



# Centralized System for Indoor Path Navigation

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# Project Inspiration

## Factory/Warehouse Automation

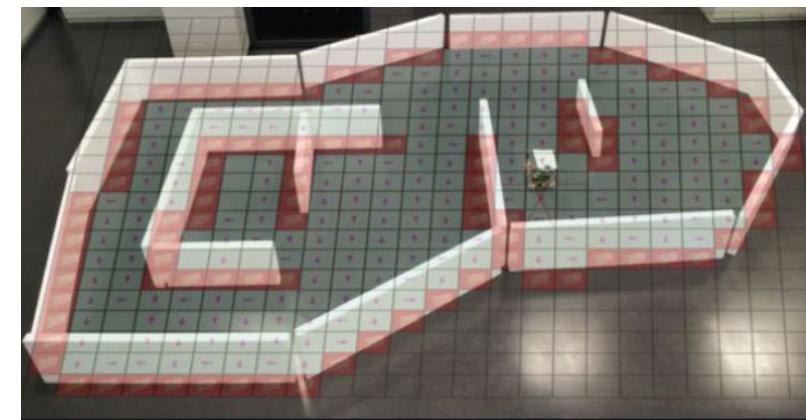
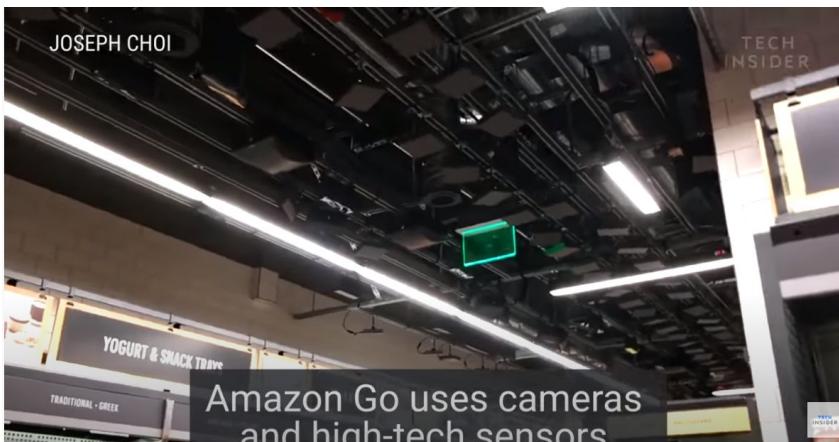
- Automated transport makes it easier to move heavy materials around
- Automation integration in warehouses improve worker production and efficiency
- Decreasing robot prices have made it more appealing to invest into automation





## Project Idea

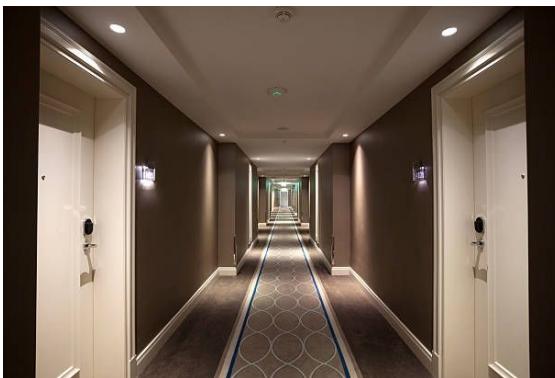
- Centralized system using multiple cameras plastered on the ceiling of a building to give a birds eye view of the indoor environment.
- These images are stitched into one image and a segmentation algorithm is run to outline robot paths and obstacles.
- The segmented image is then converted to an occupancy 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.





