Preface

The aim of this book is to provide a common platform for the researchers from diverse backgrounds to present their theoretical and applied research findings in pervasive computing, multi-agent systems, and computational intelligence. This book may prove to be a building block for enhancing/developing pervasive computing and computational intelligence systems as it highlights the core concepts as well as applicability in real world problems.

Pervasive computing enables users to interact with information resources in their everyday lives. The development of computational technologies that can exist in ever-smaller devices while simultaneously increasing processing power allows such devices to blend seamlessly into tangible environments. Of special importance of this book is the usage of machine learning, swarm intelligence optimization, multi-agent systems, fuzzy logic, and neural networks providing means for contextual information representation, reasoning, and inference in pervasive computing environments. Topics that are covered by this book are: computational intelligence in pervasive computing applications, multi-agent systems, context-aware computing, event-detection systems for environmental risks, spatiotemporal optimized deployment of wireless sensor networks, and techniques for location privacy in pervasive environments. This book provides a common platform to pervasive computing and computational intelligence researchers to disseminate new ideas and techniques.

This book is organized in self-contained chapters to provide greatest reading flexibility. In response to the call for papers, the book received around 35 abstracts. Based on the suitability, the editors invited full chapters from 32 researchers of various disciplines (Computational Intelligence, Multi-Agent Systems, Soft Computing, Context-Aware Computing, and Wireless Sensor Networks) and from 7 different countries. All submitted chapters were reviewed on a double-blind review basis, by at least three reviewers. After an evaluation process by the EBM members, 15 chapters were selected. Acceptance was based on relevance, technical soundness, originality, and clarity of presentation.

This book is organized into two sections. Section 1 refers to Multi-Agent Systems Applications with five chapters, and Section 2 refers to Pervasive Computing Applications with ten chapters.

SECTION 1: MULTI-AGENT SYSTEMS APPLICATIONS

Chapter 1: Computational intelligence techniques such as neural networks, fuzzy logic, and hybrid neuroevolutionary and neuro-fuzzy methods have been successfully applied to complex control problems in the last two decades. Genetic programming, a field under the umbrella of evolutionary computation, has not been applied to a sufficiently large number of challenging and difficult control problems, in order to check its viability as a general methodology to such problems. Helicopter hovering control is considered
a challenging control problem in the literature and has been included in the set of benchmarks of recent reinforcement learning competitions for deriving new intelligent controllers. This chapter shows how genetic programming can be applied for the derivation of controllers in this nonlinear, high dimensional, complex control system. The evolved controllers are compared with a neuroevolutionary approach that won the first position in the 2008 helicopter hovering reinforcement learning competition. The two approaches perform similarly (and in some cases GP performs better than the winner of the competition), even in the case where unknown wind is added to the dynamic system and control is based on structures evolved previously, that is, the evolved controllers have good generalization capability.

Chapter 2: A novel combination of chaotic features and Adaptive Neuro-Fuzzy Inference System (ANFIS) is proposed for epileptic seizure recognition. The non-linear dynamics of the original EEGs are quantified in the form of the Hurst exponent ($H$), Correlation dimension ($D_2$), Petrosian Fractal Dimension (PFD), and the Largest lyapunov exponent ($\lambda$). The process of EEG analysis consists of two phases, namely the qualitative and quantitative analysis. The classification ability of the $H$, $D_2$, PFD, and $\lambda$ measures is tested using ANFIS classifier. This method is evaluated with using a benchmark EEG dataset, and qualitative and quantitative results are presented. The inter-ictal EEG-based diagnostic approach achieves 98.6% accuracy with using 4-fold cross validation. Diagnosis based on ictal data is also tested in ANFIS classifier, reaching 98.1% accuracy. Therefore, the method can be successfully applied to both inter-ictal and ictal data.

Chapter 3: The automated negotiation performed by a software agent is investigated in order to improve the benefits compared to a humane face-to-face negotiation. The profitability of e-business applications can be increased by the support of automated negotiation tools. This research proposes a set of learning methodologies to support both the suppliers’ and customers’ negotiation activities. The learning methodologies are based on Q-learning technique, which is able to evaluate the utility of the actions without a model of the environment. The context regards one-to-many negotiation and multi-issues (volume, price, and due date). A simulation environment is developed to test the proposed methodologies and evaluate the benefits compared to a negotiation approach without learning support tool. The simulations are conducted in several market conditions, and a proper statistical analysis is performed. The simulation results show that the proposed methodologies lead to benefits both for suppliers and customers when both the opponents adopt the learning approach.

