Proceedings of the IFIP DSS 2018: 19th Open Conference of the IFIP WG 8.3 on Decision Support Systems

"DSS Research Delivering High Impacts to Business and Society"

13-15 June, 2018
Ljubljana, Slovenia

Biljana Mileva Boshkoska,
Marko Bohanec, Martin Žnidaršič (Eds.)

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http://ifip2018dss.ijs.si/

The International Federation for Information Processing
Working Group 8.3 on Decision Support Systems (IFIP DSS)

Proceedings of the 19th Open Conference of the IFIP WG 8.3 on Decision Support Systems (IFIP DSS 2018)
"DSS Research Delivering High Impacts to Business and Society"

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Preface

IFIP Working Group 8.3 is an international community of researchers and practitioners interested in the use of technology to support decision making. The working group operates in the context of IFIP, the International Federation for Information Processing, the leading multinational organization in Information & Communications Technologies and Sciences. The Working Group 8.3 was founded in 1981. Among other activities, the group organises biannual conferences, inviting international researchers and practitioners to present and discuss the most recent developements in Decision Support Systems (DSS) and related areas, such as Decision Making (DM), Decision Analytics (DA) and Business Intelligence (BI). Each conference has a leading theme that is chosen so as to reflect major trends in DSS at the time of the conference. Conference papers are peer-reviewed and published by renowned publishers. Some of the seminal works in DSS have been first presented at IFIP DSS conferences.

It is a great pleasure – and honour – to host the *19th IFIP DSS 2018* conference in Ljubljana, Slovenia. The conference returns to Slovenia after 20 years, in celebration of the successful conference on *Context Sensitive DSS* that was held in 1998 at Bled. Since then, a number of IFIP DSS conferences took place, including the ones in Lisbon, Portugal (2010), Anávissos, Greece (2012), Paris, France (2014), and Cork, Ireland (2016). This time, the conference is located in Ljubljana, the capital city of Slovenia, and hosted by the "Jožef Stefan" Institute, the largest national research organisation.

The theme of the conference *"DSS Research Delivering High Impacts to Business and Society"* highlights the main purpose of DSS: providing support to people and organisations faced with difficult decision problems in a variety of contexts. This requires applying DSS expertise to problems that arise in other disciplines, such as healthcare, organisation management, specific business areas, media, and many others. The IFIP DSS 2018 conference highlights the applications, methods, stakeholders and impacts of decision making and decision support in today's society and business. It emphasies the needs for collaborating between DSS with other domains in order to solve decision makers' problems. It also highlights the needs to develop appropriate methods and tools, and properly incorporate them in organisations and society.

This IFIP DSS 2018 conference features several events. First, there are two keynote speeches, presented by invited distinguished researchers:

- *Real-time decision support in smart cities: will IoT and global awareness help?*, presented by Dr. Arkady Zaslavsky, a Senior Principal

Research Scientist with Data61, Commonwealth Science Industrial Research Organisation, Australia.

- *Post-market environmental risk assessment of pesticides used in agriculture*, presented by Prof. Dr. Marko Debeljak, a Senior Research Fellow at the Department of Knowledge Technologies, "Jožef Stefan" Institute, Slovenia.

Then, there are presentations of 26 papers, which were blindly peer-reviewed and selected from 35 submitted papers. These papers are published in full by *Taylor & Francis* as a supplement to the *Journal of Decision Systems*. Abstracts of these papers are reproduced in these proceedings.

The papers will be presented at the conference in a single-track consisting of five sessions, which address the topics:

- DSS in Health Care;
- DSS for Risk, Safety, Security and Uncertainty Management;
- DSS Methodologies;
- DSS Applications;
- DSS in Organisations.

Additionally, there is a poster session with 12 posters, a record-breaking number for IFIP DSS conferences. All the posters are reproduced in these proceedings.

We hope that this package, together with several social events, will provide a fruitful working environment and memorable experience for all participants of the conference.

We thank everyone who contributed to the organisation of the conference: the authors, conference officers and reviewers. We thank the *European Working Group on DSS* (EWG-DSS) for the general support and co-organisation of one session. We thank the publisher, *Taylor & Francis*, for a kind permission to reproduce abstracts of the papers. We also thank the *"Jožef Stefan" Institute* for providing facilities for hosting the conference.

Ljubljana, May 15, 2018

The Editors:

Biljana Mileva Boshkoska
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Conference program at a glance

	13.6.2018	14.6.2018	15.6.2018
8:00-9:00	Registration		
9:00-10:30	Welcome Address Keynote 1: Marko Debeljak	Keynote 2: Arkady Zaslavsky	Panel Data Analytics for Predicting in a Decision Making Context
10:30-11:00	Coffee	Coffee	Coffee
11:00-12:30	Session 1: DSS in Health Care	Session 3: DSS Methodologies	Session 5: DSS in Organisations
12:30-14:00	Lunch	Lunch	Lunch
14:00-15:30	Session 2: DSS for Risk, Safety, Security and Uncertainty Management	Session 4: DSS Applications	IFIP WG8.3 Business Meeting
15:30–16:00	Coffee		Conference Closing
16:00-17:00	Poster Session		
17:00	Welcome Reception		
18:00		Ljubljana Tour	
20:00		Conference Dinner	

Conference Programme

DAY 1	**Wednesday, 13.6.2018**
8:00–9:00	**Registration**
9:00–9:15	**Welcome address**
9:15–10:30	**Keynote 1** Session Chair: Ana Respicio Arkady Zaslavsky: Real-time decision support in smart cities: will IoT and global awareness help?
10:30–11:00	*Coffee Break*
11:00–12:30	**Session 1: DSS in Health Care** Session Chair: Ciara Heavin Julie Cowie, Frada Burstein: A decision support tool for supporting individuals with long-term conditions make informed choices: LTC-Choices tool for continuous healthcare Valerija Rogelj, David Bogataj: Planning and Financing the Home and Facility-Based Care using the Multiple Decrement Approach Lu Bai, Frada Burstein, Rob Meredith: A Data Quality Framework, Method and Tools for Managing Data Quality in a Healthcare Setting: An Action-case Study Marcelline Blanche Manjia, Georges Edouard Kouamou, Chrispin Pettang: The Geographical accessibility as a key access parameter to health care in Cameroon: Modeling, measurement, and evaluation Marko Bohanec, Dragana Miljković, Anita Valmarska, Biljana Mileva Boshkoska, Elisabetta Gasparoli, Giovanni Gentile, Konstantinos Koutsikos, Andrea Marcante, Angelo Antonini, Dimitrios Gatsios, George Rigas, Dimitrios I. Fotiadis, Kostas M. Tsiouris, Spiros Konitsiotis: A Decision Support System for Parkinson Disease Management: Expert Models for Suggesting Medication Change
12:30–14:00	*Lunch Break*
14:00–15:30	**Session 2: DSS for Risk, Safety, Security and Uncertainty Management** *This session is co-organised with the EWG-DSS, European Working Group on DSS* Session Chair: Boris Delibašić Luís Almeida, Ana Respicio: Decision Support for Selecting Information Security Controls Stanislaw Drosio, Stanislaw Stanek: Building safe society

environment: A summary of a hybrid approach for Crisis Decision Support System
Boris Delibašić, Sandro Radovanović, Miloš Jovanović, Marko Bohanec, Milija Suknović: Integrating knowledge from DEX hierarchies into a logistic regression stacking model for predicting ski injuries
Ricardo Rodriguez-Ulloa: Systemic Methodology for Risks Evaluation and Management in the Energy and Mining Sectors (SYSMEREM-EMS) using Bayesian Networks
Jean-Charles Pomerol: Business Uncertainty, Corporate Decision and Startups

15:30–16:00 *Coffee Break*

16:00–17:00 **Poster Session**
Session Chair: Martin Žnidaršič

16:00 Rok Drnovšek, Tanja Rupar, Marija Milavec Kapun, Vladislav Rajkovič: Multi-attribute decision model for preventing ventilator-associated pneumonia

16:05 Mitja Luštrek, Aljoša Vodopija, Marko Bohanec, Miha Mlakar, Erik Dovgan, Pavel Maslov, Anneleen Baert, Sofie Pardaens, Els Clays, Paolo Emilio Puddu: heartMan: Personal Decision Support for Heart Failure Management

16:10 Alenka Žibert, Bernarda Lončar, Saša Šajn Lekše, Uroš Rajkovič, Andrej Starc: Assessment model of health supporting behaviors in pregnant women

16:15 Jean Turet, Jadielson Moura, Ana Paula Cabral, Fatima Dargam, Pascale Zaraté, Isabelle Linden: EWG-DSS Project Collab_Net (Version 5)

16:20 Aneta Trajanov, Taru Sanden, Vladimir Kuzmanovski, Heide Spiegel, Nicolas Saby, Marko Debeljak: Validation of decision support models using data mining: A case study on primary productivity in agricultural fields in France

16:25 Marko Debeljak, Jonathan Marks-Perreau, Benoit Real, Vladimir Kuzmanovski, Aneta Trajanov: Decision support system for flexible risk management: A case of water pollution by pesticides

16:30 Francesca Bampa, Rachel Creamer, Aneta Trajanov, Marko Debeljak: Structuring empirical European knowledge on soil and land management using multi-criteria decision analysis

16:35 Tanja Dergan, Aneta Trajanov, Marko Debeljak: Development and application of a decision support system for assessing service quality at tourist farms

16:40 Sonja Šterman, Mirjana Kljajić Borštnar: Multiple criteria

decision analysis for uniform selection

16:45 Bojan Cestnik, Alenka Kern: Generating actionable decision rules with fast-and-frugal trees

16:50 Adem Kikaj, Marko Bohanec: Complex decision rules in DEX methodology: Comparative analysis of algorithms

16:55 Gaetano Bruno Ronsivalle, Arianna Boldi: Data-driven decision-making: how to build a "hybrid intelligence" in organizations with Machine Learning Algorithms

17:00–19:00 *Welcome Reception*

DAY 2 **Thursday, 14.6.2018**

9:00–10:30 **Keynote 2**
Session Chair: Marko Bohanec
Marko Debeljak: Post-market environmental risk assessment of pesticides used in agriculture

10:30–11:00 *Coffee Break*

11:00–12:30 **Session 3: DSS Methodologies**
Session Chair: Gloria Philips-Wren
Petra Grošelj, Lidija Zadnik Stirn: Evaluation of several approaches for deriving weights in fuzzy group analytic hierarchy process
Mohan Krishnamoorthy, Alexander Brodsky, Daniel A. Menasce: Stochastic Decision Optimization based on Deterministic Approximations of Processes described as Closed-form Arithmetic Simulation
Andrej Bregar: Decision support on the basis of utility models with discordance related preferential information: investigation of risk aversion properties
Dijana Oreški, Nina Begičević Ređep: Data-driven decision making in classification algorithm selection
Oleg Evsutin, Anna Kokurina, Roman Meshcheryakov: Approach to the Selection of the Best Cover Image for Information Embedding in JPEG-images Based on the Principles of the Optimality

12:30–14:00 *Lunch Break*

14:00–16:00 **Session 4: DSS Applications**
Session Chair: Frada Burstein
Alex Miles, Arkady Zaslavsky, Chris Browne: IoT-based Decision Support System for Monitoring and Mitigating Atmospheric Pollution in Smart Cities
Olga Rybnytska, Frada Burstein, Andrei V. Rybin, Arkady Zaslavsky: Decision Support for Supporting Sustainable Waste Management

	Trajče Nikoloski, Andrej Udovč, Martin Pavlovič, Uroš Rajkovič: Multi-criteria assessment model for farm reorientation Biljana Mileva Boshkoska, Shaofeng Liu, Huilan Chen: Towards a knowledge management framework for crossing knowledge boundaries in agricultural value chain Siamak Farshidi, Slinger Jansen, Rolf de Jong, Sjaak Brinkkemper: A Decision Support System for Technology Selection in Software Production Kazimierz Frączkowski, Barbara Gładysz, Dorota Kuchta, Stanisław Stanek: Selection of IT projects to be implemented in an organisation to maximise their success probability
18:00	*Ljubljana Tour*
20:00	*Conference Dinner*

DAY 3	**Friday, 15.6.2018**
9:00–10:30	**Panel** Session Chair: Fred Adam Data Analytics for Predicting in a Decision Making Context
10:30–11:00	*Coffee Break*
11:00–12:30	**Session 5: DSS in Organisations** Session Chair: Fred Adam Gloria Phillips-Wren: Assessing the Impact of Corporate Board Independence and Diversity on Strategic Decision Making Stephen McCarthy, Paidi O'Raghallaigh, Ciara Fitzgerald, Frédéric Adam: Social Complexity and Team Cohesion in Multiparty Information Systems Development Projects Ciara Heavin, Daniel J. Power: Challenges for Digital Transformation – Towards a Conceptual Decision Support Guide for Managers Imad Bani-Hani, Jörg Pareigis, Olgerta Tona, Sven Carlsson: A holistic view of value generation process in a SSBI environment: a service dominant logic perspective Mary Daly, Tom Butler: Conduct Risk: towards a model for assessment and remediation
12:30–14:00	*Lunch Break*
14:00–15:30	**IFIP WG 8.3 Business Meeting**
15:30–16:00	**Conference Closing**

Venue

Conference will take place in Ljubljana, Slovenia in the main lecture hall of Jožef Stefan Institute. The address of Jožef Stefan Institute is:

Jožef Stefan Institute
Jamova 39
SI – 1000 Ljubljana
https://www.ijs.si/ijsw/JSI

How to get to Jožef Stefan Institute

Walking from the city center: If you decide to walk from your hotel to the Institute, it will take you approximately 20 minutes. Ask at the hotel reception for directions or check our website for visitors.