## Fall Semester Deliverables

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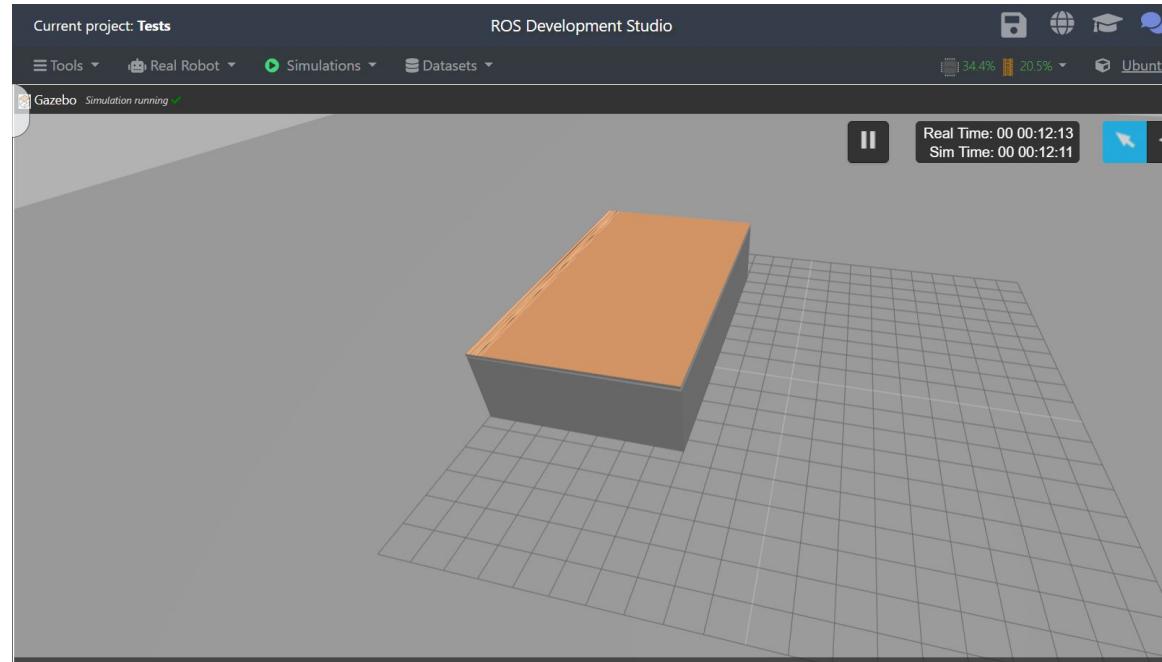
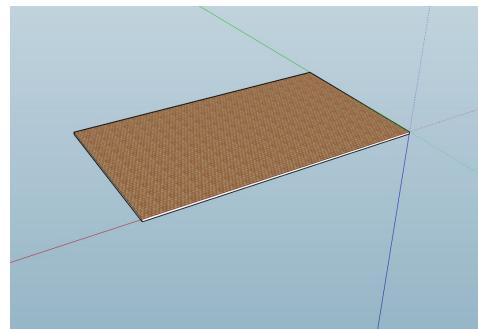
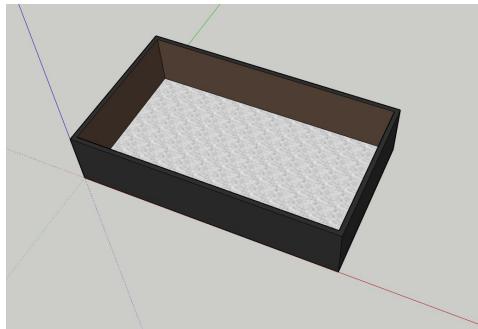
- Multiple warehouse/factory models for simulation
- Multi-camera structure for viewing overall indoor structure
- Fisheye camera research and implementation instead of regular cameras if possible
- Image stitching of multi-camera images to create a single birds eye view of entire indoor structure
-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



