Croomba: Autonomous Crawlspace Inspection Robot

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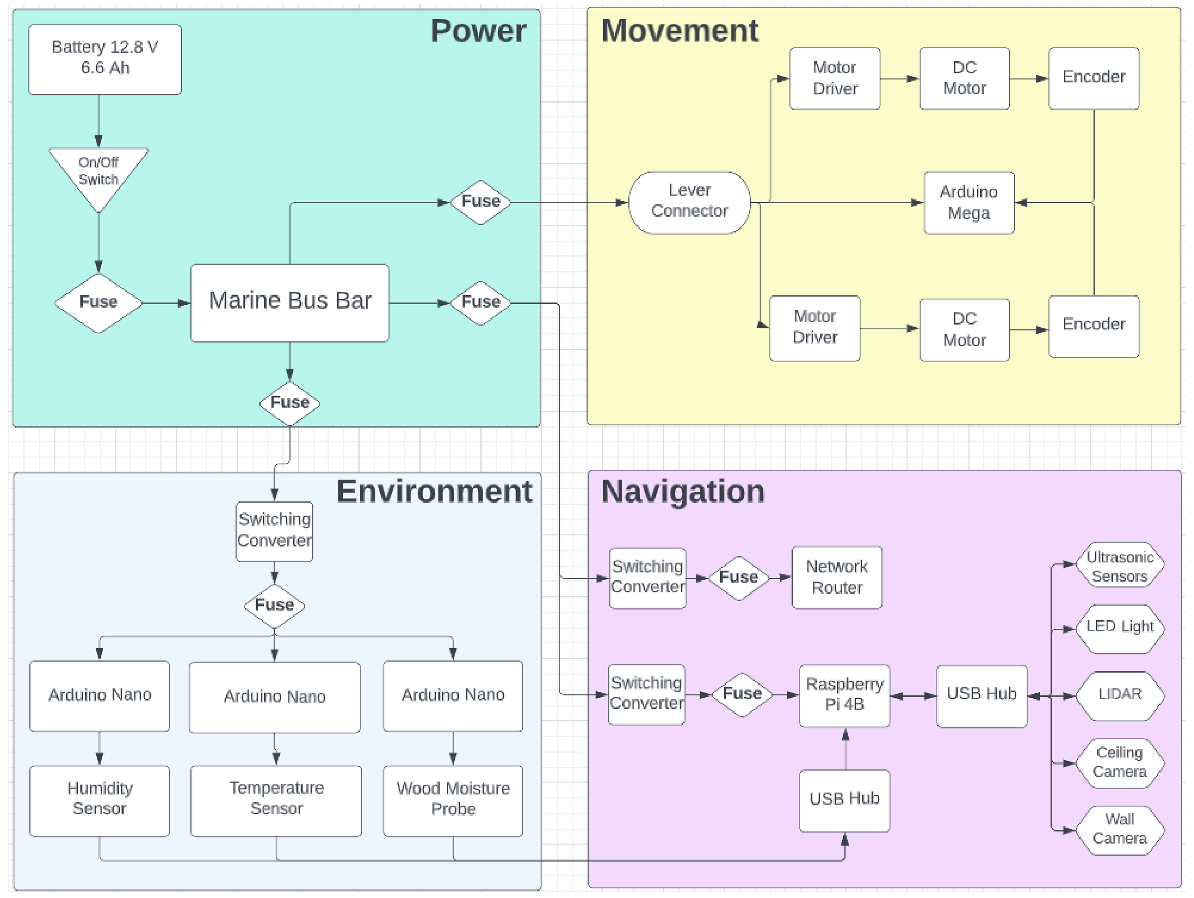
Abstract

The final objective of the Croomba project is to create a robot capable of inspecting a crawlspace autonomously while also taking pictures and recording sensor data throughout. We have designed, ordered, and built the robot hardware while also setting up programs to demonstrate basic functionality.



Navigation Capabilities

The navigation system includes a raspberry pi, a lidar, two cameras, and an array of ultrasonic sensors. It is currently capable of collision detection navigation, Hector SLAM mapping, and taking pictures at set intervals to enable image stitching.

