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The flagship event is the IFIP World Computer Congress, at which both invited and contributed papers are presented. Contributed papers are rigorously refereed and the rejection rate is high.

As with the Congress, participation in the open conferences is open to all and papers may be invited or submitted. Again, submitted papers are stringently refereed.

The working conferences are structured differently. They are usually run by a working group and attendance is generally smaller and occasionally by invitation only. Their purpose is to create an atmosphere conducive to innovation and development. Refereeing is also rigorous and papers are subjected to extensive group discussion.

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Eunika Mercier-Laurent ·
Gülgün Kayakutlu (Eds.)

Artificial Intelligence for Knowledge Management, Energy, and Sustainability

9th IFIP WG 12.6 and 1st IFIP WG 12.11
International Workshop, AI4KMES 2021
Held at IJCAI 2021
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Revised Selected Papers

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Editors
Eunika Mercier-Laurent
University of Reims Champagne-Ardenne
Reims, France

Gülgün Kayakutlu
Istanbul Technical University
Istanbul, Turkey

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Preface

Welcome to the proceedings of the International Workshop on Artificial Intelligence for Knowledge Management, Energy, and Sustainability (AI4KMES 2021), which was organized jointly by IFIP WG 12.6 - Knowledge Management and IFIP WG 12.11 - AI for Energy and Sustainability. AI4KMES 2021 took place in conjunction with the 30th International Joint Conference on Artificial Intelligence (IJCAI 2021), which was held online due to the ongoing COVID-19 pandemic, as was the previous IJCAI conference in Yokohama, Japan. The virtual conference and social events were amazing, and even though they lacked human exchanges, energy, and serendipity, the events still facilitated discussion and the exchange of new ideas and research results.

The IJCAI 2021 program was very rich including tutorials, 38 workshops, and panels. However, there were only a few communications on knowledge management and on sustainability, touching on components such as knowledge representation, dynamics of knowledge, knowledge base, knowledge transfer, shared knowledge, knowledge engineering, visual knowledge, and combining knowledge with deep convolutional neural networks. Proceedings from the main conference are available at https://www.ijcai.org/proceedings/2021/.

Knowledge management (KM) is a large multidisciplinary field having its roots in management and artificial intelligence (AI). Knowledge is one of the intangible capitals that influence the performance of organizations and their capacity to innovate. Since the beginning of the KM movement in the early 1990s, companies and nonprofit organizations have experimented with various approaches. AI has brought new ways of thinking, knowledge modeling, knowledge processing, and problem-solving techniques.

Understanding the benefits of knowledge management for research, organizations, and businesses and applying it is still a challenge for many. This is the same for sustainability, which should be considered from various perspectives. The overall process involving people, big data, and all kinds of computers and applications has the potential to accelerate discovery and innovation by organizing and optimizing the flow of knowledge. This collection of selected extended and revised papers from AI4KMES 2021 aims to challenge researchers and practitioners to better explore all AI fields and integrate feedback from real-world experience.

The first International Workshop on Artificial Intelligence for Knowledge Management (AI4KM) was organized by the International Federation for Information Processing (IFIP) Working Group 12.6 (Knowledge Management) in partnership with the European Conference on Artificial Intelligence (ECAI) in 2012, and the second workshop was held two years later during the Federated Conferences on Computer Science and Information Systems (FedCSIS) in conjunction with the 20th Conference on Knowledge Acquisition and Management (KAM 2014). The third edition of the workshop saw the beginning of the partnership with the International Joint Conference on Artificial Intelligence (IJCAI) in 2015. The fourth AI4KM workshop was held at

IJCAI 2016 in New York, USA; the fifth at IJCAI 2017 in Melbourne, Australia; the sixth at IJCAI-ECAI 2018 in Stockholm, Sweden; the seventh at IJCAI 2019 in Macao, China; and the eighth at IJCAI-PRICAI 20 in Yokohama, Japan.

With the aim of leveraging the new IFIP Working Group 12.11 - AI for Energy and Sustainability (AIES), this year's workshop was common to both AI4KM and AIES; hence, it was renamed the International Workshop on Artificial Intelligence for Knowledge Management, Energy, and Sustainability (AI4KMES).

The objective of this multidisciplinary conjunction is still to raise the interest of AI researchers and practitioners in knowledge management and sustainability challenges, to discuss methodological, technical, and organizational aspects of AI used for solving complex problems in these areas, and to share feedback on addressing these challenges with AI.

