Robotic Trash Concierge

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Electrical and Computer Engineering Department
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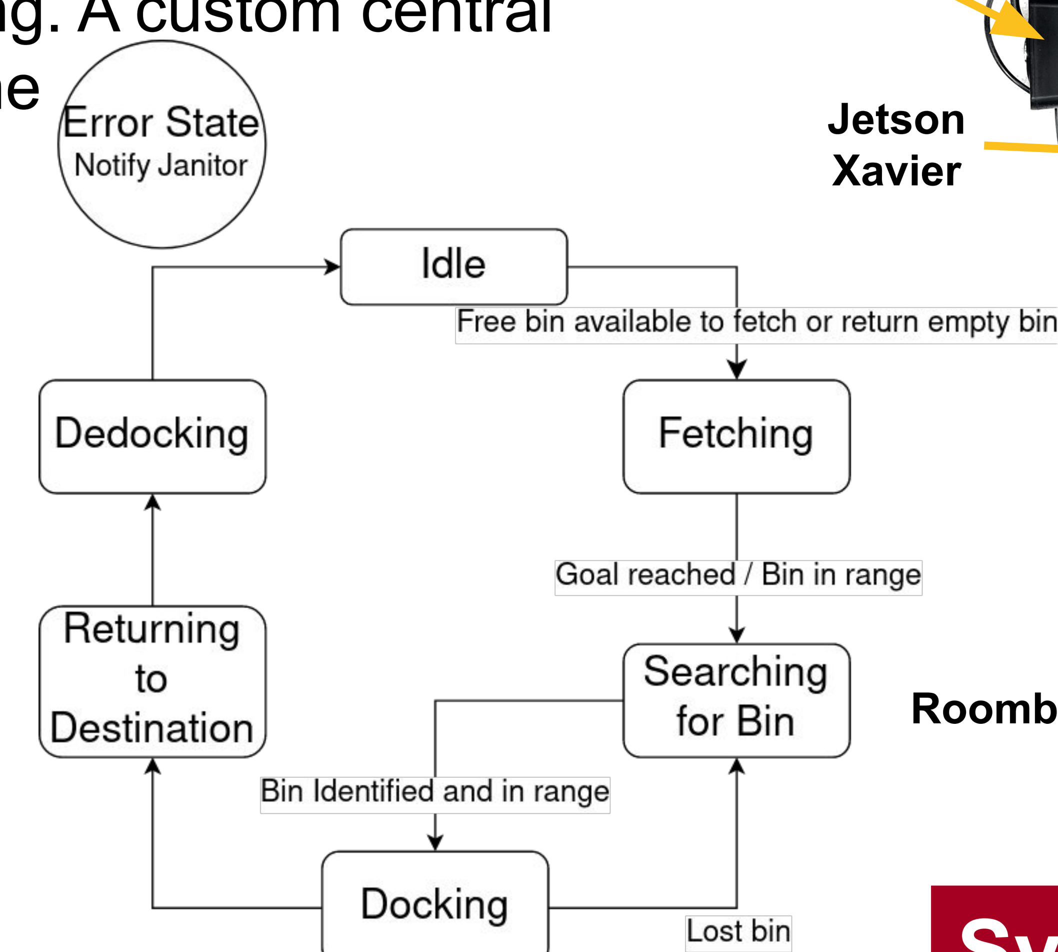
Product Pitch