Environmental Sensing Capabilities

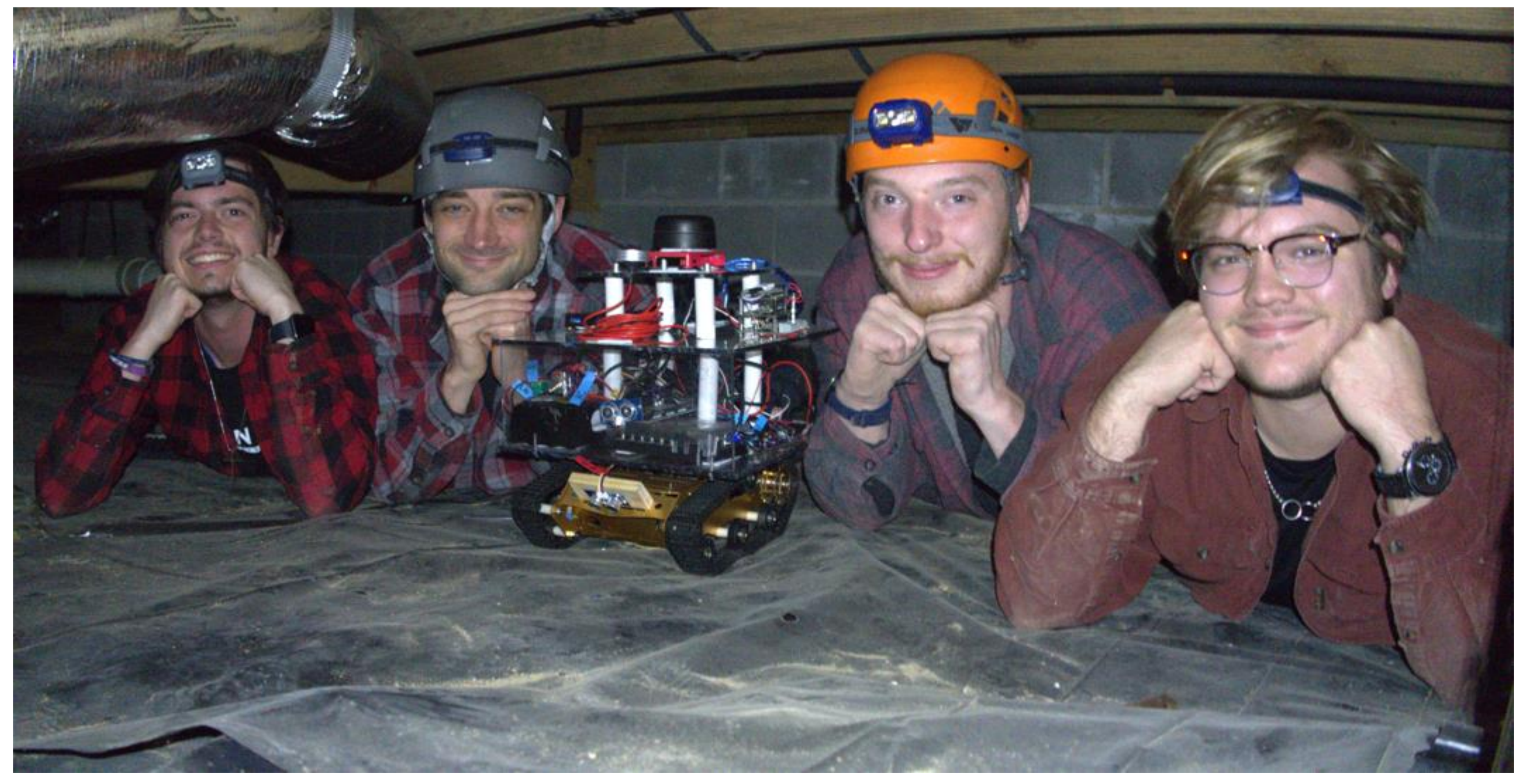
Humidity, temperature, and wood moisture content are all tested by this system. This data is then associated with a picture taken at the same time. Unfortunately, this subsystem's mechanical parts could not be physically realized due to ordering delays.

Power Capabilities

The power system can safely provide 12V and 5V power to the system components as needed. The battery was found to provide around 1.5 hours of runtime.

