

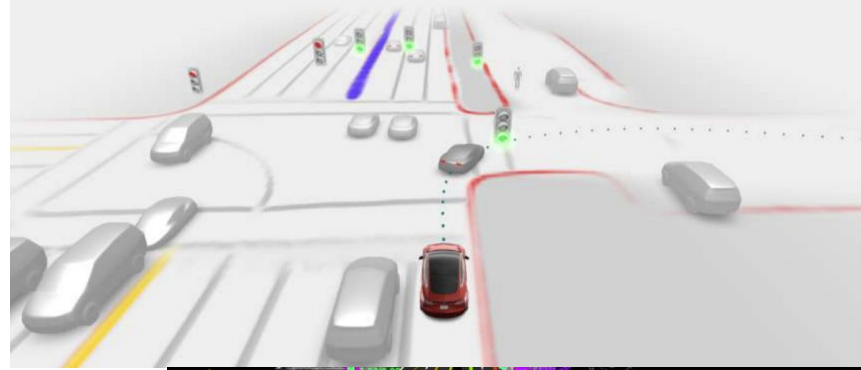
Smart Intersection Cameras

Heneil Patel, Eleonore Pichon, Peter Wilmot

This work was supported in part by the NSF REU program and the donation from nVERSES CAPITAL

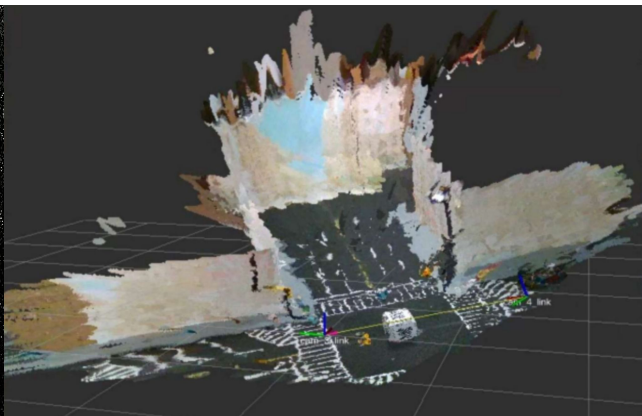
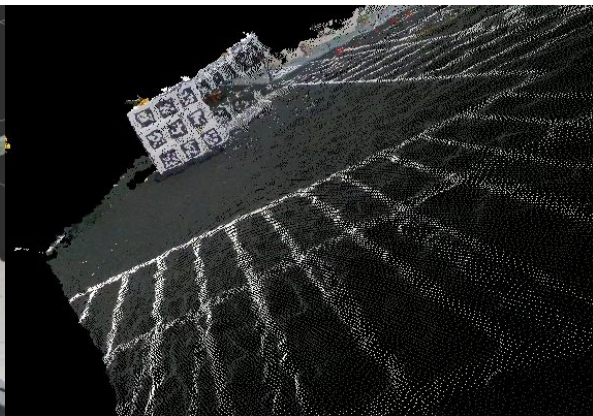
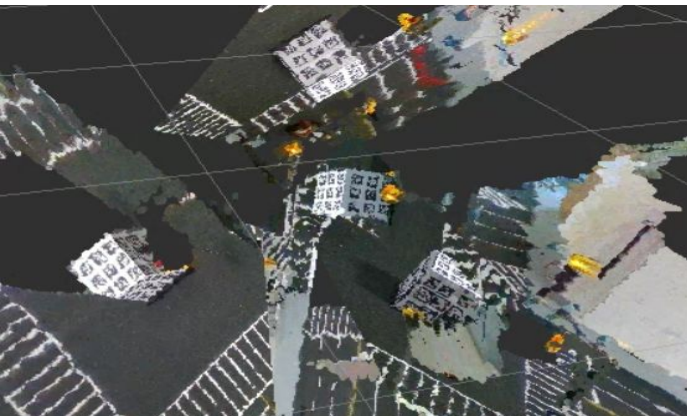
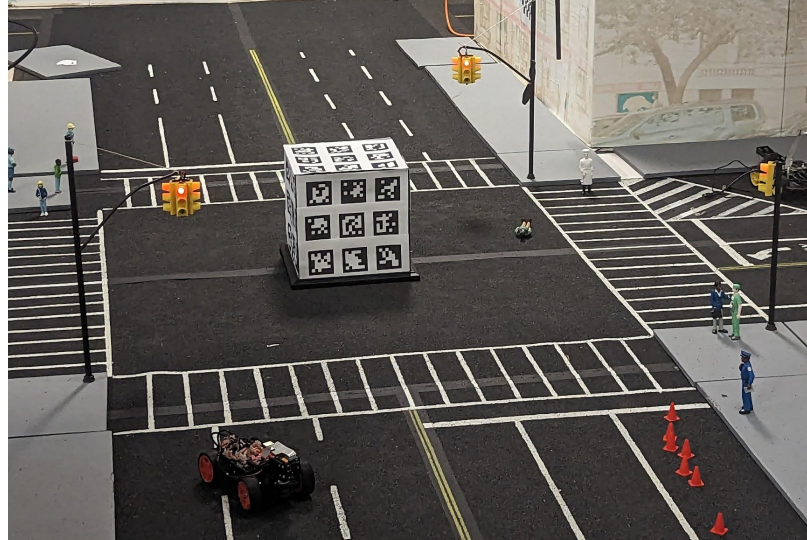
Project Inspiration/Idea

