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Janusz Kacprzyk, Polish Academy of Sciences, Warsaw, Poland
e-mail: kacprzyk@ibspan.waw.pl

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Aleksandar Rodić · Theodor Borangiu
Editors

Advances in Robot Design and Intelligent Control

Proceedings of the 25th Conference on Robotics in Alpe-Adria-Danube Region (RAAD16)

Springer

Editors
Aleksandar Rodić
Robotics Laboratory
Mihajlo Pupin Institute
Belgrade
Serbia

Theodor Borangiu
Faculty of Automatic Control
and Computers
University Politehnica of Bucharest
Bucharest
Romania

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Foreword

Congratulations to the 25th anniversary of RAAD

The most beautiful flowers grow in the absence of spotlights, and their full beauty unfolds only after having grown leaves and roots to store up energy for the upcoming bloom period. This picture comes in mind when looking at the history of the RAAD conferences. The beginning is closely connected with the political changes in South East Europe. The first RAAD meeting in 1992—in those days still considered as a "humble" workshop—was initiated by the Jožef Stefan Institute in Slovenia, two years after the first elections in that newly established country. Bearing in mind that the disintegration of former Yugoslavia just had started, accompanied by atrocities and NATO bombings, it was a heroic act to bring together roboticists in this region—which once was a "cradle" of European robotics! Humanoid robots of today still make reference to Miomir Vukobratović with his ground breaking theoretical work on biped locomotion at the Mihajlo Pupin Institute in Belgrade (1970). And based on theoretical and industrial excellence, several series of industrial robots (foremost the Goro, UMS, and Ivo Lola Ribor types) have been built between 1980 and 1988 and successfully installed in factories of Slovenia and Serbia.

It was not only heroic in those days to keep collaboration in the region alive, but it was also farsighted by transcending the horizon and encompassing now with "Alpe-Adria-Danube" a geographical "crescent" stretching from the French Alps to the Black Sea with more than 250 million inhabitants. Starting in 1992, RAAD left not a single year out—which shows the success of the concept.

Robotics is the next industrial revolution, permeating into all branches of daily life, at work and at home. This means: To participate in robotics will also decide about our economy and our welfare. However, robotics is a multidisciplinary endeavour. Most of the European states are too small to be excellent in all fields—advanced technologies require transnational cooperation.

As of today, the European Partnership in Robotics called SPARC is, with €700m funding from the European Commission and industrial obligations of three times

more, the largest civilian robotics programme in the world. As part of Horizon2020, SPARC is driven by a European roadmap on robotics which is developed by the community of European roboticists, coordinated by the European robotics association euRobotics in Brussels.

It is very likely that upcoming EU programmes will focus even more on economic growth, creating jobs, and concentrating on the equity of opportunities between all regions of Europe. Within the recent years, RAAD has developed into a network of experts who are very competent to develop regional roadmaps for robotics which identify opportunities for robotics around existing regional core competencies. This qualification underlines the growing strength of the RAAD community.

RAAD 2016 celebrates its 25th anniversary with a significant growth in quality and quantity: this Springer volume shows not only the high quality of the papers accepted, but also the growing diffusion of robotics into other sectors such as agriculture, health, and even architecture. With more than 80 registered participants from 25 nations, RAAD has gained a highly reputable share in the European robotics community. The organisers and committees of RAAD 2016 under the masterly leadership of Prof. Aleksandar Rodić are thanked for their excellent job in planning, organising, and performing this conference.

July 2016

Dr. Uwe Haass
Former Secretary General euRobotics AISBL, Brussels

Preface

The jubilee 25th International Conference on Robotics in Alpe-Adria-Danube Region, RAAD 2016 was held in the conference centre of the Best Western Hotel M, Belgrade, Serbia, from 30 June to 2 July 2016. The conference brought together academic and industry researchers in robotics from 25 countries, the majority of them affiliated to the Alpe-Adria-Danube region, and their worldwide partners in a collegial and stimulating environment.

According to its tradition, RAAD 2016 covered all important areas of research, development and innovation in robotics, including new trends such as bio-inspired and cognitive robots, visual servoing of robot motion, human–robot interaction, and personal robots for ambient assisted living. This year for the first time in the RAAD history, new topics such as cloud robots, legal and ethical issues in robotics as well as robots in arts were present in the technical programme of the conference.

Papers were solicited in topics related to new theories, advanced design of robot mechanics and intelligent control architectures and development of robot applications, including but not limited to the following:

- Novel design and applications of robotic systems
- Dexterous grasping, handling and intelligent manipulation
- Intelligent cooperating and service robots
- Advanced robot control—human–robot interfaces
- Robot vision systems and visual servoing techniques
- Mobile robots
- Humanoid and walking robots
- Bio-inspired and swarm robotic systems
- Towards micro- and nano-scale robots
- Aerial, underwater and spatial robots
- Robot integration in holonic manufacturing
- Personal robots for ambient assisted living
- Medical robots and bionic prostheses
- Intelligent information technologies for cognitive robots
- Education in robotics—history of automation and robotics

- Cognitive robots and emotional intelligence
- Cloud robotics
- Ethical, legal and social issues of robotic
- Construction robots

Human activities in many sectors are nowadays supported or replaced by robots, which range from standard robots for industrial or service applications to autonomous robots for complex activities, such as underwater and space exploration. The great versatility and flexibility of nowadays robots allows them to be employed in different sectors, to perform a diversity of tasks.