The theme of AI4KMES 2021 was "facing environmental challenges", with the specific objective of using AI approaches and techniques to support and improve the management of sustainable energy systems within smart cities, smart facilities, smart buildings, smart transportation, and smart houses. The ultimate goal of the workshop was to make a contribution towards achieving some of 17 UN Sustainability Development Goals.

This volume contains a selection of extended and revised papers from the workshop. The selection process focused on new contributions in any research area concerning the use of all AI fields for knowledge management, energy and sustainability. An extended Program Committee then evaluated the final versions of the papers, leading to this volume. We would like to thank the members of the Program Committee, who reviewed the papers and helped put together an interesting program. We would also like to thank all authors and our invited speakers, Rosiane de Freitas and Mieczyslaw Lech Owoc. Our thanks also go to the local Organizing Committee and all the supporting institutions and organizations. A summary of the papers included in this volume is provided below.

Our first invited talk by Rosiane de Freitas addressed a timely topic, "Applying AI/OR techniques and HR remote sensing to estimate how much the Amazon rainforest is helping us mitigate our carbon footprint". She presented joint research work with the National Institute for Amazonian Research, through the Forest Management Laboratory (LMF-INPA), and the Optimization, Algorithms, and Computational Complexity research group of the Institute of Computing, Federal University of Amazonas (ALGOX-IComp/UFAM). This project is partially supported by the Brazilian development agencies CNPq, CAPES, FAPEAM and led by Rosiane de Freitas (ALGOX-IComp/UFAM), João Marcos Bastos Cavalcanti (IComp/UFAM), and Niro Higuchi (LMF-INPA).

Based on the directives given by the Intergovernmental Panel on Climate Change (IPPC), there is an urgent need to provide additional guidance on the design of forest monitoring systems including issues such as forest inventory design, stratification, sampling, pools, accuracy/uncertainty assessment, and the combination of ground-based inventories with remote sensing and modelling approaches. The project concerns estimating carbon stocks by means of extrapolation and spatialization based on ground-based forest inventory combined with heterogeneous sources of remote sensing images through high-resolution satellite, radar, and LiDAR (Light Detection

and Ranging) 3D technology. One of the objectives consists of determining a set of representative trees — the widest (dominant) and the highest (emerging) — through the application of computational intelligence strategies involving pattern recognition, data mining, graph theory, image retrieval, machine learning, and combinatorial optimization techniques. To refine the carbon stock estimate, complementary research consists of the detection of clearings in the Amazon forest based on satellite and radar images using machine learning techniques, which is a valuable tool in environmental conservation. However, small-scale clearing is a challenge. This is a recent trend hindering detection by satellite monitoring.

The first and opening presentation "Greening and Smarting IT – Case of Digital Transformation" gave an overview of multiple facets of the topics discussed with a common dominator: technology. Planet protection and climate change actions often neglect the pollution induced by technology and innovation. The Green Deal and Deep-Tech Digital Transformation (DT) are among the strategic topics of the European Union program Horizon Europe. Digital transformation offers a great opportunity for disruptive innovation- the consideration of the environmental aspects in the whole process may help to better control the impacts. Most eco-innovation actions focus on smart transportation, smart use of energy and water, and waste recycling but do not consider the necessary evolution of behaviors. While technology produces a twofold effect – benefits and waste, the capacity of available technology and in particular artificial intelligence for related complex problem solving is underexplored. The objective of this research is to provide an AI-based methodology for Smart and Green Digital Transformation. This paper explains how the knowledge-based AI and connectionist approaches and techniques combined with adequate thinking may innovate the management of DT in industry, administration, and other contexts and improve the effectiveness of efforts in sustaining the planet.

The paper entitled "Crowdsourcing and Sharing Economic in the Smart City Concept. Influence of the Idea on Development and Urban Resources" considers the impact of the sharing economy on smart cities.

The sharing economy is a relatively new trend that involves a complete change of organizational and distribution models. The main structure focuses on a distributed network of people and communities. This includes mutual service provision and sharing. Crowdsourcing is a process related to the sharing economy in terms of obtaining information/knowledge. The paper analyzes the relationship between these two trends and their impact on smart cities. Verification is carried out using the example of the city-state of Singapore, which has occupied leading places in the smart city rankings in recent years. An interesting aspect discussed in the paper is also the exchange of knowledge in a smart city and the cycle of information between residents, decision-makers, and stakeholders and third parties, such as education providers or businesses.

