NYU TANDON SCHOOL OF ENGINEERING

AI4CE

Vision System For Warehouse Robotics

Kiki Yaw Sarpong

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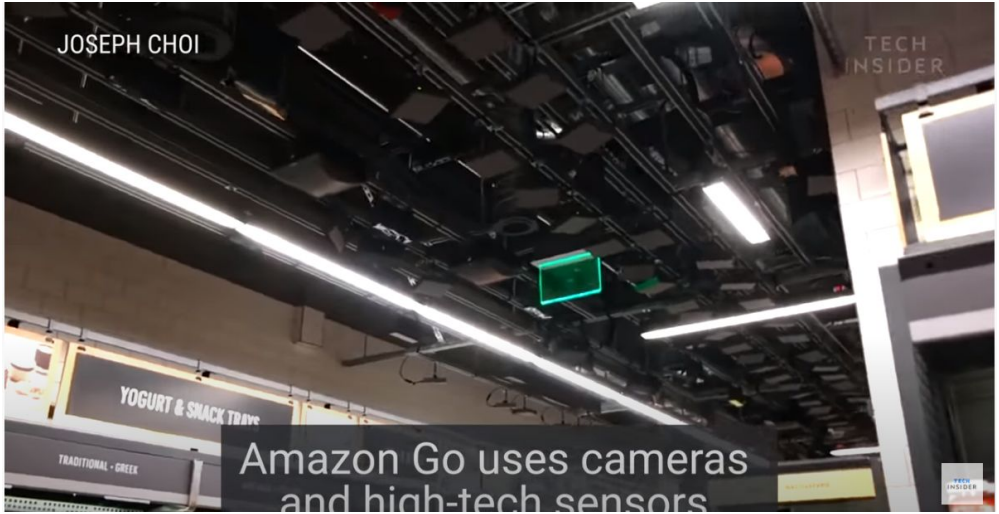
Project Inspiration

Warehouse Automation

- Automated transport makes it easier to move heavy materials from one place to another.
- Automation integration in warehouses improve worker production and efficiency.
- Decreasing robot prices have made it more appealing to invest in automation.
- Increased technological capabilities makes automation more efficient.

Project Idea

- A Centralized system using multiple cameras on the ceiling of a building to give a bird's eye view of the indoor environment.
- These images are stitched into one image and a segmentation algorithm is run to outline robot paths and obstacles.
- The segmented image is then converted to an occupancy grid and a path planning algorithm is run to provide paths for multiple robots to their respective destinations



Project Idea

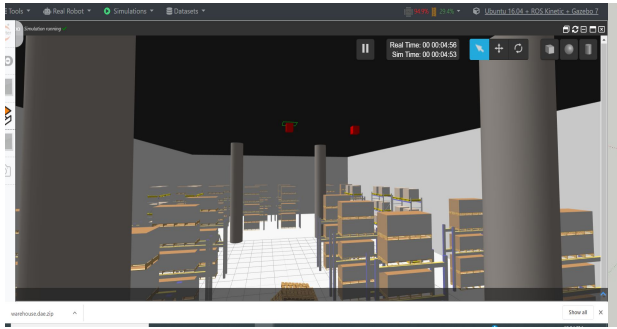
- These robots have minimal capabilities and essentially only perform actions given to them i.e in most cases just transport
- Project will be simulated on ROS and Gazebo
- This project will be great for warehouse/factory robots as well as other similar settings or environments like hotels, restaurants, supermarkets, etc because it relies heavily on a certain type of closed environment.