A number of papers included in this volume report advances in robot control and integration in production and services. Task-space control is an important approach to the control of complex robots; this control framework is of essential importance for redundant robot manipulators, especially for multi-arm robots or humanoid robots, which have more degrees-of-freedom than those required to fulfil a task, and have to perform the task in human-like way. Solving constraint satisfaction problems allows for robust, safe planning of multiple robots in manufacturing. The sustainability of robotized processes is analysed by monitoring energy consumption at operation level and consequently reconfiguring robot speed and acceleration or conducting robot allocation scenarios in an efficient way. In order to adapt themselves to the environment and characteristics of material flows, robot systems are often equipped with vision systems.

Vision-guided robot motion using look-and-move and visual servoing methods provide best performances in the generation of accurate, task-oriented motion patterns. Integrating Visual Quality Control services in manufacturing environments allows product traceability. In the context of agent-based manufacturing, some papers approach the problem of planning cooperative activities in robot teams. Theoretical principles and methods are addressed, implementing solutions and tools for visual servo control of robot manipulators in grasping tasks. Guidance vision is presented as an advanced motion control method, which provides flexibility to robots integrated in manufacturing cells with unstructured environment and in-line quality inspection.

Robotic coaching is a process of modifying the motion of a robot during execution through human intervention, in a manner of a coach. Thus, parts of the motion are changed depending on the instructions which can be provided through different approaches. Robotic coaching is treated in the conference, including methods relying on physical human robot interaction such as using compliantly controlled robots to different variations of position and force feedback.

There are also analysed new methods of using robots in interaction with humans (natural interaction) to provide assistance services. Using depth sensors, the robots are able to detect the human operator and to avoid collisions. Collision avoidance uses depth sensors which monitor the activity outside and inside the multi-robot system workspace using skeleton tracking (e.g. with the Kinect sensor), allowing the robot to detect collisions and stop the motion at the right time.

Papers in the conference address the development of software interfaces for natural-like interaction of humans with personal robots. This type of interaction is considered for communication (models of hand gestures are established that allow many natural gestures to be interpreted by the personal robot) and emulation of human skills, routine tasks (extracting reusable task knowledge from visual observation of human gestures, learning dexterous operations from human demonstration). These papers describe spatial and temporal modelling of communicative and manipulative gestures; hand gestures analysis and recognition based on multiple-image processing; reusable task knowledge extraction from visual observation of human performance and action reproduction (human tasks emulator); visual servoing for motion tuning.

Although today's robots are distinguished by an enviable degree of artificial intelligence, versatile perception and decision-making in real-time, this area is still in development. If the design approach of service robots is based on "technological copy" of the human, then we are placed in front of the impossible requirements for robots, expecting them to simultaneously solve a lot of complex numerical tasks such as planning developments and navigation, avoiding obstacles, pattern recognition, sound recognition, planning, visual-motor actions and making a decision in the absence of complete information. Performing such complex tasks in parallel (simultaneously) requires extremely powerful computing resources. In such cases, there is an alternative solution that promotes the so-called distributed ambient intelligence approach as technologically feasible, progressive approach to solving the problem of the accumulation of tasks and solving management problems in the system with simple distribution of tasks among agents. Cloud robotics is an emerging concept as real alternative to the built-in (embedded) management robot system, which overcomes the above-mentioned technological constraints in implementation.

Social interactive robot needs the same behaviours and capabilities as humans to be able to work in human daily life. Facial expressions is an examples of nonverbal cues used in inter-human interaction, that need to be recognised, possibly by deep learning techniques.

Together, the digital transformation and robotics open up new horizons for the design, construction and development of structures of modern avant-garde forms and systems. By coupling powerful CAD software tools and multitasking robot controllers, the most diverse and unusual forms in architecture and art can be today produced very accurately. This can be noticed by examining their stability and stresses in critical sections, aerodynamics, etc. When the robot is working, subjective factors of human fatigue, lack of motivation, etc. can be eliminated. For this reason, the robots in manufacturing have increased application and effectiveness and they have also a huge potential to be applied in design, construction and architecture.

The accepted papers have been grouped in ten technical sessions: (I) Intelligent Robot Motion Control, (II) Robot Vision and Sensory Processing, (III) Novel Design of Robot Manipulators and Grippers, (IV) Robot Applications in Manufacturing and Services, (V) Autonomous Systems, Humanoid and Walking

Robots, (VI) Human-Robot Interaction and Collaboration, (VII) Cognitive Robots and Emotional Intelligence, (VIII) Medical, Human-Assistive Robots and Prosthetic Design, (IX) Robots in Construction and Arts, and (X) Evolution, Education, Legal and Social Issues of Robotics.

All these aspects are treated in this book—**Advances in Robot Design and Intelligent Control**—Proceedings of the 25th International Conference on Robotics in Alpe-Adria-Danube Region of the Springer series *Advances in Intelligent Systems and Computing*, which we hope you will find useful reading.

Belgrade, Bucharest
July 2016

Aleksandar Rodić
Theodor Borangiu

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Robot Vision and Sensory Processing

Novel Design of Robot Manipulators and Grippers

Autonomous Systems, Humanoid and Walking Robots

Human-Robot Interaction and Collaboration