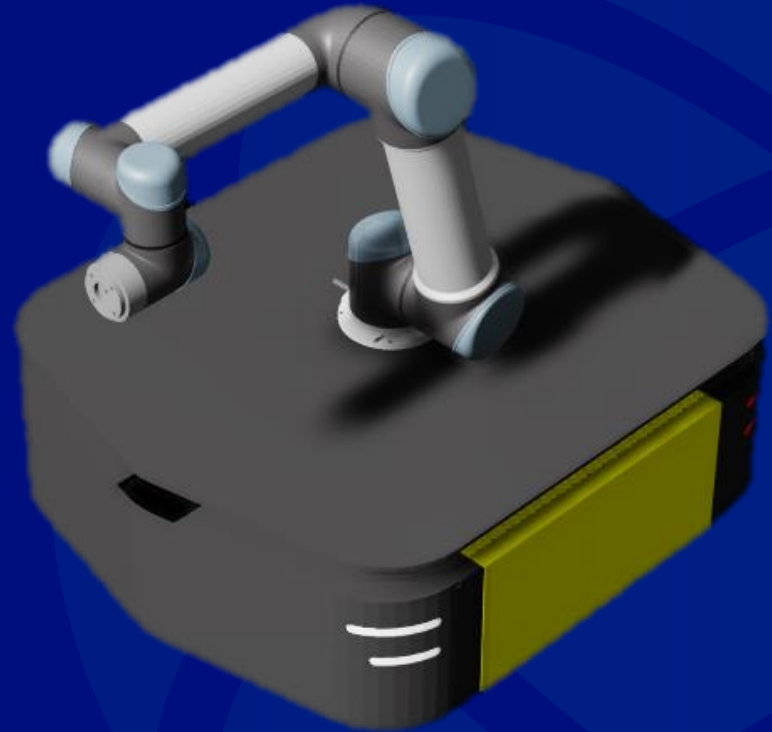


Automation in Material Inspection and Handling

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Introduction

Integrating two different types of commercial robots to demonstrate capabilities in automated material inspection and handling.



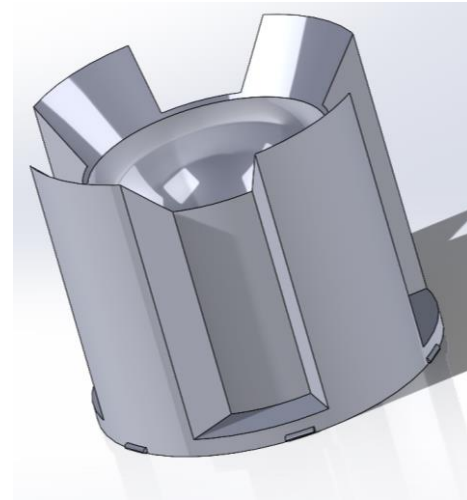
Demonstration Outline

- Phase 1:
 - Explore with object avoidance and AprilTags
- Phase 2:
 - Remove one sphere from canister
 - Scan, classify, and place in holder
- Phase 3:
 - Remove 4 spheres from canisters
 - Scan, classify, and sort onto hauling system



Inspection Environment

- Spheres are contained within holders until ready for inspection
- AprilTags used to label holders
- Holders are designed for 5" and 6" spheres



ClearPath Ridgeback

- Industrial mobile platform
- Uses LIDAR and vision to navigate
- Software developed in ROS
 - Used Python and C++
- Motion Simulated in Rviz/Gazebo
- Capabilities:
 - Payload: 220 lbs
 - Footprint: 37.7 x 31.1 x 12.2 in
 - Move Speed: 3.6ft/s
 - Run Time: 15 hrs at max payload



Universal Robots UR5 Arm

- Collaborative Robotic arm for manipulating objects
- Vacuum-powered end effector
 - Payload: 33 lbs
- Intel RealSense D435i Camera
- Capabilities:
 - Degrees of Freedom: 6
 - Payload: 11 lbs



