Gamma-Ray Raster Imaging with Robotic Data Collection

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Abstract

Currently, in order to create gamma-ray images, some form of collimation is required. The foremost imaging techniques either require physical collimation (such as the heavy shielding required for a pinhole imager) or restrictive algorithms (such as event reconstruction for a Compton imager). In addition, physically collimated approaches (pinhole or coded aperture) result in a limited field of view. This project has developed an alternative imaging capability for characterizing and imaging radioactive materials in situ. This approach uses a robotic-mounted gamma-ray detector which can move around an area of interest, sampling the space at an extremely high frequency. By rastering across the gamma-ray field, an image can be created with no physical collimation and a high efficiency. The detector was calibrated in three dimensions as a function of energy, distance, and angle. A Bayesian particle filter was implemented to localize and quantify a radioactive source in a search arena. An informative path planning algorithm was also developed to guide the robot's search path to obtain more accurate information on the source. The system has been tested using small lab sources. The use of a robotic mount allows data collection for long periods of time unattended, and it will also eliminate uncertainties in positioning typically introduced by personnel. This approach will be particularly relevant for gloveboxes, shielded cells, or process piping which may have complex, non-uniform distributions of material.

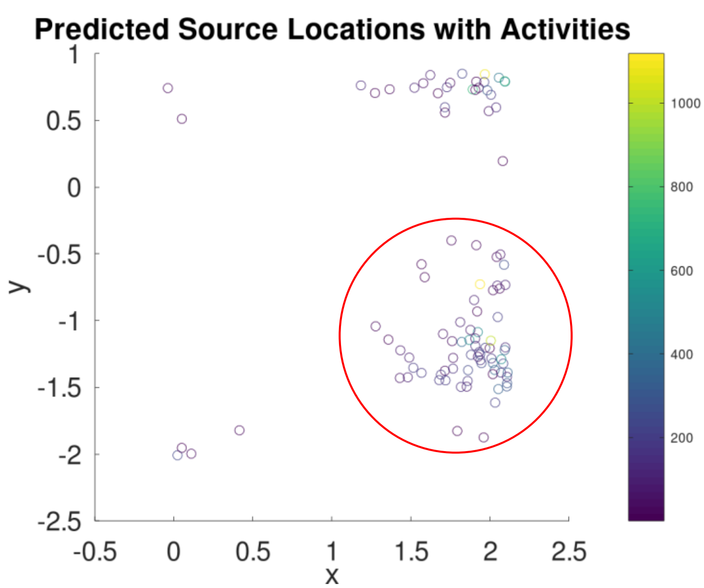

Figure 1: Distribution of most likely predicted source locations from 140 runs of particle filter algorithm.

The mean (μ ± 1σ) of the x and y-coordinates are: 1.76 ± 0.437 meters and -0.809 ± 0.851 meters.

Focusing on the highlighted cluster localized around (2 m, -1 m), the mean x and y positions, respectively, are: 1.86 ± 0.210 meters and -1.19 ± 0.296 meters

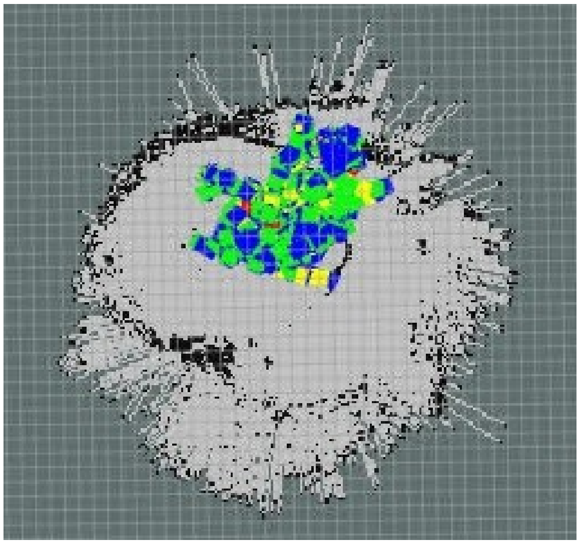

Figure 2: Raster image with a single source.

Figure 3: Experiment setup with 2 sources.

TechConnect Briefs 2021, TechConnect.org, ISBN 978-0-578-99550-2