Intelligent System” is a broad term, so giving it a precise definition can be difficult. This book deals specifically with systems that have the ability to learn and adapt during their existence in order to achieve certain goals and objectives. It concentrates on methods and approaches that might be generally referred to as “automated learning from experience.”

Indeed, most living beings learn from experience rather than from an explicit detailed model of the world around them. They develop a model automatically from observation, refining it as more experience becomes available. It is this “intelligent” model that allows us to predict what would happen to a system under particular conditions, to sort the system inputs into categories, and to optimise the performance of the system in some way. These kind of intelligent and adaptive systems have attracted increasing attention in recent years. They are considerably more robust and flexible than systems based on traditional approaches that have been developed mainly for mathematically well-defined problems. They provide more autonomy and more powerful decision-making ability in uncertain and complex environments. They also adapt better to an unknown environment without needing to explicitly model it.

This special volume has assembled some of the most intriguing applications, reviews and additions to the methodology of intelligent computing. Its main objective is to present the emerging trends of state-of-the-art intelligent systems and their practical applications. It contains open-solicited and invited chapters written by leading researchers, academics and practitioners in the field. All contributions were peer reviewed by two to three reviewers.

TARGET AUDIENCE

This book covers the state-of-the-art plus latest research discoveries and applications of intelligent adaptive systems, thus making it a valuable reference for a large community of audiences. It is an important reference to researchers and academics working in computational intelligence and its related fields, such as multi-agent systems, machine learning, pattern recognition, optimisation, knowledge-based systems, natural computing, and so forth. It will also be appealing to developers, engineers, practitioners, final year undergraduates as well as postgraduate students who may find the ideas and solutions presented fascinating.
ORGANISATION OF THE BOOK

This book comprises 12 chapters, which can be categorised into the following 3 sections:

- Section 1: Adaptive Learning Systems
- Section 2: Adaptive Evolutionary Systems
- Section 3: Adaptive Collective Systems

Section 1: Adaptive Learning Systems

The first section deals with adaptive learning systems. In general, an adaptive system is composed of a set of interacting or interdependent entities that is able to adapt its behaviour according to environmental changes or changes in its interacting parts. By focusing on the aspect of adaptation with intelligent learning, this section presents four chapters that use artificial neural networks and other learning technologies in various practical problems.

Chapter 1, by Andres Upegui, presents a set of methodologies and architectures for designing bio-inspired hardware by exploiting the reconfigurability features available in the commercial field programmable gate arrays (FPGAs). The proposed systems, which consist of two main components – the computation engine and an adaptation mechanism, allow a system-on-chip to self-reconfigure in order to adapt the hardware supporting it in a completely autonomous way. The chapter provides an in-depth discussion of the numerous architectures such as neural networks, spiking neuron models, fuzzy systems, and so forth, which could constitute the computation engine. Similarly, various optimisation methodologies including evolution, synaptic weight learning, and so on which could allow the computation engine to adapt for performing a given computation are also discussed.

In chapter 2 Ang et al. present a new face recognition system comprising of feature extractions and two custom-designed neural classifiers based on the Lyapunov stability theory: Lyapunov theory-based radial basis function neural network and Lyapunov theory-based multi-layered neural network. The authors first used principal component analysis (PCA) to extract the most expressive facial features to reduce the dimensionality of the original images, and further applied Fischer’s linear discriminant (FLD) to obtain the most discriminant features. These features were then passed to the two proposed classifiers for face classification. The simulation results have shown that the proposed system is quite promising as both the classifiers achieve higher training speeds as well as higher recognition rates compared to the corresponding conventional classifiers found in the literature.

In the next chapter (i.e., chapter 3), Albertini and Mello propose a new novelty detection technique called self-organising novelty detection neural network architecture (SONDE) which incrementally learns patterns in order to represent unknown dynamics and fluctuations of established behaviour in time-series. The authors use the thus accumulated knowledge to estimate Markov chains to model causal relationships. The subsequent model is then applied to detect and measure temporal and non-temporal novelties. The significance of this chapter lies in the fact that current studies do not fully detect and quantify these temporal novelties nor do they completely consider causal relationships. The proposed method was evaluated using various simulations and experiments and the results confirm the method to be quite promising.

Following which, chapter 4, by Palit and Anheier, proposes a computationally intelligent tool for extending the linear range of an arbitrary sensor. Typical sensors are either highly non-linear or not linear enough to be useful over a wide range of interest, and the proposed technique aims at compensating this problem by using a very efficiently trained neuro-fuzzy hybrid network. The training algorithm is based
on the Levenberg-Marquardt algorithm (LMA) and the chapter also describes a simple technique to compute the Jacobian matrix, which is generally considered to be the most difficult step in implementing the LMA. A negative temperature coefficient thermistor sensor with an exponentially decaying characteristic function is linearised to demonstrate the efficacy of the proposed procedure. The experimental results show that the new training algorithm is able to bring the performance index of the network down to the desired error goal much faster than any first order training algorithm. What makes the work significant is that the intelligent models developed here could be programmed into low-cost embedded processors or micro-controllers to overcome the losses or performance drifts of components which arise as a result of the additional electronics required for conventional linearisation.

**Section 2: Adaptive Evolutionary Systems**

The second section contains five chapters, and each of them is dealing with a unique domain of its own using evolutionary approaches. Evolutionary computing has become a very active research field nowadays, with many examples of successful applications ranging from data analysis and machine learning to telecommunication network design, logistics, scheduling, and technical engineering, among others. Across all these areas, evolutionary approaches have convinced practitioners by the results obtained on hard problems that they are very powerful algorithms.