By city bus: If you take the bus the fee €1,20 can only be paid with the Urbana Card (http://www.jhl.si/en/single-city-card-urbana), which can be bought for €2 at many locations including various tobacconists and news-stands, tourist offices, or at the central bus station. Credit can be added at these same locations or at green ticket vending machines (Urbanomat) scattered around town. The fee includes unlimited number of bus changes within a 90 minutes period. For group transport one card is sufficient, just inform the driver in advance how many persons you are paying for. Please note that Urbana is the only paying system and there is no possibility to buy a ticket on the bus.

From the city centre, we recommend you to take bus no. 1 (direction Mestni log) because it stops in front of the side entrance to the Jožef Stefan Institute on Jadranska street. Another option is to take bus no. 6 (direction Dolgi most) that stops on Tržaška street, which is about 5 minutes' walk from the Institute.

By taxi: taxi fare cost from the city center is about 5€. The cheapest taxi companies are:

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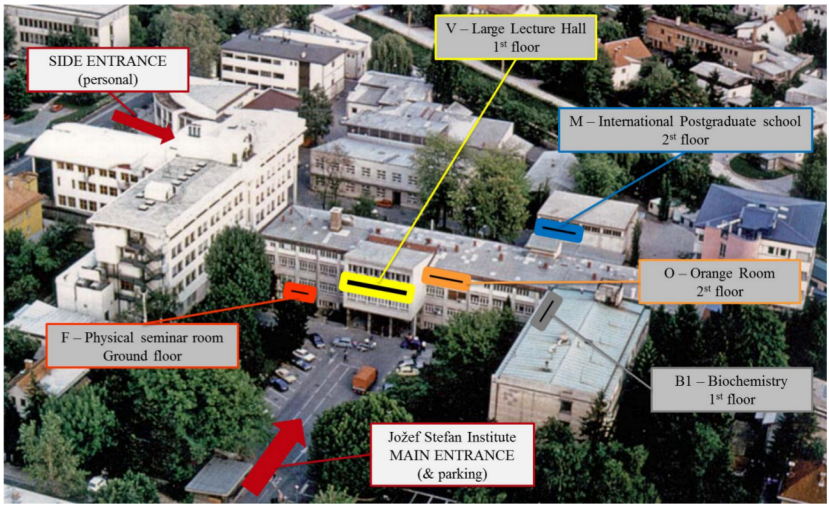
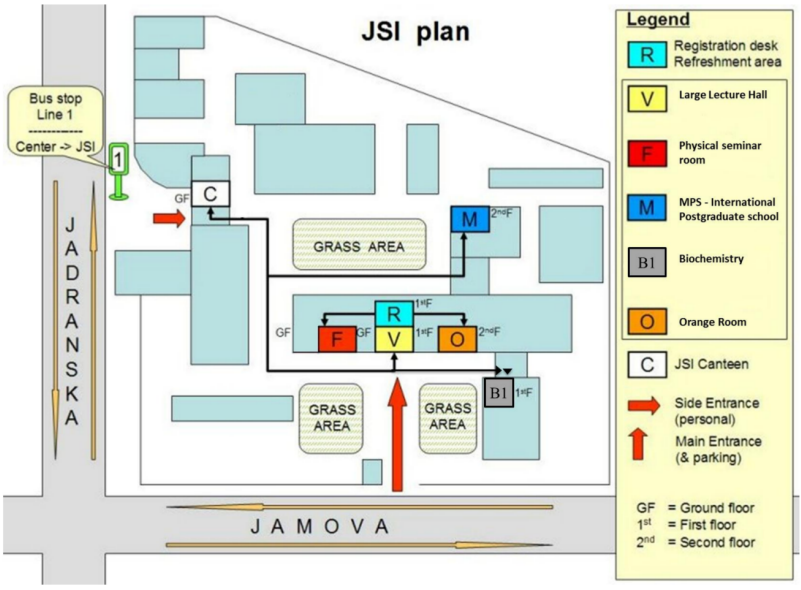
Map of the "Jožef Stefan Institute" buildings



Plan of the main building of "Jožef Stefan Institute" where the Large Lecture Hall is situated



About Slovenia

Slovenia lies in the heart of Europe, where the Alps meet the Mediterranean and the Pannonian Plain meets the Karst. You will be surprised by a fascinating variety of landscapes on no more than 20,000 square kilometres. Slovenia, the second most forested country in Europe, is a land of greenery, which offers great opportunities for activity holidays, and it is perfect for a summer holiday, a winter break or a weekend away. Its neighbours are Italy to the west, Hungary to the northeast, Austria to the North and Croatia to the South and Southeast.

Art and culture have a special place in Slovenia's history, as in many respects they helped to compensate Slovenes for their lack of national, political and governmental institutions. It is thus understandable that even today Slovenes have a very intense relationship with their national culture. To a great extent, pride in the national culture still represents a compensation for the old lack of national sovereignty. Slovenia is probably the only country in the world which has a national holiday devoted to culture.

Slovenia has a population of two million. The inhabitants of Slovenia are regarded as hard-working, diligent and proud people. The most important values for the just over two million inhabitants include family, health and honesty. Their toil and persistence has allowed many Slovenes to achieve at the global level. Something of major importance for the Slovenian national consciousness and sense of belonging is the Slovenian language, or slovenščina. This is the official language of the country, while in areas inhabited by members of the Italian and Hungarian ethnic communities, Italian and Hungarian are also official languages.

About the capital town Ljubljana

Ljubljana is a city by the river. Besides having everything that all the other modern capitals have, Ljubljana has succeeded in maintaining the relaxed atmosphere of a small city. It is classified as a mid-sized European city, but it has preserved its small-town friendliness and relaxed atmosphere while providing all the facilities of a modern capital. It is a very unique city dotted with pleasant picturesque places where you can expect all kinds of nice little surprises. During winter, its dreamy central European character prevails, and during summer its relaxed Mediterranean feel. Due to its geographical position, Ljubljana is a perfect base for exploring the many faces and beauties of Slovenia. This picturesque and very vibrant city is full of sights worth seeing. *Dobrodošli /Welcome!*

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Real-time decision support in smart cities: will IoT and global awareness help?

Arkady Zaslavsky

About the author Dr. Arkady Zaslavsky is a Senior Principal Research Scientist with Data61, CSIRO. Commonwealth Science Industrial Research Organisation (CSIRO) is Australia's national research agency. Arkady is leading Data61 R&D projects in Internet of Things, mobile analytics and context-awareness science areas. He is a technical leader of the EU Horizon-2020 project bIoTope – building IoT Open Innovation Ecosystem for connected smart objects. Professor Arkady Zaslavsky holds Adjunct-Professorship appointments with a number of Australian and International universities, including UNSW, La Trobe University, University of Luxembourg and ITMO University, StPetersburg. Arkady Zaslavsky has published more than 400 research publications throughout his professional career and supervised to completion more than 35 PhD students. Arkady Zaslavsky is a Senior Member of ACM, a Senior Member of IEEE Computer and Communication Societies.

Abstract: Smart cities are an emerging paradigm which is characterized by high diversity of applications, interoperability challenges, policy issues, data availability, big data and data access openness, challenges of deploying IoT infrastructure, diverse and heterogeneous data sources, cross-domain analytics and many other challenges. Real-time decision support for various stakeholders in smart cities is a critical challenge that can be only addressed by collective R&D effort from many disciplines of computer science, business and information systems. Among enabling technologies for smart cities is the Internet of Things (IoT) which is one of the major disruptive ICT technologies. IoT will connect billions of "things", where things include computers, smartphones, sensors, actuators, instruments, robots, objects from everyday life. IoT will be the main source of big data according to predictions of many experts. This talk focuses on myths and challenges of smart cities and the IoT. IoT big data underpins the ability to develop a notion of IoT ecosystem-wide awareness of everything that happens, happened or might happen within the system realm, whether these are processes, events, activities, locations, preferences related to human users as well as all of the components of a cyber-physical system (CPS) in question. We term this awareness as "IoT-enabled awareness" i.e. the ability of the system, application and/or service to be globally-aware, including context-aware, situation-aware, event-aware, human-aware, location-aware, process-aware, and so on and so forth. The talk will also showcase a CSIRO IoT platform "Context-as-a-Service" (CoaaS) which is being developed as part of EU Horizon-2020 project biotope. Examples of using CoaaS in various use cases, including intelligent transportation systems and smart waste management, will be also demonstrated.

Post-market environmental risk assessment of pesticides used in agriculture

Marko Debeljak

About the author Prof. Dr. Marko Debeljak is a senior Research Fellow at the Department of Knowledge Technologies, "Jožef Stefan" Institute, Slovenia. His research goals are applications of advanced decision analysis in environmental sciences, in particular to agriculture in order to improve the quality of scientific and management decisions that would facilitate sustainable management of natural renewable resources and production of healthy food. His approach is based on development of qualitative multi-attribute decision models induced by DEXi modelling tool that he applies in several agronomic domains. This includes topics concerning the adverse effects of genetically modified crops on the environment, the impacts of various agronomic practices on soil quality, traceability of agronomic products through the quality chains, environmental assessment of pesticide use and assessment of sustainable farming systems. His approach facilitates transdisciplinary and multi-actor collaboration of experts involved in the decision process and provides flexible decision support to decisions makers and decision users.

Abstract: The application of pesticides in agriculture is not always safe for human health and the environment. Despite being officially approved by authorities in terms of ecological risk, they appear in surface and ground water in concentrations above the official thresholds. Due to the existing problems with water pollution with pesticides, the improvement of post-authorisation and post-market environmental risk assessment and management of pesticides is needed.

To address this challenge, we used a decision making approach that is based on i) a combination of expert knowledge about the application of different crop and soil management practices for the reduction and elimination of water pollution with pesticides, ii) data about meteorological conditions and soil properties of the crop protection plans for specific field conditions, and iii) management constraints of the farmers (e.g., availability of field infrastructure elements, such as buffer strips, fascines, soil drainage system, etc.).

Developed decision support system (DSS) comprising risk assessment and risk management modules. The first module evaluates the risk of the application of the proposed application of pesticides for the pollution of ground and surface water with pesticides. The second module explores the possibilities for the reduction of the pollution risk, if it was recognized in the first module, and outputs a list of

mitigation measures applicable at the field level to alleviate the risk (risk management module) of water pollution with pesticides.

To develop a DSS we used a Multi Criteria Decision Analysis implemented into the DEX (Decision EXpert) integrative methodology of building qualitative multi-attribute decision models by the DEXi modelling tool. The DSS system for environmental safe use of pesticides is developed for the arable land area of the entire continental France and is designed for the application at the field level. The validation of the developed DSS system was performed on data from the experimental site La Jaillière (a reference site for the European Commission FOCUS working group), guidelines for best management practices for prevention of water pollution with pesticides disseminated by the TOPPS – EU Life project and expertise about sustainable used of pesticides provided by the ARVALIS, Institut du végétal, France. DSS is implemented in a web-based application available to end-users.

Panel

Data Analytics for Predicting in a Decision Making Context

Frédéric Adam (Chair) [1], Frada Burstein [2], Gloria Philips-Wren [3], Arkady Zaslavsky [4], Blaž Zupan [5]

Abstract: A lot of predictive analytic efforts focus on developing propensity scores (1%-100%) or probabilities that certain events or certain patterns of behavior (eg: consumer behavior) might occur. This narrow focus loses the decision making context and the execution processes required to truly understanding the implications of prediction and the resultant actions required to deliver desired impact. To reach its potential predictive analytics cannot be uncoupled from this decision making context. Participants in the panel will debate on the limits of data analytics and the role of managerial intuition in making the right call.

