PUFFER Autonomous Navigation and Coordinated Search
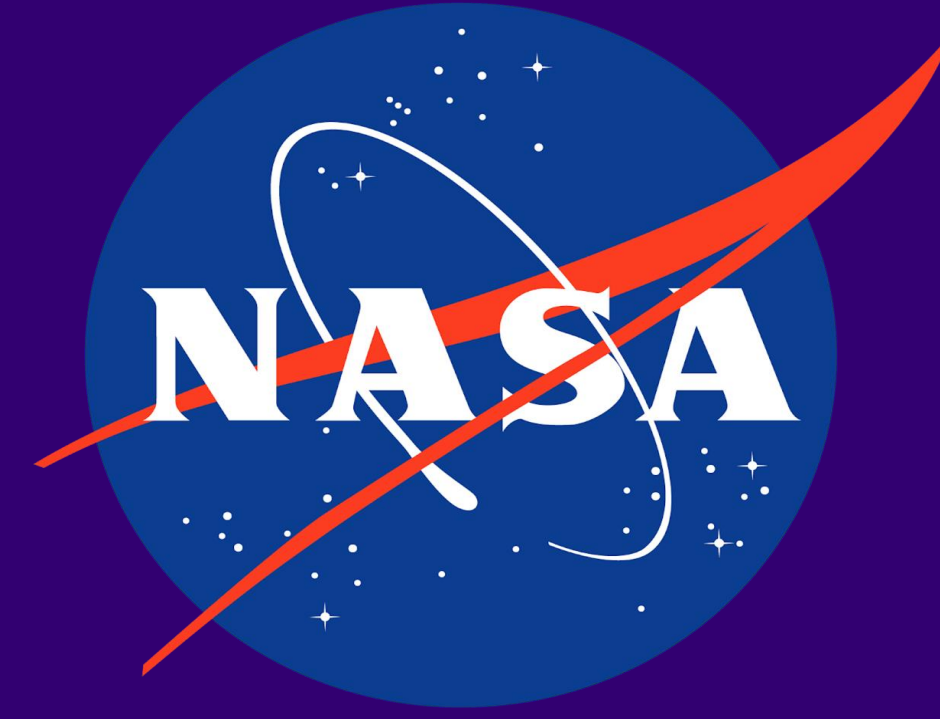
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Introduction

PUFFER, the Pop-Up Flat-Folding Explorer Rover, is designed to traverse hazardous terrain. **Our goal is to design and test multi-agent autonomous navigation and search system for PUFFER.**

Summary

Our system consists of modules for goal detection, obstacle avoidance, mapping, and search algorithm.
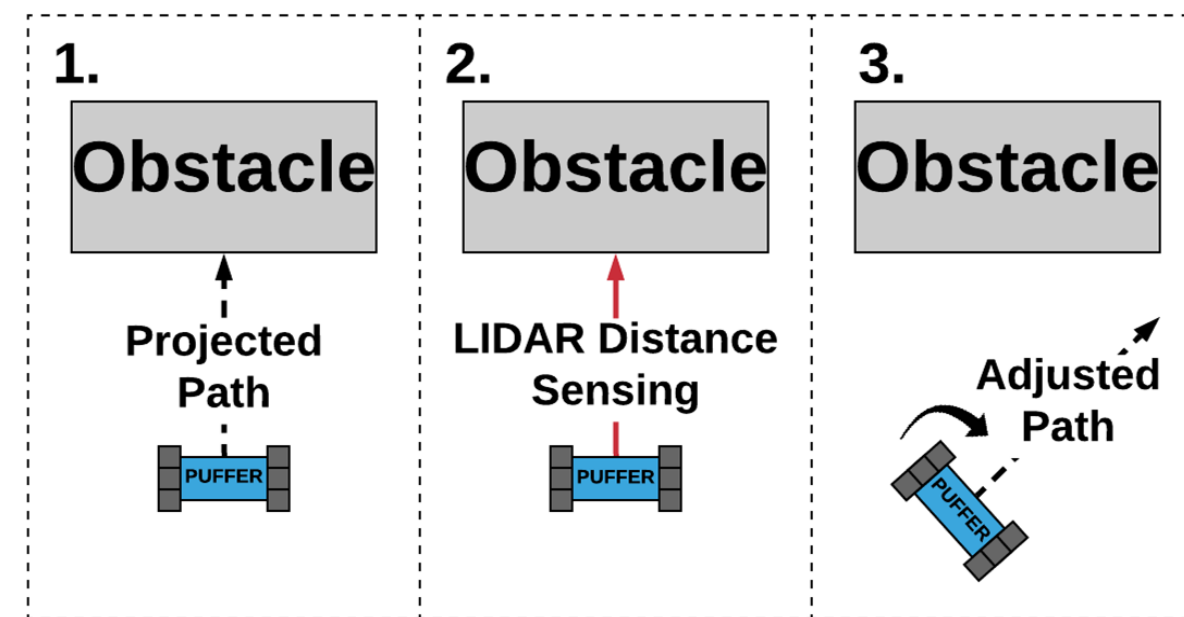
Shown to the left: Obstacle avoidance behavior. *Shown below*: Overall system

