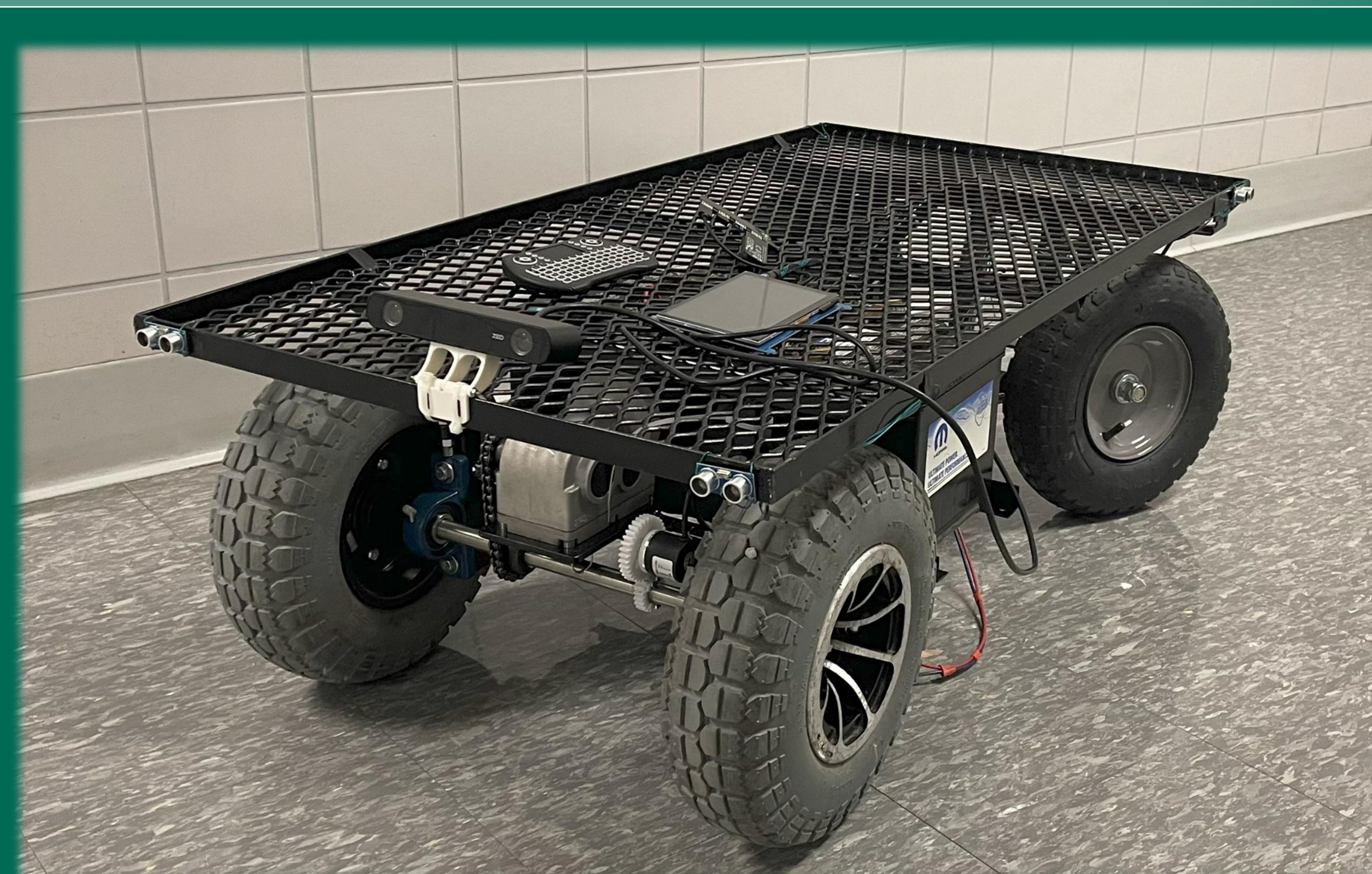
Autonomous Nursery Cart

Advisors: Dr. Linn
Instructor: Dr. Zhiqiang Gao
Team Leader: Kenneth Bender
Team Members: Russell Buttriss, Shereen Elfadil

