ANIMMA 2021
Prague, Czech Republic
June 21-25, 2021

Contribution ID: **169**

Type: **Oral presentation**

#08-169 Radiation Detection Instruments Ideally Suited for Robotic Autonomy and a Novel Approach to Reduce Collimator Field-of-View

Tuesday, June 22, 2021 2:20 PM (20 minutes)

There are many applications in nuclear environments that benefit from the use of robotics, such as the response to accidents, decommissioning and routine monitoring. Robots have some advantages over humans in the aforementioned contexts, for example: they are often better at repetitive tasks or working in confined spaces. Such situations in nuclear environments can also present a radiological or chemical risk, which can be mitigated by deploying robots in the place of people. As the needs of the situation can be very diverse, the robots available match this with a multitude of shapes and methods of locomotion, wheeled, tracked, aerial, submersible etc. To navigate their environment, robots are equipped with sensors, which can be optical and infrared cameras or Light Detection And Ranging (LiDAR), for example. Radiation detection instruments are almost essential when operating in a nuclear environment, as they can provide valuable information when decommissioning or responding to an accident. When these are combined with a tether-less robot with a degree of autonomy, more complex tasks can be undertaken. Robotics in nuclear environments have already demonstrated significant use: e.g., submersible use at Sellafield, aerial mapping over the Chernobyl Red Forest and tracked robot deployment at the CEA etc. Unfortunately, radiation instruments are seldom designed to fit within the strict limits for robot use, such as power, weight, size and operation by onboard computer. Along with improvements in hardware, there is a wealth of opportunity for better onboard data analysis going beyond mapping count-rate data.

This paper will report on the testing and deployment of two γ-ray detectors adapted for robotics and a novel data analysis method for reducing the Field-of-View (FOV) of collimation. One of the detectors is a 10-mm cubic $CeBr_3$ scintillator with photomultiplier tube (PMT), paired with a Red Pitaya STEMlab 125-14 which is repurposed as a multichannel analyser (MCA). The second detector is a combination of NaI:Tl with a PMT and a Brightspec bMCA MCA. These were selected as they are capable of spectroscopy, compact and well suited to a variety of robot platforms and applications. The associated software for them has been adapted and written to fit a number of criteria, these are: to use a widely adopted robot middleware, minimal performance loss on the robot and negligible additional work for the operator. The robot middleware used is the Robot Operating System as it is used by the robots in the collaboration. Both detector setups have been tested in a laboratory and demonstrated excellent performance, for example, achieving 5.4% and 8% resolution for $CeBr_3$ and NaI:Tl respectively when counting ^{137}Cs.

The detectors underwent preliminary field-testing at a low-level waste (LLW) drum store using a Clearpath™ Husky robot in a routine monitoring application. During field-testing, the $CeBr_3$ detector was placed inside a thin-walled collimator and mounted onto the Pan-Tilt Unit on the robot to be able to point around the environment. The NaI:Tl detector was mounted in a fixed location without collimation. Field-testing was successful in satisfying the above criteria, and the preliminary data from the $CeBr_3$ detector was combined with LiDAR. This combination was used to overlay the radiation data onto the 3D LiDAR map to highlight the activity of the adjacent drum.

For γ-ray detectors to be able to localise a source of radiation it is usually necessary for them to be surrounded by a dense material such as lead or tungsten. Producing a narrow FOV collimator means adding additional dense material to reduce the angular magnification, but this increases the mass of the system significantly. This increase in mass is a particular problem if the collimator is mounted to a Pan-Tilt Unit, which often have limited payload restrictions. An alternative technique has been developed here which processes the output from the barrel collimated detector by fitting it to a transform function, to test the hypothesis that this approach can aid source location. The arrangement is a 2-mm lead barrel collimator, the detector being panned

over a single γ-ray point source. The detector is panned incrementally using only a single dimension as a proof-of-concept for the technique. This method relies on the response of the transform function of a step input, with the accumulated counts at each increment fitted to this response. The transform is then applied in reverse, to recover the response (now being a step), revealing the location of the point-source in the data. Preliminary results demonstrate that the transform technique is successful. This is currently being tested using a collimator with ~90° FOV and a point-source at 0.5 m.

Primary authors: ALTON, Tilly (Lancaster University, UK); Prof. JOYCE , Malcolm J. (Lancaster University, UK)

Presenter: ALTON, Tilly (Lancaster University, UK)

Session Classification: 08 Decommissioning, Dismantling and Remote Handling

Track Classification: 08 Decommissioning, Dismantling and Remote Handling