Title	UAVを用いた放射能汚染地図作製と汚染源位置推定
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Citation	
Issue Date	2017-03
Type	Thesis or Dissertation
Text version	ETD
URL	http://hdl.handle.net/10119/14241
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学 位 の 種 類	博士(情報科学)			
学 位 記 番 号	博情第 355 号			
学位授与年月日	平成 29 年 3 月 24 日			
論 文 題 目	UAV-based Topographic Mapping and Source Localization of the Radiation Field			
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論文の内容の要旨

This thesis describes work in deploying a single Unmanned Aerial Vehicle (UAV) to map the radiation field, and to localize the radioactive sources. Modern UAVs have gained great popularity in the recent year both in research and commercial platforms. Deploying such UAVs in radiation fields are attractive because they allow using the robotic sensors in unstructured and cluttered environments. Furthermore, for many applications, the mission to be performed is time-limited, meaning that a rapid mapping or localization is required to minimize losses.

We bring together results from our application of four distinct problems in radiation fields. Firstly, we seek the radioactive hotspot in unknown radiation fields, where the robot makes an online path planning with myopic observations. Secondly, we estimate environmental boundaries of unknown radiation fields with an a priori known threshold value. Thirdly, accounting the cumulative effects of the sources, we seek a framework to localize the radioactive sources efficiently. Finally, we attempt to solve another problem of radiation fields that is the determination of multiple regions of interest.

We design path planners that enable the UAV to perform above mentioned tasks. We have implemented a trajectory controller to validate our assumption (related to the robot localization). We also show numerical results of experiments which are demonstrated in simulated environments.

Keywords: UAV, Radiation field, Path planning, Source localization, Contour.

論文審査の結果の要旨

Inspired by recent natural disasters, an information-theoretic approach to unknown radiation field mapping and radiation source localization is proposed based on the assumption that unmanned aerial vehicles enable safe and cost-effective emergency contamination investigation in a large area. To facilitate the strategic planning and action process, this work consists of a sequential functional units of hotspot localization, boundary estimation, and source localization. For each of the problems independent yet interconnected, a UAV navigation algorithm is proposed for active sampling and the accuracy of estimation is presented. Furthermore, automated determination of regions of interest is discussed to narrow down the exploration area. UAV localization accuracy was also experimentally verified so that a reasonable experiment condition can be made with empirical evidence. The overall algorithmic framework is well built and its validity is investigated in simulated radioactive contaminated environments with multiple radiation sources. All the proposed algorithms are grounded in probabilistic modeling and machine learning.

Specifically, this work effectively dealt with the new challenges of myopic, pointwise observation for hotspot localization using a novel hexagonal tree based active sampling, in addition to the conventional active sensing and path planning of autonomous vehicles. The adaptive angle correction boundary tracking method significantly improved the accuracy of environmental boundary estimation. Furthermore, this work simultaneously detected the number of sources and their position using a Variational Bayesian inference method to the inverse problem with a Gaussian Mixture Model. Overall, the proposed framework has made a significant contribution to online environmental monitoring through a myopic informative path planning approach, which can be effectively applied to the path planning of resource-constrained unmanned aerial/surface vehicles exploring unknown environments. This is an excellent dissertation and we approve awarding a doctoral degree to REDWAN NEWAZ, Abdullah Al.