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Full papers abstracts

Assessing the Impact of Corporate Board Independence and Diversity on Team Decision Making

Gloria Phillips-Wren[1]

Abstract: Corporate Boards of Directors are governing bodies responsible for the overall activities of the corporation in dealing with its environment. These strategic decision- making groups have been studied for their impact and reflection of societal values from perspectives such as gender diversity, racial diversity, ethnic diversity, and board independence. Yet little research has been done on underlying attributes of diversity such as diversity of thought as it affects decision making. This paper uses Social Network Analysis to investigate social ties between corporate boards using a rich dataset of 1,430 largest publicly traded firms in the US. We develop a measure of diversity from 2Step centrality and relate it to firm performance through cluster analysis. The results show that diversity of thought can be indirectly studied and related to improved team decision making.

Keywords: corporate boards of directors; diversity; independence

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A Decision Support System for Parkinson Disease Management: Expert Models for Suggesting Medication Change

Marko Bohanec[1], Dragana Miljković[1], Anita Valmarska[1], Biljana Mileva Boshkoska[1,2], Elisabetta Gasparoli[3], Giovanni Gentile[3], Konstantinos Koutsikos[3], Andrea Marcante[3], Angelo Antonini[3], Dimitrios Gatsios[4] George Rigas[4], Dimitrios Fotiadis[4], Kostas Tsiouris[5], Spiros Konitsiotis[4]

Abstract: Parkinson's disease (PD) is a degenerative disorder of the central nervous system, which requires a long-term, interdisciplinary disease management. The EU Horizon 2020 project PD_manager (http://www.parkinson-manager.eu/) is aimed at developing a decision support system for PD management. As part of this task, we have developed decision-support models that identify situations in which the disease has progressed to the point which requires a change of medical therapy. The input data includes motor symptoms, non-motor symptoms and epidemiologic data. The models were developed in collaboration with medical experts, using a qualitative multi-criteria method DEX. In this paper, we describe the process and results of model development, and assess the quality of models in terms of classification accuracy, transparency, correctness, and completeness.

Keywords: Parkinson' disease; multi-criteria model; method DEX

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A decision support tool for supporting individuals with long-term conditions make informed choices: LTC-Choices tool for continuous healthcare

Julie Cowie[1], Frada Burstein[2],

Abstract: An increasing number of individuals are now living with some form of chronic, long- term condition (LTC). The holistic perspective of LTCs makes it important to acknowledge that priorities and decisions are in fluctuation over the course of an individual's life. The landscape of digital healthcare is full of information systems that capture individuals' health data, clinical guidelines and/or advice on health conditions, which taken together can help create a comprehensive overview of suitable lifestyle choices to optimise health and well-being. Despite this, there is no evidence of existing frameworks to support individuals living with LTCs from a continuum of care perspective. In this paper we propose such a multidimensional model for a decision support tool - LTC-Choices. This tool was developed from existing work conducted by the authors around use of multicriteria to support health decision making.

Keywords: multicriteria; decision making; long term condition; digital health; stroke

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Stochastic Decision Optimization based on Deterministic Approximations of Processes described as Closed-form Arithmetic Simulation

Mohan Krishnamoorthy[1], Alexander Brodsky[1], Daniel Menasce[1]

Abstract: We propose an efficient one-stage stochastic optimization algorithm for the problem of finding process controls that minimize the expectation of cost while satisfying multiple deterministic and stochastic feasibility constraints with a given high probability. The proposed algorithm is based on a series of deterministic approximations to produce a candidate solution set and on a refinement step using stochastic simulations with optimal simulation budget allocation. We conduct an experimental study for a real- world manufacturing service network, which shows that the proposed algorithm significantly outperforms four popular simulation-based stochastic optimization algorithms.

Keywords: decision support; decision guidance; deterministic approximations; stochastic simulation, optimization; heuristic algorithm

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Multi-criteria assessment model for farm reorientation

Uroš Rajkovič[1], Trajče Nikoloski[2], Andrej Udovč[2], Martin Pavlovič[3]

Abstract: Structural changes in agriculture present a grand challenge for all levels of decision making from governmental to individual farms. A multi-criteria decision model is presented to support the decision process of farm reorientation in horticulture based on criteria regarding region and specific farm. The goal is to alleviate the process through argumentation and transparency offered by the model. It was constructed by an expert group using the DEX methodology. The model has been tested in practice and its results for selected farms are presented in this article. The added value can be viewed as a transparent knowledge management tool in different fields of regional planning and as an aid for advising farmers to better understand the consequences of their decisions.

Keywords: multi-criteria decision modelling; DEX methodology; farm reorientation

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Decision Support for Supporting Sustainable Waste Management

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Abstract: During the last few decades, research into sustainability aspects of ICT grew rapidly for most organizational and business processes. Evolution towards the development of infrastructure for Smart Cities, Green ICT with application of Decision Support Systems (DSSs) created opportunities for solving complex problems, for example, sensor- enabled smart waste management. This paper focuses on supporting sustainable decisions for garbage collection route planning and optimization. The objective is to bring practical solution for reducing CO2 emissions and reduce negative impact on the environment as a result. From the design science perspective, a DSS is proposed, researched and developed to increase the effectiveness of municipal waste management. The paper also describes evaluation of this approach against Green IS framework.

Keywords: Pervasive Computing; decision support system; Smart Waste Management

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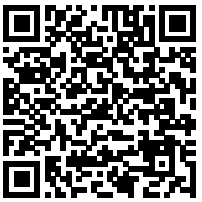
A holistic view of value generation process in a SSBI environment: a service dominant logic perspective

Imad Bani Hani[1], Jorg Pareigis[2], Olgerta Tona[1], Sven Carlsson[1]

Abstract: Self-service business intelligence (SSBI) is an emerging trend in organizations allowing users to become more autonomous in data exploration. Organizations are keen to provide such services for their employees due to its potential benefits. However, there is little empirical knowledge about the process of building a SSBI service and the role of users in this process. From an exploratory single case study of a major Norwegian online marketplace and drawing on service-dominant logic as an analytical framework, we identify and explore two major phases of building a SSBI service: co-production and co-creation. Besides providing a rich description of these phases, this study also explores the way stakeholders are involved and embedded throughout the process of value generation.

Keywords: self-service business intelligence; service-dominant logic; co-production; co-creation



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Selection of IT projects to be implemented in an organisation to maximise their success probability

Kazimierz Fraczkowski[1], Barbara Gladysz[1], Dorota Kuchta[1], Stanislaw Stanek[2]

Abstract: The paper proposes criteria to be used in a decision support system which should help to assess the success probability of IT projects considered for implementation, in order to help to make the decision whether to accept the project or not. The criteria used are both of a quantitative and subjective (qualitative) nature. They are identified on the basis of a sample of IT projects implemented in Poland, a questionnaire and the application of classification tree methods.

Keywords: IT project; project success; project success factors

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The Geographical accessibility as a key access parameter to health care in Cameroon: Modeling, measurement, and evaluation

Marcelline Blanche Manjia[1], Georges Edouard Kouamou[1], Chrispin Pettang[1]

Abstract: Equal access to social infrastructure in general and access to health care in particular, is at the centre of concerns in terms of spatial planning in each state. Obviously, the public health policy in most developing countries including Cameroon is strongly based on the health care which does not allow the present day an effective management health care supply. This situation, which results in unequal access to health care is partially due to the lack of relevant information on the real needs of patients, in particular, the geographical accessibility to health infrastructures. The present study proposes a methodological approach to assessing spatial accessibility to health care. The application was based on digital data from the city of Yaoundé.

Keywords: Geographical accessibility; Health infrastructures; GIS; Modelling; decision support.

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Evaluation of several approaches for deriving weights in fuzzy group analytic hierarchy process

Petra Grošelj[1], Lidija Zadnik Stirn[1]

Abstract: The paper discusses fuzzy group analytic hierarchy process. In the literature there are found several approaches for determining weights either directly from the individual judgments or via group comparison matrix. However, the quality of the group weights was not studied yet. In the paper we propose two new measures for the evaluation of the group weights that are adapted from classical analytic hierarchy process. We selected six approaches for deriving weights and use them in an application from the literature. We evaluated the gained weights. Our results show that the weights derived by the most popular extent analysis method are questionable in their reliability.

Keywords: decision making models; fuzzy analytic hierarchy process; triangular fuzzy numbers

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A Data Quality Framework, Method and Tools for Managing Data Quality in a Healthcare Setting: An Action-case Study

Frada Burstein[1], Robert Meredith[1], Lu Bai[1]

Abstract: The effectiveness, efficiency and reliability of health services depends on the quality of data in health information systems used by healthcare providers, managers and decision-makers. The aim of this research is to propose a data quality framework, method and set of tools to help an information management team at a healthcare institution to monitor data quality as part of their business intelligence process. The proposed tool has the capacity to capture and visualise different stakeholder perceptions of data quality depending on the user role and the task they are responsible for. This study uses an action case method to develop a prototype of the tool and provide an illustration of its implementation and usage by multiple stakeholders.

Keywords: data quality; business intelligence; healthcare; action case

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Social complexity and team cohesion in multiparty information systems development projects

Stephen McCarthy[1], Paidi O'Raghallaigh[1], Ciara Fitzgerald[1], Frédéric Adam[1]

Abstract: Despite the proliferation of Critical Success Factors (CSFs) for Information Systems Development (ISD), the rate of ISD project failure continues to remain exorbitantly high. In particular, social complexity is increasingly seen as an innate feature of multiparty ISD projects which make them less amenable to being 'tamed'. However, an understanding of the intricacies of social complexity and how it impacts team cohesion in multiparty projects remains nascent. In this paper we offer findings from the case study of a funded academia-industry collaboration to investigate the elusive phenomenon of social complexity. A theoretical framework is developed to reveal the factors which contribute to social complexity and its impact on team cohesion in multiparty ISD projects. The findings derived from the application of this lens reveal the numerous challenges to team cohesion that arose from the interplay between macro- and micro-level factors. Theoretical and practical implications from the paper are also outlined.

Keywords: Information Systems Development; social complexity; industry-academia collaboration

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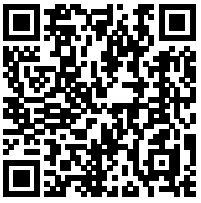
Systemic Methodology for Risks Evaluation and Management in the Energy and Mining Sectors (SYSMEREM-EMS) using Bayesian Networks

Ricardo Rodriguez-Ulloa[1]

Abstract: The paper has the purpose to show a systemic methodology for risks evaluation and management in the energy and mining sectors (SYSMEREM-EM) and its application in the Peruvian context. For this purpose, this paper shows the combination of systemic approaches and artificial intelligence technology. Thus, for the processes' modelling of the value chains in both sectors, Soft Systems Methodology (SSM) was used; for the elucidation of the risks causalities embedded in the dangerous events existing in the processes, System Dynamics' causal diagrams was used; and for risks' evaluation and management, the application of Bayesian networks expert systems for decision making was the approach used. These three techniques were used, in this sequence, within an overall framework. The paper ends with some comments about lessons learned and recommendations for further research.

Keywords: Soft Systems Methodology (SSM); System Dynamics (SD); Bayesian Networks (BN)



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Decision support on the basis of utility models with discordance related preferential information: investigation of risk aversion properties

Andrej Bregar[1]

Abstract: A fundamental and widely applied approach to decision-making is the multi-attribute utility theory. Because it aggregates preferences in the compensatory manner, it can be extended with the concept of veto function, which is adopted from the outranking approach, and models full or partial non-compensation of unsatisfactory preferences. This paper discusses the methodological foundations underlying this approach, and introduces the mechanisms of decision support on the basis of utility models with discordance related information. It then presents the main contribution of the research, in which the forms and properties of veto functions are studied, particularly with respect to risk aversion. Outcomes of risk averse, risk seeking and risk neutral veto functions are analysed and compared. Risk aversion of veto functions is also correlated with risk aversion of utility functions, which are aggregated in the same multi-attribute model and exhibit common complementary preference structures of the decision-maker. The study aims to assess the influence of risk aversion on the decision, to identify possible anomalies in preference structures, to determine the suitability of different risk aversion formats and intensities for various problem settings, and to derive key characteristics. The experimental model considers several evaluation factors, such as validity of results, ability to efficiently discriminate alternatives, richness of output data, extremeness of results, and robustness.