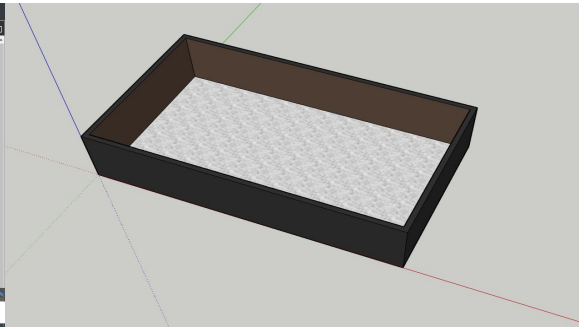
Final Deliverables

- Multiple warehouse/factory models for simulation
- Multi-camera structure for viewing overall indoor environment
- Fisheye camera research and implementation instead of regular cameras if possible
- Image stitching of multi-camera images to create a single birds eye view of entire indoor structure
- Path segmentation to create paths for multiple ground robots.
- Path planning for robots to move materials from one place to another.

Project Details

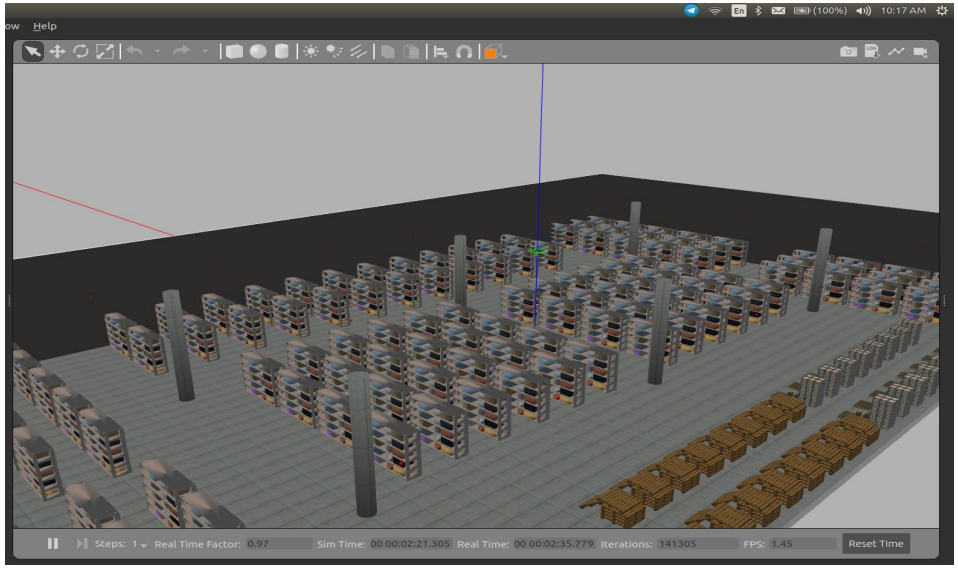
Designing warehouse





Project Details

- Redesigned and improved the warehouse model, including more warehouse-related materials to give the environment more realism making the coding more robust to different features

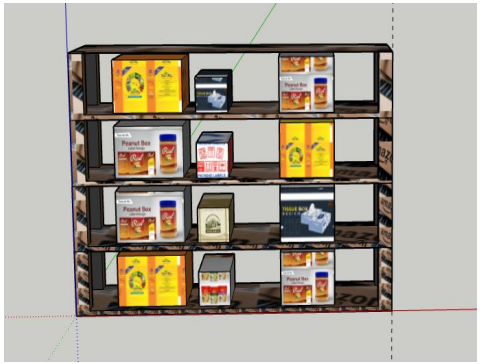


Project Details

Design details:

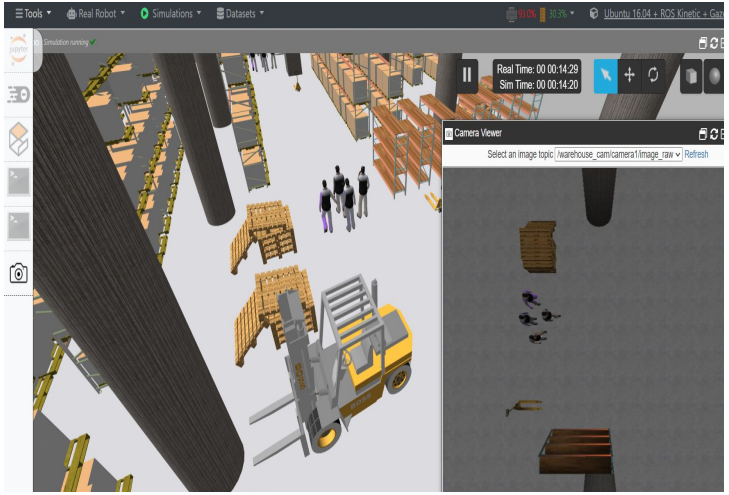
1. Warehouse was designed on “Sketchup” (online design platform) and spawned in Gazebo via a collada file (.dae)

