Towards Autonomous Thermal Imaging Robots for Heat Sensing

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***Abstract*—Heat poses a major health risk that particularly affects cyber-physical infrastructures in cities. Heat sensing maps can be used to reduce overexposure risks to humans. In this REU study, we will analyze how a robot equipped with a thermal camera can acquire a map of the surrounding area, localize its position within the map, and autonomously navigate this map to perform heat sensing measurements. The robot's poses and landmarks will need to be estimated at the same time using simultaneous localization and mapping (SLAM) algorithms. We will evaluate how different SLAM algorithms perform using thermal imagery and determine optimal navigation and sensing policies to ensure these robots can efficiently scan and detect heat hazards and changing environmental conditions.**

Index Terms: Autonomous Robot, Heat Sensing, Thermal Imaging, Localization, Navigation

I. Introduction

Environmental heat is a health concern. One way to decrease this concern is by evaluating areas around the world in order to add strategically-placed shade structures. Heat sensing maps can be used to determine the most optimal places to plant trees or other forms of shade [1].

Creating heat sensing maps is time consuming because it is not automated. An automated method is needed to create heat sensing maps more efficiently. A solution to this problem will be explored in this REU study in the form of a thermal camera automated robot. Other uses for this robot include navigation in the dark to find gas leaks, and navigation in all weather conditions [4].

Acquiring a map while localizing the position of a robot within this map can be a challenge. Because localization and mapping both depend on each other, a probabilistic approach is taken. SLAM is the simultaneous localization and mapping of a robot's position and surroundings. The simplest algorithm used for simultaneous localization and mapping utilizes the Kalman filter and a linear model [5]. It is a recursive feature-based model in which the best estimate of the state vector is predicted. Depending on the application, different variations of the Kalman filter need to be used such as the EKF-SLAM or FastSLAM, which are common algorithms used.

Using a thermal camera in place of an RGB camera is a challenge because of the different imaging characteristics. Thermal cameras have low texture information in the infrared domain, and typically are at lower resolutions than visible cameras. However, thermal cameras have some advantages including low-lighting imaging, easier pedestrian detection, and important for our application: the ability to measure black-body radiation at wavelengths sensitive to human heat exposure. In this REU proposal, different SLAM algorithms will be compared and modified to create the best fit for the application of autonomous heat sensing.

Previous research showed indoor thermal mapping where it is easier to detect boundaries of the robot's path. These systems also had a LIDAR, RGB camera, and thermal camera [2]. In this project, a system will be explored that only utilizes a thermal camera and is able to operate outdoors to perform heat mapping experiments.

In this project, Raspberry Pi and Python will be used to develop and test different motion algorithms and image processing tools. The algorithms for a digital camera will first be tested before a thermal camera is added to the robot. We will then determine what SLAM algorithms work well for thermal images outdoors.

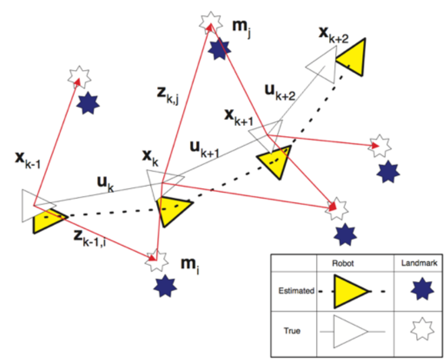

Figure 1: SLAM problem: Simultaneous estimate of robot's position and landmarks. True locations are never known completely. [3]

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