Program of the

14th European Symposium on Computational Intelligence and Mathematics including Workshop DigForASP

October 2nd - 5th 2022. Naples, Italy

COST EUROPEAN COOPERATION IN SCIENCE & TECHNOLOGY

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UCA Universidad de Cádiz
Departamento de Matemáticas

DIGFORASP

SEA EU European University of the Seas

MONDAY 3rd Location: Hotel Royal Continental	
8:30	Open Registration Desk
9:30–10:00	Inauguration
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11:00–11:20	Coffee break
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	Possibility theory and thresholds for factorizing multi-adjoint contexts Roberto García-Aragón, Jesús Medina and Eloísa Ramírez-Poussa
	Knowledge Discovery in Malware Datasets using Formal Concept Analysis Angel Mora Bonilla, Domingo López-Rodríguez, Manuel Enciso and Pablo Cordero
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	On the measure of inconsistency of fuzzy relation equations David Lobo, Víctor López-Marchante and Jesús Medina
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ΣSCiM 2022

BOOK OF ABSTRACTS

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***Keynote speech*:**

Evidence Theory Approach to Determine States of Hierarchical System

Marek Reformat

Department of Electrical and Computer Engineering,
University of Alberta, Canada

Abstract: Complex systems are composed of multiple subsystems arranged in a multi-level hierarchical architecture. Therefore, distinctive methods suitable for determining the local states of individual components and the global state of the system are needed. Subsystems' dependence on each other and unreliable inputs make defining definitions of the subsystems' states challenging. As a result, the state descriptions could contain imprecise terms in the form of data granules. The granules 'conceal' partial information and clarity on what values of inputs and states of other subsystems are required to determine the local and global states of the system.

In this presentation, we introduce and describe a novel approach to determining states – local and global – of complex multi-component systems of hierarchical architecture. We use elements of Evidence Theory and adopt a newly developed method suitable for satisfying uncertain targets to assess the system's states. In our case, the uncertain targets are definitions of subsystems' states. This process is performed in stages following the system's architecture. The inputs are used at the lowest levels of the hierarchy, and the processing at higher levels uses the results of lower-level computations. Due to the imprecision of inputs and definitions of subsystems' states, the proposed approach deals with multiple sources of uncertainty in determining the states. The origins of imprecision are categorized into: 1) uncertainty and ambiguity associated with measured quantities as inputs to subsystems, 2) degrees of imprecision in determining states of subsystems calculated based on the states of other subsystems, and 3) imprecision and incomplete knowledge included in the statements defining subsystems' states.

Additional notes on heterogeneous concept-forming operators

Peter Elia[1], Ľubomír Antoni[2], Ondrej Krídlo[2] and Stanislav Krajči[2]

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Abstract: Heterogeneous formal context represents the possible generalization of formal context which allows us to diversify the data structures of objects, attributes and fuzzy relations. Moreover, it can provide the more efficient representation of data in heterogeneous environment. In this paper, we present the extended results on heterogeneous formal context. We provide the equivalent definition of concept-forming operators on heterogeneous formal context and describe their additional properties.

Keywords: Formal Concept Analysis · Heterogeneous formal context · Concept-forming operations · Category Theory · Galois connection

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Characterizing clarify and reduce method by means of left-sided formal concept analysis

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Abstract: Multi-adjoint formal concept analysis is one relevant tool to manage information in databases. Reduce the size of a database is an important issue in several research field, specifically, in Formal Concept Analysis. Several methods were developed with this goal, as Clarify-and-Reduce method. In this paper, we will prove that latter method is a particular case of a multi-adjoint FCA.

Keywords: Attribute reduction mechanism · Multi-adjoint formal concept analysis · Left-sided adjoint triple · CR-method.

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Knowledge Discovery in Malware Datasets using Formal Concept Analysis

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Abstract: Intelligent malware detection [4] is a problem that is generating growing interest in the industry due to the increase in the diversity of threats and attacks suffered by small users to large organisations or governments, in many cases compromising sensitive information and without ruling out possible economic consequences.

Among the different problems that arise in this area, the homogenisation of the nomenclature of malware threats [5] stands out, as different antivirus engines or applications often use different names for the same threat or the same family of threats, which is related to the problem of malware family classification [7].