Keywords: decision support; multiple criteria decision analysis; utility theory, outranking relation, veto, simulation study

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Data-driven decision making in classification algorithm selection

Dijana Oreski[1], Nina Begičević Ređep[1]

Abstract: The selection of the appropriate classification algorithm for a given dataset is an important and complex issue, full of research challenges. In this paper, we present a developed meta-analysis-based framework to improve decision making in the selection of classification algorithms based on dataset characteristics. We study the effectiveness of our proposed framework with 32 datasets. Three classification algorithms—neural networks, decision trees, and k-nearest neighbors—were trained and applied to datasets with different characteristics, aiming to review the performance of algorithms in the presence of noise in the data, the interaction between features, as well as a small or a large ratio between the number of instances and the number of features. Our results show that feature noise is the most important predictor of the decision regarding the choice of the classification algorithm, and data-driven classification is found to be useful in this scenario.

Keywords: data characteristics; data-driven classification; CRISP DM; decision making; meta-learning

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Building a Safe Society Environment: A Summary of Hybrid Approaches to Crisis Decision Support Systems

Stanisław Drosio[1], Stanisław Stanek[2]

Abstract: An artifact called Hybrid Decision Support System for Crisis Management (HDSSCM) that aims at assisting crisis management centers is proposed and discussed. The paper summarizes research efforts completed over the last few years, addressing integrated hybrid platforms designed to improve crisis management processes. Alongside theoretical insights, it includes descriptions of cases that bring together ideas and practices derived from the experience of crisis management managers. To provide a broader outlook, the paper envisages further evolution paths for hybrid concepts.

Keywords: crisis management; Hybrid Decision Support System; safe society

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Business Uncertainty, Corporate Decision and Startups

Jean-Charles Pomerol[1]

Abstract: In this paper we argue that transformational entrepreneurs generate some uncertainty in business. This uncertainty must not be exaggerated; it is relatively low for incumbent business but is increasing and thus must be considered. One way of dealing with this non-probabilistic uncertainty is to have an adequate decision policy regarding startups, either following them and eventually acquiring them or encouraging innovation inside and facilitating swarming. We examine what can be the consequences: startup bubbling coming at its end or continuing.

Keywords: Decision; Non-probabilistic uncertain; Startups.

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Approach to the Selection of the Best Cover Image for Information Embedding in JPEG-images Based on the Principles of the Optimality

Oleg Evsutin[1], Anna Kokurina[1], Roman Meshcheryakov[1]

Abstract: One of the means to provide information confidentiality is the application of methods of digital steganography. These methods allow one to secretly transmit confidential information using various digital objects. When hiding information with the use of steganography, digital images are often used, among which compressed JPEG- images are of the greatest popularity. The efficiency of information embedding into JPEG-images substantially depends on properties of the source image used as a container. In the given paper, an approach to the selection of the best cover image from several JPEG-images is offered based on the principles of optimality. The implementation of the given approach with the reference to the popular method of embedding (JSteg) is given. The results of experiments show that the considered approach allows us to select such an image from a set of images-containers, for which the best visual quality of embedding is provided.

Keywords: digital images; steganography; JPEG; principles of the optimality

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IoT-based Decision Support System for Monitoring and Mitigating Atmospheric Pollution in Smart Cities

Alexander Miles[1], Arkady Zaslavsky[2], Chris Browne[1]

Abstract: Rapid increases in the world's population, increased urban density and increased congestion have created an upwards pressure that has seen traffic-related pollution growing at a rapid pace. As atmospheric pollution has a proven detrimental effect on human health and decreases the ambience and general liveability of the world's cities. Developing, deciding and implementing effective atmospheric pollution and mitigation strategies are of the utmost importance to policy makers around the world. [...] The proposed DSS is used to detect a critical level of atmospheric pollution and then may respond via the implementation of a road closure and/or diverting a subsection of the polluting traffic (eg, heavy trucks). The paper demonstrates the ability of the DSS to prevent atmospheric pollution from reaching hazardous levels and inform policy makers as to when and where mitigation treatments should be implemented for the best outcome.

Keywords: Traffic Management; Atmospheric Pollution; Air Quality Management; Mitigation measures; Modelling framework

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Integrating knowledge from DEX hierarchies into a logistic regression stacking model for predicting ski injuries

Sandro Radovanović[1], Boris Delibašić[1], Miloš Jovanović[1], Marko Bohanec[2], Milija Suknović[1]

Abstract: Machine learning models are often unaware of the structure that exists between attributes. Expert models, on the other hand, provide structured knowledge that is readily available, yet not often used in machine learning. This paper proposes the integration of expert knowledge, represented in the form of multi-criteria DEX (Decision EXpert) hierarchies or attributes, in a logistic regression stacking framework. We show that integrating expert knowledge into a machine learning framework can improve the quality of models. We tested our hypothesis on the problem for predicting ski injury occurrence, an important decision-support task in ski-resort management. Our results suggest that using a DEX hierarchy of attributes and stacking improves the AUC (area under the curve) compared to logistic regression models unaware of the DEX hierarchy from to 1% to 4%.

Keywords: domain knowledge; machine learning; multi-criteria DEX model

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Conduct Risk: towards a model for assessment and remediation

Mary Daly[1], Tom Butler[1]

Abstract: Widespread misconduct in Financial Services organisations prior to and since 2008 has put organisational culture centre stage in the minds of regulators. There is no one definition of Conduct Risk across the regulatory requirements for Financial Services organisations. This paper presents a research in progress development that provides the various groups and stakeholders in an organisation with a shared conceptualisation of what conduct risk is, along with a common language to communicate canonical accepted behaviours. The paper describes an evaluation and diagnostic tool for organizations which has two primary components 1) a Conduct Risk Model (CRM) and 2) the Conduct Risk Diagnostic System (CRDS). The Conduct Risk Model is designed to comprehensively capture each of the primary domains of conduct risk in a detailed taxonomy and ontology. The CRDS diagnostics are designed to assess, measure and supervise the conduct risk areas and domains and to provide decisional guidance.

Keywords: Financial Conduct risk; regulation; decision guidance

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Towards a knowledge management framework for crossing knowledge boundaries in agricultural value chain

Biljana Mileva Boshkoska[1,2], Shaofeng Liu[3], Huilian Chen[3]

Abstract: The paper proposes a framework for the development of a decision support system (DSS) in order to evaluate the knowledge boundaries (KB) in agricultural value chain. KB exist due to differences in the way we work, share our knowledge, expertise, different organizational culture, etc. In this paper we identify the most common KB that are reported in the literature, and propose a general framework for a preparation of a DSS to evaluate the existing KB. In particular, we are interested in identifying the KB in agricultural value chain, evaluating them and providing possible solutions of crossing them. It is a two-step method: firstly a semi-automatic ontology is generated using the freely available tool OntoGen, which we used to define the most commonly reported concepts in crossing KB, and then based on the obtained ontology we propose a DSS for evaluation of the level to which the KB exist.

Keywords: Knowledge management; knowledge boundaries; decision support system; agricultural value chain; DEX

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Challenges for Digital Transformation - Towards a Conceptual Decision Support Guide for Managers

Ciara Heavin[1], Daniel J. Power[2]

Abstract: Digital technologies are transforming operations, products and services in organizations large and small. The digital transformation of organizations is extolled as a solution to organizational challenges related to both efficiency and effectiveness. To date, there has been limited consideration of the challenges of successfully operationalizing a transformative digital transformation approach. This article examines some of the common dilemmas facing managers that may be relevant across a range of organizational scenarios. Seven factors are analyzed to provide a starting point for creating successful digital transformations in business. To begin to tackle these challenges, this research-in-progress paper proposes a digital transformation decision support guide for managers. This tool may be utilised by managers, supporting them to move from an ad-hoc technology driven approach to a more systematic integrated approach to digital transformation.

Keywords: word; digital transformation; challenges; decision support guide; managers

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Planning and Financing the Home and Facility-Based Care using the Multiple Decrement Approach

Valerija Rogelj[1], David Bogataj[2]

Abstract: The number of older Europeans 80+ is projected to increase from 27.7 million in 2016 to 65,2 million in 2070. The goal of these cohorts is to stay independent and autonomous in the community as long as possible, but a large share of this population resides in improperly built dwellings. They face a dangerous environment in surrounding of their dwelling which influences their decision to prematurely move to nursing home, which is decreasing their quality of life and increasing public expenditures. To prevent premature departure to a nursing home and make long-term care system more sustainable Member States need to develop a proper Health and Social Infrastructure including long-term care services and assisted living facilities suitable for older adults with declining functional capacities that are dependent on the help of others.

Keywords: assisted living facilities; multiple decrement model; long-term care

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A decision support system for software technology selection

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Abstract: Software producing organizations face the challenge of including new technology in their products, such as cloud technologies and database management systems. As software architects and senior developers are not experts in this domain, they need to consult external experts or acquire the knowledge themselves. Software production, therefore, is a suitable domain to deploy decision support systems, that intelligently support these decision-makers in selecting the desirable technology for their product. We present a decision support system that supports decision-makers in choosing the most suitable database technology. The case studies and experts confirm that the approach increases insight into the selection process, provides a richer prioritized option list than if they had done their research independently, besides reduces the time and cost of the decision-making process.

Keywords: multi-criteria decision-making; decision support system; technology selection; database management system

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Decision Support for Selecting Information Security Controls

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Abstract: With the emergence of the Internet, the volume of cyberattacks has been progressively growing and, therefore, adequate security of information has a crucial role in IT systems. Organizations face complex decisions regarding the selection of security controls that allow protecting their information assets. The implementation of these controls should ensure an adequate level of protection. However their selection requires knowledge about the vulnerabilities and threats existing in the organization, and the investment in security must comply with economic constraints. This work proposes a framework to support an organization to identify security vulnerabilities and optimise a portfolio of security controls to mitigate them. Those security controls may be of a mixed nature, such as hardware controls, software controls, policies, procedures, and training actions. The framework is established using the standards ISO/IEC 27001:2013 and ISO/IEC 27002:2013 to support the identification of vulnerabilities/threats and the choice of controls that can mitigate them. Once the existing vulnerabilities/threats are identified, one has to select the subset of controls to implement, assuring an adequate mitigation at the lowest cost. An integer programming model is used to address this optimisation problem within the framework, which has been implemented as a prototype decision support tool.

Keywords: Information Security; Decision Support; Vulnerabilities; Security controls; Optimisation of security portfolio

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Posters

Multi-attribute decision model for preventing ventilator-associated pneumonia

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Abstract: Ventilator-associated pneumonia is common in intensive care units since it affects ventilated patients with an inserted endotracheal tube or performed tracheostomy. Early detection of most susceptible patients is necessary to prevent infection and improve patient safety. A multi-attribute decision model was developed to provide combined risk assessment and identify most relevant areas that contribute to higher susceptibility. The result of the decision process can be used to plan and improve continuing medical and nursing care.

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Multi-attribute decision model for preventing ventilator-associated pneumonia

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Abstract: Ventilator-associated pneumonia is common in intensive care units since it affects ventilated patients with an inserted endotracheal tube or performed tracheostomy. Early detection of most susceptible patients is necessary to prevent infection and improve patient safety. A multi-attribute decision model was developed to provide combined risk assessment and identify most relevant areas that contribute to higher susceptibility. The result of the decision process can be used to plan and improve continuing medical and nursing care.

INTRODUCTION

Ventilator-associated pneumonia (VAP) is currently the most prevalent nosocomial infection in intensive care units. Infection leads to prolonged hospitalization and increased costs. While costs per infection can be accurately calculated, mortality due to VAP is often estimated with high variability, resulting from incoherent methodological approaches and contributing variables. Nevertheless, VAP is present in the clinical environment and presents a treat to patient safety and healthcare quality.

There are numerous interdisciplinary prevention strategies designed to lower incidence of VAP relaying on scientifically supported preventive measures and risk factors. However, these strategies are often poorly implemented into clinical practice.

METHODS

Risk factors and most prevalent preventive measures for VAP incidence reduction were identified with a literature review. Based on results a decision model using DEX methodology. The decision model is designed to improve preventive measures implementation and to support data, based decision making in clinical practice.

RESULTS

Working group has developed a multi-attribute, theory-based decision model that uses qualitative analysis for evaluation analysis and comparison of decision options using software DEXi.

Model design

The decision model is designed to estimate individuals' susceptibility to develop VAP. It consists of 12 attributes that are arranged in a hierarchical structure (tree of attributes) as can be seen in Figure 1. Attributes are divided into three main areas, namely leakage prevention, patient-related factors, and nursing care.

Each individual attribute was assigned a utility function in order to ensure adequate impact on overall susceptibility. Results of the decision process can be used to identify patients' overall level of susceptibility to develop VAP (Figure 2) and to identify most problematic areas that contribute to higher susceptibility. Results of a decision process with hypothetical variables for illustration purpose in presented in Figure 3.