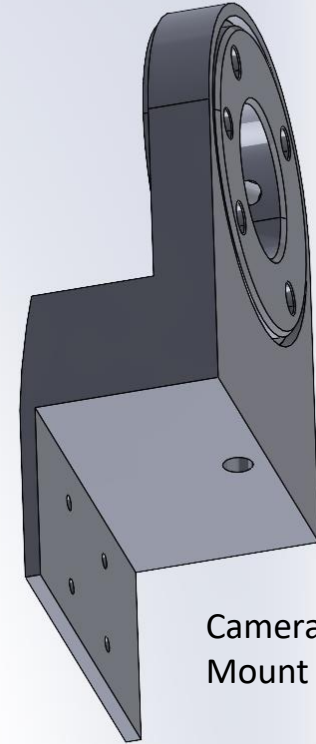
Full System Integration

- Mechanical
 - UR5 to Ridgeback
 - Camera and end effector to UR5
 - Design sphere holders and hauling trailer
- Electrical
 - Ridgeback power to UR5
 - Safety Interconnects
- Software
 - Control system
 - Sensors



Camera Mount

- Connect camera to the wrist of the UR5
 - Custom design
- Intel RealSense
 - RGB and Depth Camera
 - Capabilities:
 - RGB
 - Resolution: 1920x1080
 - FOV: 69x42
 - Depth
 - Resolution: 1280 x 720
 - FOV: 87x58

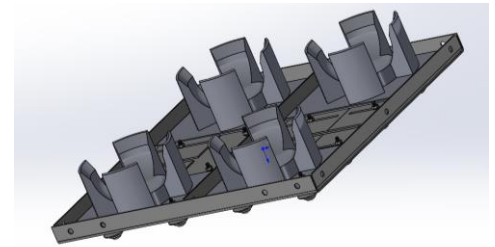


Robot
Connection

Camera
Mount

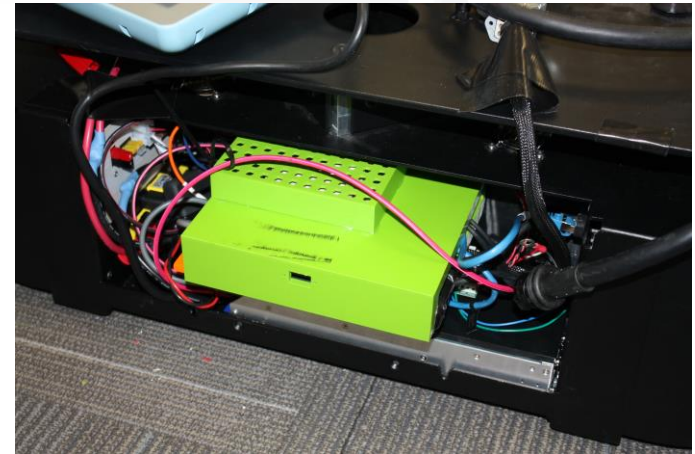
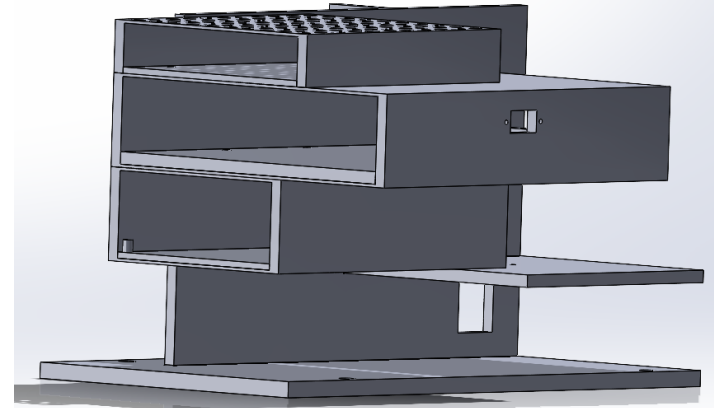
Hauling Modifications

- Ridgeback and UR5 can automate facilities not designed for automation
- Hauling task demonstrates moving objects throughout a facility
- Trailer is designed to accommodate damaged and undamaged spheres