# Project Progress

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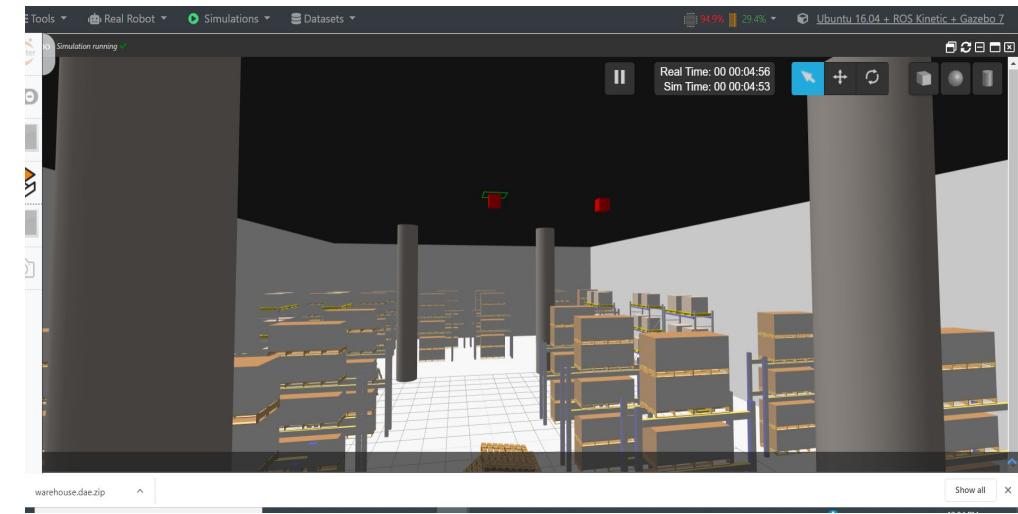
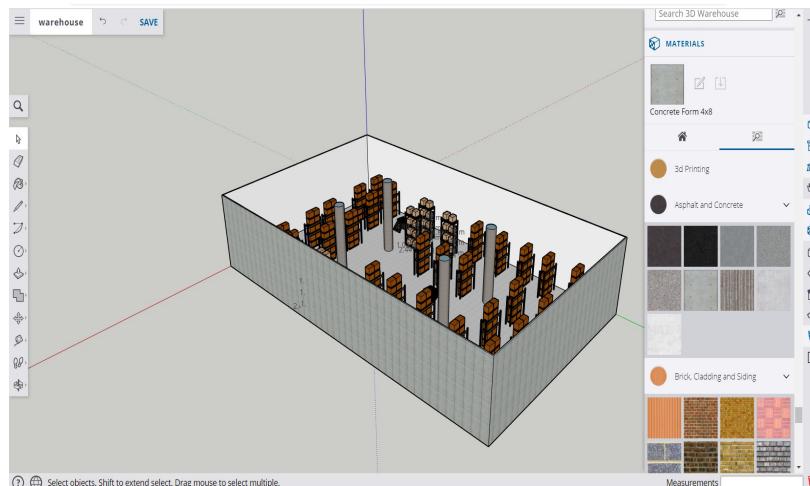
- Base models of the factory/warehouse are designed in sketchup and imported into gazebo to be spawned





# Project Progress

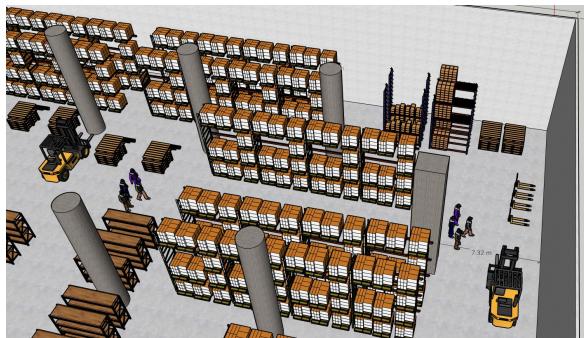
- Built a simulation of a warehouse complete with pallets, pallet racks, etc to gain a better analysis of multi-camera organization and structure in perceived environment.
- Successfully spawned warehouse model in gazebo and created camera plugins to obtain different images
- Camera model: 80-90 degrees FOV
- Warehouse model: 30 x 50 meters