Base Station   PUFFERs
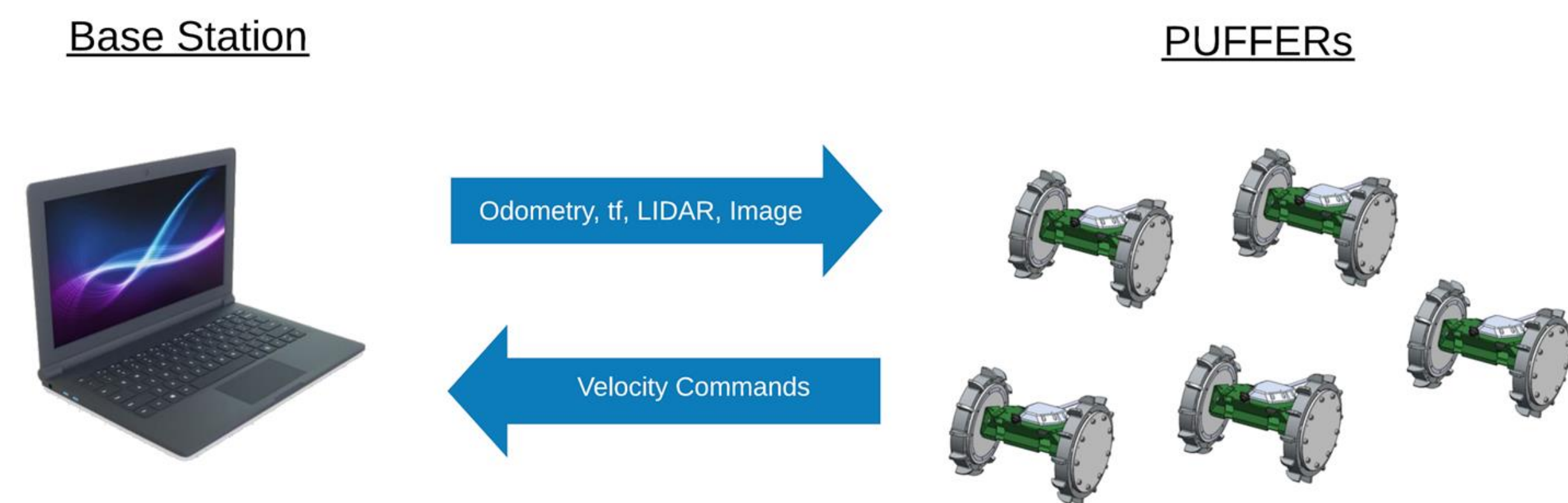
General Communication Between Puffers and Base Station

