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Editorial

Ubiquitous robots (UBIROBOTS) workshop at the UBICOMP 2012 conference

1. Introduction

Ubiquitous robots (UBIROBOTS) are smart software or physical service providers within ambient intelligence environments. The integration of these robots within cloud computing and ubiquitous computing technologies will enhance our daily lives. Ubiquitous robots, as cognitive entities, are intended to provide various value-added services compared to traditional systems. They are able to coordinate their activities with other physical or logical entities, move around, sense and explore the environment, and make decisions, act on, or react to the situations they may face anywhere and anytime.

Currently, most practical interaction strategies with ubiquitous robots and ambient intelligence environments rely on the use of web services, mobile devices, and wireless networks. Ontologies and rule languages are used to enhance the interoperability between service providers and consumers without taking into account several aspects such as the social aspects of such interactions, activities, contexts, or effects.

Enhancing both ubiquitous computing applications and ubiquitous robots with novel capabilities or new services needs new approaches that can take into account the specifics of robots' behaviors and their interaction possibilities. In this perspective, middleware for networked robots should be enhanced with functionalities such as human behavior recognition, multimodal human–robot interactions, objects and situation recognition, natural language processing, commonsense knowledge sharing, task planning, and distributed control. Moreover, implementing such functionalities would require integrating well-established features from ubiquitous computing to deal with context awareness, self-adaptation, and autonomic management of robotic services.

Cloud computing provides some promising functionalities that can be valuable for the composition and deployment of ubiquitous robot services to enable robots to quickly acquire the skills and knowledge they need in a short period of time. Connecting the robots to ontology repositories through cloud computing services allows robots and ubiquitous computing systems to exchange semantics and update their knowledge and cognitive functionalities.

Enabling intelligent interactions between humans, ubiquitous computing systems, and service robots within ambient intelligence and cloud computing environments can be envisioned for the near future. It will certainly open an unlimited space of applications such as (i) physical and virtual companions assisting people in performing their daily activities, (ii) ubiquitous robots that are able to co-work alongside people and cooperating with them in the same environment, and (iii) physical and virtual autonomic guards that are able to protect people, monitor their security and safety, and rescue them in indoor and outdoor spaces.

2. The UBIROBOTS workshop

UBIROBOTS 2012 is the flagship workshop on ubiquitous robotics research, held in conjunction with the Ubiquitous Computing (UBICOMP) 2012 international conference. The workshop was established with the main objective of facilitating discussions and building a bridge between two distinct research populations: namely, people working on ubiquitous computing and related topics, and people working on robotics and artificial intelligence. The workshop was designed to cover the following topics.

- Ubiquitous computing frameworks versus ubiquitous robotics frameworks.
- Interaction techniques for ubiquitous computing and ubiquitous robotics.
- Context awareness and cognitive capabilities.
- Ubiquitous robot integration within the semantic web and cloud computing.
- Novel application fields of ubiquitous computing and ubiquitous robotics.

The technical program of the workshop was organized in three sessions that included four keynotes talks. In each session, both theoretical and experimental presentations from both robotics and computer science communities were combined. The keynote addresses were devoted, first, to the presentation of recent progress in theoretical and applied research related to ubirobots and, second, to envisioning future directions of ubirobot research and applications. In this context, four distinguished researchers who have had a strong impact on the ubirobot research domain were invited to give presentations, namely

- Katia Sycara, Research Professor and Director of the Advanced Agent-Robotics Technology Lab at Carnegie Mellon University, USA,
- Stewart Tansley, Director of Microsoft Research Connections, USA,
- Jong-Hwan Kim, Chair Professor at KAIST, Republic of Korea, and
- Norihiro Hagita, Director of the ATR Intelligent Robotics and Communication Laboratory in Japan.

In the first talk, Professor Katia Sycara presented a tutorial entitled "From Services to Servos: Challenges and Opportunities in Ubirobotics". She made an assessment of the recent work in ubiquitous computing projects and gave a summary of the lessons learned from the use of semantic web technologies. She also discussed concerns about semantic web service matchmaking and how robot autonomous services (servos) will be the enablers in the advancement of the new generation of cognitive robots. The talk by Stewart Tansley, entitled "A Personal Perspective in the context of Natural User Interfaces", was centered on his personal