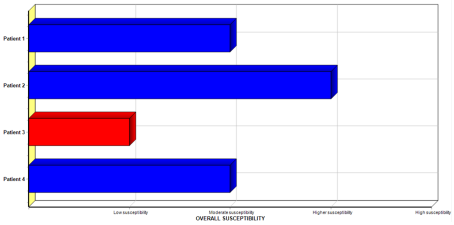

Figure 2: Overall susceptibility in four hypothetical patients

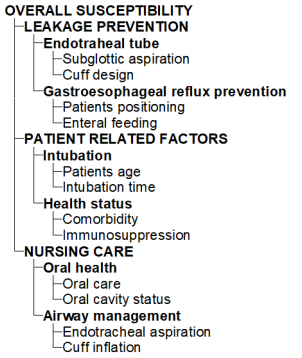

Figure 1: Tree of attributes for VAP susceptibility assessment in intensive care

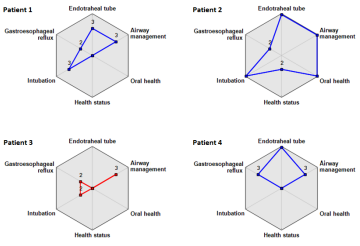

Figure 3: Polar charts showing strategically important areas for VAP susceptibility in four hypothetical patients

DISCUSSION

Presented examples show that the results of decision process can, in fact, identify patients with higher susceptibility and further contribute to lowering their susceptibility according to strategically important areas.

The design of the decision model does not include all measures in interdisciplinary VAP prevention strategies since working group developing the model is based on Nursing Science. Therefore, areas in the exclusive domain of medicine, although detected in the literature review, were not included, due to lack of medical professionals' involvement in decision model development (use of antibiotics, type of ventilation, sedatives use etc.).

Further empirical research is needed to ensure accuracy and standardization of presented decision model. Also, involvement and cooperation with experts from other fields is required to adequately include interdisciplinary strategies of VAP prevention in future model development.

Validation of decision support models using data mining: a case study on primary productivity in agricultural fields in France

Aneta Trajanov[1,2], Taru Sanden[3], Vladimir Kuzmanovski[1], Heide Spiegel[3], Nicolas Saby[4], Marko Debeljak[1,2]

Abstract: Decision support systems (DSSs) are becoming increasingly used in environmental and ecological sciences for problem solving and decision making. They enable capturing and structuring of the knowledge of one or more domain experts for a specific decision problem. The complex process of developing the DSS model involves several different profiles of people, such as problem owners, domain experts and end-users. The goal of the DSS is to reflect reality. Since the environmental "reality" is extremely complex, it is very important that the model has a satisfactory accuracy according to its intended application. Therefore, validation of the developed DSS model is an important step towards developing and releasing a high quality DSS system that can be used for decision making in complex environmental settings. In this study, we developed a DSS model for assessment of the primary productivity in agricultural fields. The validation of the DSS model was done using empirical data about primary productivity from France and improved by the use of data mining, which increased the validation results by 22%.

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INTRODUCTION

Primary productivity (PP) is the capacity of a soil to produce plant biomass for human use and is one of the cornerstones of prosperous farming communities. To assess the PP on a field, we developed a DSS model, that takes into account the soil structure, environment, crop and management of the field. The process of validation of the model was carried out using empirical data from France. To improve the results of the validation, we used data mining.

OBJECTIVES

The objectives of this study were the following:

- To develop a DSS model for assessment of the primary productivity soil function on a field;
- To validate the DSS model against empirical data;
- To use data mining methods to improve the DSS model and to increase its accuracy;
- To obtain a highly accurate DSS model to help farmers and advisors to assess the provision of the primary productivity soil function on their fields.

RESULTS

- The developed DSS model for primary productivity was structured in a way to take into account soil structure, environment, crop and management of the field and comprised 4 levels and 29 basic attributes (see Figure 1).
- It was validated using a representative dataset from France containing 507 soil samples from all around France.
- Since the accuracy of the DSS model after the validation was around 50%, we generated a highly accurate data mining model (accuracy 77.7%) to predict the primary productivity from the same data (see Figure 2).
- We used the most important attributes from the data mining classification tree to modify the integration rules in the DSS model where these attributes were involved.
- This increased the validation results of the DSS model to 72%.

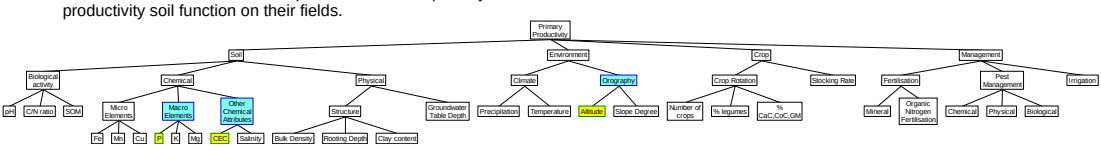

Figure 1: Decision support model for assessment of the primary productivity in a field: attributes from the DM model – yellow boxes, additionally modified integration rules – blue boxes.

METHODS

To achieve the research objectives, we used a methodology originally developed for Multi Criteria Decision Analysis (MCDA), which enables the construction of qualitative multi-attribute decision models (MADM). We employed the DEX (Decision EXpert) integrative methodology. The validation of the DSS was aided by the use of data mining methods for generation of decision trees. In particular we used the J48 algorithm for generation of classification trees, which were validated by 10-fold cross validation.

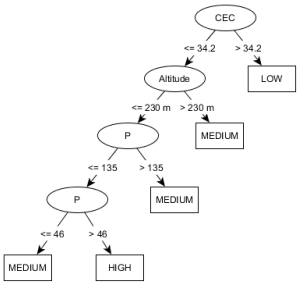

Figure 2: Classification tree for prediction of the primary productivity in a field

CONCLUSIONS

Validation of the DSS models is a crucial step in obtaining reliable and useful models that can be used in practice. The proposed methodology proves that data mining and decision support modelling can be complementary and help improve the final results. Using this approach, we have obtained a highly accurate DSS model for assessment of the primary productivity on a field.

ACKNOWLEDGEMENTS

This study was conducted as a part of the LANDMARK (LAND Management: Assessment, Research, Knowledge Base) project. LANDMARK has received funding from the European Union´s Horizon 2020 research and innovation programme under grant agreement No 635201.

Structuring empirical European knowledge on soil and land management using multi criteria decision analysis

Francesca Bampa[1], Rachel Creamer[1], Aneta Trajanov[2,3], Marko Debeljak[3,2]

Abstract: The Land management Assessment, Research, Knowledge base (LANDMARK) project is a pan European multi-actor consortium that aims to develop a coherent framework for land and soil management for sustainable production across Europe. Soils are a finite resource that provides a range of ecosystem services known as soil functions. Trade-offs between these functions has led to conflicting management recommendations and policy initiatives. Therefore there is an urgent need for a scientific and practical Functional Land Management framework able to quantify the current and potential supply of soil functions as determined by soil, environment and management practices.

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Structuring empirical European knowledge on soil and land management using multi criteria decision analysis

Franceska Bampa*[A], Rachel Creamer[A], Aneta Trajanov[B] & Marko Debeljak[BC]

[a] *Soil Biology and Biological Soil Quality, Wageningen University, The Netherlands,* [b] *Department of Knowledge Technologies, Jozef Stefan Institute, Ljubljana, Slovenia,* [c] *Jozef Stefan International Postgraduate School, Ljubljana, Slovenia.*

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INTRODUCTION

From the outset the research project engaged with stakeholders from local (farmers and advisors) to national and European scale. About 470 stakeholders from five European countries (Austria, Denmark, France, Germany and Ireland) participated in 32 structured workshops covering different climatic zones and multiple agricultural land uses.

Each workshop harvested stakeholders' **knowledge** and **needs** on soil and land management. The results of workshops include: priorities and concerns of stakeholders, perceptions on soil quality and functions, implementation of tools and management techniques, indicators and monitoring systems, activities and policies, knowledge gaps and ideas.

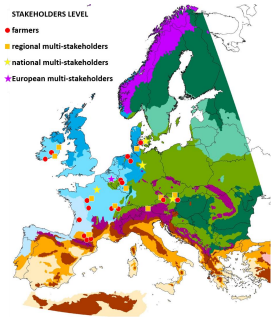

Figure 1: Map of the Environmental Zones of Europe (Metzger et al., 2005) and locations of the 32 stakeholder workshops.

OBJECTIVES

- To harvest and assess stakeholders' inherent **knowledge** and **needs** in terms of soil quality, prioritisation of soil functions, soil and land management;
- To support understanding of supply and demand for soil functions with: 1) development of a decision support tool for soil and land management, 2) development of a monitoring schema to assess soil functions and 3) guidelines for a policy framework which addresses functional land management in order to optimise the sustainable use of Europe's soil resource.

METHODS

To analyze and integrate a large volume of data from 32 reports a methodology for construction of qualitative multi-attribute decision models (MADM), was performed. Using the DEX methodology, two decision models that structure the stakeholders' knowledge and needs, have been generated. The outputs of the models are able to respond to the two main questions: 1) "*What is the current level of soil knowledge by stakeholders?*". 2) "*What further soil knowledge is required?*"

RESULTS

Results captured different soil quality perceptions depending on the stakeholder category (from farmers to decision makers), and regional differences in concepts and terminology used. The results prove good inherent knowledge of stakeholders about soil quality and functioning, but identified knowledge gaps on the implementation (e.g., of soil data, programs, policy instruments and social shared activities) have been identified.

The 32 reports, models and results can be accessed online at http://landmark2020.eu/stakeholders-platform/

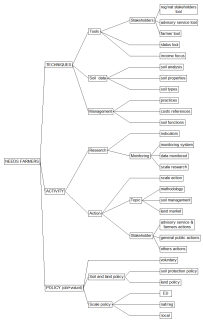

Figure. 2 Structure of the "SOIL NEEDS" model, with a total of 43 attributes, including 28 basic attributes.

CONCLUSIONS

- This methodology helped to integrate, synthetize and capture extensive qualitative information on stakeholders' expertise and knowledge requirements on soil and land management across Europe in a condensed and comprehensible way.
- The developed online platform permits access, comparisons and use of this methodology for future similar consultations.

The authors acknowledge: the 473 farmers and multi-stakeholders that participated at the 32 workshops and LANDMARK colleagues involved in the consultations: L. O'Sullivan, K. Madena, T. Sandén, H. Spiegel, C.B. Henriksen, B.B. Ghaley, A. Jones, J. Staes, S. Sturel. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 635201

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Multiple criteria decision analysis for uniform selection

Sonja Šterman[1], Mirjana Kljajić Borštnar[2]

Abstract: Aim of a uniform development process is to design, manufacture, and procure best possible clothing for the specific group of users. It is a complex process, where various stakeholders with possibly conflicting interests are involved and many criteria has to be considered. At the end, the chosen alternative is implemented in practice. Consequences of suboptimal decision result in loss of money and user discontent. The purpose of this research is to develop methodology for uniform development by using group decision support methods and validate it on a case of customs office uniforms. For this purpose a questionnaire was used to elicit user feedback, group decision method to elicit knowledge from experts, and multi-criteria decision modeling method AHP to model and analyze the decision problem. We validated the model on two alternatives (old and test uniform). Results suggest that the proposed methodology efficiently supports involvement of stakeholders throughout the process of uniform development and selection.

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Multiple criteria decision analysis for uniform selection

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INTRODUCTION

The process of development and deployment of uniforms is complex and the results are many times unsatisfactory. The process starts with a decision to procure new uniforms. Than, expert team proceeds with the planning, desigining, prototype uniform sewing, field testing, public procurement, and finally selection of the procurer. For the purpose of making the process more efficient and transparent, and provide quality uniforms for the users, we have developed a methodology, with the multi-criteria decision model in its core.

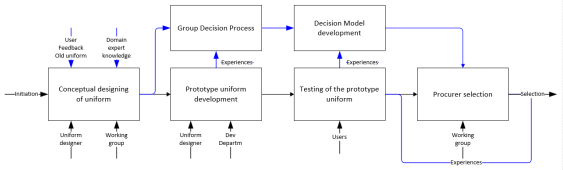

Figure 1: Simplified process of uniform development and deployment

OBJECTIVES & METHODS

System engineering approach was used to support the process of development and deployment of uniforms.

- Analyze the process.
- Define information and knowledge flows and bottlenecks.
- Elicit user feedback (309 users) and domain expert knowldge.
- Identify criteria and their importance with domain expert group.
- Hierarchical structure of criteria with domain expert group.
- Re-evaluate criteria importance with pair-wise comparison.
- Validate the model with two alternatives (old and test uniform).
- Re-adjust the model.

