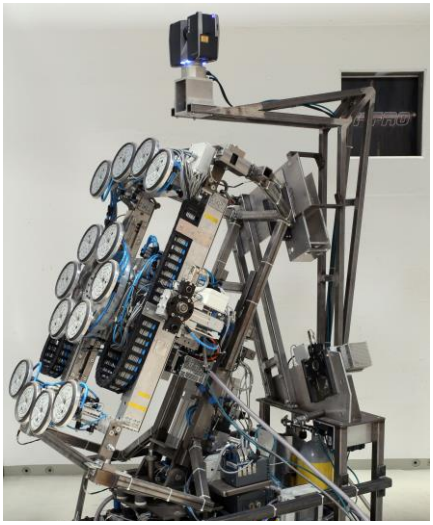
Robot Systems for Hostile Environments: Start of the ROBDEKON Competence Center

Federal Ministry of Education and Research Provides EUR 12 Million



The manipulator developed by KIT measures radioactive contamination of surfaces, decontaminates them, and measures again. (Photo: Patrick Kern, KIT)

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When remediating chemically contaminated areas or decommissioning nuclear facilities, workers are exposed to major health risks in spite of all precautions and protective equipment. In future, robot systems are to execute such decontamination work, while humans can stay away from the danger zone. In the new competence center "ROBDEKON," researchers of Karlsruhe Institute of Technology (KIT) are working on making this vision come true. The competence center is funded by the Federal Ministry of Education and Research (BMBF) with EUR 12 million.

ROBDEKON is the German acronym of robot systems for decontamination in hostile environments and is dedicated to studying autonomous or partly autonomous robot systems. It is coordinated by the Fraunhofer Institute of Optronics, System Technologies and Image Exploitation (IOSB). Among the research institutions involved apart from the Karlsruhe and Ilmenau branches of Fraunhofer IOSB are Karlsruhe Institute of Technology (KIT), the German Research Center for Artificial Intelligence (DFKI), and the FZI Research Center for Information Technology, the innovation partner of KIT. The industry

partners in the consortium are Götting KG, Kraftanlagen Heidelberg GmbH, ICP Ingenieurgesellschaft Professor Czurda and Partner mbH, and the KHG Kerntechnische Hilfsdienst GmbH.

ROBDEKON is the first competence center for robot systems in hostile environments. Funding by the BMBF under the "Research for Civil Security" program started in mid-July 2018. Initially, the competence center is planned for four years, long-term existence of the competence center, however, is envisaged.

Multi-sensory Environmental Monitoring and Movement Planning

"Our consortium combines outstanding expertise in the areas of robotics, remediation, and decommissioning of nuclear facilities," says the spokesperson of the ROBDEKON competence center, Professor Jürgen Beyerer. He is professor of informatics at KIT and Director of Fraunhofer IOSB. "We will now systematically push research into multi-sensory environmental monitoring, algorithms for movement planning, and telepresence technologies. Robots are to autonomously execute decontamination activities, while humans coordinate and supervise the work from a safe control room and interfere remotely in case of difficult tasks."

Beyerer explains that the robots used are neither classical industry robots nor humanoid robots. "We apply innovative concepts, such as climbing robots or automated construction machinery."

The project partners possess various, complementary labs that are planned to be extended, interconnected, and made accessible for external parties in the next years. With the help of users and industry partners, promising approaches will be transferred from research to systems suited for practice. The Fraunhofer IOSB will establish a ROBDEKON Coordinating Office for all inquiries relating to robot-based decontamination.

Fraunhofer IOSB: Toolbox of Algorithms and Autonomous Excavator

Within the competence center, Fraunhofer IOSB will concentrate on further developing the autonomy of construction machinery, an area where the institute has long-standing experience. "Within ROBDEKON, we will contribute our toolbox of algorithms for autonomous mobile robot systems," says the responsible Department Head Christian Frey. "These algorithms are used navigate in rough terrain, avoid

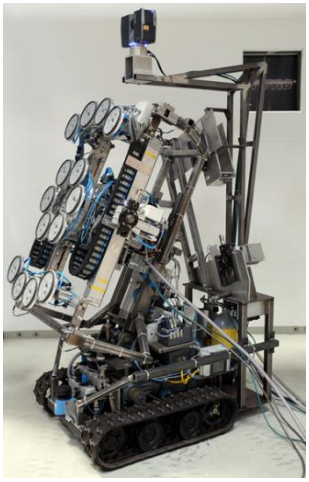
The aluminum box on the roof replaces the human driver in the cabin: the autonomous excavator "IOSB.BoB" of Fraunhofer IOSB (top). Perception of the terrain to be cleaned (bottom). (Photo: © Fraunhofer IOSB)

obstacles, and control manipulators, e.g. for an excavator shovel to take up contaminated material and unload it at the desired location."