# Project Progress

- 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 Progress

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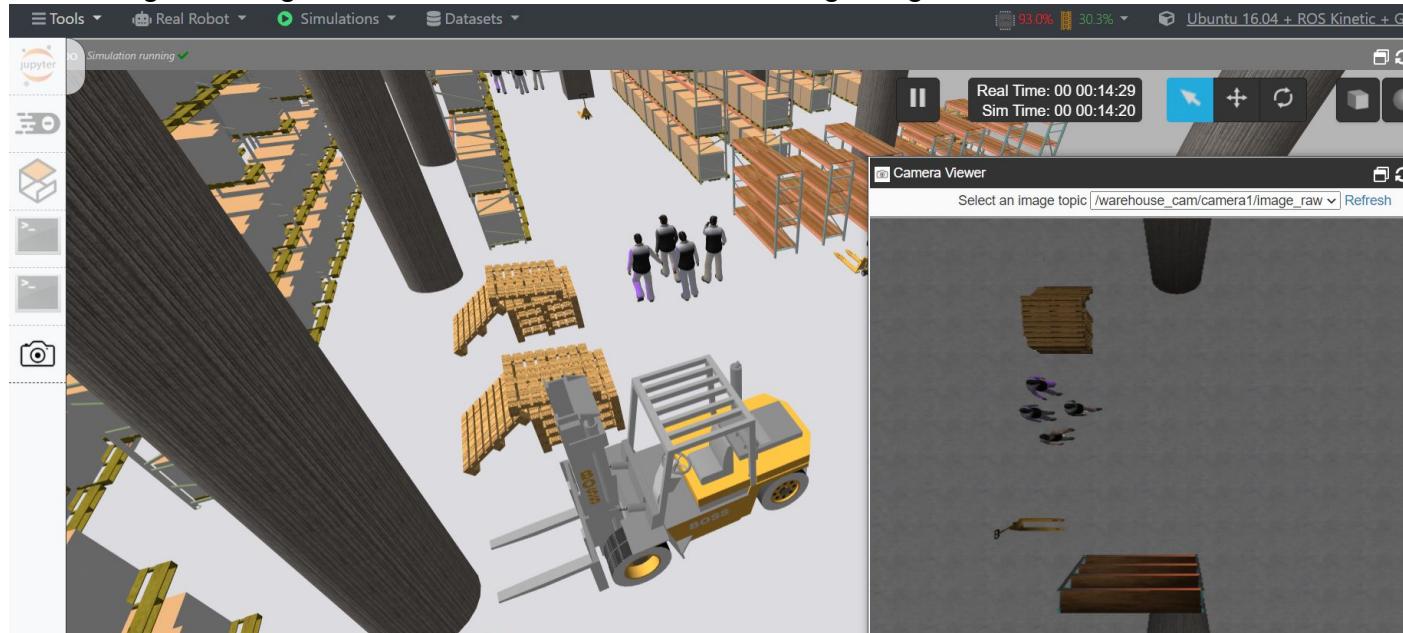
- Increased camera total to 15-grid like camera with 5m spacing between each. Estimated camera count for regular monocular cameras without wide-angle lens in a 30m x 50m warehouse is 45 cameras.





# Project Problems

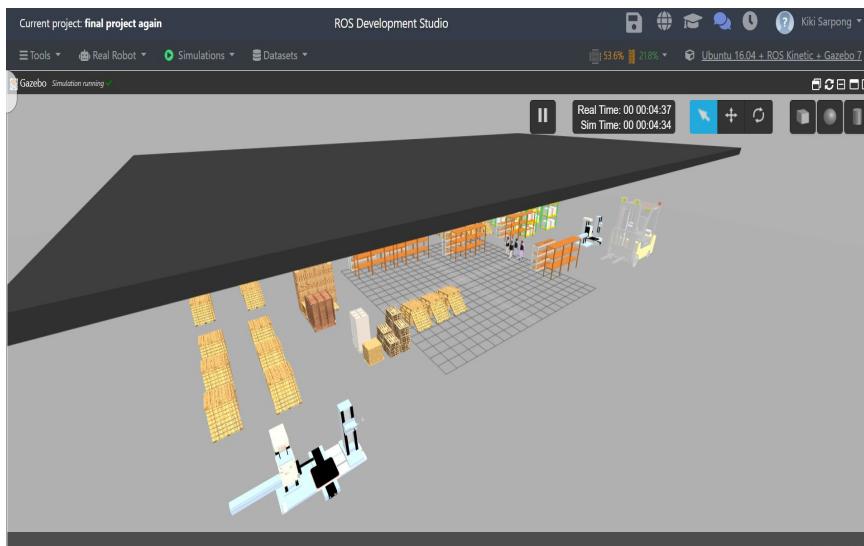
- Certain parts of the model were not visible in the camera image because multiples of the same model from sketchup could not be spawned in gazebo for an unknown reason
- Reducing the excessive amount of cameras being used to cover the warehouse/factory
  - Using wide angle lens to increase FOV and cover larger regions





