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R&D Project Proposal

Development of a framework for the localization of radioactive sources and evaluation methods

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1 Introduction

1.1 Topic of This R&D Project

- Radioactivity in a inevitable factor of life, and it is said that without radioactivity, life wouldnt be possible. The naturally occuring radioactivity heated up the earths core and there by leading to life.[**?**]
- Since Henri Becquerel and discovered Radioactivity in 1896, the field has progressed alot further and it has become an important part of how the modern world ticks.
- Radioactivity is the process in which the radioactive atom trying to reach stability by ejecting particles, or by releasing energy in other forms.
- The Radioactive materials can be misused for malicious purposes, either by using it as a weapon or by using it to contaminate the environment.
- Because of its potential for misuse and the potential for harm, it is important to find the radioactive sources and to secure them in case of contamination.
- While this approach has been explored in the past, the current methods are computationally expensive, and it needs the searching of the full area to localize the source, thereby making it efficient enough to detect the radioactive sources in a timely manner.
- The purpose of this project is to explore the methods to localize the radioactive sources and improving the localization and path planning of UAV, to develop a framework for simulating the radioactive sources realistically, and to evaluate the methods to provide a comparative evaluation of the methods.
- While there are challenges of the developing this project mostly through simulations as testing with real radioactive source is difficult to setup, the project aims to explore well established and new methods to provide a comparative evaluation of the methods.
- There also exist challenges to handle the particle attenuation and scattering, which would make the approach to the source difficult.

1.2 Relevance of This R&D Project

This Research and Developement project holds relevance due to the following reasons:

- The results of this project will be beneficial to the security agencies and the law enforcement agencies to detect the radioactive sources in a timely manner.
- This localization of the radioactive sources can be useful to the nuclear power plants to detect the leakages in the reactor.
- Localizing the the radioactive sources prevent the contamination of the environment and the food chain.
- Since 1993, there has been 4243 confirmed incidents of radioactive materials being lost or stolen, in this 52% occured during authorised transports. [**?**]
- It is also worth noting that 87% of the theft incidents for malicious intents remain undetected. [**?**]
- Therefore, the necessity for a tool that helps to source the radioactive materials is of utmost importance.
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2 Related Work

2.1 Survey of Related Work

- There has been a lot of studies and developments in the field of localization of naturally occuring sources and works towards

2.2 Limitation and Deficits in the State of the Art

3 Problem Statement

The problem of source localization involves estimating the location and intensity of an unknown source in an environment using sensor measurements and prior information. The key aspects of the problem and the approach to solve it are outlined below:

- This project aims to solve the following deficits of the existing approaches:
  - Addressing the challenge of sensor noise and uncertainty in measurements.
  - Improving the efficiency of localization in environments with limited sensor coverage.
  - Reducing the computational complexity of localization algorithms for large-scale environments.
  - Handling dynamic environments where sources or sensors may be mobile.
  - Managing the complexity introduced by multiple sources with different characteristics.
- The approach to solve the problem involves the following considerations:
  - Implementing and evaluating rollout algorithms that use Monte Carlo simulations and heuristic search techniques.
  - Utilizing entropy-based algorithms to minimize uncertainty in source location estimates by maximizing information gain from new measurements.
  - Applying Bayesian inference methods, such as particle filters and Markov Chain Monte Carlo (MCMC) techniques, to estimate the posterior distribution of source locations.
  - Exploring hybrid approaches that combine machine learning for initial source localization with optimization-based methods to refine estimates.
- The comparison of the proposed approach with existing methods will involve the following steps:

- Benchmarking the performance of the implemented algorithms against standard datasets and scenarios.
- Evaluating the accuracy and efficiency of each method in different environmental conditions and configurations.
- Comparing computational complexity and resource consumption of each approach.
- Analyzing the robustness of the approaches in handling sensor noise, limited coverage, dynamic environments, and multiple sources.

4 Project Plan

4.1 Work Packages

Planning is the replacement of randomness by error. (Einstein). Very much like you would never start a longer journey without a detailed travel plan, you should not start a project without a carefully though out work plan. A work package is a logical decomposition of a larger piece of work into smaller parts following a "divide and conquer" strategy. It is very specific to the problem that you are going to address. Refrain from a rather generic decomposition. If your work plan looks similar to those of your school mates, which may address completely different problems then you have not thought carefully enough about how you approach the problem. It is ok to have two generic work packages *Literature Study* and *Project Report*. Discuss your work packages in the ASW seminar.

The bare minimum will include the following packages:

WP1 Literature Study

WP2 Method Selection

WP3 Simulation Framework

WP4 Implementation and Experimentation

WPy Evaluation and Comparison of the implemented approaches

WPz Project Report

4.2 Milestones

Milestones mark the completion of a certain activity or at least a major achievement in an activity. Milestones are also decision points, where you reflect on what you have achieved and what options you have for continuing your work in case you have not achieved what was planned. Above all, milestones have to be measurable. As above, if your milestones are the same as those of your school mates, then you may not have thought carefully enough about how your project shall progress.

The following milestone are considered to achieve a planned and strategic approach towards the completion of the project:

M1 Completing litertaure survey

M2 Selecting the approaches to be followed

M3 Completing the implementation of simulation framework

M4 Completing the implementation of the selection methods

M5 Evaluation of the methods

M6 Final Submission

4.3 Project Schedule

Include a Gantt chart here. It doesn't have to be detailed, but it should include the milestones you mentioned above. Make sure to include the writing of your report throughout the whole project, not just at the end.

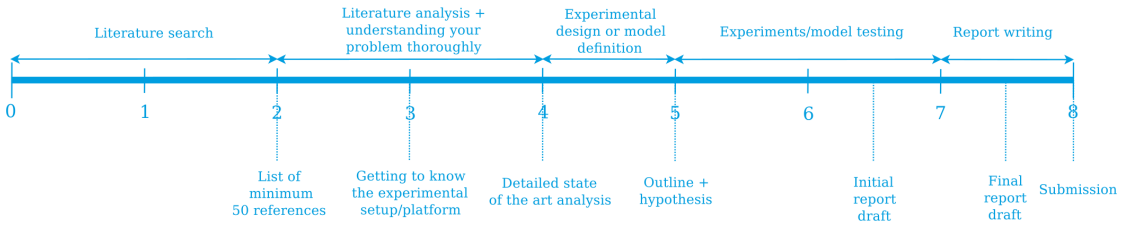

Figure 1: My figure caption

4.4 Deliverables

Minimum Viable

- Framework for simulated movement and measurement data
- Interface for the evaluation of methods

Expected

- Literature research of methods used for localization
- Implementation of 2-3 localization methods

Desired

- Add different sensor behaviours
- Evaluation of all implemented methods

Please note that the final grade will not only depend on the results obtained in your work, but also on how you present the results.