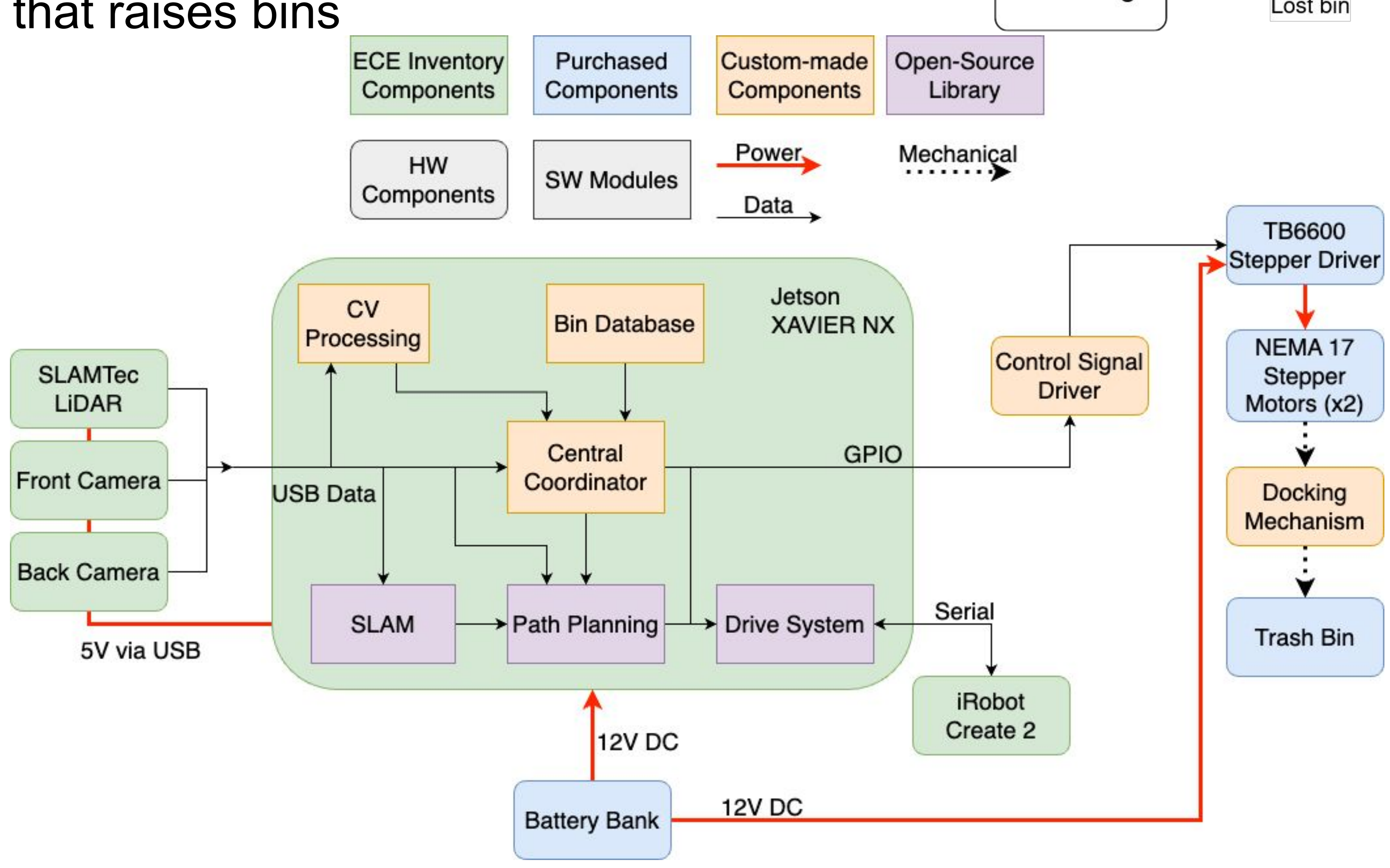
Our project aims to significantly reduce custodial load within large open office areas. The solution is designed to autonomously navigate in open office environments to trash bins every night and bring it back to a central location for janitors to take out.

Through initial testing, we found our navigation system to be quite accurate, arriving to goal coordinates with an average offset of 0.20m in a room with many chairs and tables. In office lighting conditions, we also achieved 100% accuracy on proper bin detection.