Chapter 4: During the last years, the emergence of Semantic Web has produced a vast amount of resources and a variety of content representation schemes. The latter has increased the complexity that the users are facing when searching for information in open environments. A representative example is Electronic Markets (EMs). In EMs users try to find and purchase products through interactions with providers. In such scenarios, shopbots can offer a number of advantages. Shopbots are agents that help users to find the products they want, saving them a lot of time and effort. However, building efficient shopbots is a challenging task. This is more imperative when shopbots interact with providers using different ontological terms for product description. In this chapter, the authors propose a generic ontology to describe products in EMs. They also introduce a matching algorithm that maps the specific provider ontology to the generic one in order to be used by a shopbot. Their algorithm, called S+, is based on a set of linguistic and semantic matching techniques. The authors present their approach and compare it with other proposed algorithms. Finally, they discuss their experimental results that reveal the performance of their methodology.

Chapter 5: The chapter presents UNIRA, a multi-agent system developed by the authors for a Romanian university in order to improve the resources allocation for educational programmes and courses. Different types of resources are required to deliver programmes and courses. Considering a set of resources
inquires, issued by programmes and courses, UNIRA system performs a transparent negotiation process between the managers of these resources, to find the solution for the allocation problem. During the initial stage of the multi-agent system deployment, only two types of resources are considered, professors and teaching rooms. The system is now in the validation phase. After the complete validation, the system will be integrated into the university management system. The UNIRA experience is relevant not exclusively for the academic resources management, but also for a large variety of domains, including the load distribution, production planning, computer scheduling, portfolio selection, and apportionment.

SECTION 2: PERVERSIVE COMPUTING APPLICATIONS

Chapter 6: Recent interest in integrated electronic devices (sensors) that operate wirelessly creates a wide range of applications related to national security, surveillance, military, healthcare, and environmental monitoring. Many visions of the future include people immersed in an environment surrounded by sensors and intelligent devices, which use smart infrastructures to improve the quality of life. However, a fundamental feature of sensor networks is coverage: how these tiny devices can cover a certain terrain. These devices should be organized in an optimal manner, consuming the minimum energy and covering the whole area of interest. The coverage concept is subject to a wide range of interpretations due to the variety of sensors and applications. Different coverage formulations have been proposed based on the subject to be covered (area in relation to specific items and obstacles), sensor development mechanisms (random versus deterministic), and other properties of wireless sensor networks (e.g. network connectivity and minimum energy consumption). In this chapter, the authors study the coverage problem in wireless sensor networks using the most recent algorithms. The aim of this chapter is to present these algorithms and a comparison between them based on various criteria. The Node Self-Scheduling algorithm, the Centralized Voronoi Tessellation (CVT), the Particle Swarm Optimization Algorithm (PSO), the Virtual Forces Algorithm (VFA), etc. are analyzed. Through the algorithms’ analysis, the interested reader can have a complete view of the proposed solutions related to the coverage problem.

Chapter 7: Wireless sensors are small-scale mobile devices that can programmatically measure physical quantities, perform simple computations, store, receive, and transmit data. The lattice built by a set of cooperating sensors is called a sensor network. Since sensor networks provide a powerful infrastructure for large-scale monitoring applications, an important issue is the network design to achieve an optimal placement of the sensors to allow (1) energy-efficient monitoring and (2) gathering meaningful data. This chapter presents a novel approach to optimize sensing node placement (e.g., for new to-be-deployed networks) and efficiently acquire data from existing sensor networks. A historical data analysis task is performed to discover spatial and temporal correlations and identify sets of correlated sensors. Then, an algorithm based on a cost function considering both distance and communication cost selects the candidate sensors, leading to the optimized network design and acquisition. Candidate sensors can then be deployed and/or queried instead of the whole network, thus reducing the network cost and extending its lifetime in terms of energy consumption. Experiments, performed on a real wireless sensor network, demonstrate the adaptability and the effectiveness of the proposed approach in optimizing the sensor network design and the data acquisition.

Chapter 8: The authors propose in this chapter a context grouping mechanism for context distribution over MANETs. Context distribution is becoming a key aspect for successful context-aware applications in mobile and ubiquitous computing environments. Such applications need, for adaptation purposes, context information that is acquired by multiple context sensors distributed over the environment.
Nevertheless, applications are not interested in all available context information. Context distribution mechanisms have to cope with the dynamicity that characterizes MANETs and also prevent context information from being delivered to nodes (and applications) that are not interested in it. The authors’ grouping mechanism organizes the distribution of context information in groups whose definition is context based: each context group is defined based on a criteria set (e.g. the shared location and interest) and has a dissemination set, which controls the information that can be shared in the group. They propose a personalized and dynamic way of defining and joining groups by providing a lattice-based classification and recommendation mechanism that analyzes the interrelations between groups and users, and recommend new groups to users, based on the interests and preferences of the user.

Chapter 9: Forest fires cause immeasurable damages to indispensable resources for human survival, destroy the balance of earth ecology, and worst of all they frequently cost human lives. In recent years, early fire detection systems have emerged to provide monitoring and prevention of the disastrous forest fires. Among them, the Meleager system aims to offer one of the most advanced and integrated technology solutions for fire protection worldwide by integrating several innovative features. This chapter outlines one of the major components of the Meleager system, that is the visual fire detection subsystem. Ground-based visible range PTZ cameras monitor the area of interest, and a low level decision fusion scheme is used to combine individual decisions of numerous fire detection algorithms. Personalized alerts and induced feedback is used to adapt the detection process and improve the overall system performance.