The institute already possesses several all-terrain robot vehicles and a first automated excavator. Christian Frey: "Now, we have to transfer these autonomous skills to other machines to make them even more flexible, to enhance their performance, and to facilitate handling."

KIT: Decontamination, Telepresence, and Living Lab

Work at KIT will focus on robot systems to autonomously or semi-autonomously carry out decontamination work, e.g. at nuclear power plants. Scientists of the Chair of High-performance Humanoid Technologies (H^2T) and the Intelligent Process Automation and Robotics Lab (IPR) design and build robot systems to clean or disassemble radioactively, biologically or chemically contaminated surfaces or system components. This includes the development of methods for three-dimensional environmental monitoring, for the inspection of the environment as well as for planning and executing the decontamination of objects or areas, and not least the programming of the corresponding control software.



The manipulator developed by KIT's TMB and IPR measures radioactive contamination of surfaces, decontaminates them, and measures them again for eventual release of the contaminated areas. (Photo: Patrick Kern, KIT).

Monitoring and control of these systems will be based on telepresence techniques developed by the Chair of Intelligent Sensor-actuator Systems (ISAS). A so-called teleoperator, e.g. a robot, replaces the user in remote hostile environments, if applicable. This teleoperator reproduces head movements of the user and then transmits the corresponding camera images. In addition, ISAS studies methods to measure and visualize the distribution and intensity of pollution or contamination to enhance the efficiency of operation.

At the Institute for Technology and Management in Construction (TMB), a living lab will be established, in which the robots will be tested in various realistic environments and optimized for work in nuclear power plants. In addition, TMB works on a special robot that checks concrete surfaces for hazardous contamination, identifies the contamination, and removes it. In a final step, scientists study how the new methods and systems can be applied on landfills or contaminated areas in practice.

The FZI robot Lauron can walk through rough terrain, identify and assess risks, and deliberately take them depending on the potential use. (Photo: FZI)

FZI: Force-based Handing of Hazardous Substances and Augmented Reality

Within the ROBDEKON competence center, the FZI Research Center for Information Technology will develop force-based manipulation strategies for mobile robots. These robots will be able to semi- or fully

autonomously support humans in rough terrain and in handling unknown objects during decommissioning, release measurement or recovery of contaminated objects. FZI scientist Arne Rönnau says: “The FZI has long-standing expertise in the development of force-based robotics solutions. We are happy to contribute this know-how to the ROBDEKON competence center and to increase safety of people carrying out risky work.”

The FZI package also includes detailed three-dimensional mapping of the environment and the integration of efficient navigation algorithms. Another task of FZI is the development of intuitive, clear operation concepts for human-robot interaction. The scientists will use new augmented reality and virtual reality systems for the direct integration of important environmental information into three-dimensional representations.

DFKI: Robots for Extreme Environments and Hybrid Teams

Within ROBDEKON, the Robotics Innovation Center of the German Research Center for Artificial Intelligence (DFKI) headed by Professor Frank Kirchner will share its long-standing expertise in the development of mobile autonomous robots for use in hostile and extreme environments, such as space or the deep sea. Robots used in decontaminated areas have to meet very similar requirements, in particular in terms of mobility, robustness, and capability of learning (artificial intelligence).

The DFKI research group possesses vast competence in machine learning, teleoperation, and human-robot collaboration that will help ensure safe cooperation of humans and robots in hybrid teams during decommissioning and decontamination. Within ROBDEKON, the Robotics Innovation Center will further develop novel robot systems having the capabilities required for these complex operations.

Mobile autonomous robot system of the DFKI Robotics Innovation Center. (Photo: © DFKI GmbH)

Telepresence and control room at the DFKI Robotics Innovation Center. (Photo: © DFKI GmbH)

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