The next paper, "Assessment of Smart Waste Management with Spherical AHP Method", addresses the complex problem of waste management in a smart city context. Lack of a clear criterion in the evaluation of a smart waste management system (SWMS) required the use of multi-criteria decision making (MCDM) methods, allowing evaluation of both objective and subjective criteria. As evaluation needs both tangible and intangible data, using fuzzy logic is a useful tool to solve the problem.

Therefore, the spherical fuzzy analytic hierarchy process (AHP) method is used to handle the determined problem. Three alternatives are evaluated under four determined criteria. Results show that the problem is handled with spherical fuzzy AHP method by efficiently and effectively.

The authors of the next paper deal with "Zero Carbon Energy Transition in the Kitchens". They propose to combine carbon emission reduction and energy efficiency by using a carbon tax system within the jurisdiction of local authorities to transform cooktop ovens in kitchens in the South Atlantic region, selected for high propane usage. The carbon emissions are reduced by 1.2% with the proposed optimization model using the Residential Consumption Survey (RECS) data set. Based on the benefits of the first application, a new model is developed to look at the future with increasing demand. A regression-based machine learning is used in the R software to create a general model that predicts the efficiency increases. The model is constructed to assume that 100% of the propane cooktop ovens are converted into electric induction cooktop ovens. The authors expect that the proposed model will encourage the replacement of propane cooking devices with energy-efficient electric induction cooktop ovens to reduce carbon emissions and energy accessibility will be increased as energy-efficient appliances will be donated to the users by using the budget created through the carbon tax incomes.

The paper "Barriers and Challenges of Knowledge Management in a Gas Company" points out the potential barriers to the development of knowledge management in a gas company. Gas is a greener alternative to coal and it is used to heat houses as well as fuel cars. The growing gas industry market is dominated by large companies, operating across countries and continents. Managing such companies is extremely complex due to the scale of operations, rapid development of technologies, and a large number of employees working remotely and geographically dispersed. In the context of the increasingly common treatment of knowledge as one of an organization's key resources and the growing amount of data generated by business, knowledge management has received considerable attention in the energy sector, including the gas sector, because of its impact on performance. However, organizing the whole KM system is not an easy task because of complexity of whole process.

The next paper "Characterization of Residential Electricity Customers via Deep Ensemble Learning" explains the household characteristics in an electric grid and the importance of this data for the electric retailers, allowing them to provide personalized services, improve the demand response, and develop better energy efficiency programs. To avoid gathering the privacy-sensitive data, the authors propose an alternative solution exploring the electricity consumption data to infer household characteristics using supervised learning methods. The features are extracted from the electricity consumption patterns, and the selected features are used to train a classifier or regressor. However, the existing methods depend on a single contributing model, which can possibly be undertrained. To achieve the optimal performance of classifiers for characteristics identification, the authors propose an ensemble framework based on bagging algorithms.

"Grid Imbalance Prediction Using Particle Swarm Optimization and Neural Networks" deals with fluctuations in power demand. The imbalance costs are reflected in consumer prices in the partly liberated markets of developing countries. Thus, the

accurate short-run forecast of electricity market trends is beneficial for both suppliers and utility companies to balance the physical energy supply and commercial revenue. When both the day-ahead market and the intra-day market exist to respond to the power demand, forecasting the imbalances assists both the suppliers and the regulators. This study aims to optimize the grid imbalance volume prediction by integrating particle swarm optimization (PSO) and long short-term memory recurrent neural networks (LSTMs). The model is applied for forecasts 1 hour, 4 hours, 8 hours, 12 hours, and 24 hours ahead. The mean absolute percentage error (MAPE) is also calculated. As a result, the MAPE levels are found to be 27.41 for 24 hours, 25.66 for 12 hours, 26.77 for 8 hours, 25.39 for 4 hours, and 9.25 for 1 hour. Although improvements are foreseen both in the model and in the data, the outcomes of this study would reduce the imbalance penalties for power generators and enable regulators to manage outages with a more precise approach. Hence, the economic benefits will affect the trading prices in the long term.