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experience in the domain of human–machine interaction, in particular, the development of gesture and activity recognition technologies using visual sensors. Professor Jong-Hwan Kim, as the pioneer and founder of ubirobot research, presented a talk entitled "Intelligence Technology for Ubiquitous Robots". In this talk, he presented the new concepts of Genetic Robots and Robots That Think (RTT), where robots have genetic codes that represent a specific personality. The robot's intelligence is based on its capacity to deliberately interact with the environment by selecting behaviors using a Mechanism of Thought, which mimics a living creature's thinking mechanism. The last talk, entitled "Cloud Networked Robotics for Supporting Daily Activity", was given by Dr. Norihiro Hagita. Dr Hagita presented the state of the art of the research undertaken for developing a standard middleware called the Ubiquitous Network Robot Platform (UNR-PF), where a robot's operation is based on a set of functionalities to manage multi-robots and multi-area information communication. This UNR-PF is integrated within the standardization efforts inside the Object Management Group (OMG) robotics middleware standardization group to allow for the interoperability of robotic services. Dr. Hagita also presented the latest successful experimentations of UNR-PF services in real-world scenarios for activity recognition and tracking, and active assistance in smart spaces such as shopping malls.

3. Results and future direction

The workshop concluded with a panel session that summarized the outcomes and lessons learned concerning the challenges and research directions of the next generation of ubiquitous robots. It was decided that ubiquitous robots should be more intelligent and that their cognitive capabilities should be independent from their physical and embedded software architecture. This will require more involvement of multidisciplinary expertise from various domains. In this context, prominent research activities in artificial intelligence, cognitive science, computation linguistics, and psychology can be used in combination with data-driven approaches. This will endow the robots or the environment with semantic knowledge about users' activities, behaviors, and intentions, and enable them to react in highly dynamic and uncertain environments.

The most important outcome of the workshop was bringing together the computer science and robotics communities and having them share their mutual experiences and current challenges. With respect to the future technical challenges, the emphasis should focus on three primary topics. The first one concerns the growing activities of standardization and robot middleware unification in robotics, where these activities are led not only by roboticians but also by researchers from the computer science community. The second topic concerns the enhancement of social capabilities of robots in order to make their services more human-centric and responsive to the expectations of users. Moreover, these services should be cognizant of users' activities, intentions, and effects by relying on the cloud. This will become the infrastructure to allow for robot interactions, enriched intelligence, and sharing of knowledge with other robots. The last topic concerns the enforcement of efforts devoted to the development of new robot cognitive capabilities. This will be accomplished by combining approaches from knowledge management by using semantic ontologies, formal logic reasoning, and soft computing. These approaches will impose new constraints in terms of the networking resources and high-performance computing.

Future workshops will focus on specific topics in the general area of ubiquitous robotics. A proposal was submitted for a workshop in the IROS 2013 conference on the topic of human-centric assistance, and a proposal will be submitted for the UBICOMP 2014 conference that will focus on cloud computing and social interactions.

4. Synopsis of this special issue

This special issue was organized to ensure that the significant information and results presented at the workshop reach a wider audience. We asked selected participants from the workshop to submit extended versions of their papers for inclusion in this issue of the journal.

The seven articles in this issue represent a good sampling of the types of issues that surround ubiquitous robotics. The first paper takes a broad look at the challenges and trends in ubiquitous robotics within applications such as (1) physical and virtual companions assisting people in performing their daily activities, (2) ubiquitous robots that are able to co-work alongside people and cooperate with them, and (3) physical and virtual autonomic guards that are able to protect people. It looks at these applications in the context of semantic perception, reasoning, and actuation. The second paper looks at the area of smart residential/environments, which are spaces equipped with invisible sensors and actuators. Mobile robots can use the existing infrastructure to save their own resources and to provide new ambient services to the people living there. The authors present a new approach to simulate such scenarios in order to evaluate the performance of ambient services. The third paper proposes a model and a simple example implementation which minimizes the strict line between humans, software agents, robots, machines, and sensors (HARMS), and reduces the distinguishability between these actors. The premise behind this work is that the defined line between humans and other non-humans must become more indistinguishable as robots become more ingrained and prevalent in working with humans.

Papers four through six focus on the knowledge representation aspect and how such knowledge representation can be used to further the area of ubiquitous robotics. In the fourth paper, the authors introduce the main concepts of a core ontology for the robotics and automation field, one of the first results of the newly formed IEEE-RAS Working Group, named Ontologies for Robotics and Automation. It aims to provide a common ground for further ontology development in Robotics and Automation. The fifth paper presents a newly developed knowledge methodology/model that allows for the creation of systems that demonstrate flexibility, agility, and the ability to rapidly re-task. The methodology/model is illustrated through a case study in the area of robotic kit building. The sixth paper describes a novel approach for representing state information for the purpose of intention recognition in cooperative human–robot environments. States are represented by a combination of spatial relationships in a Cartesian frame along with cardinal direction information. Based upon a set of predefined high-level states relationships that must be true for future actions to occur, a robot can use the detailed state information described in this paper to infer the probability of subsequent actions occurring.