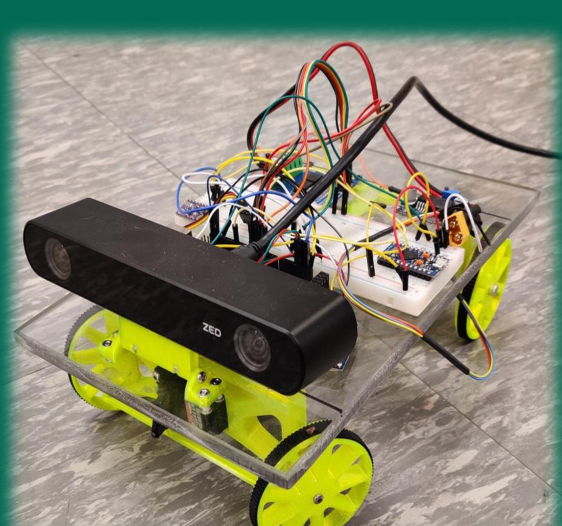
Abstract:
One of the key emerging technologies developed in the last few years is very expensive large scale autonomous vehicles. However, there is a lack of small scale affordable autonomous vehicles. This is due to a high cost per unit that can overwhelm budgets on small projects. This project aims to develop an autonomous nursery cart to help workers collect vegetables and grains from fields with complex routes. The key goal of this project was to minimize cost by lowering processing requirements, using off the shelf components and keeping everything open source.

Objectives:
The first major objective was to design and fabricate a cart capable of holding at least 350 lbs with mounting location for all the components. The next major objective was to source all the required components and design the electrical infrastructure. The last major objective was to use ROS to bring the hardware and software together and code all the algorithms.

Methods:
The cart was designed in Fusion 360 and then fabricated. Using knowledge gained from summer research all the components were then added to the cart. As development took place time was dedicated to integrating everything together using ROS. High- and low-level algorithms were written in order to control the cart. Three PID control algorithms were written in order to guarantee accurate and precise movement.

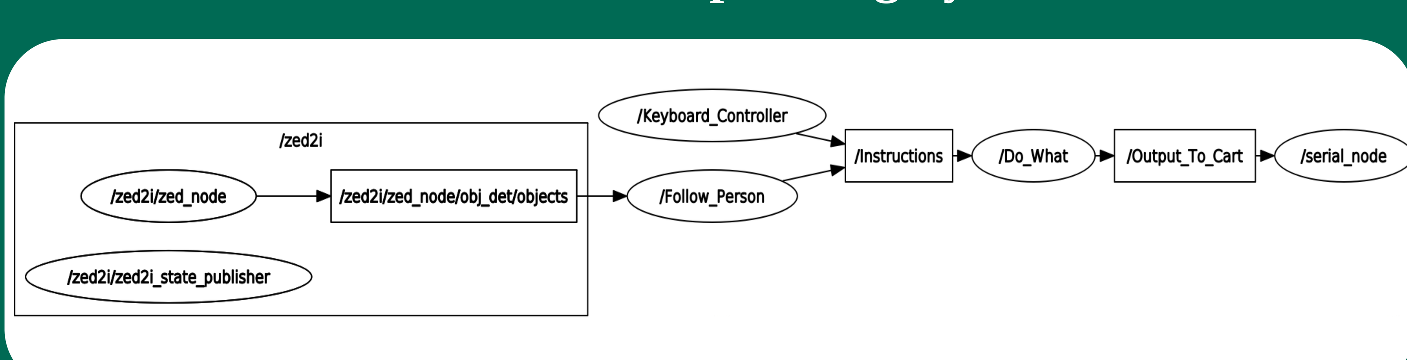


Prototype



Small-scale cart model used for initial testing and research. The prototype was designed in Fusion 360 and then 3d printed. MATLAB was then used to test various parts of an autonomous vehicle such as GPS, IMU, Encoders, disparity maps, and object detection.