Another big open problem in this field is the definition of methodologies that allow optimising the detection process itself of new threats, since the different engines have different detection capabilities and no single software can detect all the threats at one point, thus there is a need of determining which combination or possible combinations of engines cover the majority of detection and which features present in malicious software allow us to detect it at an early stage [2,1].

In this paper, we propose the use of formal concept analysis (FCA) [3] to exploit the existing knowledge in previous threat and malware databases by different detection engines. In this formal framework, based on lattice theory and logic, we can build a lattice where threat sets are organised hierarchically according to specialisation-generalisation criteria, which provides us with a direct approach to setting up a unified taxonomy of malware.

On the other hand, the use of FCA itself enables the discovery of logical rules and the application of automated reasoning methods [6] whose objective is to simplify the detection process without losing information or threat detection capacity and even increasing this capacity.

In this sense, our proposal differs from previous [4] ones in that it does not use statistical criteria, but rather an exhaustive analysis and mathematical modelling of the knowledge contained in malware databases, so that the models obtained are based on logical and algebraic tools and offer a greater degree of interpretability and explainability than previous proposals.

Keywords: Logic programming · immediate consequence operator · generalized quantifiers

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Possibility theory and thresholds for factorizing multi-adjoint contexts

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Abstract: Recently, a method for extracting independent subcontexts of formal contexts with Boolean data was proposed. In this paper, we provide a procedure to find independent subcontexts from a multi-adjoint context, based on the necessity operators used in possibility theory, which generalize the lower approximation operator in rough set theory.

Keywords: Formal concept analysis · factorization · multi-adjoint framework · independent subcontext

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Grading the unknown information via intuitionistic approach

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Abstract: Information does not use to be precise and exact and, in many cases, some data are missed or unknown. To manage with this data, fuzzy logic introduces a set of (infinitely many) values between the two Boolean truth values. Other authors use a three-valued approach, by adding an intermediate value to the set of Boolean truth-values. We propose a formal framework strongly based on Atanassov Fuzzy logic, associating each proposition with a pair of degrees characterizing our knowledge about the two truthfulness values, since this logic does not include the law of the excluded middle.

Our starting point is the crisp Formal Concept Analysis, which provides a formal framework for knowledge representation and reasoning. Information is described by means of a binary relation characterizing the relationship among a set of objects and a set of attributes. We extend the crisp framework considering a pair of degrees for each element in the relation.

Formal concept analysis provides a twofold repsentation of the knowledge: the so-called concept lattice and the implication set. In this paper we choice the second option since it better provides a symbolic manipulation of the information. Here, we introduce the syntax and semantics for a new intuitionistic implication. This notion of implication allows a further definition of an intuitionistic logic to manage this kind of information with a powerful expressive power, but avoiding the problems of the classical propositional Logic regarding its execution because of the SAT problem.

Keywords: Implications · Unknown information · Formal concept analysis · Intuitionistic logic.

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Efficiency of fuzzy rough set decision algorithms

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Abstract: This paper addresses the study of decision algorithms given in Rough Set Theory. Considering the fuzzy framework, we present a generalized notion of efficiency, which is one of the most important notions associated with decision algorithms. This new notion can be used to know the usefulness of a fuzzy rough set decision algorithm, as well as to compare it with other fuzzy decision algorithms.

Keywords: Fuzzy Rough Set Theory · Decision Rules · Decision Algorithm · Efficiency.

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Use of Fuzzy Time Series to generate linguistic descriptions of noise pollution

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Abstract: In this paper we present a proposal to represent sets of Time Series as a Fuzzy time Series (FTS) composed of linguistic labels previously defined in a set. In the definition of this set of linguistic labels the knowledge from an expert in the domain of application can be Incorporated. First, the input set of TS is represented by means of FTS whose values are fuzzy sets. Then, these fuzzy sets are transformed into linguistic labels taken from the predefined set and then a new FTS is obtained whose main difference with the previous one is that it is more interpretable. The Monte Carlo method has been used to perform this transformation. Finally, to show the validity of our proposal, in the experimentation a case use in the generation of linguistic descriptions of noise pollution is presented.

Keywords: Fuzzy Time Series · Time series aggregation · Monte Carlo methods · noise pollution.