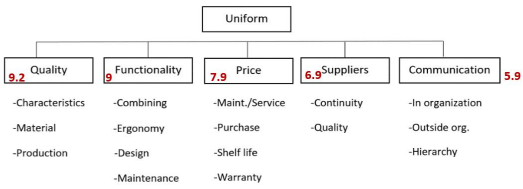

Figure 2: AHP model for uniform procurer selection

RESULTS

Domain expert group identified >200 criteria, which were grouped in 16 subgroups. The team assessed overall criteria importance and structured them in a hierarchical tree (Fig 2). Criteria importance were reassesed by conducting pairwise comparison. We validated the model on past data of public procurement.

Evaluation of the old and the test uniform was conducted by AHP model (Fig 3). According to the model the test uniform is better, the evaluation results were corroborated by the domain expert group. Final procurer was selected using the AHP model

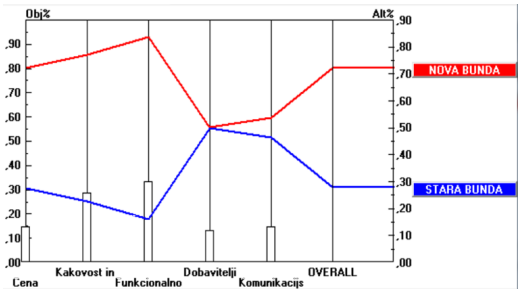

Figure 3: Overall evaluation of two uniforms

CONCLUSIONS

The problem of development and deployment of customs office uniforms was addressed. Systems engineering approach was used to involve users and domain experts with the goal to deploy the best possible uniform to the users. At the end of this process a procurer of a uniform has to be selected. The procurers are evaluated according to the criteria and their importance, that were implemented in an AHP model with the knowledge of domain experts and users. Resutls suggest that application of system engineering methods support involvement of stakeholders in the whole development & deployment life cycle. This contributes to trust building and better decision-making.

Assessment model of health supporting behaviors in pregnant women

Alenka Žibert[1], Bernarda Lončar[1], Saša Šajn Lekše[1], Uroš Rajkovič[2], Andrej Starc[1]

Abstract: By creating a decision-making model we wanted to distinguish between the low, medium and high-risk behavior of pregnant women, aiming to adjust individual health education as well as nursing and midwifery interventions in a prenatal care. Using such models could improve maternal and child health outcomes and optimize the costs of primary health care during pregnancy. For risk assessment, the multi-criteria decision model using DEX methodology was developed. The ability of the model to support analyses and clarification of results could play a crucial role in objective assessment needed for individualization of pre-natal care.

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By creating a decision-making model we wanted to distinguish between the low, medium and high-risk behavior of pregnant women, aiming to adjust individual health education as well as nursing and midwifery interventions in a prenatal care. Using such models could improve maternal and child health outcomes and optimize the costs of primary health care during pregnancy. For risk assessment, the multi-criteria decision model using DEX methodology was developed. The ability of the model to support analyses and clarification of results could play a crucial role in objective assessment needed for individualization of pre-natal care.

INTRODUCTION

Inequalities in the health of pregnant women arise from cultural and socioeconomic differences. Behavioral risk factors that can affect the health of the pregnant woman and her unborn child need to be early recognized for the effective preventive measures to be planned by healthcare professionals. Two of the most harmful risky behaviors are smoking and alcohol consumption. Poorer physical health during pregnancy also increases psychological stress and all combined, especially during the first pregnancy, can have negative health-related effects on the child especially during the first year of life.

METHODS

A decision model was constructed using multi-criteria decision methodology DEX, using software DEXi. It provided us with the opportunity to simplify a complex problem into smaller, less complex sub-problems that were easier to solve. A selected list of important criteria for monitoring health-enhancing behaviors of pregnant women was arranged in the appropriate tree structure (Fig. 1).

The list of criteria was determined after identifying a list of negative effects on the physical and mental health of pregnant women and unborn children found in the literature and analysed by an expert team. Knowledge was derived from fields of gynaecology, pediatrics, nutrition, public health, and personal experience of team members.

Four hypothetic pregnant women were assessed: A, B, C, and D. We assumed that data would be collected during a routine check-up visit to a gynaecologist or midwife.

RESULTS

Pregnant woman C received the best overall assessment with no obvious behavioral risks (Fig. 2). An in-depth analysis of lower-level criteria, similar to Fig. 3, may be valuable to identify less crucial knowledge deficiencies, which could be addressed by healthcare professionals.

Pregnant women B and D received the worst overall assessment (Fig. 2), which shows high deficit in their knowledge and/or behavior. Further analysis was supported by polar charts (Fig. 3) and shows which elements require a priority in addressing behavioral issues in the process of healthcare education. By pointing out their positive attributes it can help individualise health education.

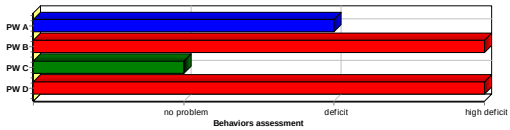

Figure 2: Overall risk levels in four hypothetical pregnant women (PW)

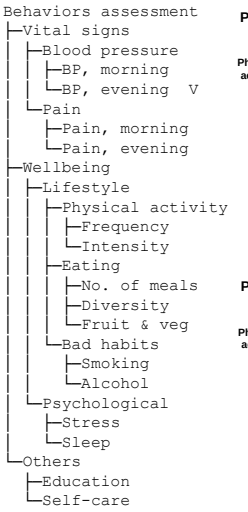

Figure 1: Tree of criteria for assessing health supporting behavior during pregnancy

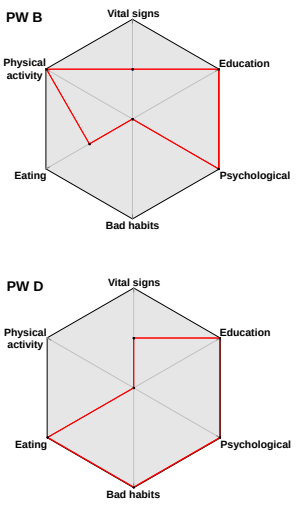

Figure 3: Chart with selected criteria presenting two pregnant women with most risky behavior

DISCUSSION

Any patient treatment should be based on equal partnership and a holistic approach to every patient. Attention should be given to all pregnant women equally, but they must be treated individually. After examining the results of the proposed decision model, we noted that special attention must be paid to all the criteria listed, since any criterion may have a negative effect on the child.

In interpreting the results, health professionals should try to avoid the subjectivity of nurses and midwives who perform assessments. In practice, this might be achieved by involving the pregnant woman in the decision-making group. Such decision models enable early detection of pregnant women in need of additional guidance and help from healthcare professionals.

Development and application of a decision support system for assessing service quality at tourist farms

Tanja Dergan[1], Aneta Trajanov[1], Marko Debeljak[1]

Abstract: The research covers a development of a qualitative multi-attribute model for the quality assessment of the services provided at tourist farms. The model was developed with the DEXi modelling tool that is based on the DEX methodology. Eight tourist farms were evaluated using empirical data. The best evaluated farm was tourist farm VII, and three of the farms achieved bad scores (I, III, V). Tourists could use the model as a decision support for selecting the most suitable tourist farm for their holidays.

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INTRODUCTION

Tourism is one of the fastest growing economic sectors in Slovenian economy. In the last decade, the demand for spending holidays at tourist farms in Slovenia has rapidly increased, and consequently the number of tourist farms has grown. In 2017, 948 tourist farms were registered in Slovenia. 395 were tourist farms with accommodation, which recorded 138996 overnights. The problem that appears, is that tourism on farms is a form of boutique tourism, whose success depends on the quality of the provided services. An assessment of the quality of services is needed and hence the need for the development of a simple quality assessment model.

OBJECTIVES

The objective of this research was the development of a multi-attribute qualitative decision model for the assessment of the services provided at tourist farms. The model should be reliable but easy and simple to use. It should highlight weakness or advantages of the assessed farms, and be able to take into account the preferences of the users in order to find the most suited tourist farm according to their expectations.

RESULTS

	LOCATION	COMPLEMENTARY ACTIVITY	THE SURROUNDINGS OF THE FARM	HOSPITALITY	HOST TO GUEST RELATIONSHIP	PRICE	OPENING TIME
VII	good	medium	good	good	good	medium	good
VIII	bad	medium	medium	bad	bad	medium	bad
VI	good	bad	bad	bad	medium	medium	good
II	good	medium	good	good	medium	medium	bad
IV	good	medium	good	good	medium	good	medium
I	bad	medium	medium	bad	bad	bad	medium
III	good	bad	bad	bad	medium	bad	bad
V	good	medium	medium	bad	bad	medium	good

Table 1: Evaluation of services at the assessed farms (red-bad, blue-medium, green-good)

According to the model (Figure 2), the farm VII was assessed as the best (only complementary and prices were assessed medium) and the worst evaluated was the tourist farm III, where only location was evaluated as good, while all other categories were assessed as bad. Three categories of tourist farms could be made according to the evaluation results: farms with low quality (I, III, V), farms with medium quality (VIII, VI, II, IV) and farms with high quality of services (VII) (Table 1).

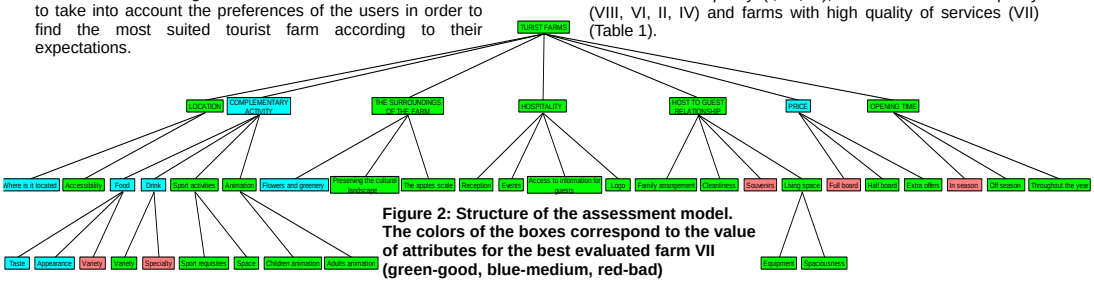

Figure 2: Structure of the assessment model. The colors of the boxes correspond to the value of attributes for the best evaluated farm VII (green-good, blue-medium, red-bad)

METHODS

The qualitative multi-attribute decision model was developed by the DEXi software modelling tool, which facilitates both evaluation and what-if analysis of decision options. The tourist farms and their regulatory standards were precisely defined in order to select attributes which have been structured in the DEXi model.

The validated model was used for evaluation of eight tourist farms (Figure 1) using data derived from interviews and survey questionnaires from farmers and guests.

Figure 1: Locations of the evaluated tourist farms

CONCLUSIONS

We found that a large amount of available references and expert knowledge needed for the construction of this kind of assessment models is available. However, getting data for evaluation of tourist farms was very demanding. Farmers who are providers of tourist services were very reluctant for collaboration, while the consumers were very open and supportive. The results revealed that successful tourist farms are very committed to their activities. They offer what they promise in the advertisements. On the other hand, the farmers that get worse evaluations usually put a lot of attention to promotion, but the difference between promised and provided services is significant. The model could be used as an effective assessment tool also at regional or national level. It would help customers to find farms that suit their needs best. On the other hand, the tool could be used also by farmers for their self-evaluation and improvement. The model could be upgraded for and used in various booking sites and tourist agencies.

Complex decision rules in DEX methodology: Comparative analysis of algorithms

Adem Kikaj[1,2], Marko Bohanec[2]

Abstract: DEX (Decision EXpert) is a qualitative multi-criteria decision-modeling methodology. DEX supports decision makers in making complex decisions based on multiple attributes. DEX is a four-tuple of basic attributes, aggregated attributes, qualitative scales of attributes, and decision rules. Each decision rule is called an elementary decision rule and consists of the condition and decision value part. Each condition part of the elementary decision rules is mapped to a single or interval of decision value of the aggregated attribute. Complex decision rules are the presentation of areas that contains several elementary rules with same decision value. This work is aimed at improving current algorithm that creates complex decision rules. DEXi is a computer program that implements the DEX methodology.

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Complex decision rules in DEX methodology: Comparative analysis of algorithms

Adem Kikaj[1, 2], Marko Bohanec[2]
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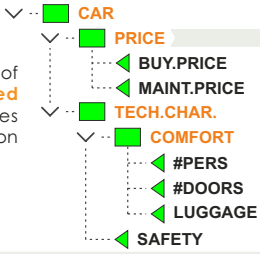
DEX Model

DEX models are composed of **basic attributes**, **aggregated attributes**, qualitative scales value of attributes, and decision rules.