The seventh paper deals with the activity recognition issue in the context of Ambient Assisted Living environments. The proposed approach is based on a new mapping for conflict evidential fusion to increase the efficiency and accuracy of activity recognition. It gives an intuitive interpretation for combining multiple sources in all conflicting activities. The proposed approach, evaluated on a real-world smart home dataset, achieves 78% accuracy in activity recognition. The results obtained outperform those obtained with existing combination rules.

Acknowledgments

We would like to thank the workshop organizing committee who helped to make this event a success by providing useful technical insights on the topics for the workshop and assisting in reviewing that papers that were submitted. The organizing and steering committees consisted of the following members.

1. *Organizing Committee:*
   - Abdelghani Chibani (LISSI/UPEC University, France)
   - Craig Schlenoff (NIST, USA)
   - Edson Prestes (UFRGS, Brazil)
   - Yacine Amirat (LISSI/UPEC University, France)
2. *Steering Committee:*
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   - Alessandro Saffiotti (Orebro University, Sweden)
   - Dimitris Plexousakis (FORTH Research Institute, Greece)
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   - Rachid Alami (LAAS CNRS, France)
   - Sumi Helal (Florida University, USA)
   - Shigeki Sugano (Waseda University, Japan)
   - Stewart Tansley (Microsoft Research, USA)
   - Xing Xie (Microsoft Research, China)
   - Hong Seong Park (Kangwon National University, Korea).

Craig Schlenoff is the Group Leader of the Cognition and Collaboration Systems Group in the Intelligent Systems Division at the National Institute of Standards and Technology. His research interests include knowledge representation/ontologies, intention recognition, and performance evaluation techniques applied to autonomous systems and manufacturing. He previously served as the program manager for the Process Engineering Program at NIST and the Director of Ontologies at VerticalNet. He leads numerous million-dollar projects, dealing with performance evaluation of advanced military technologies. He received his Bachelors degree from the University of Maryland and his Masters degree from Rensselaer Polytechnic Institute, both in mechanical engineering.

Abdelghani Chibani has been awarded an M.Sc. degree in Computer Science from Paris 6 University, and a Ph.D. degree in computer science from Paris Est Créteil (UPEC). After more than 9 years as a senior consultant in the computer industry, he joined UPEC in 2008 as an associate professor in the networking and telecommunication department of the Créteil-Vitry technology institute. His research interests concern the design of autonomous systems for ubiquitous computing/robotics and ambient assisted living (AAL) applications.

Edson Prestes received his B.Sc. degree in computer science (CS) from the Federal University of Pará (UFPa), Brazil, in 1996 and his M.Sc. and Ph.D. degrees in CS from the Federal University of Rio Grande do Sul (UFRGS), Brazil, in 1999 and 2003, respectively. Currently, he is associate Professor and Head of the Theoretical Informatics Department at Informatics Institute (UFRGS); vice chair of the working group funded by IEEE RAS entitled Standard for Ontologies for Robotics and Automation (IEEE RAS WG ORA); a member of the IEEE RAS Special Interest Group on Humanitarian Technology (IEEE RAS SIGHT; and a member of IEEE, IEEE RAS (Robotics and Automation Society), and IEEE SA (Standards Association).

Yacine Amirat received his Ph.D. degree in computer science and robotics from the University of Pierre et Marie Curie, Paris, France, in 1989, and his Habilitation degree in artificial intelligence and control of complex systems from the University of Paris 12 University in 1996. He co-created the Laboratory of Computer Sciences and Robotics, Paris 12 University (newly UPEC), Créteil, France, in 1990. He is currently the Director of the Laboratory of Image, Signal and Intelligent Systems (LISSI) — UPEC, and the Scientific Director of several research projects. He has authored or co-authored more than 100 papers in scientific journals, books, and conference proceedings. His current research interests include artificial intelligence, soft computing, knowledge processing, and control of complex systems. Application fields are intelligent and robotic systems such as ubiquitous and service robots, wearable robots, and ambient intelligence. Prof. Amirat has served as a reviewer for many international journals and conferences and a Technical Committee Member, Session Chair, Session Organizer, or Associate Editor of several IEEE-RAS conferences. He is actively collaborating with industrial and academic partners in various European projects.

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