is needed to achieve the Europe's targets, since energy efficiency is not yet considered as an attractive investment by the financial sector. The lack of expertise and knowledge, as well as the different perspective of project developers and financing institutions are some indicative challenges that have to be overcome. Specific to energy efficiency in buildings this is reflected by the current insufficient trends observed in the renovation rates of buildings, which reveal the urgent need for action since this is the largest consumer of energy in Europe. Furthermore, a combination of public and private funding through innovative financing instruments is required to overcome current barriers that prevent mobilization of necessary investments. The aim of this paper is to set up a rolebased methodological approach for the deployment of an integrated matching and blending mechanism on an ICT platform to boost energy efficiency investments in an easy-access and trust-worthy way. The methodology envisages to follow a multidisciplinary perspective which takes into account the interactions between various key factors, such as stakeholders and barriers, so as to facilitate the complex set of decision-making actions for building renovation. The core of concept centres around the definition of the roles of the potential users of a big data for buildings platform, their interdependency and requirements with the ultimate purpose of accelerating renovation rates.

Keywords: Decision Support, Energy Efficiency, Sustainable Finance, Private Finance, Big Data Platform, Building Sector

Prevention and Detection of Network Attacks: A Comprehensive Study

Paul Addai1, Ryan Freas1, Elnatan Mesfin Tesfa1, Max Sellers1, and Tauheed Khan Mohd1[0000−0002−7989−6908]

Department of Math and Computer Science, Augustana College, Rock Island, Illinois, 61201, USA

{pauladdai19, ryanfreas19, elnatanmesfintesfa20, maxsellers20, tauheedkhanmohd}@augustana.edu

ABSTRACT

Cybersecurity is currently a topic of utmost significance in tech sectors. The ever-evolving landscape of this field makes it particularly difficult to navigate. This paper aims to help the reader understand the complexity of network attacks and also show how we may never 'solve' the problem of cyber attacks. Our paper may be accessible to the layman, but a basic understanding of networking fundamentals would be desirable. The words computer security, cybersecurity, or information technology security may all be used interchangeably throughout the paper. An 'attack' will refer to a breach in security to an online system that may cause (but is not limited to) the following: unauthorized information disclosure, theft of technology, or disruption of services.

Keywords: cybersecurity, network, system, attack, security

Building Risk Prediction Models For Diabetes Decision Support System

Sarra SAMET, Ridda Mohamed LAOUAR
Laboratory of Mathematics, Informatics and Systems (LAMIS)
University of Larbi Tebessi
Tebessa 12004, Algeria
sarra.samet@univ-tebessa.dz, ridda.laouar@univ-tebessa.dz

ABSTRACT

Diabetes mellitus early detection is one of the most important issues in the literature nowadays. It contributes to the development of many deadly conditions, including heart disease, coronary disease, eye disease, kidney disease, and even nerve damage. As a result, its prediction is critical. Over the years, several academics have attempted to build an accurate diabetes prediction model. However, due to a lack of relevant data sets and prediction methodologies, this area still has substantial outstanding research concerns. The study attempts to solve the challenges by investigating healthcare predictive analytics. This project employs supervised learning through the application of 3 classification algorithms to early anticipate diabetes with high performance. To train and evaluate the prediction models, we used a sizable diabetes dataset based on actual health data gathered from the Centers for Disease Control and Prevention, which was properly pre-processed in this study, such as how the imbalance was handled utilizing resampling technique. We went with the Logistic Regression Algorithm, Decision Tree Algorithm, and Random Forest Algorithm to analyze the dataset. Based on several evaluation matrices, the results reveal that the RF algorithm outperformed other machine learning algorithms with an F1score of 93.01%. The results of the trial indicate that our suggested model outperforms cuttingedge alternatives. This study's findings may be useful to health professionals, organizations, students, and researchers working in diabetes prediction research and development.

Keywords: Machine Learning, Artificial Intelligence, Decision Support System, Health Care, Data Mining, Diabetes.

Day 2	**Wednesday, May 31st 2023**	Room 1A22

Session 5a

DSS Case studies

12:00 – 13:00

Chair: Ana Paula Costa Cabral

Room 1A22

#1	*Parallel screening of teachers and schoolkids to highlight the potential for the production of podcasts on climate change as teaching and digital community engagement tool*	José Castro, Fatima Dargam, Panagiota Digkoglou, Lucia Fanini, Rosário Ferreira, Carla Machado, Anamaria Magri Pantea, António Martins, Krasimira Miteva, Kiki Mousafiri, Zhaklyn Neycheva, Jason Papathanasiou, Maurizio Pinna, Tatyana Shurelova and Katina Mladenova
#2	*Adoption of Blockchain Technology for Sustainable Food Security: Drivers, Barriers and Potential Solutions for Agri-food Supply Chain in Nigeria*	Ruth Goma, Shaofeng Liu, Charles Thornton and Huilan Chen
#3	*Supply Chain Network Design for a New Circular Business: a Case Study in Electric Conversion of ICE Vehicles*	Ziqing Wu, Victor Estavoyer, Mathieu Windenberger and Raphaël Oger
#4	*Designing Discrete Envelopment Simulations of Single Units for Socially Inclusive Banking Services*	Thyago C. Nepomuceno, Naialy Patrícia Rodrigues, Jonas Ferreira da Silva and Flávia Barbosa

Parallel screening of teachers and schoolkids to highlight the potential for the production of podcasts on climate change as teaching and digital community engagement tool

José Castro
Agrupamento de Escolas Camilo Castelo Branco, Portugal
657@aeccb.pt

Fatima Dargam
REACH Innovation, Austria
f.dargam@reachinnovation.eu

Panagiota Digkoglou
University of Macedonia, Greece
gdigkoglou@uom.edu.gr

Lucia Fanini
University of Salento, Italy
lucia.fanini@unisalento.it

Rosário Ferreira
Agrupamento de Escolas Camilo Castelo Branco, Portugal
rosarioferreira@aeccb.pt

Carla Machado
Agrupamento de Escolas Camilo Castelo Branco, Portugal
1986@aeccb.pt

Anamaria Magri Pantea
International Integrity Foundation, Malta
anamaria@ascendconsulting.eu

António Martins
Agrupamento de Escolas Camilo Castelo Branco, Portugal
sergiomartins@aeccb.pt

Krasimira Miteva
English Language School "Geo Milev", Bulgaria
k_miteva@aegburgas.org

Kiki Mousafiri
1o. Dimotiko Sxoleio Alexandria, Greece
kikimous12@gmail.com

Zhaklyn Neycheva
English Language School "Geo Milev", Bulgaria
zh_neycheva@aegburgas.org

Jason Papathanasiou
University of Macedonia, Greece
jasonp@uom.edu.gr

Maurizio Pinna
University of Salento, Italy
maurizio.pinna@unisalento.it

Tatyana Shurelova
English Language School "Geo Milev", Bulgaria
t_shurelova@gpaeburgas.org

Katina Mladenova
International Integrity Foundation, Malta
katina_plamenova@yahoo.com

Note: Authors are listed alphabetically, with the exception of Katina Mladenova, who was in charge of the task. Corresponding author: Lucia Fanini

ABSTRACT

This short paper presents the baseline results of the EcoPodcasts Consortium (an Erasmus+ action aiming at the production and use of podcasts from schoolkids to schoolkids) in terms of podcasts current use by teachers and students of primary and secondary schools of the six Consortium Countries (Austria; Bulgaria; Greece; Italy; Malta; Portugal). Targeting a common background on which activities can be implemented and shared across-countries, mirroring sets of questions, were submitted to teachers and students (formulated appropriately to age and role), with respect to: 1) podcasts use as learning tool, and 2) attitudes towards podcasts' potential use as tool to raise awareness and promote information flow about climate change. While podcasts are not yet broadly used in school's context, there is an acknowledged positive attitude towards the exploration of podcasts as learning tool, especially when related to topics such as the climate change and developed at school as classroom project.

Keywords: Climate Change, Podcasting, Primary & Secondary School, Erasmus+ Project

INTRODUCTION

Climate Change (hereafter CC) is a topic of enormous relevance, with cross-disciplinary implications related to its study, the identification and prioritization of changes needed to mitigate it, and the communication of all those information to a broad range of audiences. Needless to say, education and in particular environmental education has a role of paramount relevance in the generation of behavioral changes. rooted into society by the direct engagement of children (citizens of tomorrow) and the indirect involvement of their families. Narrative can be built around topics of high complexity (such as e.g., ecosystems) and return storytelling, and storytelling with data [1]. Whereas the topic of CC implies a high degree of uncertainty when comes to projections and fine detail [2] and can result difficult to communicate down to the very local level, actions to mitigate its causes and effects are many. They can be developed at multiple levels, also allowing creative expression at the community, if people are educated to do that. However, to date, only 47% of school curricula out of a sample of 100 Countries [3] include CC as topic. Within this 47%, CC is tackled in a shallow way, and teachers reported difficulties in explaining the severity of CC effects as connected to their local context (with reason, an appropriate way to engage schoolchildren). While teachers reported to be willing to engage 'head', 'heart' and 'hands' of their students about the topic of CC [3], they also asked for proper own training. In fact, within the curricula including CC, this is mostly treated as a topic for primary schools rather than for higher level or professional schools, and only 55% for teacher training curricula include it.

At the same time, podcasts are tools for communication, soon turned tools for education as well, recording a steep increase in use since their emergence in the early 2000s [4]. They are a unique combination of availability and portability, hence extremely valuable for distance learning. For teachers specifically, podcasts are easy to produce and distribute. This made radio-style podcasts widespread, stressing their value as alternative to texts, where instead a voice creates a sense of connectedness between teacher and learner, and finally reflecting on the motivation of students to engage actively e.g. with online forums [5].

On these premises, the Erasmus+ Project EcoPodcasts[*] intends to create a meeting point between teachers and students of primary and secondary schools, answering the needs of support in terms CC education, with specific emphasis on the hands-on part and the local perspective as parts of a larger, global context where everyone is learning to play an unique role [6]. The screening of teachers and students' attitudes, with respect to podcasts as tool for education about CC, was therefore a necessary step. The depiction of patterns in this respect, as well as the identification of synergistic attitudes between teachers and students, were the objective of this work.

In this short note, we provide results related to an excerpt of questions from the screening, to offer a data-driven baseline towards a) the integration of podcasts as school didactic

[*] Erasmus+ Co-funded Project (2021-1-BG01-KA220-SCH-000027685), "EcoPodcasts: Students Podcasts on Eco-Conscious and Sustainable Living". http://www.ecopodcasts.eu/.

tool, and b) the integration of CC adaptation and mitigation topics into training curricula, crosscutting students and teachers' needs.

Results are meant to provide a baseline and guidance towards the realization of CC-related podcasts made by students for students, as their realization and release into the digital space is expected to support the building of a more resilient system facing CC-related drivers.

MATERIALS AND METHODS

Two questionnaires addressing students 10-15 years old and teachers of primary and secondary schools were prepared and validated by the EcoPodcasts Consortium*, which includes schools, universities, and enterprise over a range of six European Countries: Austria, Bulgaria, Greece, Italy, Malta, Portugal. The questions for teachers and those for students were mirroring each other: formulated with different language and adapted to the age but targeting the same information. Targeting a common background on which the Consortium could implement shared activities across national intrinsic differences, the questionnaire considered overarching questions -this is the reason why data are presented as pooled.

The questionnaires (full text available at [7]) were translated and submitted via Google forms to teachers and students, to be filled out completely anonymously. Sampling was a combination of systematic through networks of teachers or school clubs, and opportunistic in occasion of school events, targeting 120 teachers and 180 students across the participating Countries. Targets were exceeded, with 207 teachers and 500 students providing responses to the questionnaire. However, the option to leave blanks was left available, to avoid participants abandoning the questionnaire. As a consequence, there is a slight fluctuation in the number of responses to single questions. Numbers by single questions are therefore reported along with each result shown.

RESULTS

Approximately 30% of students and teachers do not use podcasts (Figure 1).

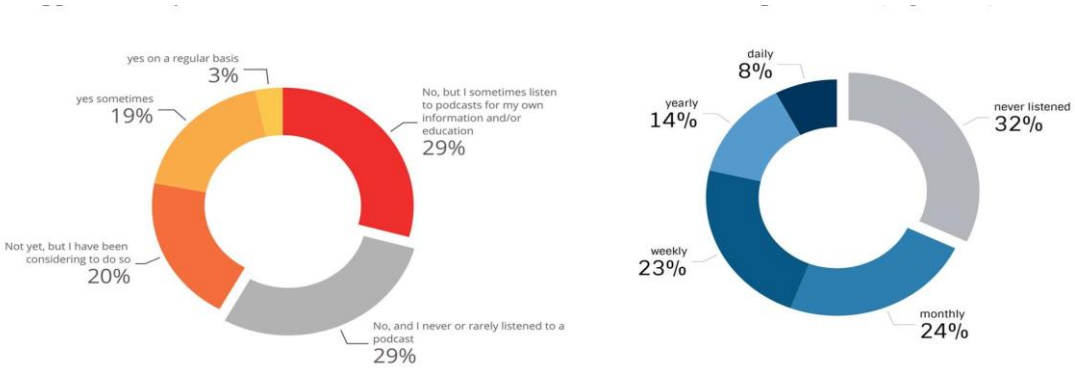

Figure 1. "Do you use podcasts as support to your work as teacher?" (teachers' questionnaire, warm colors scale, N = 205), and "Do you listen to podcast, and if so, how often?" (students' questionnaire, blue colors scale, N = 493).

* EcoPodcasts Partners: http://www.ecopodcasts.eu/cms/index.php/partners

However, when asked whether they thought that listening to podcasts would improve teaching skills/improve learning skills and help with assignments, attitudes of both students and teachers resulted in a positive shift on a Likert scale (Figure 2). The same positive shift was recorded when they were asked to go beyond passive listening and consider producing a podcast as project in the classroom or use podcasts to learn on specific topics like CC and how to act about that (Figure 3). The reference to CC was introduced to teachers in question 2 while to students in question 3, in both cases to give to the question an applied meaning, keeping it closer to the classroom/school context, and introduce CC as learning topic.

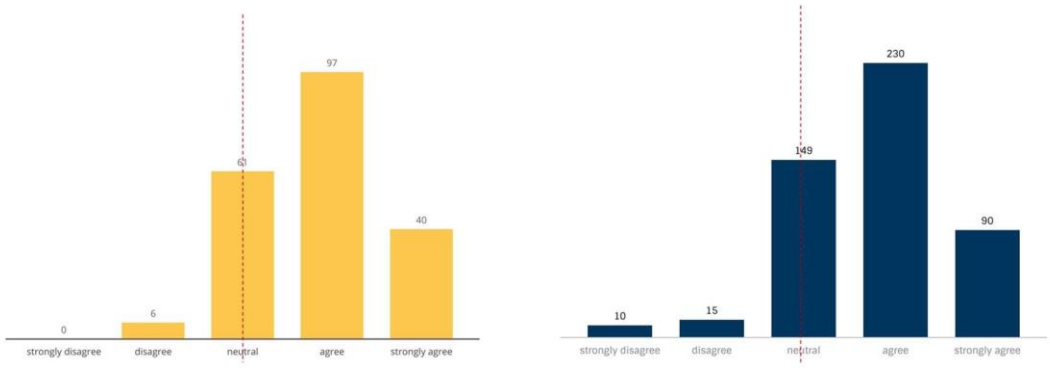

Figure 2. “Do you think that podcasts would improve your options to interact with other teachers, students and communities, increasing awareness on specific topics such as CC and propose hands-on solutions?” (teachers’ questionnaire, yellow bars, N=206). “Do you think that listening to podcasts can improve your learning and communication capabilities, help you with your assignments?” (students’ questionnaire, blue bars, N = 494). Histograms related to the two groups are scaled along the Y axis to smooth for the intrinsic differences in sample sizes. The red line indicates neutrality.

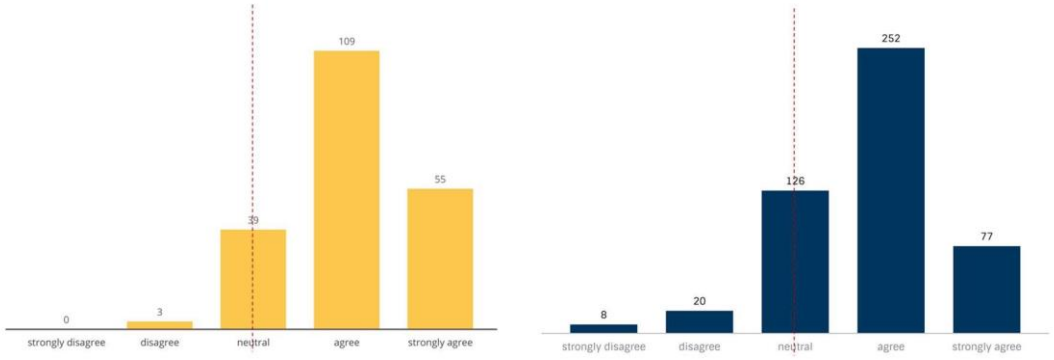

Figure 3. “Do you think that producing a podcast in the classroom would be an interesting project?” (teachers question, yellow bars, N = 205); “I find that podcasts would be a valuable way to learn, for instance about CC, as well as proposing solution to the problem” (students’ question, blue bars, N = 483). Histograms related to the two groups are scaled along the Y axis to smooth for the intrinsic differences in sample sizes. The red line indicates neutrality.

When sourcing for information about CC occurs through search for media contents, this is mostly performed by topic (Figure 4). Trends are very similar between students and teachers, with students tending to explore more broadly also using channels, pictures and suggestions by others to a higher extent tan teachers. When asked about their most used social media, 72.40% of the students reported Instagram, which has the strongest visual

component. However, in spite of such marked attitude towards visual contents, 55.34% of the students would still search by topic when comes to CC related information.

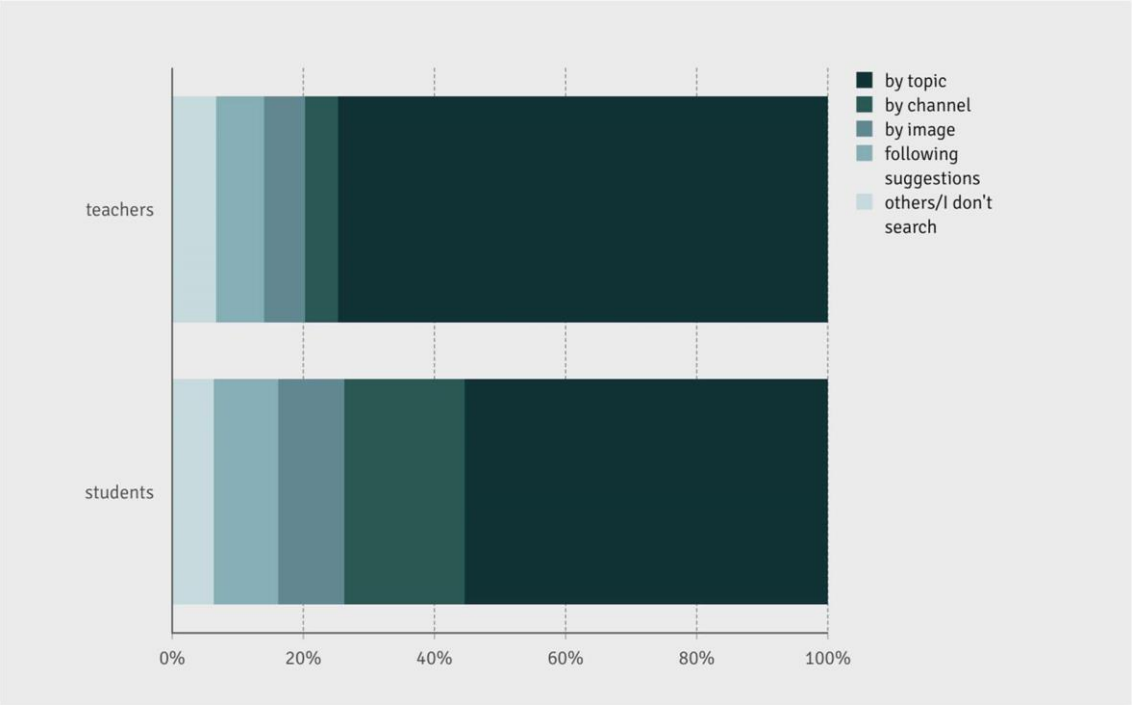

Figure 4. “How do you browse for CC related topics?” Same question for both teachers (N=178) and students (N=477).

CONCLUSIONS

While listening to and producing podcasts has become widespread, and podcasts are considered an excellent outlet also for research results e.g., in scientific communication (Quintana and Heathers, 2021), their potential for use in primary and secondary schools still needs to be exploited. To do so, a match between teachers and students’ attitudes, as found in this baseline survey, represents an optimal background. Even though one/third of the teachers and students are not familiar with podcasts, their attitudes agree with the podcast-users in considering podcasts a promising tool to work hands-on on a topic. In particular when the topic relates to CC and a podcast content would span from gathering knowledge, to awareness raising, to proposing solutions, attitudes of both teachers and students were positive. The production of podcasts as classroom project (an expected product of EcoPodcasts) seems a suitable response to issues reported by UNESCO in [8], namely to 1) the fact that CC in curricula was mainly addressing primary school pupils overlooking teachers training, and 2) the call of teachers for increasing connection of the CC topic with hands-on learning methods for learning. The relevance of the topic to the search for contents suggests that the explicit reference to CC and related issues/actions should be kept as element of identity, and findability. Through the making of podcasts, it will be created a context in which students and teachers can screen information, adapt it to their communities and stream it to meet other groups with matching interests. This is expected to finally make the community digital and the learning about CC increasingly engaging.

On the short term, the results obtained will guide the decisions of the EcoPodcast Consortium, channeling contributions by its diverse partners into the synergistic development and implementation of curricula among schools on the respective territories.

ACKNOWLEDGEMENTS

The survey and the analyses were performed within the EcoPodcasts Erasmus+ Project Nr. 2021-1-BG01-KA220-SCH-000027685, http://www.ecopodcasts.eu/.

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Adoption of Blockchain Technology for Sustainable Food Security: Drivers, Barriers and Potential Solutions for Agri-food Supply Chain in Nigeria

Ruth Goma, Shaofeng Liu, Charles Thornton, Huilan Chen
University of Plymouth
Plymouth, Devon, PL4 8AA, United Kingdom
{ruth.goma, shaofeng.liu, charles.thornton, huilan.chen}@plymouth.ac.uk

ABSTRACT

Agri-food supply chain (AFSC) is becoming more difficult to manage because there are so many global issues decision makers need to consider when they make decisions. Food security is one of the most challenging global issues today as it entails how to provide adequate, safe, and nutritious food to the world populace sustainably. Achieving food security and sustainable food systems is becoming a growing concern not only at the international policy level but in developing countries, especially Nigeria where the number of persons facing emergency levels of hunger is presently around 4.5 million. Prevailing societal issues like food waste, food fraud, food safety and food quality affect different stages of the supply chain thereby impeding food security. It is therefore critical that these issues are tackled in the AFSC using advanced technologies like the blockchain. The focus of this research is on how to help decision support system managers and operators make better decisions for food security by understanding the key drivers, barriers, and potential solutions of blockchain technology (BCT); and most especially how potential solutions can help impact food security in Nigeria. So far, a systematic literature review (SLR) method is adopted. The review is based on 93 papers published from 2008-2022 from five databases: Web of Science, Business Source Complete, Science Direct, Scopus and Emerald. A conceptual framework is developed based on the literature review. This research identified from literature 17 main drivers, 16 barriers, and 21 potential solutions for adopting blockchain technology and grouped them into different clusters or categories. The drivers were grouped into four clusters: Operational, Technical, Commercial and Financial. The barriers for implementing BCT also grouped into four: Intra-organisational, Inter-organisational, System-related, and External while the potential solutions into six clusters: Political, Economic, Social, Technological, Environmental and Legal. The research also tries to find out how potential solutions can help to improve food security through reducing food waste, preventing food fraud, increasing food safety and quality. This research is a work in progress, therefore for the next stage of this research, primary data will be collected through a semistructured interview. A multi-method approach of thematic analysis, total interpretive structural modelling (TISM) and fuzzy cross impact matrix multiplication applied to classification (MICMAC) will be employed to analyse the primary data collected. Research results will include the identification of blockchain drivers, barriers, and potential solutions. Relationships existing between the clusters will be established especially the impact of potential solutions on food security. The research will prioritise and recommend the most important clusters for implementation of blockchain technology in Nigeria.

Keywords: blockchain technology; agri-food supply chain; food waste; food fraud; food safety & quality; food security

INTRODUCTION

The agri-food supply chain is a complicated structure responsible for the distribution of agrifood products from the underlying phase of production to the final phase of consumption [1, 2]. It is typified by multiple stakeholders who strive to achieve their goals interdependently across five generic stages, from farm to fork to include the producers, processors, distributors, retailers, and consumers [1]. AFSC is becoming more difficult to manage because there are so many global issues decision makers need to consider when they make decisions. Food security is one of the most challenging global issues today as it entails how to provide adequate, safe, and nutritious food to the world populace sustainably [3-4]. According to the Food and Agriculture Organisation (FAO) of the United Nations, food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life [5].

Contemporary issues like food waste, food fraud, food safety and food quality are major concerns that affect the different stages of the AFSC [4]. Statistics, according to the World Food Programme, shows that one third of the total food produced for human consumption yearly (amounting to about 1.3 billion tonnes worth approximately 1 trillion US dollars) is wasted or lost globally while more than 820 million people around the world do not have access to adequate food [5-6]. The World Health Organisation reports that one out of 10 people fall ill from contaminated food and 420,000 die yearly resulting in the loss of 33 million healthy life [4]. Presently, a total of 49-50 million people in 46 countries around the world are facing emergency levels of hunger as they are now at risk of famine or food crisis, Nigeria is one of these countries with the number of persons facing emergency levels of hunger around 4.5 million [5]. The persistent increase in food insecurity in Nigeria has motivated this research as an urgent call to adopt blockchain in the Nigerian AFSC as a disruptive innovation to achieve sustainable food security.

Blockchain is a digital decentralised technology underpinned by the Agriculture 4.0 to ensure data integrity and preventing tampering and any single point failure by offering fault-tolerance, immutability, trust, transparency, and full traceability of the stored transaction records to all agri-food value chain partners [1]. Though still in the early stages of adoption, particularly in the agricultural sector, blockchain has the potential to improve food security as opposed to other technologies due to its distinctive features like traceability, decentralisation, immutable database, transparency, security, autonomy, and smart contract mechanisms [2,5,7].

LITERATURE REVIEW

The systematic literature review (SLR) method is adopted for this research to identify, evaluate, and interprete existing research relevant to blockchain drivers, barriers, potential solutions as well as food security in sustainable agri-food supply chains. SLR has been chosen because of its strengths over other review methods, including analysing literature in a disciplined and transparent approach, scientific, replicability and visualising systematic results of the extant research to minimise the chance of missing information or bias. This research followed the five stage guidelines set out by Denyer and Tranfield in [8]: (i) Question formulation; (ii) Locating papers; (iii) Selecting and evaluating papers; (iv) Analysis and synthesis; and (v) Presenting results.

i. **Question formulation:** The first step is the formulation of questions stage. For this study, the following four research questions have been formulated:
RQ1. What are the main drivers for adopting blockchain technology?

RQ2. What are the main barriers for adopting blockchain technology?

RQ3. What are the potential solutions for adopting blockchain technology?

RQ4. What is the impact of potential solutions on food security?

ii. **Locating papers:** This review is based on papers published from five databases: Web of Science, Business Source Complete, Science Direct, Scopus and Emerald. The rationale for selecting these databases is because they include the world's top science and technology journals having some of the largest business research repositories. Defined keywords were combined through Boolean connectors as the search criteria in a combination of terms pertaining to blockchain technology, agrifood supply chain and food security and a total of 174 search strings were identified and included in the search process. At the initial stage, a total number of 3,347 papers was realised respectively: Web of Science-1157, Business Source Complete447, Science Direct-777, Scopus-656 and Emerald-266. In addition to this, 28 papers were included through cross-referencing in order to include potential papers that had not been selected from the above-mentioned papers. Also, 16 papers on the basis of recommendations made by experts were considered.

iii. **Selecting and evaluating papers:** The study used the inclusion and exclusion criteria to reduce the number of papers from over 3,000 to a manageable number in order to conduct meaningful analysis. The inclusion criteria covered full text papers, theoretical and empirical journal articles, high quality conference papers, peerreviewed papers, papers able to answer the formulated review questions, papers written in English and publication period from 2008-2022. The reason for this time frame is because blockchain is a very recent research area which was first coined in 2008 and its idea was hardly discussed before 2008. The exclusion criteria covered parts of the original text, pure marketing purpose, non-peer reviewed papers, papers missing out the review questions, non-English written papers, and publications dated before 2008. Careful analysis of titles, abstracts, introductions, and conclusions was used to distinguish relevant papers from irrelevant ones resulting in an outcome of 358 papers. The study examined the key elements inside each paper, from theoretical foundation through research methods, data collection and analysis to contribution to new knowledge and management implications in line with the quality assessment criteria and got 93 papers in the final collection.

iv. **Analysis and synthesis:** The selected papers were analysed based on the defining characteristics like journal title, year of publication; methodology adopted, while the themes addressed were classified according to the focus of each study and the key issues investigated.

v. **Presenting results:** The findings of SLR will be presented in section 3.

CONCEPTUAL FRAMEWORK

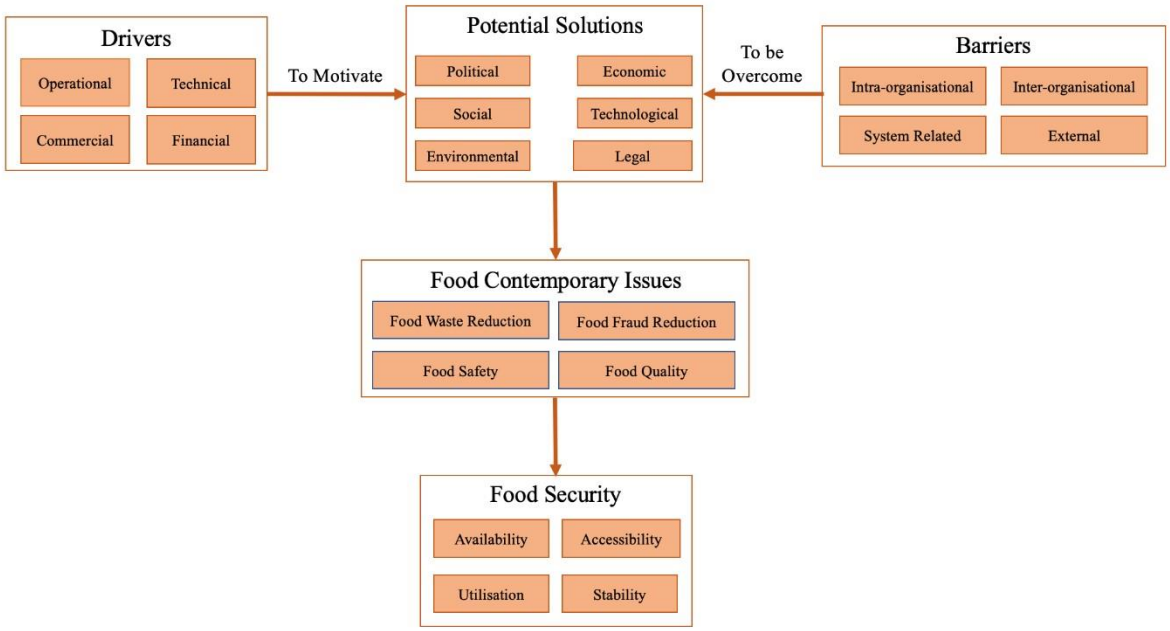


Figure 3.1: Conceptual Framework

A conceptual framework has been developed based on the analysis of literature review and review of practice in Nigeria. The conceptual framework is made up of five constructs:

blockchain drivers, barriers, potential solutions, food contemporary issues, and food security.

3.1 Drivers: Drivers are motivations or forces that influence interest in the implementation of blockchain. The construct of drivers is made up four clusters and these clusters have been grouped based on the analysis of literature [4,7].

Operational drivers: traceability, decentralised database, smart contract, immutable database, real time information available to agro stakeholders, and trust in agri-business.

Technical drivers: privacy, certification of agro-product & process, settlement platform for agro-activities, and governance platform.

Commercial drivers: provenance of agro product, monitoring of agro practice & process, and ethical sharing amongst agro stakeholders.

Financial drivers: auditability, secured transaction, efficient database, and crowdfunding platform.

3.2 Barriers: Barriers of blockchain are the impediments inhibiting the wide adoption of blockchain. Some groups of researchers have classified the barriers to blockchain implementation into four categories which encompass most factors mentioned in literature and these classifications have been adopted by many scholars [2,9]. They include:

Intra-organisational barriers: high implementation cost, lack of skills, lack of knowledge and expertise, lack of deep understanding and knowledge of blockchain by companies.

Inter-organisational barriers: inaccurate inputs, variation of companies' standards, supply chain readiness, possibilities of raw data manipulation before uploading to blockchain.

System-related barriers: scalability and interoperability, speed transaction issues, high consumption, storage capacity issues, smart contract designing, and target of interest for cybercrime.

External barriers: government policy, regulation problems, digital gap between developed and developing countries, and difficult to require all stakeholders within the AFSC to adopt blockchain.

3.3 Potential solutions: Literature has identified different potential solutions for adopting blockchain [2,9]. These solutions have been grouped into six clusters:

Political solutions: corruption in public procurement or government contracting, and grant disbursement.

Economic solutions: decentralised and sustainable resource management in area of energy consumption, water supply and allocation system.

Social solutions: social innovation to reduce hunger and poverty, migration, supply chain sustainability, good health and wellbeing.

Legal solutions: land title registries and property deeds, beneficial corporate ownership registries, intellectual property rights, and documents notarisation.

Environmental solutions: increase consumers demands for information along products supply

chain because of food safety issues, food quality issues and food fraud issues, food traceability because of information asymmetry, food resilience, and food insecurity. Technological solutions: decentralised storage schemes like the ethereum smart contracts and interplanetary file storage system (IPFS) to overcome issues like high latency, low throughput and bottleneck thereby achieving complete traceability, lightning network to solve the problem of speed, simplified payment verification to reduce users' storage in blockchain payment verification, and application of ring of signature scheme to improve privacy.

3.4 Food security: Research show that food security is made up of four fundamental characteristics [5]:

Food availability: entails having enough food in both quantity and quality and is dependent on domestic production, import, food stocks and food aid.

Food accessibility: the ability to have access to the food and is dependent on income, purchasing power and own production, transport and market infrastructure and food distribution.

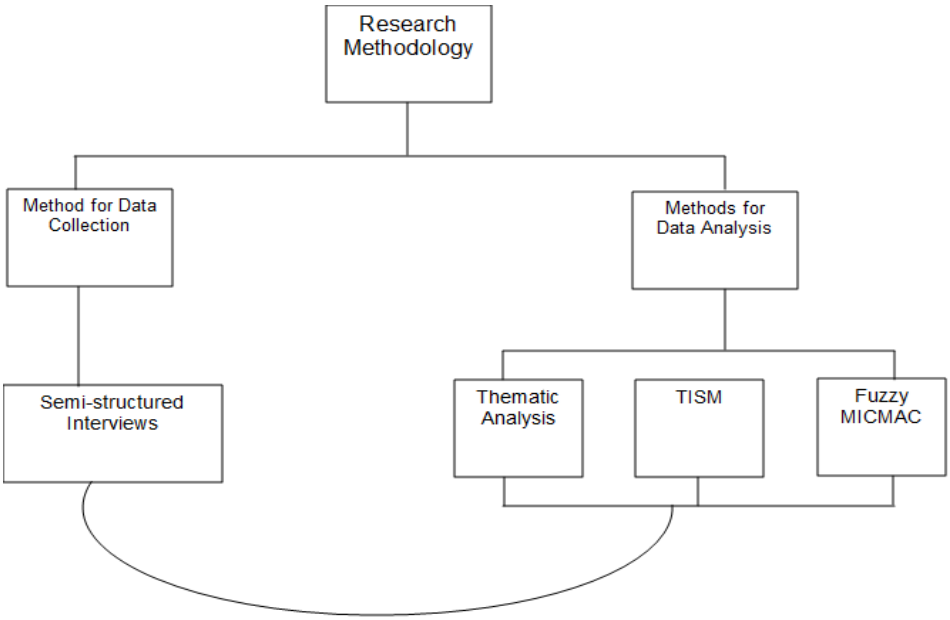
Food utilisation: safe and nutritious food which meets dietary needs of the people and is dependent on food safety and quality, clean water, health and sanitation and care, feeding and health seeking practices.

Food stability: the availability of food over time, that is sustainability of food and is dependent on weather variability and seasonality, price fluctuations, political factors and economic factors.

3.5 Food contemporary issues: Contemporary issues like food waste, food fraud, food safety and food quality have been identified from analysis of literature. Works have been done on how food waste, food fraud, food safety, and food quality affect food security but were done as separate indices. Literature on the combination of these four have not been found neither have their relationships with the potential solutions of blockchain [2,3].

PLANNED METHODOLOGY FOR EMPIRICAL STUDY

Figure 4.1: Planned Methodology



This work is research in progress. So far, we have developed a conceptual framework as presented in section 3. Sections 1,2&3 are not empirical study but literature. For the next stage, which is empirical study, we have devised the research methodology for primary research in the context of Nigeria. The rationale for choosing Nigeria is owing to the fact that Nigeria is now at risk of famine or food crisis because the number of persons facing emergency levels of hunger is around 4.5 million [5]. The purpose of the primary research is to evaluate the conceptual framework to see which part will work in Nigeria. Data will be collected from the

Nigerian food chains to help people to understand the adoption of blockchain drivers, barriers, potential solutions as well as the impact potential solutions have on food security. A semistructured interviews method will be employed for collecting these data. The method is necessary because the themes are not well established in literature and semi-structured interviews will present the researcher with a predetermined list of drivers, barriers, potential solutions and food security and vital questions relating to the themes thereby guiding the course of the interview [10]. A multiple data analysis method of thematic analysis, total interpretive structural modelling (TISM) and fuzzy cross impact matrix multiplication applied

to classification (MICMAC) will be employed to analyse the data collected from the semistructured interview. Thematic analysis will be used to analyse the data collected from semistructured interviews as it is a qualitative analysis technique for "identifying, analysing, and reporting themes within data. TISM will be used to establish the relationships between different drivers, barriers, potential solutions; and how potential solutions can impact on food security. Fuzzy MICMAC will be used to cluster the identified drivers, barriers and potential solutions and evaluate the importance of each. The researcher believes that a combination of these three methods will help to balance the strengths and weaknesses inherent in each method.

CONCLUSION

We have already identified blockchain drivers, barriers and potential solutions from the systematic literature review. For the next stage, we will collect primary research, compare findings from literature on the identified drivers, barriers and potential solutions with those from the Nigerian context, and to establish relationship between them, especially to find out the impact of potential solutions on food security.

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Supply Chain Network Design for a New Circular Business: a Case Study in Electric Conversion of ICE Vehicles

Ziqing Wu, Victor Estavoyer, Mathieu Windenberger, Raphaël Oger
Centre Génie Industriel, IMT Mines Albi, Université de Toulouse
Albi, 81000, France
ziqing.wu@mines-albi.fr, victor.estavoyer@mines-albi.com
mathieu.windenberger@mines-albi.fr, raphael.oger@mines-albi.fr web-page:
https://cgi.imt-mines-albi.fr/

ABSTRACT

This paper explores the decision support for supply chain network design (SCND) in the context of a new circular business. The number and locations of each supply chain actor, as well as product flows are determined during the SCND process. Different supply chain configurations are evaluated based on economic and environmental aspects using agent-based modeling and discrete event simulation techniques. A case study on retrofit service for Internal Combustion Engine (ICE) vehicles is proposed. The paper provides managerial insights that will assist circular business providers in making informed decisions regarding SCND.

Keywords: Supply Chain Network Design; Circular Economy; Sustainability; Decision Support Systems; Agent-Based Modeling; Discrete Event Simulation

INTRODUCTION

Circular Economy (CE) has been increasingly recognized as a key solution towards achieving sustainability. It involves the creation of a restorative and regenerative system, where waste and emission are minimized, and resources are conserved [1]. The ReSOLVE framework introduces six different business practices that can be implemented within a circular economy [2]. New circular business initiatives can be generated by choosing and combining these practices. Among other possibilities, loop and exchange can be combined to extend the lifetime of an existing product. An example of this combination can be the electric conversion of ICE vehicles [3]. Aligned with the value capture principle of CE, existing local facilities can be potentially employed by this type of business [4].