# Project Progress

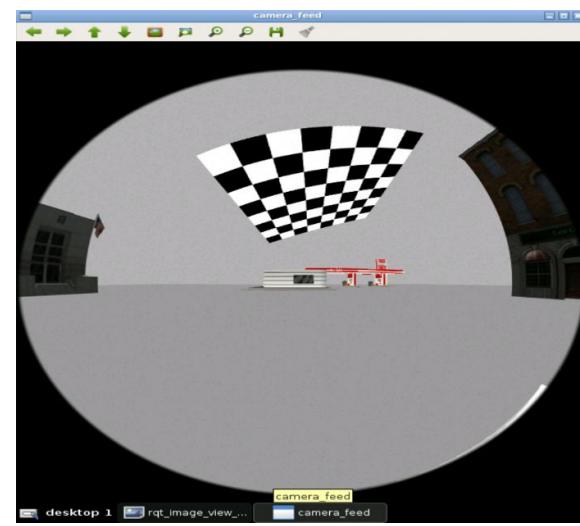
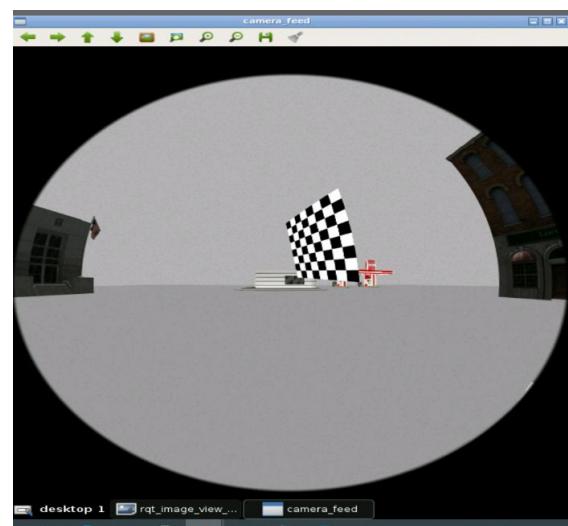
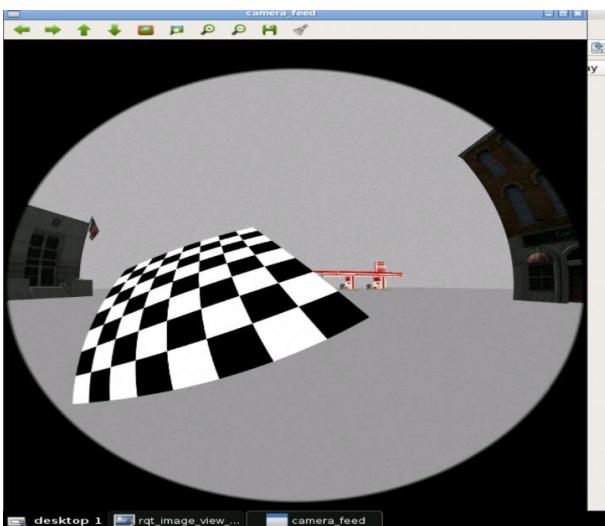
- Missing model in camera image solution: To populate warehouse with different warehouse components by independently retrieving single models from sketchup and spawning in gazebo
- Empty warehouse model not visible in gazebo but visible through camera view





# Project Progress

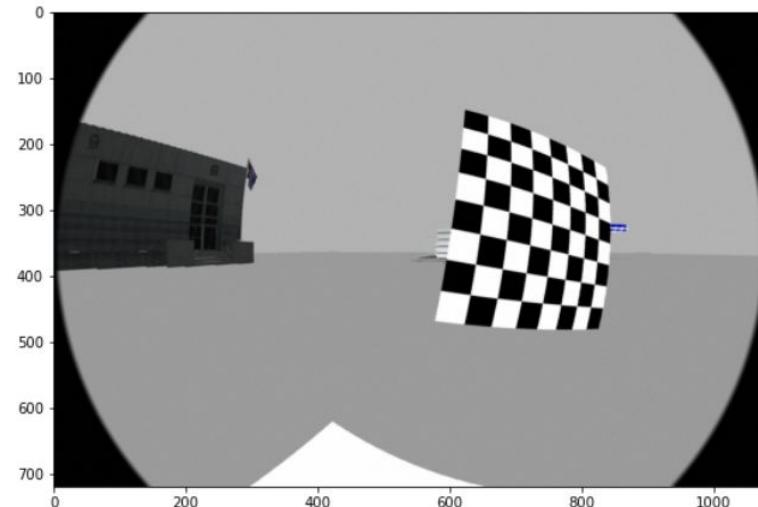
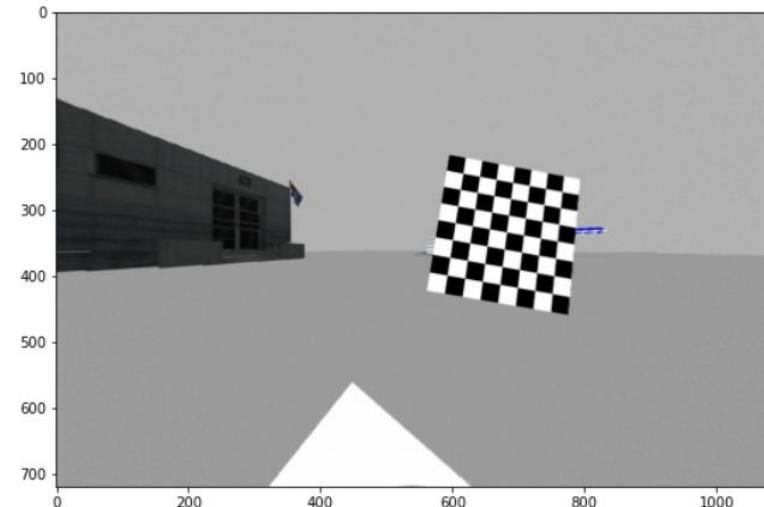
- Begun working with fisheye cameras
  - Fisheye camera calibration and undistorting images