Chapter 10: Wireless Sensor Networks (WSNs) receive significant attention due to the wide area of applications: environment monitoring, tracking, target detection, etc. At the same time, in some cases, the captured information from the WSN might be considered as private, for example, location of an important asset. Thus, security mechanisms might be essential to ensure the confidentiality of the location of the information source. In this chapter, the authors present an approach called iHIDE (information HIDing in Distributing Environments) to enable source-location privacy in WSNs. iHIDE adopts a non-geographical, overlay routing method for packet delivery. This chapter presents the architecture and assesses its performance through simulation experiments, providing comparisons with relative approaches.

Chapter 11: In game theory, presenting players with strategies directly affects the performance of the players. Utilizing the power of automata is one way for presenting players with strategies. In this chapter, the authors studied different types of automata and their applications in game theory. They found that finite automata, adaptive automata, and cellular automata are widely adopted in game theory. The applications of finite automata are found to be limited to present simple strategies. In contrast, adaptive automata and cellular automata are intensively applied in complex environment, where the number of interacted players (human, computer applications, etc.) is high, and therefore, complex strategies are needed.

Chapter 12: Mobile context-aware applications are required to sense and react to changing environment conditions. Such applications, usually, need to recognize, classify, and predict context in order to act efficiently, beforehand, for the benefit of the user. In this chapter, the authors propose a mobility prediction model, which deals with context representation and location prediction of moving users. Machine Learning (ML) techniques are used for trajectory classification. Spatial and temporal on-line clustering is adopted. They rely on Adaptive Resonance Theory (ART) for location prediction. Location prediction is treated as a context classification problem. The authors introduce a novel classifier that applies a Hausdorff-like distance over the extracted trajectories handling location prediction. Two learning methods (non-reinforcement and reinforcement learning) are presented and evaluated. They compare ART with Self-Organizing Maps (SOM), Offline kMeans, and Online kMeans algorithms. Their findings are very promising for the use of the proposed model in mobile context aware applications.
Chapter 13: Location-based services are receiving signification attention over the last few years due to the increasing use of mobile devices. At the same time, location privacy is important, since position information is considered personal information. Thus, in order to address this issue, several mechanisms have been proposed protecting the mobile user. In this chapter, the authors present an architecture to shield the location of a mobile user and preserve the anonymity on the service delivery. This architecture relies on un-trusted entities to distribute segments of anonymous location information, and authorizes other entities to combine these portions and derive the actual location of a user. The chapter describes how the architecture takes into account the location privacy requirements, and how it is used by the end users’ devices, e.g., mobile phones, for the dissemination of location information to service providers. Furthermore, it notes privacy issues for further discussion and closes with proposed exercises.

Chapter 14: The development of pervasive technologies has allowed the improvement of services availability. These services, offered by Information Systems (IS), are becoming more pervasive, i.e., accessed anytime, anywhere. However, those Pervasive Information Systems (PIS) remain too complex for the user, who just wants a service satisfying his needs. This complexity requires considerable efforts from the user in order to select the most appropriate service. Thus, an important challenge in PIS is to reduce user’s understanding effort. In this chapter, the authors propose to enhance PIS transparency and productivity through a user-centred vision based on an intentional approach. They propose an intention prediction approach. This approach allows anticipating user’s future requirements, offering the most suitable service in a transparent and discrete way. This intention prediction approach is guided by the user’s context. It is based on the analysis of the user’s previous situations in order to learn user’s behaviour in a dynamic environment.

Chapter 15: The location privacy issue has been addressed thoroughly so far. Cryptographic techniques, k-anonymity-based approaches, spatial obfuscation methods, mix-zones, pseudonyms, and dummy location signals have been proposed to enhance location privacy. In this chapter, the authors propose an approach, called STS (Share The Secret) that segments and distributes the location information to various, non-trusted, entities from where it will be reachable by authenticated location services. This secret sharing approach prevents location information disclosure even in situation where there is a direct observation of the target. The proposed approach facilitates end-users or location-based services to classify flexible privacy levels for different contexts of operation. The authors provide the optimal thresholds to alter the privacy policy levels when there is a need for relaxing or strengthening the required privacy. Additionally, they discuss the robustness of the proposed approach against various adversary models. Finally, the authors evaluate the approach in terms of computational and energy efficiency, using real mobile applications and location update scenarios over a cloud infrastructure, which is used to support storage and computational tasks.

Kostas Kolomvatsos  
National and Kapodistrian University of Athens, Greece

Christos Anagnostopoulos  
Ionian University, Greece

Stathes Hadjieftymiades  
National and Kapodistrian University of Athens, Greece