The first chapter of this section, chapter 5 by Garcia et al., presents a review and analysis of evolutionary prototype selection in data mining and its application over different sizes of data sets, with a special focus on the scaling-up problem. The authors review the representative evolutionary prototype selection algorithms of the two common strategies on the use of evolutionary algorithms: general evolutionary models, and models specific to prototype selection. These algorithms are described in detail and their performances analysed in terms of their efficiency and effectiveness. These results are then used to determine the benefits and drawbacks of each model.

Subsequently, chapter 6, by Weise and Chiong, gives a systematic overview of the wide array of applications of evolutionary optimisation to distributed systems. The focus, here, is on genetic algorithms and genetic programming and their application in solving problems from five different domains of network optimisation: network topology, routing, protocol synthesis, network security, and parameter settings and configuration. The authors also provide some applications from these areas to serve as illustrative examples. The chapter should be able to encourage readers to incorporate not only evolutionary algorithms but also other bio-inspired methods to solve various dynamic, large scale or NP-hard problems faced in network optimisation.

In chapter 7 Gary Yen proposes a novel idea based on evolutionary algorithm for adaptation of the user interface in complex supervisory tasks using a combination of genetic algorithm for constrained optimisation and probabilistic modelling of the user. The algorithm has been tested with an automated user and a group of real users in an air traffic control environment and the results have shown that the proposed method is flexible and easy to use in various problem domains. The results also demonstrate that the method is able to improve human-computer interaction and the author argues that the approach is pragmatically a valid design for interface adaptation in complex environments. A significant contribution of this chapter is a general framework for adaptation under ill-defined situations using statistical, non-parametric methods.

In chapter 8 Tlelo-Cuautle et al. demonstrate the application of a particle swarm optimisation (PSO) to size analog circuits which are synthesised by a genetic algorithm from nullor-based descriptions. The analog circuits are first synthesised by applying a genetic algorithm at the transistor level of abstraction, following which the multi-objective PSO evaluates the performances until optimal transistor-sizes are
found by using a standard CMOS technology of 0.35µm of integrated circuits. As an example, two synthesised current conveyors (CCII+ and CCII-) were optimised by applying the proposed multi-objective PSO algorithm. The experimental results show that this algorithm is able to improve the performance of the above-mentioned current conveyors in comparison to the algorithms mentioned in the literature.

This section wraps up with its last chapter (i.e., chapter 9), by Teixeira and Romariz, that presents the application of a comprehensive statistical analysis for both algorithmic performance comparison and optimal parameter estimation on a multi-objective digital signal processing problem. Several algorithms such as genetic algorithms, particle swarm optimisation, simulated annealing, non-dominated sorting genetic algorithm (NSGA II), and multi-objective simulated annealing (MOSA) are applied to design non-linear digital finite impulse response (FIR) filters. Also, optimal parameter values were obtained using statistical exploratory analysis instead of the common trial and error process. This has allowed the authors to conduct a fair and effective performance comparison among the different approaches. A comprehensive statistical comparison of the above-mentioned algorithms indicates a strong performance from NSGA II and the pure genetic algorithm with weighting scalarization. In particular, it was observed that the latter was able to obtain the best average performances.

Section 3: Adaptive Collective Systems

The last section of the book presents three chapters from diverse fields: social networks, automatic programming, and manufacturing. They, however, do share a common theme – they all exhibit collective intelligence. Collective systems differ from other intelligent systems in a way that the components in these systems do not directly influence the behaviour of one another. The outcomes are often being formed via the collective behaviour of some decentralised, self-organised entities within it.

There is often a lag time between an innovation’s first appearance and its adoption by a substantial section of the society. This diffusion process is quite essential in enhancing future innovations by providing feedback about the innovation’s utility. Moving away from the engineering and computing systems of the first two sections, chapter 5, by Akira Namatame, provides an overview of the research examining how the structure of social networks impacts this diffusion process. There is further discussion on how the structure of social networks determines the dynamics of various types of emergent properties that occur within those networks. By focusing on the stylised facts of macroscopic emergent phenomena that are the results of bi-directional interactions, the chapter outlines various circumstances conducive for desirable emergent properties to appear.

The penultimate chapter of this book, chapter 11 by Mariusz Boryczka, presents several improvements to the ant colony programming (ACP) method. Some of these improvements include the elimination of introns - which helps improve the readability of solutions as well as reduce their evaluation time, the use of a specimen list to reduce the solution’s construction time, establishing a set of instructions, and tuning of the ACP’s parameters. While most of the improvements are discussed as a review of the information already present in the literature, the latter is a novel idea. The described method with these improvements seems to be able to solve not only the problem of approximation, but also other problems, such as finding the perfect hash functions or different problems from the game theory. As an example of the nature-inspired algorithm, this method may be interesting for researchers and academics and may also be developed towards automatic programming.

In the final chapter (i.e., chapter 12), Paolo Renna proposes an innovative coordination mechanism in manufacturing systems by pheromone approach in a multi-agent architecture environment. As an illustrative example, the chapter focuses on the job shop scheduling problem in cellular manufacturing systems. Comparative studies are conducted between the pre-existing methods in the literature and
two new methods based on the above-mentioned approach. One of these methods is based on the parts’ memory whereas the next is based on the queue of a manufacturing cell. Experiments have been conducted in a dynamic environment which is characterised by the following parameters: inter-arrival, machine breakdowns, and processing time efficiency. The experimental results show that the first method based on the parts’ memory is inefficient while the second method is able to outperform the efficiency-based approach in case of medium dynamism in the manufacturing environment. The author draws several important conclusions regarding the performance of these new methods which might be helpful while developing new approaches.

Raymond Chiong
Editor