Multi-Robot Collaborative Exploration and Navigation

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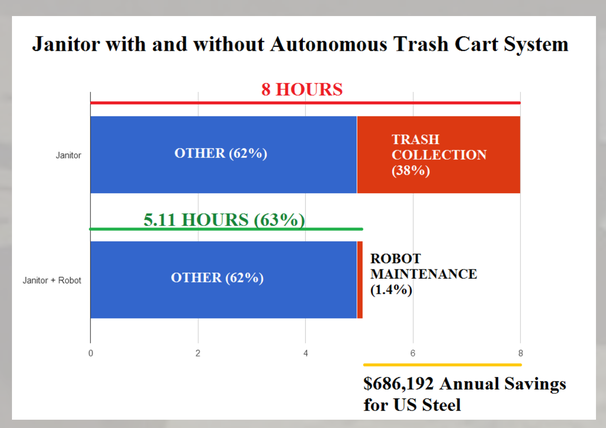
Problem Statement

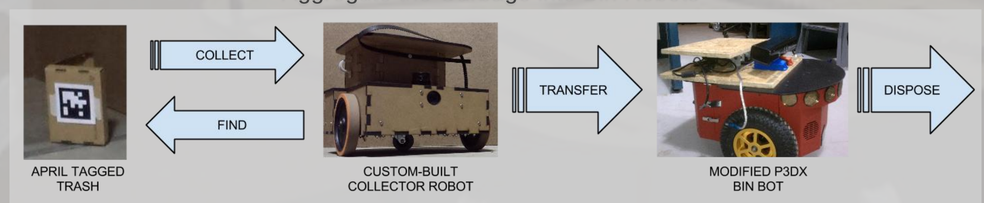
Robots Forage Office Cubicle Environments to Assist in Trash Removal



Potential Cost Savings Opportunity

Approach

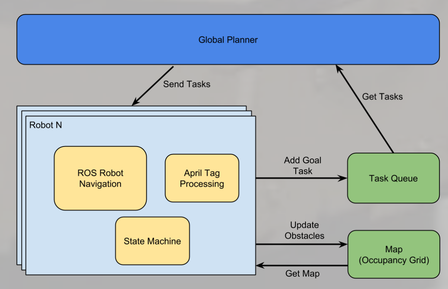
Collector Robots Search for AprilTags in the Environment representing Garbage, Collect, and then Aggregate the Garbage into Bin Robots



Conceptual Approach Used To Design System and Complete Task

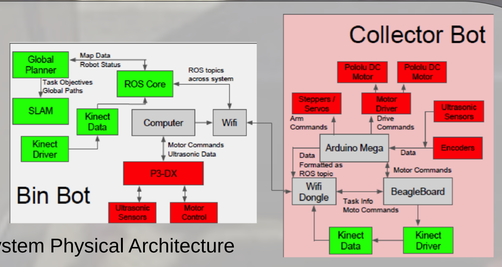
Software Design

The Team Designed Software to Integrate With the ROS Navigation Stack to Intelligently and Efficiently Search an Environment for AprilTags While Fusing Data From Multiple Sensor Sources. The State Of The Robots, Tasks, and Trash Cans are Maintained by the Global Planner.



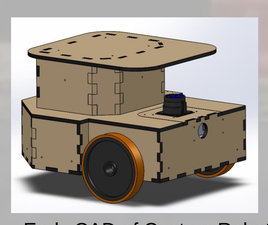
Hardware Design

A Modified P3-DX with A Microsoft Kinect and A Custom Mobile Base Were Designed to Do Carry Out the Task.
The Custom Robots were Designed with the Successes of the P3-DX In mind.