Supply Chain Network Design (SCND) is a strategic process, that determines the number and locations of facilities, and the product flows among them [5]. This process is critical to new businesses as it can lock up to 80% of the costs of the supply chain [5]. This paper is focused on the decision support of SCND in the context of a new circular business. While numerous SCND models have been proposed in the literature [6], the integration of circularity in the supply chain remains relatively limited [7]. In this article, we aim to fill this research gap by exploring the considerations involved in the SCND process for a new circular business.

STATE OF THE ART

Addressing SCND decision support involves defining network configurations, objectives, and decisions. Possible network configurations in CE can include reverse, closed-loop and open-loop supply chains [8]. Reverse supply chains focus on the material flows from the consumer side to the manufacturer

side. A closed-loop supply chain is a system in which products are produced, used and then recovered and recycled into new products. On the other hand, an open-loop supply chain is a system in which used materials are not returned to the original producers, but to the others. In an ideal scenario, both closed-loop and open-loop flows should be employed in the supply chain to accelerate the CE implementation [4].

The design objectives shall cover all three dimensions of sustainability, including economic, environmental and social factors. Typical indicators to be considered in SCND can be cost, emission and job opportunities. Cost can be furtherly decomposed into facility location cost, facility operating cost, inventory cost, transportation cost, among others. [6]. Similarly, emission shall encompass greenhouse gas emission caused by supply chain activities, such as facility opening emission and transportation emission. [9]. Decisions made from SCND can be both strategic and tactical, guiding long-term and mid-term arrangements, such as facility location, capacity expansions, transport flows selection and allocation [8].

Techniques used to support SCND decisions can be put into three categories: mathematical programming, simulation and hybrid models [10]. Although mathematical programming can provide optimal solutions for a given set of decision variables and constraints, simulation has been shown to be better suited for capturing the dynamics of large-scale complex systems [10]. Simulation employs three common methods which are System Dynamics (SD), Discrete Event Simulation (DES) and Agent Based Modeling (ABM). Each one serves a specific range of abstraction levels. The multi-method model can be used to capture different aspects of a complex system [11].

RESEARCH METHODOLOGY

This study aims to provide decision support for circular business providers by considering the number and location of each supply chain actor as decision variables. To achieve this, different scenarios of supply chain configuration are proposed and their economic and environmental performances are compared.

In this work, DES and ABM are combined to model a circular supply chain. Each type of actor on the supply chain is modeled by a type of agent, whose behavior is customized. Order processing and truck dispatching are managed by DES. Geographic Information System (GIS) is integrated to provide spatial information and enable the modeling of the physical space where agents operate. Specifically, the model uses a GIS search engine to place the supply chain actors in their respective initial locations. The model also utilizes the real road network to simulate the movement of trucks between the agents. Anylogic® 8.8.1 is used to build the simulation model.

CASE STUDY

The circular business considered in this study is the electric conversion for Internal Combustion Engine (ICE) vehicles, termed also retrofit. Retrofit consists of replacing the engine with an electric one, adding batteries and changing other auxiliary parts. With the expansion of low/zero emission zones [12] in European Union, it seems to be a promising solution to satisfy urban mobility needs. The report from ADEME [13], the French environment and energy management agency, has confirmed that retrofitting is a convincing solution to the air quality and greenhouse gas emission issues. As one of the new businesses under CE, retrofit shows however ephemeral characteristics, due to the gradual replacement of ICE vehicles by electric vehicles, which bring challenges to SCND decision-making.

Thus, reusing current facilities in the supply chain shall be a recommended practice as this induces fewer capital expenditures.

One possible business model of retrofit can be franchising eligible garages to conduct retrofit services. From a user's perspective, garages are easily accessible as they are often located in local neighborhoods. From a garage's perspective, retrofit creates extra revenue streams and compensates the counterpart of the reduced revenue from the decreasing maintenance demands due to the popularity of electric cars. From a business provider's perspective, the fact that garages already possess the required equipment for retrofit not only reduces the initial investment but also allows maximization of the efficient use of supply chain assets, which is essential for a circular economy [14].

The supply chain layout considered in this study is shown in Figure 1. A set of parts required by retrofit service for a given vehicle is called a retrofit unit. Retrofit units are produced in a manufacturing plant. Then the distribution of retrofit units from the manufacturing plant to garages is conducted by distribution centers (DC). Recycling centers are also involved to recover materials from extracted ICEs and wastes, provide recycled materials back to the manufacturing plant or secondary market for the use of other supply chains. The supply chain is a priori onshore. The focus of this work is on the distribution part of the network as outbound logistics cost is estimated to have a higher impact than inbound one for this case. The concerned supply chain actors are indicated by a colored square in Figure 1.

Before simulating the supply chain network, some hypotheses are introduced. Firstly, the geographical coverage of the retrofit service is the Occitanie region in France. Secondly, the capacity for each garage is around two cars retrofitted per day, as a retrofit service provider stated that a car can be retrofitted in 4 hours [15]. Thirdly, the retrofitting process will prioritize vehicles with Crit'Air 4, 5, and non-classified labels as they are the first ones to be restricted by low-emission zone policies. It is assumed that 10% of them will be retrofitted in three years. The data used to estimate the retrofit demand is circulating vehicle fleet data in France published by the French ministry for ecological transition and territorial cohesion [16].

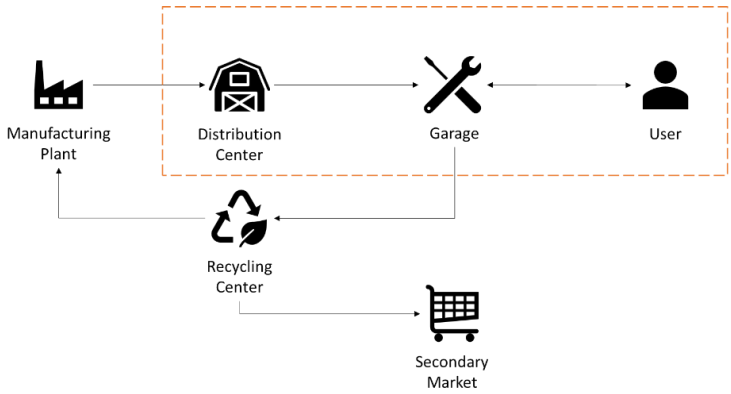

Figure 1: Supply Chain Layout for Retrofit Service

Determining the number and locations of garages

For each department in the region, a sufficient number of garages shall be franchised to meet the local customers' needs. The number of garages per department is determined by its average daily demand. The location of garages is determined based on the population of cities in the department. For instance, two garages are needed in Le Tarn which will be located in Albi and Castres, the two most populated cities in the department. Table 1 presents the demand per department of vehicles to be

retrofitted in Occitanie in three years, as well as the number of garages calculated based on the average daily demand per department.

Table 1: Estimated Demand per Department of Vehicles to be Retrofitted in Occitanie

Departments in Occitanie	Total number of vehicles to be retrofitted	Estimated average daily demand	Number of garages
Ariège	20122	1.84	1
Aude	38409	3.50	2
Aveyron	35274	3.22	2
Le Gard	65277	5.96	3
La Haute-Garonne	93035	8.49	4
Le Gers	24669	2.25	2
L'Hérault	85116	7.77	4
Le Lot	23988	2.19	2
La Lozère	10101	0.92	1
Les Hautes-Pyrénées	27752	2.53	2
Les Pyrénées orientales	45411	4.14	3
Le Tarn	42110	3.84	2
Le Tarn-et-Garonne	29616	2.70	2

Comparing the number and locations of DCs

Several scenarios are compared for the different configurations of distribution activities. One can envisage renting only one DC in the region, or three DCs to reduce potentially the outbound transport cost. Scenarios are modeled and simulated by combining ABM, DES and GIS techniques. A possible configuration is shown in Figure 2.

Cost and emission are used as economic and environmental indicators to compare different configurations. Cost is divided into infrastructure cost, which is the rent of distribution centers (DCs), and transportation cost, estimated to be €20,000 and €0.5/km, respectively. Emission is divided into infrastructure emission induced by DC installation, operation, and truck production, and transport emission induced by truck operation, estimated to be 2.5 t CO_2eq, 0.18 t CO_2eq/year, 3 t CO_2eq, and 0.12 kg CO_2eq/km, respectively.

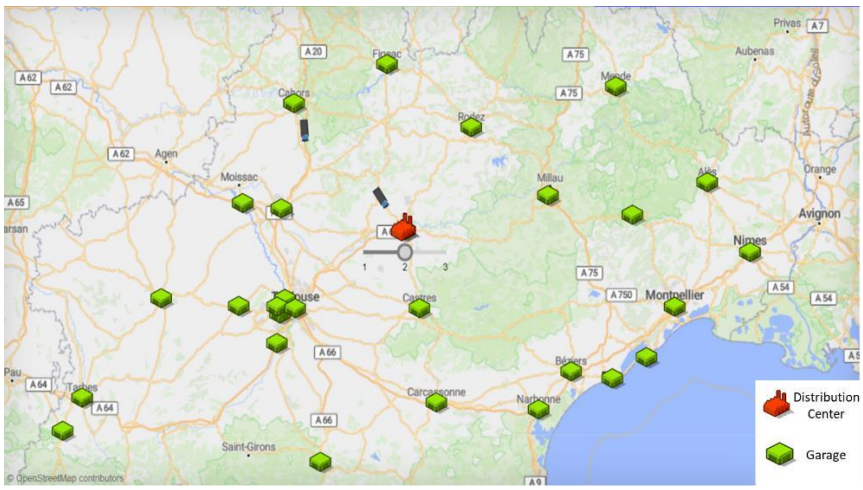

Figure 2: Scenario Where a Central DC Located in Albi

Six scenarios are compared including one DC located in Toulouse, Montpellier or Albi, and three DCs located in Toulouse - Montpellier - Nîmes, Toulouse - Montpellier - Perpignan and Montauban - Foix -

Montpellier. The proposition of these scenarios takes both city population and geographical location into consideration. The simulation is run for one year for each scenario and the performances are shown in Figure 3. The Pareto optimal solutions in this case are thus scenarios where one DC is in Albi and three DCs are in Toulouse, Montpellier and Perpignan. Decision makers need to make a tradeoff between cost and emission.

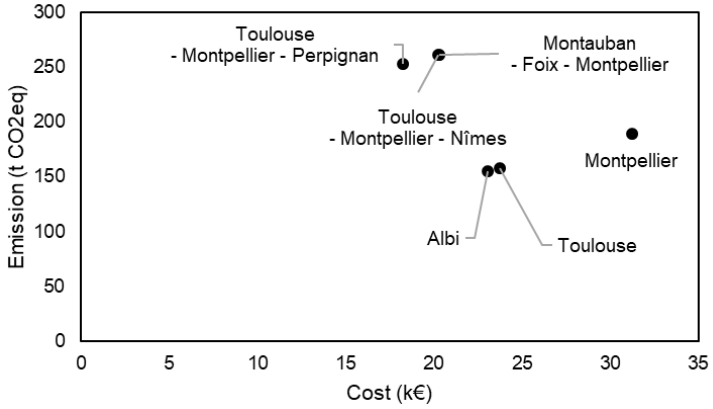

Figure 3: Cost and Emission for Six Scenarios

CONCLUSION AND PERSPECTIVES

In conclusion, this study intends to propose decision support for SCND of a new circular business. Through the use of simulation, different supply chain configurations are compared and evaluated from economic and environmental aspects. A case study on retrofit service is proposed. From the business providers' perspective, managerial insights obtained from the results can guide them to make informed decisions in SCND. Future perspective involves revisiting the hypotheses in the case study, involving optimization techniques to determine a baseline scenario, introducing uncertainties into the model, and covering more stages of the supply chain.

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Designing Discrete Envelopment Simulations of Single Units for Socially Inclusive Banking Services

Thyago C. C. Nepomuceno, Naialy Patrícia Rodrigues, Jonas Ferreira da Silva
Universidade Federal de Pernambuco
Campus Agreste (CAA), Av. Marielle Franco, s/n - Km 59 - Caruaru, 55014-900, Brazil
thyago.nepomuceno@ufpe.br, naialy.rodrigues@ufpe.br, Jonas.ferreirasilva@ufpe.br

Flávia Barbosa
INESC TEC, Faculdade de Engenharia da Universidade do Porto
R. Dr. Roberto Frias, s/n, 4200-465, Porto, Portugal flavia.barbosa@inesctec.pt,

ABSTRACT

Discrete Event Simulation (DES) is a valuable tool for modelling complex systems and constructing digital process representations in banking services considering customer arrivals, service times, and resources that can be simulated to identify bottlenecks and improve overall system efficiency. However, to enable managers to make informed decisions to improve overall performance, it is necessary to consider a production scenario with multiple inputs and outputs that can be modelled by resorting to Data Envelopment Analysis (DEA). In this work, we integrate both perspectives into a combined approach for measuring the efficiency of banking services when the data available is insufficient for constructing a production frontier. The case of *Caixa Econômica Federal* (the Brazilian Federal Savings Banks) during the COVID-19 pandemic reinforces the methodology's social importance. We discuss the best-simulated production scenarios for resource reallocation and the different periods with the most options for the efficient allocation of employees to support the optimal selection of human resources for specific moments and banking sectors.

Keywords: Discrete Event Simulation, Data Envelopment Analysis, Banking Services, COVID-19, Brazil

INTRODUCTION

The study on queuing theory dates back to the work of Agner Erlang (1909) [1], addressing the problem of telephone line traffic in Copenhagen. Since this seminal work, many empirical and theoretical approaches have been proposed to assess daily problems with queues and waiting lines in several public or private institutions. These applications in service systems are equally evident in both sectors [2-4]. The main objective is to balance how long the customer can wait for the service and the service's costs and quality. Understanding the main aspects, statistical measures and factors impacting the service provisions is crucial for attaining such a purpose. For instance, Muting et al. [5] work on queuing theory and simulation in a banking environment found that the average queue length and waiting time are the two most important factors influencing customer perception of service quality.

The Queueing Theory has been improved to design Process Twins as digital replicas of realworld banking processes. It can support testing and optimizing the financial services before they are implemented, evaluating the impact of different staffing and service strategies on customer wait times

and improving efficiency by eradicating activities within the service process that has no value for the customer [6-9]. By creating queue-based process twins, organizations can devote particular attention to the customer's waiting time to be served and simulate different scenarios to test how the service will perform in different situations, including socially inclusive banking services, which is one of the main objectives of Caixa Econômica Federal (CEF), a public financial institution in Brazil and the second-largest bank in the country in terms of assets. Simulations that can reproduce financial services can be a tool for this purpose.

Discrete Event Simulation (DES) is a powerful tool for creating process twins representing discrete events that occur over time. These events include the arrival of customers, the completion of tasks, or the failure of servers. By simulating these events, DES can provide valuable insights into the performance of a process and help identify areas for improvement in different sectors and domains of applications [10]. One of the key advantages of using DES to create process twins is that it allows testing and optimizing a process's performance in a controlled and repeatable environment. Because event simulations based on queuing theory offer a metric for only one output of banking service (service time or the number of clients served), this limits the conduction of performance evaluations based on multiple input-output production configurations other than those measures of performance and prevents determining the best production scenario of servers over time.

The non-parametric frontier estimations are attractive linear programming developments to address such a limitation. These estimations are based on radial contractions and expansions of multiple input-output technologies and were first proposed by Charnes et al. [11] from a constant return to scale perspective and then extended by Banker et al. [12] into variable returns to scale approach. Data Envelopment Analysis (DEA) offers favorable optimal efficiency measures for the service unit under evaluation based on cross-sectional, time-series, or panel-data comparisons considering production possibilities with multiple resources and products. Thus, the purpose of the current research is to combine the advances in Data Envelopment Analysis with Discrete Event Simulations to support the construction of dataset scenarios and comparisons with simulated data for situations when cross-sectional or timeseries data are unavailable. For instance, such a methodology can be beneficial when the only available data is the current production for a single Decision Making Unit (DMU).

DATA & METHODOLOGY

Caixa Econômica Federal was founded in 1861 and is currently one of the largest financial institutions in Brazil, offering a wide range of services to individuals (*Pessoa Física*) and businesses (*Pessoa Jurídica*). One of the main areas of focus for CEF is providing banking services to low-income individuals and families. The bank has several programs and services that are designed to support vulnerable populations in gaining access to financial services and improving their economic status. For example, CEF offers low-cost checking and savings accounts, loans for small business owners, and income transfers for workers. Additionally, the bank has a program called "*Minha Casa Minha Vida*" (*My House My Life*), which offers lowinterest loans for affordable housing.

For this research, we selected only the bank segments directly in contact with clients requiring assistance related to government income transfers and social programs, such as FGTS and the COVID-19 Emergency Aid. The sectors for the optimization process are: Caixas (teller services), Expresso (segment responsible for rapid assistance), and Gov-Social (responsible for the social programs). Those sectors represent around 80% of the clients in a regular branch. During the pandemic, they had higher demands from the Emergency Aid and the anticipation of the FGTS. The working time is seven hours

a day instead of six because staff usually stay after regular working hours to finalize the service of people already in the queue after closing the Branch.

Data were collected from January 2019 to December 2020 in one specific bank branch in *Jaboatão dos Guararapes*, a municipality in Pernambuco. The city is the second in the state on the human development index and has an average income of two minimum wages for formal workers, with an estimated population of 711,330 residents. The period is considered ideal because it allows two scenarios, the first one before the pandemic can simulate a "normal" service context for the bank segments, i.e., prior to the increase in demand due to the Emergency Aid, and the second, during the pandemic with the increasing demand for these services. Table 1 reports the main descriptive statistics related to the average service time for each sector.

Table 1 - Descriptive Statistics

Year	Sectors	Min	1st Quartile	Average	Median	3rd Quartile	Std. Dev
2019	Caixa	3658.00	4191.00	4659.67	4661.00	4962.00	641.62
	Gov-Social	1931.00	2432.00	3044.42	3199.00	3438.25	792.45
	Expresso	3198.00	3877.00	4511.08	4382.50	4795.25	955.67
2020	Caixa	995.00	1151.25	2325.17	1821.00	3538.50	1321.93
	Gov-Social	0.00	0.00	696.92	4.50	568.75	1304.55
	Expresso	657.00	3160.00	4610.92	4634.50	6161.25	2414.01

The methodology is composed of two parts. In the first part, we conduct discrete event simulations to calculate each group's average arrival and service times. Each sector's best empirical probability distribution was carried out using Kolmogorov-Smirnov goodness-of-fit. The occurrence probability for each sector is given based on experience and expert knowledge from an employee of the bank..

From the results of simulating employee and service scenarios, we incorporate the generated input and output data into a time-series (internal frontier) variable returns-to-scale slack-based DEA model [12] to identify optimal employee configurations that can support efficient resource allocation strategies over time and banking sectors. To include internal frontiers instead of peer evaluations of different units, we consider the same decision unit (*Jaboatão* branch) evaluated within specific periods t = 1, 2, 3…, p, defined as:

$$max \sum_{i=1}^{n} s_i + \sum_{r=1}^{m} s_r$$

$$Subject\ to: \quad \sum_{t=1}^{p} \beta_t \dot{x}_{it} - \varphi^* \dot{x}_{ig} + s_i = 0 \qquad (1)$$

$$\sum_{t=1}^{p} \beta_t \dot{y}_{rt} - (\dot{y}_{rg} + s_r) = 0$$

$$\sum_{t=1}^{p} \beta_t = 1$$

$$\lambda_j \geq 0$$

where β is the scalar defining the linear combination to construct the efficiency frontier and φ^* is the efficiency score applied in a self-evaluation perspective with the same interpretation as λ and θ^* in the traditional efficiency measure of decision units for the *r* = 1, 2, …, *m* outputs, and *i* = 1, 2, …, *n* inputs as defined by [14] and [15]. The $\dot{x}_{it}$ and $\dot{y}_{rt}$ are the simulated amount of input *i* in time *t* and output *r* in time *t*, instead of the actual production. As a result, we have efficient periods (months) to identify the best combination of employees for each specific scenario.

PRELIMINARY RESULTS

The Average service rate μ and utilization rate (ρ) used to calculate the interval between arrivals (I.C.) are described in Table 2. Table 3 reports the main preliminary results of this application. Ten simulations considering the following combinations of employees were considered for each month (120 scenarios): (Caixas, Gov-Social, Expresso) = (3,3,1), (3,5,1), (4,3,1), (3,3,2), (3,3,3), (3,2,2), (5,3,2), (4,4,2), (5,4,4), (6,3,4).

Table 2 – Simulation Inputs for each sector

	Calculation	CAIXA	GOV-SOCIAL	EXPRESSO	IC
Interval between arrivals (I.C.)	$(IC) = \frac{1}{\lambda}$	2.02 min/entity	3.17 min/ entity	2.18 min/ entity	0.68 min/ entity
The average rate of service (μ)	$(\mu) = \frac{1}{Av.Service\ Time}$	0.4946	0.3165	0.4542	
Usage Rate (ρ)	$\rho = \frac{\lambda}{\mu \times M}$	0.99	1.55	3.24	

Table 3 – Efficiency Results and Allocation Options

Months	Average Effciency	Best Efficient Employee Configurations			
		Caixas	Gov-Social	Expresso	Service Time
January	0.978	3	5	1	29.76
February	0.986	4	4	2	6.41
		5	4	4	5.78
March	0.932	3	3	1	49.32
April	0.955	3	2	2	27.05
May	0.968	3	5	1	23.08
June	0.971	3	2	2	19.25
July	0.968	3	3	1	29.21
August	0.985	3	3	1	24.91
		3	5	1	22.73
		4	3	1	17.96
		3	2	2	16.44
		5	3	2	9.49

		6	3	4	9.36
September	0.977	3	3	1	30.04
October	0.951	3	2	2	26.57
November	0.959	4	3	1	24.57
December	0.936	4	3	1	33.47

The configuration with 3 caixas (tellers), 5 Gov-social employees, and 1 Expresso employee seems is prominent regarding efficient results. August is the month with the most options for efficient allocation of employees: seven efficient productions resulting in service time varying from 25.41 to 40.96 minutes. February is the most critical month for the branch: the best production configuration still results in an unacceptable service time of over 40 minutes. This situation can be attributed to the carnival festival, which increases the demand for bank services days before and after the holidays. Particular attention should be given to this scenario.

CONCLUSIONS

This short application on the Brazilian Federal Savings Bank (Caixa Econômica Federal or CEF) proposed a conceptual framework for simulated performance evaluations to identify optimal production configurations supporting efficient resource allocation strategies over time and banking segments. The main contribution of this proposal is supporting the construction of simulated datasets for situations when cross-sectional or time-series production data are not available. This is valuable for complex processes, such as those involved in socially inclusive banking services, which may be challenging to test and optimize in the real world. By simulating different scenarios and process variations, decision-makers can identify bottlenecks, optimize resource utilization, and make other improvements that lead to more efficient and effective services.

Some limitations of the preliminary results that must subside future extensions of the current analysis are the number of bank sectors and the possibility of accounting for seasonality and exogenous trends in demand for the services. Creating accurate and user-friendly process simulations can optimize the service before it is implemented and ensure that these services are accessible and effective for all members of society. We aim to extend such perspective by providing theoretical efficiency models based on real and simulated frontiers comparisons more appropriate for the business's empirical context and social goals.

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Day 2	**Wednesday, May 31st 2023**	Room 1A24

Session 5b

Decision Making Technics

12:00 – 13:00*

Chair: Marko Bohanec

Room 1A24

#1	*DEXi Suite: Renewing Qualitative Multi-Criteria Decision Modeling Software*	Marko Bohanec
#2	*Data-driven classification of negotiation processes*	Rudolf Vetschera
#3	*The common-sense knowledge about artificial intelligence across groups of drivers: A social representation approach*	Luciano Moreira, Bruno Cardoso, Ana Carolina Mora, Sérgio Pedro Duarte, Sara Ferreira and Antonio Lobo
#4	*Revolutionizing Decision Making in Education: Leveraging Deep Learning for Arabic Spoken Digit Recognition to Assess Adult Learners' Speech Therapy Progress*	Zineb Touati Hamad and Mohamed Ridda Laouar

* 10 minutes/presentation + Q&A

DEXi Suite: Renewing Qualitative Multi-Criteria Decision Modeling Software

Marko Bohanec

Jožef Stefan Institute, Department of Knowledge Technologies Jamova cesta 39, SI-1000 Ljubljana, Slovenia marko.bohanec@ijs.si

web-page: https://dex.ijs.si

ABSTRACT

Multi-criteria decision analysis (MCDA) is an approach to solving decision problems having multiple and possibly conflicting objectives. MCDA proceeds by decomposing the problem into multiple dimensions (criteria, attributes), measuring decision alternatives along these dimensions, and aggregating those partial evaluations into final assessments. On this basis, alternatives are selected and/or ranked. MCDA models developed in this way can be embedded in Decision Support Systems to support recurring decision processes.

DEX (Decision Expert) is a hierarchical, qualitative and rule-based MCDA method, particularly suitable for sorting and classification decision problems. DEX has been always supported with software that helped decision makers to formulate decision models in terms of attributes, their structure and decision rules, and to employ them in the evaluation and analysis stages. To date, the main and *de-facto* implementation of DEX was a Windows desktop program called DEXi (https://kt.ijs.si/MarkoBohanec/dexi.html). DEXi has been conceived more than 20 years ago and is becoming increasingly difficult to maintain and extend.

In this paper, we present work in progress aimed at developing a new generation of DEX software, called *DEXi Suite* (https://dex.ijs.si/dexisuite/dexisuite.html). With the aim to gradually replace DEXi, the new implementation follows a number of technical, useroriented and methodological objectives: using modern programming languages and environments, backward compatibility with DEXi, supporting all relevant platforms, introducing new modeling features, etc. Currently, *DEXi Suite* consists of five components: *DEXiLibrary*, a central class library implementing DEX, *DEXiWin*, a desktop program implementing all DEXi functionality, and *DEXiEval*, *DEXiPy* and *DEXiR*, packages for using DEXi models from the command line and in Python and R environments, respectively. In the paper, these components are described in more detail, and DEXiWin is illustrated using an employee-selection use case. Future plans include development of two more components, a DEX-modeling API and Web application.

Keywords: Multi-Criteria Decision Analysis, Decision Support, Software, DEX (Decision EXpert), DEXi Suite

INTRODUCTION

Multi-criteria decision analysis (MCDA) is an established and effective methodological approach to solving hard decision problems that involve multiple and possibly conflicting objectives [1]. MCDA methods generally help decision makers in formulating the decision problem, identifying key objectives, formulating criteria, developing multi-criteria decision models and using them for decision-making tasks such selection, evaluation, ranking and analysis of decision alternatives. MCDA is often supported by software tools [2], which are particularly beneficial in the stages of model development (model creation and editing, elicitation of decision makers' preferences) and assessment/analysis of

alternatives. In the case of recurring decision problems, it is often necessary to incorporate decision models in other software products, such as decision support systems [3].

Over the years, more than 200 MCDA methods have been developed, which differ greatly in terms of decision problem formulation, preference elicitation and types of preference information, desired features of a preference model, and construction of the decision recommendation [4]. In this paper, we focus on one of them, DEX (Decision EXpert) [5]. DEX has been conceived as a fusion of MCDA and artificial intelligence, and is generally characterized as a full-aggregation, hierarchical, qualitative and rule-based MCDA method [5]. DEX is particularly suitable for sorting or classification decision tasks, which are aimed at assigning decision alternatives to predefined categories, which are either preferentially ordered ("sorting") or not ("classification"). Giving just three examples from 2022, DEX was used for decisions on cereal-legume intercrops [6], assessing health and self-care ability [7] and selection of crop species for saltwater aquaponics [8]. Recently, DEX models have been incorporated in three large-scale decision support systems for severe accident management in nuclear power plants [9], assessment and management of soil functions [10], and assessment and management of sustainability of legume agri-food value chains (http://pathfinder.ijs.si).

Since 2000, the method DEX has been implemented in terms of free software called DEXi (http://kt.ijs.si/MarkoBohanec/dexi.html). DEXi is a desktop application for MS Windows that supports an interactive creation and editing of all components of DEX models (attributes, their hierarchy and scales, decision tables, and alternatives) and provides methods for the evaluation and analysis of decision alternatives (what-if analysis, "plus-minus-1" analysis, selective explanation, comparison of alternatives, option generator). There are also additional DEXi-related software tools that facilitate using DEXi models in different environments, such as command line, Java, C#, and HTML (https://dex.ijs.si/dexiclassic/dexiclassic.html).

While still maintained, fully operational and used worldwide, DEXi has become rather aged. There are two technical reasons that make it really hard to maintain and improve: using old technology (Delphi, which was actually great and ahead-of-time in the 1990s, but is now lagging behind with the lack of free development tools and skilled developers) and insufficiently modular/flexible software architecture. On the other hand, the demand is increasing for including more and more features in DEXi, and supporting state-of-the-art software standards and environments. All these were strong motivational factors for pursuing a thorough reconstruction of DEX-related software, which is reported in this paper.

In what follows, we first formulate the requirements and expectations for the new generation of DEX software. Then, we describe five software components that currently constitute the new *DEXi Suite* (https://dex.ijs.si/). Among these, we illustrate the main modelediting software DEXiWin with two screenshots solving a simple employee-selection task. The paper is concluded with a summary and plans for future development.

METHODS

Objectives and Requirements

The design and implementation of *DEXi Suite* was guided by technical, softwarearchitectural, methodological and user-oriented objectives and requirements.

Technical aspects. We wanted to move towards using modern programming languages and development environments, hoping to simplify the development, extend the life cycle of products, attract young developers and facilitate using the software in all major environments (various operating systems, the web). While the web-based approach seems the ultimate longterm option, we first had

to focus on upgrading the available code to a suitable cross-platform class library and implementing desktop applications. For that, we chose the modern Pascalbased programming language Oxygene (https://www.remobjects.com/elements/oxygene/).

Software architecture. The objective is to redesign software architecture to make it more adaptive for change. Before in DEXi, model-editing and user-interface code were somewhat intermixed, and the code was scattered among different software components and tools. For *DEXi Suite*, we deemed it necessary to design a single central class library to be used by all software components and to detach it from the user-interface functionality.

Methodological improvements. The objective is to include long-awaited extensions of the DEX method that are often needed in practice. While the wish list is longer, *DEXi Suite* already implements the following new features:

- Representing and evaluating decision alternatives in terms of probabilistic and fuzzy value distributions (while DEXi supports only representations with sets).
- Using numeric attributes as inputs to DEXi models. Consequently, DEXi models have been extended with components that implement numeric scales and discretization functions.
- Extending methods for the analysis of decision alternatives: target analysis (an improved version of DEXi's "option generator") and plus-minus analysis (a generalization of DEXi's plus-minus-1 analysis).

User-oriented requirements. First, the new software is required to be fully backward compatible with DEXi, so that old DEXi models could be used in *DEXi Suite* without change. Second, while DEXi is free-to-use, but not open-source software, all the new software is to be released as open-source under liberal licenses (GPL or MIT, depending on the component). Last but not least, there is a long list of required user-interface improvements that range from very detailed, such as consistent use of colors, to general ones, e.g., improved and entirely new functionality for handling reports and charts.

Software Components

DEXi Suite (https://dex.ijs.si/dex.html) currently consists of five software components, called DEXiLibrary, DEXiWin, DEXiEval, DEXiPy and DEXiR. They are all in the *beta* development stage, which means that they are fully functional, but may still have bugs, require additional testing and are incompletely documented.

DEXiLibrary is a core component of *DEXi Suite*, providing all classes and methods for representing and operating on DEX models. This includes classes for representing DEX attributes, scales, functions, alternatives and whole models, as well as methods for the evaluation and analysis of alternatives. The functionality of DEXiLibrary is deliberately restricted to the level that can be easily ported to different platforms and thus excludes all user-interface functionality. Currently, DEXiLibrary targets the Java and .NET platforms, and makes the respective class libraries (`jar` and `dll`), which can be dynamically linked to and used by other software components.

DEXiWin is a desktop program for Microsoft Windows aimed at gradually replacing DEXi. It implements all DEXi's features (apart some obsolete data formats) and adds all new features that are implemented in the DEXiLibrary. It also introduces many small, but important improvements in the user interface, for instance displaying model components in userselectable columns, graphical display of model structure, tree-structured display/editing of evaluation results, consistent use of colors for displaying "good" and "bad" values, etc. See the example below.

DEXiEval, DEXiPy and DEXiR facilitate using DEX models in environments other than DEXiWin. DEXiEval is a command-line utility for evaluating decision alternatives. DEXiPy and DEXiR are software packages

for using DEX models in the environments of programming languages Python and R, respectively. All these components are fully compatible with the new features of *DEXi Suite*.

ILLUSTRATIVE EXAMPLE

Let us illustrate DEXiWin with two screenshots using the employee-selection example, adapted from [5] to highlight new features. This demo model is aimed at the assessment of applicants for a Project Manager position in a small company. The tree of attribute consists of 14 attributes, grouped into subtrees *Educat*, *Years* and *Personal*.

Figure 1 shows the main model-editing page of DEXiWin with displayed attributes' structure, descriptions and scales. Apart from a substantially redesigned interface in comparison with DEXi, the essential novel feature is the introduction of numeric input attributes, in this case *ExperYears* and *AgeYears*. The former is preferentially ordered and the latter is not. Both are discretized into qualitative attributes *Experience* and *Age*, respectively, using discretization functions (not shown here).

Figure 2 then shows the evaluation of five employee candidates. Among them, the candidate E illustrates the concept of using probability distributions. For this candidate, her communication abilities are unknown (denoted '*') and her leadership ability is assessed fifty-fifty between 'appropriate' and 'more'. The aggregation guided by decision rules formulated in the model (not shown here) and following the probabilistic propagation finally leads the final assessment of 'unacceptable' or 'excellent' with probabilities 0.25 and 0.75, respectively.

CONCLUSIONS

DEXi Suite is work in progress aimed at delivering a new generation of software tools for supporting the qualitative multi-attribute method DEX. At this point, the main contributions of this development are technical and user-oriented: using modern programming languages and development environments, redesigning the software for change, consistent and rich user interfaces. Methodological advances are moderate: introducing numerical attributes, discretization functions and evaluation using value distributions. These were all known before, but now they are for the first time consistently and completely implemented in DEX software.

One of the important goals has not been reached yet: availability of DEX software in all relevant platforms. DEXiWin works only on MS Windows. To reach the goal, two additional components are planned for *DEXi Suite*: an API (Application Programming Interface) supporting DEX-model operation on a server, and a single-page web application providing a user interface for accessing those services. Other future activities include extensive testing of *DEXi Suite*, possibly on real-world use cases, writing documentation and adding new functionality, such as representing decision tables with decision trees, pruning evaluation of alternatives at given attributes, and supporting probabilistic/fuzzy decision rules.

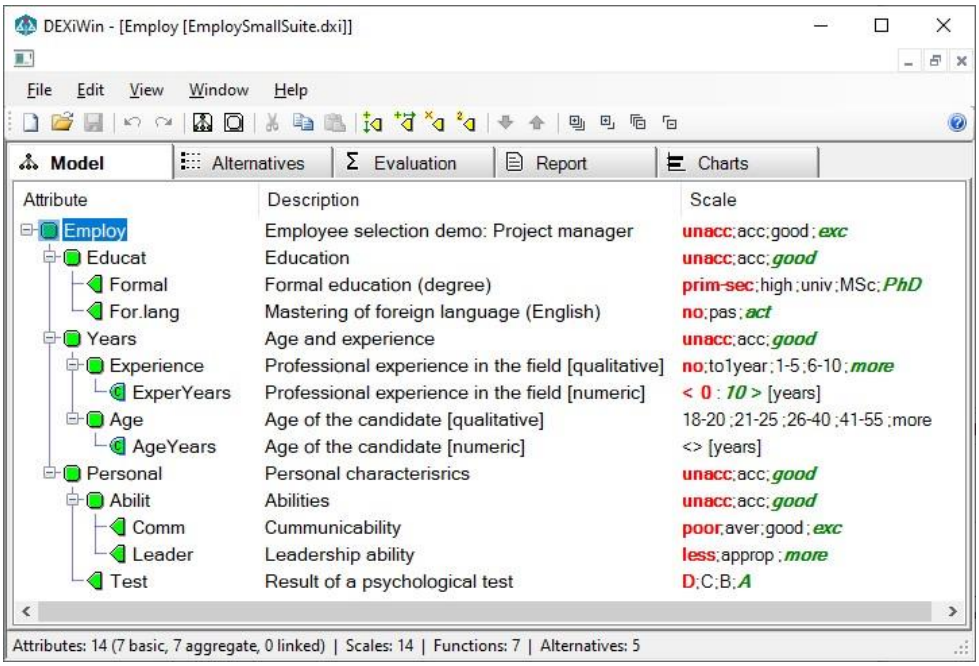

Figure 1: DEXiWin: Model-editing page displaying the Employ model

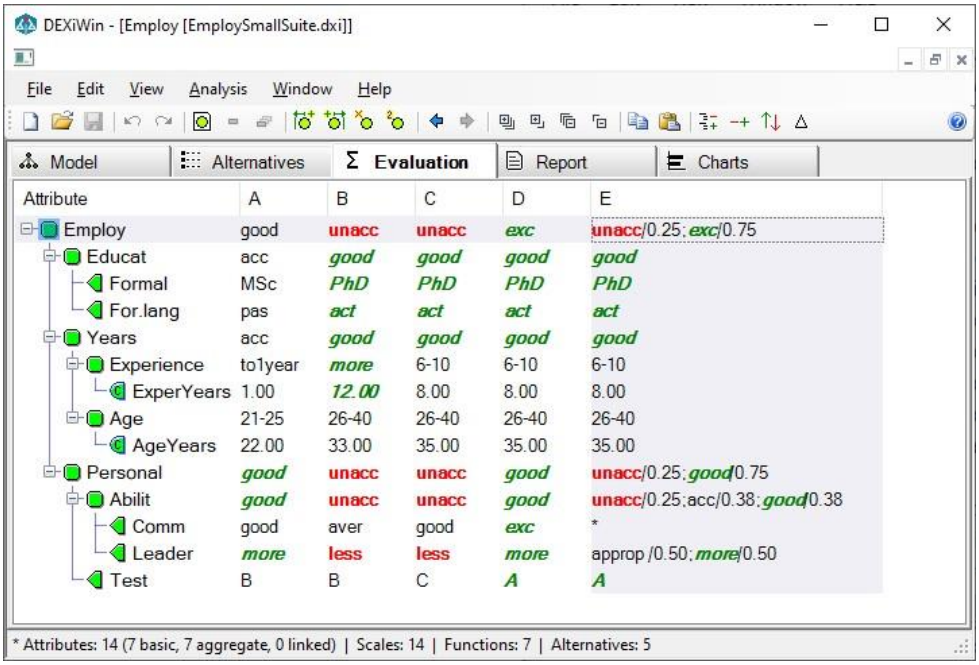

Figure 2: DEXiWin: Evaluation page displaying five employee candidates **ACKNOWLEDGMENT**

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Data-driven classification of negotiation processes

Rudolf Vetschera
University of Vienna
Oskar Morgenstern Platz 1, A-1090 Vienna, Austria
rudolf.vetschera@univie.ac.at http://bda.univie.ac.at

ABSTRACT

We study whether a recently developed dynamic bargaining model, that allows to classify negotiator behavior and negotiation processes from offers, can be applied when utilities of negotiators are not known but only approximately estimated from observations made during a negotiation. Our results indicate that to a certain extent, this is indeed possible, offering the opportunity for a data-driven approach to classify negotiation processes based solely on observed data.

Keywords: Negotiation process; Classification; Negotiator confidence; Zeuthen-Hicks bargaining

INTRODUCTION

Negotiation literature has developed many classifications of strategies and tactics that negotiators might use during the negotiation. At a very general level, one can distinguish between integrative and distributive approaches to negotiations [1, 2]. Distributive bargaining relies on "hard" negotiation tactics and is associated with negotiators mainly interested in their own outcome [3], while integrative bargaining aims for win-win solutions and takes the interest of both parties into account. To provide effective support of negotiators, it is necessary to identify a negotiator's strategy during an ongoing negotiation. Such a classification could be useful both for systems that support one negotiator and identify the opponent's strategy, as well as for systems serving as a neutral mediator that could, e.g., alert negotiators if their chosen strategies are likely to lead to an impasse.

However, there is still a lack of formal models to characterize different negotiation strategies [4, 5]. Several studies have used concession curves [6, 7] for that purpose. A concession curve represents the current level of a negotiator's demands (in terms of utility values of the negotiator's current offers) over time in the negotiation. A concave shape of the concession curve indicates that a negotiator makes only small concessions at the beginning of the negotiation and large concessions towards the end of the negotiation and is therefore associated with distributive bargaining strategies, while a convex curve represents the opposite behavior and therefore is associated with integrative bargaining.