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A Novel Fingerprint Identification Fuzzy System Using a Center-Distance Weighted Local Binary Pattern

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Abstract: Despite the rapid development of the automated fingerprint identifica-tion system, some challenging fields need more enhancement. Typically, finger-prints suffer from distortion, partial cuts, and noise, making the identification process uncertain and more probabilistic. In this research, we aim to improve the fingerprint identification system using the well-known image-based local binary pattern method based on assigned weights determined by the distance from the center area of the processed fingerprint image. The proposed Fuzzy Fingerprint Identification System (FFIS) starts with image enhancement using Fourier do-main analysis, then the image is cut into 200x200 around the core-area, after that, the feature vectors of the local binary images are extracted and matched based on the distance of their histograms. Finally, a fuzzy approach is used to retrieve the suitable linguistic form to help clear the uncertainty of the results. The proposed Fuzzy Fingerprint Identification System (FFIS) showed its efficiency through ex-tensive experiments conducted on the FVC2002 database.

Keywords: Fingerprint · Distortion · Partial cuts · uncertainty · Binary pattern.

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Projective and Computational Intelligence-Based Price Index Theory: Mathematical Models, Representations and Fuzzy Transitions

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Abstract: The price index is an economic measure of well-being, price level stability and inflation. Even so, the index numbers in one dimension cannot measure the dynamically changing era of the 21st century including wars, pandemics and other unpredictable events. Thus, there is a high demand for data-based, multidimensional methods and models, that can capture the consumption processes and economic dependencies. In the present paper, we discuss the Price Index Theory both from the practical and theoretical point of view, as a basic measuring and modelling method of economic processes. The significance and applicability of the models, theorems and representations are briefly introduced in the paper.

Keywords: Index Theory · Matrix model · Duality · Fuzzy-transition · Value-matrix · Space of goods

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Global Sensitivity Analysis and Low Magnitude Pruning for Convolutional Neural Networks Reduction in ImageNet based on Transfer Learning State of the Art Models

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Abstract: Transfer learning is a technique for reapplying to a new task, the knowledge held by a neural network. With constantly growing network architectures, pruning algorithms are being researched with the intent of compressing data while having the least impact on accuracy. This article investigates the Global Sensitivity Analysis (GSA) method for creating generalized pruned networks for transfer learning, and compares it with the Low Magnitude Pruning (LMP) technique. These techniques reduce popular convolutional neural networks: ResNet50V2, ResNet152V2, VGG16, VGG19 and InceptionV3, when pre-trained on ImageNet as applied to classify cifar10, cifar100 and fashion MNIST datasets in benchmark applications.

Keywords: Global sensitivity analysis · convolutional neural networks · pruning · imagenet · transfer learning · sota models

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Fuzzy approximating metrics and their relations with fuzzy partial metrics and modular metrics

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Abstract: We generalize the concept of a fuzzy metric by introducing its approximating counterpart in order to make it more appropriate for the study of some problems related to theoretical computer science. Approximating fuzzy metrics are compared with (fuzzy) partial metrics which have extensive applications in theoretical computer science and with modular metrics having important applications in theory of multivalued functions.

Keywords: KM-fuzzy metrics · GV-fuzzy metrics · CB-fuzzy metrics· approximating fuzzy metrics · modular metrics · fuzzy partial metrics

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***Keynote speech*:**

Trusted Execution Environments: the enabling technology of protection of data in use

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Abstract: Even the most secure algorithm is vulnerable, if the computing environment where it is executed is not adequately protected. Effective protection mechanisms must be provided throughout the data cycle, i.e. data must be handled securely at all times and in all locations. This results in stringent confidentiality and integrity requirements, not only when data is "in transfer" (e.g. when it is exchanged over a network connection) or "at rest" (e.g. when it is stored on a disk) but also when it is "in use" (e.g. it is loaded in the RAM or in the CPU for executing a computation). While protection of data in transfer and at rest is relatively easy to achieve, protection of data in use is still - to a large extent - an open issue. The challenge here is that data must be also protected from attacks by privileged users (e.g. system administrators or cloud providers) and software (e.g. the operating system or the hypervisor). Protection of data in use is a number one priority in security research, since it the enabling factor of a number of business opportunities. Suffice to say that there is a huge business case around Cloud Computing. The Cloud Security Alliance report lists the top threats to cloud security and one of these is the insider threat, which is a major obstacle to the real adoption of the cloud computing paradigm. Some of the big players of the cloud market have already realized that addressing the insider threat is a number one priority, and offer cloud solutions which provide high guarantees of being immune from such a threat (for instance Microsoft Azure Confidential Computing). MS ACC "safeguards data from malicious and insider threats while in use". The availability of a "Trusted Cloud" would unleash the potential of a number of application domains. As an example, the option of moving security and/or safety critical applications (e.g. Industrial Control Systems) to the cloud – often referred to in scientific and technical literature as "cloudifying critical applications" – is receiving more and more attention in the last few years, since the cloud paradigm has a dramatic potential in terms of reduction of costs for maintenance and management of hardware and software platforms, not to mention the advantages with respect to availability which are brought about by the inherent redundancy of the underlying IT infrastructure. The talk will introduce the basic concepts of hardware-assisted security and give an overview of the current State of The Art of CPU support for Trusted Execution Environment technology.