System Architecture

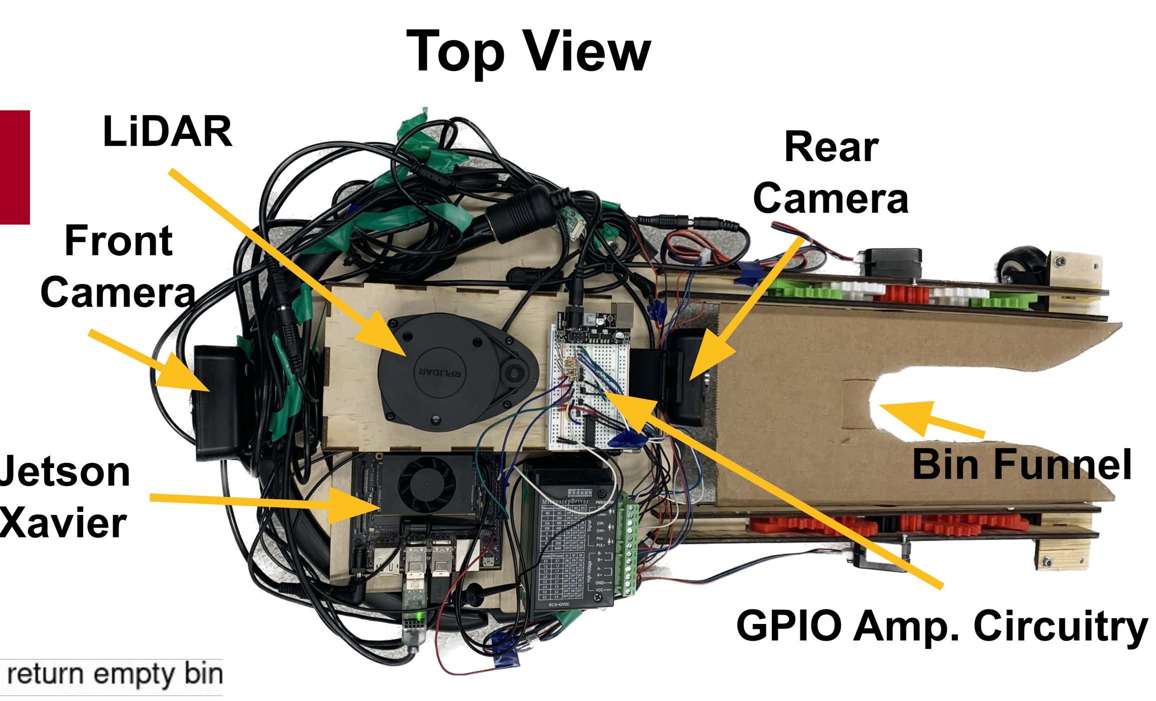
The Robot uses a series of open source ROS packages for movement, navigation and mapping. A custom central coordinator acts as a state machine to publish commands to various ROS nodes. A database backend is used to store trash bin locations and their fetch status. The OpenCV library combined with ArUco tags are used to locate and align to bins during pickup. The lift motors are controlled by the Jetson's GPIO pins, which drive a custom gear system that raises bins