# Project Progress

- Applying intrinsic parameters to undistort images and retrieve full image
  - 30% of original image is lost if additional functionalities are not applied

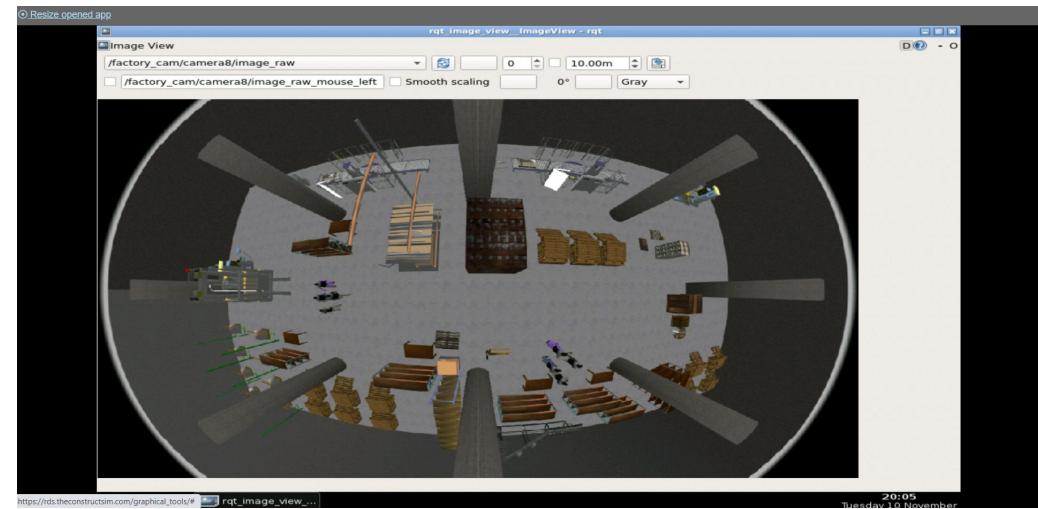


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# Project Progress

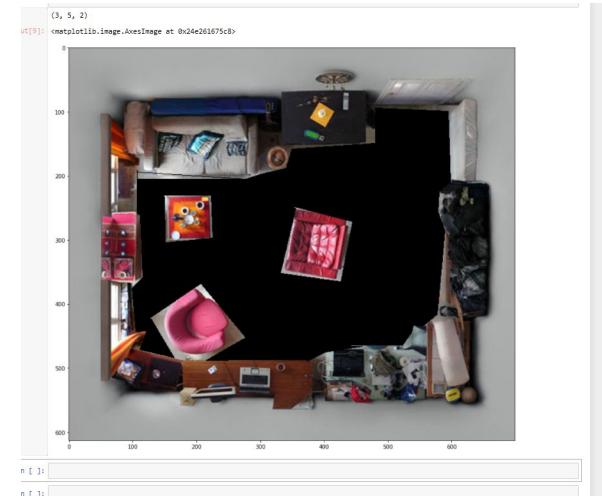
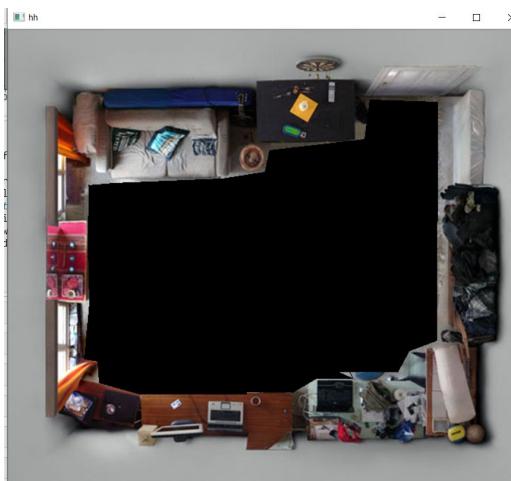
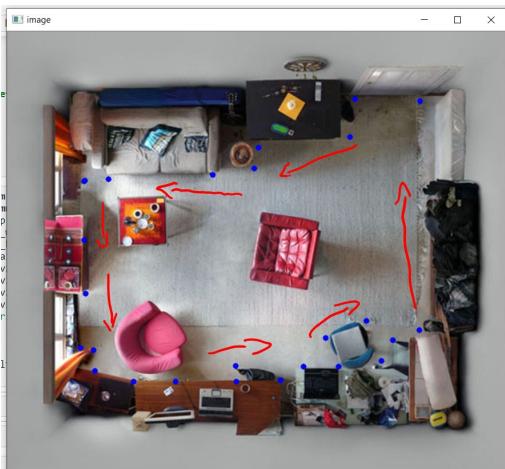
- Implementation of fisheye cameras
  - Changed all factory cameras to fisheye cameras
  - 15 fisheye (**FOV:175° - 180°**) cameras cover the whole 30m x 50m factory at 10m apart compared to 45 (**FOV: 80°**) regular cameras needed at 5m apart.





