Robotics

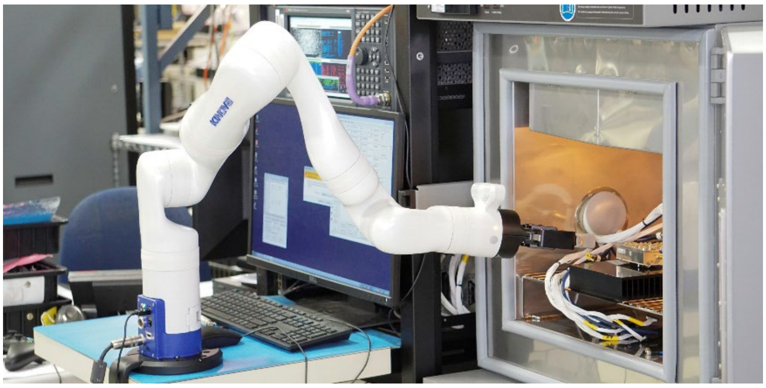
Theme Summary

Due to the hazardous nature of nuclear materials, it is often difficult and time-consuming for human workers to carry out certain tasks. Using robots to automate processes reduces the chance of human error and also the need for excessive conservatism, therefore allowing operators to interact with radioactive environments more safely and efficiently.

Whilst having the appropriate operating platform is important, the complementary data collection systems are equally necessary for time and cost savings to be realised.

Key research areas in this theme are:

- Remote inspection and characterisation – radioactive source localisation
- Autonomous systems
- Waste handling and cell decommissioning
- Safety & verifiability
- Underwater interventions
- Site monitoring – radiation mapping using UAVs and UGVs and novel sensors



Credit: Kinova

Theme Leads

Professor Manuel Giuliani, Co-Director Bristol Robotics Laboratory, University of the West of England
Contact: manuel.giuliani@brl.ac.uk
Manuel's research is focused on human-robot interaction, teleoperation of robots in nuclear facilities, teleoperated sort and segregation of nuclear waste, mapping of nuclear facilities using mobile robots, VR-based interfaces for robot operators.

Professor Tom Scott, NNUF Hot Robotics Director, University of Bristol
Contact: t.b.scott@bristol.ac.uk
Tom's research in robotics is focused on remote inspection and characterisation of irradiated materials, waste handling, and UAV-based site monitoring of hazardous environments.

Research Capabilities and Facilities

Remote Autonomous Inspection and Handling

Key academics: Prof. Manuel Giuliani, Prof. Tony Pipe, Dr Antonia Tzemanaki, Dr Paul Bremer (Bristol Robotics Laboratory)

Research in this area focuses on creating the provision of the robotics and autonomous systems technology required for the safe dismantling of all of the nuclear assets that are currently scheduled for decommissioning in the UK.
Whilst robotic systems offer long-term cost, time and safety savings, current technology still requires development for functional tasks such as gripping objects or turning valves. Furthermore, systems needing an operator still can result in human error, and incur labour costs as well as the technology costs.

Capability is in the development of novel interfaces for humans who interact and tele-operate robots in nuclear environments, and methods for variable autonomy and shared control in this context. This will enable the step-change required to see these methods become industry-standard and deliver the significant cost, efficiency and safety improvements.

Radioactive Source Localisation and Segregation

Key academics: Prof. Tom Scott, Prof. Tom Richardson, Dr Peter Martin, Dr Dave Megson-Smith (University of Bristol)

Nuclear waste is usually classified according to its peak radioactivity, which is often concentrated in a highly localised contaminated area. Therefore, to make the sort and segregation of waste more efficient, the use of a robot can deliver accurate localisation and quantification of radiation, to ensure that the materials are classified into the correct waste level. This means only the segments of waste that actually are highly radioactive need to be treated as such, thereby minimising legacy storage and handling costs.

Associated data collection and analysis techniques are required to inform the process; one such method, a Projective Linear Reconstruction algorithm, can successfully locate a series of radiological sources to within 2cm of the true locations.

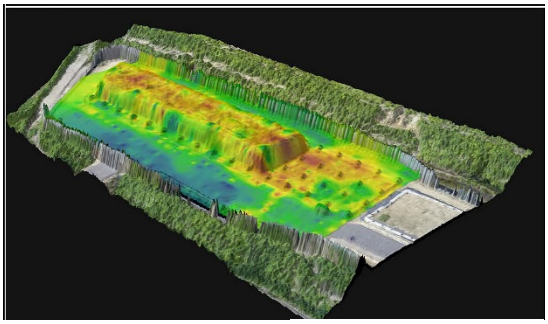
Case Study – Remote-operated nuclear materials sort and segregation

A KUKA LBR iiwa robotic manipulator was equipped with an Intel RealSense LiDAR depth camera to generate a 3D visualisation of a scene involving both active and non-active sources. This information allowed a gripper connected to the arm to autonomously pick up objects and present them to a gamma spectrometer unit where they could b radiometrically characterised.

By integrating detection and classification technologies, the system can more accurately identify low (LLW), intermediate (ILW) and high-level (HLW) waste materials and segregate them accordingly.

Site monitoring and characterisation

Key academics: Prof. Tom Scott, Prof. Tom Richardson, Dr Peter Martin, Dr Dean Connor



Credit: Dr Dean Connor

Nuclear sites requiring characterisation are often large, topographically challenging and have access restrictions. In addition, high levels of radiation make it difficult or impossible for humans to enter areas to conduct characterisation surveys.