The use of concession curves to identify bargaining strategies has several drawbacks for negotiation support. First of all, although the relationship between shapes of the concession curve and bargaining behavior is plausible, it lacks a theoretical foundation. Furthermore, the complete concession curve is available only at the end of the negotiation, therefore, it is only of limited use to support negotiators during an ongoing negotiation, in particular in its early stages.

Recently, Dias and Vetschera [8] developed a dynamic bargaining model which represents the decisions of negotiators in single steps of a negotiation. In contrast to game-theoretic models such as [9], which typically predict that perfectly rational negotiators would find an agreement in the first step of a negotiation, this model represents negotiators who use only myopic information in a multi-step bargaining process. This model can be interpreted as an extension to the Zeuthen-Hicks bargaining model [10], which includes the negotiator's subjective expectation about bargaining outcomes. In a later empirical study [11], it was shown that his model fits actual behavior in a bargaining process and has high external validity also in relation to other characteristics of bargainers. It therefore can be considered a useful way to measure actual bargaining behavior in an ongoing negotiation.

One drawback of this model is that it assumes that the utility functions of bargainers are known. These utility functions are needed to calculate model parameters that reflect the negotiator's expectations. In a dynamic negotiation support setting, this information is typically not available. In the present paper, we therefore study whether this model can also be used when utility functions are not known, but are inferred from bargaining steps made by the negotiators. We present a model to estimate the utility functions from offers made by negotiators, and use data from a negotiation experiment to verify whether results obtained by this approach match results that would be obtained when knowing the negotiators' true utility functions.

The remainder of the paper is structured as follows. In section two, we briefly describe the models used. In section three, we present empirical results and section four concludes the paper.

MODELS

The bargaining model of [8] considers the situation of a negotiator who can either accept the opponent's offer on the table, quit the negotiation, or continue the negotiation with a counteroffer (adjust the currently standing own offer). We denote the utility function of a negotiator *m* for offer *x* by $u_m(x)$. If the negotiation fails, both parties will obtain a utility of zero. If the negotiator decides to make a counter-offer, negotiations will fail with probability *p* and the negotiator expects the eventual outcome of a continued and eventually successful negotiation to be *z*. Furthermore, we denote the current standing offer of the negotiator by x_m and by the opponent by x_o. The negotiator will decide to continue the negotiation (rather than accept the opponent's current offer) if

$$u_m(x_o) < (1-p)u_m(z) \tag{1}$$

Since the outcome of the negotiation will be in between the two offers currently on the table, we can write its utility as a linear combination of the utilities of the two offers:

$$u_m(z) = \gamma_m u_m(x_m) + (1-\gamma_m)u_m(x_o) \tag{2}$$

Here γ represents the negotiator's confidence. Negotiators who have a high level of confidence expect the negotiation to end near their own current offer, while negotiators with low confidence will expect it to end near the opponent's current offer. Similar to Zeuthen-Hicks bargaining, negotiators will make concessions so that the critical probability of failure that the negotiator could tolerate according to (1) is larger than the opponent's critical probability.

According to the model, negotiator *m* will therefore make a concession if the condition

$$(\gamma_m/\gamma_o)(u_m(x_m) - u_m(x_o))u_o(x_m) > (u_o(x_o) - u_o(x_m))u_m(x_o) \quad (3)$$

is fulfilled, and the opponent *o* will make a concession in the opposite case. As was shown in [8], the bargaining process depends only on the ratio of the confidence levels of the two parties and for concave utilities will converge to the asymmetric Nash bargaining solution which maximizes

$$u_m(x)^{\gamma m} \cdot u_o(x)^{\gamma o} \quad (4)$$

In [11], methods were developed to estimate the ratio of confidence parameters $r = \gamma_m/\gamma_o$ from actual offers made during a negotiation using eq. (3). An offer from negotiator *m* provides a lower bound on *r* as

$$r > \frac{(u_o(x_o) - u_o(x_m))u_m(x_o)}{(u_m(x_m) - u_m(x_o))u_o(x_m)} \quad (5)$$

and an offer from negotiator *o* an analogous upper bound. For this estimation, the utility functions of the parties are clearly needed.

To estimate the negotiator's utility function from observed offers, we make two assumptions. First, we assume that the negotiator's utility in a multi-issue bargaining problem can be represented by an additive multi-attribute utility function with linear marginal utilities:

$$u(x) = \sum_k w_k \frac{x^k - x^{\underline{k}}}{x^k - x^{\underline{k}}} = \sum_k w_k v_k(x_k) \quad (6)$$

where w_k is the weight of attribute *k*, and x_k and $x_{\underline{k}}$ refer to the best and worst possible outcome in attribute *k*, respectively. For short, we express the linear marginal utility for attribute *k* as $v_k(.)$. For simplicity, we have omitted the index referring to the negotiator. Second, we assume that negotiators bargain in good faith and that their offers represent concession so that each offer they make provides them a lower utility than the previous offer so that $u(x_{t-1}) \geq u(x_t)$ where the index refers to the time at which an offer was made.

This ordering defines a set of constraints on the attribute weights. Within the set defined by these constraints, we can find the central vector of weights by solving the following LP problem:

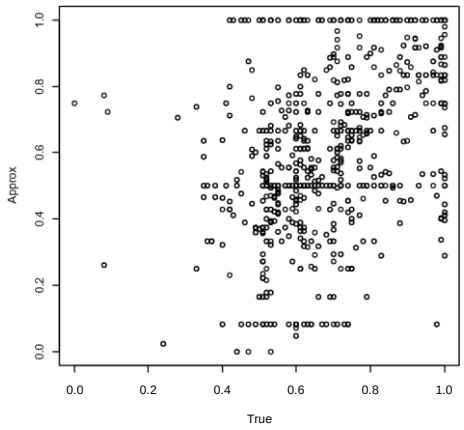
$$\begin{aligned} &\max z \\ &\text{s. t.} \\ &\sum w_k \left(v_k(x_{k,t}) - v_k(x_{k,t-1})\right) - z \leq 0 \\ &\sum w_k = 1 \end{aligned} \quad (7)$$

EMPIRICAL RESULTS

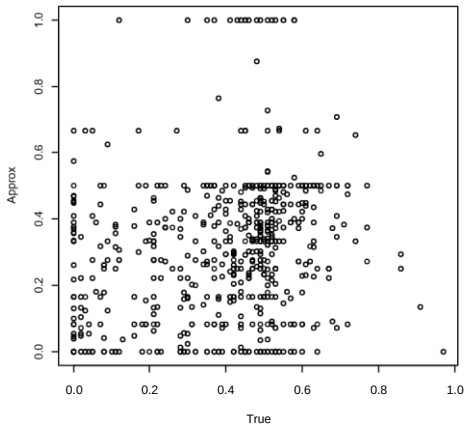
We test the quality of this approximation empirically by using data from a negotiation experiment in which utility values were provided to subjects and are thus known, so we can compare the outcome of a process evaluation using approximation (7) to an evaluation of the process using the true utilities.

The data we use results from a comprehensive negotiation experiment in which different types of negotiation support were tested. Details of the experiment can be found in [12]. The negotiation problem involved a joint venture negotiation between a national manufacturing company and a foreign investor. The case involved seven issues, preferences of negotiators were exactly opposed in all issues. The data set used for this analysis contains data on a total of 1,194 offers made in 117 negotiations.

Utility: Investor / Offers: Investor



Utility: Investor / Offers: Local partner



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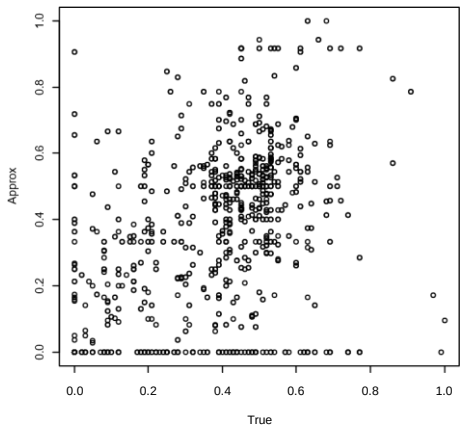

Utility: Local partner / Offer: Local partner

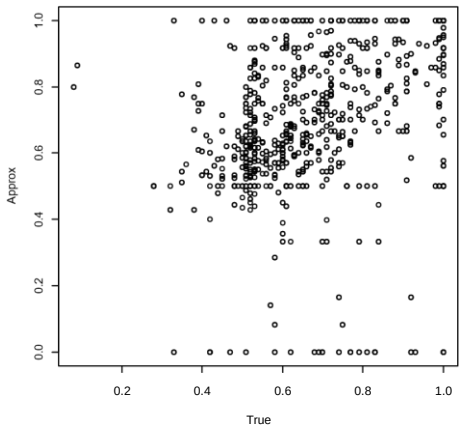

Figure 1: True vs. approximated utilities

First, we consider the correspondence between the true utilities and utilities estimated model (7). Although that model allows only to estimate weights for a party based on that party's offers, we can

also use the weights obtained in that way to evaluate the offers from the other party. Thus, we obtain utilities of both sides for the offers of both sides.

As Figure 1 shows, although there is a tendency of the approximation to generate extreme utilities, overall, the approximation works quite well. This is also confirmed by the correlation coefficients between true and approximated utilities shown in Table 1, which are all significant at the 0.1% level.

Table 1: Correlations of true and approximated utilities

	Offer by	
Utility of	Investor	Local partner
Investor	0.3024	0.3733
Local partner	0.4061	0.2757

Next, we consider the correspondence between bounds calculated according to eq. (5) using the true utilities and the approximated utilities. As long as negotiators prefer their own offer over the opponent's offer, bounds calculated according to (5) will always be positive. However, since negotiators do not know their opponent's utilities, it can happen that negative bounds are calculated. Furthermore, if the denominator in (5) is small, bounds, might take on extreme values. We therefore here consider bounds only within a reasonable range of zero to three.

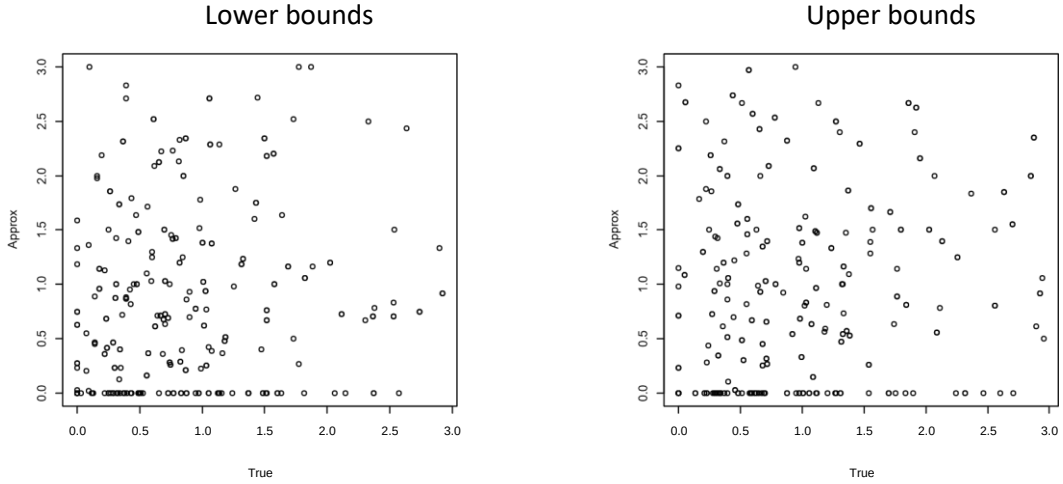

Figure 2: Bounds on ratio of confidence parameters obtained from true vs. approximated utilities

As Figure 2 shows, there is a correspondence between the bounds calculated for true and approximated utilities, although the bounds calculated from approximate utilities sometimes remain close to zero. This is confirmed by the correlation coefficients of 0.1490 (p=0.0105) for the lower and 0.1276 (p=0.0297) for the upper bounds, which are both significant at the 5% level.

CONCLUSIONS

Efficient support of negotiators requires models of the negotiation process that are based on a dynamic perspective of negotiations and that can be estimated from ongoing negotiations with a minimum amount of a priori known information. The recently introduced bargaining model [8] allows to classify negotiator types by their confidence level and thus to determine whether there is significant imbalance in the negotiators' behavior. Identifying such imbalance can on the one hand be used to alert the weaker negotiator about the possibility of being exploited and on the other hand to inform both parties that the current development of the negotiation might lead to a breakdown of the negotiation. In the present paper, we have studied whether this model can also be applied if utilities of parties are unknown and can only be approximated by observing actual offers made during the negotiation. While the fit between approximation and true utilities, as well as between confidence parameters calculated from approximated vs. true utilities, is far from perfect, we still found a significant relationship that could be used to provide substantial support to negotiators.

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The common-sense knowledge about artificial intelligence across groups of drivers: A social representation approach

Luciano Moreira[1], Bruno Cardoso[2], Ana Carolina Mora[3], Sérgio Pedro Duarte[2,3], António Lobo[2,3], Sara Ferreira[2,3]

[1] CETAPS – Centre for English, Translation, and Anglo-Portuguese Studies, Faculty of Arts and Humanities of the University of Porto, Via Panorâmica, 4150-564 Porto, Portugal, lucianomoreira@letras.up.pt

[2] Centro de Investigação do Território, Transporte e Ambiente, Rua Dr. Roberto Frias, s/n, 4200-465 Porto, Portugal

[3] Faculdade de Engenharia da Universidade do Porto, Rua Dr. Roberto Frias, s/n, 4200-465 Porto, Portugal, lptt.dec@fe.up.pt

ABSTRACT

Artificial intelligence (AI) is gaining momentum in driver monitoring systems and redesigning mobility ecosystems. In the short- to medium-term, AI value offer relies not on substituting the driver but on supporting drivers adapting their driving behaviour accordingly. The aim of this study is to explore the relationship between the common knowledge of AI and social groupings in the context of driving. Based on the social representations theory, we surveyed 121 participants from different social groupings (driving trainers, car salesmen, college students, and others) about how they represent AI and their acceptance of a specific intelligent driver monitoring system. A correspondence analysis was run on the data. Preliminary results suggest that representations of AI vary across social groupings, with instructors anchoring AI to driving systems, salesmen to feelings of distrust, and students to engineering and programming. We have not found any association between representations and technology acceptance. The study is promising and significant because it suggests that, although no consensus exists in society about AI, representations seem not to mediate technology acceptance. Next studies should clarify if this lack of association results from a sense of fatality of technological determinism and if other representations are being used to mediate technology acceptance.

Keywords: artificial intelligence, social representations, driving, driving assistance systems

INTRODUCTION

Human factors, such as fatigue, stress, cognitive load and distraction are responsible for more than 90% of road accidents [1], with an estimated cost of hundreds of billions of euros per year [2]. Distraction is the biggest cause of accidents worldwide, followed by falling asleep and, only after that, speeding, alcohol abuse and others [3]. On the other hand, stress and cognitive load are responsible for aggressive and inattentive driving, causing an increase in the risk of traffic and a risk to health, so informing the driver about his condition becomes critical [4-6]. Intelligent driver assistance systems are seen to reduce human error. They allow to identify the driver's state and alert them in real-time, decreasing accident risk [7]. Recently, autonomous vehicles have been making the headlines of newspapers and advertised as the next big thing in intelligent mobility. At the same time, public

concerns exist about the safety and efficiency of such solutions as some accidents in real-life settings have been reported [8].

Current levels of vehicle automation still require human interactions [9], but possible distractions require faster decision-making and shorter reaction times. Changes in the technology available in the market have not been radical but rather introduced gradually, allowing drivers to contact with small increases in driving support (e.g., cruise control, lane keeping, etc.). Without realising it, drivers are putting more and more trust in driver assistance systems and potentially being more distracted from the driving itself. This is where drivingsupport tools using AI play an important role, as they can monitor the driver's behaviour and alert them about wrongdoings or monitor the driver's ability to continue driving. Nonetheless, these tools cannot support the driver's decisions unless there is public acceptance of AI. However, we know little about how people are representing AI, and thus, we cannot properly understand their concerns and implications for the reshaping of driving ecosystems.

The social representations theory is suitable for us to understand better how social groups think and behave regarding novelty, may it be scientific theories [10] or technology [11]. As shown before, the support systems of drivers are more and more connected with AI. Understanding social groupings common sense about AI is, thus, critical to better design and promote safer systems and facilitate wider adoption. Previous studies show that representations of new driver assistance systems are constructed concerning previous representations [12]. Social representations theory allows us to move from the individual to the collective level by understanding the motivations, beliefs, knowledge and preferences of social groupings that form a social reality [13] and consequently how they act [14;11].

The question that guides this study is the following: What is the relationship between the symbolic field of artificial intelligence with positional and psychosocial variables expressing social groupings and their intention to use, adjust behaviour and recommend intelligent driver assistance systems?

METHODS

Context

This study was carried out within the scope of road safety at the Faculty of Engineering of the University of Porto with students from the previously mentioned school, driving instructors and people of the city of Porto, considering different age groups. This study is part of a broader investigation, the BBAI (Brain Behavior analysis using the most advanced Artificial Intelligence and Computer Vision) project, which aims at developing a new AI-based driver monitoring system capable of identifying, through visual computing, physiological and psychological states that are dangerous for driving, using advanced techniques in the collection and marking of data collected in real and simulated driving environments.

Participants

Through an intentional, snowball sampling, we surveyed participants from different social groupings directly or indirectly related to driving and driver support systems. After removing the participants that did not contribute with any response to the ranked association technique, the study includes 121 participants, 78 men and 43 women, with an average age of 40 years old; 49 are driving trainers, 15 salespeople, 30 higher education students, and 27 form a heterogenous group with diversified occupations. Most participants are Portuguese and daily drivers. In addition, we distributed

participants by three age groups: 43 participants are from Age Group 1 (born between 1945 and 1970); 37 are from Age Group 2 (born between 1981 and 1988), and 41 are from Age Group 3 (born from 2002 onwards). Of this total of participants, more than 50% travel up to 4 thousand kilometres per year and have an average of 30 years of driving license.

Measures

The questionnaire was structured in different sections and aimed to collect verbal and numeric data. It included sociodemographic questions, a ranked association question about AI, acceptance indicators of intelligent driver assistance systems, besides other original and adapted scales or items that are not reported in this article. In the ranked association question, we asked participants to recall at least five words or ideas they associate with artificial intelligence and then rank them by order of importance. Thus, the verbal data reported in this paper refers to AI. Acceptance of intelligent driver assistance systems was measured by three different items (on a scale from 1 to 7) regarding the behavioural intention of use, recommend and adjust behaviour based on the information received (Table 1).

Table 1

Acceptance dimensions and full translated items

Acceptance	Full item (translated from Portuguese original)
Behavioural intention of use	If I could, I would use the BBAI system.
Recommend	I would recommend the BBAI system to other drivers.
Adjust behaviour	If I owned the BBAI system, I would adjust my driving behavior based on the information received.

Data analysis

Verbal data was submitted to a content analysis by the first three authors. After the content analysis, a few repeated words/themes in individual contributions have been removed. Numerical data has been organised into thirds per variable, according to cut-off points presented in the next section for each variable.

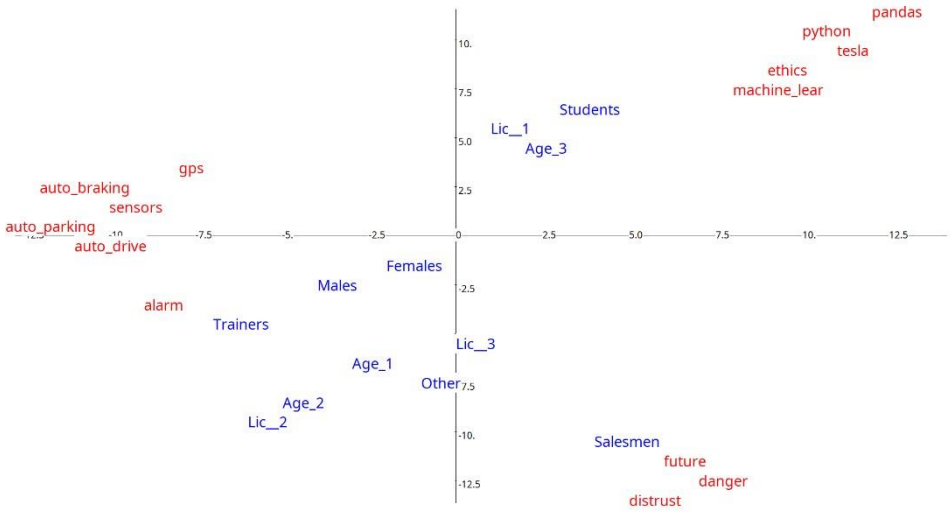
Correspondence analysis is an exploratory data analysis technique applied on researching social representations [15]. In this specific case, the analysis was carried out with the Dtm-Vic software, which performs the analysis (VISURECA) from a word matrix and makes it possible to position one or more illustrative variables in the Cartesian plane. The variables considered in this study were the following: age, profession, years of driving license and technology acceptance indicators. In the Cartesian plan, we have only projected themes with contributions equal or above |2| and illustrative variables with test-value equal or above |2|, which means that there is a 95% probability that placement is not due to chance [16].

RESULTS

After we removed terms that were said by only one or two participants, we were left with 470 words, of which 48 were different. For correspondence analysis, we used terms mentioned at least three times. Participants' acceptance (cut-off points: 4 and 6) to use the project's intelligent driver monitoring system varied, but two-thirds showed good levels of acceptance. Figure 1 shows the projection of the themes and illustrative variables onto a Cartesian space. The x-axis (factor 1) is

defined exclusively by driving-related themes or sensors familiar to driving trainers. The y-axis (factor 2) suggests a tension between distrust and programming/technology, with salesmen associated with the former and students with the latter (see Tables 2 and 3 for complementary data). Each social group seems to anchor AI to wellknown, familiar realities in their trades. The semantic field is filled in with images that objectify artificial intelligence. The other significant illustrative variables (years of driving licence and age) are consistently related to the social groups' position in the Cartesian space. It is worth noting that acceptance measures show no relation to the symbolic field.

Figure 1 Correspondence Analysis of AI with Illustrative Variables



Note: We constructed Figure 1 based on the first (horizontal axis) and second (vertical axis) factors extracted in the correspondence analysis with a threshold of ≥ 20 occurrences and with illustrative variables with test-value ≥ |2| with coordinates transformed into ranks. The first two axes explain 10.59% of the variance. The labels of the axes were added by the authors as part of the interpretation of the data.

Table 2

Coordinates and Contributions of the Themes to the Correspondence Analysis of the AI

Theme	Coordinates		Absolute contributions	
	Factor 1	Factor 2	Factor 1	Factor 2
Alarm	-2.63	-.08	9.1	0.0
Auto braking	-3.24	0.31	10.3	0.1
Auto drive	-2.94	0.14	28.4	0.1
Auto parking	-3.55	0.23	16.5	0.1
Ethics	0.57	2.17	0.30	5.4
GPS	-2.60	.34	6.6	0.1
Pandas	0.71	4.34	0.5	21.8
Python	.63	3.12	11.3	11.9
Sensors	-2.92	0.29	16.8	0.2
Tesla	0.63	2.72	0.4	8.5

Table 3

Coordinates and Test-Values of the Illustrative Variables in the Correspondence Analysis of the AI

Illustrative variable	Coordinates		Test values	
	Factor 1	Factor 2	Factor 1	Factor 2
Occupation				
Salesmen	.30	-.54	1.2	-2.2
Students	.28	.63	1.8	3.9
Trainers	-.31	-.10	-2.8	-.9
Others	.08	-.21	.5	-1.3
Age				
Age 1	.06	-.20	.5	-1.6
Age 2	-.18	-.23	-1.3	-1.7
Age 3	.10	.42	.8	3.3
Years of license				
Lic 1	.10	.45	.7	3.5
Lic 2	-.18	-.28	-1.5	-2.3
Lic 3	.09	-.15	.6	-1.0
NA	.26	-.26	.5	-.5

DISCUSSION

In this study, we explored the relationship between the common sense about AI and social groupings in driving context. We observed that social groupings have a different understanding of AI but that this does not influence their acceptance of intelligent driver monitoring systems. The social representations theory has been scarcely used in the driving context, although it yielded interesting results [10] to show how drivers make sense of novelty. This study brings to the foreground relevant social groupings and articulates different levels of analysis [11]. Driver instructors will be key players in teaching people how to cope with more sophisticated vehicles, salesmen promoting and bridging the gap with buyers, and students representing a new generation of drivers. Each social group represents AI from a specific angle. On the one hand, anchoring AI to current driving assistance systems, feelings of risk, or programming poses some concerns about the readiness of social groups to critically receive intelligent driver monitoring systems. At the same time, each group shows partial awareness and understanding of dimensions critical for a well-informed integration of AI in driving systems. Together, their perspectives build a polemic semantic field that should be considered when promoting the public discussion of integrating AI into assistance systems. The fact that representations seem not to mediate technology acceptance is significant. Next studies should clarify if this lack of association results from a sense of fatality of technological determinism and if other representations are being used to mediate technology acceptance.

ACKNOWLEDGEMENTS

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Revolutionizing Decision Making in Education: Leveraging Deep Learning for Arabic Spoken Digit Recognition to Assess Adult Learners' Speech Therapy Progress

Zineb TOUATI-HAMAD, Mohamed Ridda LAOUAR
Laboratory of mathematics, informatics and systems (LAMIS), Echahid Cheikh Larbi Tebessi University, Tebessa, 12002, Algeria
zineb.touatihamad@univ-tebessa.dz, ridda.laouar@univ-tebessa.dz

ABSTRACT

In the field of education, it is crucial to assess the learning progress of students in order to make informed decisions and provide effective support. In recent years, deep learning has emerged as a powerful tool for speech recognition, enabling more accurate and efficient assessment of adult learners' speech therapy progress. In this paper, we present a deep learning model based on convolutional neural networks (CNN) for classifying Arabic spoken digit from 0 to 9. The proposed model is trained on a multivariate dataset of recordings of spoken Arabic digits from native Arabic speakers of varying ages and proficiency levels. The results demonstrate that our CNN-based model achieves high accuracy in recognizing and classifying Arabic spoken digit, with an overall accuracy of 96.10%. We also discuss the implications of our findings for decision making in education, highlighting the potential of our model to improve the assessment of adult learners' speech therapy and inform more effective support strategies. The proposed model can be applied in various educational contexts and can facilitate the use of speech recognition technology in speech therapy for adult learners.

Keywords: Deep Learning, Convolutional Neural Networks, Speech Recognition, Adult Learning, Speech Therapy, Arabic Spoken Digit, Decision Making.

INTRODUCTION

In recent years, deep learning has emerged as a promising technology for speech recognition and has shown significant success in various languages [1]. However, the Arabic language presents unique challenges due to its complex phonological system, where subtle differences in pronunciation can alter the meaning of words [2]. Therefore, the application of deep learning in Arabic speech recognition is of particular interest in the field of education, where accurate assessment of language proficiency is essential for effective decision making and support for students.

The use of ASR technology in adult education has gained significant attention in recent years due to its potential to assess and support learners' progress in speech therapy.

However, the current ASR models based on neural networks, particularly MLPs, have limitations related to their learning style [3]. MLPs consider each neuron as independent and assign a different weight to each incoming signal, which can result in suboptimal recognition rates. CNNs, on the other hand, are designed to handle pattern recognition tasks and have demonstrated promising results in speech recognition.

Moreover, the proposed CNN-based model aims to recognize Arabic speech numbers from 0 to 9, which is a significant challenge due to the complex nature of the Arabic language. To address this challenge, we use the UCI Machine Learning Repository's Spoken Arabic Digit Dataset to train and

evaluate our model. This dataset includes recordings of Arabic speech numbers pronounced by different speakers, which provides a diverse set of data for training and testing the proposed model.

The use of CNNs in ASR has shown remarkable results in recent studies, where it has achieved state-of-the-art performance in various speech recognition tasks [4]. The proposed model can contribute to improving the performance of ASR technology in adult learning by providing accurate assessments of learners' progress in Arabic spoken digit recognition as a part of their speech therapy. Ultimately, this can lead to more effective decision making and support for adult learners, enabling them to achieve their speech therapy goals.

The structure of this paper comprises several sections. The second section presents the background of the study. The third section outlines the research motivation. The fourth section presents the related works. The fifth section describes the methodology employed in the study. The sixth section details the experiments. Finally, the paper concludes with a conclusion and suggests avenues for future research.

BACKGROUND

Speech recognition

Speech recognition is a rapidly growing field in computer science, with a wide range of applications in various domains, including education. Automatic speech recognition (ASR) technology has the potential to provide valuable insights into student learning and support their progress in language learning [5]. In the context of education, ASR technology can be used to assess students' speaking and listening skills, providing feedback on pronunciation and identifying areas for improvement.

One of the main challenges in ASR is the variability of speech signals, which can be affected by factors such as speaker accent, background noise, and speaking rate. To address these challenges, deep learning techniques have shown promising results in speech recognition tasks. Convolutional neural networks (CNNs) have gained popularity in recent years, as they have been shown to be effective in handling complex patterns and achieving high accuracy in speech recognition tasks.

Decision support systems

Decision support systems (DSS) are computer-based tools that help people make better decisions [6]. They use data, models, and algorithms to analyze complex problems and provide recommendations to decision-makers. DSS can be used in a variety of fields, including business, healthcare, and government. They are especially useful for tackling problems that are too complex for humans to solve alone. DSS have been around since the 1960s, but they have become much more powerful and sophisticated in recent years, thanks to advances in machine learning and big data analytics.

Deep learning

Deep learning (DL) is a subfield of machine learning that involves the use of neural networks with many layers [7]. It is inspired by the structure and function of the human brain and has been used to achieve breakthroughs in a wide range of applications, from image recognition to natural language processing. Convolutional neural networks (CNNs) are a type of deep learning architecture that has been particularly successful in image recognition tasks [8]. They work by using multiple layers of filters to detect features in images, and they have been used to achieve state-of-the-art performance on many benchmark datasets.

CNNs have become a popular choice for various pattern recognition tasks. CNNs can extract features from speech signals, such as mel-frequency cepstral coefficients (MFCCs), which can be used to train a model for speech recognition [9]. Moreover, CNNs have shown impressive results in speech recognition tasks, demonstrating their potential to improve the accuracy of ASR systems. In the context of the Arabic language, there has been a growing interest in ASR technology, particularly in the field of Arabic speech recognition. However, the complex nature of the Arabic language, which includes various dialects and phonetic variations, poses a challenge for ASR systems. Therefore, the use of deep learning techniques, particularly CNNs, can contribute to improving the accuracy of ASR systems for Arabic speech recognition.

RESEARCH MOTIVATION

The Arabic language is one of the most widely spoken languages in the world. It is a language of great cultural significance. However, Arabic is a morphologically rich and highly ambiguous language, with many colloquial dialects that differ from Modern Standard Arabic (MSA), used in formal communication [10]. This linguistic complexity presents significant challenges for Arabic Automatic Speech Recognition (AASR) systems, particularly for adult learners undergoing speech therapy. Recognizing spoken words accurately is critical for effective communication and treatment outcomes. However, the complexity of the language can pose significant challenges that impede the progress in therapy and hinder the development of speech and language skills in adult learners.

To address this challenge, we propose using Convolutional Neural Networks (CNNs) for Arabic speech number recognition, which has shown impressive performance in ASR applications. The use of CNNs is particularly effective at handling individual variations in the speech signal and improving the speaker invariance of the acoustic model [10].

Therefore, the main motivation for this research is to develop an accurate and reliable ASR system for Arabic spoken digit recognition that can be integrated into a decision support system to aid adult learners' speech therapy processes in the Arabic language. This will help to bridge the gap in the current Arabic education system, which lacks effective and accessible tools for adults to improve their speech and language skills.

RELATED WORKS

Several research studies have been conducted using deep learning models for speech recognition in various languages, including Arabic. These studies have shown that deep learning models, such as Convolutional Neural Networks (CNNs), can significantly improve speech recognition accuracy compared to traditional methods. For example, in [10] the authors proposed a robust method for Arabic speech recognition using deep CNNs. Similarly, in [11] the authors provided an overview of deep learning-based Arabic speech recognition and highlighted the effectiveness of using CNNs in this field.

In the context of education, decision support systems have been developed to support student learning in various areas, such as academic performance prediction, student engagement, and personalized learning. The authors of [12] developed an intelligent decision support system to predict students' academic performance in Jordanian public universities.

Our contribution to this field is the development of a decision support system that focuses on adult learners' speech therapy progress in Arabic spoken digit recognition. The system employs deep learning models, particularly CNNs, for speech recognition and classification. The system's goal is to

aid adult learners in improving their speech therapy progress by providing real-time feedback on their pronunciation of Arabic spoken digits from 0 to 9. The system is designed to be interactive and engaging, with visual and auditory feedback that motivates adults to practice and enhance their skills.

PROPOSED MODEL

In this study, a convolution neural network (CNN) approach was implemented and the architecture of the network was modified and improved by experimenting with various combinations of parameters.

The use of CNNs for processing spectrograms represented as 2D images was explored. Discriminatory features were extracted from the MFCC frequency in the selected dataset by applying a medium-sized CNN with varying numbers of convolutional layers and filters of different sizes. The number of convolutional layers was selected based on the complexity of the data, and after two or three layers, the gain in accuracy became stable while learning took a long time. The CNN operation with several filters was used to obtain a feature map, which was then passed through the activation function ReLU. The Max-pooling operation was used to obtain more significant features by selecting the maximum value of the other values of the map. This process was repeated with another convolutional layer and Max-pooling operation to obtain new features, which were then passed to two fully connected layers. A dropout layer was included to prevent overfitting, and the last layer contained the Softmax function, which provided the probability distribution on each class. The Adagrad stochastic gradient algorithm was used to optimize the network, and the categorical cross-entropy loss function was used since the study involved a multi-class classification problem.

Layer (type)	Output Shape	Param #
conv2d_12 (Conv2D)	(None, 256, 256, 16)	448
max_pooling2d_12 (MaxPooling2D)	(None, 128, 128, 16)	0
conv2d_13 (Conv2D)	(None, 128, 128, 32)	4640
max_pooling2d_13 (MaxPooling2D)	(None, 64, 64, 32)	0
conv2d_14 (Conv2D)	(None, 64, 64, 64)	18496
max_pooling2d_14 (MaxPooling2D)	(None, 32, 32, 64)	0
dropout_13 (Dropout)	(None, 32, 32, 64)	0
flatten_6 (Flatten)	(None, 65536)	0
dense_13 (Dense)	(None, 256)	16777472
dropout_14 (Dropout)	(None, 256)	0
dense_14 (Dense)	(None, 10)	2570

Total params: 16,803,626
Trainable params: 16,803,626
Non-trainable params: 0

Figure 1: The CNN model

EXPERIMENTS Dataset

The Spoken Arabic Digit dataset is a collection of mel-frequency cepstrum coefficients (MFCCs) corresponding to spoken Arabic digits from 0 to 9. It includes recordings from 88 native Arabic speakers, consisting of 44 males and 44 females, between the ages of 18 and 40. Each speaker was asked to pronounce each digit ten times, resulting in a total of 880 recordings for each digit. The dataset provides a valuable set of data, with 75% allocated for training and 25% for testing, for speech recognition models, particularly for the recognition of Arabic numbers. The dataset is publicly available in the UCI Machine Learning Repository [14].

Table 1: Dataset description [14]

Data Set Characteristics:	Multivariate, Time-Series	**Number of Instances:**	8800
Attribute Characteristics:	Real	**Number of Attributes:**	13
Associated Tasks:	Classification	**Missing Values?**	No

Results and discussion

In this study, the proposed model was trained and evaluated using a 75% training dataset and a 25% test dataset, as previously mentioned. A series of tests were conducted to identify the optimal hyper-parameters for the model. These parameters, which include the network structure (such as the number of neurons and layers, activation functions), batch size, and number of iterations, play a significant role in the performance of the model during training. Once a suitable model was identified with minimum error rate and maximum accuracy, it was then tested on the independent test subset. The experiment involved 10-class classification on a dataset of 6600 training spectrograms and 2200 test spectrograms. The model was trained for a number of epochs ranging from 10 to 100. The results of the experiment are presented in the table above.

Table 2: Accuracy and loss results for different epochs

Epochs	Train accuracy	Test Accuracy
10	0.6740	0.5151
50	0.9227	0.8671
100	0.9610	0.8943

The results of the experiment indicate that the model begins to learn the classes from the first 10 epochs, and its accuracy improves as the number of epochs increases until it reaches an acceptable value of 96.10% for the learning dataset and 89.43% for the testing dataset. It is observed that the model begins to stabilize after reaching a certain threshold of epochs, and the increase in the number of epochs is not as significant as at the beginning. However, it is worth noting that while increasing the number of epochs improves the classification of Arabic digit, the execution time also increases with each iteration.

CONCLUSION AND FUTURE WORKS

The ability of a computer to recognize human speech or voices poses a new challenge for modern scientific research, particularly as communication between humans and electronic devices has increased significantly. Consequently, researchers are striving to develop intelligent software capable of speech recognition without any human intervention.

In this study, we designed a system for automatic recognition of spoken Arabic digit using a CNN model to aid decision-making processes regarding adult learners' speech therapy progress.

We provided two subsets of data, one for learning and the other for testing, containing Arabic digit from 0 to 9 given by MFCC coefficients. The MFCC coefficient parameterization is widely used in this field to extract features and has also produced good results. Every recognition model undergoes a classification step, and we chose convolutional neural networks (CNN) in this study, which yielded satisfactory results after recognizing completely unknown speech samples. Therefore, CNNs proved to be a better technique for learning and identifying new data than other neural networks. Our research work serves as a starting point for launching future projects, such as continuous speech recognition, and also proposes ideas for improving our model, such as testing it on larger databases, adding additional training data to a database, and incorporating different languages.

ACKNOWLEDGMENT

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Day 2 **Wednesday, May 31st 2023** Room 1A22

Session 6

DSS Analysis

14:30 – 16:00

Chair: Peter Keenan

Room 1A22

#1	*Scientific Authorship in DSS Research: Past Trends and Future Opportunities*	Peter Keenan and Ciara Heavin
#2	*Towards an integrative assessment model for port sus-tainability decisions: A systematic review*	Xiaofang Wu, Shaofeng Liu, Shaoqing Hong and Huilan Chen
#3	*Behavioral studies for the use of visualization in holistic evaluation for multicriteria decision problems decision*	Evanielle Barbosa Ferreira, Tarsila Rani Soares de Vasconcelos, Lucia Reis Peixoto Roselli and Adiel Teixeira de Almeida
#4	*An investigation on Cloud ERP adoption using Technology-Organisation- Environment (TOE) and Diffusion of Innovation (DOI) theories: a systematic review*	Sin Ting Cheung, Uchitha Jayawickrama, Femi Olan and Maduka Subasinghage

Scientific Authorship in DSS Research: Past Trends and Future Opportunities

Peter Keenan and Ciara Heavin

ABSTRACT

As an area of research, Decision Support Systems (DSS) has undergone various changes over the last 60 years. Drawing on contributions from fields including Economics, Operations Research/Management Science (OR/MS), Information Systems (IS), and management, DSS research has traditionally focused on supporting managerial decision-making. In recent years, with the exponential increase in the volume of research characterised as "Business Intelligence and Analytics," the boundary of the DSS area is unclear, rendering the future of the field uncertain. To better understand the DSS landscape, this article uses a bibliometric analysis to investigate current publishing trends in DSS as a research area, co-authorship by gender, and location. By leveraging Scopus, we identify notable patterns and developments in DSS research over a five-year period from 2018 to 2022. Finally, we present initial recommendations to guide the future research efforts of both DSS academics and practitioners.

Keywords: Decision Support, Decision Support Systems, DSS, bibliometric analysis, gender, author, location.

Towards an integrative assessment model for port sustainability decisions: A systematic review

Xiaofang Wu[1*], Shaofeng Liu[2], Shaoqing Hong[3], Huilan Chen[4]

1 Jimei University, Xiamen, 361021, China xiaofang.wu@jmu.edu.cn
2 University of Plymouth, Plymouth, PL4 8AA, UK
3 Xiamen Suixiang Space Culture Communication Co., Ltd, Xiamen, 361027, China
4 University of Plymouth, Plymouth, PL4 8AA, UK

ABSTRACT

The slow pace of sustainability poses questions about what sustainability purposes are served and how to assess the status quo of sustainability for effective decision support. Having recognized the fuzzy concept of sustainability and the lack of sustainability assessments for ports that play key nodes of global logistic networks, this study applies a systematic review method to broadly collect theoretical and practical data from literature databases and relevant organizations, to identify sustainability requirements, port sustainability perceptions, and existing sustainability assessment approaches and methods. Results show that the sustainability concept is moving to eco-centric and contextspecific thinking while the port sustainability still lies in traditional triple lines and the elements of the concept lack recognition of the business-environment nexus. Although dozens of specific methods have been available from the existing sustainability assessments, previous assessment approaches rely much on subjective expert judgments or quantitative data, which may affect the reliability and validity of assessments. As such, this study provides a new integrative assessment model for port sustainability decisions to meet ecological needs. The proposed model integrates the interactions between port activities and the environment. It is a datadriven, evidence-based approach to reducing subjectivity and saving time. The proposed assessment model contributes to the understanding the port sustainability situations and finding preferable options in terms of interaction mechanisms.