- Create a 3D model of an intersection
- 3D cameras on each corner
 - More coverage
 - 2D can only see front of object
- Why?
 - Detailed traffic/pedestrian info
 - Send details to smart cars
 - Allows “sight” around a corner/blockage
 - Allows for advanced tracking/prediction



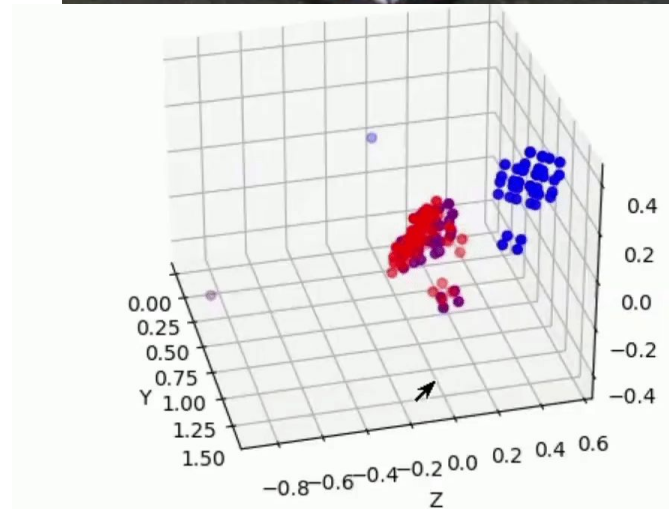
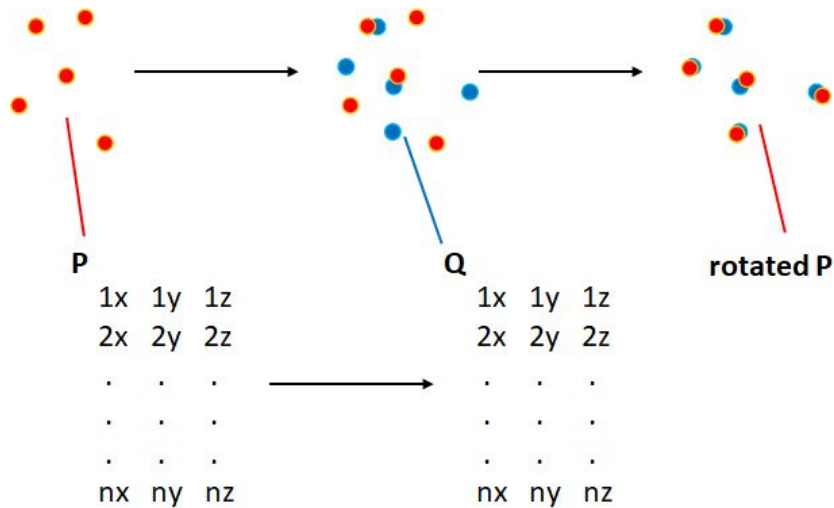
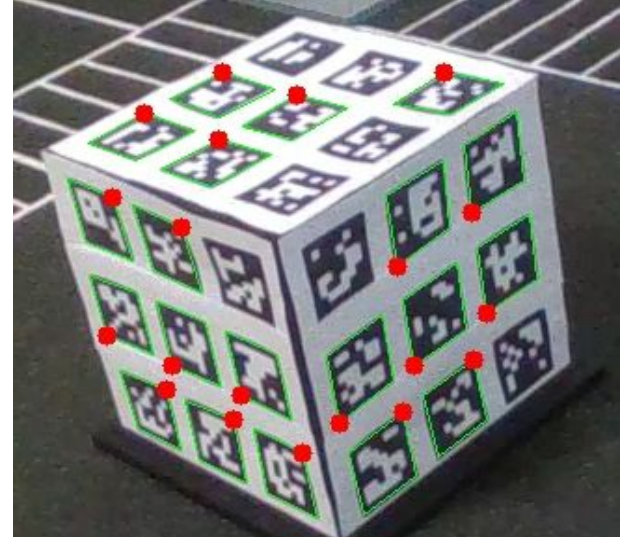
Project Methods/Equipment