***Keynote speech*:**

Fuzzy sets as manifolds - a new direction in data analysis

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Abstract: In the pursuit of data-driven modeling, we arrive at a space with a manifold structure. If the structure is defined, then modeling consists in characterizing objects and their relationships in terms of local coordinates. In the talk, we will focus on the approach to determining the structure of the manifold from the easy-to-understand concept of the fuzzy partition of the universe. We will show examples of image processing.

Generalized linearity of aggregation and related functions

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Abstract: We study aggregation functions and some of their generalizations which are linear splines. We recall some construction methods and discuss two (four) simplices based forms. Our approach brings also an alternative definition of the Choquet integral and of a parametric class of singular copulas with pre-described support.

Keywords: Aggregation function · Boolean operations · Choquet integral · copula · fusion function

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A study on semicopulas on finite chains

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Abstract: Semicopulas are the operators chosen to model conjunction in the fuzzy/many-valued logics. In fact, a special kind of semicopula, called t-norm, is widely used in many applications of logic to engineering, computer science and fuzzy systems. In this work we pose the problem of counting the number of semicopulas on finite chains and show some preliminary results, together with some examples to illustrate the ideas behind the current conjectures.

Keywords: Semicopula · Conjunctor · Aggregation Function

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Closure operators on AMV-valued fuzzy sets

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Abstract: Many of the new L-fuzzy structures with values in a complete MV-algebra L, such as intuitionistic, neutrosophic, or fuzzy soft sets or their combinations, cannot be explicitly expressed as classical L-fuzzy sets $X \to L$. On the other hand, they can be transformed into $\mathcal{F}(L)$-fuzzy sets $X \to \mathcal{F}(L)$, where $\mathcal{F}$ is a functor from the category of MV-algebras to the category of the so-called almost MV-algebras. We show how this transformation of the new L-fuzzy structures can be used to define in a universal way the closure operators on the powerset objects of these new L-fuzzy structures.

Keywords: Dual pair of semirings · semirings-valued fuzzy sets · closure theory of semirings-valued fuzzy sets · applications to neutrosophic and fuzzy soft sets

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An Application of a Fuzzy Multi-Criteria Decision Making Process for Explainable Machine Learning in the Actuarial Context

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Abstract: There is an ever-increasing need for system interpretability in artificial intelligence and machine learning. Explanation, or system interpretability, has always been necessary in applications where critical decisions, for example, in actuarial context applications, need to be made. This work presents a case study of applying Fuzzy Multi-Criteria Decision-Making (MCDM) models for solving actuarial problems using machine learning methods. The used explainable framework includes a Fuzzy Inference System paired with a modified MCDM-based model to obtain a rank of relevant variables both in global and local decisions.

Keywords: Insurance · Explainable Artificial Intelligence · Decision Support Systems

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A software tool for solving the Traveling Salesman Problem and related non-fuzzy and fuzzy optimization problems

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Abstract: Routing optimization nowadays is an important and popular topic, it plays a key role in the transport and logistics industry. In this paper we present a software tool for solving the Traveling Salesman Problem and related non-fuzzy and fuzzy optimization problems. For this purpose the Discrete Bacterial Memetic Evolutionary Algorithm (DBMEA) was implemented in this software which is a proven efficient method for handling the examined type of optimization problems.

Keywords: Software · optimization · TSP · DBMEA · fuzzy.