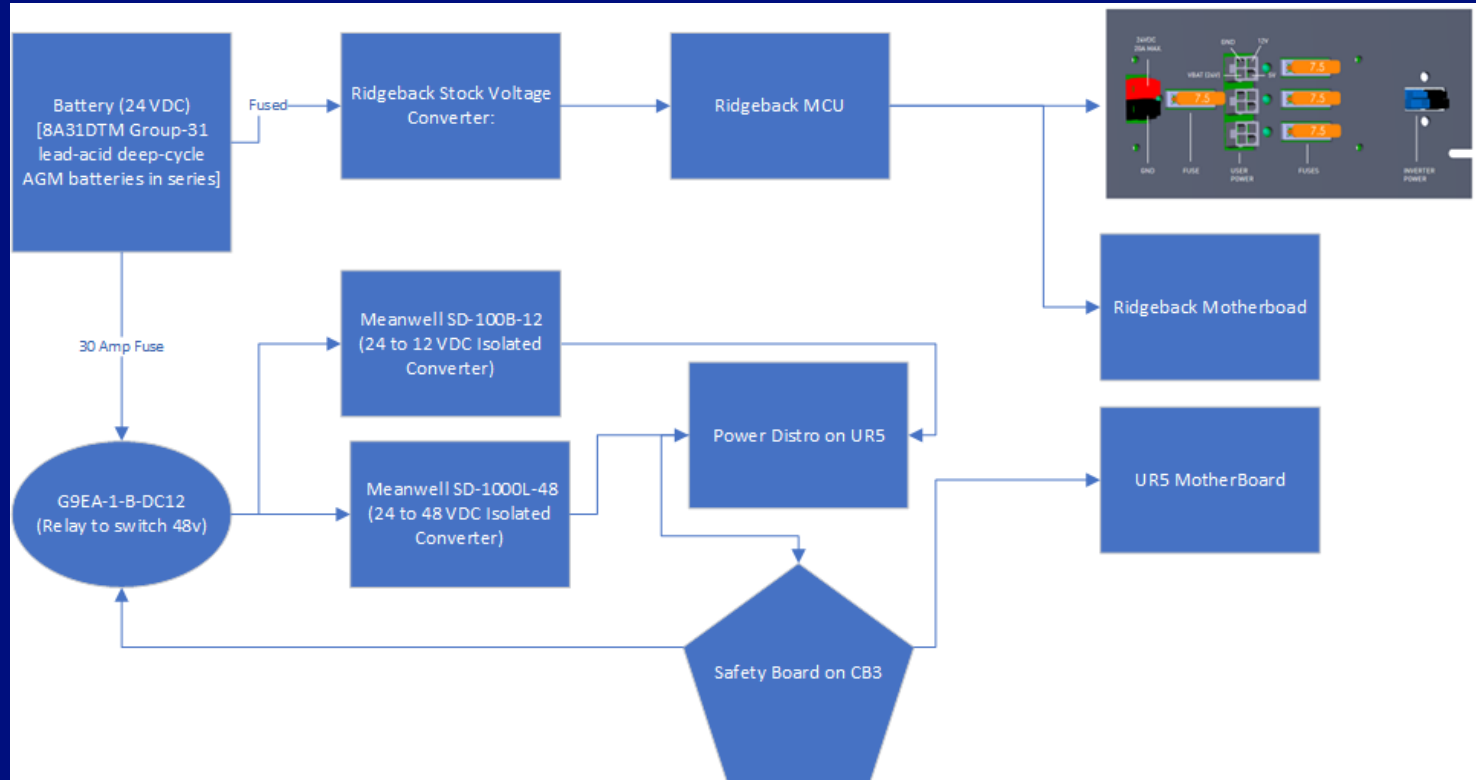


Integration: UR Controller (CB3)

- Reduced weight of CB3 mounting
 - Mounted CB3 inside of Ridgeback
 - Designed and fabricated mounting solution
- Tapped Ridgeback's batteries to power UR5
 - Replaced UR5 AC to DC power supplies with DC to DC