Keywords: Sustainability purpose, sustainability assessment, approach and methods, systematic review

Behavioral studies for the use of visualization in holistic evaluation for multicriteria decision problems decision

Evanielle Barbosa Ferreira[1], Tarsila Rani Soares de Vasconcelos [1], Lucia Reis Peixoto Roselli1[0000-0001-6930-0552] and Adiel Teixeira de Almeida1[0000-0002-2757-1968]

[1] Center for Decision Systems and Information Development (CDSID), Universidade Federal de Pernambuco, Recife/PE, Brazil

evanielle.ferreira@ufpe.br
tarsila.vasconcelos@ufpe.br lrpr@cdsid.org.br
almeida@cdsid.org.br

ABSTRACT

Several behavioral studies have been performed related to MCDM/A (Multi-Criteria Decision Making/Aiding) methods, although not many of them aim directly to modulate (transform) those methods. Some of the studies intended to modulate methods provide suggestions to improve the FITradeoff decision process and the design of its Decision Support System (DSS). In this context, this paper presents behavioral study which has been constructed during the Covid-19 Pandemic and has been applied until now. These studies are concerned with the use of visualization in holistic evaluation for multicriteria decision problems decision using online survey to compare bar graphics and tables during the holistic evaluation Although these studies are contextualized for the FITradeoff Method, their results can be applied to any other methods in the context of MAVT (Multi-Attribute Value Theory), with additive aggregation. This study tested how DMs use bar graphics and tables to perform the holistic evaluation of alternatives. The experiment considers two types of visualizations: bar graphics and tables. Also, it uses two decision processes: the selection of the best alternative and the elimination of the worst alternative. In the past, DMs can only select the best alternative during the decision process in the FITradeoff DSS. However now, the elimination process is also included in the DSS, providing flexibility for Decision-Makers. As result, the experiment suggests that for some types of visualizations, the DMs performed better on the elimination process than the selection process. Moreover, results also showed that most of DMs prefer to select the best alternative than to eliminate the worst, even performing better in the elimination process. Hence, this result reinforce the flexibility provided in the DSS, but recommend another experiment using neuroscience tools, permitting to compare cognitive efforts during both decision process.

Keywords: FITradeoff method, Elicitation process, Holistic evaluation, MultiCriteria Decision Making/Aiding (MCDM/A), Online survey.

An investigation on Cloud ERP adoption using Technology-Organisation-Environment (TOE) and Diffusion of Innovation (DOI) theories: a systematic review

Sin Ting Cheung[1][0000-0002-2104-0912], Uchitha Jayawickrama[2][0000-0002-7159-6759], Femi Olan[3][0000-0002-7377-9882], Maduka Subasinghage[4][0000-0002-6717-8634]

[1] Saïd Business School, University of Oxford, Oxford, United Kingdom

[2] School of Business and Economics, Loughborough University, Loughborough, United Kingdom

u.jayawickrama@lboro.ac.uk

[3] Essex Business School, University of Essex, Essex, United Kingdom

[4] Faculty of Business, Economics and Law, Auckland University of Technology, Auckland, New Zealand

ABSTRACT

The purpose of this study was to explore the important factors for the adoption of Cloud ERP systems. When organisations make decision on implementation of innovative technology such as Cloud ERP, there is a range of factors to be considered. This paper aims to identify the most significant 9 TOE and DOI factors which have positive influence towards Cloud ERP adoption by conducting a systematic literature review (SLR). A conceptual framework was proposed which is useful reference for potential Cloud ERP adopters who are making decisions on Cloud ERP adoption. The conceptual framework includes the identified 9 factors as independent variables; adoption of Cloud ERP as dependent variable; firm sizes and countries as the two moderating variables.

Keywords: Cloud ERP adoption, Diffusion of Innovation, Technology-Organisation-Environment framework, SLR, SMEs, LEs, developed countries, developing countries.

Day 2	**Wednesday, May 31st 2023**	Room 1A22

Session 7a

Digital Twins

16:30 – 17:30

Chair: Uchitha Jayawickrama

Room 1A22

#1	*Mitigating Business Process Debt with Digital Process Twins*	Nikolaos Nousias, George Nedos, George Tsakalidis and Kostas Vergidis
#2	*An Introduction to a Methodology for Decision Making based on Digital Twins*	Daouda Kamissoko, Matthieu Allon and Blazho Nastov
#3	*Multi-criteria decision-making techniques and tools for sustainability assessment in nanomaterials manufacturing es*	Maria-Paraskevi Belioka, Jason Papathanasiou and Georgios Aretoulis

Mitigating Business Process Debt with Digital Process Twins

Nikolaos Nousias, George Nedos, George Tsakalidis, Kostas Vergidis
Department of Applied Informatics, University of Macedonia Egnatia 156, Thessaloniki 54636, Greece nnousias@uom.edu.gr, mai22049@uom.edu.gr, giorgos.tsakalidis@uom.edu.gr, kvergidis@uom.edu.gr

ABSTRACT

It is common practice for organizations to opt for short-term over long-term gains in a Business Process Management (BPM) initiative, which in many cases leads to accumulated process inefficiencies. Following the need to quickly respond to competition, customer needs, and market changes, organizations tend to accelerate a BPM project by taking shortcuts and applying workarounds to the BPM lifecycle. This trade-off between speed and efficiency has been studied previously in the software development community and is known under the metaphor of Technical Debt (TD). This study applies this metaphor to the BPM domain by introducing the Business Process Debt (BPD) term, for expressing the gap between the AS-IS and the optimal TO-BE state of a business process when applying such shortcuts to the BPM lifecycle. Out of the varying sources that lead to BPD, the authors focus on process interventions as a common and important source of process waste. The interventions and their associated BPD value need to be analyzed prior to their implementation to the actual process. This study explores the applicability of Digital Process Twins (DPTs) as a more sophisticated tool towards mitigating BPD, providing a risk-free virtual environment in which a given set of process interventions can be simulated without appending existing workflows. In this sense, a DPT architecture is proposed to facilitate decision-making by determining whether and how to intervene in a business process and eliminate the drawbacks of conventional approaches. The latter is enacted through: (i) process discovery that is performed automatically through process mining and (ii) simulations that are triggered upon automatically generated models, driven by event logs of the actual process.

Keywords: Business Process Debt, Technical Debt, Digital Process Twins, Business Process Management, Decision-making

INTRODUCTION

Since the outset of process-thinking and the consolidation of Business Process Reengineering (BPR), BPM has attracted considerable attention in both academia and industry. The growing body of literature on empirical BPM research indicates that BPM has become an established discipline [1]. In general, BPM constitutes a managerial approach that is organized in a lifecycle methodology, systematically integrating process improvement into an iterative feedback cycle [2]. Whilst BPM bears the potential to provide significant benefits to organizations, its success is subject to numerous pitfalls [3]. One of them is when organizations take shortcuts in the BPM lifecycle opting for short-term over long-term gains, disregarding the fundamental BPM principle of continuity [4]. For example, with the goal of accelerating a BPM initiative, organizations might apply quick and limited workarounds to process flows that one day will have to confront and

rectify. As a result, process waste is accumulated resulting in a limited AS-IS performance and indicating redesign costs in the future to make the process efficient and maintainable again.

This trade-off between short-term workarounds and long-term effective solutions has already been explored in the software development community and is known under the metaphor of Technical Debt (TD). In recent literature [5–7], researchers try to intertwine TD with the BPM discipline and in particular by incorporating a business-driven logic into prioritizing TD. What is missing though is the opposite interrelation, as to the best of our knowledge, no previous research has applied the TD context to the BPM domain. In this paper, the term Business Process Debt (BPD) is introduced to account for the gap between the AS-IS and the optimal TO-BE state of a business process. Articulating this metaphor in terms of BPM could raise awareness of the BPD that is accrued and will have to be paid down in the future with *"interest"*, when organizations apply inefficient, yet seemingly convenient shortcuts to the BPM lifecycle.

Although there might be many sources of BPD (e.g., lack of process modeling, inadequate process analysis, etc.), this study focuses on process interventions as a potentially significant and common source of waste. Concretely, intervening in a business process by applying a quick and limited solution might entail redesign costs in the future, hence accruing more BPD in the present. On the contrary, applying an effective long-term solution in the first place, ensures an optimal process performance that reduces the likelihood of process redesign and hence the BPD value. As a result, it is evident that process interventions have a direct impact (i.e., positive or negative) on the BPD. To mitigate the risk of accumulated BPD due to erroneous process interventions, organizations' decision-making on whether and how to intervene in a business process must be enhanced with more sophisticated tools. Thus, the challenge is to create an environment in which, based on the current state of a business process and a set of possible process interventions, an optimal intervention - i.e., in the context of this study we consider an intervention to be *"optimal"*, that when applied to a business process will have the least negative impact on the BPD value, or in other words accumulate less BPD - can be determined and subsequently applied to the real business process. Digital Process Twins (DPTs) could address this challenge by providing a reliable environment for what-if analysis and determine an intervention that provides the highest benefit with respect to a given objective function [8]. In the context of this study, the focused objective function is the mitigation of BPD, and we assume that DPTs could be utilized to determine which intervention accumulates less BPD.

Overall, the aim of this exploratory paper is twofold. Firstly, to define the BPD within the BPM context, an aspect that has yet to be studied in the BPM community and relevant literature. Secondly, to explore the applicability of DPTs for the mitigation of BPD and propose their architecture for this purpose. The remaining sections of the paper, introduce the BPD term, present the DPTs landscape and explore their potential applicability for mitigating BPD, before concluding with key outcomes and directions for future research.

THE BUSINESS PROCESS DEBT

The TD metaphor has reached a certain maturity level in the software development community, as exemplified by the quantity and quality of the current body of literature and the existence of domain-specific conference series like the ACM/IEEE International Conference on Technical Debt. The term was first introduced by Ward Cunningham in 1992 [9] to explain a situation in software development, in which long-term code quality is traded off for shortterm benefits. In other words, it refers to a quick, yet limited, implementation approach that is

expedient in the short term but creates future pressure to remediate it [10]. As Cunningham [9] states, *"every extra minute spent on not-quite-right code counts as interest on that debt"*. Given the interest accrued over time, the same work will entail additional effort and cost to do later, than it would cost in the present [10].

The early definition of TD was restricted only to technical issues [11]. Since then, it has been expanded and classified in terms of the phase in which it occurs in the software lifecycle [12]. As a result, Process Debt (PD) emerged as a distinct type of TD, encountered during the software design phase [11, 13]. Although there is limited information about PD in literature, previous works have defined it as sub-optimal software development processes [11] and deviations from baseline software practices [14].

Considering that PD has been defined only in the context of software development, it does not apply to generic business processes. However, sub-optimal BPM initiatives that focus on short-term results, might be a common pitfall in process-oriented organizations. Therefore, we consider its application in the BPM domain a timely contribution that could raise awareness of accumulated process waste and rework costs when organizations deviate from the BPM lifecycle and apply shortcuts to it. For this purpose, and to distinguish it from previous definitions of PD in the software community, we introduce the BPD term. Specifically, we define BPD as *"the gap between the AS-IS and the optimal TO-BE state of a business process, caused by shortcuts in the BPM lifecycle (e.g., lack of process modeling, inadequate process analysis, process flow workarounds, etc.) that might be beneficial in the short-term, yet implying redesign costs in the future to reach the process optimal state"*. As with a financial debt, we assume that BPD is composed of the principal and the interest. The principal on the debt corresponds to the cost of redesigning the process (i.e., paying off the debt), while the interest constitutes a *"penalty"* in the form of reduced current process performance and the additional effort in the future to make the process work optimally.

Although there can be many factors that move a process away from its optimal state, process interventions constitute a significant and common source of BPD. As process intervention, we consider a change in a business process (e.g., resequencing of tasks, automating a task, etc.), as a response to business opportunities, environmental changes, or internal inefficiencies [8]. Irrespective of its type, a process intervention can either make a process operate closer to its optimal state, thus decreasing BPD, or imply further redesign costs in the future and a higher BPD value in the present. Towards mitigating such a source of debt, it is critical to foresee in advance the impact of each process intervention on the BPD value. Hence, the challenge can be formulated as that of constructing an environment that given the current state of a business process and a set of possible interventions, an optimal intervention (i.e., results in the lowest BPD) can be determined and subsequently performed in the actual process.

MITIGATION OF BPD THROUGH DIGITAL PROCESS TWINS

To address this challenge, traditional approaches would involve manual process modeling to capture the current state (i.e., AS-IS) of the business process, and, in addition, business process simulations to perform what-if analysis. However, since such approaches entail (i) a challenging process discovery [15] and (ii) manually designed models, that often capture the main control flow of the process [8] and are prone to human error, simulations and predictions are likely to be performed upon inaccurate models. An erroneous intervention could hence be proposed as optimal and subsequently applied to the actual process, unexpectedly accumulating BPD.

Therefore, more sophisticated tools are needed to address the drawbacks of traditional approaches and enable more accurate and reliable decision-making prior to actual interventions in a business process.

A challenge similar to the one described above was first addressed in the aerospace and manufacturing industries, where the aforementioned environment is known as a Digital Twin (DT) [8]. The term DT was first introduced by Grieves in 2003 [16] to describe the existence of a virtual representation (i.e., twin) of a physical object, with bidirectional communication between the two counterparts. Specifically, data is transferred from the physical to the virtual world, creating a digital asset that represents the exact state of its physical twin at any point in time. In turn, physical states are simulated and predicted in the virtual environment before insights and corresponding actions are implemented in the physical world. With technological advances in areas such the Internet of Things (IoT) and Artificial Intelligence (AI), digital twinning is no longer limited to physical objects [17]. Among other applications, it can be used to mirror business processes, which is referred to as DPTs [8].

A DPT is a virtual representation of a business process that provides an environment to predict process performance in different scenarios. Without the risk of appending existing workflows, organizations are able to modify parameters and observe how outputs are affected, identifying unseen process inefficiencies and potential points of failure in advance of time. DPTs could be utilized in the context of this study to proactively prevent erroneous interventions from happening in the first place. Specifically, practitioners could simulate a series of process interventions in a risk-free environment and determine the intervention that accumulates the least BPD. Applying the proposed optimal intervention to the actual process, BPD can be mitigated.

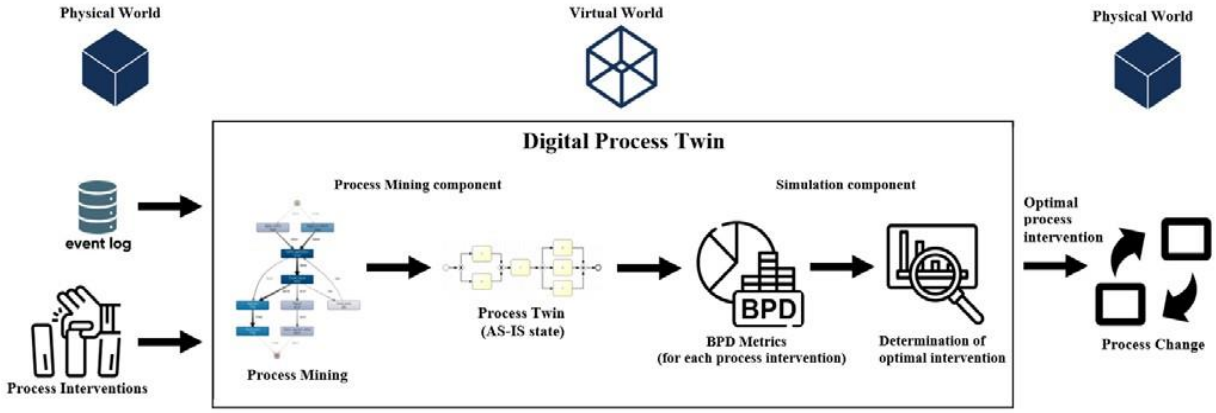

Figure 1: Proposed DPT architecture for the mitigation of BPD

The architecture of a DPT utilized for such purpose is proposed in Figure 1. It is composed of a process mining and simulation component, and a two-way connection to the physical world. Initially, event logs and a set of process interventions can be transferred from the physical world to the DPT (i.e., physical-to-virtual connection). Therein, a process mining component can discern the flow patterns and create a highly accurate twin of the actual business process, representing its AS-IS state. For each of the given process interventions, a simulation component can subsequently calculate BPD metrics and determine based on a what-if analysis the intervention that is about to accumulate the least BPD. To close the loop between the virtual and physical world, the proposed intervention should be applied automatically to the actual process (i.e.,

virtual-to-physical connection). This last part has been achieved previously through action-oriented process mining [18].

CONCLUSIONS

In this paper, we introduced the BPD term in the BPM domain, a context that has not been studied previously in literature, and explored how DPTs could be applied towards mitigating one of its common and significant sources, namely process interventions.

To this end, the key outcomes of this work are the following: (i) BPD functions like any other type of debt: it might provide convenience in the short-term, but the principal on the debt plus interest must be paid off later. In other words, by trading off speed over efficiency, a BPM initiative can be accelerated in the present, yet implying a limited current process performance and redesign cost in the future. (ii) When organizations are not aware of the amount of waste that accumulates in a BPM initiative, it is much easier to take shortcuts in the BPM lifecycle and defer tasks that increase BPD. Thus, the BPD metaphor could help companies understand how to manage and optimize their processes and make process-related decisions that are beneficial in both the short and long term. (iii) Given the fact that business processes are subject to frequent changes, process interventions constitute a common and significant source of BPD. Each time a faulty intervention is made in a business process, BPD accrues and future pressure to fix that intervention is created. For this purpose, organizations need to adopt a proactive approach that would allow preventing accumulated waste from happening in the first place. The idea of utilizing DPTs for this purpose is appealing, considering that all possible decisions can be evaluated without causing waste and costs. (iv) Due to their nature to virtually mirror a business process and conduct what-if analysis for a given set of parameters in a risk-free virtual environment, DPTs could address the aforementioned challenge, by simulating the process performance for each intervention and then determining the optimal one in terms of the associated BPD value. In this sense, BPD can be mitigated by applying the proposed optimal intervention to the actual process.

Overall, this work contributes towards a fundamental understanding of the invisible debt that arises in a BPM initiative when decisions are made primarily based on speed, and in addition shifts the discourse towards potential applications of DPTs in the BPM domain. As future work, we intend to evaluate the proposed DPT architecture through experimental investigation and case studies. Furthermore, we plan to establish metrics to facilitate practitioners quantify the impact of process interventions on the BPD value, and we intend to create a taxonomy that will encompass different sources of the BPD phenomenon, classified by the BPM lifecycle phases in which these sources are found.

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An Introduction to a Methodology for Decision Making based on Digital Twins

Daouda Kamissoko
IMT Mines Albi
University of Toulouse, Albi, France daouda.kamissoko@mines-albi.fr

Matthieu Allon, Blazho Nastov Ansys
4 avenue des Saules, Lille, France
matthieu.alon@ansys.com, blazho.nastov@ansys.com

ABSTRACT

Nowadays, Digital Twins (DT) attract particular attention, among other fields, in the model-driven engineering and Decision Support Systems domains, to solve the problem of model obsolescence and facilitate system maintenance via system-model(s) synchronization. This is possible by using different types of data sources (sensors, experts, BIM, GIS etc.) to get data from the real system and by integrating seamlessly the data into models. This paper demonstrates that Digital Twins models are better suited as a base for decision making activities, as a result to the system-model(s) synchronization. In addition, the decision-making activities are guaranteed to incorporate the latest information from the real system, and therefore, stakeholders should have more confidence in making and implementing decisions. This paper aims at introducing a methodology to build DT models for decision making. The methodology is defined throughout multiple generic steps and required domain expert roles for each step.

Keywords: Digital Twins, Decision Support Systems, Decision Making, MBSE, MDE

INTRODUCTION

In recent years, software engineering has been able to cope with the system increasing complexity. MDE (Model Driven Engineering) [1] allows to represent all the dimensions of engineering, its products and processes, by models. However, during designed system evolution, a gap can occur between the models and the real system, reaching a point of obsolescence. Such models cannot be used as a basis for decision making processes.

Nowadays, the Digital Twin concept has gained the attention in Model Driven Engineering [2], but also in other domains like the Cyber-Physical Systems (CPS - [3]) and Model-Based System Engineering (MBSE – [4]). Digital Twins solve the model obsolescence problem and facilitate the system (physical or informational) maintenance thanks to the synchronization between the models and the represented system. In addition, and as a result to the system-model(s) synchronization, Digital Twin models are better suited as a base for decision making activities, incorporating the latest information on the real system, and therefore, stakeholders should have more confidence in making and implementing decisions. This is possible through the acquisition, processing, visualization, and analysis of the system data collected via different sources (e.g., sensors, experts, etc.), during the Digital Twin life cycle. For the latter, the authors adopt the notion defined in [4]. According to the Digital Twin objectives, this life cycle comprises two spaces that are reality (notably the system) and the Digital Twin virtual space. The latter itself includes two main notions. The “as-is” Digital Twin allows to model and implement the system. With the “tobe” Digital Twin, the system maintenance modifications are represented (identified using system monitoring or predictions).

In this paper, the contribution, detailed in the next section, is an introduction to a method for building and adapting Digital Twin to a specific domain with the perspective of decision making. This requires an identification of the generic Digital Twin building steps, the domain expert roles and how both can be associated to obtain a specific domain Digital Twin.

Decision making processes are integrated into the Digital Twin building steps.

PROPOSAL

This section aims to answer the question “how to build Digital Twin and adapt it for a given domain. To answer this question, two Digital Twin synchronization phases are identified Firstly, the one starting from the physical or informational object* towards the models (Object-to-Models or O2M), and then, the one going from the models to the object (Models-to-Object or M2O). Figure 1 shows, within a UML activity diagram, the Digital Twin lifecycle. The first activity consists of defining the context using the domain expert knowledge. What is called "context" corresponds to the targeted domain specificities, i.e., that in which the DT is used. The two synchronization phases (O2M and M2O) use therefore the context for the DT adaptation.

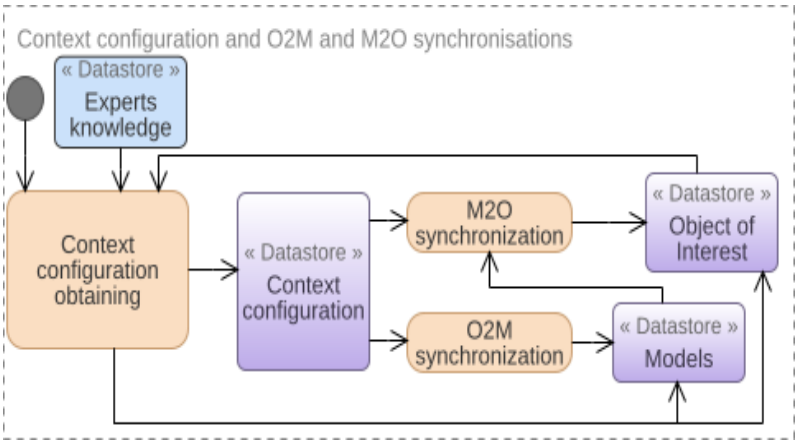

Figure 1: Context configuration and O2M and M2O synchronisations

The Object-to-Models phase consists in synchronizing the object with the models, resulting in an object data integration in the models. Thereafter, the Models-to-Object phase allows to define actions to be undertaken according to the model data to (re)establish specific desired business characteristics within the object. These actions correspond to a context redefinition. We see here the importance of the exchange between the domain expert knowledge and the two synchronization phases. This is presented in the two following sections.

Object to models (O2M)

Like the second synchronization phase presented in the next section, the current one is composed of various steps, depicted in Figure 2. However, in order to consider the expert business knowledge, a configuration phase is necessary (visible in the right part of figure 2 In this latter, the expert roles and their relations with the Object-to-Models synchronization steps are defined. This is detailed in the following paragraphs.

* in the rest of the paper, an “object” is the entity mirrored by the DT

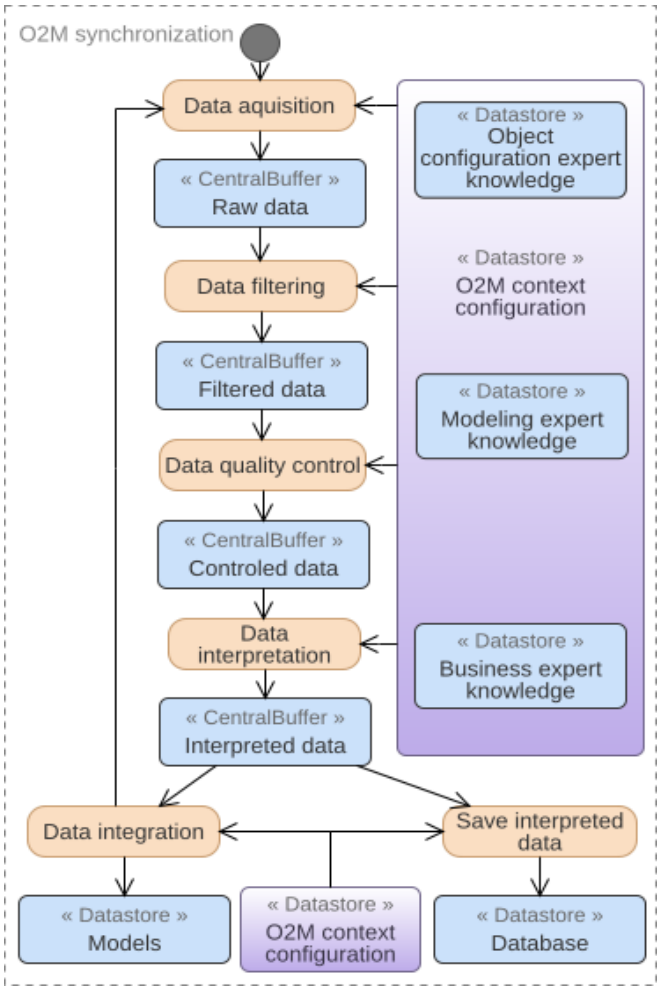

Figure 2: O2M synchronization, using configuration definition.

Data acquisition: The data acquisition step goal is in a successful data source connection. For this, its configuration consists of a (i) required data identification, a (ii) data source identification and a (iii) data source interfacing. Using the business expert knowledge, the required data identification process goal is to find the domain characteristics that are (a) important for stakeholders and (b) must be kept up to date in the Digital Twin. For example, a safety observer must monitor data related to the infrastructure safety. Then, the data source identification (e.g., sensors, maps, simulations, etc.) uses the object configuration and business expert knowledge. As for the data source interfacing process, it consists of connecting with different data sources (automatically or not) which can be human or technical. Hence the object configuration expert knowledge use necessity.

Data filtering: The data filtering step aims at filtering data and in extracting relevant information, according to those identified with the business expert in the previous step.

Indeed, data sources transfer row data that usually contain more information than needed for a given study (e.g., a traffic flow from a road camera, where the detected vehicles number is the relevant data). The extraction function is defined and implemented by the object configuration expert. For example, an algorithm for car detection can be implemented by such an expert.

Data interpretation: This step allows to interpret, using business rules, (i) the object data and (ii) the simulation ones to provide data adapted to the domain characteristics for a better stakeholder

understanding and object monitoring. The business rule implementation is made via the object configuration expert knowledge. As an example, consider data coming from a camera in a mall. A business rule, concerning handshakes and a COVID propagation risk, could be formulated in these terms: “if a handshake is detected, there is a risk of COVID19 contamination”.

Data integration: The interpreted data is then integrated in the model. The context configuration is possible using the business and modeling expert knowledge, since the former knows the domain characteristics and the latter the model elements corresponding to it.

Data storing: The data is saved in a database, allowing to have data traceability. For instance, during the analysis step presented in next section, a database can be used to monitor the values of a characteristic in a specific period(s) in the past, and thus reconstructing a model for the specified period(s). Since this step is a technical one, the object configuration expert knowledge is here used.

Model to Object (M2O)

This synchronization phase is composed of different steps, visible in Figure 3. Just like the other synchronization phase (see previous section), a configuration phase is necessary (visible in the right part of figure 3) to consider the domain expert knowledge. Each of the Model to Object synchronization steps and their relationship with the corresponding expert roles are detailed in the following paragraphs.

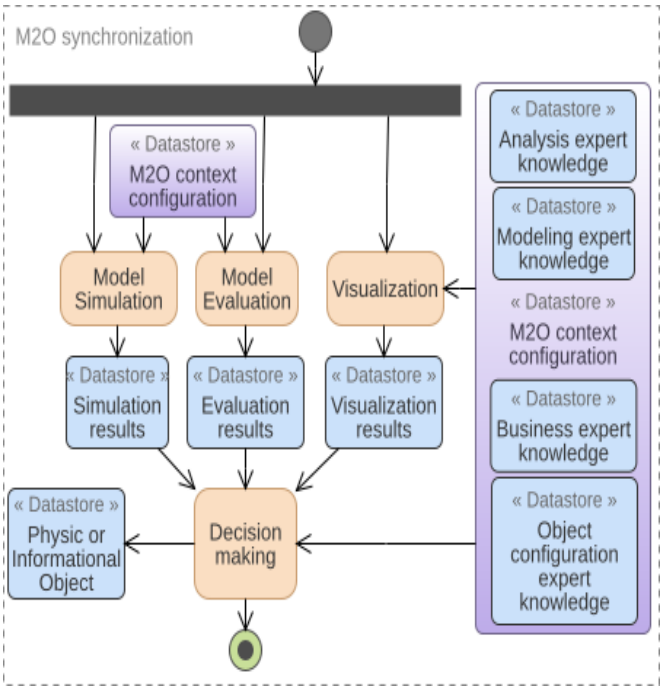

Figure 3: M2O synchronization, using configuration definition.

Model simulation: This step is complementary to the data acquisition and integration (both presented previously in the Object to Model phase) steps: both latter consist of an object monitoring while the former is predictive. Indeed, simulation executes business rules to offer stakeholders various possible scenarios concerning a situation before it happens, so that they can (i) make decisions and (ii) justify them. In addition to the business expert knowledge for the rules, the simulation model is based on the modeling expert knowledge.

Model evaluation: It allows to evaluate an object characteristic based on the characteristics provided by the Object to Model interpretation step and using the analysis expert knowledge. This evaluation can result on various object (functional or not) property levels. For instance, it can be resilience ones, as in [5] in order to evaluate the resilience of a physical object. The evaluation can be a statement (evaluation according to received data) or a prediction (evaluation according to simulation data).

Model visualization: This step grants to visualize data using various strategies (table, graph, etc.) to offer visualizations adapted to stakeholder needs. To configure this step, the knowledge of the modeling and business experts are necessary. The latter provides information about the various domain user roles and which representation each one needs, while the former implements the chosen representation.

Decision making: It allows to help and guide the stakeholders to make decisions, justify them and apply it on the object and / or the models. The analysis expert knowledge allows to select a decision-making process and the business one provides some information about the characteristics (e.g., their business relative importance). To apply the decisions, the modeling and object configuration expert knowledge are used to respectively impacts the model(s) and the object.

The approach proposed and implemented in a tool (under development) allows to:

- Evaluate a non-functional property of the system in the past, in the present and in the future, either at a given time, or over a period, either for the whole infrastructure or for a part of the infrastructure.
- Integrate the views of stakeholders in the evaluation of non-functional properties.
- Identify the best decision.
- Assess the impact of a disruption.
- Determine the worst-case scenario.
- Determine the best decision strategy.

CONCLUSIONS

Digital Twins (DT) solve the problem of model obsolescence and facilitate system maintenance via system-model(s) synchronization by using different sources (sensors, experts, etc.) to get data from the real system and by integrating seamlessly the data into models. As such, DT models are better suited as a base for decision making activities as a result to the system-model(s) synchronization. In addition, the decision-making activities are guaranteed to incorporate the latest information on the real system, and therefore, stakeholders should have more confidence in making and implementing decisions.

This paper introduces a generic method to build and adapt a DT to a specific domain (context). For this purpose, authors presented the two synchronization spaces between a DT and the physical or informational object linked to it. The two synchronization space steps are defined, as well as the expert roles and their relations with each steps.

Defining such an adaptation method raises many issues. The first results brought by the prototype implementation (case study demonstration available at [6]) concerning the O2M synchronization phase have shown that there are still several open questions: the definition of the steps themselves, particularly regarding the quality control of the data, the configuration phase definition and implementation and the way the experts' knowledge intervenes within them. In addition, there are more fundamental related issues concerning Model Driven Digital Twins Engineering and, in particular, issues concerning means to facilitate and improve DT construction and reuse.

ACKNOWLEDGEMENTS

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Multi-criteria decision-making techniques and tools for sustainability assessment in nanomaterials manufacturing

Belioka Maria-Paraskevi , Papathanasiou Jason
Department of Business Administration, UoM 156 Egnatia Str.,
Thessaloniki 54636, Greece
marivi.belioka@uom.edu.gr, jasonp@uom.edu.gr
Aretoulis George
School of Civil Engineering, Faculty of Engineering, AUTh Egnatia Street, 54124,
Thessaloniki, Greece garet@civil.auth.gr

ABSTRACT

The complicated and wide-ranging field of nanotechnology holds up a lot of hope for advancements that will help humanity. This study discusses the many strategies employed to provide a complete and trustworthy set of criteria for assessing the synthesis and sustainability of nanoproducts. There are several methods available for creating nanomaterials. Regulators, product developers, consumers, or other organizations worried about possible dangers linked with nanomaterial manufacturing and usage face a significant challenge from engineered nanomaterials. The handling of a wide range of information kinds, parameters, and uncertainties is necessary for sustainability evaluations. Due to its adaptability and capacity to foster communication between stakeholders, analysts, and scientists, multi criteria decision analysis (MCDA) has been recognized as an appropriate collection of techniques for conducting sustainability evaluations. However, it has been noted that when selecting one MCDA approach over another, researchers frequently fail to adequately describe their justifications. Multi-criteria decision analysis (MCDA) is a potent analytical framework for managing the creation of nanomaterials and assessing risk associated with them, despite the fact that there are several potential decision-making strategies. MCDA has been suggested as a top contender to carry out sustainability assessment, and several applications have surfaced. However, in the vast majority of evaluations, the choice of the MCDA technique depends more on comfort and affinities with the approach than on the decision-making scenario being taken into account. To analyze the dangers related to nanomaterials, it is crucial to combine several information sources.

Keywords: MCDA, nanotechnology, nanomaterials manufacturing, sustainability assessment

INTRODUCTION

Research in the fast expanding field of nanotechnology is already having a significant impact on consumer goods. The creation and usage of materials at the nano-scale, which is typically defined as less than 100 nm in one dimension, can be referred to as the field of nanotechnology. Nanomaterials can be created naturally (for example, from combustion byproducts) or artificially. Despite the possibility of commercial benefits, in vivo and in vitro experiments have revealed that some nanomaterials are harmful. The physicochemical characteristics of a material may have a significant impact on its probable environmental destiny and toxicity (as well as exposure potential and risk). Tightly bound to soil surfaces, potentially hazardous nanoparticles may only migrate slowly through the ecosystem. For these particular uses, such materials might be thought to be reasonably safe. Such knowledge

is crucial because a lack of awareness of the dangers and toxicity of nanomaterials could prevent the full-scale industrial implementation of nanotechnology[1].

There are several technologies available to help with risk assessment and management of manmade nanomaterials (MN). The majority of them demand input information on physicochemical qualities, toxicity, and exposure details unique to various scenario types. To guarantee transparent risk assessments for commercial and governmental decision-making, technologies that can manage data gaps in an organized manner are required as this data are currently not easily available[2]. In the absence of conclusive data, a thorough characterization of factors causing toxicity and dangers could serve as a guide for nanomaterial development and legislation. Researchers have put up a risk-based classification scheme for nanomaterials that takes into account a number of factors frequently related to the risk and toxicity of nanoparticles. These factors range from the physicochemical properties of the nanomaterial to anticipated ambient concentrations to destiny and transport modes.

The goals of greener/sustainable nanotechnology are focused on supporting the fundamental tenets of sustainable development, such as economic sustainability and environmental responsibility (eliminating product hazards whenever possible and minimizing the effects of nanomaterial production from extraction to end-of-life). Designing sustainable and environmentally friendly nanoscale products requires adhering to the fundamental principles of I removing hazards, (ii) designing nanomaterials for end-of-life (reuse, repurpose, or degradation), and (iii) incorporating safety by molecularly engineering the material to prevent exposure. As a result, crucial choices must be made[3]. The comparability and evaluation of nanotechnology outputs can be improved by using multiple criterion decision analysis (MCDA) approaches in conjunction with the sustainability data on nanotechnology that is now available[4].

Multi-criteria decision analysis can be used to classify the clustering of nanomaterials into ordered risk groups (MCDA). A collection of techniques known as MCDA are used to provide the decisionmaking process structure. The MCDA process typically consists of four steps: Nanomaterial properties in this case) relevant to the decision at hand, (2) eliciting the model's parameters (weights, thresholds, etc.), and assigning measurements for each alternative (e.g., nanomaterial risk group), (3) executing the model through computer software, and (4) interpreting the model's results and, potentially, repeating the process from step 1 or 2 by re-evaluating the model.

Another crucial step in assessing the risk of nanomaterials is hazard identification, which is required globally by numerous regulatory regimes. A technique called hazard screening (or rating) compares the risk potential of various nanomaterials. The evaluation of the weight of the evidence (WOE) has been proposed as a technique for assessing the risk associated with nanomaterials, however the majority of WOE frameworks are qualitative in character and fall short of the objectivity and transparency required for sound decision-making[1, 5].

RESULTS & DISCUSSION MCDA

Methods and tools

To give a systematic analytical technique for combining risk levels, uncertainty, and valuation, MCDA approaches use a decision matrix of criteria and performance scores. This permits evaluation and ranking of several alternatives.

Nearly all MCDA approaches follow a similar structure and decision matrix construction process, however they all synthesize information in different ways. Various approaches use distinct optimization algorithms and call for varied kinds of value information. Some strategies provide an incomplete ranking, others find a single ideal alternative, some rank the options, while others distinguish between acceptable and unsatisfactory options[6, 7].

Simple MCDA techniques can be applied to simplify complicated issues into a single basis for choosing a preferred solution. These techniques, however, do not always balance the relative relevance of the many criteria and combine them to generate an overall score for each possibility. While straightforward and frequently executable without the aid of computer software, rudimentary procedures are best suited for single-decision maker situations with few alternatives and criteria—a circumstance that is rarely present in environmental initiatives.

More complex methods include the analytical hierarchy process (AHP), multi-attribute utility theory (MAUT), multi-attribute value theory (MAVT), and multi-attribute value theory (MAVT). MAUT combines various criteria into a single scale of utility or value by using utility or value functions. MAUT is predicated on the suppositions that the decision-maker is consistent in his judgments, rational, and in possession of perfect information. The maximization of utility or value is the aim of the decision-makers in this process.

AHP aggregates many aspects of the choice issue using a single optimization function called the objective function, much like MAUT does. AHP aims to choose the alternative that maximizes the value of the objective function. AHP is a method of compensating optimization, much like MAUT. Instead of using utility and weighting functions, AHP employs a quantitative comparison technique based on pair-wise comparisons of choice criteria[6].

The synthesis techniques used to create nanomaterials were categorized into green chemistry using a classification model based on decision rules developed using the dominance-based rough set approach (DRSA). Based on the chosen criteria, DRSA can spot potential trade-offs that the DM might be considering subconsciously. As there is no need for data translation and no timeconsuming weight elicitation, it is especially advantageous when the data is both qualitative and quantitative. DRSA's disadvantage is that since the common software in this field can only handle one choice at a time, comparisons and changes to classifications and rankings must be carried out separately[8].

In order to determine whether one option is at least as good as another, the elimination and choice expressing the reality (ELECTRE) approach compares options pairwise utilizing the four binary relations of indifference, preference, weak preference, and incomparability. Cinelli et al. created ELECTRE models by offering performance classes with defined levels of uncertainty for the green chemistry-based production of silver nanoparticles. The disadvantage of the ELECTRE approach is that it only uses the ordinal nature of the data, making it unable to account for the extent of performance differences[7, 8].

The present problem for the field of nanotechnology is building a framework for choosing appropriate nanomaterials and making policy decisions with ambiguity and insufficient information, like with any new technology or science. For the explicit inclusion of decision makers' and stakeholders' value judgments in management and policy decisions, as well as for the integration of heterogeneous information (technical, social, and political), MCDA methodologies provide a framework.

