

Berichte aus der Robotik

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Field and Assistive Robotics

Advances in Systems and Algorithms

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Preface

In one short sentence, *Field Robotics* can be described as a subject of building autonomous systems for the real world. *Assistive Robot* technologies, on the other hand help such autonomous systems to share their work area with humans. When we say that field robots are meant for the real world, we emphasize that such systems are meant to work in highly uncertain and unstructured environments such as forests, agricultural fields, mines, battlefields, disaster areas and even on other planets. The level of sophistication required for such solutions can be appreciated by comparison with traditional indoor robotics such as those for a factory floor or an urban home where an autonomous systems would still require tremendous complexity and sophistication in precisely controlled and highly structured environments. Aerial, ground and underwater field robots are a leap ahead in complexity from their industrial and indoor cousins. Despite several decades of research, the state-of-the-art in field robotics is still at its infancy, in that reliability and robustness needed to tackle tasks like land-mine clearance, agricultural automation, excavation, building construction and planetary exploration is beyond the reach of today's most sophisticated robots. In cases, where technological feasibility has been demonstrated (such as in planetary exploration, robotic surveillance and bomb disposal), the high costs prevent scalability and large-scale adoption. However, many hazardous, repetitive and difficult tasks demand robotic solutions to remove the human out of the loop, both to ensure safety and improve on economy. Therefore, the impetus to overcome these challenges comes directly from industry, government and society with an appreciation of the advances in this area at every step forward.

Assistive robotics take on another complementary challenge. While, field robots aim to remove the human out of the work area, assistive robots bring the human back and enables an interaction with the machine. This opens a whole new set of challenges that are related to safety, productivity and comfort of the human co-worker. Such assistance is needed in both indoor and field applications. While it is not necessary that field robotics applications demand a higher sophistication in human-robot interaction than indoor applications, assistive technologies are highly challenging in the field, nevertheless. This volume discusses some recent advances in systems and software in both field and assistive robotics, and in particular areas where the two complement and support each other.

In the last three years, an active research collaboration has been established between the Robotics Research Lab (RRLAB) at University of Kaiserslautern, Kaiserslautern, Germany and the Laboratory for Cyber Physical Systems (CY-PHYNETS) at Lahore University of Management Sciences (LUMS) in the areas of field and assistive robotics. Five workshops by the name of WFAR (Workshop on Field & Assistive Robotics) have been held on the topic, two in Germany (2012, 2013) and three in Pakistan (2011, 2012, 2013). This book is a representative of the some of the work that has been presented in these workshops. In particular,

this volume draws from selected works presented in the fourth workshop of the series (WFAR-4) held at Leibniz Center for Informatics at Schloss Dagstuhl, Germany in 2013. This book is targeted for early career researchers and graduate students looking for their thesis topics. It provides an insight to a variety of still open challenges that are yet to be solved and suggests some possible solutions that may help in future.

The book presents several themes in one volume ranging from broad system-level issues to detailed analysis of particular algorithms and methods. The first paper by Armbrust et al. shares experiences of robot development for search-and-rescue unmanned ground vehicles in a 17.5 Million Euro European FP7 project. The second paper by Muhammad et al. provides a high level overview of an extremely low-budget land-mine detection system developed in Pakistan. The paper provides a good study of mobile manipulation in an unstructured environment and helps understand how such challenges can be met. These two papers help compare & contrast the solutions and activities related to the design of field robotic solutions for developed and developing world markets. The third paper by Volk discusses software architecture for a robotic excavator for unmanned construction. The paper aligns with the trend seen in several other papers of this volume, where robotics researchers are resorting to open source software tools such as Robot Operating System (ROS) for development and testing. In the fourth paper, Fuchs et al. address the problem of measuring the angle between a truck and a trailer using a rear view camera. The aim is to assist the driver in safety of operations. The first four papers provide good examples of design concepts and systems engineering in the field and assistive robotics. In the fifth paper by Naseer et al., the robot can fly and the field robotics problem has an assistive dimension. The authors describe methods to perform human detection, tracking and following from an aerial platform using techniques of computer vision and sound practices of systems engineering. In the next paper by Piao and Berns, the authors study the problem of tracking and detection of moving objects such as humans in more detail. The authors provide a generic TLD (Track-Learn-Detect) framework for multi-object tracking and give examples of their implementation in various scenarios. The last two papers return to the classical issues of localization and mapping in robotics under uncertainty. In the paper by Langerwisch and Wagner, the authors introduce a technique of solving localization errors with noisy sensors. Although the experimental results are given for an indoor scenario, the issue is extremely important for outdoor field robots and provides insights into extending the method in more unstructured environments. In the final paper, Manzoor and Muhammad perform a system theoretic observability analysis of the popular MonoSLAM algorithm in 2D. Many robotic systems replace binocular stereo vision with a kind of motion based stereo with single camera to solve the problem of Simultaneous localization and mapping (SLAM). This work clarifies why such a system works and under what conditions the introduction of a motion-stereo based disparity can improve SLAM performance. Both computer vision and control theory stand out as fundamental

analytical tools that underpin the development of robot algorithms described in this volume.

We are very thankful to our reviewers who provided an in-depth and thorough reviews of each book chapter. Besides members of RRLab and CYPHYNETS, special thanks to Dr. Khawaja Muhammad Umar Suleman and Dr. Yasir Niaz Khan at FAST-NUCES, Pakistan for their efforts in reviewing the book chapters. We are also thankful to speakers and participants of various WFAR workshops whose work did not appear in this book but who helped to increase the quality of these events and subsequently this volume.

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