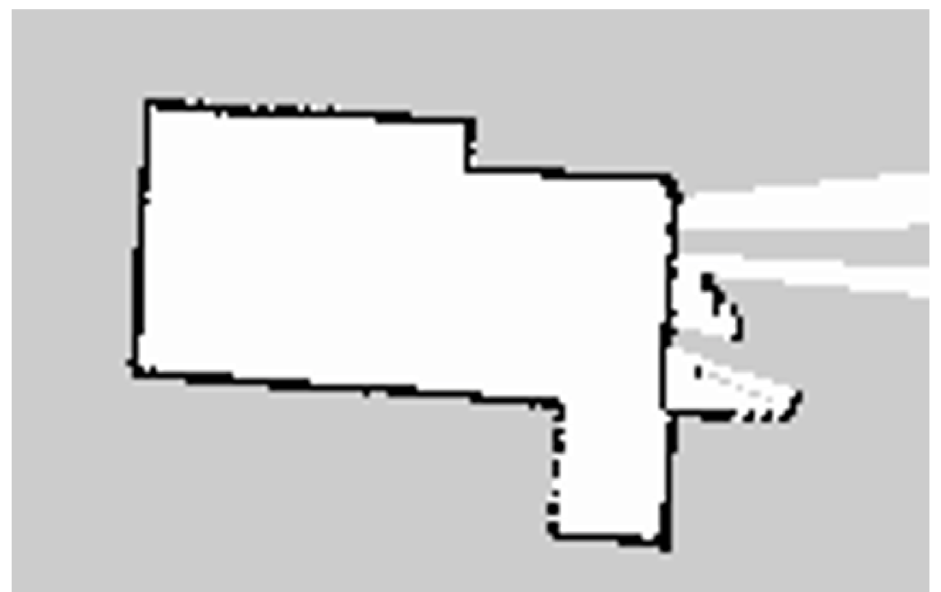
Mechanical Capabilities

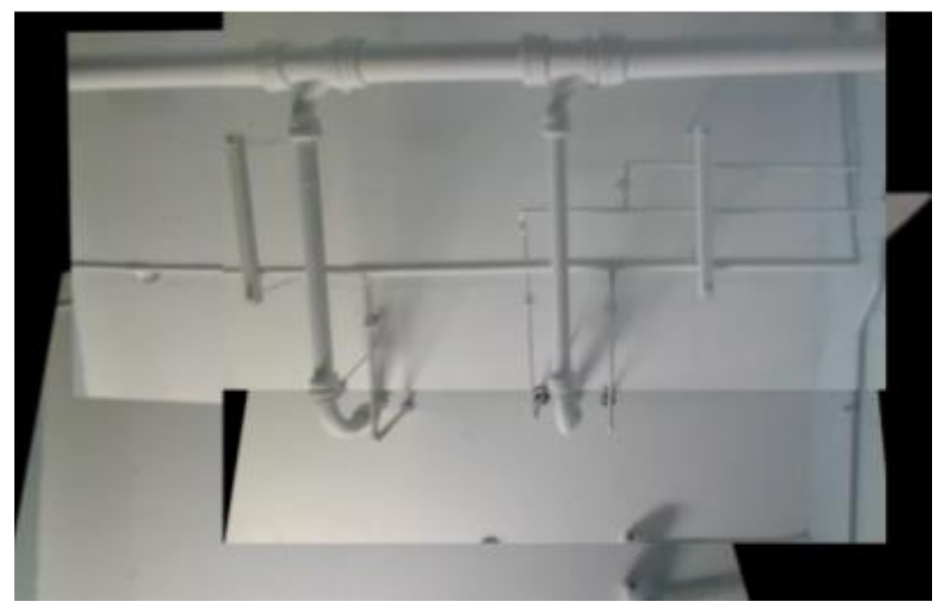
Although the mechanical design was not the project's focus, a chassis was assembled to allow all the electronic parts to be mounted. Motor encoders were also integrated into this system to allow for monitoring of the speed and direction of the motors.



Mapping and Imaging

The implemented mapping and imaging algorithms allow the robot to survey its surrounding environment and record critical distance and environmental sensing information. The team utilized the Hector SLAM mapping algorithm, which was implemented in the Ubuntu-based Robot Operating System (ROS) environment. The Hector SLAM algorithm tracks changes in the robot's position and creates a two-dimensional map of the crawlspace environment. Through the Python-based library, OpenCV, the robot captures images of the ceiling and stitches them together into a single image. The resulting image allows users to monitor the health parameters of the subfloor.





