Autonomous Building Lighting Assessments

AggiE_Challenge

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Impact

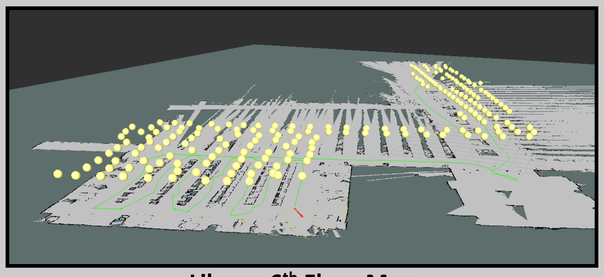
Lighting audits can yield cost reductions of up to 80%[1]. This can mean savings in the hundreds of thousands of dollars for large facilities. Automating the lighting audit process will make the process faster and more accessible, resulting in large-scale energy and cost savings for businesses.

Design Requirements

- Create 2D Map
- Locate all Lights
- Identify Light Type
- Fully Mobile Package

Design Approach

The problem was divided into two parts: Lighting, and Mapping. The Robot Operating System (ROS) was chosen to handle multithreading and communication between software packages. Building on the experience of previous teams, we wanted to create a working prototype by the end of the year to showcase the individual components and their ability to function as a cohesive unit.

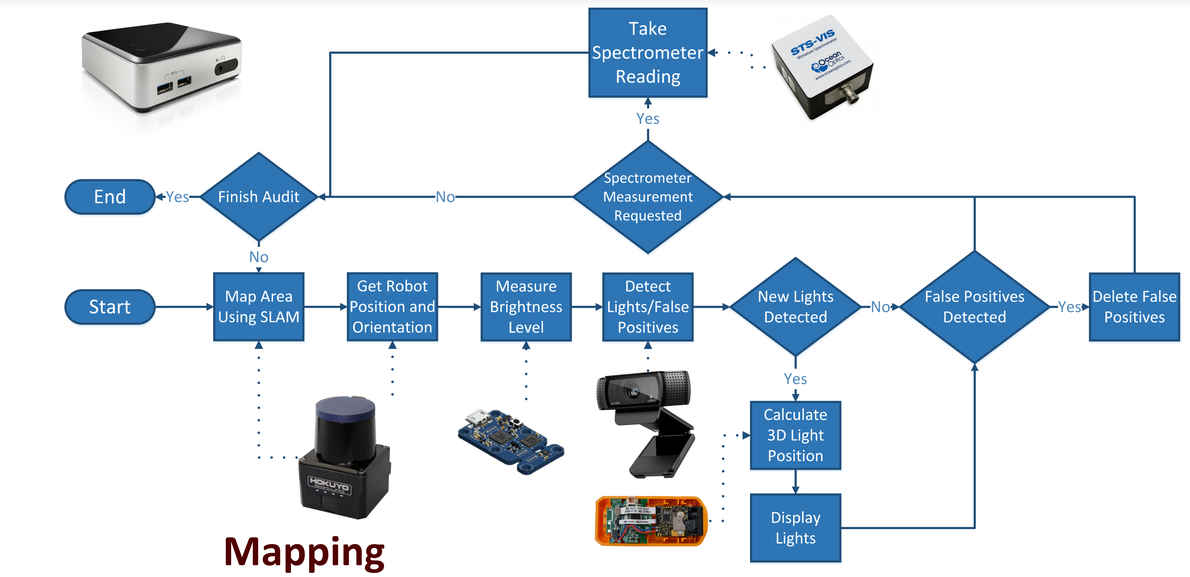


Library 6th Floor Map

References:

[1] GE Brochure: http://www.gelighting.com/LightingWeb/na/images/VERT036-GE-Industrial-Lighting-Systems-Brochure_tcm201-93762.pdf

[2] S. Kohlbrecher and J. Meyer and O. von Stryk and U. Klingauf, 2011. "A Flexible and Scalable SLAM System with Full 3D Motion Estimation", in *Proc. IEEE International Symposium on Safety, Security and Rescue Robotics (SSRR)*,IEEE.



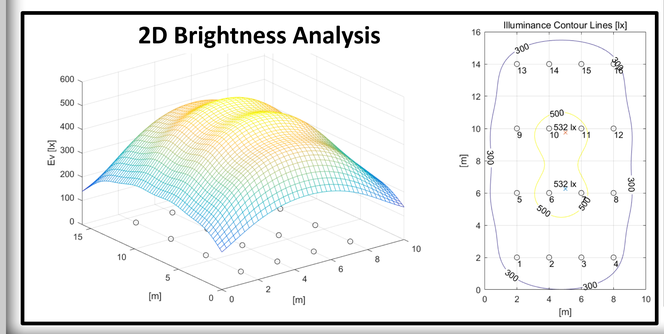
Mapping

We created a package that uses the input from a laser scanner and sends the data to a hector slam[2] package that results in 2D positional tracking, and a 2D map of the facility, with an accuracy of ±40 mm.