2. Individual warehouse components created in sketchup were also spawned in Gazebo and repopulated using gazebo tools



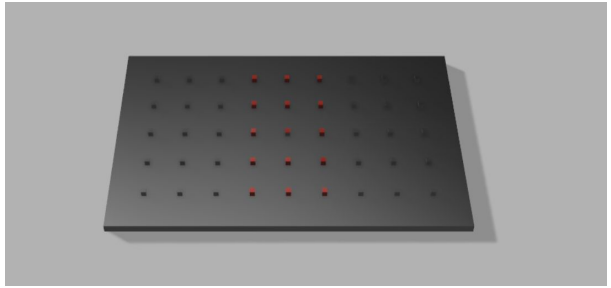
Design challenges:

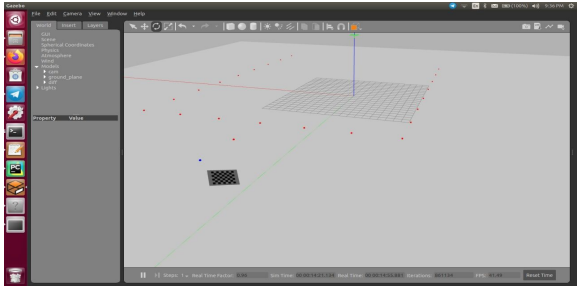
1. Repetitions of the same model created in sketchup and spawned in Gazebo could not be seen through the image viewer.

