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Pervasive Computing

Innovations in Intelligent Multimedia and Applications

Springer

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Preface

The main objective of pervasive computing systems is to create environments where computers become invisible by being seamlessly integrated and connected into our everyday environment, where such embedded computers can then provide information and exercise *intelligent control* when needed, but without being obtrusive. Pervasive computing and intelligent multimedia technologies are becoming increasingly important to the modern way of living. However, many of their potential applications have not yet been fully realized. Intelligent multimedia allows dynamic selection, composition and presentation of the most appropriate multimedia content based on user preferences. A variety of applications of pervasive computing and intelligent multimedia are being developed for all walks of personal and business life. Pervasive computing (often synonymously called ubiquitous computing, palpable computing or ambient intelligence) is an emerging field of research that brings in revolutionary paradigms for computing models in the 21st century. Pervasive computing is the trend towards increasingly ubiquitous connected computing devices in the environment, a trend being brought about by a convergence of advanced electronic – and particularly, wireless – technologies and the Internet. Recent advances in pervasive computers, networks, telecommunications and information technology, along with the proliferation of multimedia mobile devices – such as laptops, iPods, personal digital assistants (PDAs) and cellular telephones – have further stimulated the development of intelligent pervasive multimedia applications. These key technologies are creating a multimedia revolution that will have significant impact across a wide spectrum of consumer, business, healthcare and governmental domains.

Pervasive computers, networks and information are paving the road towards a smart world in which intelligent computational paradigms are distributed throughout the physical environment to provide trustworthy and relevant services to people. This intelligent pervasive computing environment will change the computing landscape because it will enable new breeds of applications and systems to be developed, and the realm of computing possibilities will be significantly extended by embedding intelligence in everyday objects.

This edited volume provides an up-to-date and state-of-the-art coverage of diverse aspects related to pervasive computing and intelligent multimedia technologies. It addresses the use of different computational intelligence-based approaches to various problems in pervasive computing such as video streaming, intelligent

behaviour modelling and control for mobile manipulators, teleGaming, indexing video summaries for quick video browsing, Web service processes, virtual environments, ambient intelligence, prevention and detection of attacks to ubiquitous databases and so on.

This volume comprises 19 chapters including an overview chapter providing an up-to-date and state-of-the review of the current literature on computational intelligence-based approaches to various problems in pervasive computing, and some important research challenges.

The book is divided into 4 parts:

Part I: Intelligent Multimedia and Pervasive Systems

Part II: Ambient Intelligence and Ubiquitous Computing

Part III: Web services and Situation Awareness in Pervasive Computing

Part IV: Pervasive Networks and Ecommerce

Part I on Intelligent Multimedia and Pervasive Systems contains eight chapters. It discusses about pervasive computing approaches in the context of intelligent multimedia.

Chapter 1 by Peters et al. introduces a wireless, pervasive computing approach to adaptive therapeutic telegaming considered in the context of near set theory. Near set theory provides a formal basis for observation, comparison and classification of perceptual granules. A perceptual granule is defined by a collection of objects that are graspable by the senses or by the mind. The problem considered in this chapter is how to assess the performance of a handicapped player, e.g., an arthritis patient with pain and joint stiffness problems. In the proposed pervasive computing approach to telegaming, a handicapped person with limited hand, finger and arm function plays a video game by interacting with familiar instrumented objects such as cups, cutlery, soccer balls, nozzles, screw top-lids, spoons, so that the technology that makes therapeutic exercise game-playing possible is largely invisible. The basic approach to adaptive learning in the proposed telegaming environment is ethology-inspired and is quite different from the traditional approach to reinforcement learning. The telegaming system connects to the Internet and implements a store and feed-forward mechanism that transmits gaming session tables constructed and saved during each gaming session to a remote registry accessible to therapists and researchers. The telegaming module for this game makes it possible for the results of all exercise gaming sessions to be forwarded over the Internet to a rheumatoid arthritis (RA) Function PORTAL, as well as local rehabilitation centres and therapists to monitor and provide timely feedback to a client in a remote setting. A complete Automatic Tracking & Assessment (ATA) Exercise Gaming System for RA finger-hand function is explained.