Requirements

Assumptions
- Flat terrain
- No battery limitation

- Uniformly lit environment
- Known starting positions

Autonomy
- Visually detect goal and investigate
- Detect/avoid obstacles

- Share information about environment with other PUFFERs

Methods

Robot Operating System
- Integrates several open source packages
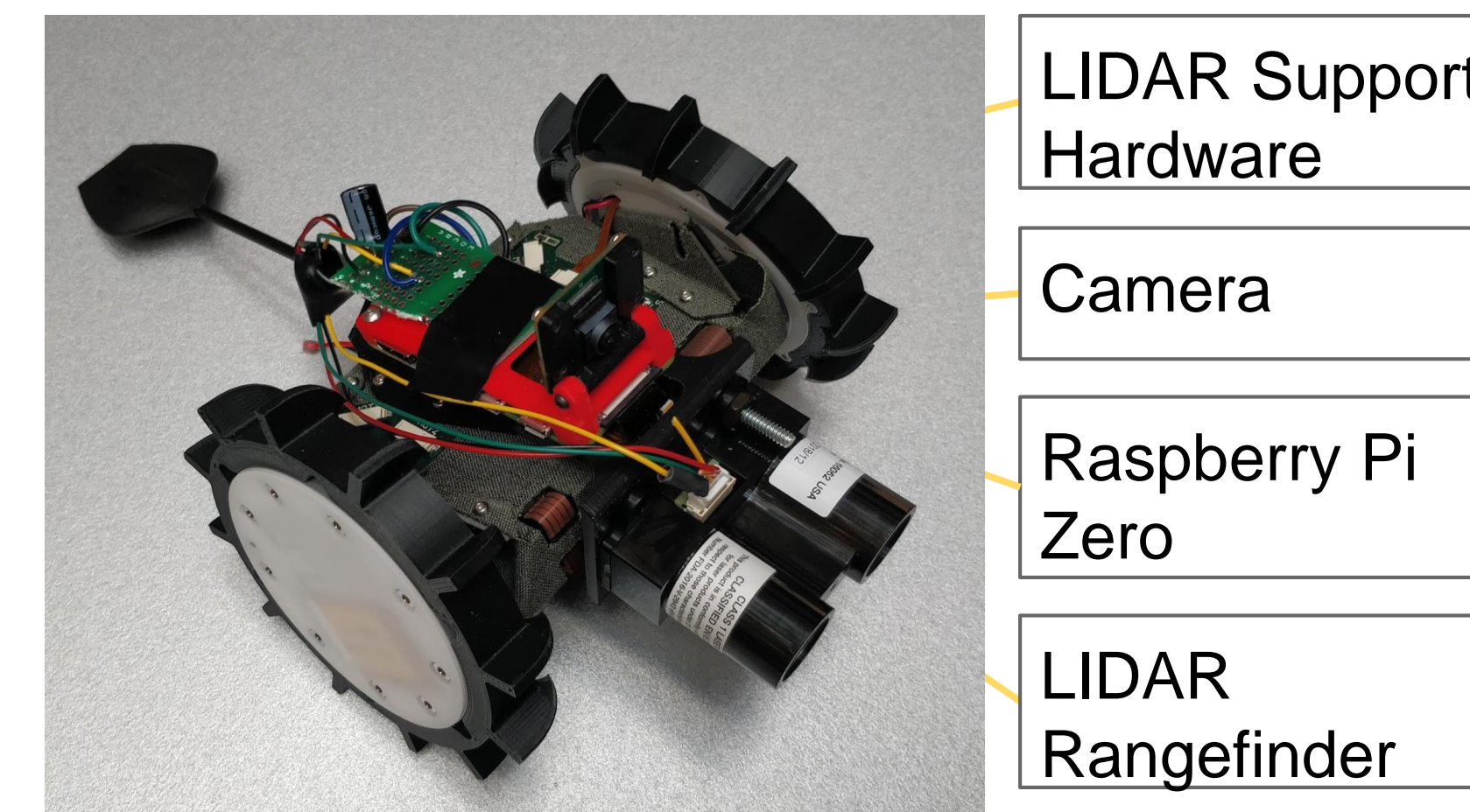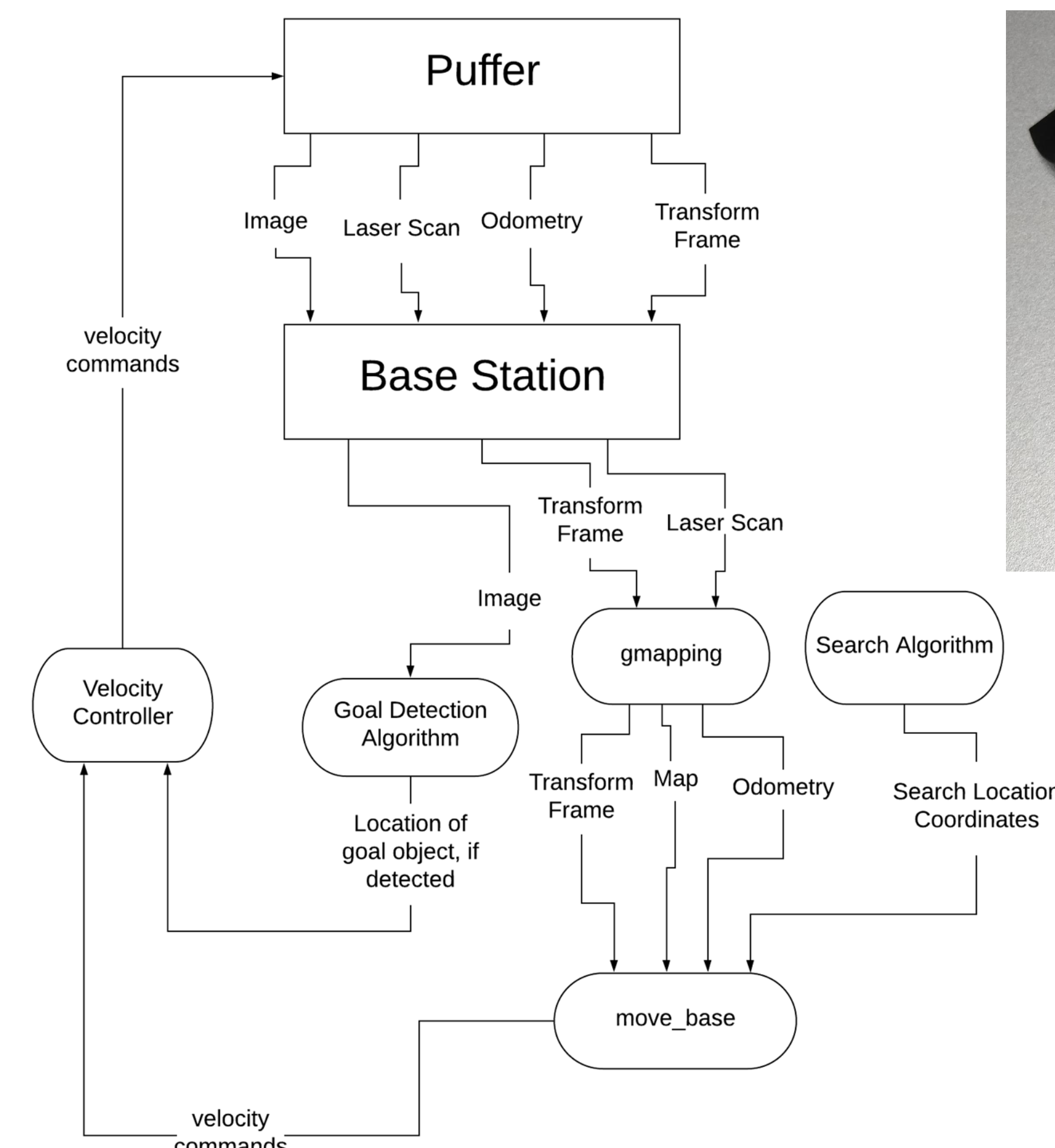- Directs data flow between programs

