Editorial

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Robotic systems for decontamination in hazardous environments

To boldly go where many still work today

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It is well known that robots are preferably used for tasks that are dull, dirty, or dangerous. A special area of dangerous tasks is decontamination where today people still do the majority of the work. For example, workers in protective gear clean parts of nuclear power plants with high-pressure cleaners during the dismantling process. Others work in externally ventilated excavator cabins while remediating contaminated landfill sites. The risk to human health becomes obvious during the salvage and handling of (potentially unknown) hazardous materials.

So what could be more obvious than sending decontamination robots into these hazardous environments to get humans out of the danger zone? What sounds like a good idea at first glance is not so simple in practice. Decontamination robots are faced with very special challenges: The operating environments are often highly unstructured or even unknown in advance and the manipulation tasks are very intricate. This means that, on the one hand, a high degree of flexibility and autonomy is required to support the operators, but on the other hand, the operators must also be able to work closely with the robot so that they can incorporate their expertise.

Many of the challenges mentioned are already part of active research work, but decontamination robots have not yet been able to establish themselves in practice. On the one hand, this is due to the fact that there are still functional gaps to be filled during the transition to practice, so that the robot systems can operate in tough 24/7 use. On the other hand, they do not yet appear economical to many users, or there is a lack of confidence in the performance of the systems or simply a lack of imagination for the future shape of existing work processes.

In order to accelerate the practical application of robots for decontamination tasks, the Federal Ministry of Education and Research (BMBF) has been funding the competence center "ROBDEKON – Robotic Systems for Decontamination in Hazardous Environments" within the scope of the German Federal Government's "Research for Civil Security" program. This application-oriented special issue provides a detailed insight into the research and development work and presents the results achieved at the end of the first funding phase.

The survey article "ROBDEKON – competence center for decontamination robotics" by Philipp Woock et al. provides an overview of the state of the art in decontamination robotics and briefly introduces the topics and the consortium of the ROBDEKON competence center.

The article "Grasping and retrieving unknown hazardous objects with a mobile manipulator" by Arne Roennau et al. presents a shared operation approach for the identification and localization of unknown hazardous objects as well as a 3D mapping approach for mobile robots.

In "Humanoid robotic system for grasping and manipulation in decontamination tasks" Christoph Pohl et al. present a fully autonomous decontamination setup with a humanoid robot that can manipulate unknown objects as a first important step for the decontamination of nuclear power plant parts.

The article "An autonomous crawler excavator for hazardous environments" by Christian Frese et al. describes the methods used and results obtained during the development of a technology demonstrator for remediation of contaminated landfills with focus on planning and control.

In "ARTER: A walking excavator robot for autonomous and remote operations" Ajish Babu et al. present their concept for converting a walking excavator into a robot and equipping it with autonomy capabilities for terrain-adaptive driving and manipulation.

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A universal human-machine interface for teleoperating of a broad range of decontamination robots of different types is provided by Michael Fennel et al. in “Intuitive and immersive teleoperation of robot manipulators for remote decontamination”.

The article “From environmental exploration to clearance measurement – developing mobile robot systems for decommissioning of nuclear power plants” by Ziyuan Chen et al. shows what a future robot-based process for decommissioning of building structures could look like.

In “Future control stations for heavy machinery” Steffen Planthaber et al. propose several concepts for teleoperating decontamination robots using different levels of abstraction and immersion.

Last but not least, the forum article “Contaminated site, abandoned mine, landfill Morgenstern” by Walter Schmotz et al. provides an inside look at a severely contaminated landfill site and the remediation-related issues and challenges faced by potential decontamination robots.

The contributions to this special issue illustrate very well the wide range of challenges that have to be solved in order to make decontamination robots suitable for practical use. This requires the entire range of relevant robotics expertise: In ROBDEKON, existing state-of-the-art algorithms have been applied and extended in the areas of autonomy, sensor fusion, localization and mapping, path and action planning, as well as control, and novel methods have been developed, e.g., in the area of manipulation, to close functionality gaps. The technology demonstrators described in this special issue are intended to provide a basis for future robotics solutions in the areas of remediation of landfills and contaminated sites, dismantling of nuclear facilities, and generally in the handling of hazardous materials. In this way, we hope to make our contribution to the restoration of a healthy environment – free from hazards for workers and citizens in general.

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