Nuclear power stations could be decommissioned with the help of autonomous robots

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Credit: University of Glasgow

Nuclear power stations could be decommissioned in the future with the help of teams of autonomous robots known as the SMuRFs, scientists

have suggested.

Engineers from University of Glasgow, University of Manchester, Bristol Robotics Laboratory and Heriot-Watt University are behind the development of the SMuRF system, which is short for Symbiotic Multi-Robot Fleet.

The system provides a seamless method to enable wheeled, four-legged and airborne robots to collaborate and complete tasks that could be difficult or harmful for humans to undertake on their own.

Instead, a single human supervisor can remotely observe the actions of the robots as they share sensor data between themselves, combining their abilities to achieve results far beyond the reach of a single machine.

SMuRFs could offer authorities, regulators and industry a safer, faster method of monitoring nuclear facilities, as well as opening up new opportunities for the maintenance of engineering infrastructure in challenging environments like offshore wind power platforms.

In a new paper titled "Lessons Learned: Symbiotic Autonomous Robot Ecosystem for Nuclear Environments," and published in the journal *IET Cyber-Systems and Robotics*, the researchers outline how they deployed the SMuRF in a practical demonstration at the Robotics and Artificial Intelligence Collaboration (RAICo) facility in Cumbria.

RAICo is a collaboration between the UK Atomic Energy Authority (UKAEA), Nuclear Decommissioning Authority (NDA), Sellafield Ltd and the University of Manchester.

During the demonstration, the SMuRF successfully completed an inspection mission in a simulated radioactive storage facility containing some of the challenges found in real nuclear power decommissioning

environments.

The robots' ability to collaborate is the result of a sophisticated computer system developed by the researchers, which they call a 'cyber physical system or CPS.

The CPS is capable of communicating with up to 1,600 sensors, robots and other digital and physical assets in near to real-time. It also allows robots with very different abilities and operating systems to work together and most importantly, update the human operator.

The data collected and processed by the CPS enables the creation of a 3D digital twin of a real space. That allows the SMuRF to navigate around the space and carry out tasks with minimal oversight, while providing human operators with a wealth of data via a specially designed digital dashboard to help the SMuRF make informed decisions if required. Human operators can also take direct control of the robots if they need to.

Combining the robots' abilities allowed them to complete a series of tasks often applied to radiation monitoring around nuclear sites known as post-operational cleanout.

The robots collaborated to map the environment, creating a 3D digital twin of the space using their onboard sensors, which was supported by further mapping from an aerial drone piloted by a human operator.

Boston Dynamics' Spot fetched tools for closer scans using its flexible arm, while wheeled robots Scout and CARMA mapped radiation levels across the testing environment. The CARMA robot successfully detected a simulated spill of radioactive liquid underneath a waste barrel, a detection that could help ensure proper containment and cleanup in a real-world environment.

Daniel Mitchell of the University of Glasgow's James Watt School of Engineering is the paper's corresponding author. He was recently named as the Institution of Engineering and Technology's Rising Star 2023 in recognition of the impact of his research.

He said, "The robots we programmed and designed in this prototype SMuRF each have their own unique abilities and limitations, as well as their own operating systems.

"During the deployment of the SMuRF at RAICo, we were able to show how well the robots can work together and how the digital twin we built can provide remarkable situational awareness for human operators.

"That could make them ideally-suited for the challenges of working in potentially hazardous environments such nuclear inspection and decommissioning.

"Humans will still be required to oversee and direct the robot fleet, but their high level of autonomy could help keep people safe by allowing them to interact with the robots from their desks instead of visiting work sites."

David Flynn, Professor in Cyber Physical Systems at the University of Glasgow, is a co-author of the paper. Professor Flynn added, "These kinds of autonomous robotic fleets have a great deal of potential to undertake a wide range of dangerous, dirty, dull, distant and dear jobs.

"In addition to work in the nuclear sector, there's tremendous additional potential in sectors like offshore power generation, where SMuRFs could handle many routine inspection and repair tasks. Currently, these tasks are expensive because they often require staff to be helicoptered out to offshore sites, a process which can be hampered by bad weather.

"However, they are critically important to preventing downtime and ensuring a steady flow of power to the grid. Having a robot crew permanently on-site to carry out these routine tasks would maximize the potential of all kinds of renewable energy platforms.

"The next step for our research is to integrate a wider range of robots in our fleets, with even more diverse abilities to sense their surroundings, move through them in new ways, and manipulate objects."

Dr. Paul Baniqued of the University of Manchester said, "The digital architecture was inspired by the fleet management system, as seen in strategic video games, which depicts individual members of the SMuRF operating simultaneously in the digital twin environment. This allows the human operator to focus their attention on a single interface, enabling a better understanding of the task at hand."

More information: Daniel Mitchell et al, Lessons Learned: Symbiotic Autonomous Robot Ecosystem for Nuclear Environments, *IET Cyber-Systems and Robotics* (2023). doi.org/10.1049/csy2.12103

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