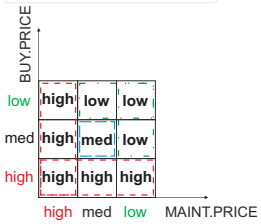


Elementary decision rules

BUY.PRICE	MAINT.PRICE	PRICE
high	high	high
high	med	high
high	low	high
med	high	high
med	med	medium
med	low	low
low	high	high
low	med	low
low	low	low

Elementary decision rules are defined by mapping all the combinations of **basic attributes** values to the value of the **aggregated attribute**.

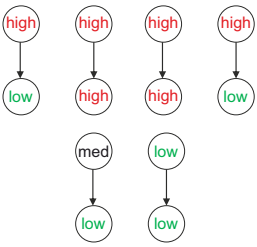
DEXi's algorithm



DEXi's algorithm finds areas of elementary rules starting from one elementary rule and **extending** it for each **basic attribute**.

jRule

jRule algorithm is a novel algorithm which creates complex rules. jRule identifies **lowest** and **highest** values of **basic attributes**, respectively it identifies largest possible areas. Unlike DEXi's algorithm areas in jRule are gradually **reduced**.



Complex rules

BUY.PRICE	MAINT.PRICE	PRICE
*	high	high
high	*	high
med	med	medium
>=med	low	low
low	>=med	low

BUY.PRICE	MAINT.PRICE	PRICE
*	high	high
high	*	high
med	med	medium
>=med	low	low
low	med	low

Comparison

	Running Time			Number of rules	
Aggregated Attribute	DEXi	jRule	Ratio	DEXi	jRule
CAR	54 ms	9 ms	6	7	7
PRICE	52 ms	7 ms	7.4	5	5
X[1]	1280 sec	395 ms	708.86	121	64
Y[2]	1.94 sec	98 ms	19.79	11	26

1 Aggregated attribute from different DEX model with six basic attributes.
2 Aggregated attribute from different DEX model with eight basic attributes.

Conclusion: The experimental comparison between DEXi's and jRule algorithms for different aggregated attributes showed that:
(1) jRule is faster regarding the running time and
(2) the number of complex rules produced by jRule is usually lower.

EWG-DSS Project Collab_Net (Version 5)

Jean Turet[1], Jadielson Moura[1], Ana Paula Cabral[1], Fatima Dargam[2], Pascale Zaraté[3], Isabelle Linden[4]

Abstract: The main goal of the Collab-Net is to allow researchers of the DSS community to analyze their own collaborative network, as well as possibilities for future collaboration with EWG-DSS members using a Web-based platform anywhere at anytime. In 2016 the scientific research collaboration has been extended to include social network analysis, which concerns in evaluating the collaborative interaction among papers and authors within publication databases. The Collab-Net platform investigates the publication relationship in anautomatic way by a Web-based platform. The system was developed using free platforms for software development and database system purposes and can be used with Administrator and Member profiles. Version 5 of the Collab-Net Project integrates the graphic visualization to the online collaboration network, which was already specified and initiated in Version 1.

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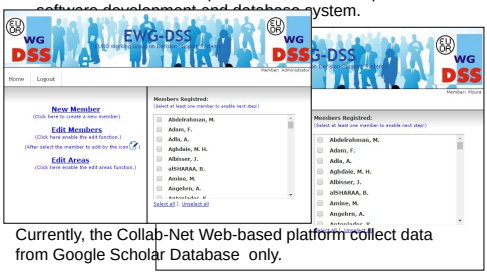
PROJECT COLLAB-NET

Collab-Net Functionalities andfTechnical Description:

- A login page is available; Two users' roles are possible. Administrator can add new members, edit members profile and remove members, add areas, edit areas, and remove areas. Member can edit his own profile, find researchers by keywors or areas, run members reseach in the google scholar, and export the results in Excel format.
- Online Platform developed with base on free platforms of software development and database system.



Currently, the Collab-Net Web-based platform collect data from Google Scholar Database only.

Figure 1: Collab-Net Platform – Adm. & User Profiles

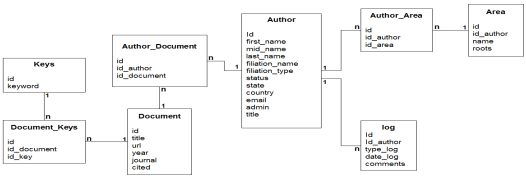


Figure 2: Collab-Net Database Model

COLLAB-NET V. 5 OBJECTIVES

The Collab-Net Project Version 5 will take into consideration the graphic visualization of our Collaboration Network using the functionalities of Network Analysis Platforms like NWB (http://nwb.slis.indiana.edu/) and Payek (http://vlado.fmf.uni-lj.si/pub/networks/pajek/). Studies using an initial Collab-Net author-publication dataset in Version 1, already gave us some results, shown in the network figures Fig. 3 and Fig. 4. This is going to be expanded and integrated with the online platform in Version 5.

COLLAB-NET NETWORK ANALYSIS

The figures below show initial results of the Collab-Net Network Analysis with respect to the researchers' collaboration in terms of co-authorship and related research topics.

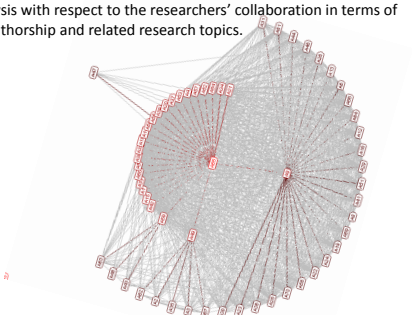


Figure 3: NWB Radial Graph Visualization of the Co-authorship Collaboration with respect to Research Topics.

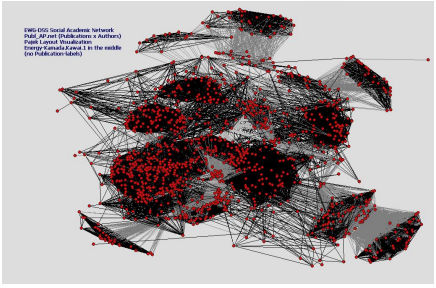


Figure 4: Collab-Net Pajek Visualization Publications x Authors.

CONCLUSIONS

Collab-Net Project Version 5 supports members in the research of their collaboration network by key areas within the EURO Working Group on Decision Support System. It allows EWG-DSS registered members to access and update their data using the web-based platform, enabling information access regarding published papers, such as: title, journal, year, citation numbers and co-authors to be investigated. The project also allows that information recovered may provide future analysis on the researches collaboration and identify cluster areas of the EURO DSS group within a more global DSS Community.

Generating actionable decision rules with fast-and-frugal trees

Bojan Cestnik[1,2], Alenka Kern[3]

Abstract: Improving usability and trust in electronic public services remains a challenging task in the modern society. We analyzed the responses to a survey among the users of a public service in housing tender for buying housing facilities. Our aim was to detect cues that can be used to differentiate between the users that deliberately use the electronic form submission channel and those that prefer using the paper one. The identified cues hierarchically organized in the form of a fast-and-frugal tree can be used to efficiently identify delicate citizen groups that might require a more focused communication strategy to reduce the risks of potential electronic services dropouts.

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INTRODUCTION

Relations between customer characteristics and usability requirements for online services that are keys to successful citizens' inclusions in e-service society have been analyzed in several recent national and international studies.
In our experiment we used fast-and-frugal trees (FFTs) to analyze responses to a survey and identify key factors (cues) for not using a certain digital service.
FFTs are designed to facilitate efficient binary decisions based on limited information (Phillips et al., 2017).

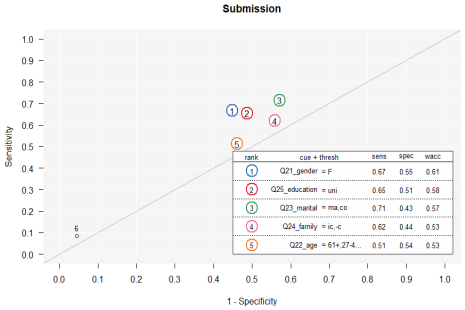

Figure 1: Detected cues presented in ROC diagram

OBJECTIVES

Our main objective was to detect the user characteristics that can be used to differentiate between the users that deliberately decide for the electronic form submission channel and those that prefer using the paper one. More specific plan was as follows:

- Collect and analyze responses to a survey among the users of a public housing electronic service;
- Identify cues that are relevant in distinguishing between users that submit paper or electronic forms;
- Construct an actionable piece of knowledge that can be used to identify a delicate group that might require a more focused communication strategy;
- To achieve higher actionability of the results we limited our focus on demographic characteristics (psychographic characteristics might also be relevant to our study).

METHODS

We collected responses form 238 completed questionnaires (26 questions, 83 attributes):

- Submission to a housing service: 154 electronic, 84 paper;
- Identify cues that best distinguish between the two user groups (see Figure 1);
- Demographic cues were used to construct FFT: gender, age, marital status, family type, education, employment.

RESULTS

1. The main result is the constructed FFT classification tree (shown in Figure 2) that can be efficiently used to support practical decisions;
2. Performance measures such as accuracy, sensitivity and specificity are also included for the assessment of results;
3. Diagram in the lower right corner of Figure 2 shows comparison with other popular learning algorithms

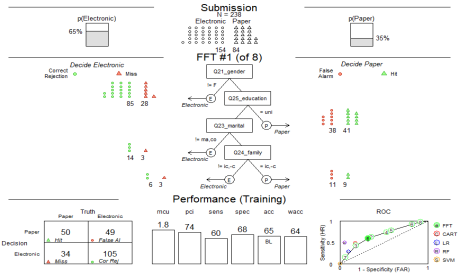

Figure 2: FFT for classification of submission channel

CONCLUSIONS

The presented approach was used to identify important cues for using (or not using) a certain digital service. The results can be used in practice to prepare a more focused communication strategy to reduce the risks of potential services dropouts.

REFERENCES

Phillips, N.D., Neth, H., Woike, J.K., Gaissmaier, W. 2017. FFTrees: A Toolbox to Create, Visualize, and Evaluate Fast-and-Frugal Decision Trees. *Judgment and Decision Making* 12 (4). Society for Judgment; Decision Making: 344–68.

Decision support system for flexible risk management: A case of water pollution by pesticides

Marko Debeljak[1,2], Jonathan Marks-Perreau[3], Benoit Real[3], Vladimir Kuzmanovski[1], Aneta Trajanov[1,2]

Abstract: Surface and ground waters are highly exposed to pollution with pesticides in areas with intensive agriculture. To prevent water pollution with pesticides we developed multi-attribute decision models (MADM) for risk assessment and risk management by employment of the DEX (Decision EXpert) integrative methodology, implemented in the DEXi modelling tool. Both models were integrated into a decision support system that helps farmers to assess the pollution risk and to provide changes of the application plan according to their technical and economic preferences, which makes the proposed risk management procedure highly flexible.

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INTRODUCTION

Surface and ground waters are highly exposed to pollution with pesticides in agricultural landscapes. When a risk of water pollution by pesticides exists, the pesticide application plan has to be modified. However, farmers could face several management constraints (e.g., no possibilities to install till-drainage system, no machinery for specific soil management, no place for grass buffer strips, etc.) that limit their choice of possible mitigation measures. A decision support system (DSS) that would enable flexible selection of mitigation measures that suite farmers' technical and financial management constraints would significantly reduce water pollution with pesticides and allow production of healthy food.

OBJECTIVES

The main objective of this research was development of a DSS for a risk management of water pollution. Thus, the first goal was the development of a model for assessment of the risk of water pollution and the second goal was the development of a model that will help farmers to select the most suitable mitigation measures to prevent water pollution with pesticides.

METHODS

To achieve the research objectives, we used a methodology originally developed for Multi Criteria Decision Analysis (MCDA), which enables the construction of multi-attribute decision models (MADM) of risk assessment and risk management. The approach is based on a hierarchical integration of selected qualitative attributes using integration roles determined by domain experts. We employed the DEX (Decision EXpert) integrative methodology implemented in the DEXi modelling tool that was used for construction of the risk assessment and the risk management models of DSS. The DSS integrates both models as presented in Fig.1. Inputs to the DSS are data that are discretized into a finite set of values of the initial attributes, while the outputs propose changes of the pesticide application plan that are given as mitigation measures.

RESULTS

The developed DSS consists of risk assessment and risk mitigation models (Fig.2). The risk assessment model is populated with data describing climatic conditions, physical, chemical and hydrological properties of the soil, crop, chemical properties of the active ingredient of pesticide and its concentration. The risk management model provides a list of suitable mitigation measures. The farmer can select those that suite his technical and economic capabilities the most. The DSS takes into account the selected mitigation preferences, performs iterative pollution risk tests and provides a list of possible changes of the pesticide application plan. The farmer has to select one of the proposed modifications, which gives him/her additional management flexibilities. The DSS was validated on data from the long-term experimental site La Jaillière, France.