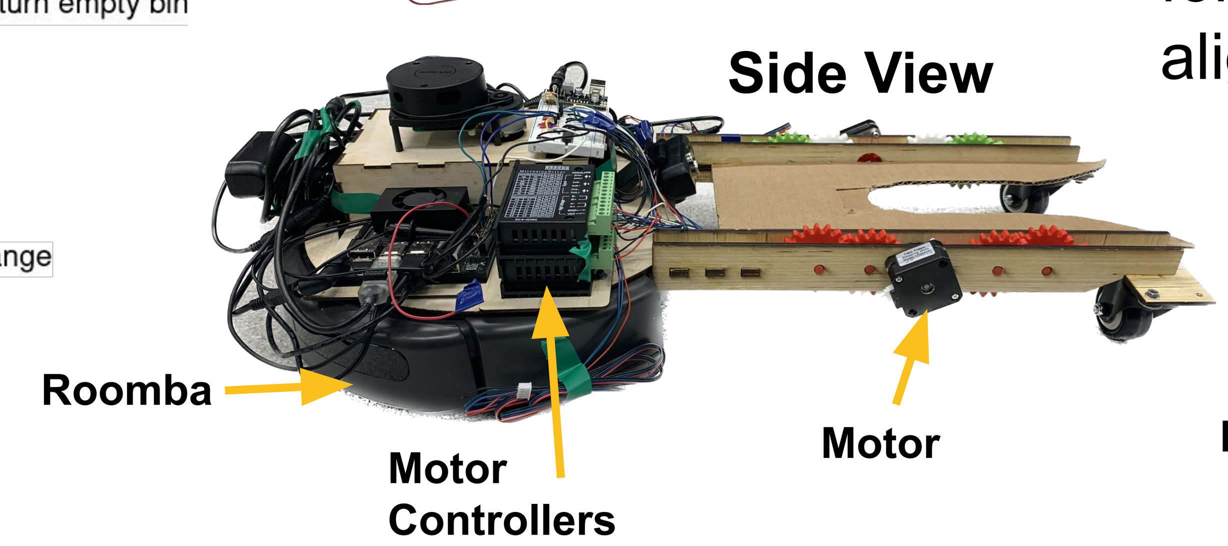


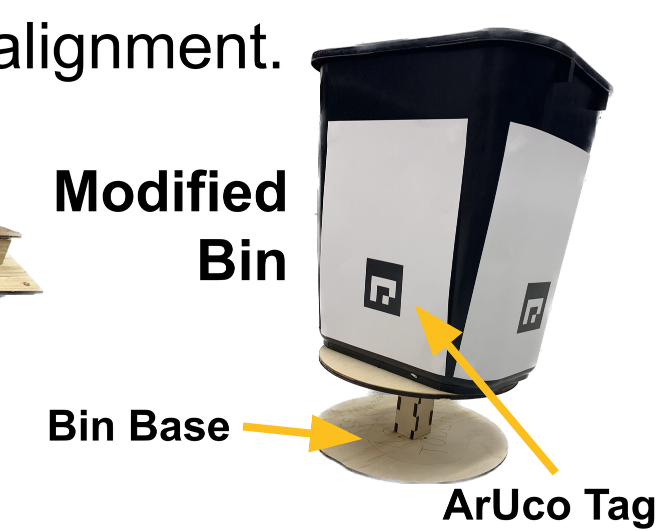


System Description

The software is handled entirely by the main processor of the robot, the Jetson Xavier. Separate processes communicate in real time through a pub-sub system supported by ROS. The central coordinator utilizes ROSpy to fetch position and LiDAR information by subscribing with background callbacks. It also publishes commands to control drive and alignment when needed. To do so, tuning of linear and angular velocities and timing parameters was necessary due to imprecise motor controls. An embedded database is used to track bin locations. Hardware components are interfaced through USB connections and GPIO. The GPIO sends signals which are amplified by the circuitry on a breadboard to control the stepper motor drivers for bin lift. The Jetson streams video data from both cameras for bin Identification and alignment.

