Ann. Telecommun. (2012) 67:295–296
DOI 10.1007/s12243-012-0314-y

FOREWORD

Ubiquitous networked robots

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Published online: 20 June 2012

With the growing emergence of ambient intelligence, ubiquitous computing, sensor networks, and wireless networking technologies, "ubiquitous networked robotics" is becoming an active research domain of intelligent autonomous systems. It targets new innovative applications in which robotic systems will be integrated into ubiquitous computing environments as physical autonomous entities. These entities are able to interact autonomously with the ambient environment and provide added value services. So far, robots as cognitive entities will be able to coordinate their activities with other physical or logical entities, move around, sense and explore the ambient environment, and decide and act to respond to the situations they may face. These cognitive operations will become part of these networks of artefacts, to provide, individually or collectively, novel capabilities and various assistive services anywhere and anytime. This paradigm aims to build a bridge between ubiquitous computing and robotics, i.e., the creation of flexible, Internet-based, extensible architectures able to support any sort of *intelligent and autonomous robotic services* capable of interacting—in a typical "Internet of people, things and services" mode—with *virtual or real artefacts*.

The paradigm of ubiquitous networked robots (UNR) raises a number of important research challenges such as: (a) real-time communication using heterogeneous wired and wireless networking technologies, in which relevant requirements concern the quality and continuity of communication services; (b) interoperability between the different pieces of hardware and software technologies used to guarantee a seamless interaction between the UNR and the surrounding devices and systems; (c) new paradigms of human–robot–environment interaction, including implicit communication mechanisms and artificial perception and reasoning; and (d) adaptability to the ubiquitous environment and scalability management. The UNR systems require more flexibility, mobility, security, reliability, and robustness through middleware mechanisms such as autonomic discovery of entities and services, service composition and orchestration, self-adaptation, and context awareness with uncertainty management.

This special issue focuses on the most relevant ongoing research on UNR main challenges. It aims at providing the readers with a set of papers presenting the latest developments made in this area to support the requirements of emerging UNR applications.

A. Bardella, M. Danieletto, E. Menegatti, A. Zanella, A. Pretto and P. Zanuttigh present a very complete solution for the integration of robots and wireless sensor networks in an ambient intelligence scenario. The proposed approach allows the robot to progressively acquire environmental awareness by interacting with the smart objects located in the space. The feasibility of this vision has been proved by means of an experimental prototype of the system, in which a robot has proved to be able to discover the objects in radio range by using RF communication, then to roughly map

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them into the area through an RSSI-based localization algorithm coupled with a proper initialization scheme based on particle filters, and finally to recognize the objects in its visual perspective by matching the information transmitted from the object with the appearance descriptors obtained from the onboard cameras.

An important challenge shared by ubiquitous computing and UNR and consisting in providing context-aware services in dynamic environments under response time constraint is addressed by J.-Y. Tigli S. Lavirotte, G. Rey, V. Hourdin, N. Ferry, C. Vergoni and M. Riveill. They propose a low response time and dynamic context adaptation rule system, called ORCA, featuring simple context processing, parameter adaptation, dynamic activation of rules depending on context observer availability, and composition of rules relying on policies.

K. Kamei, T. Ikeda, M. Shiomi, H. Kidokoro, A. Utsumi, K. Shinozawa, T. Miyashita and N. Hagita develop an original ubiquitous market platform. This interactive system as an ubiquitous networked robot system is organized in a shopping environment. In this environment, the purchasing behaviors of customers are observed by a sensor network. Two experiments using 80 participants were conducted with the constructed system to evaluate the effectiveness of the robots' navigation, especially that of cooperative navigation, by analyzing the changes in customers impressions of the robots.

A. Yachir, Y. Amirat, A. Chibani and N. Badache address important challenges for UNR: automatic service composition, context and quality of service management, and service selection under uncertainty and changes. They propose a layered design approach for flexible and failure-tolerant service composition. Service composition is generated in an abstract way, using rule-based techniques while service selection is based on the quality of service estimation of concrete services. The proposed algorithms are evaluated from scalability and reactivity point of views with respect to dynamic and uncertain nature of the ubiquitous environment.

An interesting perception system developed in the European Project called ubiquitous networking robotics in urban settings is proposed by L. Merino, A. Gilbert, J. Capitan, R. Bowden, J. Illingworth and A. Ollero. The proposed paradigm considers a team of mobile robots, a set of static cameras, and a wireless sensor network in an urban environment to offer urban services. The authors present a decentralized system that aims to use multiple sensors to accurately track people within a concrete surveillance context. The system makes extensive use of data fusion procedures to incorporate all the information available.

S. Hoceini, A. Mellouk, A. Chibani, Y. Touati and B. Augustin propose a routing approach for robots swarm networks, which permits to increase their performances in terms of information exchange and cooperation. The approach introduces a polynomial time approximation path navigation algorithm and constructs dynamic state-dependent navigation policies. It uses an inductive method based on trial/error paradigm combined with swarm adaptive approaches to optimize simultaneously two independent criteria: cumulative cost path and end-to-end delay path. Robustness and performances of the proposed approach are evaluated in simulation for a standard network topology and for different network traffic patterns between robots.

Due to the growing interest in using robots to provide elderly people living alone with opportunities for conversation, K. Ouchi and M. Doi propose a low-throughput recognition method for in-home living activity recognition as a way to improve the quality of the conversation. The proposed method enables to recognize context by using only off-the-shelf sensors, namely, an accelerometer and a microphone, which are commonly applied in mobile phones. Experiments confirm the feasibility of the proposed method.

Finally, we thank the staff of *Annals of Telecommunications* for their support and help. We also thank all reviewers for their valuable and hard work and all authors who submitted their paper for consideration for this special issue. We sincerely hope that you will enjoy reading it.