University of Bristol researchers have developed several platforms and systems to conduct faster and more accurate radiation surveys using UAVs, UGVs and other autonomous vehicles. These allow detailed information to be gathered on a contaminated area from distance, and be streamed live in real-time to operators positioned in a safe zone.

Research has developed and refined a payload including: a miniaturised gamma-ray spectrometer, GPS receiver, distance ranging LiDAR and associated control electronics, that combines radiation and position data for high resolution, multi-level mapping of radiation levels.

Case Study - radiation mapping in the Chernobyl Exclusion Zone
University of Bristol researchers have deployed various UAV and UGV systems in the Chernobyl Exclusion Zone, augmenting off-the-shelf robotic platforms with radiation detection and monitoring equipment. This includes multi-rotor and fixed-wing UAVs, a Boston Dynamics quadraped, and other autonomous ground vehicles to support decommissioning and emergency response activities in Ukraine.

Facilities

Bristol Robotics Laboratory

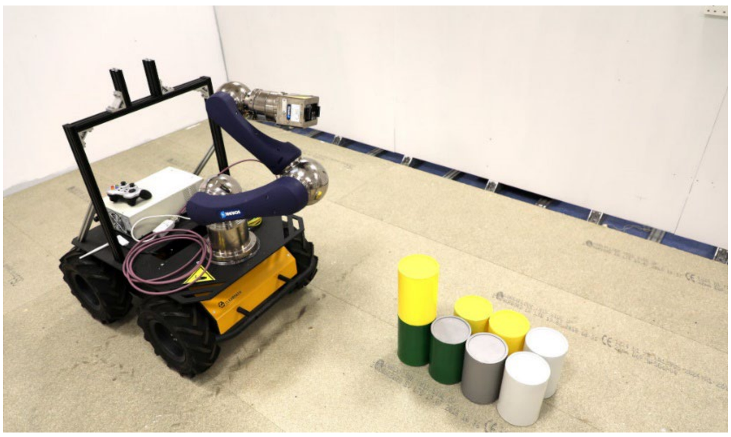
Key academics: Professor Manuel Giuliani, Professor Tony Pipe, Dr Antonia Tzemanaki, Dr Paul Bremer

Bristol Robotics Laboratory (BRL) is the most comprehensive academic centre for Robotics in the UK. It comprises of a community of over 450 academics, researchers and industry practitioners. BRL is also a partner in national research programmes such as the National Centre for Nuclear Robotics (NCNR) and Robots for Nuclear Environments (RNE).

BRL houses an experimental test bed for nuclear robotics. The test bed is a 64m² simulated nuclear facility that acts as test bed for technical developments and user studies. It consists of a separate 'room in a room' that can be completely closed so that one cannot see inside from the outside, similar to a real nuclear facility. The closed room is equipped with four network cameras to allow supervision of experiments.

In front of the closed room there are three desk working spaces equipped with powerful workstations to support immersive VR-based tele-operation. The room is equipped with two industrial robot arms. The robot arms are used for an immersive remote tele-operation setup in which an operator controls the remote robot arm using the local robot arm. There are also available two industrial grade Ensenso RGB-D depth cameras, two stereo cameras, and a range of infrared and LIDAR sensors.

BRL also has a range of robot grippers that are available for research in autonomous handling of nuclear waste. The test bed also contains a simulated nuclear waste storage facility that is patrolled by a multi-robot team. The robot teams consist of a Husky robot platform with mounted Schunk robot arm, four smaller Turtlebot 3 robots, and two bigger Turtlebot 3 Waffle robots.



The Clearpath Husky robot platform

Contact: enquiries@southwestnuclearhub.ac.uk

National Nuclear User Facility for Hot Robotics

hot-robotics.co.uk
Contact: nnuf-hr@bristol.ac.uk

The National Nuclear User Facility for Hot Robotics offers UK academia and industry access to cutting-edge equipment for research in robotics and artificial intelligence for application in extreme and challenging nuclear environments.

The University of Bristol's Fenswood Facility (one of four national facilities in this project) offers 245 acres of space for developing mobile robotic applications and test deployments. It specialises in UAVs and mobile ground vehicles as enhanced tools for environmental field surveying.

The equipment and facility is split between a new mezzanine and the robot barn research spaces, available for internal and external users. The facility also includes a kitchen/meeting area for hot-desking and group meeting space.

UAV equipment available includes DJI Matrice 100 and 600 (pictured below right), DJI Mavic 2 and Pro, a Wingtra One and a Baby Shark VTOL plane fixed-wing UAV. These can be combined with sensor equipment such as SIGMA50 Scintillation Spectromter, GR1+ Gamma-Ray Spectrometer or a Velodyne Puck.

Ground robots, or UGVs, include the Unitree A1 Robot Dog (pictured below left), Leo Rover, and a Superdroid HD2 treaded robot.

Credit: Unitree Robotics

A funded User Access Scheme is available to allow any UK-based university researcher to apply to access facilities affiliated with NNUF. The facilities are free at the point of access for successful applicants under this scheme. Application rounds for access are run quarterly and will be reviewed by the NNUF Management Group, and accepted on the basis of scientific merit. Industrial users can also apply to the User Access Scheme in collaboration with a researcher from a UK University, or apply directly to the Hot Robotics facility to discuss requirements.

Find out more: hot-robotics.co.uk