In the last several years, *mobile manipulators* have been increasingly used and developed from a theoretical viewpoint, as well as for practical applications in space, underwater, construction and service environments. Chapter 2 by Elkady et al. deals with the problem of intelligent behaviour modelling and control of a mobile manipulator for the purpose of simultaneously following desired end-effectors and platform trajectories. A new algorithm for measuring manipulability index used for serial manipulators and implemented simulations supporting the methodology on different

manipulators is presented. Furthermore, the chapter provides some simulations that are implemented on different serial manipulators such as the Puma 560 manipulator, a six DOF manipulator and the Mitsubishi Movemaster manipulator. Finally, they describe how mobile manipulator capabilities are a key to several robotic applications and how the manipulability measure is crucial in performing intelligent behaviour.

Video must be delivered to its consumers, but delivery over the Internet and other access networks will not be successful if the problem of network congestion is not solved. Computational intelligence offers a solution to this problem, and Chap. 3 by Fleury et al. demonstrates how higher quality video can be delivered across fixed and wireless networks to display devices in the home. In this way, video can follow the user wherever they are in a seamless and ubiquitous manner. The chapter also shows that this is one of the areas where type-2 fuzzy logic has significant potential outstripping the control offered by traditional type-1 logic.

Multimedia data are used in many fields. The problem is how to manipulate large volume of data. One of the proposed solutions is an intelligent video summarization system. Summarizing a video consists in providing another version, which contains pertinent and important items. The most popular type of summary is the pictorial summary. Chapter 4 by Karray et al. proposes a global architecture of a system, which helps users to navigate into news broadcast archive. It presents a concept of a digital video archive that offers three access levels, thereby making easier the search for video sequences. The first access level offers to the user a full access for the whole archive. The second access level allows the user to browse video archive by consulting video summaries. They contribute by adding a third access level, which accelerates the archive browsing by adding an indexing subsystem that operates on video summaries. Moreover, they propose to index video summaries to accelerate the research of desired sequences.

Virtual reality (VR) technology has matured to a point where humans can navigate in virtual scenes; however, providing them with a comfortable, fully immersive role in VR remains a challenge. Currently available sensing solutions do not provide ease of deployment, particularly in the seated position, because of sensor placement restrictions over the body, and optic-sensing requires a restricted indoor environment to track body movements. Chapter 5 by Gulrez and Tognetti presents a 52-sensor laden garment interfaced with VR, which offers both portability and encumbered user movement in a VR environment. Participants who navigated in a virtual art gallery using natural body movements were detected by their wearable sensor shirt, and the signals are then mapped to electrical control signals responsible for VR scene navigation. Experiments based on several different types of tasks demonstrate the necessity and effectiveness of proper coordination between the human operator and the VR system.

In Chap. 6, Sharda explores how innovative applications can be developed to meet the needs of the next generation hotels. Futuristic hotel rooms aim to be more than "home-away-from-home," and as a consequence, offer tremendous opportunities for developing innovative applications of pervasive computing and intelligent multimedia. Next generation hotels make use of increased use of technology

products to attract new customers. High-end TV screens, changeable room ambiance, biometric guest recognition and electronic check-in facilities are some of the features already being implemented by some hotels. Entirely futuristic hotels in the sea, the stratosphere or the outer space are also being proposed. All of these provide many novel opportunities for developing innovative solutions using intelligent multimedia and ubiquitous computing.

Recently, human–computer interaction has shifted from traditional desktop computing to the pervasive computing paradigm where users are engaged with everywhere and anytime computing devices. Mobile virtual environment (MVE) is an emerging research area that studies the deployment of VR applications on mobile devices. In Chap. 7, Lazem et al. present MVEs as a real-time interactive distributed system and investigate the challenges in designing and developing a remote rendering perfecting application for mobile devices. Furthermore, test-bed architecture for MVEs was introduced to evaluate the remote rendering application through two implementation phases. The flexibility of the proposed architecture allowed for evaluating the system against different combinations of user, environment and network scenarios. The case study was used as a vehicle to illustrate the use of game theory to model, interactive, real-time distributed systems.

