

# Towards Autonomous Thermal Imaging Robots for Heat Sensing

## SenSIP Algorithms and Devices REU

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### ABSTRACT

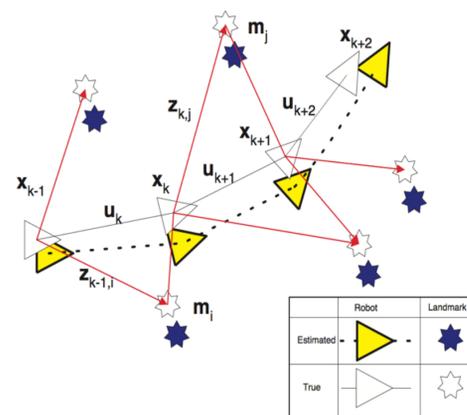
- Heat sensing maps can be used to reduce overexposure risks to humans by
  - finding the most comfortable pedestrian walking routes
  - strategically placing shade structures
- Our goal is to automatically generate these heat sensing maps by creating a robot that utilizes SLAM and thermal imagery

### MOTIVATION

- Environmental heat is a health concern
- Creating heat sensing maps is time consuming because it is not automated
- A platform that utilizes a thermal camera to both navigate and obtain heat sensing maps is cost-efficient and convenient

### PROBLEM STATEMENT

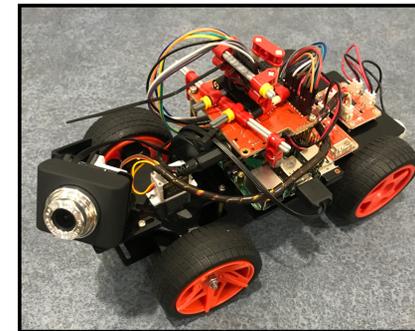
- How can a cost-effective robot autonomously acquire a thermal map of the surrounding area?



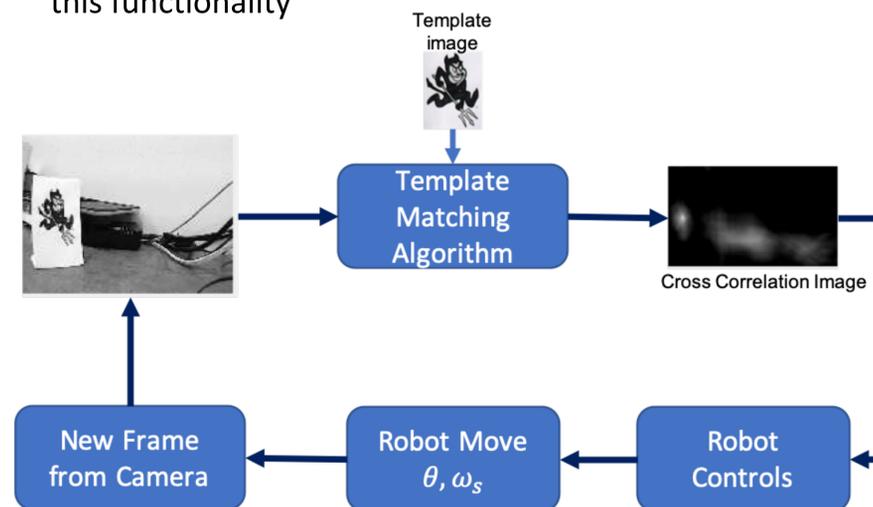
SLAM problem: Simultaneous estimate of robot's position and landmarks. True locations are never known completely [1]

### METHODS

- Our final goal is to enable SLAM algorithms for autonomous navigation with a thermal camera outdoors
- Our robot platform will be used to develop and test different motion algorithms and image processing tools
- One semi-autonomous task: Follow a climate scientist as she collects data, and take a subsequent ground truth measurement using thermal camera. This helps speed up acquisition of data for the scientist
- We propose a Marker Following algorithm using template matching on a target to enable this functionality



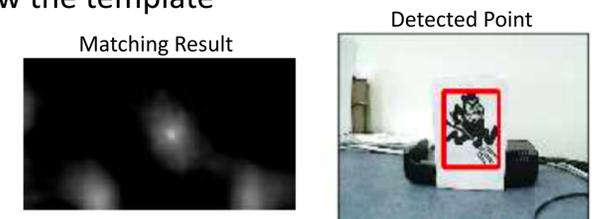
Robot platform utilizing Raspberry Pi, Robot Hats, PCA9685 PWM Driver, TB6612 Motor Driver, DC Gear Motors, USB Camera, and FLIR Lepton Dev Kit



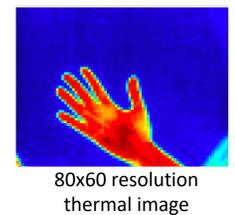
Marker Following Algorithm: A 2D convolution between the template and camera frame outputs a cross-correlation image. Robot is steered toward the highest cross-correlation value (shown as brightest spot)

### PRELIMINARY RESULTS

- Optimized template matching code by comparing results from different templates
- Implemented multi-scale template matching to allow robot to follow the template

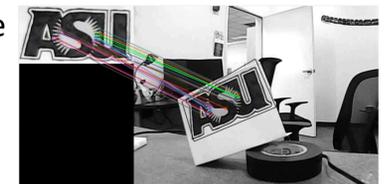


- Connected FLIR Lepton thermal camera to Raspberry Pi and Robot Hats to utilize thermal images for heat sensing



### NEXT STEPS

- Apply feature matching to improve template matching under extreme viewpoints/perspective distortion
- Implement SLAM algorithms with ROS for autonomous navigation
- Determine optimal map navigation and location sampling required to capture thermal images of the surrounding area to obtain a full heat sensing map



Feature Matching by ORB algorithm

### REFERENCES

[1] P. Bashmakov, "Robotics Projects: Navigation, Mapping, Control, Deep RL and others," *Capsules Bot*, 11-Jun-2018. [Online]. Available: <https://capsulesbot.com/blog/2018/06/11/robotics-projects.html>. [Accessed: 22-May-2019].  
 [2] S. Thrun, W. Burgard, and D. Fox, *Probabilistic robotics*. Cambridge, MA: MIT Press, 2005.  
 [3] C. Hoehne, D. Hondula, M. Chester, D. Eisenman, A. Middel, A. Fraser, L. Watkins, K. Gerster, "Heat exposure during outdoor activities in the US varies significantly by city, demography, and activity," *Health & Place*, vol. 54, pp. 1-10, November 2018.

### ACKNOWLEDGEMENT

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