MEOB 3rd Floor Map

Light Identification

A spectrometer is used to determine light type. Bulb dimensions can be calculated from the images. Brightness readings are captured while mapping. We can then optimize the lighting level distribution to meet minimum lighting requirements while maximizing efficiency.



Light Detection

Lights are detected using a camera and OpenCV. With the input from a distance sensor measuring ceiling distance, the light's 3D position is calculated by finding the light ray's intersection with the ceiling plane.

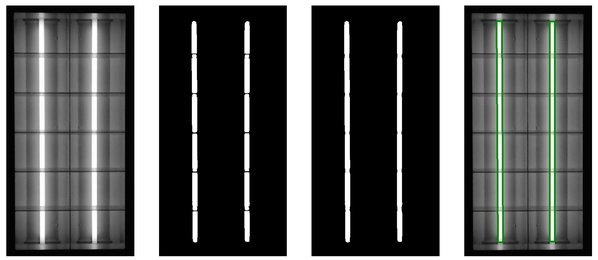
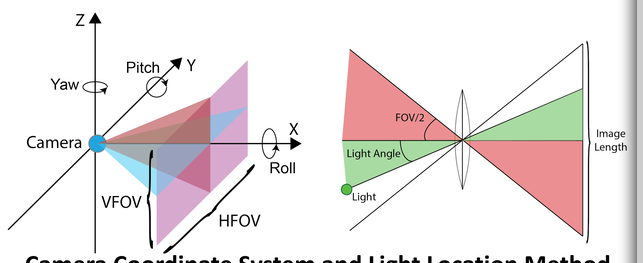
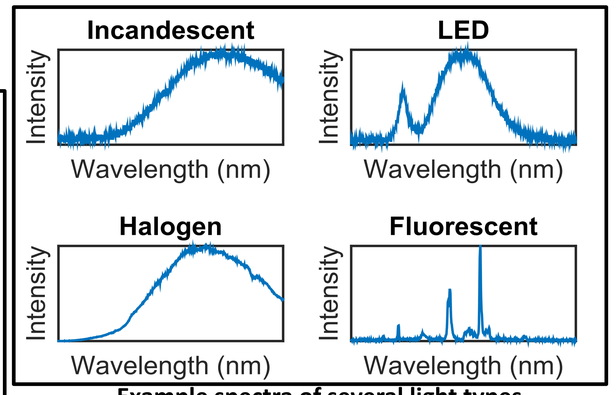


Image Processing Breakdown



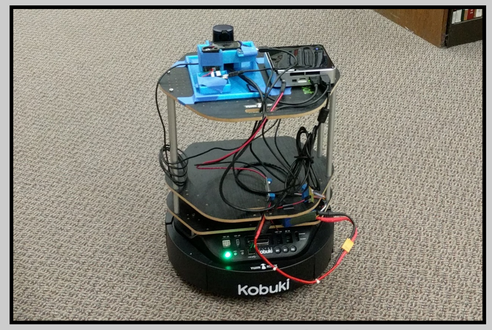
Camera Coordinate System and Light Location Method



Example spectra of several light types

Major Accomplishments

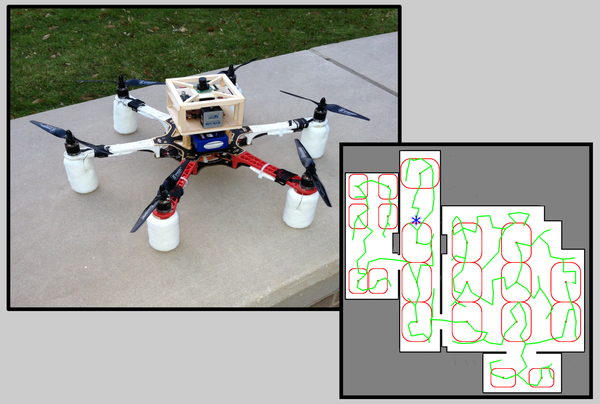
- 2D map creation
- 3D light detection
- Light identification by spectroscopy
- Fully mobile prototype robot



Prototype Ground Robot

Future Work

Autonomous navigation will be an important addition to finally make the entire system autonomous. Implementation of stereo cameras will aid light detection and placement accuracy. The addition of an IMU could provide more accurate position data, and allow the system to be mounted on a variety of platforms. The system could be miniaturized to fly on a UAV, increasing mobility.



Learning Outcomes

This was the first time for many of us to work on an interdisciplinary team. We learned valuable lessons about integrating software packages. In creating a working prototype we learned about packaging, coordinating and combining various hardware, and the issues that can arise while implementing a real-world solution.

Acknowledgments:

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