Part II on Ambient Intelligence and Ubiquitous Computing contains five chapters that describe several approaches in a ambient intelligent and ubiquitous environment, such as AI techniques in a context-aware ubiquitous environment, a distributed ambient intelligence-based multi-agent system for Alzheimer health care, and case study in pervasive computing including volcano monitoring, an agent-based architecture for preventing and detecting attacks to ubiquitous databases, hybrid multi-agent architecture for home care.

In Chap. 8, Coppola et al. propose MoBe: an approach for providing a basic infrastructure for pervasive context-aware applications on mobile devices, in which artificial intelligence techniques, namely, a principled combination of rule-based systems, Bayesian networks and ontologies, are applied to context inference. The aim is to devise a general inferential framework to fasten the development of context-aware applications by integrating the information coming from physical and logical sensors (e.g., position, agenda) and reasoning about this information in order to infer new and more abstract contexts.

Chapter 9 by Tapia et al. presents ALZ-MAS, an ambient intelligence-based multi-agent system aimed at enhancing the assistance and health care for Alzheimer patients. The system makes use of several context-aware technologies that allow it to automatically obtain information from users and the environment in an evenly distributed way, focusing on the characteristics of ubiquity, awareness, intelligence, mobility, etc., all of which are concepts defined by ambient intelligence. ALZ-MAS makes use of a services-oriented multi-agent architecture to distribute resources and enhance its performance.

In Chap. 10, Peterson et al. present a case study for developing a real-time pervasive computing system, called OASIS for optimized autonomous space In-situ sensor web, which combines ground assets (a sensor network) and space assets (NASA's Earth Observing (EO-1) satellite) to monitor volcanic activities at Mount

St. Helens. OASIS's primary goals are to integrate complementary space and in situ ground sensors into an interactive and autonomous sensor web, to optimize power and communication resource management of the sensor web and to provide mechanisms for seamless and scalable fusion of future space and in situ components. The OASIS in situ ground sensor network development addresses issues related to power management, bandwidth management, quality of service (QoS) management, topology and routing management, and test-bed design. The space segment development consists of EO-1 architectural enhancements, feedback of EO-1 data into the in situ component, command and control integration, data ingestion and dissemination and field demonstrations.

Chapter 11 by Pinzon et al. proposes the SiC architecture as a solution to the SQL injection attack problem. This is a hierarchical distributed multi-agent architecture, which involves an entirely new approach with respect to existing architectures for the prevention and detection of SQL injections. SiC incorporates a kind of intelligent agent, which integrates a case-based reasoning system. This agent, which is the core of the architecture, allows the application of detection techniques based on anomalies as well as detection techniques based on patterns, providing a great degree of autonomy, flexibility, robustness and dynamic scalability. The characteristics of the multi-agent system allow architecture to detect attacks from different types of devices, regardless of the physical location.

Home care (HoCa) is one of the main objectives of ambient intelligence. Nowadays, the dependent and elderly population, which represents a significant part of our society, requires novel solutions for providing home care in an effective way. Chapter 12 by Fraile et al. presents a hybrid multi-agent architecture that facilitates remote monitoring and care services for dependent patients at their homes. HoCa combines multi-agent systems and Web services to facilitate the communication and integration with multiple health care systems. In addition, HoCa focuses on the design of reactive agents capable of interacting with different sensors present in the environment, and incorporates a system of alerts through SMS and MMS mobile technologies. Finally, it uses RFID and Java Card technologies to provide advanced location and identification systems, as well as automatic access control facilities. Moreover, HoCa is implemented in a real environment and the results obtained are presented.

Web services and Situation Awareness in Pervasive Computing is Part III of the book. It contains two chapters discussing the issues in Web services and situation awareness in pervasive computing environment.

Chapter 13 by Di Pietro et al. proposes a new approach to the discovery, the selection and the automated composition of distributed processes in a pervasive computing environment, described as semantic Web services through a new semantic annotation. This approach has been tested in a real-world case study, where real Web services provided by Amazon, eBay and PayPal have been annotated with the language proposed in this chapter, and then, selected and composed. Furthermore, automated composition has been compared with hand-written composition made by an experienced programmer.