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On measuring the solvability of a fuzzy relation equation

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Abstract: Solvability of fuzzy relation equations is a problem that often arises when it comes to modelling databases. When a fuzzy relation equation is unsolvable, it can be due to multiple reasons, as lack or excess of information. In this paper, we present a first approach on measuring the solvability of a fuzzy relation equation. Specifically, based on a recently published method for computing approximated solvable equations, we introduce three ways to measure the solvability of a fuzzy relation equation.

Keywords: Fuzzy Relation Equation · Multi-adjoint · Approximation · Solvability measure

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Extension of The Time Dependent Travelling Salesman Problem Model with Interval-Valued Fuzzy Soft Sets

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Abstract: The Traveling Salesman Problem (TSP) is an extensively studied NP-hard graph search problem. Many researchers pursued the most efficient and practical solutions, by applying various techniques to find the optimum or semi optimum solution (the one with least cost). There are numerous practical extensions and modifications of the original problem, such as The Time Dependent Traveling Salesman Problem (TD TSP). Indeed. the TD TSP was towards more realistic assessment of the traffic conditions of the original TSP. The edges be-tween nodes are assigned different costs (weights), depending on the fact that they are traveled during the rush hour periods or they crossed the traffic jam regions (such as city centers). However, in the TD TSP, the edges are assigned higher costs using concrete numbers, which might be looked at as a limitation because those jam factors are non-deterministic. In this paper we introduce an even more realistic novel fuzzy-based extension, the IVFSTD TSP (Interval-Valued Fuzzy Soft Time Dependent Traveling Salesman Problem). Our core concept employs interval-valued fuzzy soft sets on the costs between nodes to realistically quantify the traffic jam regions, and the rush hours periods effects on any tour. Since the interval-valued fuzzy sets are generalization of the original fuzzy sets, which has the ability to simulate uncertain road conditions more efficiently than concrete numbers, then our approach is a useful extension and a practical alternative model of the original abstract problem.

Keywords: Rush hours · Jam regions · Interval-valued fuzzy soft sets · Time Dependent Traveling Salesman Problem.

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ITAMACDSS: A Fuzzy Clinical Diagnostic Support System for Coeliac Disease

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Abstract: Preliminary results obtained by ITAMACDSS, a Fuzzy-based Clinical Diagnostic Support System (CDSS) for Coeliac Disease (CD), part of the ITAMA project, are presented and discussed. CD is a chronic disease of the small intestine triggered by repeated gluten consumption, for which confirmed diagnosis depends on biopsy. As biopsy is an invasive and costly procedure, especially in children, alternative ways of diagnosis are sought. ITAMACDSS can be used to help assess risk and confidence factors during a diagnostic pathway, reducing costs and improving prioritization of patients. On a preliminary test on 20K subjects, ITAMACDSS delivered positive and negative classification with 99accuracy, 86% sensitivity, 99% specificity and 96% precision.

Keywords: Fuzzy Logic · Diagnosis Support Systems · Fuzzy Classification

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Preference in multi-adjoint logic programming based on ordered adjoint pairs

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Abstract: This paper introduces a preliminary study on how the selection of different ordered adjoint pairs affects the computation of the minimal model of a fuzzy logic program in the framework of multi-adjoint logic programming. Moreover, the usefulness of these ordered adjoint pairs is also illustrated.

Keywords: Logic programming · fuzzy sets · immediate consequence operator · adjoint pairs.

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***Keynote speech*:**

Digital Forensics: a case for Neuro-Symbolic approaches.

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Abstract: One main issue which is coped with by Artificial Intelligence in Digital Forensics is image recognition. Convolutional Neural Networks are often used to this purpose and provide good performance. However, the precision they reach on data unseen before is sadly lower that expected, and the network is in general not able to indicate an outcome as «uncertain». We propose an architecture encompassing neural network and symbolic reasoning, in a combination of induction and abduction, implemented via Answer Set Programming, in order to improve the precision of image recognition while also introducing uncertainty.

Lattice valued aggregation operators applicable in digital forensics

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Abstract: The aim of this paper is to develop a framework based on lattice-valued aggregation operators that can enable ranking data in different problems of digital forensics. While the measure of the importance of each segment of the investigated data is predetermined by an expert, the measure of interaction of different segments is based on the appropriate choice of aggregation operators. This choice should adequately represent the opinions of experts, and express strengthening of interaction with an increase in the number of segments involved. The main contribution of the approach proposed in this paper is the development of specific generalized lattice-valued aggregation operators that can aggregate the measure of interaction that is adaptable to the guidelines indicated by the experts.