PUFFER Hardware
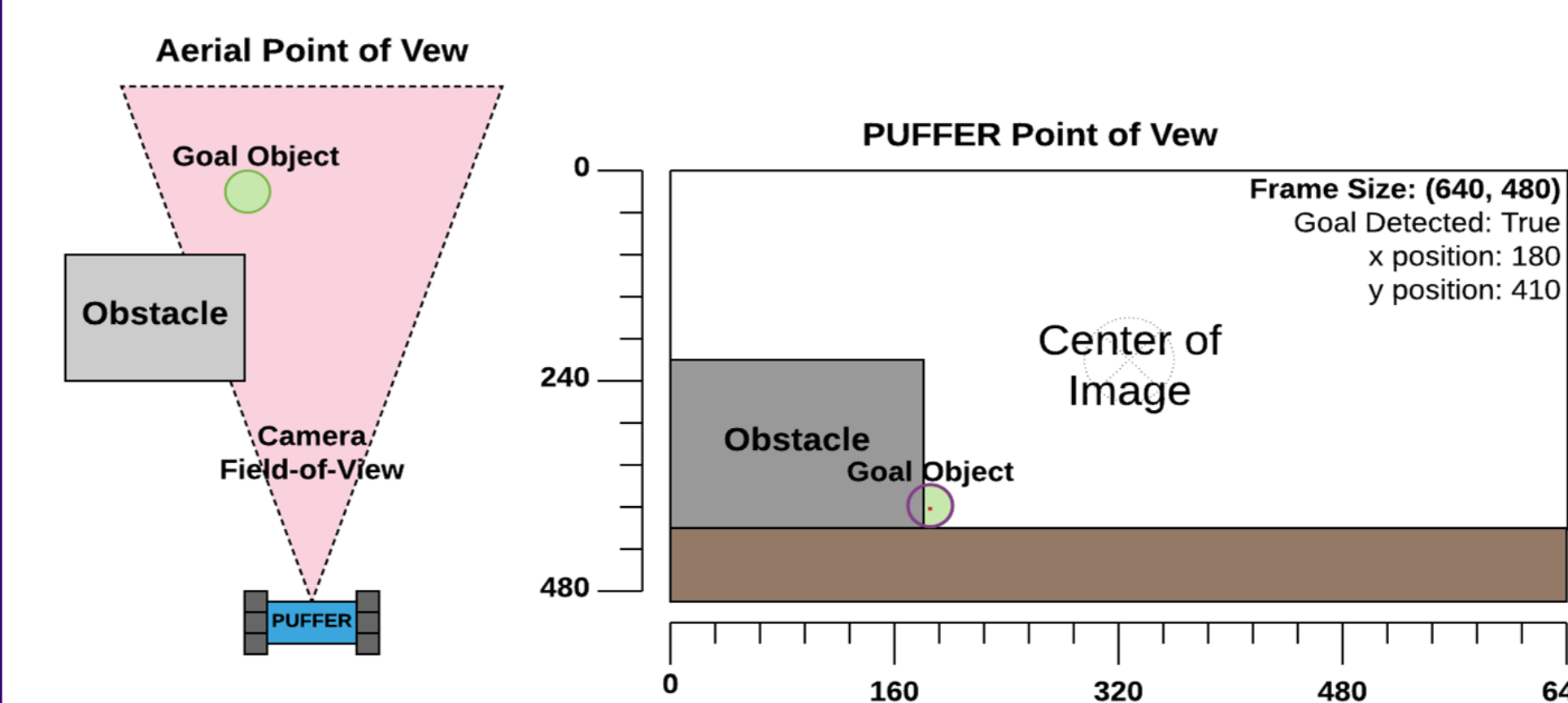- Raspberry Pi Zero W microcomputer
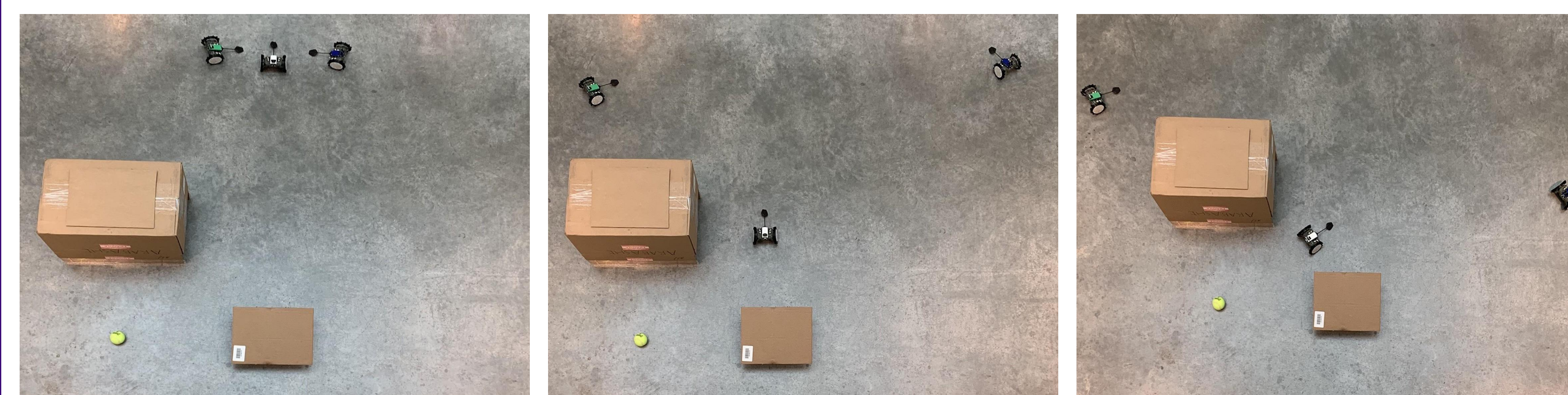- Camera
- LIDAR rangefinder