Ubiquitous applications such as health care monitoring applications need to analyze and process data streams that are generated at very high rates in real time. Therefore, it is of great importance for data stream mining techniques to be equipped with adapting strategies to promote the continuity and consistency of the running application. Current ubiquitous data stream mining approaches have limited levels of adaptations (mainly focusing on battery or memory). To enhance adaptation of data stream mining algorithms, there is a need to consider the contextual/situational information in the adaptation phase. Integrating data stream processing with situation awareness provides intelligent and cost-efficient analysis of data, and enables continuity and consistency of mining operations. In Chap. 14, Haghighi et al. present a novel approach for situation-aware adaptive processing (SAAP) of data streams for pervasive computing environments. This approach uses fuzzy logic principles for modelling and reasoning about uncertain situations and performs gradual adaptation of parameters of data stream mining algorithms in real-time according to availability of resources and the occurring situations.

The final part of the book deals with the Pervasive Networks and Ecommerce. It contains five chapters, which discuss the wireless network application, including mobile agents and e-commerce. Today, there are more applications than ever that require using the network, consuming the bandwidth, and sending packets far and wide. The service providers are actively upgrading the Internet backbone to fulfil the demand for high bandwidth applications such as multimedia communications. Chapter 15 by Ivan Lee illustrates the performance of a distributed video streaming framework, which utilized video source coding and distributed network adaptation schemes. An efficient video coding technique using multiple descriptions coding technique is applied, and the encoded sub-streams were transmitted over client/server, centralized P2P and decentralized P2P network infrastructures.

In Chap. 16, Agboma and Liotta introduce pervasive systems and services from the telecommunication perspective. They look at the enabling technologies and different pervasive services that are currently being provided to users. In view of this, the authors emphasize on why quality of experience (QoE) in telecommunication systems is important. Furthermore, they elaborate on the different requirements needed to provide pervasive services from the user's perspective. A case study is presented, illustrating how the sensitivity of different network parameters (such as bandwidth, packet loss and delay) for a pervasive service can affect QoE.

In Chap. 17, Al-Jaljouli and Abawajy describe robust security techniques that ensure a sound security of information gathered throughout agent's itinerary against various security attacks, as well as truncation attacks. A sound security protocol is described, which implements the various security techniques that would jointly prevent or at least detect any malicious act of intruders. Authors reason about the soundness of the protocol using STA (Symbolic Trace Analyzer), a formal verification tool that is based on symbolic techniques.

In Chap. 18, Liu et al. investigate a multi-swarm approach to the problem of neighbor selection in P2P networks. Particle swarm shares some common characteristics with P2P in the dynamic socially environment. Each particle encodes the upper half of the peer-connection matrix through the undirected graph, which

reduces the search space dimension. They also attempt to theoretically prove that the multi-swarm optimization algorithm converges with a probability of 1 towards the global optima. The performance of the introduced approach is evaluated and compared with other two different algorithms. The results indicate that it usually requires shorter time to obtain better results than the other considered methods, especially for large-scale problems.

Mobile ad hoc networks (MANETs) are a fundamental element of pervasive networks, where users can communicate anywhere, anytime and on-the-fly. In fact, future advances in pervasive computing rely on advancements in mobile communication, which includes both infrastructure-based wireless networks and non-infrastructure-based MANETs. MANETs introduce a new communication paradigm, which does not require a fixed infrastructure – they rely on wireless terminals for routing and transport services. Because of highly dynamic topology, absence of established infrastructure for centralized administration, bandwidth constrained wireless links and limited resources in MANETs, it is challenging to design an efficient and reliable routing protocol. Qadri and Liotta in Chap. 19 review the key studies carried out so far on the performance of mobile ad hoc routing protocols. The authors discuss performance issues and metrics required for the evaluation of ad hoc routing protocols. This leads to a survey of existing work, which captures the performance of ad hoc routing algorithms and their behaviour from different perspectives and highlights avenues for future research.

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