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

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Introduction

- Radioactivity is a fundamental aspect of life, essential for heating the Earth's core and enabling life to develop.
- Discovered by Henri Becquerel in 1896, radioactivity has advanced significantly and is crucial to modern society. [5]
- Radioactivity involves atoms seeking stability by emitting particles or energy.
- Radioactive materials can be misused for harmful purposes, necessitating detection and securing to prevent contamination.
- Project Focus: Identify a method or combination of methods that will efficiently and accurately localize radioactive sources with minimal computational cost and also without the need for exploring the full search space.

Relevance of the topic

- The results of this project will be beneficial to the security agencies and 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 radioactive sources prevents the contamination of the environment and the food chain.

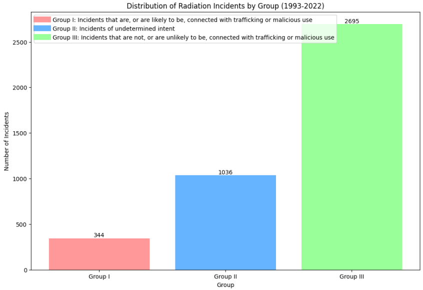

Figure 1: Incidents of Radioactive Material Loss or Theft from a total of 4243 incidents since 1993. [3]

Related works

- Dual-Stage Planner for Autonomous Radioactive Source Localization in Unknown Environments [8]
  - Two-stage process: Source Tracking and Relocation.
  - Utilizes convex polyhedrons for complex environments.
  - High success rate with fewer measurements.
- Adaptive Bayesian Sensor Motion Planning for Hazardous Source Term Reconstruction [2]
  - Uses Markov Chain Monte Carlo for source parameter estimation.
  - Selects maneuvers based on maximum entropy sampling.
- Airborne Radiation Mapping: Overview and Application of Current and Future Aerial Systems [1]
  - Utilizes UAVs for rapid area mapping.
  - Effective for radiation detection from aerial platforms.

Related works: continued

- Particle Filter Based Information-Theoretic Active Sensing [4]
  - Employs particle filters for estimating target locations.
  - Minimizes entropy over a receding horizon.
- Detection and Localization of Hidden Radioactive Sources with Spatial Statistical Method [6]
  - Uses spatial statistical methods and Poisson distribution models.
  - Effective in various environmental conditions.
- Path Planning Algorithm Ensuring Accurate Localization of Radiation Sources [7]
  - Combines UAV and UGV for fast mapping and accurate localization.
  - Uses Generalized Travelling Salesman Problem (GTSP) solver.
  - Minimizes total path length while ensuring accurate source localization.

Deficiencies of the current approaches

- High Computational Cost and scalability: Many methods require significant computational resources, challenging real-time applications and not easily scalable to large environments.
- Hardware Limitations: UAV-based methods are constrained by battery life, weather conditions, and hardware capabilities.
- Real-Time Applicability: Achieving real-time performance while maintaining accuracy and reliability is a common challenge across many methods.
- Exploring full search space: Many methods explore the full search space, leading to high exploration time and cost.

Proposed approach

- Enhance localization and path planning for UAVs to detect radioactive sources.
- Develop simulation and evaluation framework for radioactive sources.
- Evaluate and compare different methods for radioactive source localization.
- Address challenges such as particle attenuation and scattering in detection methods.

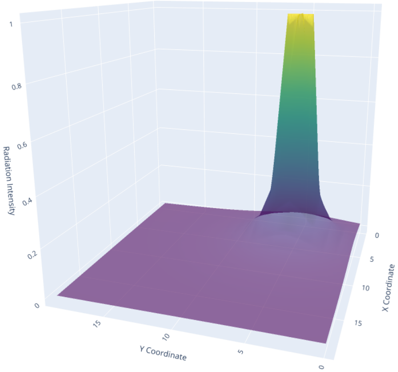

Figure 2: Single source radiation distribution in an environment

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