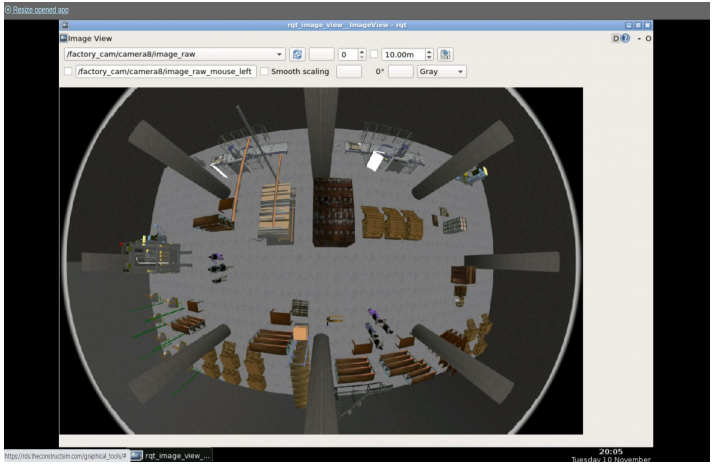


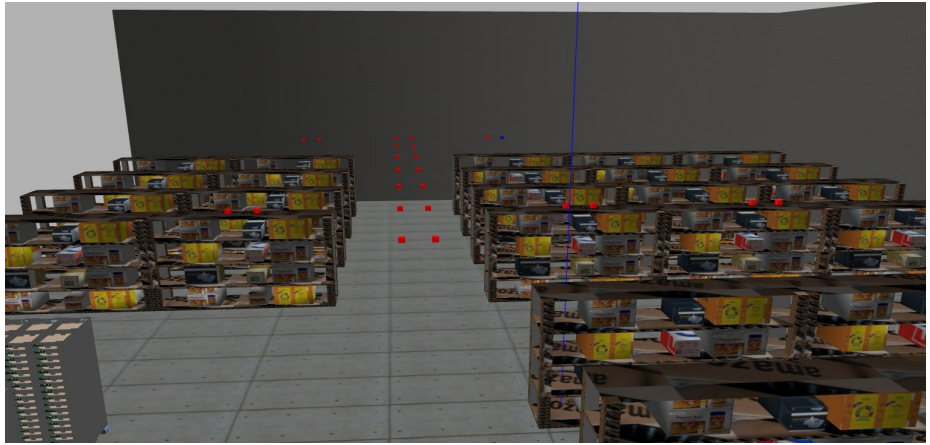
Project Details

Camera setup iterations and fisheye camera implementation









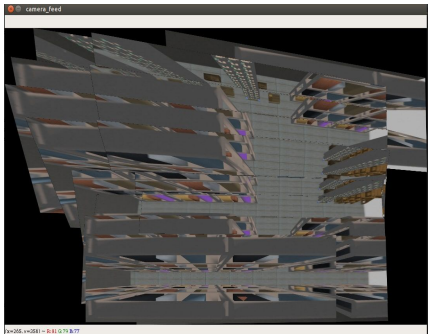
Project Details

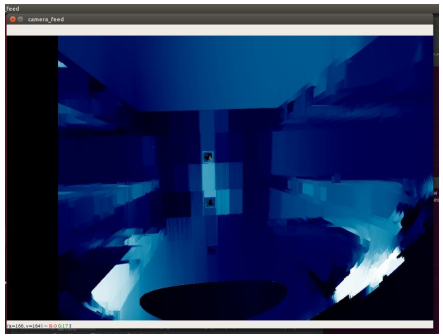
Camera details:

1. Regular camera FOV is 80-85 degrees
2. Fisheye camera FOV is 175-180 degrees
3. Camera separations between regular cameras was about **5m** and **10m** for fisheye cameras.
4. Camera separations for stereo was **50cm** between cameras **3m** for every stereo pair
5. 12 pairs (24 cameras total)

Camera challenges:

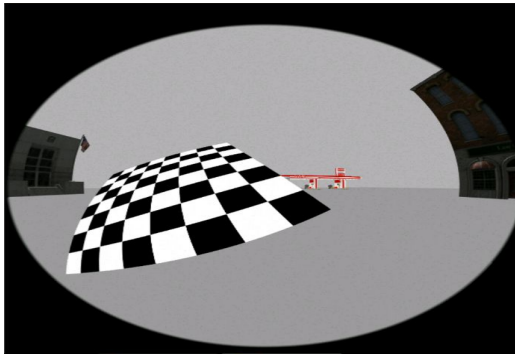
1. Fisheye cameras don't give good stitches or stereo
2. Regular camera FOV can't cover larger spaces hence more cameras are needed