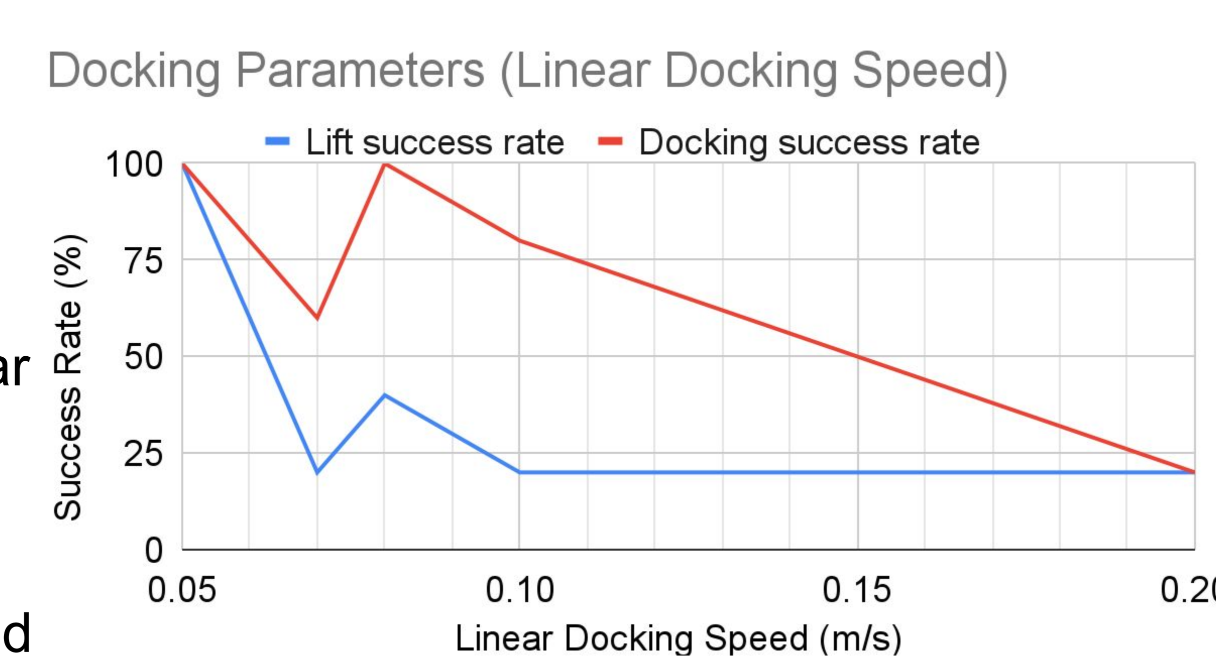


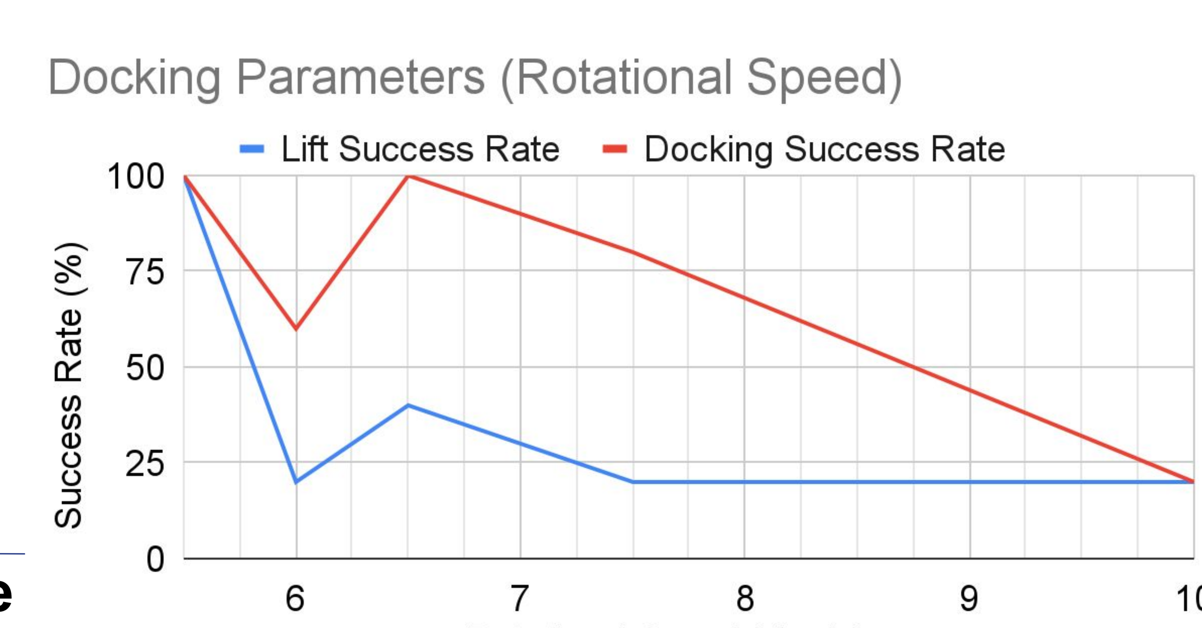




System Evaluation

We tested navigation to specific office locations, bin identification through CV, travel speed, and battery life. We focused specifically on tuning linear and rotational speeds through bin docking tests. We found that lower velocities greatly increased bin detection and docking performance, with steep drop offs as speed increased. Qualitatively, we noticed stronger localization performance and lower collision rates.





Navigation Performance

Test was performed over multiple paths in a 8.5x8.5m room

Trial #	Goal (x,y)	starting loc (x,y)	Robot Offset from (in)
1	0.0, 0.0	4.5, 0.0	12.5
2	0.0, 0.0	4.5, 0.0	7
3	0.0, 0.0	4.5, 0.0	5.5
4	0.0, 0.0	4.5, 0.0	6.5
5	0.0, 0.0	4.5, 0.0	8
1	4.95, -3.93	0,0	8
2	4.95, -3.93	0,0	10
3	4.95, -3.93	0,0	8.5
4	4.95, -3.93	0,0	8.5
5	4.95, -3.93	0,0	6.5

Docking tests also led to several design changes, such as adding a guide funnel to the arms, as well as a rear camera for ArUco detection, which increased bin detection abilities from 0% to 100%.

Conclusions & Additional Information

Our aspirations were high, especially given our lack of prior robotics experience and the time available, but the project was a great stepping stone to a more refined product. The foundation is solid: we have navigation, collision detection, and bin identification in a great state, but bin pickup could be polished more in a future redesign. We learned how important hardware design is to fit within software limitations, such as adding a funnel to make docking easier.

http://course.ece.cmu.edu/~ece500/projects/s23-teamb4/

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