- Stitch multiple point clouds together
 - Cosmos scale intersection
 - Intel RealSense D415 Depth Cameras



Aruco Markers

- OpenCV
- 3D point projection
- Kabsch Algorithm

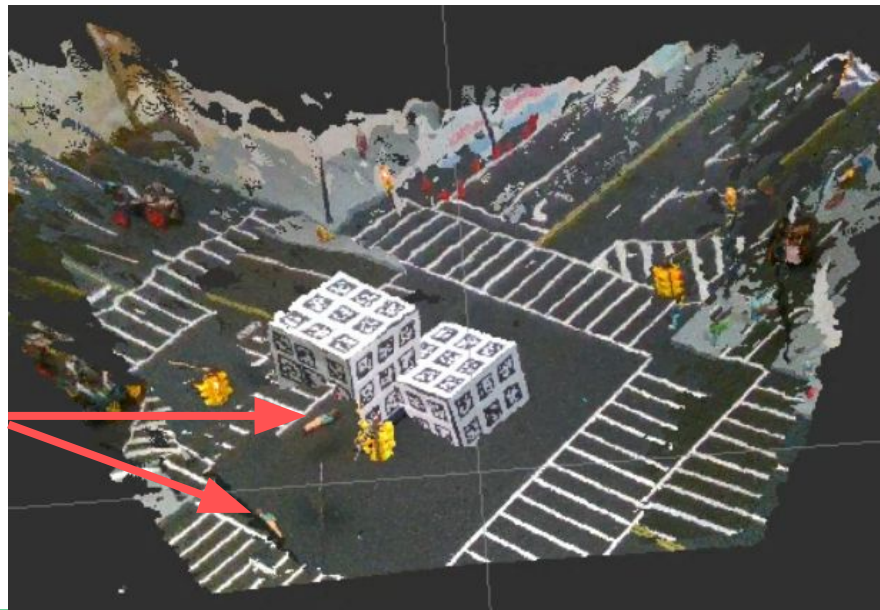


ROS/Rviz

- Allowed for easy streaming
 - pre-configurations for realsense camera
- Many pointcloud viewer options
- Inconsistent transformations
- Time/Resource consuming to install