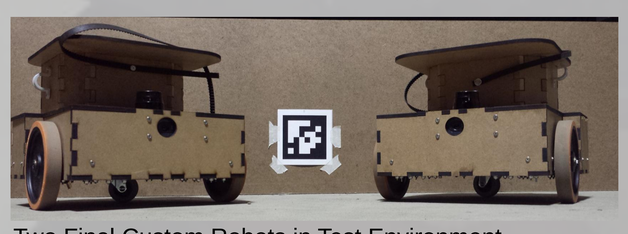


System Physical Architecture

P3-DX with Custom Mount



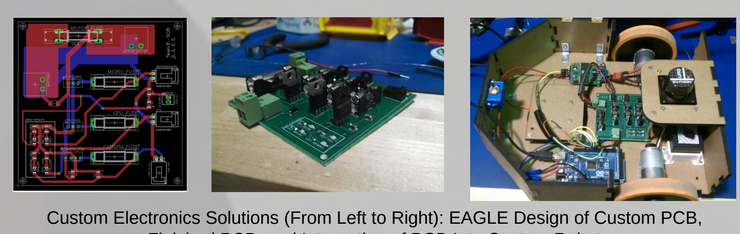
Early CAD of Custom Robot



Two Final Custom Robots in Test Environment

Electronics Design

Custom Electronics Had to Be Designed to Bring Power to All On Board Subsystems

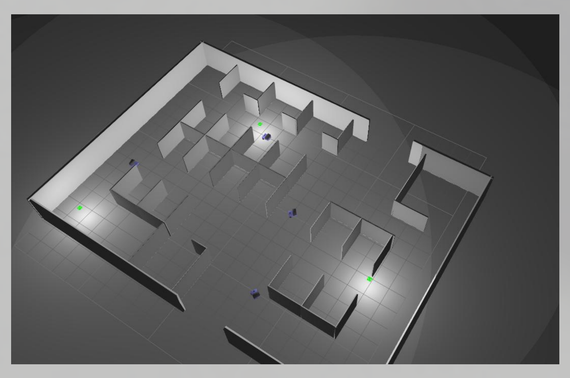


Custom Electronics Solutions (From Left to Right): EAGLE Design of Custom PCB, Finished PCB, and Integration of PCB Into Custom Robot

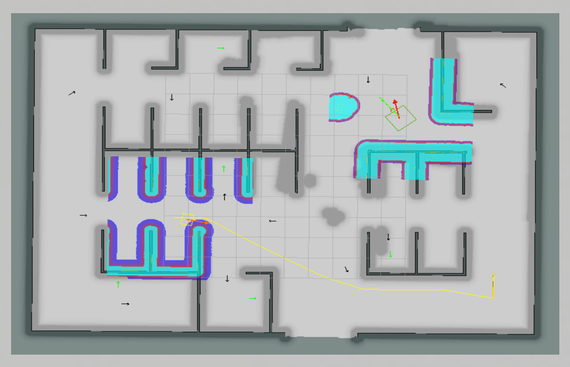
Results

The Team Successfully Implemented The System First in Simulation to Test Various Global Planner Strategies and Parameters, as Well as General System Feasibility. After Stability was Reached In Simulation, the Team Integrated that Software With the Hardware System for Real World Testing and Application.

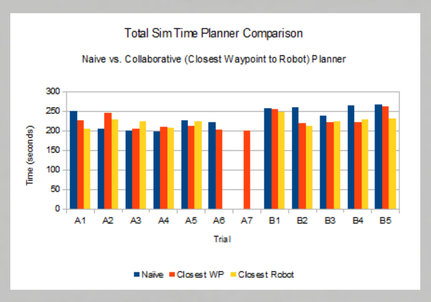
Simulation



Gazebo Simulation Environment



Two Robot Simulation w/Paths & Costmaps



Naïve	Closest WP	Closest Robot	
257.12	235.7	228.85	Average Total Time
Difference	21.42 (8.33%)	28.27 (11%)	Seconds Saved (% Improvement)

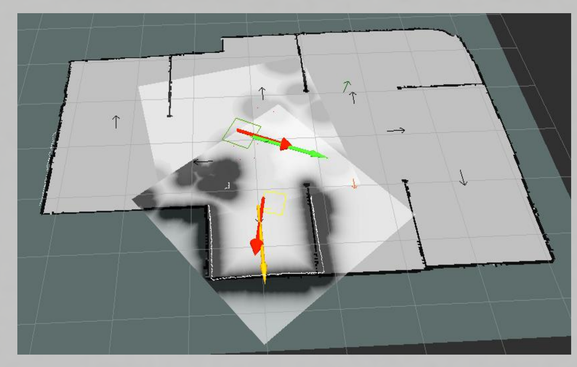
Planner Efficiency Improvements vs. Naïve

Requirements	Simulation	Real
Sensor Fusion	✗	✓
Localization	✓	✓
Obstacle Avoidance	✓	✓
Landmark Recognition	✓	✓
Garbage Identification	✓	✓
Trash Transfer	✓	✓
Collaborative Planning	✓	✓
Robustness	✓	✗
Arm	✗	✗

Summary of Requirements Performance

Real

Real Test Site Environment



Visualization of Robot States in rViz for Real Test Site

Conclusions

The results from our tests show that significant performance gains can be achieved by using a collaborative planning approach to navigating and exploring partially known environments with multiple heterogeneous robots.

Thanks To

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