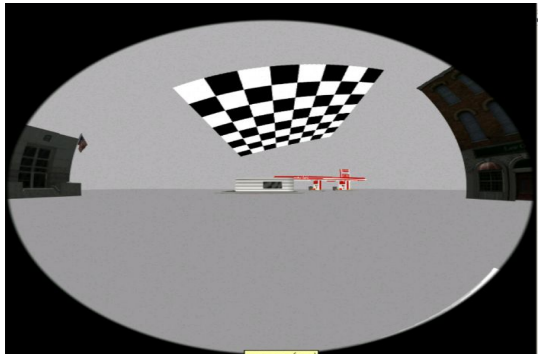


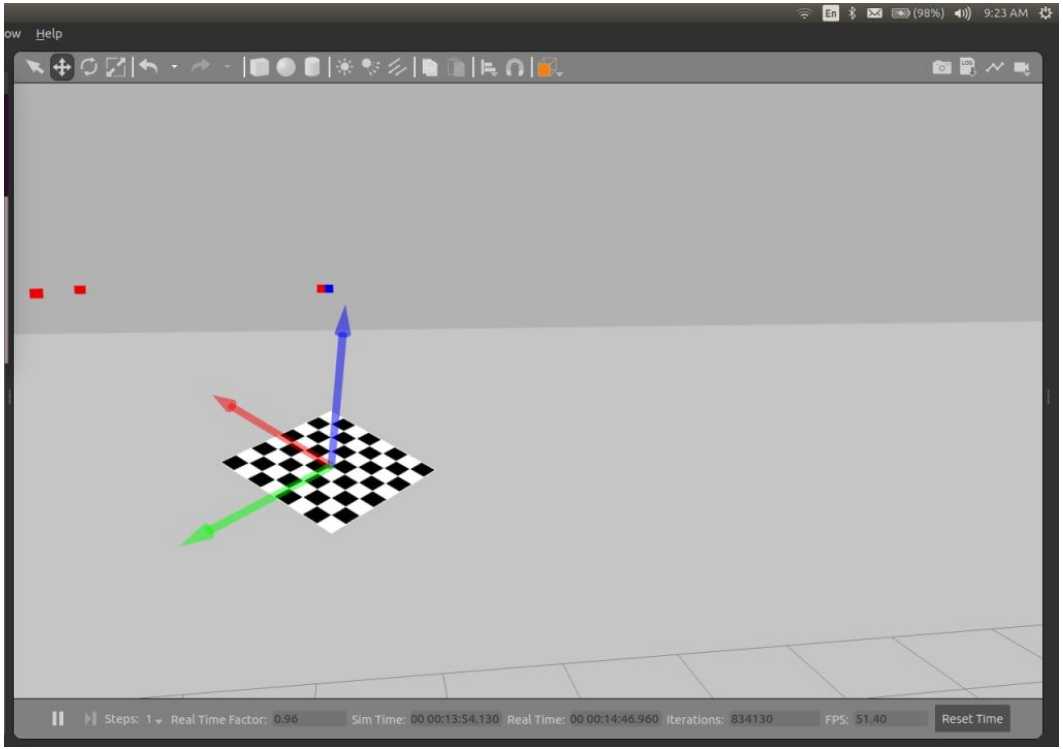


Project Details

Calibration process







Project Details