MCDA tools could be helpful in selecting the criteria to employ, figuring out the relative weights of each criterion, and comparing the results to find the optimum option.

Using MCDA techniques has a number of benefits over less structured decision-making procedures, including: The MCDA provides both a formal mechanism for combining data from many sources and a clear and transparent methodology for decision-making. Decisions made using MCDA are therefore more defendable than those made using less structured techniques.

It is crucial to remember that while MCDA tools can aid in visualizing ambiguity and currently available information, they cannot replace missing information. Like any tool, information gathering and its application to the calibration and validation of risk and decision models are essential to their effectiveness. It may also be necessary to integrate multi-criteria decision analysis with value of information (VOI) assessment in order to prioritize competing objectives, research priorities, and funding distribution alternatives. The value of new information being gathered to lessen or eliminate uncertainty in a scientific or managerial environment can be assessed using VOI analysis. The most advantageous method for gathering information is determined using VOI analysis, which clearly quantifies estimated potential losses from uncertainty-related decisionmaking errors[6].

Life cycle assessment (LCA)

Using a variety of environmental factors, the life cycle assessment (LCA) technique evaluates how product systems will affect the environment. Because LCAs for nanomaterials frequently omit the moments at which nanoparticles are discharged during their entire life cycle, they are not evaluating them according to their ecological relevance. These steps were omitted from the LCA for a variety of reasons, including limited information regarding the use of nanoproducts and lack of understanding of their long-term effects on the environment during use and disposal. Consumer goods are one industry where the life cycle assessment of nanomaterials' use phases has been researched, and it is claimed that better performance has a reduced influence on the total product.

Quantitative data are only available for a tiny subset of specific nanomaterials and manufacturing procedures related to nanomaterials, making it challenging to properly conduct LCAs of nanomaterials as a whole. As a result, it is imperative that data be made broadly accessible in order to expand LCAs from cradle-to-grave. Also, industry data must be used rather than data that has been extrapolated from literature or guessed from other sources. Due to the composition of nanomaterials, simplistic numerical estimations do not accurately reflect their environmental impact when scaling up[8].

Risk assessments

Understanding the effects on environmental and human health is a key component of nanoparticle assessments. One technique used to concentrate on the toxicity of certain compounds is risk assessment (RA). Hazards, effects, and exposure assessment are the

foundation of RA. Other testing methods are currently being developed, which shows that quantifiable and trustworthy impacts data are still a ways off in terms of evaluation. The issue of exposure assessment, which is still in its early stages, is another one. In working environments, nanomaterial concentration levels have not yet been accurately measured. Although general assessments can be carried out for a single endpoint, they cannot be applied to several endpoints. While helpful, it's important to be aware of this fundamental drawback.

Risk assessments by itself are insufficient due to the absence of data on the economic and environmental effects, but when integrated with LCA and Life Cycle Costing (LCC), they can be useful in creating Life Cycle Sustainability Assessments[8, 9].

CONCLUSIONS

The ability to assess the value of nanotechnologies is a crucial responsibility that should be taken on by regulatory bodies both domestically and internationally. Governmental programs have used a variety of general types of indicators to gauge their effectiveness, including input indicators, which track the amount of resources used, output indicators, which track the quantity of goods or services produced, and efficiency indicators, which track the price per unit of output or result. Agencies have just started to understand that when making planning and project development decisions, they must examine the whole spectrum of prospective benefits and costs[4].

While there has been some effort put into creating cost-based performance standards and metrics, applications of environmental and health performance indicators are less common.

Even though, stakeholder values are not formally taken into account while using specific technical indexes. Governmental agencies will be assisted in their efforts to defend funding requests and facilitate communication with stakeholders by developing performance indicators linked to management guidelines for nanotechnology. Under the umbrella of MCDA, a wide variety of tools and methods are accessible[10, 11].

Different stakeholders with different backgrounds will probably have different ideas on what benefits and risks exist in the development of nanotechnology. Analyzing and communicating risks in an ethical and responsible manner is essential to the responsible development of nanotechnology. For this, it's important to have solid, factual data on both the technological dangers and how society views risk. Real and perceived risk are equally crucial for achieving better results, not just for normative and ethical grounds but also for practical ones[10, 11].

The framework that combines multi-criteria decision analysis, value of information analysis, and adaptive management tools and is described in this paper may serve as an excellent basis for both integrating various information sources to evaluate risks related to nanomaterials as well as for creating justifiable and open regulatory decisions[4].

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Day 2	**Wednesday, May 31st 2023**	Room 1A24

Session 7b

Case studies

16:00 – 17:00

Chair: Daouda Kamissoko

Room 1A24

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The Application of Digital Technologies in the Agri-Food Supply Chain of China: Enablers Identification and Prioritization

Guoqing Zhao
School of Management, Swansea University, Swansea, United Kingdom
guoqing.zhao@swansea.ac.uk

Xiaoning Chen, Shaofeng Liu
Plymouth Business School, University of Plymouth, Plymouth, United Kingdom
xiaoning.chen@plymouth.ac.uk, shaofeng.liu@plymouth.ac.uk

Xiaotian Xie
Surrey Business School, University of Surrey, Surrey, United Kingdom
x.xie@surrey.ac.uk

ABSTRACT

Agri-food supply chains (AFSCs) are facing more pressures in terms of increasing volatility, growing population, and intensifying climate change. It is expected that global agri-food production must be doubled by 2050 in order to tackle the world population explosion crisis. Digital technologies have the capability to produce more food with fewer resources, reduce food waste and loss, and revolutionize the agri-food industry completely, which has been widely recognized by scholars and practitioners as a potential solution. However, it is not clear about enablers to facilitate digital technologies application from a developing country's perspective. Thus, this study aims to analyze enablers to the application of digital technologies in the AFSC of China. Three research questions were formulated to understand what digital technologies are applied in the China's agri-food industry, what are the enablers to facilitate AFSC practitioners to use digital technologies, and how the identified enablers are prioritized. To answer these research questions, we employed a mixed-method approach, including semistructured interviews to collect empirical data from 16 experienced AFSC practitioners, thematic analysis to identify enablers, and fuzzy analytical hierarchy process (AHP) to prioritize the identified enablers.

Our study significantly contributes to new knowledge. For example, this study identifies that frequently discussed digital technologies such as blockchain technology, big data analytics, and automatic tractor are seldom used in the agri-food industry of China, other technologies such as water-fertilizer integrated technology, internet of things (IoTs), and smart greenhouses are widely deployed. Ten enablers are identified that may facilitate AFSC practitioners to apply digital technologies, including those merely mentioned by scholars, such as workforce reduction, early detection of plant diseases, accurate determination of the maturity of crops, and improving working conditions. Finally, our prioritization results show that reducing working intensity, reducing water and fertilizer consumption, and improving fertilizer use efficiency are the top three enablers. This study also contributes to managerial practices.

Keywords: Agri-food supply chain, Digital technologies, Fuzzy AHP, Enablers identification and prioritization

INTRODUCTION

Digital technologies are the digital tools, systems, devices and resources that generate, store or process data. Their advantages in speeding communication, facilitating interaction, strengthening data security, and accelerating automation have been widely recognized by researchers and practitioners [1]. Thus, various digital technologies such as IoTs, blockchain technology, robotics, machine learning

(ML), and artificial intelligence (AI) are applied to improve products, services, and processes. For example, blockchain technology has been applied to improve AFSC's traceability performance by providing security and full transparency. IoTs have been applied to reduce incorrect deliveries, excessive waiting time, and product losses. Extant literature in this filed has analyzed barriers and enablers to the adoption of different digital technologies, the application of digital technologies in improving supply chain resilience, sustainability, and leanness, and the implications of digital technologies on supply chain management, a paucity of them has investigated enablers to the adoption of digital technologies of AFSCs from a developing country's perspective. In particular, China's agri-food industry is moving from Industry 1.5 to Industry 4.0 by employing different digital technologies, having an understanding on the enablers to the adoption of digital technologies would help practitioners and policymakers better deploy these technologies. Thus, this study aims to analyze enablers to the application of digital technologies in the AFSC of China. Three research questions are formulated:

RQ1: What digital technologies are applied in the AFSC of China?

RQ2: What are the enablers to facilitate AFSC practitioners to apply these digital technologies?

RQ3: How are these identified enablers prioritized?

To answer RQ1, we employed semi-structured interviews to collect data from experienced AFSC practitioners from China to understand what digital technologies have been applied in the AFSC. To answer RQ2, thematic analysis was adopted to identify enablers to the adoption of digital technologies. To answer RQ3, we adopted fuzzy AHP to understand the relative importance of the enablers to adopt digital technologies [2]. AHP is a widely applied multicriteria decision-making (MCDM) method to prioritize alternatives based on pair-wise comparisons. However, the pair-wise comparison may be imprecise due to involvement of subjective judgements. Thus, fuzzy sets have been combined with AHP to alleviate the uncertainty of human judgements and improve accuracy of the present work.

The remainder of this paper is organized as follows. A review of relevant literature discussing enablers to the adoption of digital technologies in supply chains is presented in Section 2. The research methodology is discussed in Section 3, while the empirical data collection process is shown in Section 4. In Section 5, we presented the data analysis process and findings of this study. Finally, discussion and conclusions are presented in Section 6.

LITERATURE REVIEW

Agri-food production must be doubled by 2050 to fulfil the global population demand and the world's population is expected to increase significantly to 9.7 billion by 2050 [3]. A feasible way to achieve this task is to equip AFSCs with digital technologies to produce more food with fewer resources, reduce food waste and loss, and revolutionize the agri-food industry completely. Thus, various researchers have dedicated themselves into investigating digital technology application of agri-food industry. For example, [4] research results indicate that higher income for farmers, increased output, and improved food security are the top three enablers for African farmers to use digital tools. After analyzing enablers to use electronic traceability in Indian AFSC, [5] proposed that competitive advantage, coordination and transparency, management support, and appropriate technology for e-traceability are the significant enablers to e-traceability implementation. Exploring digital technologies application in agri-food industry is a trending topic. Various research areas are explored, including sustainability, business model and framework establishment, using digital technologies to tackle the COVID-19 crisis,

and optimizing AFSCs with different digital technologies. However, a rare of them have analyzed enablers to the application of digital technologies in the AFSC of China, which pertains a valuable research gap that should be filled.

RESEARCH METHODOLOGY

A mixed-method approach was adopted in this study because of its advantages in balancing out the limitations of each method, strengthening findings, and providing a better understanding of the problem. Thus, three methods were adopted in this study, including semistructured interviews, thematic analysis, and fuzzy AHP.

Semi-structured interviews were employed in this study to collect data from experienced AFSC practitioners. We selected this data collection method because it provides us with a set of themes to focus on and is less formal than structured interviews, thereby providing flexibility in exploring the perceptions and opinions of respondents.

Thematic analysis was then selected to identify, analyze, organize, describe, and report themes found within the data collected from semi-structured interviews. Thematic analysis was selected over content analysis, narrative analysis, and discourse analysis because it does not require the detailed theoretical and technological knowledge of other qualitative approaches, provides a more accessible form of analysis, and fewer prescriptions and procedures to implement it [6].

Finally, fuzzy AHP was implemented to prioritize the enablers identified by thematic analysis. Fuzzy AHP is widely applied in social, manufacturing, political, industry, and government areas because of its ease of use, structuring problem systematically, and calculating both criteria weights and alternative priorities.

EMPIRICAL DATA COLLECTION

We conducted empirical data collection activities in China between December, 2021 and April, 2022. We selected this specific time period to collect data because of different agricultural technologies (e.g., temperature, light, and humidity management systems) are frequently used during wintertime of China in order to provide sufficient off-season vegetables to Chinese. Thus, it would be easily for us to know what digital technologies have been used in the agri-food industry of China. China was selected to conduct research because of two reasons. First, we have wide connections with the agri-food industry of China because we participated in several projects funded by Horizon 2020 and National Natural Science Foundation of China. The collaboration allowed us to find suitable participants to participate in this research. Second, Chinese government proposed to achieve climate-smart agriculture in 2035 and began investment to facilitate agricultural science and technology innovation. Thus, we believe that more digital technologies should be applied to accelerate the transformation of

China’s agri-food industry.

We developed an interview guide to enable participants to focus on the topic. The interview guide contains three sections, including interviewee information, main digital technologies applied in the agricultural sector, and enablers to apply digital technologies in the agricultural sector. Then, we conducted pilot interviews with two professors in operations and supply chain management and one agri-food industry practitioner. The pilot interviews suggest that more elaborations on the interview questions should be given. For example, more examples on digital technologies should be given when

we are asking the question “what kind of smart technologies have been applied in the agricultural sector of China”.

Purposive sampling was applied to recruit suitable participants to participate in this research. Two criteria were applied: (1) the selected participants should be the technical lead or senior level members of their organization, to ensure they have sufficient understandings on smart or digital applications in agriculture, and (2) the selected participants should have more than 10 years working experience on the agri-food industry to ensure high-level professional experience and knowledge. Based on our criteria, 16 agri-food professionals were selected and were all happy to accept our interviews. Two co-authors of this paper who are affluent in Chinese and have interests in agri-tech acceleration conducted the interviews.

DATA ANALYSIS AND FINDINGS

In this section, we elaborated how the enablers were identified through thematic analysis and how the identified enablers were prioritized through fuzzy AHP.

Enablers identification through thematic analysis

The qualitative data collected through semi-structured interviews were analyzed through thematic analysis. The analysis approach consists of five steps: transcribing, familiarizing, coding, categorizing, and producing results. Initially, each interview audio file was transcribed verbatim to ensure that we understand any elements emerged from the responses given by the interview participants. Then, repeated reading of the transcripts several times until we are familiar with all aspects of our data. Thereafter, data relevant to enablers for applying digital technologies in AFSCs were coded inductively. During the open coding process, *NVivo* 13 was applied to assist the retrieval and management of data. Next, the codes derived from the open coding process were then collapsed into second-order themes, which were labelled using established constructs from the literature of digital acceleration in agri-food industry. We also synthesized a number of overarching themes that characterize the key concepts in the analysis. Finally, we produced a table that includes first-order codes, second-order themes, and overarching themes to present our findings. Based on our analysis, we identified ten enablers across human resource management (reducing work intensity, improving work conditions, and workforce reduction), crop management (early detection of plant diseases, accurate determine the maturity of crops, food safety improvement), and environment sustainability categories (reducing carbon emissions, reducing water and fertilizer consumption, improving fertilizer use efficiency, avoiding groundwater pollution).

Enablers prioritization through fuzzy AHP

The identified ten enablers were then prioritized through fuzzy AHP. The fuzzy AHP approach implemented in this study consists of five steps.

Step 1: Hierarchical structure construction. This step involves understanding the objective of this study. One of the research objectives is to rank the enablers of applying digital technologies in the AFSC of China. Thus, we constructed a three layers hierarchical structure to assist understanding, including the objective was placed on the top layer of the hierarchical structure followed by the evaluation criteria on the second layer, and then the enablers were placed on the bottom layer.

Step 2: Constructing the fuzzy judgment matrix E. The fuzzy judgment matrix E is pairwise comparison among each enabler and evaluation criteria. Assign linguistic terms to the pairwise comparisons by asking which one of two criteria is more important:

$$\tilde{E} = \begin{bmatrix} \tilde{1} & \tilde{E}_{12} & \dots & \tilde{E}_{1n} \\ \tilde{E}_{21} & \tilde{1} & \dots & \tilde{E}_{2n} \\ \dots & \dots & \dots & \dots \\ \tilde{E}_{n1} & \tilde{E}_{n2} & \dots & \tilde{1} \end{bmatrix} = \begin{bmatrix} \tilde{1} & \tilde{E}_{12} & \dots & \tilde{E}_{1n} \\ \tilde{E}_{12}^{-1} & \tilde{1} & \dots & \tilde{E}_{2n} \\ \dots & \dots & \dots & \dots \\ \tilde{E}_{1n}^{-1} & \tilde{E}_{2n}^{-1} & \dots & \tilde{1} \end{bmatrix},$$

Where

$$\begin{cases} \tilde{1}, \tilde{3}, \tilde{5}, \tilde{7}, \tilde{9}, \text{criterion i is relative importance to criterion j,} \\ \tilde{1}, i = j, \\ \tilde{1}^{-1}, \tilde{3}^{-1}, \tilde{5}^{-1}, \tilde{7}^{-1}, \tilde{9}^{-1}, \text{criterion i is relative less importance to criterion j} \end{cases}$$

Step 3: Calculating fuzzy weights of each criterion. The fuzzy weights of each criterion are calculated based on the research of [6]. Details are shown as follows:

$$\tilde{r}_i = [\tilde{E}_{i1} \otimes \tilde{E}_{i2} \otimes \tilde{E}_{13} \ldots \otimes \tilde{E}_{in}]^{1/n}, \forall \mathrm{i} = 1, 2, 3 \ldots, \mathrm{n},$$
$$\widetilde{w}_i = \frac{\tilde{r}_i}{\tilde{r}_1 \oplus \tilde{r}_2 \oplus \tilde{r}_3 \ldots \oplus \tilde{r}_n},$$

where E_{ij} is the fuzzy comparison value of criterion i to criterion j, $\tilde{r_i}$ is the geometric mean of fuzzy comparison value of criterion i to each criterion, and $\tilde{w_i}$ is the fuzzy weight of the ith criterion.

Step 4: Hierarchical layer sequencing. The final fuzzy weight value of each alternative is calculated by hierarchical sequencing as

$$\widetilde{U}_i = \sum_{j=1}^{n} \widetilde{w}_j . \tilde{r}_{ij}$$

where $\tilde{r_{ij}}$ is the fuzzy weight value of the jth criterion to the ith enablers. $\tilde{u_i}$ can be indicated by a triangular fuzzy number, $U_i = (l, m, u)$.

Step 5: Ranking enablers. The final fuzzy weight values of enablers are represented in terms of fuzzy numbers. Thus, we follow the method proposed by [8] to defuzzify and rank the fuzzy numbers.

$$x(U_i) = (l + m + u)/3$$

Based on the value generated by the above equation, we can rank and determine the optimum enablers. The data analysis results are shown in Table 1. For example, human resource management holds the first rank, environmental sustainability comes second, and crop management occupies the third place in the priority list. Among the identified ten enablers, reducing work intensity ranks first, followed by reducing water and fertilizer consumption and improving fertilizer use efficiency hold the second and third places in the priority list. It is easily to understand that managers using digital technologies in AFSCs is to reduce operational costs.

Table 1 Final ranking of enablers to digital technologies adoption

Category of enablers	Relative weighting	Relative rank	Specific enablers	Relative weighting	Relative rank	Global weighting	Global rank
Human resource management	0.7125	1	Reducing work intensity	0.7125	1	0.2864	1
			Improving work conditions	0.0675	3	0.0303	9
			Workforce reduction	0.2200	2	0.0775	5
Environmental sustainability	0.2180	2	Reducing carbon emissions	0.1108	3	0.1124	4
			Reducing water and fertilizer consumption	0.6139	1	0.2173	2
			Improving fertilizer use efficiency	0.2301	2	0.1342	3
			Avoiding groundwater pollution	0.0451	4	0.0305	8
Crop management	0.0695	3	Early detection of plant diseases	0.6069	1	0.0314	7
			Accurate determine the maturity of crops	0.0872	3	0.0160	10
			Food safety improvement	0.3058	2	0.0639	6

DISCUSSION AND CONCLUSIONS

This study employs a mixed-method approach to analyze enablers to the apply of digital technologies in the AFSC of China. Three RQs were formulated in this study, including RQ1: what digital technologies are applied in the AFSC of China, RQ2: what are the enablers to facilitate AFSC practitioners to apply these technologies, and RQ3: how are these identified enablers prioritized. In answering RQ1, we employed semi-structured interviews to collect data from 16 experienced AFSC practitioners. This study identifies that water-fertilizer integrated technology, IoTs, and smart greenhouses are frequently used by the AFSC practitioners, whereas other technologies such as blockchain technology, big data, and automatic tractor are seldom used because of various barriers. In answering RQ2, thematic analysis was used to analyze the data collected from the semi-structured interviews. Based on the thematic analysis results, we identified 10 enablers that may facilitate AFSC practitioners to apply digital technologies, such as workforce reduction, reduce water and fertilizer consumption, and early detection of plant diseases. In answering RQ3, fuzzy AHP approach was employed to rank the identified enablers. Among all categories of enablers, the human resource management category receives the highest priority weight, whereas crop management category holds the last place in priority list. Among the identified ten enablers, the top three enablers are reducing work intensity, reducing water and fertilizer consumption, and improving fertilizer use efficiency. Currently, one and a half tons of agrichemical products and approximately 500 kilograms water are used in cultivating one acre of vegetable in China in comparison with only one third are used in developed countries. The application of digital technologies has great potential in helping Chinese farmers to reduce water and fertilizer consumption, further helping to achieve environmental sustainability.

This study does have limitations. For example, this study concentrates only on the farming stage of AFSCs, not including other stages such as food processing, wholesaling, distributing, and marketing. This is the reason why the identified digital technologies such as water-fertilizer integrated technology and smart greenhouses, are only related to farming. Further study could extend this work by interviewing processors, wholesalers, logistics service providers, and retailers to get a more comprehensive understanding on digital technology application in the AFSCs.

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Quantifying the House of Quality components

Sanaz Azarnoosh[1], João Carlos Lourenço[2], Isabel Maria João[3]

[1,2,3]CEGIST, Instituto Superior Técnico, Universidade de Lisboa

Av. Rovisco Pais 1, 1049-001 Lisboa, Portugal web-page:

https://cegist.tecnico.ulisboa.pt/

[3]ISEL – Instituto Superior de Engenharia de Lisboa, IPL

R. Conselheiro Emídio Navarro 1, 1959-007 Lisboa, Portugal web-page:

https://isel.pt/

[1]sanaz.azarnoosh@tecnico.ulisboa.pt, [2]joao.lourenco@tecnico.ulisboa.pt, [3]ijoao@deq.isel.ipl.pt

ABSTRACT

The House of Quality (HoQ) is a Quality Function Deployment (QFD) tool used in product development. The purpose of HoQ is to turn the voice of customers into the voice of designers to help the latter develop customer-oriented products. It starts by identifying the customers' requirements (CRs) for a given product, their weights (also known as priorities), and the technical requirements (TRs) that may contribute to product improvement. The CRs' weights and the intensities of the relationships between CRs and TRs (the relationship matrix) are then used to obtain the TRs' weights. This paper focuses on the assessment of TRs' weights, essential parameters for decision-making in product design. This assessment has been subject to several misunderstandings that result in arbitrary TRs' weights. Namely, the CRs' weights are usually obtained by direct assignment, based on the erroneous idea of their intrinsic importance, or by inadequate analytical methods. The intensities represented in the relationship matrix are also affected by similar misconceptions. To deal with these deficiencies, we propose the MACBETH method to weigh CRs, according to specific improvements in their performance ranges, and the concept of swing improvement for the relationship matrix that indicates how a defined improvement in the performance of a TR impacts the performance of a CR. We also separate the two components of (customer and technical) evaluation, first by defining a descriptor of performance for each CR (and TR), and second by constructing, for each of them, a value function based on judgments of difference in attractiveness between performances. To describe the proposed approach, we present an illustrative example concerning an operating room's door for hospitals.

Keywords: House of Quality, relationship matrix, descriptor of performance, value function, weighing, MACBETH.

1 INTRODUCTION

To increase customer satisfaction with product design, companies need a customer-oriented approach. The House of Quality (HoQ) [1] is a primary tool of Quality Function Deployment (QFD),

which is used for developing customer-oriented products. The HoQ requires identifying customer requirements (CRs) and assessing their weights, discovering the technical requirements (TRs) that contribute to CRs' improvements and the extent of that contribution using a relationship matrix, developing competitive assessments and technical benchmarks for the product, and obtaining weights for TRs.

The TRs' weighing is a critical task in the HoQ because of its impact on resource allocation and final decision-making in product design [2]. The TR's weights directly depend on the CRs' weights and the intensities of the relationships between CRs and TRs, which also turns them into determinant elements for product design.

The CRs' weights are usually identified by direct assignment, pairwise comparison, preference ordering [3], or with the entropy method [4]. The Kano model [5] is the most used tool in categorising CRs based on the value perceived by customers into five groups: must-be (M), one-dimensional (O), attractive (A), indifferent (I), and reverse (R).

The relationships between CRs and TRs, are usually expressed by 3-point ordinal scales (e.g., weak, medium, strong) quantified by numerical values such as 1, 3, and 9 [6]. However, the meaning associated with these point scales is unclear, and the scales are not anchored to a fixed, natural zero [7], which should be related to the absence of a relationship.

Obtaining TRs' weights aligned with customers' needs within a proper measurement scale requires applying a sound-based method to quantify CRs' weights and CRs–TRs relationships (i.e., the relationship matrix parameters). We propose using the MACBETH method [8] to assess meaningful CRs' weights based on the comparison of well-defined improvements in the performances of CRs, between a "neutral" performance (i.e., a performance that is neither positive nor negative) on the CR and a "good" performance (i.e., a significant attractive performance). We also preconise applying an approach to derive the relationship matrix parameters by measuring the effect on the CRs of a "neutral" to "good" performance improvement on a TR, establishing a real cause-effect connection between TRs and CRs. This requires, first, assigning a descriptor of performance to each CR (and TR), and second, constructing a value function for each CR (and TR) to transform performances (factual data) into value scores, which rely on the (subjective) judgments of the actors involved in the development of the HoQ (the customers, and the design team, respectively for CRs and TRs).

The remainder of this paper is organised as follows. Section 2 provides a brief literature review regarding the HoQ. Section 3 describes the new proposed approach for quantifying the HoQ components based on a constructed example, where the HoQ tool is used to improve an operating room's door for hospitals. Finally, section 4 presents the conclusion of the paper.

2 LITERATURE REVIEW

Table 1 presents a summary of the most used methods and tools applied to address the deficiencies of the traditional HoQ, in weighing CRs (also referred as prioritising), scoring performances, obtaining the parameters of the relationship matrix, and assessing TRs' weights.

Table 1. Literature review on the HoQ's components

Components	Methods/ tools
Weighing CRs	Pairwise comparison; AHP [9] and ANP [10] Fuzzy Logic method to deal with uncertainty [11] Preference orderings [12]
Scoring performances	Direct comparison using a scale of 0 through 5, in which 0 is the worst rating, and 5 is the best [13]
Quantifying parameters of the relationship matrix	Assigning values to relationship intensities (e.g., 1 to the weak relationship) [14] Kano model [15] and the integrated BWM and FUCOM within the HoQ [16]
Weighing TRs	MCDM methods (e.g., EDAS [17] and MACBETH [18]) Use of the fuzzy set theory and rough set theory [19]

3 METHODOLOGY

This section presents a new approach using an operating room's door for hospitals as an illustrative example. The customers' expectations concerning the operating room's door are based on the needs of those who use the door frequently, such as doctors, nurses, and other auxiliary staff.

3.1 Identifying CRs and TRs

The customers identified three CRs for the operating room's door and their corresponding descriptors of performance (see Table 2). Then the design team listed the five TRs that satisfy these CRs and their associated descriptors of performance (see Table 3). Table 4 shows an example of a constructed descriptor (namely, for CR_3).

Table 2. Customer's requirements for the operating room's door

Customer requirement	Descriptor of performance
CR_1: Ease of use	Constructed descriptor
CR_2: Reduce infections	Percentage of infections
CR_3: Spacious walkway	Constructed descriptor

Table 3. Technical requirements for the operating room's door

Technical requirement	Descriptor of performance
TR_1: Easiness of the door operation	Constructed descriptor
TR_2: Hold-open time	The time the door is kept opened (second)
TR_3: Opening speed	The speed of opening the door (cm/s)
TR_4: materials usage	The materials used for the door maintenance
TR_5: Width of the door	*The width that is available to pass through when the door is opened (cm)*

Table 4. Descriptor of performance for CR_3: Spacious walkway

Performance levels	
The door allows the simultaneous passing of …	
Six people plus one wheeling bed	SixPplBed = good
Six people plus two wheelchairs	SixPplWchr
Four people plus one wheeling bed	FourPplBed

Four people plus one wheelchair	FourPplWchr = neutral

3.2 Weighing customer requirements

For weighing CRs, we propose the MACBETH method and its software tool M-MACBETH [8]. MACBETH makes use of qualitative judgments concerning the CRs' neutral–good performance improvements to assess the CRs' weights. It uses the qualitative semantic scale of difference in attractiveness: no (difference), very weak, weak, moderate, strong, very strong, and extreme. The software tool M-MACBETH is used to validate the consistency of the judgments inputted and to generate, by mathematical programming, a proposal of CRs' weights [8].

In the weighing matrix shown in Figure 1, the rightmost column ([all neutral]) shows that the neutral–good performance improvement on CR_1 was judged "very strong" (v. strong), whereas the neutral–good improvements in CR_2 and CR_3 were both deemed "strong". The cell ([CR_1], [CR_2]) shows that the difference in attractiveness between neutral–good in CR_1 and neutral–good in CR_2 was deemed "weak", whereas the difference between neutral–good in CR_1 and neutral–good in CR_3 was deemed "strong" (cell ([CR_1], [CR_3]). Figure 2 shows the resulting weights proposed by M-MACBETH considering the qualitative judgments expressed by the customers: 45%, 35%, and 20% for CR_1, CR_2 and CR_3, respectively. From these weights, we may see, for example, that the neutral–good improvement on CR_2 was judged to be worth 1.75 times ($35\% \ / \ 20\%$) the neutral–good improvement on CR_3 (meaning that one value unit in CR_2 is worth 1.75 value units in CR_3).

	[CR1]	[CR2]	[CR3]	[all neutral]
[CR1]	no	weak	strong	v. strong
[CR2]		no	moderate	strong
[CR3]			no	strong
[all neutral]				no

Figure 1. M-MACBETH weighing judgments

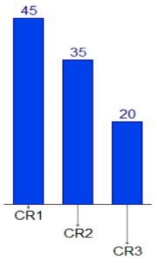

Figure 2. CRs' weights

3.3 Constructing value functions

Value functions transform the performances of the hospital's door on each CR (or TR) into their corresponding values scores. For each CR (or TR), the "neutral" and "good" reference performances are anchored on 0 and 100 value units. To build a value function with MACBETH, it is necessary to obtain judgments of difference in attractiveness between two performances at a time. For example, to create a value function for "CR_3: Spacious walkway," the customers were asked to judge the difference in attractiveness between each of the two performances listed in Table 4, from which resulted the matrix of judgments presented in Figure 3. We may see in Figure 3 that the difference in attractiveness between SixPplBed and SixPplWchr was deemed "moderate", whereas the difference in attractiveness between SixPplBed and FourPplBed was considered "strong". Considering all the judgments inputted, M-MACBETH proposed the value function shown in Figure 4. We note that the performance SixPplBed is the "good" reference and FourPplWchr is the "neutral", to which were assigned the fixed scores of 100 and 0, respectively. In the value function presented in Figure 4 it is possible to observe that an improvement from FourPplBed to SixpplWchr (44 value units) is worth twice the improvement from ForPplWchr to FourPplBed (22 value units).

	SixPplBed	SixPplWchr	FourPplBed	FourPplWchr
SixPplBed	no	moderate	strong	strong
SixPplWchr		no	strong	strong
FourPplBed			no	weak
FourPplWchr				no

Figure 3. Matrix of judgments for CR_3

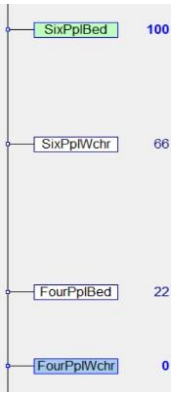

Figure 4. Value function for CR_3

3.4 Establishing the relationship matrix

To establish the relationship r_{ij} between CR_i and TR_j, we propose using the notion of *swing improvement* that indicates how much the neutral–good improvement on a TR causes an improvement in the performance of a CR. For example, to obtain a measure of the intensity of the relationship between CR_3 and TR_5 (depicted by r_{35}), we must measure the impact that the neutral–good improvement on TR_5 has on CR_3. In this case, the improvement in width of the door (TR_5) from 160 cm to 200 cm (neutral to good) improves the performance of CR_3 from its current performance FourPplBed to the new performance SixPplBed (good). Then, r_{35} is computed using equation 1, resulting in 0.78, as shown in equation 2. The complete relationship matrix is shown in Table 5, where the blank cells represent no relationship between the respective CRs and TRs.

$$r_{ij} = \frac{v_{CRi}(new) - v_{CRi}(current)}{v_{CRi}(good) - v_{CRi}(neutral)}, \text{ for a given } j \quad (1)$$

$$r_{35} = \frac{v_{CR3}(\text{SixPplBed}) - v_{CR3}(\text{FourPplBed})}{v_{CR3}(\text{SixPplBed}) - v_{CR3}(\text{FourPplWchr})} \quad \frac{100 - 22}{100 - 0} == 0.78 \quad (2)$$

Table 5. Relationship matrix

	TR_1	TR_2	TR_3	TR_4	TR_5
CR_1	0.50				
CR_2	0.14	0.36	0.36	0.57	0.14
CR_3			0.44		0.78

3.5 Weighing technical requirements

The weight of each TR of the product is the aggregation of the associated CRs' weights and the corresponding relationship matrix parameters depicted in Table 5. Equation 3 shows how to calculate the relative weight of TR_j, given by w_{TRj}, where w_{CRi} is the weight of CR_i, and r_{ij} is the intensity of the relationship between TR_j and CR_i.

$$w_{TRj} = \sum w_{CRi}.\, r_{ij} \quad (3)$$

The weight of TR_5 is calculated in equation 4. Table 6 shows all the TRs' weights after normalisation, so that they sum to 1 (or 100%).

$$w_{TR5} = (w_{CR2}.\, r_{25}) + (w_{CR3}.\, r_{35}) = (0.35 \times 0.14) + (0.20 \times 0.78) = 0.205 \quad (4)$$

Table 6. Normalised TRs' weights

w_{TR1}	0.27
w_{TR2}	0.21
w_{TR3}	0.12
w_{TR4}	0.20
w_{TR5}	0.20

4 CONCLUSIONS

In this paper, we propose an approach for the HoQ to help designers identify the technical features of a product tailored to the customers' needs. The new approach was applied to weigh TRs by correctly weighing CRs, using the MACBETH procedure and software, and assessing the relationship matrix parameters by introducing the concept of the effect of a *swing improvement* in a TR has on the improvement of a CR. Moreover, instead of directly comparing the performances of a product, we propose using an indirect performance assessment by means of a descriptor of performance and a value function for transforming performances into scores for each CR (and TR). A created example with a hospital operating room's door is used to describe the new approach.

In the present paper, for the sake of simplicity, we assume that TRs are mutually independent. However, for future work, we recommend considering the interrelationships between TRs (the so-called roof of the HoQ), which provide essential information for resource allocation. We should also note that the proposed performance evaluation may be applied to competitive assessment and technical benchmarking, so that to compare the current product with competitors' products from the customers and technical viewpoints. At the end of the HoQ process the design team must select the TRs to improve and how much to improve them, to obtain a better product, but not ignoring the resource usage that is associated with that selection.

ACKNOWLEDGEMENT

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Day 3	**Thursday, June 1st 2023**	Room 1A22

Session 8

DSS and Green projects

9:00 – 10:30*

Chair: Shoafeng Liu

Room 1A22

#1	*Attracting financing for green energy projects: A City Readiness Index*	Aikaterini Papapostolou, Charikleia Karakosta, Filippos Dimitrios Mexis and John Psarras
#2	*An Asset-Based Causal Loop Model to Improve Corporate Value*	Romain Ben Taleb, Matthieu Lauras, Mathieu Dahan, Aurelie Montarnal and Romain Miclo
#3	*Impact of Industry 4.0 on OEE improvement*	Emna Masmoudi, Laurent Piétrac and Séverine Durieux
#4	*A Lean Knowledge Management Processes Framework for Improving the Performance of Manufacturing Supply Chain Decisions in an Uncertain World*	Jiang Pan, Shaofeng Liu, Sarah Tuck and Aira Ong

* 20 minutes/presentation + Q&A

Attracting financing for green energy projects: A City Readiness Index

Aikaterini Papapostolou[1], Charikleia Karakosta[1], Filippos Dimitrios Mexis[1], John Psarras[1]
[1]Decision Support Systems Laboratory, School of Electrical & Computer Engineering,
National Technical University of Athens
Ir. Politechniou 9, Zografou 157 80, Athens, Greece
kpapap@epu.ntua.gr, chkara@epu.ntua.gr, pmexis@epu.ntua.gr, john@epu.ntua.gr

ABSTRACT

Standard population projections show that virtually all global growth over the next thirty years will be in urban areas. At the same time, the last decades of constant economic and population growth, the modern lifestyle of developed countries and the creation of new needs have led to an increase in energy use per capita and at an overall level resulting to environmental pollution and strengthening of the greenhouse effect. It is important, therefore, not only at a county level, but also to a city level, to boost investments in green energy projects. However, there are important barriers that hinder local authorities from investing in this kind of projects. Among others, these barriers include the lack of internal capacity to identify and implement innovative financing schemes, high cost of financing or lack of private financing. This paper presents a software tool for assessing cities' readiness to receive the necessary financial assistance in order to implement green energy projects. The cities' performance is evaluated along three axes (i) Investment Attractiveness, (ii) Utilization of Financial Resources and (iii) Project Implementation, while the methodology is based on multicriteria analysis. A pilot application in ten European cities has been conducted and fruitful outcomes have been derived from the comparative analysis.

Keywords: Energy Transition, Sustainable Energy, Green Projects, Green Financing, City Readiness, Assessment Tool, Pilot Application, Europe

An Asset-Based Causal Loop Model to Improve Corporate Value

Romain Ben Taleb[1], Matthieu Lauras[1], Mathieu Dahan[2], Aurélie Montarnal[1] and Romain Miclo[3]

[1] Center of Industrial Engineering, University of Toulouse, IMT Mines Albi
Albi, France
romain.ben_taleb@mines-albi..fr; matthieu.lauras@mines-albi.fr; aurelie.montarnal@minesalbi.fr

[2] School of Industrial and Systems Engineering, Georgia Institute of Technology
Atlanta, GA, USA mathieu.dahan@isye.gatech.edu

[3] AGILEA [1]
Toulouse, France romain.miclo@agilea-group.com

ABSTRACT

Assessing a company's value is an important leverage for decisionmaking. Indeed, all decisions made within a company are generally aimed at maximizing the company's value. In accounting, almost all models for assessing the value of a company are related to the amount of cash the company is able to generate. As a result, maximizing the value of a firm is usually about maximizing cash flow. However, beyond the usual accounting models, several recent initiatives have highlighted the key role of managing all assets, and not only the ones considered by the general accountability, in decision making and cash generation. Unfortunately, these methods are currently limited to conceptual and qualitative proposals that do not lead to a real decision support system thus far. This paper proposes a first step of formalization aiming at providing tools for these assetoriented decision support approaches. Based on a dedicated literature review, we design and formalize an asset-based causal loop model. We then develop an instantiation on an illustrative case via simulation in order to verify the relevance of the proposal and to show how such a model can be used in practice for decision making.

Keywords. Assets, Causal-Loop Model, Decision Support, Corporate Value.

Impact of Industry 4.0 on OEE improvement

Emna Masmoudi[1], Laurent Piétrac[1], Séverine Durieux[1]

[1] Université Clermont Auvergne, Clermont Auvergne INP, CNRS, Institut Pascal, F-63000 Clermont-Ferrand, France
emna.masmoudi@sigma-clermont.fr

ABSTRACT

Overall Equipment Effectiveness (OEE) has remained a valuable performance indicator over the decades. Yet, methods for improving equipment effectiveness have changed and advanced over time. This paper deals with the contribution of the Industry 4.0 in OEE improvement in the context of production systems monitoring and control through an analysis of the current literature. Industry 4.0 provides innovative technologies to enable new ways of tracking, taking decisions and acting upon production system health data. Internet of Things (IoT) when integrated into production systems, enables tracking of operational parameters remotely in real-time. Big Data and Artificial Intelligence enable analyzing historical and current operational data to using the results for predictive maintenance. Simulation and digital twins allow to test various production scenarios to measure their impact on production systems performance… This leads to better insights on production performance, identification and minimization of losses, and enhanced decision making in favor of increasing OEE values consistently. In this work, we give an overview of the Industry 4.0 technologies used in the literature. Then we identify and present different use cases that combine a number of these technologies to assure production monitoring and control.