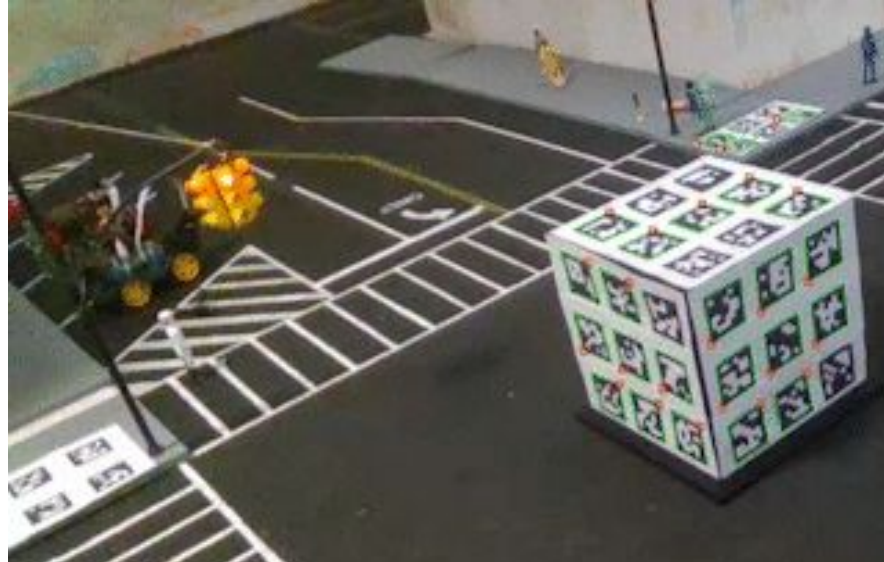
Worse than it looks

90 degree rotation



Improving Marker Detection

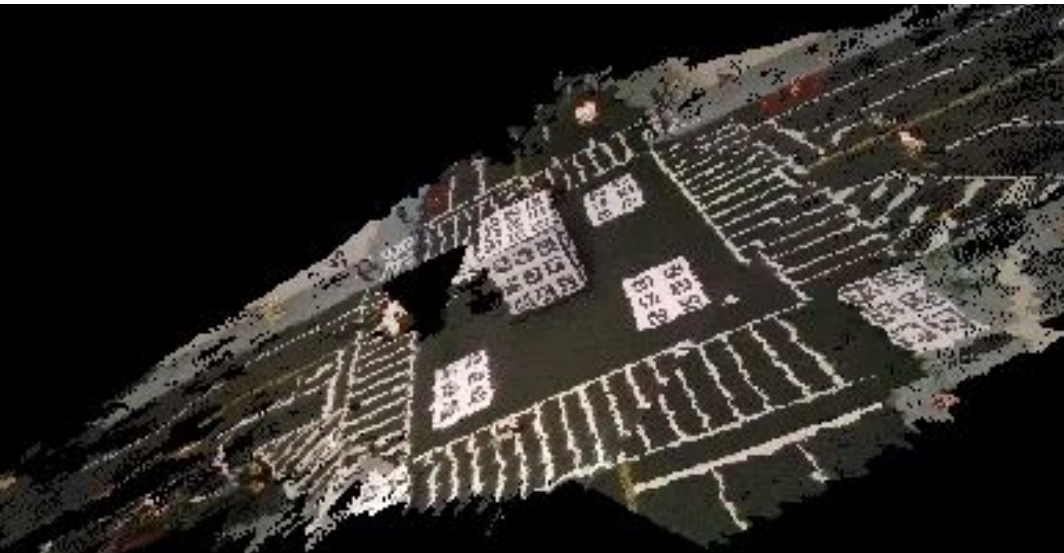
- Different markers detected each frame
- Our solution:
 - Cache markers from last frame
 - Challenges with data types
 - Multidimensional arrays
 - Tuples
 - Lists
 - Up to 20 marker increase



```
Markers detected this frame: 40  
Total markers detected: 54
```

More ArUco markers

- Almost perfect calibration
- Not practical for real life
 - Need realistic reference points



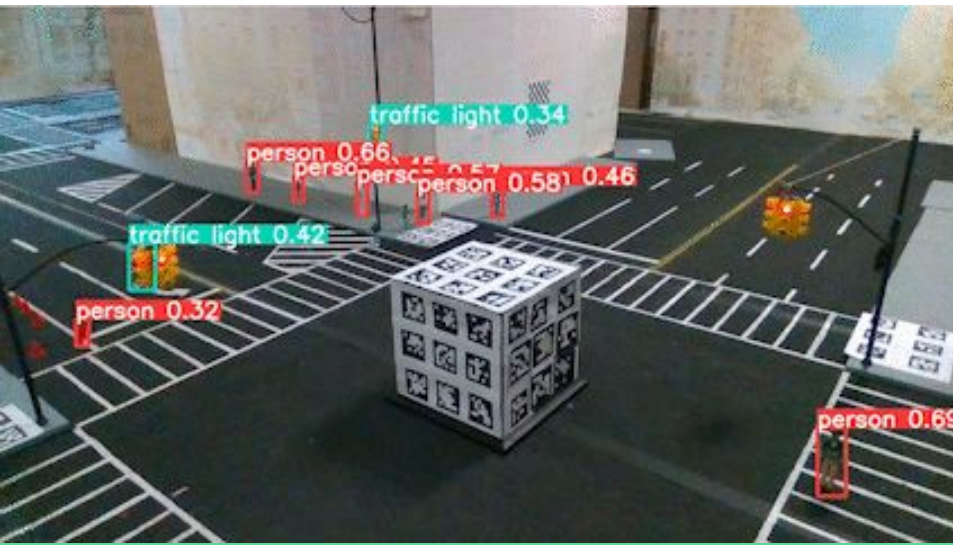
Sending multiple point cloud frames

- Loop:
 - Clients send files
 - Server downloads files
 - Viewer reads files
- Issues
 - Error when read and download same file at same time
 - Stops after few seconds of loading local and streamed files



Implementation after calibration

- Use PyTorch to analyze/modify images
 - YOLOv8
 - Deep Learning
 - Object Recognition



YOLOv8 Car Detection

- Train custom model for DIY cars
- 19 manually labeled images
- Many false positives
- Deployed on ultralytics hub mobile app
- Slower than regular YOLO (memory leak?)