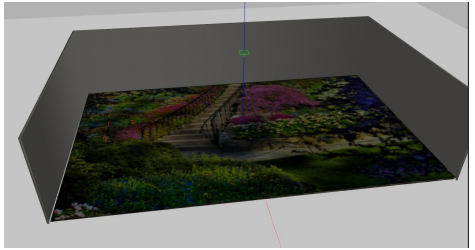
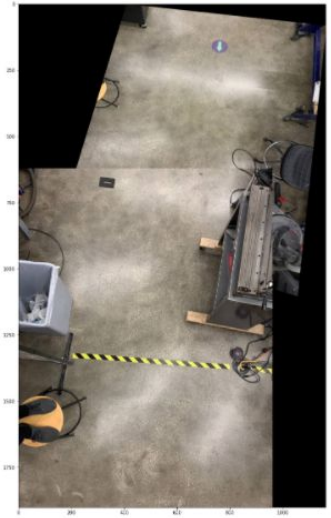
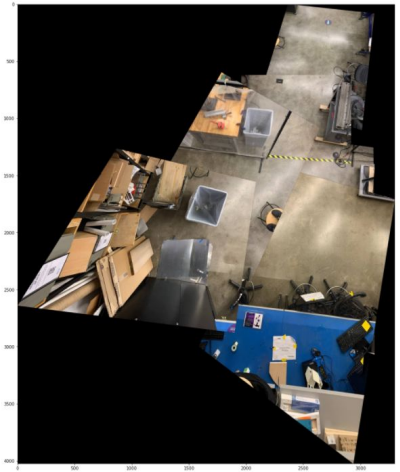
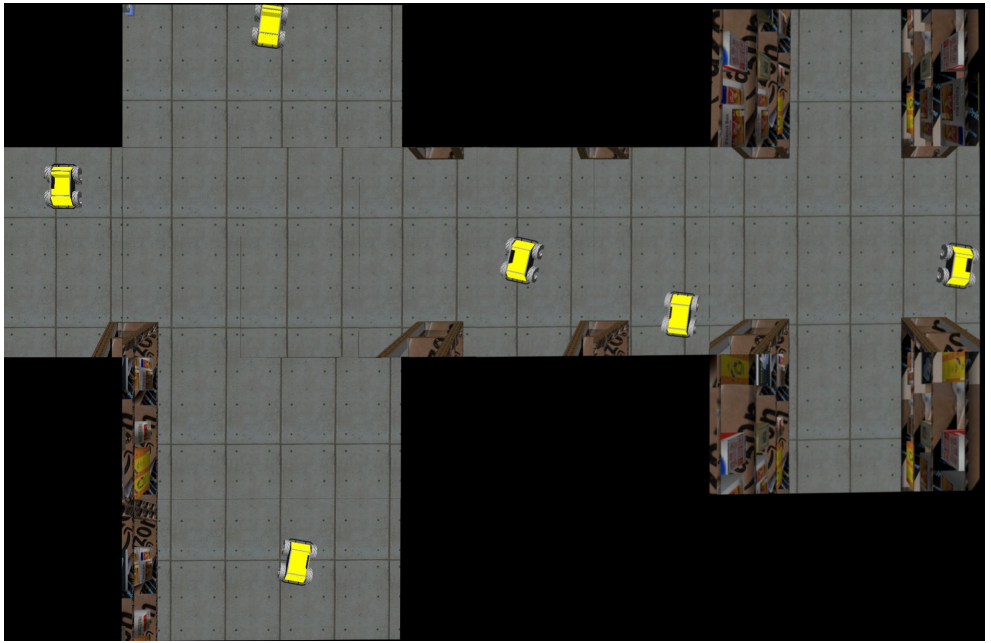