Keywords. OEE, production system, monitoring, control, Industry 4.0

A Lean Knowledge Management Processes Framework for Improving the Performance of Manufacturing Supply Chain Decisions in an Uncertain World

Jiang Pan[1][0000-0001-6860-1302], Shaofeng Liu[2][0000-0002-8330-3335], Sarah Tuck[3][0000-0002-8113-3328], and Aira Ong[4][0000-0002-0457-9182]

Plymouth Business School, University of Plymouth, UK

{jiang.pan, shaofeng.liu, s.tuck, aira.ong}@plymouth.ac.uk

ABSTRACT

As a consequence of the COVID-19 pandemic and the ongoing Russian-Ukraine war, global supply chain has been disrupted, causing worldwide shortages and affecting consumer patterns. To combat this circumstance and build more resilient manufacturing supply chains, this paper develops a Lean Knowledge Management Processes framework to improve manufacturing companies' knowledge management performance. Ultimately, it contributes to providing decision makers with sufficient and high-quality information and knowledge to make more accurate decisions in this uncertain world. The framework is empirically tested by partial least squares structural equation modelling approach with survey data using 359 responses from two types of manufacturing industries (i.e., machinery and electronics manufacturing and food and drink industry), two types of business sizes (i.e., SMEs and Large companies), and three countries (i.e., the US, China, and the UK).

Keywords: supply chain uncertainty, Lean knowledge management, knowledge flow, decision support system, decision making.

Day 3	**Thursday, June 1st 2023**	Room 1A22

Session 9a

DSS procedures

12:00 – 13:00

Chair: Sergio Duarte

Room 1A22

#1	*Understanding interdependencies of success factors for truck platooning implementation: a facilitators' perspective*	Sérgio Pedro Duarte, Liliana Cunha, Sara Ferreira and António Lobo
#2	*Sharing Economy: How to support users in selecting the right transaction partner?*	Pascale Zaraté, Aysegul Engin and Rudolf Vetschera
#3	*Enhancing Privacy when Accessing Public WiFi with Raspberry Pi*	Tauheed Khan Mohd, Christopher Le, Kidus Getachew and Estephanos Jebessa
#4	*Are the Internet Connections at Augustana College Good Enough for Student Productivity?*	Tauheed Khan Mohd, Kashav Piya, Jon Cathcart, Minh Nguyen and Jacob Speirer

Understanding interdependencies of success factors for truck platooning implementation: a facilitators' perspective

Sérgio Pedro Duarte[1*] Liliana Cunha[2], Sara Ferreira[1] and António Lobo[1]

[1] CITTA – Centro de Investigação do Território, Transportes e Ambiente,
Faculdade de Engenharia, Universidade do Porto
Rua Dr. Roberto Frias, 4200-265 Porto, Portugal
[2] CPUP – Centro de Psicologia da Universidade do Porto,
Faculdade de Psicologia e Ciências da Educação, Universidade do Porto
Rua Alfredo Allen, 4200-135 Porto, Portugal
*s.duarte@fe.up.pt

Abstract. The implementation of truck platooning promises diverse benefits for many societal sectors. Overall, truck platooning is being announced as a safer and greener way for long-distance freight transport that offers lower transport costs and easier driving tasks. However, those benefits can be seen, by some actors, as hindrances. Thus, expectations of potential adopters must be managed, by considering their requirements and perceived risks, to increase acceptance levels and facilitate a successful implementation. In a complex context as truck platooning, finding a common solution calls for the intervention of regulators and road operators, as facilitators of the implementation process. With the purpose of supporting regulators and road operators (facilitators) in developing safe and attractive conditions for implementation, we have studied the requirements regarding the different dimensions of the truck platooning ecosystem. The requirements were collected via focus groups with three road operators, operating in Portugal, and two interviews with Portuguese regulators. The focus groups and interviews highlighted the interdependence between the actions of regulators, road operators, and vehicle manufacturers. The results were analyzed considering a systems approach of truck platooning to identify those interdependencies and their influencing factors. The results from this analysis enable a deeper understanding of what are the decisions that facilitators need to make, and what are the objectives that potential adopters and users have.

Keywords: Truck Platooning, Vehicle Automation, Systems Approach, Focus Group, Strategic Decision-making.

Introduction

The transport sector is being pushed to develop new and greener solutions, for both passenger and freight transport. In the case of freight, road transport alone is responsible for 50% of freight transport [1], thus finding a sustainable solution for road transport is essential to answer to the 2050 goals established by the European Commission regarding road safety and emissions [2], [3]. One of the solutions under study, and being tested [4], is truck platooning, which happens when a set of trucks travel in a convoy taking advantage of communication technology and vehicle automation (e.g., using cooperative adaptive cruise control and lane keeping systems).

Nonetheless, the introduction of truck platooning in the daily operations of freight transport relies on the acceptance of the technology by carriers and other logistics service providers, and by the drivers

themselves. While companies may see in truck platooning a way of innovating their operations [5], drivers may resist and see risks regarding the safety of vehicle automation [6] and, eventually, due to lower job opportunities. This example demonstrates that truck platooning value depends on the perceived benefits and risk each sector has. The role of regulators and road operators is crucial in defining rules and offering optimal conditions for implementation, making sure that benefits and risks are balanced for all groups of actors.

To prepare for, and facilitate, the implementation of truck platooning, regulators and road operators need to know requirements from drivers and companies. Even more, regulators need to know what technology will be available to be able to regulate it, and, in turn, operators need to know regulatory demands to prepare the infrastructure to receive truck platoons. This mutual dependency between technological evolution and regulatory developments emerges as a governance challenge caused by uncertainty, suggesting the use of a systems approach to support the development of solutions that potentiate acceptance.

The objective of this research is to increase knowledge about the factors that influence the acceptance of truck platooning, and their interdependencies, by performing a systemic study to support regulatory and technological decisions. We identify the requirements of different groups and map what aspects regulators and road operators must decide about, in order to meet those requirements. Although there are studies about truck platooning acceptance focused on the representations of a group of actors [7]–[9], there are still few studies that consider a holistic perspective of the system.

According to Wang et al. [10] there are three phases in a systems approach: preliminary analysis, specified analysis, and comprehensive analysis. This paper presents the preliminary results of our research, focused on the first phase of the systems approach. Based on the interviews and focus groups conducted with regulators and road operators, operating in Portugal, we point out some of the key requirements that ensure increased acceptance, considering them as objective functions. The aspects to be regulated are considered decision variables. In the next section we present a brief overview about technology acceptance and systems approach in the transport domain. Then, we describe the methodology and some results, and end the paper with some conclusions and considerations about future research.

Introducing new technology in the transport sector

Recent developments in technology have increased the offer of transport modes (e.g., electric vehicles, scooters, etc.) and transport-related services (e.g., mobility-as-a-service applications, e-commerce order tracking, etc.). Although users' behavior is changing and adapting to a digital paradigm [11], there is still some uncertainty regarding what path technology should follow. For that reason, some studies have been made focusing on the market introduction of new technology and its acceptance, while other studies have considered the implications using a systems approach to analyze technology and market evolution. In this section, we describe a brief context of truck platooning acceptance studies and present the tools and methods those studies used in their analysis, and how they inspired our methodology.

2.1 Hindrances of truck platooning implementation

On the way to full automation of road vehicles, and trucks in particular, intermediate levels of automated driving technology will alleviate drivers from the driving task, but impose new risks while

human intervention is still needed for supervision and fallback of technology [12]. Truck platooning drivers will be allowed to engage in secondary tasks, such as performing administrative work, and interacting with mobile phone and other systems. The shift in drivers' work conditions reflects major safety concerns, increasing the risk of accidents due to passive fatigue, the increase of drowsiness, and consequently the decrease of drivers' reaction ability [13], [14]. Additionally, because drivers are often unaware of the limits of technology [8], freight companies consider that mandatory education and training programs for safety issues in platooning must be implemented [14].

Truck drivers, as the ultimate users of platooning technology, have been at the center of the acceptance studies developed to date. The survey conducted by Castritius et al . [8] confirmed that the reduced gap between vehicles, responsibility/liability issues, and fear of losing jobs were the main concerns among drivers. However, after a hands-on experience in real traffic, safety concerns reduced among the test drivers, but they still stressed that technology maturity needs to evolve to increase ease of use and users' trust. Richardson et a l. [9] compared drivers' perceptions against those of their employers, showing very different concerns. Once again, drivers are afraid of losing their jobs, technology failures, and losing driving pleasure, but understand that platooning may increase their comfort during long journeys. Logistics companies see potential economic and safety benefits, but are worried about drivers' attitudes towards the system, strengthening the importance of drivers' acceptance for the technology adoption by operators. Castritius et al. [7] compared the perceptions of the general public (non users) in Germany and California. The authors found a good overall acceptance level (higher in California), as most respondents feel comfortable in sharing the road with platoons and even consider cutting in between platooning trucks. However, technology reliability still emerges as the main concern.

2.2 Technology acceptance in the transport sector

Several technology acceptance models and theories have been developed [15] that can help to better plan investments in technological solutions. Originating in both psychology and information systems domains, some focus on understanding technology acceptance itself (Technology Acceptance Model, TAM), whereas others focus on understanding motivations and predicting future behaviors (Theory of Reasoned Action, TRA, and Theory of Planned Behavior, TPB). In an attempt to unify existing theories, Venkatesh et al. [15] developed the Unified Theory of Acceptance and Use of Technology (UTAUT).

The application of these models in the transport sector has been explored in cases as autonomous vehicles, driverless buses, and advanced driver assistance systems [16]– [18]. These examples also demonstrate how the aforementioned models are complemented with revealed- or stated-preference surveys that can lead to the application of statistical methods, such as structural equation modelling [17] or factor analysis [16].

Despite of their utility, the theories and models focused on previous research analyze individual motivations and acceptance of certain societal groups (drivers, decisionmakers, etc.) [15], and do not analyze the relations between the different groups and the influence they have on each other. Those influencing relations have been studied by models considering a systems approach, as it will be exposed next.

2.3 Systems approach in the transport sector

Systems approaches introduce new mindsets to complex ecosystems and offer methodologies for understanding and dealing with the interrelations between parts of the same system. More than theories, systems approaches provide forms of thinking (systems thinking) and structuring systemic problems [19].

A very well-known method that uses systems thinking is Systems Dynamics (SD). SD is a simulation method to support decision-making [20] and aid the design of strategic policies [21]. Its application to the transport sector was first presented by Abbas and Bell [22], who identified strengths and weaknesses of using SD to complex transport policy challenges.

Shepherd [21] points out that SD has been applied in several transport situations, such as modelling the uptake of alternative fuel vehicles, supply chain management with transportation, highway maintenance and construction, strategic policy at urban, regional and national levels, and airlines and airports. Concerning the scale of the models, SD has been applied in high-level contexts, such as the study of land use and transport interactions [23], and in more specific situations, such as the adoption of electric vehicles [24] or the trends of urban logistics [25].

Systems thinking, and more specifically SD, served as an inspiration to our research due to the complexity of the freight transport system and the need to explore the interdependencies between systems' dimensions.

Truck platooning system: influencing factors and interdependencies

This research was developed in the context of the project TRAIN that aims at mapping risks and requirements for the safety of truck platooning, concerning mainly human factors (e.g., drivers' ability to adapt to automated driving). Despite the project's focus on drivers, the complexity of truck platooning benefits from a systems approach, as we have shown above. Drivers' safety is conditional on available technology, which, in turn, is limited by existing regulation; therefore, inspired by systems approaches such as SD, we have studied the introduction of truck platooning holistically.

According to the flowchart for SD modelling proposed by Wang et al. [10], we have concluded the stage concerning the preliminary analysis which included the following steps:

1. Problem identification – In an exploratory literature review, and during the planning process of this project, we identified some barriers to the introduction of truck platooning (see previous section). Based on the outputs of that revision, the study focus was defined as the acceptance of truck platooning.
2. System boundary definition – As truck platooning is a highly multidisciplinary subject and, as shown previously in this paper, there are different concerns, depending on the perspective of the problem, we have opted to study the sub-systems associated with technology acceptance, infrastructure, regulation, and business operations. This was reflected in the next step.
3. Analysis of influencing factors and cause-and-effect relations – To identify the factors related to truck platooning acceptance and deployment, and following what was established in point 2, we performed 11 focus groups with drivers, logistic service providers/carriers, regulators, and road operators (respectively four, two, two, and three).

In the next section, we detail more about the third step of our methodology, focusing on the results from the facilitators (regulators and road operators).

3.1 Systems approach to truck platooning

Considering the role of regulation and infrastructure in the deployment of truck platooning, The factors influencing truck platooning acceptance were identified through focus groups and interviews with representatives from two Portuguese regulators and three road operators, as a form of identifying possible decision variables. The acceptance factors were derived from requirements and risks shared by participants.

First, to set up a holistic perspective of the system, we mapped the relations between the different groups of actors (Fig. 1). Society may benefit from the introduction of the technology but is not an active actor in the decision process. The results were structured in three dimensions, referring to the different concerns participants showed. In our case, the dimensions were: safety and security, labour and working conditions, and transport and logistics operations. These were considered the main target domains to be regulated.

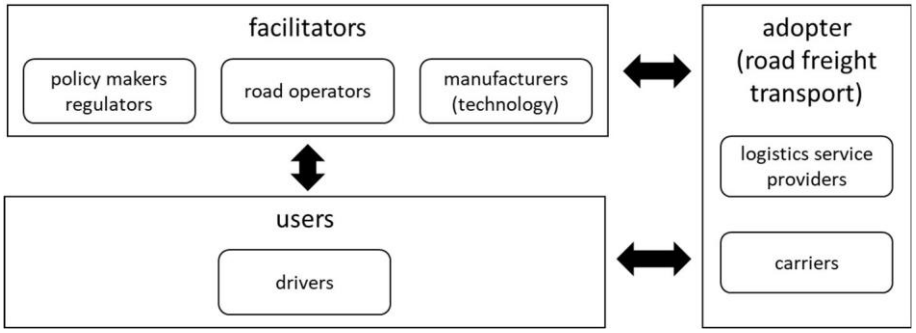

Fig. 1. Actors' groups

Safety and security may refer to issues related to infrastructure quality and communication technologies (V2V, V2I, etc.) to ensure road safety for both truck drivers and passenger vehicles. Moreover, it includes security aspects regarding border control or cybersecurity.

Labour and working conditions include topics such as drivers' working and resting hours, drivers' skills to use automated vehicles, number of shifts and shift duration, etc.

Transport and logistics operations cover infrastructure requirements (also present in the safety dimension) that appear as constraints in logistics operations. For instance, there can be limits to the type of road in which truck platoons can operate, or road operators may only allow this transport to happen at certain periods (e.g., during the night).

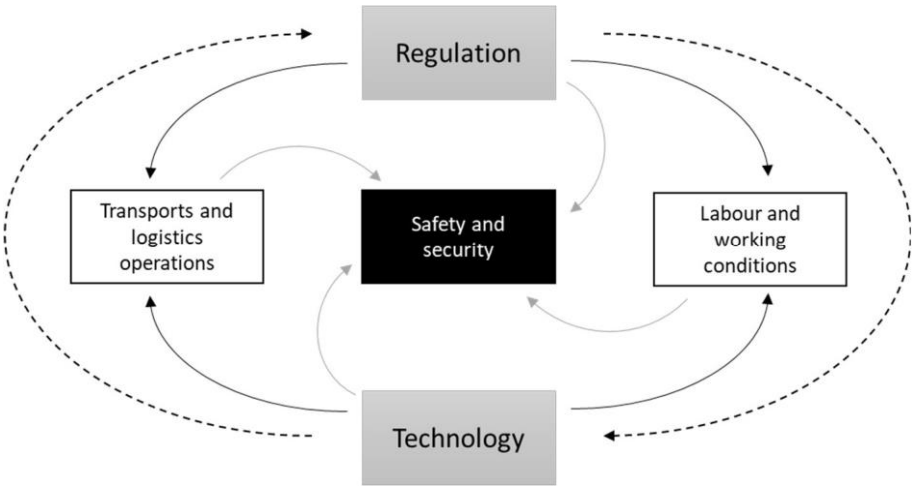

Fig. 2. Influencing relations between system dimensions, plus regulation and technology.

These examples confirm that there is a high interdependency between the three dimensions, plus a strong relation with the pace of technology evolution and the type of regulation (more, or less strict). In the focus group sessions, regulators mentioned that they "can only regulate existing technology", implying that they are waiting on the evolution of vehicle and infrastructure technology. On the other hand, road operators stated that, without regulation, they cannot know what is expected from them. In the end, these groups are both dependent on what business models will be adopted by logistics companies and what technology will be required. At the same time, vehicle manufacturers continue to push the development of innovative technology, increasing invehicle driving assistance capabilities, which will dictate several aspects of the new business models.

Each dimension was then interpreted as a subsystem in the freight road transport ecosystems. After, we identified the influencing relations between the different dimensions (Fig. 2).

Since safety and security requirements should be ensured, we consider that these should be the main objectives of regulatory measures and technological developments. Regulators' concerns are focused on safety and security and establish minimum requirements to ensure a societal benefit. Nonetheless, to achieve that, regulators create limits and guidelines that influence the other two considered dimensions, thus indirectly influencing the core dimension of the system. On the other side of the implementation, technological developments are offered to potential adopters and users, hence influencing transport and logistics operations, and labour and working conditions. Safety and security are also major concerns of technological developers, whether it is imposed by regulation, or it is a result of product testing/maturity or ensuring users' requirements. In the end, technology and regulation are mutually influenced. As previously mentioned, technology must obey to regulatory constraints, and regulation will evolve alongside with technological value offers. In fact, regulators approach is focused on the tasks and capabilities of both humans and vehicles, allowing for technology to be slowly introduced to the market, while keeping regulation flexible and not obsolete.

3.2 From systems dependencies to decision support

From the analysis described, we have inferred the structure of a decision problem by identifying the objectives and decision variables. These will later be used in a systemic model to simulate the acceptance of truck platooning.

The objectives are linked to the dimensions of the system, and result from the requirements from companies and drivers (Fig. 3). Some objectives derive from goals established for societal gains. There are four objectives that reflect one high-level objective of increasing acceptance of truck platooning and facilitating its deployment, through the improvement of safety and security of the technology. In our work we have considered that these are objectives and not constraints as we could not establish a minimum or a maximum value. Moreover, the inputs from the FG suggested that each dimension contributes equally to the safety and security of truck platooning.

The decision variables are the aspects that regulators, road operators and manufacturers need to consider. The identified variables are the aspects that those actors (the facilitators) have the ability to change (act upon) in order to indirectly influence the outcome and achieve the objectives. The relative importance of the decision variables is dependent on the perspective of each group, and can only be inferred later in the process, during the quantitative analysis.

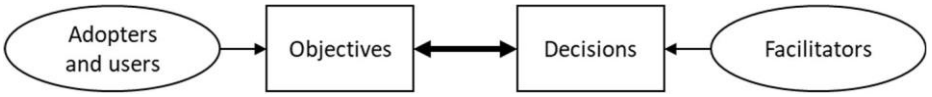

Fig. 3. Process of identifying objectives and decision variables.

The objectives identified are the ones that, if met, are most likely to increase public acceptance: lower number of accidents, lower emissions from lower fuel consumption, lower operational costs, and better working conditions. To each objective corresponds a set of variables that can be managed to satisfy actors' requirements. Examples of those variables are displayed in Table 1.

Table 1. Objectives and examples of decision variables.

Objectives	Decision variables
Lower number of accidents	Distance between platooning vehicles
	Distance between platoons
	Road layout and traffic signs
	V2I communications
	Shift duration
Lower fuel emissions	Distance between platooning vehicles
	Vehicle automation level
	V2V communications
Lower operational costs	Number of employees
	Shift duration
	Travel distance without resting stops
Better working conditions	Shift duration
	Mandatory resting periods
	Drivers' training level

Some variables are related to more than one objective in a conflicting way, creating challenges to regulators. For instance, for safety reasons, the distance between vehicles cannot be too low and depends on the in-vehicle installed technology (i.e., if the automated driving technology still demands for human interaction), but for fuel emissions, the lower the distance, the more fuel savings are achieved. The same happens with the safety and working conditions offered to drivers, since increasing shift durations can lower operational costs but might decrease drivers' ability to drive due to increased (passive) fatigue.

Some other variables require a deeper analysis as they can present correlations. An example is the case of fuel consumption that can impact both costs and emissions, suggesting that two of the objectives are correlated. However, there are many other factors influencing costs (e.g., number of employees) and emissions that reducing one may not cause a reduction in the other. Moreover, the objective of minimizing emissions benefits the society in general, while the objective of minimizing costs comes from the companies' perspective.

Better working conditions should also reflect a lower number of accidents, being this another example of correlation. Although, the objective of improving working conditions is lowering road safety, therefore is has been considered a separated a specific objective. These issues are to be dealt with during the phase of structuring the system and in the quantification analysis.

Conclusions

The introduction of new technology in the transport sector imposes a deep understanding of its impacts, as its value is perceived differently by adopters and users, and by developers. The challenge for decision-makers, it to balance the benefits and risks caused by introducing said technology. The application of a systems approach provides a holistic perspective of the entire system, enabling the analysis of the influencing factors and the interactions between them.

By taking advantage of systems approach's characteristics, we studied the implementation of truck platooning, focusing on understanding the factors that are expected to increase the success of the implementation. Furthermore, we analyse the interaction between those factors, considering the different dimensions of the truck platooning system. Then, taking into account the different roles that actors play in the system, we interpreted adopters' requirements as objectives and influencing factors as variables that decision-makers can control.

In this paper, we have presented preliminary results from the TRAIN project, obtained from focus groups and interviews with regulators and road managers. The participants' inputs aided the definition of the boundary of our system. In spite of the potential impacts on other areas (e.g., climate and economy), we selected three system's dimensions and four objectives that, in the participants' perspective, may promote the acceptance of truck platooning.

The approach here described contributes to the development of a systemic model of truck platooning acceptance. After having identified systems' dimensions, influencing factors and their interdependencies, the next steps include model structuring and quantitative analysis. This quantitative analysis will include the development of statistical models, supported by a sample collected through a questionnaire, that will be applied to professional truck drivers and logistics companies, to validate and quantify the factors' relationships.

Acknowledgements

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Sharing Economy: How to support users in selecting the right transaction partner?

Pascale Zaraté[2][0000−0002−5188−1616], Ay¸segu¨l Engin[1][0000−0002−2330−0888], and Rudolf Vetschera[1][0000−0003−2809−8989]

[1] University of Vienna Department of Business Decisions and Analytics, Oskar - Morgenstern - Platz 1, 1090, Vienna, Austria
{ayseguel.engin,rudolf.vetschera}@univie.ac.at

[2] Toulouse 1 Capitole University — IRIT-UT1-UT2-UT3-INPT, 2 Rue du Doyen-Gabriel-Marty 31042 Toulouse Cedex 9 pascale.zarate@ut-capitole.fr

Abstract. Sharing economy is a new way of coordinating economic activities that is more and more growing in importance. This economy is closely linked to collaborative platforms. This environment creates a large risk of opportunistic or even inappropriate behaviours. Therefore, it becomes important to find and select trustworthy transaction partners. The aim of this proposal is to define a model able to take into account the possibility of opportunistic behaviours of end-users in order to support decision makers in their choice of the right partner.

Keywords: Sharing Economy · Recommender system · Opportunistic Behaviour.

Introduction

The emerging digital economy creates an environment that differs significantly from the usual assumptions of economic analysis. On the one hand, electronic media make markets much more transparent. It is far easier than in former times to find suitable transaction partners, to compare prices between different suppliers, and in general to obtain information on any aspect of a transaction and to process this information almost instantly. This creates an environment that more and more resembles the ideal of a perfect market. On the other hand, the physical distance and anonymity of cyberspace create many opportunities for opportunistic behavior that would not exist in conventional markets and the multitude of offerings increases the complexity of choice problems for consumers.

One example in which these two aspects are particularly visible is provided by collaboration platforms. Collaboration and sharing platforms allow a wide range of participants to share resources and conduct transactions of different types. From an economic point of view, these platforms, therefore, enable the creation of a contractual relationship between users, which exhibits the abovementioned tension between the availability of information and the possibility of opportunistic behavior to a large extent. As a consequence of these opportunistic behaviors, the decision makers (end-users) are not very confident with the partners. Even if these collaborative platforms provide information about the trustworthiness of users, making a good choice of partners is not an easy task. In this paper, our aim is to define a general framework in order to develop a recommender system that would be able to recommend good and trustworthy partners.

The paper is organised as follows. In the first section a literature review about collaborative platforms and their use is presented. A definition of sharing economy is also given. In this literature review a section is devoted to recommender systems. The second section presents our proposal for a specific recommender system for partner selection and the last section concludes the paper.

Literature Review

Many collaboration and sharing platforms involve transactions that cover a comparatively long time period. In case of physical exchange of goods, the potentially large geographical distance of transaction partners meeting in Cyberspace implies long transport times, contracts involving services like accommodations (as offered e.g., by one of the largest sharing platforms, Airbnb) often involve a long period between concluding and actually fulfilling the contract. These long intervals create ample opportunity for opportunistic behavior, such as cancellations of contracts, incomplete shipments, providing inadequate services (Williams et al., 2020), unresolved and unregulated disputes (Al-Ramahi and Ahmed, 2019), increased environmental pressure and resource exploitation (Tussyadiah and Pesonen, 2016), etc. These problems are further aggravated by anonymity and the lack of efficient mechanisms to enforce compliant behavior against transaction partners who are far away and potentially anonymous.

Sharing Economy

Economic theory would argue that the resulting risk can be mitigated by formulating more complete contracts, which specify the expected behavior of all contract partners in detail and which can be enforced by recourse to legal action. This in turn would increase transaction costs, possibly leading to the transaction being coordinated in a hierarchy rather than via the market. Collaboration platforms deal with this problem in a different way. Instead of more elaborate contractual mechanisms, they aim at increasing the trust between transaction partners. Trust between transaction partners can result from different sources, in particular from social interaction between them and from information that is provided about (potential) transaction partners as well as the object of the transaction.

Consequently, the choice of an adequate, trustworthy transaction partner becomes a crucial issue in collaboration platforms. Collaborative platforms already provide some mechanisms to support users in selecting trustworthy partners such as reputation mechanisms that allow users to rate their transaction partners after completing a transaction. However, in comparison to the recommender systems that many platforms offer to support users in selecting products, these features are rather limited. In general, the two problems of recommending products and recommending transaction partners share the property that evaluations must combine multiple criteria, with only incomplete knowledge of the user's preferences.

Recommender Systems

Existing research mainly deals with recommender systems that support the selection of products and services rather than transaction partners. Still, existing classifications of such systems can be useful to identify important design parameters for such systems. Literature distinguishes four types of recommender systems: personalized recommendation based on the past behavior of the user, the content based recommendation considering characteristics of the objects, collaborative recommendation that is based on all users and finally the hybrid recommendation which, as its name indicates, combines the other three methods

Personalized recommendation is based on the user's past behavior. For example, products previously purchased or selected from an e-commerce site, or previous actions or decisions made by the user are analyzed to predict new products which may be of interest to the same or similar users. These systems are sometimes also called referral systems. Advertisements (e.g., Google Adsense) are considered to be personalized referral systems based on past behavior of the user (navigation, clicks, search history, etc.)

Content based recommendation involves recommending objects (or contents) based on qualities and properties intrinsic to the object itself and correlates them with the preferences and interests of the user. This type of system will therefore extract a number of features and content-specific attributes, in order to be able to recommend content to the user with similar properties. This method creates a set of attributes/properties that characterize each object. For example, the decision to select and recommend a document to a user can be based on its content, comparing the themes covered in the document with the themes of interest to the user. Examples of systems using this principle can be found in (Billsus et al., 1998; Pazzani and Billsus, 1997; Zhang et al., 2002).

This type of content recommendation has the advantage that it does not need a large community of users. A list of recommendations can be generated even if there is only one user. However, only some attributes can be extracted automatically from content. For example, it is relatively easy to deduce certain semantic properties of a text document automatically. We also see that in practice, characteristics and properties like the genre of a book or the list of actors in a movie, are usually provided by their creators. What remains more problematic is the acquisition of subjective and qualitative properties such as style, design, etc. These are difficult to acquire automatically, and will instead have to be introduced manually, leading to problems such as cost and possible errors.

Collaborative or *social recommendation* (Billsus et al., 1998; Breese et al., 1998) consists of recommending objects based on the past behavior of users with similar preferences and interests. Methods are used to collect and analyze data on the behavior, activities and preferences of users and algorithms try to predict what the user will like by searching for users who have the same behaviors. The main assumption of this approach is that if users have shared the same interests in the past, there is a good chance that they also share the same tastes in the future.

The purely social recommendation approach does not exploit or require knowledge of the contents. The social recommendation is able to recommend content without the need to understand the meaning or the semantics of the content itself. Information specific to the object need not be introduced into the system. A problem of this approach is scalability: often the platforms on which collaborative filters are used have millions of users, products, and content. Thus considerable computational power is needed to offer suggestions to users. This is a particular problem in memory-based approaches, which maintain a comprehensive database of all ratings. In an item-centric or model-based approach, the data is previously processed offline and the system then uses pre-processed templates to make predictions. The model-based approach is less precise, but avoids the problem of scalability. Another problem is the Cold Start: Social recommendation systems need a lot of data and many users to perform. The launch of a recommendation system may suffer from a lack of users and information.

Finally, there is the problem of sparsity: since the number of products or content is huge, even the most active users will have noticed or evaluated a very small subset of the entire database. So even the most popular article will have very few ratings. In such a situation, two users will have few commonly valued items, making the correlation task more difficult. This is a situation encountered when the system has a high ratio of content in relation to users, which is also often found at the initial stage of the launch of the referral service.

Hybrid methods (Basu et al., 1998; Schein et al., 2002), which are a combination of the above three approaches, are more and more used, because they solve problems such as cold start and sparsity found in a purely social advocacy approach. For example, Amazon uses all 3 approaches (personalized, social, and object). Amazon (Linden et al., 2003) has a highly sophisticated system, the

recommendations are on the one hand customized based on the past individual behavior of the user (browsing history and history purchase), and on the other hand, Amazon also uses the features of the item itself (subject recommendation) and behaviors of others (social recommendation). Anyone who has ever made a purchase on Amazon probably read the message from Amazon telling us “People who bought x also bought y”. This approach is simply the item-based nearest neighbor approach (Schafer et al., 2007) previously described. It would appear that Amazon’s recommendations result in more than 30 percent of the company’s total turnover (in 2009).

Proposal

We propose to apply similar concepts that are up to now used to recommend products or services also for recommending potential transaction partners to users. Following the state of the art, we consider a hybrid method most appropriate, which combines collaborative recommendation similar to existing approaches for evaluating transaction partners after concluding a transaction with an innovative “content based” approach. We consider personalized recommendation less suitable for our purpose. If a user already has experience with a transaction partner, the used has concluded several transactions with that partner and thus has already developed a sufficient level of trust in that partner. For recommending transaction partners, “content” here means properties of users. Trust refers to both the competence and the benevolence of the potential transaction partner (McKnight et al., 2002). Trust in competence is the belief that the transaction partner is indeed able to provide the goods or services ordered, and trust in benevolence is the belief that the transaction partner is also willing to do so. Both of these main dimensions can be further separated into various sub-dimensions, so evaluation of the trustworthiness of a transaction partner is a multi-criteria evaluation problem. Furthermore, information both on the competence and the benevolence of the potential transaction partner can be collected by the recommender system itself (e.g. by collecting statistics on previous contract violations), and from the experiences (ratings) of users who previously interacted with that transaction partner.

Ratings provided by other users therefore serve a double role: on the one hand, they provide a basis for collaboration in the sense that users directly rate and recommend a potential transaction partner. On the other hand, they serve as the source of information for a detailed, multi-criteria evaluation of transaction partners. For this purpose, comments made by users on their transaction partners need to be mined for specific information such as the number of times in which a transaction partner has violated a contract in a certain way, e.g. by delayed shipment. Identifying such behavioral patterns in user comments will require the use of adequate Natural Language Processing tools.

These multiple dimensions of evaluating the trustworthiness of potential transaction partners need to be aggregated to an overall evaluation and recommendation according to the personal preferences of users. Some users might be more interested in their transaction partner’s competence, others in benevolence. Some users might want to rely more on objective data collected by the system, others on personal experiences of other users. A recommender systems for transaction partners therefore needs an elaborate model of user preferences towards the multiple evaluation criteria. We expect that criteria will be highly interdependent and therefore consider Choquet or Sugeno integrals as adequate models of such complex preference structures.

Conclusion

The sharing economy based on collaboration platforms is gaining more and more importance. While sharing platforms provide a new way of using resources efficiently, they also bring a significant risk of opportunistic behavior. Therefore, the choice of the right transaction partner in a sharing platform becomes even more important than in the traditional economy, where contracts were concluded in personal interaction.

Recommender systems are already widely and successfully used to assist users in selecting the right product in a complex environment with many, sometimes confusing choices. We therefore propose to apply this concept also to the selection of transaction partners in sharing platforms. Developing a recommender system for this purpose requires first of all the definition of criteria to be used for making such recommendations. We have outlined a broad classification of possible criteria using the distinction between trust in competence and trust in benevolence, and between different information sources in this paper, but it is clearly necessary to develop a more precise list of criteria. The second step is the formulation of a preference model. This on the one hand needs to contain descriptive elements to consider how users in a sharing platform actually develop trust in a transaction partner and which criteria are important for them. On the other hand, to make valid recommendations, this preference model also needs a prescriptive perspective to identify which criteria are objectively important and how they should be aggregated to provide useful recommendations. Such a model based on economic theory is currently under development. Once these important questions are resolved, a prototype recommender system can be created and tested in empirical studies.

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Enhancing Privacy when Accessing Public WiFi with Raspberry Pi

Christopher Le[1], Kidus Getachew[1], Estephanos Jebessa[1], and Tauheed Khan Mohd[1][0000−0002−7989−6908]

Department of Math and Computer Science, Augustana College, Rock Island, Illinois, 61201, USA
{christopherle19, kidusgetachew18, estephanosjebessa19, tauheedkhanmohd}@augustana.edu

Abstract. When we are out of our personal WiFi's reach, public WiFi or cellular data seems to be the solution for our internet accessibility. While not many people are capable of having solid and stable cellular connections, they tend to choose public WiFi instead. If we are not careful, our devices can be vulnerable to security attacks due to the lack of protection from public WiFi. More importantly, hackers can use open WiFi to access your data and sensitive information. To deal with this security issue, encryption of networks is now being widely used either by using VPN (a virtual private network) [1], firewalls, or updated and patched up online window's defender. Even then, there is still a risk that WiFi sniffers capture and download the packet and malicious users uncover the data. Having a small device such as Raspberry Pi in the middle of the WiFi and device would enhance your security by adding a layer of encryption when accessing open WiFi can be more secure and convenient.

Keywords: VPN, virtual private network, security, open WiFi, raspberry pi

Introduction

Having a personal router at home is one of the most popular ways to access the internet nowadays. However, when you are outside, using open WiFi or cellular data is some of the possible options for you to access the internet. While cellular data can be secured, not everyone can have equivalent finance to sustain monthly cellular connections, concerning now faster connections such as 5G is often expensive [2]. Not to mention, not everywhere and not every location has stable cellular coverage. That said, using open WiFi can be a better choice for some. Open WiFi can be found anywhere, from malls, colleges, parks, etc.

Accessing public WiFi is the most convenient and free way to get the internet. Having the freedom of using the internet with privacy is also very important to users. These days you commonly hear security analysts and experts say don't use your financial information on public WiFi and if you have to use a VPN. VPN (Virtual Private Networks) [1] is an encryption method where queries of information will be tunneled through private servers located around the world(usually you choose a location in the process), which helps encrypting your data.

The problem with this can be WiFi sniffers can capture and download packets of data in which a malicious user can decrypt and reveal the information. Using Raspberry Pi we can add a layer to that packet transfer and potentially use multiple devices on the Raspberry Pi [3] to make devices more secure. These days everything is virtually connected to the internet, namely Smart Watches, TV's, voice assistants and even speakers can potentially be connected to the Raspberry Pi [3] and be more secured.

The need of a more secure router is even more important now since if it is an Enterprise network and a low level user is more susceptible to a malicious user it would not endanger the whole network. Nowadays if a low level user for a company network is hacked and all his information is taken usually it would prove harmful for the whole network. Using a Raspberry Pi you can add that extra layer of encryption in addition of giving extra authentication for the access of the Raspberry Pi.

The purpose of this project is to create an effective and safe way to use VPN to browse with privacy and secure from attackers. The objective is to study how to use the VPN implementation technique for assuring network control. Besides, to design and implement VPN into Raspberry Pi to provide access for connected devices. When a device connects to the Pi, we can test all traffic routed through a VPN tunnel to reach the Internet. This device acts as a portable that can plug into any device and it has the capability of protecting the user from being monitored, and the sensitive information is hidden as needed because it hides the Internet Protocol (IP) [4]. To avoid data interception from attackers, this innovation is capable of encrypting end-to-end connection between a user's devices by implementing a VPN into a Raspberry Pi. To hide the user's IP address, we will use an open server which is an open source VPN where we can customize it. In conclusion, this portable network tool can help users to secure their network activities and minimize hacking attempts, at least making it harder for hackers to gain access.

RELATED WORKS

An issue when connecting to open WIFI is that user may be targeted to Man in the Middle attack [5]. MITM or Man in the Middle attack is a very common attack method done by hackers by using either Bluetooth or WiFi (WiFi's more commonly used since they are always open and ready to connect). The goal of an attack is to steal personal information, such as login credentials, account details, and credit card numbers. Targets are typically the users of financial applications, SaaS businesses, e-commerce sites, and other websites where logging in is required. The attacker usually intercepts the packet before it goes to the intended IP address which might be either Bank of America or Chase. There are different ways an attacker can spoof and trick a user into entering the user's personal information.

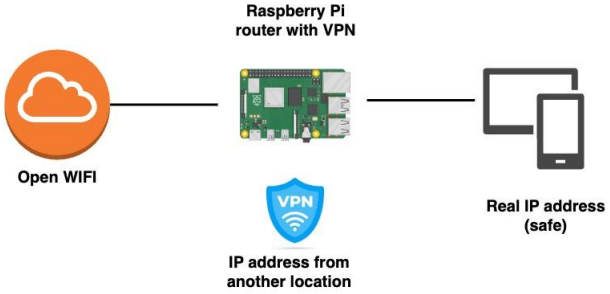

Fig.1. What we aimed to achieve

This ranges from IP spoofing to DNS spoofing. To deal with these kinds of attacks, VPNs are created by establishing a point-to-point connection through the use of virtual protocols and tunneling links or encrypted data traffic. The part of the link in which private messages are entered is called a tunnel. Messages transmitted through the tunnel are encrypted. VPNs usually have an encryption key

exchange protocol in either RSA-2048 or ECDH. They also have ciphers that are AES (GCM/CBC), Blowfish, or Camellia which are military-grade ciphers that provide good encryption.

In addition, it is important to establish a secure connection using a reliable VPN service [6]. in their research conduct two experiments to enhance security and privacy in local area network (LAN) with TORVPN [6] using Raspberry Pi as access point. In their two experiments, the Raspberry Pi will automatically start and connect to the VPN server once it boots up. This allows Raspberry Pi to direct user traffic into the encrypted network, which is a VPN network. On the VPN server side, all traffic sent from the Raspberry Pi access point is randomly routed to multiple Tor servers.[6] In this way, the user connection is protected from data theft or traffic analysis. Therefore, the user can surf the Internet safely and anonymously. In addition, the user can browse all the blocked content over the Internet.[6] The Raspberry Pi boots with a Raspbian operating system based on Debian optimization. It offers a targeted kernel and software supporting multiple types of ARM instructions [7].

The design they implemented in their study requires users to apply the Raspberry Pi TORVPN [6] access point to get an anonymous and more secure connection on the network, and users are protected from any internet surveillance, also known as traffic analysis [6]. This design includes the TORVPN area network operating within the Direct Sim router area network. The internet connection was provided by an ISP that went through a direct sim router before going through the TORVPN access point to allow its clients to connect to the internet. [6] The purpose of their first experiment was to verify the confidentiality related to the encryption of the data packet that entered the internet by using the direct sim router network and the TORVPN access point network. Both packets from both networks were sniffed and analyzed. According to their results table, The users who used public networks to access an unencrypted website like an HTTP website were easily targeted as victims of MiTM attacks. The password or other browsing information contained in the data package can be easily captured and analyzed by an unauthorized person. However, if the packet originates from clients on a TorVPN access point network, the data packet has been fully encrypted and contains password or browsing information. The data packet has not been intercepted by another unauthorized person. [6]

In their second experiment, the main goal was to measure the performance of the Internet connection when tunneling to the VPN server connected to the Tor network. The results show that the Tor network [8] connected from the TORVPN access point exhibited unstable performance as it changes the IP address of the last node or another name called exit relay.[6]

Another experiment was done by Abidah Mat Taib et al on the VPiSec to test the functionality of OpenVPN, Pi-hole, and OSSEC IPS [9]. The test done with OpenVPN showed that the user IP and location were hidden, which means it works successfully. VPiSec [10] helps Internet users secure their network activities. This project proposes to improve a command that can make Pi-hole update its database automatically. Also changes the router configuration for the IP table to forward all traffic going into the router that also goes to the VPiSec [10].