# Project Progress

- Path Segmentation
  - path segmentation for occupancy grid to generate robot pathways





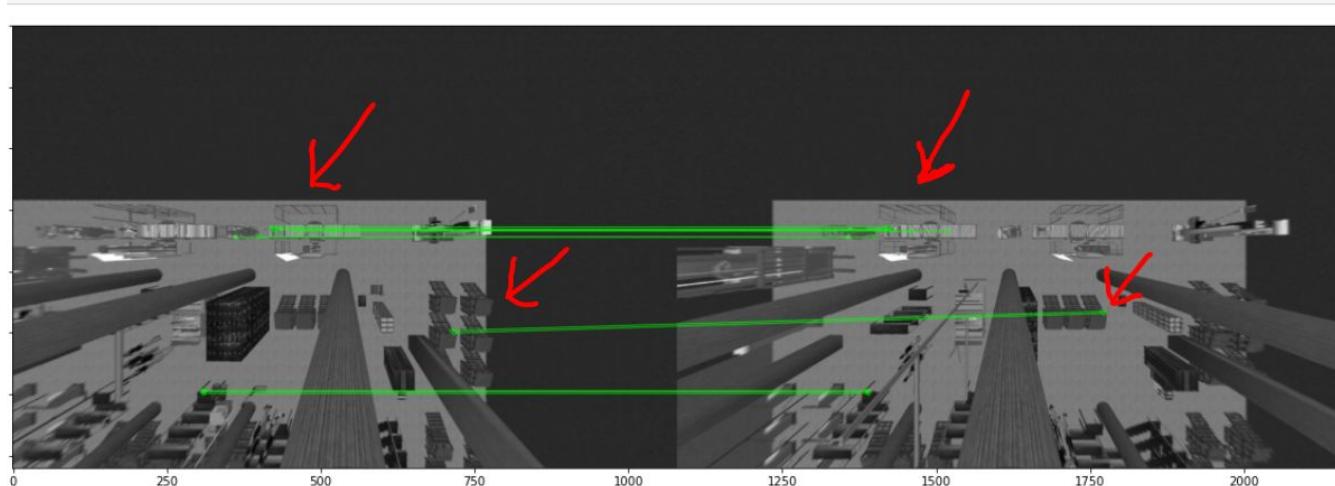
# Project Progress

## • Image Stitching Problems

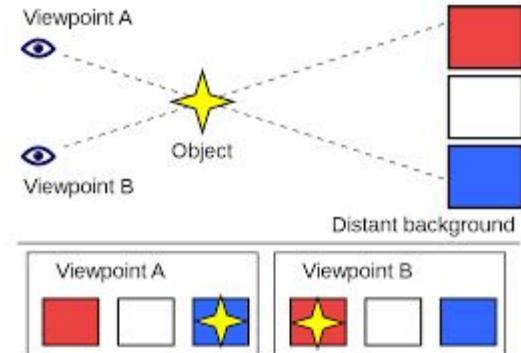
- Used both the ORB and SIFT feature detection to find the best features
- Also tried both the Brute force matcher as well as the KD tree.
- Working on adjusting parameters to cv2.RANSAC, feature matches aren't robust and a lot of wrong features are being passed as inliers.



