PREFACE

In recent decades significant advances in intelligent computation techniques applied to control systems have been observed. Intelligent control is the use of general-purpose control systems which learn over time how to achieve goals in complex, noisy, nonlinear environments whose dynamics must be learnt in real time. Traditionally, this domain embraces classical control theory, neural networks, fuzzy logic, and a wide variety of search techniques, such as evolutionary algorithms. Investigations in this direction have been driven by acute needs to solve complex real-world problems. Indeed, there are numerous examples of real industrial applications where these techniques proved to be powerful and outperformed classical approaches to control system design.

The main motivation for employing computational intelligence in control system design is the fact that conventional control algorithms require a mathematical model of the dynamical system to be controlled. This model then provides the basis for controller design. But in many practical situations it is not possible to build an accurate mathematical model of the controlled system. In this context, fuzzy logic control offers a way of dealing with modeling problems by implementing linguistic, nonformally expressed control laws derived from expert knowledge. In turn, neurocontrol methods hold big potential in the synthesis of highly specialized controllers that are relevant when the system to be controlled is in some sense difficult to stabilize or when the performance is extremely important. Although the use of fuzzy logic and neural networks for control applications is now a well-established area, there still exist difficulties in designing optimum fuzzy or neural controllers for specific problems. Here is where evolutionary computing comes into the picture. Evolutionary algorithms can be used to optimize the topology of a fuzzy or a neural system.

In spite of many tremendous successes, intelligent control of complex nonlinear dynamic systems still remains a challenging task. It is a great pleasure for us to introduce this special section of the *International Journal of Applied Mathematics and Computer Science*, the journal that has a long tradition of highlighting particularly interesting and timely topics. It is a lasting result of a workshop that was held at the University of Zielona Góra, Poland, on 24 October 2008. This one-day technical meeting was organized jointly by the Polish Chapter of the IEEE Control Systems Society, the Polish Chapter of the IEEE Computational Intelligence Society, the Intelligent Systems Section of the Committee on Automatic Control and Robotics of the Polish Academy of Sciences, and the Commission on Engineering Cybernetics of the Poznań Branch of the Polish Academy of Sciences. This event brought together researchers from all over Poland. A total of eight speakers had the opportunity to present and discuss their latest results, as well as exchange ideas on new trends in the field of intelligent robotics and control systems. Based on their talks, five participants decided to prepare full papers in which the conceptual development, the experimentation and the validation of their initial results were extended. These papers have undergone a complete review to ensure that extensions were significant and the manuscripts remain of high quality and clarity.

The papers presented in this special section cover a large spectrum of topics that are all well-aligned with the scope of workshop. In the first paper, *Nonlinear predictive control based on neural multi-models*, Ławryńczuk and Tatjewski propose neural multi-models based on multi-layer perceptrons to make the nonlinear model predictive control algorithm more efficient from a computational point of view. The model determines future predictions without reference to previous ones. Consequently, unlike the classical NARX model, the proposed multimodel is not used recurrently in MPC and the prediction error is not propagated. In order to circumvent nonlinear optimization, in the discussed suboptimal MPC algorithm the neural multi-model is linearized on-line, and the future control policy is found by solving a quadratic programming problem.

In the paper *Local stability conditions for discrete-time cascade locally recurrent neural networks*, Patan investigates a discrete-time recurrent neural network built using dynamic neuron models. The dynamics are reproduced within each single neuron, so that the reported network is a locally recurrent globally feedforward one. As an acute problem for dynamic neural networks regards their stability and stabilization in learning problems, the author formulates local stability conditions for the studied class of neural networks using Lyapunov's first method. What is more, the stabilization problem is defined and solved as a constrained optimization task to be solved using a gradient projection method.

In their paper *The HeKatE methodology. Hybrid engineering of intelligent systems*, Nalepa and Ligęza develop a new approach, the HeKatE methodology, aimed at the design of complex rule-based systems for control and decision support. The main paradigm for rule representation, the so-called eXtended Tabular Trees (XTT), ensures high density and transparency of visual knowledge representation. In contrast to traditional, "flat" rule-based systems, the XTT approach is focused on groups of similar rules, rather than single ones. Such groups form decision tables which are connected into a network for inference. Efficient inference is assured through firing only rules necessary to achieve the goal identified by the context of inference and partial order among tables. The paper exposes in detail a new version of the language, XTT2, which is based on ALSV(FD) logic. A set of software tools supporting the visual design and development stages is also described.

In *On classification with missing data using rough-neuro-fuzzy systems*, Nowicki presents a new approach to fuzzy classification in the case of missing data. The rough-fuzzy sets are incorporated into logical neuro-fuzzy structures and a rough-neuro-fuzzy classifier is outlined. The proposed solution is capable of selecting input instances where, despite the lack of data, classification is still possible. It is worth emphasizing that, in the case considered, competitive solutions, e.g., those based on the k-NN algorithm, usually produce much more correct classifications, but the number of misclassifications is higher, too. The main benefit of the proposed modification is robustness against the misclassifications in the case of missing input data.

In their paper *A biologically inspired approach to feasible gait learning for a hexapod robot*, Belter and Skrzypczyński report results of research on designing feasible gait patterns that could be used to control a real hexapod walking robot. The gaits are to imply the fastest possible movement under limitations imposed by the robot mechanics and terrain conditions. Owing to a large and complex search space, the authors focus their attention on progressive reduction of the search space for the leg movements, which yields effective gait patterns. This strategy enables an evolutionary algorithm to discover proper leg co-ordination rules for a hexapod robot, using only simple dependencies between the states of the legs and a simple fitness function. The gaits produced in simulations are also shown to be effective in experiments on a real walking robot.

In our personal opinion, the papers in this special section make notable contributions to the state of the art in the field of intelligent control. We hope the reader will share our point of view and find this special section very useful. We would like to acknowledge all the authors for their efforts in submitting high-quality papers. Last, but not least, we are also very grateful to the reviewers for their thorough and critical reviews of the papers within the short stipulated time.

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