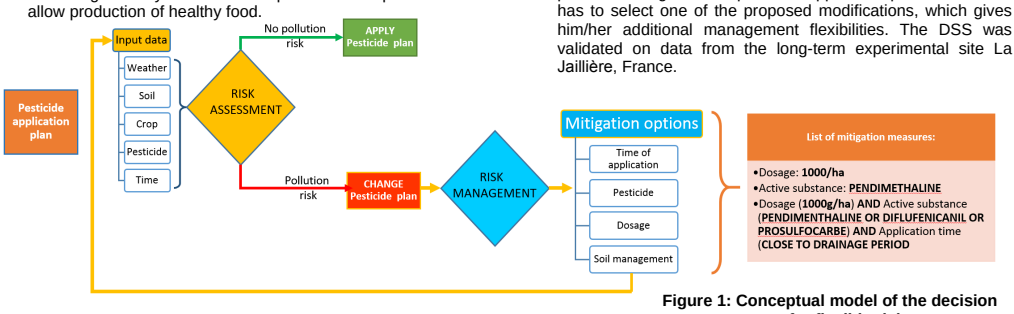

Figure 1: Conceptual model of the decision support system for flexible risk management

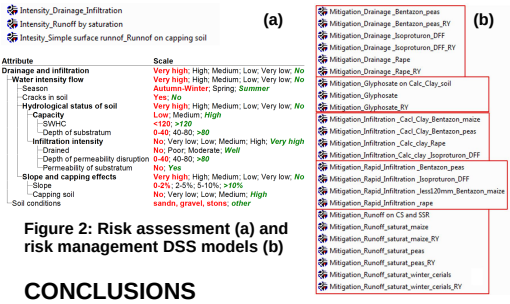

Figure 2: Risk assessment (a) and risk management DSS models (b)

CONCLUSIONS

The developed DSS provides a reliable risk assessment of water pollution by pesticides and provides modifications of the pesticide application plan in case a risk of pollution exists. The end-users are involved in the selection of mitigation constraints and can make final selection of the proposed measures according to their technical and economic preferences.

ACKNOWLEDGEMENTS

This study was conducted as a part of the EVADIF project (Evaluation of existing models and development of new decision-making tools to prevent diffuse pollution of water caused by phytopharmaceutical products) financed by ARVALIS, Institut du végétal, France.

HEARTMAN:Personal Decision Support for Heart Failure Management

Mitja Luštrek[1], Aljoša Vodopija[1], Marko Bohanec[1], Miha Mlakar[1], Erik Dovgan[1], Pavel Maslov[1], Anneleen Baert[2], Sofie Pardaens[2], Els Clays[2], Paolo Emilio Puddu[3]

Abstract: Congestive heart failure (CHF) occurs when the heart cannot pump enough blood to meet the body's needs. The symptoms include shortness of breath, excessive tiredness and leg swelling. In developed countries, around 2 % of adults have heart failure, increasing to 6–10 % at ages over 65, when it becomes the leading cause of hospitalisation. There is no cure, and around 50 % of patients die within 5 years from diagnosis. Since CHF cannot be cured, its management is critical for survival and quality of life. In addition to taking medications, the patients must monitor their condition, exercise appropriately, watch what they eat and drink, and make other changes to their lifestyle. Since CHF management is complex and the patients mostly elderly, they often find it difficult to remember what exactly they need to do. We thus developed a mobile application that delivers personalized CHF management advice. Its heart is a personal decision support system using workflows, rules, DEX decision models and predictive models built with machine learning.

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BACKGROUND AND MOTIVATION

- Congestive heart failure (CHF) occurs when the heart cannot pump enough blood to meet the body's needs. The symptoms include shortness of breath, excessive tiredness and leg swelling. In developed countries, around 2 % of adults have heart failure, increasing to 6–10 % at ages over 65, when it becomes the leading cause of hospitalisation. There is no cure, and around 50 % of patients die within 5 years from diagnosis.
- Since CHF cannot be cured, its management is critical for survival and quality of life. In addition to taking medications, the patients must monitor their condition, exercise appropriately, watch what they eat and drink, and make other changes to their lifestyle.
- Since CHF management is complex and the patients mostly elderly, they often find it difficult to remember what exactly they need to do. We thus developed a mobile application that delivers personalized CHF management advice. Its heart is a personal decision support system using workflows, rules, DEX decision models and predictive models built with machine learning.

WEEKLY EXERCISE PLANNING

- Endurance (e.g., walking) and resistance exercises (e.g., lifting)
- Exercise programme defines frequency and duration for each week
- Start with initial frequency and duration according to the programme
- Each week increase or decrease depending in patient's adherence to medications and his/her request to change the programme

Model: endurance frequency (other models similar)

Attribute	Scale
EnduranceFrequency	2x; 3x; 4x; 5x
Normative	2x; 3x; 4x; 5x
Category	low; *normal*
Week	1; 2; 3; 4; 5; 6; 7; 8; 9; 10; 11; 12; 13; 14; 15; 16; 17; 18; 19; 20; 21; 22; 23; 24; *more*
Current	2x; 3x; 4x; 5x
Transition	decrease; stay; increase; automatic
Adherence	no; yes
PatientsRequest	decrease; stay; increase; automatic

According to the exercise programme

Depends on patient physical capacity

As actually done (can be ahead or behind the plan)

Whether to change the frequency from one week to another

Decision table: normative frequency (defined by the exercise programme)

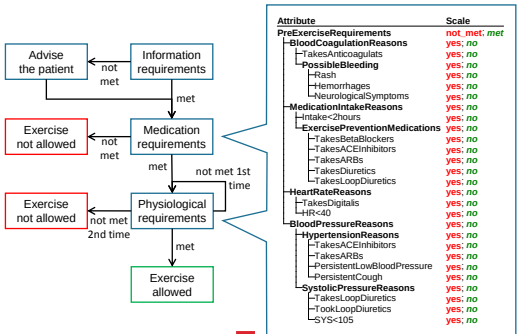
Category	Week	Normative
low	<=4	2x
low	5–12	3x
normal	<=6	3x
low	13–18	4x
normal	7–12	4x
low	>=19	5x
normal	>=13	5x

Decision rules: transition (* = any value)

Adherence	PatientsRequest	Transition
*	decrease	decrease
no	>=stay	stay
*	stay	stay
yes	increase	increase
yes	automatic	automatic

DAILY EXERCISE

- Each day the weekly exercise plan prescribes exercise, the patient is provided assistance to perform it safely
- Check if information on blood pressure and heart rate is available and the values are within prescribed boundaries, and check if there are any problematic interactions with medications

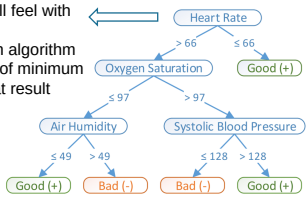


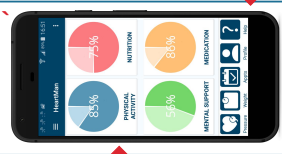
ENVIRONMENT

- We built models that predicts the feeling of health based on physiological and ambient parameters
- Since it is hard for the patients to modify their physiological parameters, the model is mainly used for decisions about ambient temperature and humidity

Procedure

1. Predict how the patient will feel with the current parameters
2. If bad, use an optimisation algorithm to find minimum changes of minimum number of parameters that result in the patient feeling good
   a. Change directly modifiable parameters
   b. Compute parameters correlated with the directly modifiable ones using linear regression
   c. Predict how the patient will feel with new parameters
   d. Discard solutions in which the feeling remains bad
3. Advise the patient to make the smallest modifications that result in feeling good





MOBILE APPLICATION + SENSING WRISTBAND

MEDICATION

- Reminders for medications at appropriate times
- Instructions to fill a pill organiser once a week
- Questions about the number of pills remaining to estimate how many the patient skipped

NUTRITION

- Nutrition knowledge questionnaire in week 1 (e.g., How much salt are you allowed to eat per day?)
- Nutrition behaviour questionnaire in week 2 (e.g., How much did you drink yesterday?)
- Repeat every three months
- In between, advice on topics identified as problematic in the questionnaires (inadequate knowledge or unhealthy behaviour)

Data-driven decision-making: how to build a "hybrid intelligence" in organizations with Machine Learning Algorithms

Gaetano Bruno Ronsivalle[1], Arianna Boldi[1]

Abstract: The "intelligent organization" is an organization capable of making data-driven decisions to survive and be competitive in an increasing complex world. To take full advantage of digitalization and to deal with its consequences, organizations may decide to "extend" their intelligence by adopting artificial intelligence (AI) and machine learning tools. The "Six times Six" model proposed represents a possible response for companies, as it supports them to assess their intelligence, that is the ability to make effective decisions, to identify any critical nodes and to implement tools to enhance the whole data science process. As a result, the organization becomes endowed with a hybrid intelligence, where humans and automata cooperate to effectively orient the decision-making process. The paper also described a Taxonomy of Machine Learning Algorithms and their application, to be a practical guideline for both Governance and Management professionals.

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INTRODUCTION

The **intelligent organization** is an organization that can make effective data-driven decisions to survive and be competitive. The flood of data, the growing chaos of the environmental conditions (both endogenous and exogenous ones), the volatility of the markets, the digital storm and the geopolitical dimension of the economic variables, make **decision making** a tough issue. To deal with complexity effectively and quickly, companies may decide to enhance or *extend* their intelligence through the adoption of Artificial Intelligence tools and, above all, Machine Learning.

This extension basically implies an important transformation of the data flow management model, with the introduction of smart software systems capable of supporting the decision-making process and automating. An organizational **transformation** that, if not ethically and properly directed, could have a devastating impact on the workers, towards an indiscriminate substitution of human resources with machines.

Today companies need more than ever a solid but economic **method** to manage the introduction of AI in a sustainable, rational and "human" way.

OBJECTIVES

To give a possible response to this need we (1) have elaborated a **"Six times Six" model**, to analyze the organizational functions through which the organization practically expresses its intelligence and, specifically, the ability:

- to make data-driven decisions;
- to identify any critical nodes;
- to plan the introduction of software tools aimed at enhancing the process of data management and data processing.

The paper also includes (2) a **Taxonomy** of Machine Learning Algorithms able to supervise and extend the various functions of organizational intelligence, with the purpose to guide the progressive construction of a hybrid intelligence, where humans and automata can cooperate to effectively orient the decision-making process.

METHODS

The model has been created by confronting a) the models elaborated in the "**Organizational Cybernetic"** area, b) the recent researches concerning Data Science and c) data professionals skills, d) the models concerning human intelligence and e) artificial intelligence. These tools have been actually tested on a banking organization to solve a crucial problem: the results can be found in Ronsivalle, Boldi "*Six Times Six model: 36 indexes to evaluate a company's intelligence in decision-making"* (2018).

RESULTS

(1) The ability to use data to get useful information and make effective and quick decisions can be declined in 6 macro indicators or functions. A total of 36 indicators can be used to assess the decision-making intelligence of a company (Figure 1).

We identify three sources of data, during the evaluation process: **people**, **processes** and **allocated resources.**

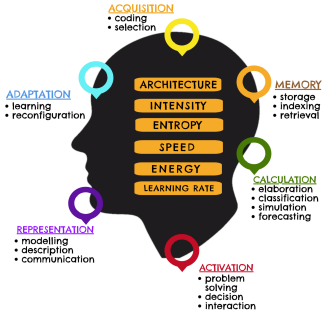

Figure 1. The model

(2) How can the Machine Learning tools support the six functions? By giving values at each indicator of the model, after the assessment phase, we can identify the most effective algorithm to manage the data and the information flow. Table 1 shows ten classes of Machine Learning algorithms and their applications to one or more functions.

Algorithms	Functions					
	Acquisition	Memory	Calculation	Activation	Representation	Adaptation
Deep Learning			x	x		x
Ensemble			x	x		
Artificial Neural Networks			x	x		x
Regularization	x	x	x	x		x
Association Rule Learning	x	x	x		x	
Regression			x	x		x
Bayesian			x	x		x
Decision Tree			x	x		
Dimensionality Reduction	x	x	x		x	
Instance Based	x	x	x		x	
Clustering	x	x	x		x	

Table 1. Taxonomy of Machine Learnin tools

CONCLUSIONS

The application of the model, in terms of process and tools (i.e. surveys) that should be implemented in practice during the organizational diagnosis, represent the topic of the next research **Wemole Srl** is working on in collaboration with the authors of the paper.

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