Plane induced parallax



Parallax

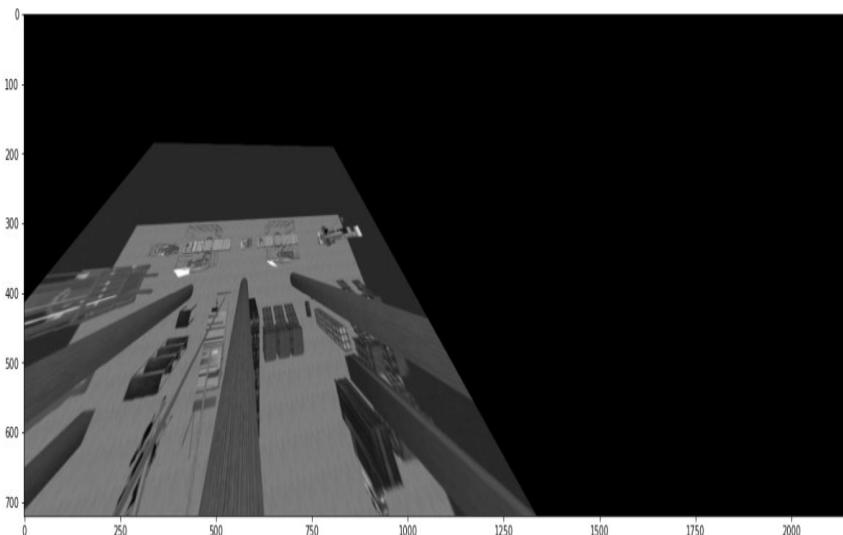




# Progress Report

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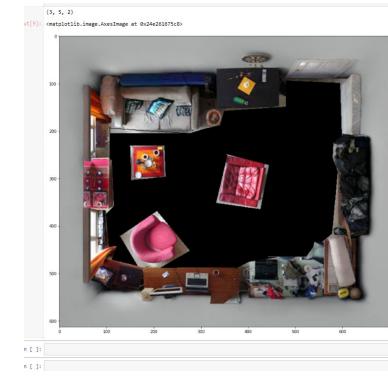
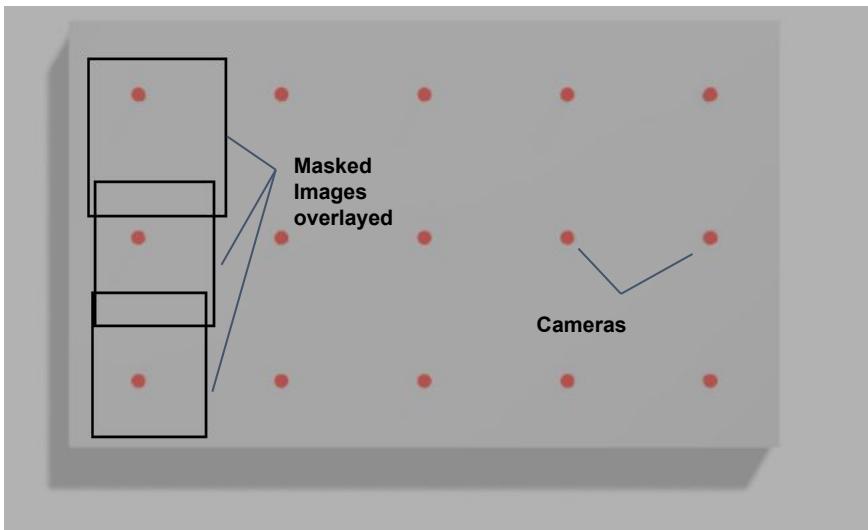
- Image Stitching results due to error
  - Image stitching tests with two images do not look good for already stated reasons





# Progress Report

- Image stitching alternative due to occlusion in certain images
  - Create mask in all 15 images
  - Get pixel to world measurement scaling
  - Create mask overlay (easier to update maps compared to full image stitch)
  - Cameras need to be on the same plane with no rotation.





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# QUESTIONS?