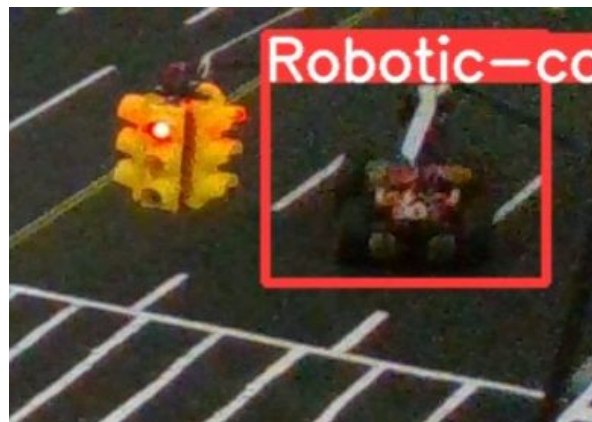
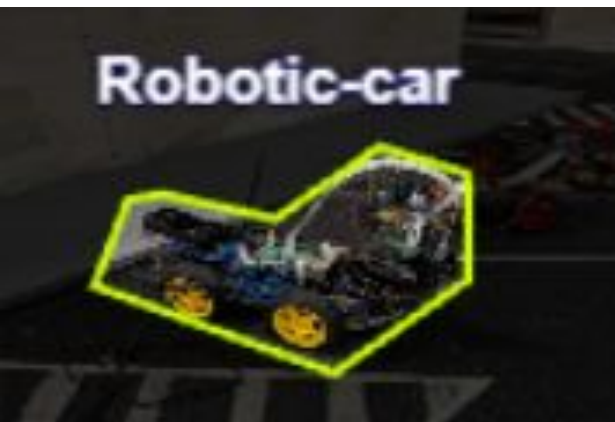
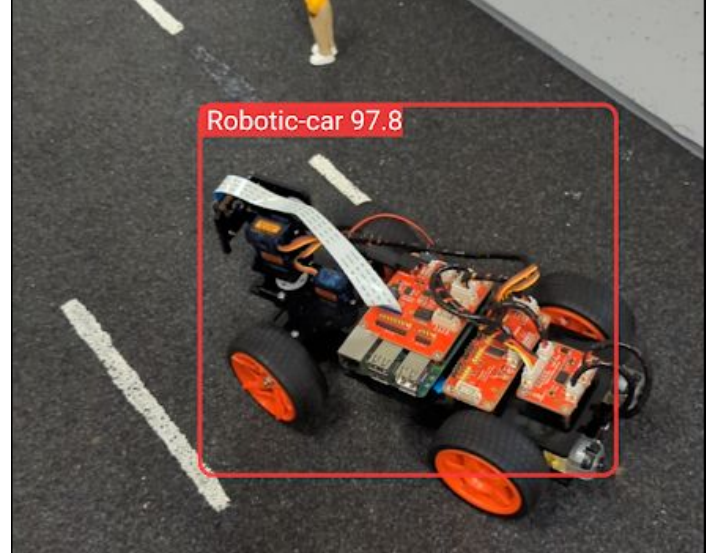


Image Segmentation

- Coordinates of segmented “mask” in 2D
- Able to draw segmentation mask independently
- Allows for 3D object mapping



```
[ 0.38594, 0.40833 ],  
[ 0.3875, 0.41111 ],  
[ 0.3875, 0.42222 ],  
[ 0.38906, 0.425 ],  
[ 0.38906, 0.43056 ],  
[ 0.39062, 0.43333 ],  
[ 0.39062, 0.43611 ],  
[ 0.39219, 0.43889 ],  
[ 0.39219, 0.44444 ],  
[ 0.39375, 0.44722 ],  
[ 0.39375, 0.45833 ],  
[ 0.39531, 0.46111 ],  
[ 0.39531, 0.47222 ],
```



Future Improvements

- Fix point cloud video viewer
 - Lock/Unlock files for receiving/reading
 - Send frames directly
 - Implement queue/buffer
- Translate masks to 3D
- Combine masks into 3D mesh or bounding box

