COMPUTATIONAL INTELLIGENCE ALGORITHM-BASED COMPREHENSIVE HUMAN EXPERT AND DATA DRIVEN MODEL MINING FOR THE CONTROL, OPTIMIZATION AND DESIGN OF COMPLICATED SYSTEMS [1]

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Abstract: The development of modern society requires the implementation of cutting-edge technological achievements in various areas, which could be performed by combining computational intelligence algorithms with human expert knowledge, leading to the possibility of data-driven modelling and the design of complicated systems and natural phenomena.

Key words: computational intelligence, data analysis, expert knowledge, modelling automation.

1. INTRODUCTION

Today, humankind faces serious challenges relating to the holistic description of complicated systems and processes that could provide opportunities for intelligent decision support, information processing, and understanding natural phenomena and sophisticated technologies. The era of computers and digital devices generates new terms such as pervasive computing, big data, digitalization and others of this kind. They can approximately reflect ideas that should be taken into consideration in order to adequately respond to this challenge in the field of the impact of (computing) technology on society and implement adequate decision support models and tools. Contemporary science, or more specifically computer science, system and algorithm engineering, decision theory and mathematics, has appropriate ideas and techniques to support humankind in its efforts in this area. However, there is a growing gap between ideology and technology, especially in the readiness to apply existing scientific ideas in everyday reality. The latter requires not only a consideration of the

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specificity of a given problem when designing the necessary tools, but also a high level of adaptation possibilities during everyday use of these tools. The fine-tuning of intelligent technologies of information processing and decision support in various areas such as nature phenomena, life sciences, management analytics, personalized medicine, smart cities, smart grids and communication networks, smart targeting in education, risk analytics, human-machine interaction, social and technological security and safety, and autonomous robotics, requires the development of novel technological approaches and for them to be brought into the practice.

2. COMPUTATIONAL INTELLIGENCE AND DATA-DRIVEN MODELS

The comprehensive modelling of complicated systems requires the involvement of a wide range of high-quality specialists not only in the area of interest, but also in mathematics, algorithm engineering and information processing technologies, which is not always possible in practice for an organization. This makes necessary the development and implementation of self-adapting, self-configuring and self-tuning technologies of data-driven and human expert based predictive modelling. The main results here are:

- self-configuring genetic and evolutionary algorithms of optimization and modelling, which automatically configure, tune and adjust themselves to a problem in hand within one run,
- competitive-cooperative bio-inspired algorithms, which dynamically redistribute resources within one run to assign them to the current best algorithm,
- engaging the given optimization and modelling algorithms in the automated design of decision support, machine learning and modelling tools also with automated identification of the most important inputs and outputs, as well as ensembles of such tools,
- specific approaches for the automated identification of dynamic systems with differential equations and their automated solving in evident symbolic form.

The experience in applied R&D in engineering [1, 2], natural science [3, 4] and medicine [5] shows that the use of self-adaptive computational intelligence techniques can significantly expand the scope of intelligent data analysis and machine learning applications, and essentially simplify the processes of their development for a given problem. This approach could be called "*CI@A-based exhaustive HEAD-driven model mining for the control, optimization and design of complicated systems*" (CI&A is an abbreviation for **C**omputational **I**ntelligence and **A**pplications, HEAD is an abbreviation for **H**uman **E**xperts **A**nd **D**ata).

Computational intelligence methods allow us to design a full range of mathematical models describing the functioning of complex systems: static and dynamic models (symbolic regression, differential equations), approximation models (artificial neural networks, symbolic regression), causal relationship models (fuzzy logic, decision trees), classifying and predictive models, as well as hybrid

models, ensembles of models and so on. The automation of the design of these models can be performed by the self-adaptive methods listed above, allowing us to solve complicated optimization problems with many criteria and constraints, algorithmically defined functions, multi-scale variables, dynamic and non-stationary problems, and determined and stochastic, among others.

The application of such algorithms allows us to automatically choose an effective model structures (including the order and type of differential equations, structure and type of neural networks, and fuzzy logic knowledge base) and their parameter adjustment, as well as to automatically define the most informative attributes and design complicated models (ensembles), which complement each other and describe the system from different points of view. Having such tools at our disposal, we must investigate ways for their application in the comprehensive modelling of natural phenomena, complex processes and systems of systems in order to be able to generate holistic descriptions of the real world, i.e. more reasonable and understandable applications of AI tools.

In order to achieve this objective, the following tasks must be considered and solved:

1. Investigation into ways of assembling the above-mentioned approaches and algorithms into a holistic system of comprehensive modelling, i.e., a process of model space construction and methods of the use of this space in designing AI tools.
2. Ascertainment and development of methods of models interaction for their mutual improvement, i.e. ways how one model could be used to increase a level of accuracy, correctness and understandability of another model, which could enable significantly more complex models based on limited data as well as getting previously unknown information (in interaction with a human expert).
3. Ascertainment and development of methods of interaction with human experts by including in advance their knowledge into algorithms of modelling and optimization as well as their involvement in the interactive human-AI modelling process, i.e. an investigation into the development of human-guided data analysis.
4. Investigation of the developed approach to holistic modelling automation regarding its ability to essentially improve privacy preserving and understandability as well as to its applicability for flexible high-level adaptiveness in everyday use.

3. CONCLUSION

The automated self-adapting technologies of comprehensive modelling are a new solution to the problems of the purposeful processing of the accumulated information and extraction of the valuable knowledge from the data sets that do not require the end user to have expert knowledge in the area of mathematical modelling, algorithm engineering or intelligent data analysis technologies. This will allow much wider applications of mathematical modelling and intelligent data analysis in many areas of science and technology because it will allow significant acceleration in their

development and an increase in the reasonableness of decision-making when they are implemented.

The most challenging direction based on all the above points is research into understanding what is holistic and how we could estimate the level of integrity.

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