Integration: Electrical Power Diagram

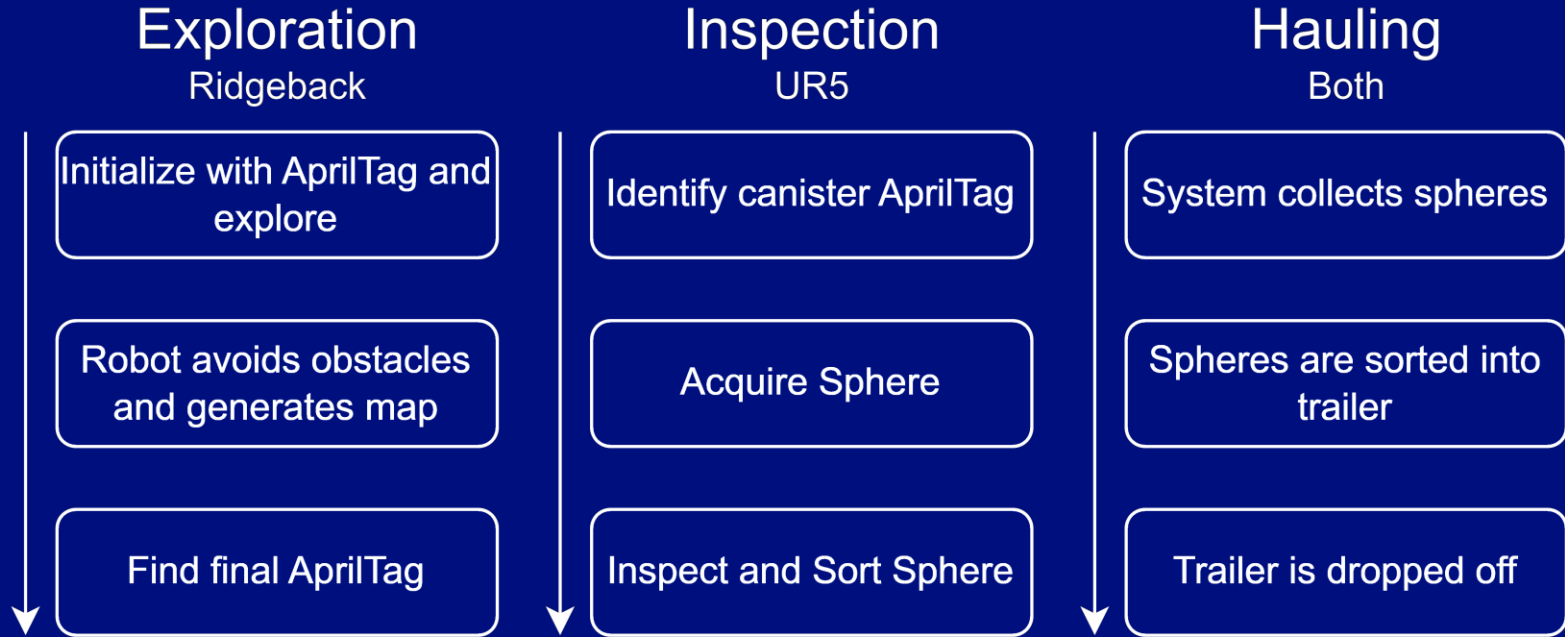


Integration: Safety

- Autonomous systems require safety controls
- Engineering Controls ensure a mode 0 stop
 - Emergency Stops (E-Stops)
 - UR5 has pendant E-stop
 - Ridgeback has four on the corners
- If one system faults, both systems fault
 - Connect E-stops together
 - Wireless E-stop employed for operator
 - If E-stop loses connection, then system stops