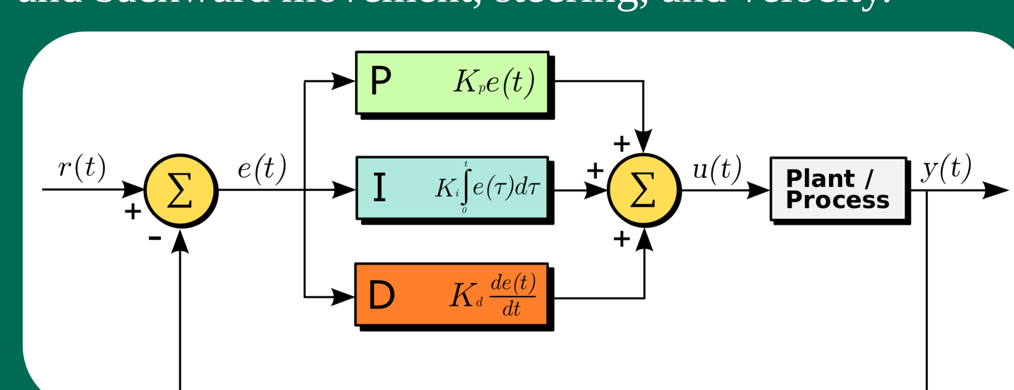
Ros – Robotic Operating System



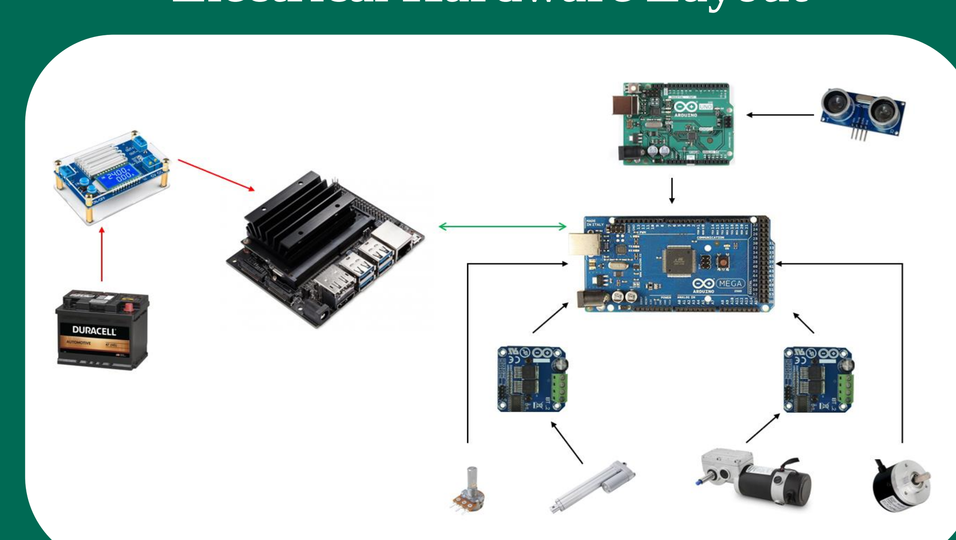
- Open-source software development platform.
- Accurate and precise simulations
- Thousands of tools and libraries
- Seamless integration between software and hardware
- Runs on light operating systems such as Linux