Image Stitching

- Images are continuously stitched together to obtain a full bird's-eye view of the environment.



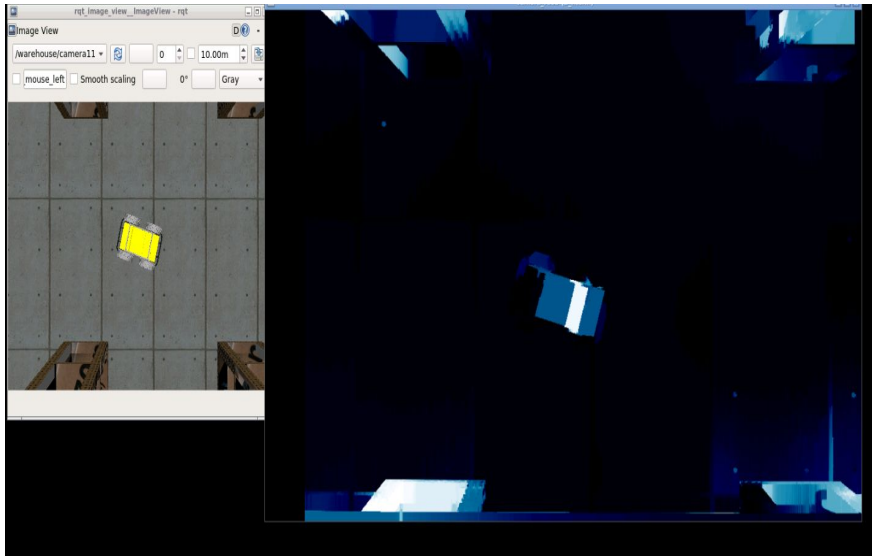


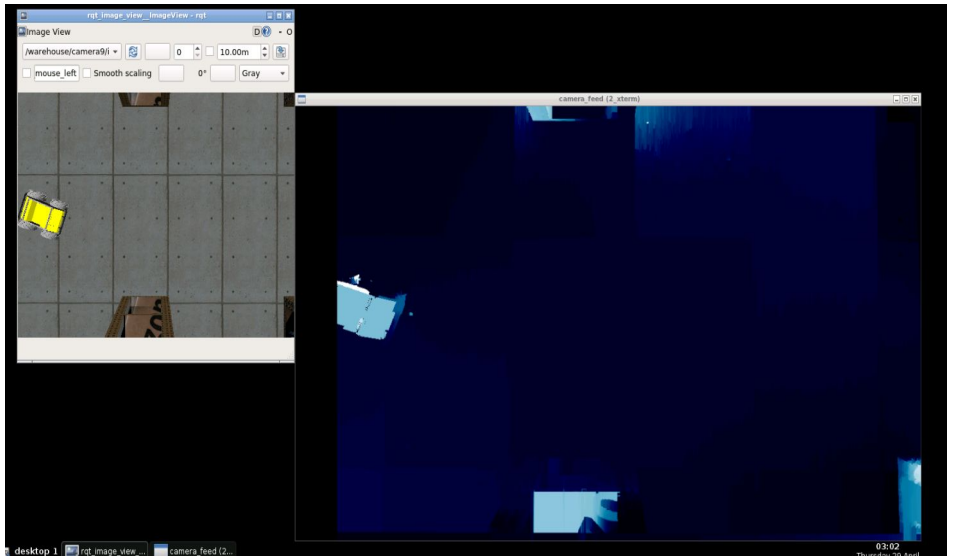


Project Details

Stereo-Imaging

- Two cameras used for stereo imaging with a 50 cm spacing.
- Stereo Image depth map segmented by color density; Brighter colors indicate closer objects.
- Images are segmented based on depth to outline clear paths





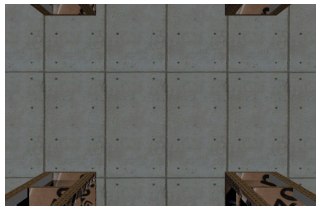
Project Details

Stereo-Imaging

- Segment image based on depth to get traversable paths



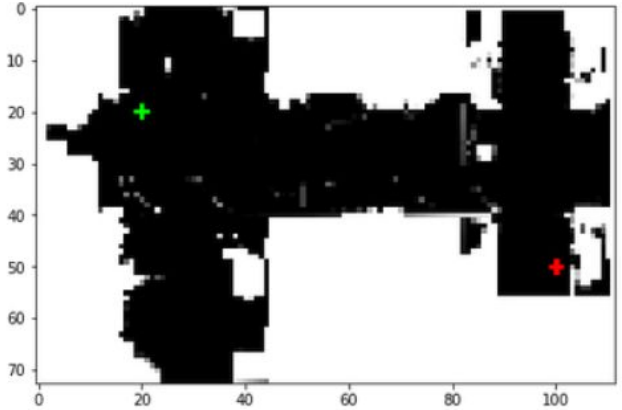



Project Details

Path planning

- Convert image to grayscale and reduce dimensionality
- Ran A* search



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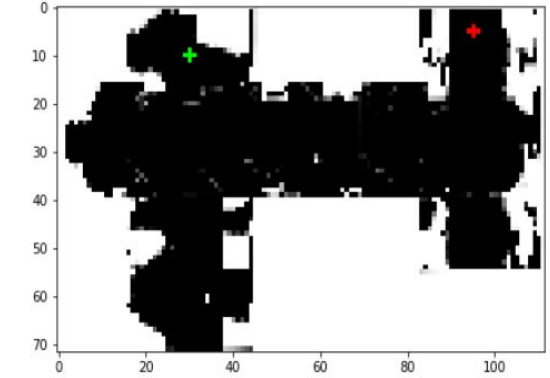