RESEARCH/FINDINGS

Getting VPN configuration

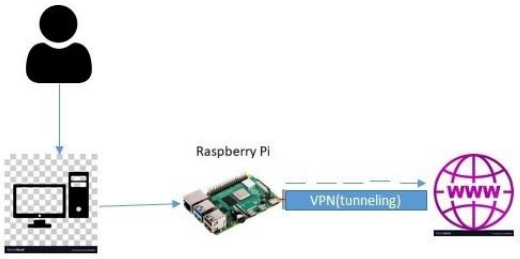

Fig.2. Visual Implementation of the Raspberry Pi function

In this research, PIVPN [11], a set of shell scripts to turn Raspberry Pi into VPN server using two free, open-source protocols Wireguard and OpenVPN was used.

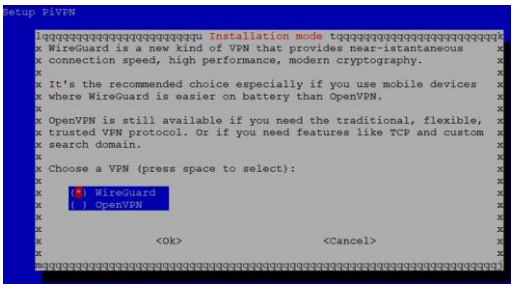

Fig.3. PIVPN's sample interface

OpenVPN has been one of the most used VPN protocols for several years due to its fast and secure connection. However, with around 400,000 lines of code, the tool is hard to maintain, be used on smart phone and can be hacked or cracked by hackers. On the other hand, WireGuard is newer and faster than OpenVPN [12]. With the latest technology in encryption, WireGuard [13] is also more secure. With 4,000 lines of code, WireGuard is easier to maintain and harder for hackers to crack. Not to mention, when exporting the VPN profile from the Raspberry Pi, OpenVPN [14] default export option was to a permission-denied folder while WireGuard allowed us to install the profile directly from the QR code generated by PIVPN on the Raspeberry Pi. That said, in this research paper, both WireGuard and OpenVPN were used to explore the pros and cons of using them. In order to run PIVPN on Raspeberry Pi, open the terminal and run curl -L https://install.pivpn.io — bash to download and install the package. During the installation, PIVPN will ask whether if you use a DHCP [15] reservation or static IP address. Static IP address is unique number assigned to each computer on a network with static means the IP Address will remain unchanged over time. Meanwhile, DHCP reservation or Dynamic Host Configuration Protocol [15], will assign an IP address for the computer whenever it is connected to the internet. In this research paper, DHCP reservation was used in order to hide our real IP Address which can reveal our location information.

Next, after choosing DHCP and WireGuard for our configuration, the system will ask the user to choose a communication protocol: TCP [16] or UDP [17]. In this paper, both UDP for WireGuard and TCP [16] for OpenVPN were tested. One advantage of UDP over TCP [16] is that it is faster than TCP, but usually come with the cost of less reliable connection [18]. Devices connect using public WiFi or cellular data and use a VPN. Next, connect the Raspberry Pi to the wired router via Ethernet LAN. A user must always be near the router and make sure the Raspberry Pi is connected to the router in order to establish his

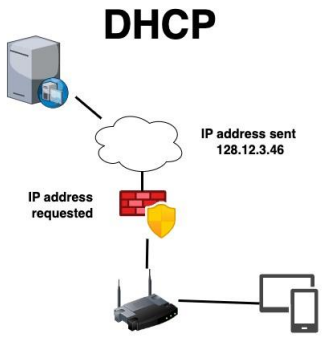

Fig.4. How DHCP works

VPN connection from a smartphone or laptop. You can keep using your VPN even when you're away from home. The advantage of this connection is that if an attack gets into your system, your ISP will expose the Raspberry Pi instead of the device's real IP address. After this step, VPN port for WireGuard as 51820 (default) and 1194 for OpenVPN (default) were selected. Since hackers and other hacking software use port 22 to gain access to our server, it will not be the default port; however, the IP address will not be static during installation. It will be given a DHCP address by your router if it has never been rebooted or if the router is turned off. Watching images, implementing a large number of requests, and more are all examples of high load.Users can display their home directories as Raspberry PI shares using the default configuration file. PIVPN will also ask to set the DNS provider. Since dynamic DNS was not set up for the scale of the project, local PIVPN DNS server were chosen with public IP address.

In the next steps, we will choose a public IP address due to the scale of this research project. The server key and HMAC key [19] will be generated once done, following with a reboot. After reboot, run pivpn add to add the profile and create configuration (.opvn)

The proposed system leaves the basic functioning of the VPN server untouched and adds on an extra feature for better usability and security. This extra layer of security is provided by a Multi-tier Authentication Module. The Multi-tier Authentication Module provides three tiers of authentication. Tier 1: This tier comprises the basic functionalities of the VPN that includes authentication of client files. Tier 2: This tier incorporates a PAM module [20] - Pluggable Authentication Module, that uses low level authentication mechanisms to integrate different modules and use one simple authentication for all of them. This authentication is provided at the server side. PAM provides the same level of security as LDAP but in a more optimum way. Additionally, it also allocates a dedicated desktop for each client. Tier 3: This tier generates a Client Specific Private Key that eliminates the

possibility of multiple users using one client file to log in to the VPN server. The connection once established, on the client machine, can be extended to other handheld devices using the Wi-Fi hotspot that is created on the client machine.

The problem of PIVPN in this research topic is that it requires port forward which requires admin access to the open wifi. This is not possible concerning you are accessing the open wifi from places such as coffee shops, libraries, etc. Therefore, when we get the configuration file from PIVPN, whose file ending is .opvn, we will use it for the next steps with RaspAP

Making Raspberry Pi a VPN router

RaspAP [21] is a feature-rich wireless router software that just works on many popular Debian-based devices, including the Raspberry Pi. With RaspAP, we can import our VPN configuration file exported from PIVPN earlier and make our Raspberry Pi a WIFI travel router. What it does is acting as the bridge between the open wifi and our device as the middle hot-spot. The benefit is that with VPN, RaspAP will hide our real IP address, and replace it with the IP address from the VPN server which is located in a different location from us. That way, hackers cannot find out our real IP address and our access location.

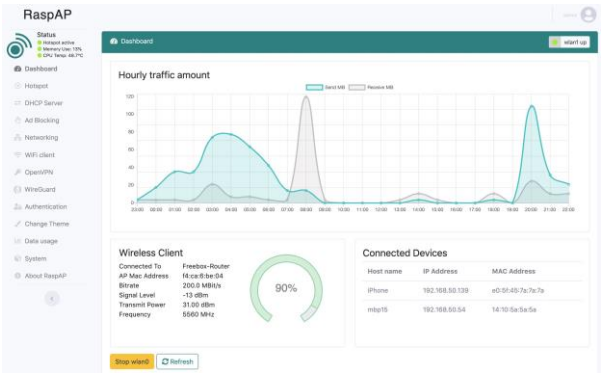

Fig.5. RaspAP's sample interface

Firstly, update the Raspberry Pi to its latest version, including the kernel and firmware, followed by a reboot by running: sudo apt-get update sudo apt-get full-upgrade sudo reboot
Set the WiFi country in raspi-config's Localisation Options: sudo raspiconfig

To install RaspAP, run curl -sL https://install.raspap.com — bash

Following a reboot, the wireless AP network will be configured as follows. To access the admin page, enter the brower the follwing IP address with the corresponding username and password IP address: 10.3.141.1 Username: admin Password: secret

Next, if you go to Hostspot setup, you will see the SSID and default password listed below which can totally be changed. SSID: raspi-webgui Password: ChangeMe

It is strongly recommended that you change these default credentials in RaspAP's Authentication, Hotspot and Security panels. In other to setup OpenVPN or WireGuard, go to VPN tab and enter the credential infomation with the configuration exported from PIVPN. Once the settings is saved, VPN will be added to the router.

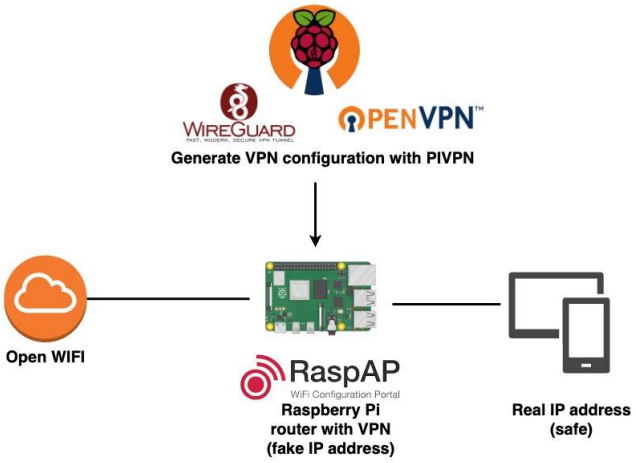

Fig.6. Final model

CONCLUSION

The research project was initially to secure open WiFi's connection with Raspberry Pi. Our initial approach is to use PIVPN to make Raspberry Pi a VPN server with VPN. However, connecting with PIVPN requires port forwarding which requires admin access to the open WiFi. Such access is not feasible in situations such as libraries, traveling, coffee shops, etc. Therefore, after exporting the VPN configuration file from PIVPN, importing to RaspAP, a wireless router software made for Debian-based devices, including the Raspberry Pi, was important. With RaspAP Raspberry Pi could be used as a VPN hostpot and hide our real IP address. As the result, our devices were able to be connected to Raspberry Pi and hide the real IP address.

In terms of the comparison between WireGuard and OpenVPN, while they both serve the same feature, we found that WireGuard had better app's support as exporting and importing VPN profile and configuration from WireGuard was much easier.

For connection test, we found that the closer our devices to the hostpot, the better the connection to the Raspberry Pi is. The number of devices connected can be changed with the number of allowed channels on RaspAP. However, the connection from RaspAP would not be stable when connecting to VPN. We received estimated three-second delay when connecting a VPN server in Canada from Illinois. There is also interruption in the connection to the main WiFi when RaspAP is turned on every-time the machine boots. As uninstall function for RaspAP was not available at the moment, manual un-installation was required to connect with the main WiFi.

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Are the Internet Connections at Augustana College Good Enough for Student Productivity?

Kashav Piya[1], Jon Cathcart[1], Minh Nguyen[1], Jacob Speirer[1], and Tauheed

Khan Mohd[1][0000−0002−7989−6908]

Department of Math and Computer Science, Augustana College, Rock Island, Illinois,

61201, USA

{kashavpiya19, joncathcart19, minhnguyen19, jacobspeirer19, tauheedkhanmohd}@augustana.edu

Abstract. The Internet is a vast network of connections connected to millions of devices around the world to share information and communicate with each other. The Internet has become an inseparable part of human life as every device used today is likely to be connected to a network in one way or another, and it serves its purpose. It has also become an integral part of a student's life, from sending emails, and completing assignments to even taking classes over the internet. The study's purpose is to find out if a private school like Augustana College provides its students with adequate internet connection for its students to be productive. The study will be looking at various connections available at Augustana College throughout its campus in different buildings such as Swanson Commons for residential halls, Gerber Center for Student Life, and Olin Center for Academic building, and test out its download speed, upload speed, latency, ping to its server and so on to see if the connections are good enough. The study will also look at internet connections outside of Augustana's campus and connections in other colleges, which will be used to compare and see how Augustana's connection stacks up against them. Finally, the study will come up with suggestions that could help Augustana College provide better internet to its students, along with suggestions for students to get the most out of the available internet connection.

Keywords: Network, Internet Connection, Internet Speed, productive, Netgear

Introduction

The Internet is a vast network that connects computers all around the world which allows people to share information and communicate with each other from anywhere in the network and anywhere on the globe or beyond.[1] Internet has become an integral part of our lives in the last few years for a lot of reasons. From emailing your colleagues, playing music, to playing video games with friends or shopping, we use internet to do the most basic things in our lives. Not only is internet important to get our daily routine done but also important to help organizations and businesses run smoothly with a lot of these companies digitizing in the recent years. Additionally, 'Work from home' has become popular after COVID-19 which would require internet to work.

"With the development of the Internet, and with the increasing pervasiveness of communication between networked computers, we are in the middle of the most transforming technological event since the capture of fire. I used to think that it was just the biggest thing since Gutenberg, but now I think you have to go back farther", J.P. Barlow says.[2] Since the development of internet, it has kept

growing and has spurred the progress of the society. This shows that today's world is very dependent on the internet and having a good, reliable internet connection has become a priority.

With that being said, what is a good internet connection, how important is having a reliable internet connection for a college student and does Augustana College provide a satisfactory internet connection for its students? According to the Federal Communications Commission(FCC), a good internet speed for a student is 25 megabytes per second for download and 3 megabytes per second for upload.[3] However, these speed are outdated and might not be enough for full online capabilities like uploading large files for assignments, watching a lecture online or attending a Zoom or Meets session seamlessly without the call dropping. So, ideally a college/university would be providing an average internet download speed of at least 100 megabytes per second specially with a large number of devices that gets connected. There are more factors such as latency, packet loss, connectivity and others to determine if a connection is reliable.

So, is the internet provided by Augustana College to its student good enough and dependable? To answer this question, the review will be looking at various connections that Augustana College provides. Augustana College has mainly four different WiFi network that students can connect to: AugieWiFi(Secured), OpenAugieWiFi, GameConsolesAC and GuestsOfAugustana. Students can also have a wired connection through an ethernet cable which would be connected to the secured connection that Augustana College has. Additionally, each houses on campus get their own network, however, for the purpose of this review, those will not be looked at.

To go in further depth about each network, OpenAugieWiFi is an unencrypted connection, whereas the AugieWiFi(Secured) is the encrypted and secured with Augustana network authentication. The college recommends using the Secured network over OpenAugieWiFi when possible for security reasons. The GuestsofAugistana connection is a network for the guests to connect to. Finally, the GameConsolesAC network is meant only for game consoles and the Information Technology Services department at the college wants students to connect their game consoles to this network rather than other networks.[4]

Related Work

Augustana College provides two different wireless access points. These are Ruckus and Netgear. Each campus building have either of these two, provided in the college map shown, identifying each building to Ruckus or Netgear.

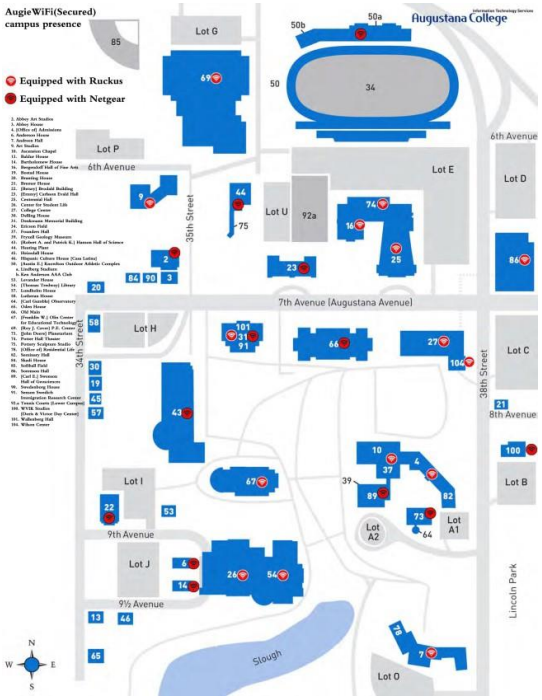

Fig.1. Map of wireless connections on Augustana College campus.

In this study, both access points will be tested and compared to, as well as between each campus WiFi. A study of the analysis of Ruckus wireless described the benefits of using their products. The connection has increased range, increased throughput at any given range, and is more consistent[5]. With Netgear, there isn't much analysis but seems that it is used more at a consumer level and possibly has a stronger signal, better performance, but less stable than Ruckus [6]. With Augustana college, using both of these access points can go unnoticed to most using them. It is important to analyze with one is better overall for the benefit of students on campus. The fact that each building is scattered from one other can be an interesting study, because even if buildings use the same WiFi company, some could be stronger solely based on location. In this study, stability will be a key component, since college students need a secure connection and one that is not vulnerable to crashing.

Internet Access, Usage, and Policies in Colleges and University

The Internet revolution arrived faster and with more complications than many academic institutions expected. The rapid development of search engines and the expanded use of the Web by all types of organizations increased the demand for Internet-related services on college campuses. To assess the impact of these changes, a questionnaire was mailed to selected computer center directors listed in the 1998 Higher Education Directory (U.S.). The questionnaire asked respondents various institutional demographic questions and how Internet access is provided to students, faculty, administrators, and staff. The paper presents survey results in text and graphical format. The paper includes graphs that display the rates of increases (or decreases) regarding access and usage of e-mail, the World Wide Web, telnet, and other Internet features [7].

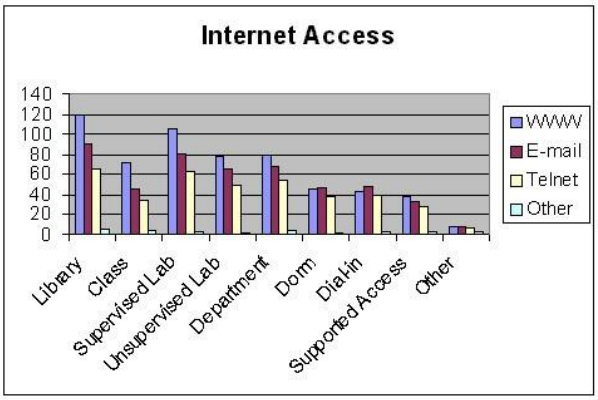

Fig.2. Internet Access

The authors believe that one reason for the crisis is the lack of faculty, administrators, and funding agencies to appreciate fully the impact of technology adoption on the teaching profession. Only when the issue of technology adoption becomes a common agenda item will it be possible to address this issue. Funding concerns coupled with issues of appropriate usage will therefore continue to be important policy topics as colleges and universities attempt to define the role the Internet has in instruction and instructional delivery.

Online Isn't Optional: Student Polling on Access to Internet and Devices

While COVID-19 is not as serious a danger as it used to be, it still can affect any person. In higher education, the ability to be able to switch to remote learning at any time is still necessary. For students to be able to easily switch to remote learning, colleges must have a fast, reliable Wi-Fi network. According to a report done by the Institute for Higher Education Policy (IHEP) in 2021, approximately 1 in 4 students report sometimes having difficulty connecting to college courses due to internet issues [8]. For students who could only sometimes access college course content, doing assignments and attending lectures was a difficulty which was out of the students' control. This difficulty could lead to a lack of engagement in courses, and may potentially lead to a student dropping the class, or dropping out of college. Also, according to the report, for students with unreliable internet while most can access online content, it is slow, unreliable or difficult[8]. This means that students with unreliable internet may not be able to complete or submit assignments due to circumstances outside of their control. This means courses are more difficult not because of the students actions, but because of something which they do not have control over.

Research/Findings

This study is going to be looking at different variables like download speed, upload speed, idle latency, ping to its optimal servers, download latency, and upload latency. The study will look at all these metrics to analyze if the internet options provided by Augustana College is a good enough to serve its purpose to an average student. The study will use 'Speedtest by Ookla' which is one of the most trusted tool available to measure these metrics.[9] The speed test tool provides all the necessary metrics that the study will take a look at as we can see in Figure 3. To make sure that the study is not skewed, for each network, the speed test will be ran 7 times and the average of all the runs will be documented. This way the study becomes more comprehensive and the data collected will have more integrity.

Fig.3. Speedtest by Ookla is a trusted tool to measure metrics about network connections

Before looking at the numbers or findings, one will need to know what each of these variables mean. First of all, according to highspeedinternet website, download speed is often referred to as bandwidth and it measures how fast information from the internet gets to your device. [10] As for upload speed, just like download speed, it is just how fast information from your device can reach to another device or location on the internet. [10] Both download speed and upload speed are usually measured in megabits per second (Mbps). Finally, latency refers to the time it takes for signals to travel from your device to the service provider or the server and back. [10] This metric is usually only important if one is doing something real time such as playing an online multiplayer games or even video calls/internet telephony. Latency is measured in millisecond(ms).

One way to improve the internet experience at Augustan is to look at similarly sized colleges and universities. The California Institute of Technology is working with technology solutions businesses to implement 802.11ac wireless network throughout the campus[11]. A more up to date network designed by technology solution businesses may help prevent areas having slow internet or no internet at all. While overhauling the entire network system of a campus can be time consuming and costly, it may become a necessity as the internet becomes more integral to everyday life. At Macalester College in Minnesota, in the Macalester Room and Board contract, there is a section which talks about network services in the residential halls[12]. Requiring students to read part of the Information Technology Services(ITS) policy will not fix slow internet. However, it may temper student's surprise and anger when the internet does become slow. Most colleges have ITS to help deal with internet problems. The ITS department should be looking at the infrastructure of the campus wifi and make sure that everything is up to date, so unforeseen outages do not occur.

In this study, the networks are going to be tested in various buildings on campus such as a residential building, buildings with classes or buildings with businesses or where students like to hangout. For the purpose of the study, Swanson Commons was chosen as the residential building where the tests will be run as it is the newest and most up-to-date building on campus. For an academic building, Olin Center was chosen as it is a building for computer science, math and technology and one of the buildings where internet is most essential. Finally, for the student life building, the tests will be run in the Gerber Center of Student Life as it consists of places like the dining center, library, coffee shop and event halls which gets used very frequently.

Table 1. Off-Campus Speedtest

Download Speed(Mbps)	240.02
Upload Speed(Mbps)	19.53

Idle Latency (ms)	27.2
Download Latency (ms)	71.2
Upload Latency (ms)	41.7

This table shows the speeds of a Wi-Fi connection done at a house not on Augustana's campus. The purpose of this test was to gain a base measurement for download speed and upload speed. It was also done to give a comparison of non-Augustana Wi-Fi to test against Augustan Wi-Fi.

Result

The first tests were run at Swanson Commons which is a residential building.

Table 2. Different Internet Connections Available at Augustana College in Swanson Commons, a Residential Building and its Download and Upload Speeds.

Name of Internet Connection	Download Speed(Mbps	Upload Speed(Mbps)
Ethernet Connection(Secured)	57.10	90.26
AugieWiFi(Secured)	53.30	87.37
OpenAugieWiFi	52.52	87.60
GameConsolesAC	49.52	89.26
GuestsofAugustana	46.54	87.85

Table II shows the download speeds and upload speeds for various networks provided in the residential halls by the Information Technology Services at Augustana College. The networks as previously mention include Ethernet Connections, AugieWiFi(Secured), OpenAugieWiFi, GameConsolesAC, and GuestsofAugustana. It shows that a wired connection tends to result in faster download speeds than wireless connections. For the wireless connections, the connections that students use the most frequently while on campus, have the fastest download speed. To further explain, AugieWiFi(Secured) is the connection most student will use while on campus which means it need to fastest download speed to be able to accommodate a large number of students. OpenAugieWiFi is the connection that every student needs to use to gain access to AugieWiFi(Secured) which means that OpenAugieWiFi needs to be able handle periods of time where many students connect to the network. GameConsolesAC is a connection for gaming consoles on Augustana. Not every student brings with them a console that needs to connect to the internet, so it does not need to have as fast a download speed as the previous connection. GuestsofAugustana is for, well, guests of Augustana. This means is will experience the least amount of traffic on a daily basis and will only be connected to by a fraction of the devices that the other networks are connected to.

Table II also shows that the wired connection results in faster upload speeds than wireless connections. However, instead of AugieWiFi(Secured), the connection most student use on a daily basis, having the fastest upload speed, GamConsolesAC has the fastest upload speeds. This is, partly, because there are less consoles connected to the network than there are device connected to AugieWiFi(Secured). It is also because of multiplayer video games. Many multiplayer games need a good connection so it can transmit the player's data to a server or another player's console. The console is constantly uploading its player's data to a different place which mean that it needs a fast upload speed. The other three wireless connections have a similar upload speed because each of the connections is not constantly uploading data from a device to some where else.

Table 3. Different Internet Connections Available at Augustana College in Olin Center, an Academic Building and its Download and Upload Speeds.

Name of Internet Connection	Download Speed(Mbps	Upload Speed(Mbps)
Ethernet Connection(Secured)	678.06	503.84
AugieWiFi(Secured)	34.25	50.74
OpenAugieWiFi	53.95	80.95
GameConsolesAC	N/A	N/A
GuestsofAugustana	16.95	44.07

Tables II and III both show the download and upload speeds of different connections in different types of buildings on campus. Table III does not have a GameConsoleAC connection because this connection is specific to residential buildings. At a glance, the academic building has a stronger Ethernet connection than the residential building. However, for each other connection, the residential building has a download and upload speed that is as fast or faster than the academic building. The only exception to this is the download speed of OpenAugieWifi.

Table 4. Different Internet Connections Available at Augustana College in Swanson Commons, a Residential Building and its idle latency, download latency and upload latency.

Name of Internet Connection	Idle Latency (ms)	Downl Latency (ms)	adUpload Latency (ms)
Ethernet Connection(Secured)	17.29	32.14	38.29
AugieWiFi(Secured)	13.43	29.57	37.43
OpenAugieWiFi	17.71	31.71	36.43
GameConsolesAC	15.29	28.14	35.71
GuestsofAugustana	20.0	26.14	32.86

Table 5. Different Internet Connections Available at Augustana College in Olin Center, an Academic Building and its idle latency, download latency and upload latency.

Name of Internet Connection	Idle Latency (ms)	Downl Latency (ms)	adUpload Latency (ms)
Ethernet Connection(Secured)	16.14	17.86	12.86
AugieWiFi(Secured)	17.43	64.29	512
OpenAugieWiFi	19.57	72.57	253.86
GameConsolesAC	N/A	N/A	N/A
GuestsofAugustana	56.14	179.14	876.43

Tables IV and V have the idle latency, download latency, and upload latency for a residential building and academic building respectively. The residential building has a higher latency in all three categories when comparing Ethernet connections while the academic building has a higher latency in all three categories for every other connection which both buildings share, those being AugieWifi(Secured), OpenAugieWiFi, and GuestofAugustana.

Table 6. Different Internet Connections Available at Augustana College in Gerber Center of Student Life, a Student life Building and its Download and Upload Speeds.

Name of Internet Connection	Download Speed(Mbps	Upload Speed(Mbps)
Ethernet Connection(Secured)	736.17	513.77
AugieWiFi(Secured)	232.36	136.83
OpenAugieWiFi	329.46	171.17
GameConsolesAC	N/A	N/A
GuestsofAugustana	380.5	184.09

Conclusion

Internet is a vital part of a student's life. Ever since its invention, internet has changed the way academic communities work significantly as texts, images, videos and other information is readily and abundantly available online. [13] Internet undoubted has increased the productivity of students and other studies on this topic have shown that students considers availability of good internet to be one of the main reason for their success as they can access information over the internet efficiently and effectively.[14]

Table 7. Different Internet Connections Available at Augustana College in Gerber Center of Student Life, a Student Life Building and its idle latency, download latency and upload latency.

Name of Internet Connection	Idle Latency (ms)	Downl Latency (ms)	adUpload Latency (ms)
Ethernet Connection(Secured)	15	22.29	14.86
AugieWiFi(Secured)	28.57	162	357.71
OpenAugieWiFi	17	66.71	310
GameConsolesAC	N/A	N/A	N/A
GuestsofAugustana	17.43	52.86	304.88

Based on the results, the study found that Augustana College provides almost average internet connection for its students. The internet connections had an underwhelming performance in the residential halls where even with an Ethernet connection, the average download speed that was achieved was about 57Mbps. The study deemed that this was due to the fact that hundreds of students were connected to the networks at the same time in the residential halls which results in distributed bandwidth for its residents/students. The wireless connections also had poor performance in the residential halls which is also a result of too many devices connected to the same internet connection. However, the study found that adding an additional WiFi connection for game consoles was effective as it helps to keep the traffic on the other networks to a minimum.

The study also looked at academic buildings, specifically Olin Center where the Math and Computer Science department is located. This is the building where internet is used and required the most. The wired connections in this building were very impressive even with the shear amount of devices connected in this building. However, none of the wired connections were stable enough for devices to stay connected. The internet download as well as upload speeds to struggled. The study came to the conclusion that this is due to the computer labs being located in the building as the information technology services sees it as less important to have a good wireless connection when there are multiple labs in the building with hundreds of computers.

Finally, the study looked at student life building and chose Gerber Center as the location to test as it is the only student life building which includes a coffee shop, dining hall, library, event halls and many more. The wired connection was impressive again with libraries being in the building that require a decent download speed. Out of all the buildings, this building had the best wireless connection, and the study found out that it might be due to it being the most used building in the entire campus which is why the information technology services prioritizes this building for the best wireless connections.

Even though the connection at Augustana College is about average in comparison to other colleges, based on the study, the following suggestions have been recommended for a better internet usage or connection.

- Everyone should be provided with training to how to connect to the internet connections securely as one of the biggest problem that was detected was students and teachers not knowing how to get connected to the secured WiFi or the wired connections. This will reduce the amount of device that is connected to the OpenAugieWiFi as well as the GuestsofAugustana WiFi which will help improve the download and upload speeds for those connections.
- Computers with better specifications should be put in the laboratories as well as library which promotes them to use the wired connection which in turn reduces traffic on the wireless connections that can be used by the people who actually need it.
- The information technology services should acquire a higher bandwidth connection as it looks like there are more devices on the network than it can handle at the moment. This will help in increasing the download speeds of the internet.
- Students should be self-conscious about how many devices they have connected to the internet. If a device is not being used, they can disconnect it from the internet.

All in all, this study concludes that the higher the bandwidth of the internet there is more productivity among students. This can be supported by other studies as well, as it turns out that higher bandwidth not only helps students but also has economic and social benefits.[15]

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Day 3	**Thursday, June 1st 2023**	Room 1A24

Session 9b

ML and DSS

12:00 – 13:00

Chair: Ana Paula Cabral

Room 1A24

#1	*Prediction of Sentiment Using Machine Learning and Deep Learning Approaches for Restaurant Reviews*	Adrija Majumdar, Jayant Choudhary and Trisha Pravin Sarwade
#2	*A dynamic model for planning and management resources and maintenance activities*	Gabrielle Ribeiro and Ana Paula Costa
#3	*Why did you fail? An interpretability system for NLP models*	Mohsen Rahimi, Giulia De Poli, Andrea Masella and Matteo Bregonzio
#4	*Decision Support Procedure for Maturity Assessment in Asset Management*	Gabriel Herminio de Andrade Lima and Ana Paula Cabral de Seixas Costa

Prediction of Sentiment Using Machine Learning and Deep Learning Approaches for Restaurant Reviews

Adrija Majumdar
Indian Institute of Management Ahmedabad
Vastrapur, Ahmedabad, India adrija@iima.ac.in

Jayant Choudhary, Trisha Pravin Sarwade
Indian Institute of Technology Kharagpur
Kharagpur, India
jayantchoudhary14082000@iitkgp.ac.in, trisha_sarwade@kgpian.iitkgp.ac.in

ABSTRACT

Reviews serve as an important factor in the consumer decision-making process. Further, businesses can assess their service quality by observing the sentiments expressed in the reviews. The COVID-19 situation has disrupted the hospitality sector and the information needs of consumers also increased. The role of sentiments expressed by consumers has become more important since the industry is in itself going through its downturn. We provide a framework consisting of both machine learning and deep learning models that can be used to infer sentiments. We find that deep learning approaches provide superior results than machine learning models. Our results have implications for businesses.

Keywords: online reviews, natural language processing, Yelp, deep learning, machine learning

INTRODUCTION

A review is an evaluation of a publication, product, service, or company and reflects the opinion of the customer purchasing the product or service. A customer review is thus, a written reflection of the customer's experience and has a major impact on the revenue of the company [1]. Reviews can influence sales of products or services, as prospective customers often rely on these for decision-making [2], [3]. Over 60% of people look into the reviews of a restaurant before choosing to dine in it. These statistics are the highest among all other industries. As all the reviews come from one's personal experience, these ratings and text reviews are of great importance and are extremely valuable. These reviews also help the restaurant in analyzing and evaluating its progress. Responding to reviews efficiently shows their consideration and attempt in understanding the customer.

There are various platforms available to post reviews of one's experience. Some of them are Google Reviews, Amazon, Yelp, and social media. Yelp is the second most used platform for reviewing, after Google reviews. Around 45% of consumers find the best restaurant through the Yelp platform. A study by Harvard business school says that a 'onestar' increase in the ratings results in almost a 9% hike in revenue. On the other hand, a 'one-star' decrease in the rating results in around a 5% decrease in the revenue of the business.

In this research, we use the Yelp dataset to explore sentiments of the online reviews posted by users about a restaurant and its services. On the Yelp platform users provide a detailed account of their experiences and other prospective users often find this to be useful for decision-making regarding choosing a particular restaurant. Since COVID-19 has disrupted the hospitality sector whereby consumers were concerned regarding safety protocols, takeaway options, hygiene standards, etc, the role of online reviews for decisionmaking increased further. The field of natural language processing aids to explore insights from unstructured text data and we rely on this field to predict sentiments. Thus, our research provides methods to compute the sentiment of the reviews expressed in the reviews. We primarily, provide a framework on how to compute sentiments systematically for online reviews using machine learning and deep learning approaches. VADER, a rulebased sentiment analysis technique was used for labeling the text data. Machine Learning and Deep Learning models were built on this labeled data to compute the sentiment of the reviews. TF-IDF vectors were used for building the Machine Learning models like XG Boost, SVM, Random Forest, etc. Various Deep Learning models such as BERT, LSTM, Bi-directional LSTM, GRU, DNN, and CNN were employed to predict sentiments. Our research provides a range of algorithms to compute sentiments and we provide a comparative analysis of the accuracy measures of these methods. In general, we observe that the performance of the deep learning models is superior to machine learning models. Thus, we suggest that apart from using dictionary methods of computing sentiments, or machine learning approaches, researchers may explore deep learning models to attain better sentiment prediction. Appropriate sentiment computation aids in decision making process of retailers and brands to capture accurately consumer experiences.

RESEARCH METHODOLOGY

Data collection

We collect online reviews from restaurants located in Portland and Boston, one of the largest cities in their respective counties, Multnomah and Suffolk. These are also among the top fifty largest cities by population in the U.S. For further analysis, the restaurants with a take-out facility have been considered as some of these restaurants switched to pure takeout services in different phases of the lockdown. We collected data on Yelp restaurants' information, such as business ID, user ID, rating stars, and textual reviews posted between 1st January 2019 and 31st January 2021. In total, 1,97,949 reviews were retained for data analysis.

Exploratory data analysis

An exploratory analysis of the data revealed that 53.6% consumers have provided 5star rating. Around 18.6% have provided 4-star numeric rating, followed by 9.3% people who have provided 3-star rating, 7.1% who have provided 2-star rating and 11.3 % that have given 1 star number rating. This is consistent with the inherent nature of the provision of online reviews as observed in many other studies[4]. It suggests that the volume of top-rated reviews outweighs reviews that receive 1-star. Analysis of numeric ratings may give an incomplete picture, and it is important to explore the actual content of the reviews. Hence, sentiment analysis of the text content provides more information about the true intent of consumer experiences.

Data Cleaning

A key task in natural language processing is text pre-processing. It consists of text cleaning, tokenization, parts of speech tagging (POS), stop word removal, and lemmatization. In the cleaning

part, we first removed all special characters and numerals except the alphabets. Then we proceeded with the tokenization of text. Tokenization is the process of dividing or splitting the entire text into small units called tokens. Next, POS tagging is performed. Stopword removal was performed in the next step. In the last step of text preprocessing, lemmatization was performed. Lemmatization aims to remove inflectional endings and return the root or dictionary form of a word.

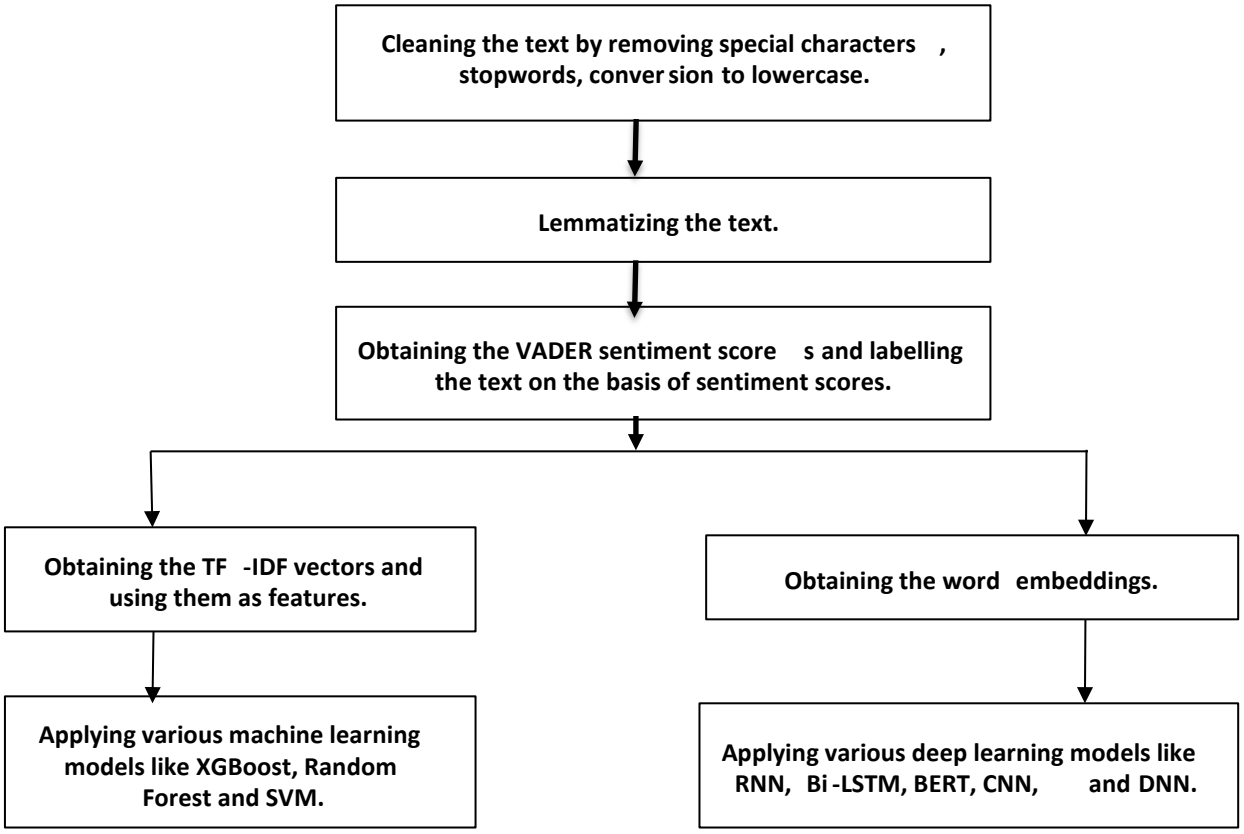

Figure 1: Overview of the methodological approach

Rule-Based Approach

In a Rule-based approach, there are a set of rules based on which the text is labeled as positive/negative/neutral. These sets of rules are also known as lexicons. Hence this approach is also known as Lexicon Based Approach. In our case, the VADER technique was used for scoring the reviews. The compound score is used as a metric for the overall sentiment. The value of the compound score ranges from -1 to 1. For the positive compound score, the sentiment of the review was labeled as positive, and for the negative compound score, the sentiment of the review was labeled as negative. This labeled data was used for building various machine learning and deep learning models. In Figure 1 we provide the methodological approach followed in this research. The first step involves cleaning the data and is followed by lemmatization. Next, to obtain the labels for the classification we followed a rule-based approach and used the VADER lexicon to tag data. Next, we create TF-IDF vectors and implement machine-learning approaches. We also create word embeddings and implement Deep learning models.

Machine Learning Models

To run the machine learning models we first used text vectorization. Term Frequency Inverse Document Frequency (TF-IDF) was used to create the vectors.

Term frequency (TF) serves as a metric to determine a word's occurrence in a document as compared to the total number of words. It is given by,

Term Frequency= (Number of instances of word(w) in document(d)) /Total number of words in document

Inverse Document Frequency (IDF) is a parameter that gives a numeric value of the importance of a word. It is the measure of whether a term is common or rare in a document [5]. It is defined as the total number of documents (N) in a text corpus D, divided by the number of documents containing w.

IDF= log[(Total number of documents(N) in text corpus(D) /(Number of documents containing w)]

Various ML models such as Logistic Regression, SVM, Random forest, and XGBoost were then applied using the TF-IDF vectors as features.

