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A Framework for Automated Nuclear Waste Classification

Authors : Seonaid Hume, Gordon Dobie, Graeme West

Abstract : Detecting and localizing radioactive sources is a necessity for safe and secure decommissioning of nuclear facilities. An important aspect for the management of the sort-and-segregation process is establishing the spatial distributions and quantities of the waste radionuclides, their type, corresponding activity, and ultimately classification for disposal. The data received from surveys directly informs decommissioning plans, on-site incident management strategies, the approach needed for a new cell, as well as protecting the workforce and the public. Manual classification of nuclear waste from a nuclear cell is time-consuming, expensive, and requires significant expertise to make the classification judgment call. Also, in-cell decommissioning is still in its relative infancy, and few techniques are well-developed. As with any repetitive and routine tasks, there is the opportunity to improve the task of classifying nuclear waste using autonomous systems. Hence, this paper proposes a new framework for the automatic classification of nuclear waste. This framework consists of five main stages; 3D spatial mapping and object detection, object classification, radiological mapping, source localisation based on gathered evidence and finally, waste classification. The first stage of the framework, 3D visual mapping, involves object detection from point cloud data. A review of related applications in other industries is provided, and recommendations for approaches for waste classification are made. Object detection focusses initially on cylindrical objects since pipework is significant in nuclear cells and indeed any industrial site. The approach can be extended to other commonly occurring primitives such as spheres and cubes. This is in preparation of stage two, characterizing the point cloud data and estimating the dimensions, material, degradation, and mass of the objects detected in order to feature match them to an inventory of possible items found in that nuclear cell. Many items in nuclear cells are one-offs, have limited or poor drawings available, or have been modified since installation, and have complex interiors, which often and inadvertently pose difficulties when accessing certain zones and identifying waste remotely. Hence, this may require expert input to feature match objects. The third stage, radiological mapping, is similar in order to facilitate the characterization of the nuclear cell in terms of radiation fields, including the type of radiation, activity, and location within the nuclear cell. The fourth stage of the framework takes the visual map for stage 1, the object characterization from stage 2, and radiation map from stage 3 and fuses them together, providing a more detailed scene of the nuclear cell by identifying the location of radioactive materials in three dimensions. The last stage involves combining the evidence from the fused data sets to reveal the classification of the waste in Bq/kg, thus enabling better decision making and monitoring for in-cell decommissioning. The presentation of the framework is supported by representative case study data drawn from an application in decommissioning from a UK nuclear facility. This framework utilises recent advancements of the detection and mapping capabilities of complex radiation fields in three dimensions to make the process of classifying nuclear waste faster, more reliable, cost-effective and safer.

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