Keywords: Aggregation operator · Bounded lattices · Fuzzy measure.

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Power consumption-based identification of used encryption solution in IoT environments

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Abstract: State-of-the-art encryption algorithms, if applied properly, provide virtually unbreakable protection of confidentiality and integrity of data. However, there are black-box attacks that can provide the attacker with valuable sensitive (meta) information – e.g. the identity of the person using the system, the presence of the user, the schedule of use, etc. In this paper, we present some early results related to the identification of used encryption protocols in IoT environments, based on energy consumption. We measured power consumption on three Nvidia Jetson devices, within the 128 sessions, when using plain FTP, WireGuard, OpenSSL, and OpenSSL+WireGuard-based transfers. Finally, we used classification algorithms to determine the reliability of this approach in identifying the protocol that was used in a data transfer.

Keywords: Power consumption · encryption · IoT.

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Maritime Cyber- Attacks Detection Based on a Convolutional Neural Network

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Abstract: Maritime transportation is the lifeblood of the global economy; it accounts for the transport of 90% of the world's trade goods. In regard to modern ships and other vessels, increasing the integration of the maritime internet of things (IoT) and connectivity to global communication systems means that the maritime domain is now part of cyberspace. The issue of cyber security plays a major role in maritime transportation system technologies. Vulnerabilities in maritime embedded technology tools are of interest to attackers. Increasing the degree of automation of the maritime transportation system increases the probability of cyber- attacks; In fact, these have increased by 900% over the last three years. Some targets of cyber attacker in maritime transportation system are altering the course of vessels to cause accidents and increasing port congestion. To protect the data in maritime transportation systems, a convolutional neural network is proposed, which works to detect data anomalies in maritime communications.

Keywords: Maritime security · cyber security · data anomalies · GNSS.

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Epistemic Logic and Theory of Mind for Modelling Group Dynamics of Criminal Organizations

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Abstract: In this paper, we show how the Logic of "Inferable" *L-DINF* is able to model (aspects of) the group dynamics of cooperative agents, and in particular of criminal organizations. We outline how this logic allows a designer to model real-world situations encompassing joint intentions and plans with roles, preferences and costs concerning action execution. All such aspects can be particularly useful to allow investigators to model and understand the activities of criminal organizations, as we demonstrate by means of a significant example.

Keywords: Multi agents system · modal Logic · epistemic logic · logic.

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Intrusion detection using intelligent systems

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Abstract: Intrusion detection is an important task, many times extremely difficult, related to the security policies of an organization that uses digital data and information distributed networks. Intrusion Detection Systems (IDSs) should monitor network traffic and user activity at the same time, to detect malicious traffic and abnormal activity. In this paper we propose an intelligent agent security approach for adopting IDSs in a distributed computational network-based environment. The solution is a decentralized, agent-based IDS that allocates tasks to knowledge-based agents for collecting, analyzing and delivering at the same time data needed for identifying threats and for doing effective actions. The advantages of this approach are: scalability, handling increased load and network latency, and no single point of failure.

Keywords: Industry 4.0 · intrusion detection system · smart manufacturing system · distributed system · intelligent agent · multiagent system

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Analysing the influence of the pandemic on crime patterns in North Macedonia

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Abstract: Reducing national crime rate is an extremely important, but also difficult problem. For solving it, it is necessary to discover patterns of its occurrence, the various factors that influence it and the connection between criminal actions, which can help forecast future events, especially violent crimes where the police should act immediately. However, some major events, such as the COVID-19 pandemic may significantly affect these models. Therefore, this paper focuses on analyzing the impact of the pandemic on the crime rates and patterns and the way the crime forecasting models are affected by these changes, using North Macedonia's crime records as case study. The results show significant change in the rate and types of crimes during the pandemic period, when compared to the pre-pandemic period. Due to these changes in the crime patters, the crime forecasting models are also different, in terms of their accuracy and in terms of the importance of the input features that are used for the prediction.

Keywords: Crime pattern · crime forecasting · pandemic correlation

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