Results

Shown above: The various hardware parts making up the PUFFER sensor suite

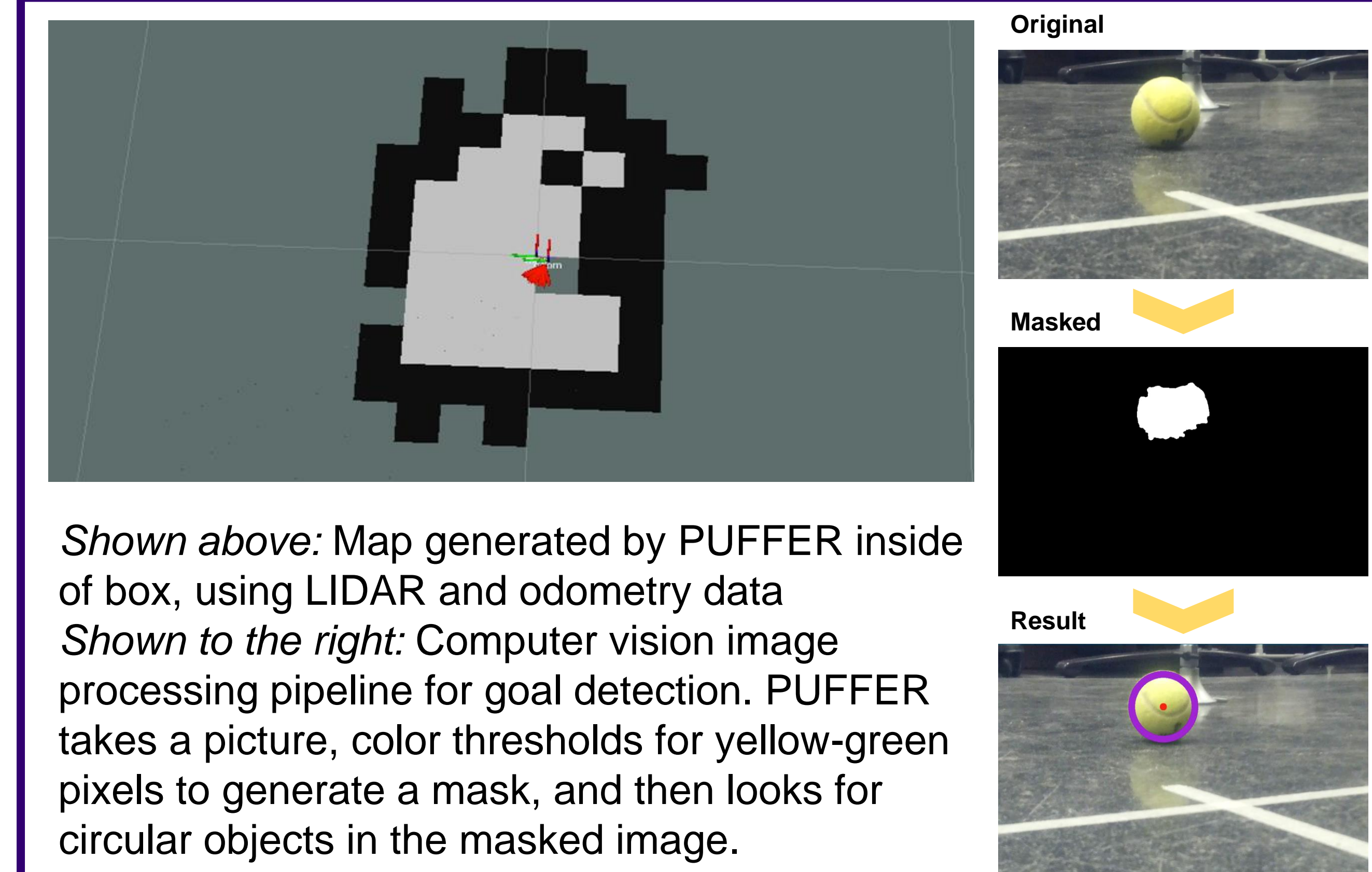*Shown above: Flow chart of information exchange between PUFFERs and base station*

Shown above: Goal detection system use case diagram.

Storyboard example execution of PUFFER detecting tennis ball

Results

Shown above: Map generated by PUFFER inside of box, using LIDAR and odometry data
Shown to the right: Computer vision image processing pipeline for goal detection. PUFFER takes a picture, color thresholds for yellow-green pixels to generate a mask, and then looks for circular objects in the masked image.

Discussion/Future Work

PUFFER was a unique and challenging robot platform
- Small and agile, but limited computing/battery power
- Future work must address challenges of real mission
  - Uneven terrain, unbounded search area

Goal Detection
- Faster algorithm
- More robust algorithm (adaptive thresholding)

Conclusions

Navigation
- Odometry from wheels localized PUFFER well
- More powerful LIDAR would improve mapping

Goal Detection
- Sensitive to lighting conditions, needs parameters tuned
- Higher resolution can detect goal at further distances
- Processing speed is limited by hardware

Acknowledgements

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