As our wish was also to introduce biomimetics, our second invited speaker and bee keeper, Mieczyslaw Lech Owoc, delivered an inspiring talk on the "Collective Intelligence of Honey Bees for Energy and Sustainability".

From the very beginning, the most promising AI methods have been inspired by the human environment and nature. In particular, the collective intelligence of non-human societies can surprise researchers and developers of new solutions. It is a matter of specific abilities of particular species oriented on cooperation and, moreover, awareness of precisely defined goals and resources used in very optimal ways. For example, we may admire honey bees' methods of building cells and organizing their work, where the problems of task planning and optimization of pollen collection are being solved through a certain sort of common intuition and collective intelligence. The proposed bees algorithm (as an example of swarm algorithms) has been applied in continuous domains (optimization of neural networks) or combinatorial ones (scheduling jobs for a machine). The goal of this paper is to present applications of collective intelligence in relatively new directions: energy acquisition and selected processes assuring sustainable development. Both directions seem to be very innovative and promising – especially in the ecosystems context.

The next two papers are devoted to nuclear plant safety. The first is entitled "The Application of Artificial Intelligence to Nuclear Power Plant Safety".

Through application of artificial intelligence (AI), the burden of analytical computational load for analysis of any given problem where countless variables have to be taken into account is virtually eliminated. Since for engagements in real life operations and instantaneous actions are of paramount importance, AI can be a strong alternative to overcoming complex problem solving in short time frames. As such, in this study a brief review of AI basics is given and literature for AI applications in the nuclear field such as defect detection in the nuclear fuel assembly, dose prediction in nuclear emergencies, fuel and component failure detection, core monitoring for reactor transients, core fuel optimization models, gamma spectroscopy analysis, and, specifically, nuclear reactor safety in operation are assessed. Afterwards, an AI model for analyzing transients in the VVER type nuclear power plants that are being built in Turkey is proposed. This model must keep up with instantaneous data flow and give actionable feedback to the operator for both the cause and the solution of any problem.

A semi-autonomous AI control system that helps operator decision making is a significant contributor to the safety of a nuclear reactor.

The authors of "Capacity to Build Artificial Intelligence Systems for Nuclear Energy Security and Sustainability: Experience of Belarus" address a new type of innovation, called "situational innovation", essential for ensuring people's health and safety. As in recent decades the danger of man-made hazards in the nuclear field has increased dramatically, Belarusian scientists have accumulated considerable innovative potential in health care, agriculture, and the creation of new life support technologies in radioactively contaminated areas. This information is required when working out catastrophe scenarios at nuclear power plants. The definition of situational innovations is developed. Highlighting situational innovations makes it possible to determine their adaptation, use, and replication in other economies, to diffuse the knowledge, and to increase cost effectiveness. The results of the study indicate that the unique experience of Belarus in overcoming the consequences of a nuclear disaster is of great practical importance for other countries operating nuclear objects. The situational innovations resulting from such disasters need to be consolidated into an international database of nuclear research results. The application of artificial intelligence (AI) systems allows the accumulation, storage, and retrieval of information in a single source and would provide the necessary situational innovations in the case of a nuclear accident. AI systems also help to prevent and reduce the risk of nuclear accidents. Development and use of AI will allow countries worldwide to develop nuclear disaster information management systems and reduce existing disaster risk for sustainable development in the future.

Smart electrical grids also play a major role in energy transition but raise important software problems. The authors of "Automated Planning to Evolve Smart Grids with Renewable Energies" propose to solve some of them using AI techniques. In particular, the increasing use of distributed generation based on renewable energies (wind, photovoltaic, among others) leads to the issue of integration into distribution networks that were not originally designed to accommodate generation units but to carry electricity from the distribution network to medium and low voltage consumers. Some methods have been used to automatically build target architectures, to be reached within a given time horizon (of several decades), capable of accommodating a massive insertion of distributed generation while guaranteeing some technical constraints. However, these target networks may be quite different from the existing ones and therefore a direct mutation of the network would be too costly. It is therefore necessary to define the succession of works year after year to reach the target. The authors address this by translating it to an automated planning problem. They define a transformation of the distribution network knowledge into a PDDL representation. The modeled domain representation is fed to a planner to obtain the set of lines to be built and deconstructed until the target is reached. Experimental analysis, on several networks at different scales, demonstrates the applicability of the approach and the reduction in reliance on expert knowledge. The objective of further work is to mutate an initial network towards a target network while minimizing the total cost and respecting technical constraints.