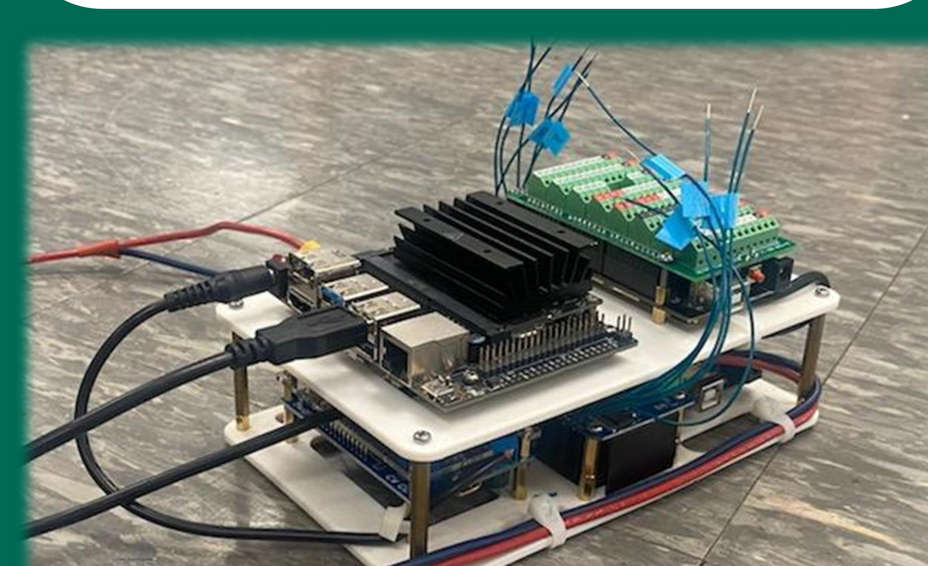
PID – Controls

Contains 3 separate PID control algorithms for forward and backward movement, steering, and velocity.



Electrical Hardware Layout





Results:
We were able to successfully build and design an autonomous cart capable of following and assisting workers as they pick. The cart chassis and electronic infrastructure were designed and fabricated from the ground up, solving many unique design challenges. High- and low-level logic algorithms were written giving the cart the ability to safely follow workers. Lastly, ultrasonic distance sensors were added for safety to prevent the cart from bumping into anything.

Conclusion:
All goals set for the autonomous nursery cart were reached. Not only were we able to successfully build a nursery cart capable of following workers but we built the foundation for future senior design groups. We will be giving future senior design groups all the information they need in order to recreate the autonomous nursery cart and offering help every step of the way.

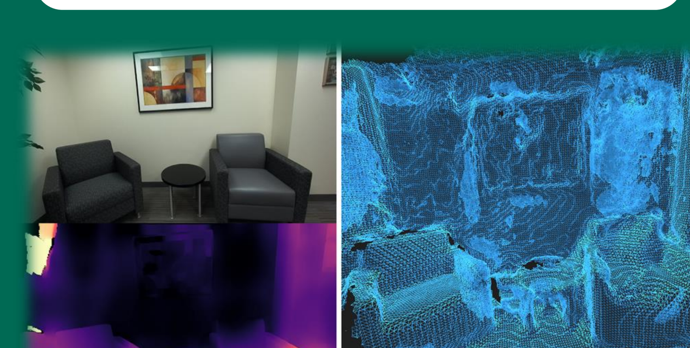
Future Improvements

Future improvements include making the cart fully aware of its surroundings so it can understand its environment and reacting accordingly. The cart can also be redesigned and refined to be a production model. Many parts of the cart need to be finalized and polished before the cart would be ready for retail. Everything accomplished in this project will be offered to future senior design groups giving them the ability to make multiple future improvements.

Computer Vision

The Zed 2 stereo camera uses both of its imaging sensors to triangle the distance of any object within a 20-meter distance and 120° FOV. We can use the depth information to create disparity, occupancy, and environmental maps as the cart drives around.

Another key component for this project to be successful is to have sufficient object detection and Semantic segmentation. Object detection requires accurate data of an object's position and coordinates in a plane. The ZED SDK provides seamless integration giving the user access to object detection, generating disparity maps, various sensor data and much more.



Object Detection