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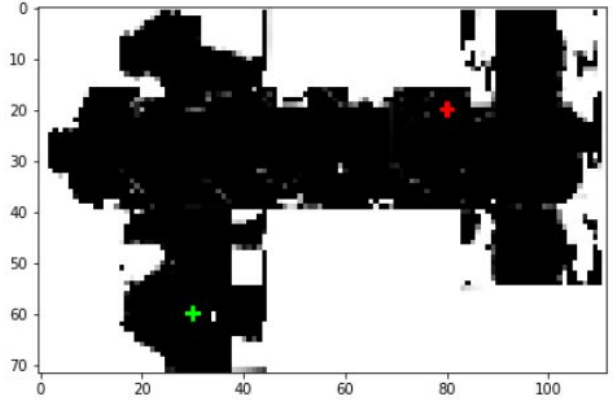
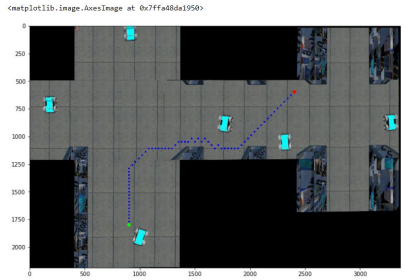
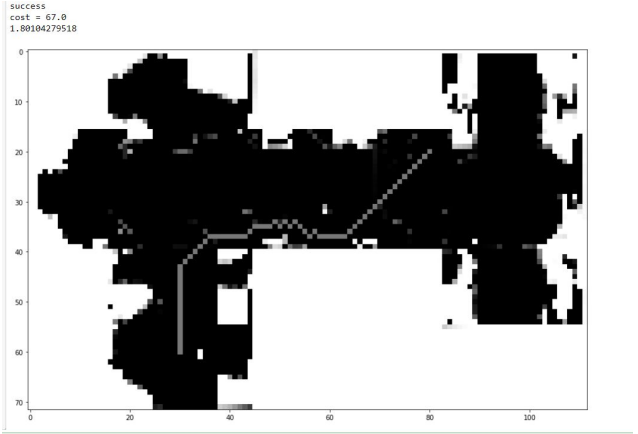


Project Details

Path Planning

- Upscale image and plot path.

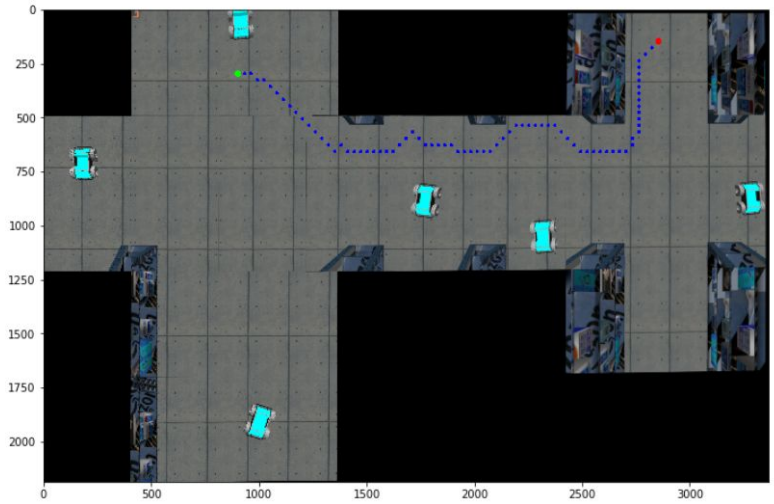


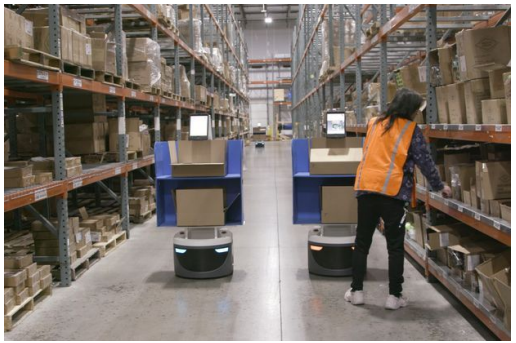


Project Details

Final model Improvements

- Noise reduction
- Constraining path planning.





Summary

Project Benefits (Preferred career industry: Autonomous driving)

- Mobile robotics simulation experience (ROS & Gazebo)
- Multi-view Geometry
- Computer vision /Image processing
- Stereovision
- Path planning

QUESTIONS?