Acknowledgments

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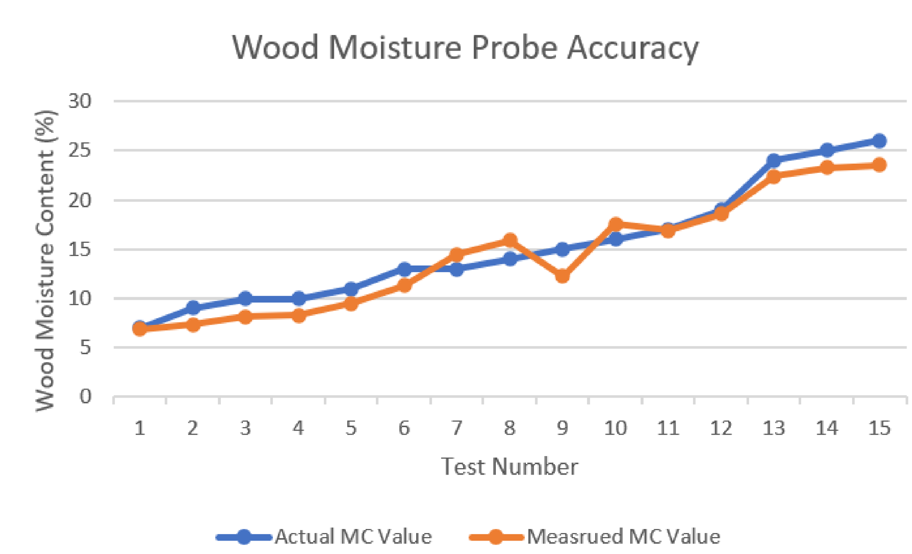
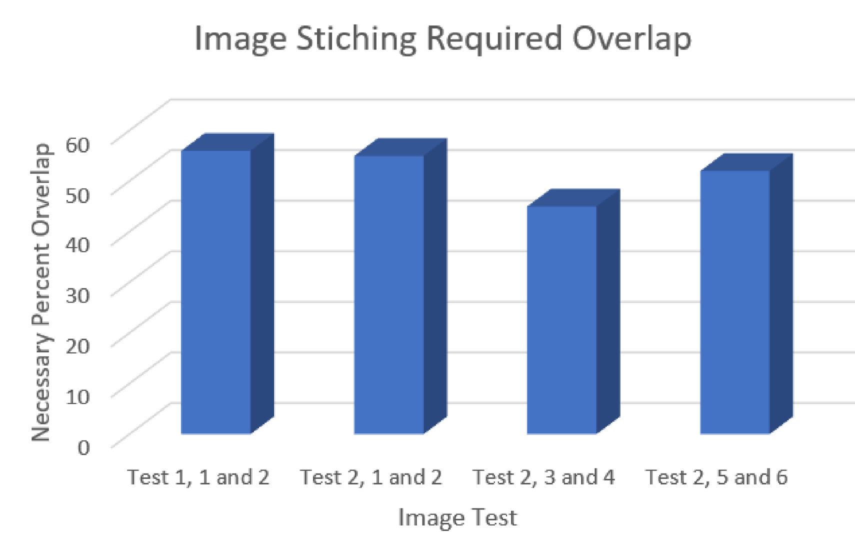
Industry Impact

Home inspections require a trained, licensed professional to spend valuable time moving through inhospitable, sometimes dangerous, environments. The Croomba has the potential to become an invaluable tool for the home inspection industry by automating the task of crawlspace inspection.

Experimentation

A variety of experiments were performed to determine the robot's functionality. Primarily, the team measured the robot's ability to accurately measure environmental data inside the crawlspace, how quickly the robot navigated the crawlspace, and the quality of the map and pictures that the robot formed as it maneuvered about the landscape.





Highlights

The Croomba was able to successfully map out a variety of different environments while navigating autonomously through the space. Base-level image stitching algorithms were implemented to create a holistic image of the area's ceiling. While moving throughout the crawlspace, the robot collected sensor data to be visually represented on the stitched picture. Backup systems have also been implemented to allow the robot to be manually controlled in case of autonomy failure. Finally, the power system successfully filtered the supply to provide the constant voltages necessary for operation.

Future Work

The modular nature of this project provides many opportunities for future work to be implemented on later iterations of the robot. Possible new features include upgrades to the hardware, a higher level of autonomy, improved chassis, and additional hardware for the sensing system. The image stitching algorithm will also be improved in future iterations. The Croomba will become a legacy project that future teams will continue to develop.