Deep learning models

For the deep learning models, word embeddings were used. Word embeddings take into consideration interrelationships between words, unlike the bag of words approach. Hence it is supposed to provide higher performance. We have used Bidirectional Encoder Representations from Transformers (BERT) to capture word embeddings. Various Deep Learning models were applied to these word embeddings, these include LSTM, Bidirectional LSTM, GRU, BERT, CNN, and DNN.

In the following section, we provide a brief background of these methods. Firstly, BERT was implemented on the labeled data obtained using the VADER score (0 indicating negative sentiment, 1 indicating positive sentiment). Next, BERT was implemented on the same text data of reviews but this time using review stars (having values 1,2,3,4,5) obtained from the Yelp website as labels. It was observed that in the second case, the model gave less accuracy as compared to the first case.

Long Short-Term Memory (LSTM) is a special kind of recurrent neural network that is capable of learning long-term dependencies in data. This is achieved because the recurring module of the model has a combination of many layers interacting with each other [6]– [10]. In this model, the first layer was an embedding layer. It contains embeddings from word2vec. In the next layer, LSTM was added with 128 units of neurons. The final layer was made using 1 neuron and an activation function sigmoid.

Bidirectional LSTM is a sequence processing model of two LSTMs. It takes an input in the forward direction and the other in a backward direction [8], [11], [12]. It improves the context available to the algorithm by increasing the amount of information available to the network. Thus, enhancing the model performance. The first layer used was the embedding layer. Then the vectors obtained from the embedding layers were given as input to the bidirectional LSTM layer having 128 neurons. Finally, the output layer consisted of 1 neuron and had an activation function sigmoid.

A Gated Recurrent Unit is a variant of the RNN design and employs a gated process to control and manage the flow of information between cells in the neural networks [6], [8]. The first layer used was the embedding layer. Then the vectors obtained from the embedding layers were given as input to the GRU layer having 128 neurons. Finally, the output layer consisted of 1 neuron and had an activation function sigmoid.

Bidirectional Encoder Representations from Transformers (BERT) is a transformerbased machine learning technique. BERT is designed to pre-train deep bidirectional representations from an unlabeled text by taking into account both left and right context in all layers. BERT uses Word Piece Tokenization for tokenizing the text. For building the final model, text was pre-processed, and a BERT

tokenizer was used for tokenizing text. The pre-trained BERT model was used as the first layer in our final model and then further fine-tuning was done using our supervised data of restaurant reviews. It gave the best results as compared to all other deep learning models.

Convolutional neural networks are used to recognize and process images. It uses a system very similar to multilayer perceptrons that are designed for reduced processing requirements [6], [9]. The first layer was an embedding layer followed by a 1D convolution layer and a max pool layer. The output from the max pool layer was fed as an input to a dense layer of 128 neurons. Finally, the output layer consisted of 1 neuron and had an activation function sigmoid.

Deep Neural Networks are stacked neural networks and have several layers. The first layer was the embedding layer. The output from this layer was fed as input to a dense layer of 128 neurons and 264 neurons. Finally, the output layer consisted of 1 neuron and had an activation function sigmoid.

RESULTS

Amongst the machine learning models, SVM performed the best with precision, recall, F1 score, and accuracy at 0.89,0.84,0.86, and 0.953 respectively. BERT performed the best amongst all the deep learning models giving precision, recall, F1 score, and Accuracy as 0.89,0.84,0.86, and 0.953 respectively. Also, it was observed that using the labels based on sentiment scores obtained from VADER gave better accuracy than using the original review stars of the reviews as labels.

Table 1: Performance measures of different machine learning and deep learning model.

Models	**Type**	**Precision**	**Recall**	**F1 score**	**Accuracy**
LSTM bidirectional	Deep Learning	0.89	0.84	0.86	0.953
LSTM	Deep Learning	0.87	0.86	0.86	0.952
DNN	Deep Learning	0.86	0.82	0.84	0.946
BERT	Deep Learning	0.90	0.89	0.90	0.964
CNN	Deep Learning	0.82	0.84	0.83	0.937
GRU	Deep Learning	0.87	0.85	0.86	0.950
SVM	Machine Learning	0.89	0.84	0.86	0.953
Logistic Regression	Machine Learning	0.90	0.79	0.84	0.950
XGBC	Machine Learning	0.88	0.62	0.67	0.921
Random Forest	Machine Learning	0.92	0.59	0.62	0.917

CONCLUSION

This research in progress provides a framework on how to compute sentiments of textual online reviews. Reviews serve as an important factor in the consumer decision-making process, as well as businesses can assess their service quality by observing the sentiments expressed in the reviews. The COVID-19 situation has disrupted the hospitality sector and the information needs of consumers also increased. The businesses were also trying to perform their best, owing to the COVID-19-induced economic downturn. Thus, the role of sentiment expressed by consumers becomes more important in this situation. We provide methods to analyze the sentiment expressed by consumers. Both machine learning and deep learning approaches can provide insight into the sentiments expressed. Appropriate sentiment computation aids in decision making process of retailers and brands to capture accurately consumer experiences.

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A dynamic model for planning and management resources and maintenance activities

Gabrielle Rosa Ribeiro, Ana Paula Cabral Seixas Costa
Federal University of Pernambuco
Av. Prof. Moraes Rego, Recife, Brazil gabrielle.ribeiro@ufpe.br,
apcabral@hotmail.com

ABSTRACT

The costs associated with maintenance represent a significant portion of the entire cost cycle of a business, which has been one of the main reasons for the increase in the economic relevance of maintenance and the use of adequate management methodologies. In this context, the challenge for managers is to be able to structure the process, maintenance activities and manage the available resources to be used. With the aim of support maintenance, several studies were developed about tools and models applied in management maintenance. The development of maintenance models supports the idea that planning is a very important step, mainly to be a process that identifies the necessary elements to define and execute maintenance actions. In real situations, once the plan is defined, the dynamics of the process can affect the condition of the components or events may occur, like a failure in an equipment, implying the replanning of the activities planned, to reduce unproductivity or improve the use of available resources. Therefore, this research presents a model of maintenance planning to support the management decision process, proposing a management of maintenance activities and resources. A dynamic model of schedule updates the activity schedule defined in the plan as changes occur during their execution, resulting in an economic scale of total costs, taking advantage of the cost of downtime, considering maintenance and human and material resources as a limitation in the analysis. Two numerical examples were applied, and as a result it was possible to verify a reduction of 54.55% in the unproductive time of the system due to the action of programmed stops in an industry that produces conveyor belts and automotive products, and a reduction of 31% in a park power generator. It is proposed to implement an optimization methodology in this model and include other significant resources for maintenance management.

Keywords: Maintenance schedule, Dynamic schedule, Maintenance management, Management resources.

INTRODUCTION

Although maintenance is considered an organization strategic nowadays, the tradeoff between investments and benefits still is a preoccupation for the managers [1]. In modern production systems, costs associated with maintenance represents a substantial portion of the entire cost cycle [2], which has been one of the main reasons that contributed to the increase in the economic relevance of maintenance and the selection of appropriate management methodologies. Once small improvements in the management of activities can result in economies of scale [3].

However, the challenge for managers is to be able to structure the processes, maintenance activities and manage the available resources to be used in the best way possible, to guarantee an efficient

and effective management integrated with the organization's strategic objectives [4,5]. In this context, several studies searched support maintenance management, as [6] who present a reliability-centered maintenance approach combined with an optimization model for development of maintenance plans in hospital environments. [7] proposed a model of optimization to find an optimal solution for maintenance planning and resource allocation in wind farms. [8] developed a road maintenance planning model with an approach to balance costs, as well as [9] propose a model capable of integrating real-time process information of the production system to obtain a dynamic maintenance plan with minimal cost.

The development of maintenance models supports the idea that planning is a very important step for the maintenance sector, mainly to be a process that identifies the necessary elements to define and execute maintenance actions [10]. In general, the objective of planning is supporting managers to define the items that need to be maintained and when maintenance interventions should be carried out. The implementation of planning leads to the establishment of maintenance policies, which can be associated with a mathematical model, to help establish the levels of each action, periodicity, and optimization of associated resources [4].

In maintenance, optimization has the main objective of finding an effective implementation of these policies to maximize system availability or minimize costs associated with maintenance [11]. In real situations, the dynamics of the process can affect the condition of the components and consequently the maintenance schedules, generating the need to incorporate current information to obtain a dynamic schedule [9] Once the plan is defined, events may occur that imply the replanning of the activities planned, to reduce unproductivity or improve the use of available resources.

Opportunistic maintenance is one of the most popular approaches about optimization in maintenance [12], because it is based on the idea of optimizing the use of resources, due to its great potential for economies of scale. The identification of these opportunities helps to obtain the optimal maintenance policy, once, in a system with dependencies, the maintenance in one component may depend on the states of the other components [13]. This method is directly associated with the failure-based method, where the optimization considers the dynamic process of equipment [14]. More specifically, the definition of a dynamic schedule of maintenance activities provides the opportunity to define the ideal moment for preventive activities, since new information is incorporated throughout its execution. By considering these variations, it is possible to avoid causing unnecessary stoppages and preventive maintenance activities, generating total cost savings.

Specifically, the dynamics of the process can affect the condition of the components and consequently the predefined periodicities in the schedule, resulting in the need to incorporate current information to obtain a dynamic maintenance schedule instead of a fixed one based on project information [9]. Therefore, the definition of a dynamic schedule of maintenance activities provides the opportunity to define the ideal moment for preventive activities, since new information is incorporated throughout its execution. It is possible to avoid unnecessary stops and excessive maintenance activities, generating total cost savings.

However, in the scope of planning, some basic questions must be answered, such as the identification of the necessary resources, since maintenance actions are increasingly restricted to other business functions, such as the control of spare parts [15,16]. Therefore, the supply of spare parts and the availability of labor are key issues to ensure an effective implementation of maintenance requirements [11]. In practice, the excess stock of spare parts results in a high inventory cost, on the other hand, the lack of inventory can cause a downtime and lead to production losses. In this way, the adequate development of maintenance strategies does not depend only on the moment in which

the maintenance actions occur, but also on the human and material resources available to implement such strategies [17].

This paper presents a dynamic model of maintenance planning that can support the decision management process, proposing a management of maintenance activities and resources. Thus, in this way, the activities defined in the plan can follow the changes that occur during its execution, resulting in a scale economy of total costs, by taking advantage of the cost of downtime, considering maintenance and human and material resources as decision variables when proposing a schedule.

METHODOLOGY

The model proposed in this work is an improvement of the work developed and published in [18]. It aims to add to the annual maintenance plan the dynamics in defining the schedule of activities. When new information about failures and maintenance actions is registered, the model can identify the resulting opportunities considering the limitations of maintenance. In practice, it is common that during the occurrence of failures in a physical system, the plan of maintenance activities remains unchanged, causing a large volume of downtime, in the case of critical items for the production process.

Two moments are considered as opportunities. The first is when a failure in the equipment, which is maintained, and the other scheduled activities are readjusted respecting the preestablished periodicity by the manager. The second is when the stop occurs due to a failure or maintenance activity in an equipment that causes a downtime in the system, resulting in the opportunity to perform maintenance on the other equipment that are part of the same system.

Firstly, it is necessary to inform the equipment that are interrelated, because the downtime of an equipment can be or can be not result in an opportunity for other equipment, this fact depends on which equipment is part of the same system. Therefore, the identification of dependencies between the equipment will indicate which opportunities arise during the execution of the plan. The identification of these opportunities is made from the information provided by the manager to the system. The model identifies occurrences of downtime and maintenance records, every time a new event occurs, adjusting the schedule of registered activities when it is available. The model has the logical structure presented in Figure 1.

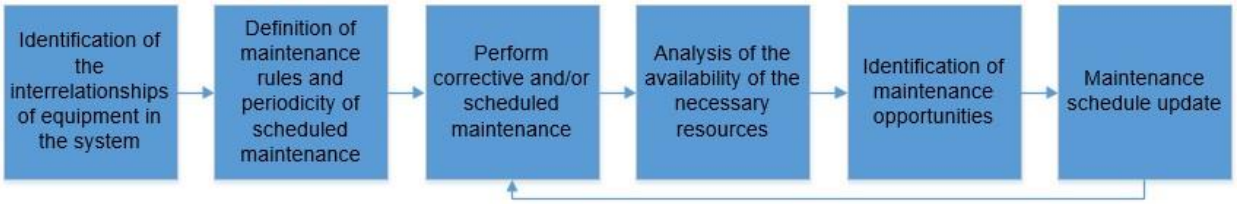

Figure 1: Diagram of the proposed model.

In front of the complexity of the maintenance system, some assumptions related to the development of the proposed model were adopted:

i. They are considered interdependent multicomponent systems, the stop item in the system implies in the other;
ii. Each component has its own deterioration process and periodicity independent of each other. Reported by the manager;

iii. Maintenance activities are considered perfect, when an item is maintained, it returns to the state of “as good as new”;
iv. Maintenance can only be anticipated;
v. Maintenance opportunities are considered the moment when the process stops due to a failure in a component, or due to scheduled maintenance;
vi. The periodicity threshold of the opportunistic maintenance is fixed;
vii. Maintenance activities are prioritized according to the age, where units that have the closest age to the failure time are prioritized;
viii. At the start of plan execution, all component is age zero;
ix. The operating time of the component since the beginning is assumed as its age.

Based on the rule presents in [19], the minimum thresholds of opportunistic maintenance (n_i) correspond to 55% of the periodicity defined for each maintenance rule. In this way, opportunistic maintenance occurs when the age x of the equipment i in the time t ($x_i(t)$) is greater than or equal to 55% of the scheduled age for scheduled maintenance (N_i) and less than 100% of the N_i.

i. If an equipment in the system fails at time t or achieves age N_i, the other equipment in the system that has age $x_i(t) \geq N_i$ is subject to scheduled maintenance;
ii. If an equipment in the system fails at time t or achieves age N_i, the other equipment in the system that has age $n_i \leq x_i(t) < N_i$ is subject to opportunistic maintenance;
iii. If an equipment in the system fails at time t or achieves age N_i, the other equipment in the system that has age $x_i(t) < n_i$, nothing is done;

Application

In this section, two numerical applications are going to be presented to illustrate the logic of the proposed model. One of them was in an industry that produces conveyor belts and automotive products. The model was applied in the rubber mixing room, which is composed of the weighing station, homogenization, Batchoff, mixer feed, mixer, and utilities.

In this application, the availability of labor (mechanics and electricians) per shift and outsourcing were considered. The maintenance manager used management software for maintenance activities, but he claimed that the software did not do an analysis of opportunistic maintenance to reduce production downtime. The objective was to provide a schedule considering maintenance downtime, aiming to maximize the Overall Equipment Effectiveness (OEE) and Total Effectiveness Equipment Performance (TEEP), reduce labor costs and increase asset reliability.

The maintenance sector operates in three shifts, each shift with two mechanics and two electricians, and an administrative shift made up of two leaders, four inspectors and four people responsible for maintenance planning and control. In addition, when necessary, the company hired outsourced labor from mechanics and electricians.

For the development of the model, the maintenance schedule was available, generated by the company's software, only for the critical items of the process, those that cause the stops of other items when they are not in operation. The information provided for the development of the model was the periodicity of each action, the timely maintenance limit, the time each operation takes, date of the last maintenance, number of mechanics and electricians is necessary. Based on this information, it was possible to apply the model to reduce the number of stops in the production

system, the downtime of the factory in 54.55%, as well as the amount of overtime compared to the initial schedule in 50%.

The second application was in an energy generating park, made up of its own plants and other energy generation projects. The objective was to minimize production stoppages, by taking advantage of the moment when the sector was stopped, due to a maintenance action, to carry out maintenance on the other components. Therefore, reduce the unproductive time of the industry.

In this application, were considered the most critical items of the processes that cause the total stoppage, the amount of available labor, and the total time in which the production can be stopped. The management provided a spreadsheet with the maintenance plan, which informed the date of each of the scheduled activities, the frequency each one is carried out, the need for electrical or mechanical labor, and the number of man-hours needed to perform the maintenance activity.

As a result of the application, a total reduction of 31% of scheduled stops was obtained. However, some inspection and cleaning activities must be carried out every week, which would not be able to relocate to another date, just take advantage of the moment when they are being carried out to carry out others or carry out all of them at the same time.

CONCLUSIONS

Based on the results obtained, it was possible to achieve the proposal of this research to implement a dynamic model to the maintenance plan, so that the schedule of activities could be adjusted, as new information is entered into the system. The proposal is to obtain a more practical schedule, reduce the total cost of maintenance, avoiding stoppages and excessive maintenance practices, considering the limitations of the process.

The results revealed, after rescheduling activities based on timely maintenance, that it is possible to significantly reduce system downtime by aggregating scheduled maintenance activities. Resulting in a 54.55% reduction in scheduled downtime compared to the initial maintenance plan in the conveyor belts and automotive products industry. It was also possible to demonstrate a 50% reduction in working Sundays, which would result in savings in the cost of extra employees. In the case of the energy generating park, the reduction presented was 31% of the scheduled stoppages in relation to the initial maintenance plan presented by the management.

Therefore, the presented model proves to be a good tool to support managers in strategic decisions. It provides a dynamic method of programming the schedule of activities, which aims to reduce downtime, considering some limitations such as availability of labor and available time that the plant can remain without operation to carry out maintenance. A decision support system is being developed to operate the model presented in this research. For future works, the proposal is that the dynamic model be implemented as an optimization model and that other significant resources in the management of maintenance activities be included in the analysis.

ACKNOWLEDGEMENT

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Why did you fail? An interpretability system for NLP models

Mohsen Rahimi, Giulia De Poli, Andrea Masella, Matteo Bregonzio

Datrix S.p.A.

Foro Buonaparte 71, 20121 Milan, Italy

mohsen.rahimi@datrixgroup.com, giulia.depoli@datrixgroup.com, andrea.masella@datrixgroup.com, matteo.bregonzio@datrixgroup.com web-page: www.datrixgroup.com/

ABSTRACT

Interpretability is an important aspect of artificial intelligence and refers to the ability to understand how a model makes its predictions and why it makes certain decisions; furthermore it is crucial for a trustworthy approach. Interpretability is particularly important in natural language processing (NLP) since it can help to identify potential biases and errors in the model, and can also help to improve the overall model performance. This paper discusses the increasing complexity of NLP models and the need for interpretability to ensure their reliability, impartiality, and accuracy. The paper proposes an interpretability system that can analyse and interpret the predictions of black-box NLP models using adversarial examples. The system uses a hybrid approach that combines both local and global interpretability methods to achieve a more comprehensive understanding of the model's behaviour.

The proposed system provides a state-of-art solution to the challenge of understanding how NLP models arrive at their decisions and when they can fail, thus improving trust between humans and machines in real-world applications. It can be used to identify potential biases and errors and to build more robust, trustworthy, and accurate models.

Keywords: Interpretability, Trustworthy AI, XAI, NLP

INTRODUCTION

Natural language processing (NLP) is a field of artificial intelligence (AI) that focuses on the interaction between computers and humans through natural language. Its applications span diverse areas, including sentiment analysis, text classification, machine translation, and chatbots. NLP models have exhibited remarkable performance in numerous tasks, which has enabled their deployment in real-world applications. However, the increasing complexity of these models has posed a challenge in comprehending how they work and arrive at decisions, necessitating the need for interpretability [1].

Interpretability refers to the ability to comprehend and clarify the decisions made by an NLP model in a way that humans can understand and trust. This is crucial because, without interpretability, it is challenging to determine whether the decisions made by an NLP model are impartial, unbiased, and consistent with human values. Additionally, it is challenging to detect and rectify any inaccuracies or biases in the model. One of the significant challenges of achieving interpretability is that NLP models frequently function as black boxes, making it difficult to comprehend how they arrive at their decisions. For instance, a sentiment analysis model might predict that a sentence is positive or negative, but it may not be evident why it made that prediction. The lack of transparency can lead to

distrust in the model, which is a significant concern in applications where the model's decisions have significant consequences [2].

Several approaches have been devised to achieve interpretability in NLP. One approach is to employ simpler models that are more accessible to interpretation, such as decision trees or logistic regression models [3]. Another approach is to use visualisation methods to exhibit how the model is arriving at its decisions. For example, heatmaps can be used to display which words in a sentence are most crucial in predicting its sentiment [4]. Finally, several metrics can be used to evaluate the model's performance and ensure that it is making decisions that conform to human values [5].

We propose an interpretability system that is capable of analysing and interpreting a prediction from an NLP black-box model, focusing on the detection of the model's weaknesses. The system leverages adversarial examples, inputs specifically crafted to cause a model to output wrong predictions, and interprets the model behaviour at the local level (single input interpretation) and global level (generalised model interpretation).

The paper is organised as follows. The next section presents a literature review in the field of AI model interpretability. Later, the proposed interpretability module is discussed with a focus on the local and global submodules. The fourth section shows experimental results, testing the system on a Hugging Face sequence-to-class model and validating it with the help of human labelling. The final section summarises conclusions and achievements, suggesting future works.

RELATED WORK

Machine learning models are susceptible to malicious attacks (e.g. adversarial attacks), which can compromise their accuracy and reliability [1,2]. However, existing strategies for preventing such attacks are not always effective and may even introduce new vulnerabilities

[5,6]. One proposed approach to address this issue is the adoption of Explainable AI (XAI) models to improve the interpretability and transparency of decision-making [7]. One approach to using XAI models for adversarial attacks is to build a "defensive model" specifically designed to detect and interpret adversarial attacks. For example, deep neural networks have been suggested for recognizing and comprehending hostile attacks on image classification systems [8]. However, the limitations of relying solely on gradient masking techniques for defending against adversarial attacks raise questions about the robustness and effectiveness of defensive models in addressing the increasing sophistication of adversarial attacks. Another strategy is to employ XAI models to explain the choices made by a system when facing adversarial attacks at a global level, using rule-based explanations. This can help justify the decisions made by a machine learning model that has been attacked and determine the contributing factors of the attack [9]. However, the fragility of interpreting neural networks and the limitations of explainable AI in improving the resilience of decision support systems against adversarial attacks may pose challenges in practical applications. To further enhance the understanding and resilience of AI models against adversarial attacks, it has been proposed to use interpretable models instead of black box machine learning models [10]. Recent studies provided a comprehensive survey of the current state-of-the-art in adversarial attacks and defences in machine learning, identifying various types of attacks and defences, and outlining research challenges and future directions for the field [11, 12]. Keller et al. [13] proposed a defence mechanism against poisoning attacks on language models, utilising a probabilistic model to detect and remove poisoned examples from the training data, while Shi et al. [14] proposed a new approach applying adversarial supervised contrastive learning (ASCL) as a defence mechanism against word substitution attacks in NLP

However, these approaches may not fully address the challenges of explaining the decisions of complex machine learning models under adversarial attacks, as the diversity and complexity of adversarial attacks in real-world decision support systems beyond patch-based attacks may require more comprehensive solutions. Therefore, further research is needed to examine the efficacy and viability of XAI models for adversarial attack interpretability in decision support systems, taking into consideration the limitations and gaps highlighted by previous works [1,15].

INTERPRETABILITY SYSTEM

The system we propose leverages adversarial attack samples to interpret the NLP model prediction, identifying in which context the model fails. It is composed of three modules, as shown in Figure 1. The first module generates adversarial attack samples, the second and third ones leverage the previous output to apply interpretability techniques at the local and global levels. This work focuses on the interpretability of NLP sequence-to-class models using adversarial samples to interpret the model behaviour. Using adversarial attacks on the input text allowed us to identify the words that were modified and to compare the original and attacked versions of the text, focusing interpretability on the model's potential prediction failures. In the next subsections, we describe the two interpretability modules at a local and global level.

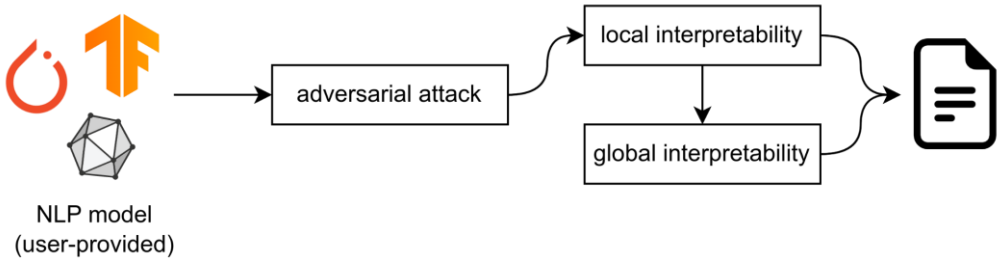

Figure 1: The system architecture is composed of three blocks. The system receives as input an NLP model and the first block generates adversarial samples. The second and third blocks provide local and global interpretability producing a report as the final output

Local interpretability

To gain insights into the impact of the adversarial attack at a local level, we leveraged SHAP (SHapley Additive exPlanations) [16], a popular approach used to explain the output of machine learning models. SHAP values quantify the contribution of each feature to the output of a model, and can therefore be used to understand how the model's output changes when the input is modified.

Specifically, we computed SHAP values for each word in both the original and attacked versions of the text. This approach,based on game theory, provides a theoretical framework for understanding how different agents interact with one another and how their behaviours affect the overall outcome. The SHAP values allow us to gain insights into how the model is making decisions and how it is affected by changes to the input, enabling us to better understand the dynamics of this interaction.

To evaluate the impact of the adversarial attack, we computed the SHAP values for each word in both the original and attacked versions of the text. Then, we compared the SHAP values between the two versions to identify the differences. In more detail, we calculated the absolute difference between each word's SHAP values in the original and attacked versions of the text. We defined a moving threshold, computed separately for each input sentence, as the median absolute deviation (MAD) of

the absolute difference of the SHAP values between the changed words. Words with a value higher than the threshold are selected as having an impact on the change of prediction.

Global interpretability

The global interpretability module consists of generating a set of rules that can explain at a global level the model's weaknesses and strengths.

A set of general rules is extracted to generalise the local explanation based on the grammar part of speech (POS) and semantic similarity. As a first step, POS is extracted from each couple of words (original word and substitute word in the attacked sample); secondly spaCy similarity score[17] between 0 and 1 is computed. General statistics are computed from the extracted values such as number of POS types (e.g. noun, adjective, etc) and number of semantically similar words which successfully attacked the model, based on the local interpretability output.

We define an algorithm to extract rules from the computed statistics. Based on a greedy approach, we first select the POS that has the highest impact in changing the prediction. From the selected POS, the algorithm evaluates if there is a difference between similar or non-similar words. The final output is a set of rules defining weaknesses in model prediction such as if the model is not robust to (1) modification of adjectives and (2) semantically similar nouns.

EXPERIMENT

The system was tested on the DistilBERT-base-uncased model [18] generating adversarial attack samples on 100 sentences from the IMDb dataset [19] that were manually labelled by three human labellers, indicating for each sample which ones of the changed words they thought had an impact on the prediction and to select two rules that describe the general behaviour of the model. The experiment results show that the system's output is consistent with human labelling while also being more robust to bias, outperforming a single human labeller and reducing human bias and variability. This indicates that the system's interpretability and generalizability make it a promising approach to understand model output

	Precision	**Recall**
Recognised by all three	0.04	0.14
Recognised by at least one	0.93	0.75

Table 1: Comparison of precision and recall metrics for changed words. Precision and recall measure the number of words that were recognised by humans compared to the ones detected by our system.

Table 1 shows the experiment results for local interpretability. The experiment shows that 93% of words detected by our system were identified by at least one human, validating the output of the model. On the other side, the same does not apply to values recognised by all three, where precision lowers down to 4%, showing that our system outperforms a single human labeller, reducing human bias and variability in labelling while cutting the time needed to manually label the samples.

The second part of the experiment validates the global interpretability module. The system outputs two rules: the model is not robust to (1) changes in verbs (independently of semantic similarity) and (2) changes in adjectives that are not semantically similar. Compared with human-generated rules, the first rule was identified by one of the three, while for the second rule two of them indicate a model

weak against adjectives, showing that the system is consistent with human labelling and able to generalise the solution. Additionally, human labelling was not able to identify the difference in behaviour with semantically similar words for the second rule. The final output is a combination of local and global interpretability. Figure 2 shows an example of the system output for one sentence, highlighting words that had more impact on the prediction change.

Original

I **love** that almost the whole movie is set in this everyone of them and the script was **amazing** I another movie. In my book Thursday is the kid thing after a shady past but then his old the Thursday. This is one of my **favorite** movies suburban house. The characters were great really wish Skip Woods would write and direct **flawless** tale of this guy trying to do the wife and drug dealer buddy shows up and it becomes quite [...].

Modified

I **iike** that almost the whole movie is set in this everyone of them and the script was direct another movie. In my book Thursday is suburban house. The characters were great **staggering** I really wish Skip Woods would write and the **irreproachable** tale of this guy trying to do the wife and kid thing after a shady past but then his old drug dealer buddy shows up and it becomes quite the Thursday. This is one of my **preferable** movies [...].

Figure 2: One example of the original text and the modified one. Four words were changed and our system detected two relevant changes from "love" to "iike" (sic.) and from "amazing" to "staggering". Compared to human labelling, two out of three were able to recognize the change from "love" to "iike" (the most important change), while just one detected "amazing" to "staggering". Additionally, both detected changes are described by the first general rule: model not robust to changes in verb.

CONCLUSIONS

We present a novel end-to-end system that addresses the challenge of interpreting NLP model weaknesses by leveraging cutting-edge practical and theoretical approaches. Our system includes an interpretability module capable of detecting potential model failures at both local and global levels based on adversarial attack. Local interpretability provides immediate insights into the words in each sentence that may cause the model to fail in its predicted output, while global interpretability suggests general rules that capture the model's behaviour based on parts-of-speech (POS) and word similarity. One of the unique aspects of our approach is its consistency with human labelling, yielding results comparable to those produced by a group of human labellers. This makes our system a valuable tool in reducing bias arising from different human interpretations and mitigating the time-consuming manual labelling and interpretation steps required for NLP model training. Our approach thus presents a new and effective means of enhancing interpretability in NLP models. Future work is needed to investigate better generalisation performance to produce more detailed rules and generation of new adversarial samples based on the model weakness output.

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Decision Support Procedure for Maturity Assessment in Asset Management

Gabriel Herminio de Andrade Lima, Ana Paula Cabral de Seixas Costa
Center of decision and information system, Federal University of Pernambuco
Recife, Pernambuco, Brazil
gabriel.herminio@ufpe.br, apcabral@hotmail.com

ABSTRACT

Physical assets are significant organizational resources, contributing to achieving business value, which includes achieving the objectives of internal and external stakeholders. Measuring the asset value is complex, demanding to develop ways to incorporate this measurement to organizational routine. In this context, measuring the physical asset management process, through asset management maturity model (AMMM), may identify the delivery of asset value. However, not all AMMMs present assessment procedures or enough information that allows the application by organizations. Motivated by these difficulties, this research in progress proposes an AMMM and a self-assessment maturity procedure, being instrumented by a decision support system, that may reduce the challenges in its application. It is expected that organizations can use this procedure to understand its delivery of asset value and prioritize actions for improve maturity.

Keywords: Asset Management, Maturity Model, Asset Value, Decision Support Procedure.

INTRODUCTION

The interest for physical asset management (AM), such as equipment, machine, and vehicle, has increased due to the asset impact in the contribution of business value and objectives [1, 2], mainly for asset-intensive organizations. Evidence in the literature has suggested that AM capabilities influence organizational performance [3, 4]. Consequently, diverse frameworks and systems have emerged to achieve the maximum value of assets.

Although understanding value is relevant, this task of designing approaches to value measurement is highly complex, with distinct ways to measure the asset value [5]. On the other hand, measuring the AM process can be a useful way to measure the contribution of assets in the value for the business because processes are created to generate value for stakeholders [6].

One major characteristic in AM is that organizations need to achieve the objectives of internal and external stakeholders [1], which has demanded holistic approaches [7]. In this context, enterprise maturity models are tools that support improving the effectiveness of processes that satisfy stakeholders and organizational objectives [8]. Then, greater maturity in the process would result in greater value delivery. Thus, asset management maturity model (AMMM), with its maturity classes, is a potential solution to support decision-making in this context.

When analyzing the available AMMMs in the literature and in the international enterprises can verify that there is not a unique assessment methodology, for example, there are AMMMs with 3, 5, and 6 classes of maturity. Although assessment methodologies are an essential element to guide an organization in the application [9], most of these models do not offer enough information to guide the application as well as do not demonstrate a precise way to make the class assessment. These difficulties in the operating of maturity models may hinder their use by organizations [8].

Based on these obstacles, this paper proposes a procedure to support self-assessment to AMMM of 6 classes, which was developed using the three initial steps of design science research [10], literature review, and analysis of enterprise asset management reports. With the aim of improving the usability and viability of the procedure has been developed first version DSSforAMMM – a decision support system that incorporates this procedure.

AMMM PROCEDURE

As mentioned in the introduction to this paper, the AMMMs found in the literature and enterprise reports have not presented enough instructions, mainly in the interplay between stages of assessment, that would guarantee replicability and usability. For example, some of these models focus on the assessor to manage the interviews, not to mention limited interpretation and attribution of the maturity classes. In this context, a maturity assessment procedure of AM is proposed to be applied in the maturity models with 6 maturity levels. These proposed levels are based on the AMMMs of 6 classes found in the literature and the enterprise report [11, 12, 13]. Table 1 describes each maturity class [11].

Table 1: Maturity classes

Class	Definition
Innocent	The organization has not recognized the need for this requirement and/or there is no evidence of commitment to put it in place
Aware	The organization has identified the need for this requirement, and there is evidence of intent to progress it.
Developing	The organization has identified the means of systematically and consistently achieving the requirements, and can demonstrate that these are being progressed with credible and resourced plans in place.
Competent	The organization can demonstrate that it systematically and consistently achieves relevant requirements.
Optimizing	The organization can demonstrate that it is systematically and consistently optimizing its asset management practice, in line with the organization's objectives and operating context.
Excellent	The organization can demonstrate that it employs the leading practices, and achieves maximum value from the management of its assets, in line with the organization's objectives and operating context.

The available AMMMs to make an assessment and to assign a maturity level take into account AM key dimensions, which correspond to the key process areas in AM that need to be assessed. Depending on the organizational context, these dimensions can have different importance, so the organization needs to establish the degree of importance for each dimension. To evaluate the organization in each dimension will need to collect information on the perception of different employees involved with

AM. To this, the application of an instrument with questions related to the maturity of the dimensions is required. Afterwards, the knowledge of these employees needs to be aggregated, in other words aggregating distinct assessments that reveal the AM maturity of the organization. These steps are presented in Figure 1 and detailed in followed.

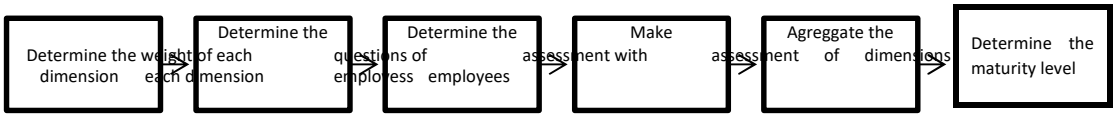

Figure 1 - AMMM Procedure

1ª Step – Determine the dimensions

In this research, dimensions are key process areas that include the set of activities needed to achieve relevant goals [14], which are aligned with the 39 subjects cited in the global forum on maintenance & asset management that allow a shared understanding of the scope of AM [15]. Although most AMMMs do not aggregate all dimensions specified in the literature [16], maturity models are effective. Hence, organizations need to select relevant core dimensions in AM to improve the main AM capabilities. Analyzing AMMMs on academic papers, institutional reports, and AMMM tools based on excel, the most dimensions cited (Table 2) can be used as core dimensions. Moreover, these AM dimensions are aligned with recent finds that strategy, planning, risk management, life cycle delivery, and performance are relevant and central for AM [4, 17].

Table 2: Dimensions more cited

Dimension	Frequency		Frequency
AM policy	88%	Asset information systems	71%
AM strategy and objectives	76%	Procurement e supply chain management	71%
AM planning	76%	AM leadership	82%
Resourcing Strategy	65%	Competence management	82%
Data and information Management	82%	Risk assessment and management	94%
Asset information Strategy	59%	Asset performance and health monitoring	100%

2ª Step – Determine the importance of dimensions

Each enterprise has a specific business that may incorporate different emphasis in AM dimensions [11]. Therefore, the weight is a manner to obtain the relative importance of dimension by an organization, which is incorporated in the determination of the maturity level phase and can support in the prioritization of actions. In addition, the maturity model enforces that many employees answer the maturity assessment, imposing different points of view to gather the weights by group, consequently increasing the complexity. So, we suggest scoring the weights vector (w) by the frequency of dimensions, applying the normalization procedure (equation 1) that does not allow null weights.

$$w_i' = \frac{f(D_i)}{Max\ f(D_i)} \qquad (1)$$

3ª Step – Determine the question set

The questions set should evaluate the dimensions, demanding at least three questions per dimension to guarantee truthfulness [18]. The literature provides some questions for these dimensions. We select and adapt three questions to each dimension that are assessed in five maturity levels [0-4] that describe the degree of attendance or evidence to the question, that is, the levels of capability (Table 1). The minimum level indicates that the organization has not put in place the required element, while the maximum level indicates the organization has achieved maximum value and exceeds the mandatory requirements.

4ªStep – Make assessment with employees

An objective of this procedure is to reduce the dependence on the assessor in the assessment of maturity. For this, the organization needs to record and store the questionnaire answers anonymously. In this case, DSS web is required to operationalize and maintain assessment information.

5ª Step - Aggregate the assessment of employees

The average is a common procedure to attain the group metric, nevertheless, researchers have shown that the average is not adequate to aggregate opinions when the opinions have a high variation [19,20], demanding alternative ways to aggregate the group opinion. In this way, the fuzzy number constructed method based on a grading process is a way to reach the group preference [20].

As noted above, n employees make evaluation of questions in a five points scale (g , … , g , where g ≠ g for at least one pair of $i \neq j$). This method explores localize the center, for this, calculate the distance matrix $D = d$ between each g . Afterwards, the average of relative distances is calculated for each g (equation 2), which allow to evaluate the closeness to the center of all scores. To each $\vec{d}$ is assigned a weight (k) that establishes the importance through a pair-wise comparison matrix $P = p$ obtained by equation 3.

$$\bar{d}_i = \frac{1}{(n-1)} \sum_{j=1}^{n} d_{ij} \quad (2) \qquad p_{ij} = \frac{\bar{d}_j}{\bar{d}_i'} \quad (3) \quad k_j = \frac{1}{\sum_{i=1}^{n} p_{ij}}, j = 1, \dots, n. \quad (4)$$

The mode m of the fuzzy number is defined as $m = \sum k\ g$, substituting the arithmetic average. Similarly, to obtain the aggregation of each dimension s, we incorporate the average of set of questions Q de each dimension (equation 5). $A = \_\_ \sum \sum \quad k\ g \quad , z = 1, \dots, Q\ and\ s = 1, \dots, D$ (5)

Where D is the number of decision maker and D is the dimension.

6ª Step - Find the maturity level

All dimensions of AMMM should be aggregated to attain the unique metric, the maturity level Ml, that represent the current capability in AM. For this, equation 6 measures the maturity level AM, between 0 and 4, that is the scale utilized to measure each question.

$$Ml = \frac{\sum A}{\sum} . w , z = 1, \dots , Q , s = 1, \dots , D \; and \; Ml \in [0,4] \quad (6)$$

Based on the $Ml \in [0,4]$ we adopted the following classification to determinate the maturity class:

$$Class: \begin{cases} No\ applied, iff\ Ml = 0; \\ Aware, iff\ 0 < Ml < 1; \\ Developing, iff\ 1 \leq Ml < 2; \\ Competent,\ iff\ 2 \leq Ml < 3; \\ Optimising, iff\ 3 \leq Ml < 4; \\ Excellent, iff\ Ml = 4. \end{cases}$$

CONCLUSIONS

Asset-intensive organizations need to map value delivery of their assets for improve AM performance, which can be done by AM process. Thus, this paper introduces a procedure to support the self-assessment of maturity in AM for these organizations, focusing on the main AM processes.

In the theoretical perspective, the procedure contributes to evolving elements different that improve the applicability, such as taking into account the relative importance of dimension by each organization in the assessment [11], aggregating the group assessment [19, 20], and documented assessment methodology [9].

In the practice perspective, the procedure and DSS web allows operationalize and ease the self-assessment of AM maturity by the organization, as well as reduce dependence on accessor. In addition, the maturity level and the weight vector organizations can locate the dimensions that have constrained the growth, and thus, prescriptions can be allocated to improve the maturity level in effective way. Consequently, the organization may achieve maturity model and AM benefits, like as enhance the contribution of the asset value, and organizational performance and knowledge [1,2,3,4,6,8]

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