The paper "Artificial Intelligence Application for Crude Distillation Unit: An Overview" focuses on crude distillations units (CDU), for which energy optimization has been a tremendous challenge because of their complexity. The presented overview

shows that soft sensors are the most common application of artificial intelligence for a CDU, although a number of recent publications focus on optimization problems. The approaches for optimization are very diverse, which makes them difficult to apply in the current engineering practice. This work provides a guideline for selecting the right method, but also addresses the fact that different methods excel at different problems and with different data set sizes. For neural networks (NN), this further depends on their architecture and hyperparameter adjustment. This urges future research, where the goal could be a workflow that would automatically adapt methods and perform parameter tuning with minimum user input.

In "Deep Reinforced Learning for the Governance of a Sample Microgrid" the authors propose a proximal policy optimization reinforcement learning system to handle the energy dispatch management of a sample microgrid. The considered microgrid has three participants of different classifications, signifying their relative importance and how sensitive they are to energy shortages. The energy within the microgrid is generated by these participants, who are individually equipped with a solar panel and a wind turbine for energy generation, along with an energy storage system. The environmental conditions, i.e. temperature, wind velocity, and irradiation figures for Istanbul, are considered to obtain accurate energy generation figures. The microgrid is designed to be grid connected in order to compensate for the uncertainties caused by the weather changes, and hence utility service is accessed when the energy produced and stored cannot respond to the demand. Information security of the participants is respected and to that end, direct energy generation, consumption, and storage figures are not supplied to the agent, instead only supply and demand figures are transferred. The agent, using this information, after a period of training, optimizes the system for a reward scheme that rewards energy exports and punishes energy deficits and imports. The results verify the feasibility of proximal policy optimization in managing microgrid energy dispatch.

The authors of the paper "Residential Short-Term Load Forecasting via Meta Learning and Domain Augmentation" observe that with the increasing adoption of electric devices and renewable energy generation, electric load forecasting, especially short-term load forecasting (STLF), has recently attracted more attention. Accurate short-term load forecasting is of significant importance for the safe and efficient operation of power grids. Deep learning-based models have achieved impressive success on several applications, including short-term load forecasting. Yet, most deep learning models require a large amount of training data. However, in the real world, it may be very difficult or even impossible to collect enough data to train a reliable machine learning model. This makes it hard to adopt deep learning models for several real-world scenarios. Thus, it will be very helpful if deep learning models can be learned to tackle tasks with a limited amount of training data and unseen tasks. The authors propose to use the meta-learning framework to train a long short-term memory-based model for short-term residential load forecasting. Specially, by minimizing the task-level loss (loss over several tasks), the model is trained to perform well on different tasks. They also use domain randomization techniques to further augment the training tasks, which may further improve the generalization ability of the proposed model. The proposed model is evaluated on real-world data sets and compared against some classic forecasting models.

The increasing urban population creates escalating problems such as housing, infrastructure, transportation, health, environment, safety, and energy consumption. Climate change, emission mitigation, and limited energy supply force urban managers to consider sound measures with the support of technological developments. This is based on data collection and accumulation using IoT, sensors, digital networks, and other means. "Smart urbanism" is a concept that considers predicting, designing, and creating solutions in a systematic, sustainable, and agile manner based on the data collected. Energy is an indispensable dimension in this context. Optimum energy management makes it "smart energy" with the inclusion of clean and sustainable renewable energy resources as well as energy efficiency. In "Renewable Energy Investment Decision Evaluation for Local Authorities" the possible inclusion of geothermal, solar, and wind power is analyzed to identify the best feasible alternative considering the parameters of location, climate, space availability, and capital and operational expenditures as well as construction, operation, and maintenance. The fuzzy analytic hierarchy process (AHP) technique is used to evaluate the ranking. The proposed method uses fuzzy mathematics for solving problems containing uncertainties as well as less quantifiable inputs. This study proposes a methodological framework for the analysis of competitiveness of alternative renewable energy generation in urban environments. The municipality of Balıkesir is chosen for the case study presented in this work.

We hope you enjoy reading these papers.

January 2022

Eunika Mercier-Laurent
Gülgün Kayakutlu

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