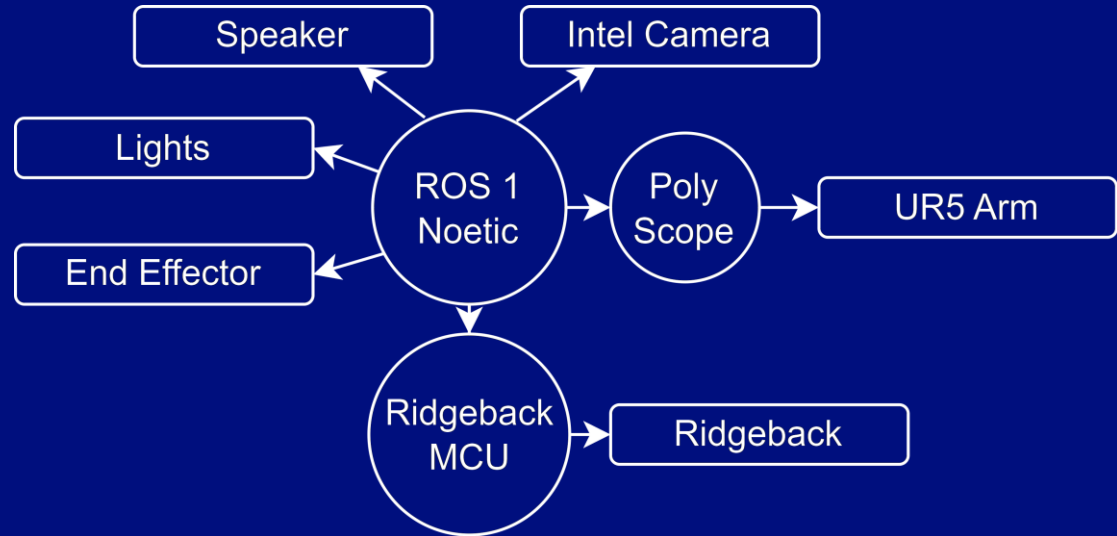


Software Mission Plan



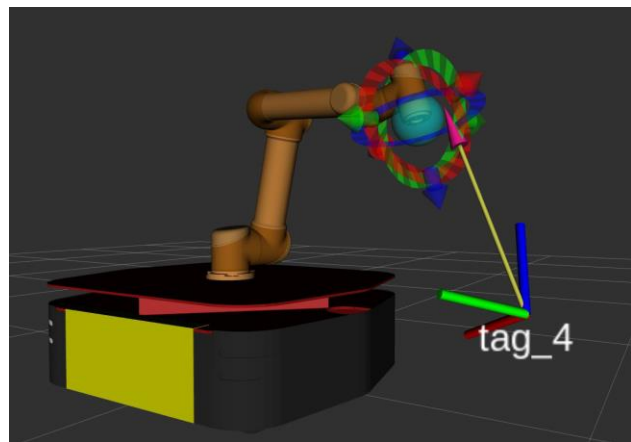
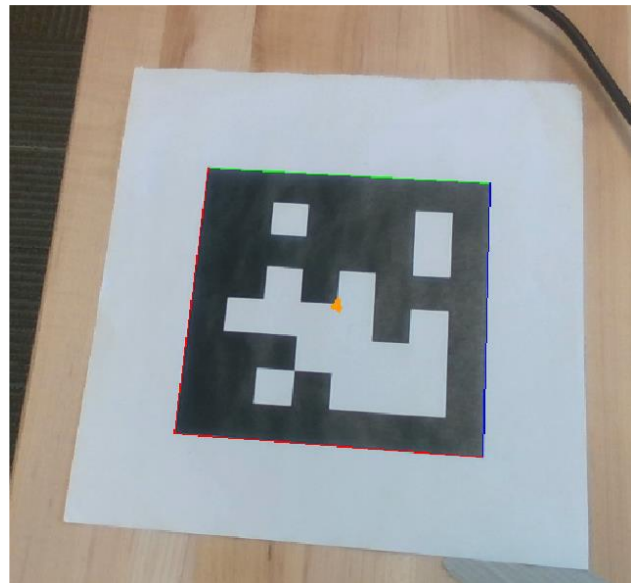
ROS

- Integrates software subsystems together
- Communicates via nodes, topics, and services
- Simulates robotic systems



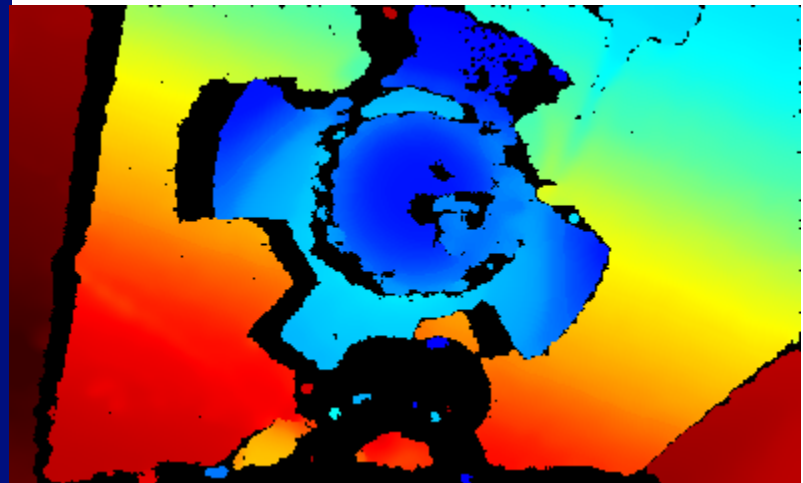
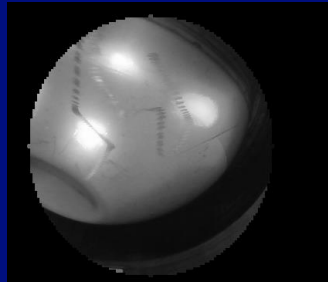
AprilTags

- AprilTags provide a way to identify objects
- AprilTags are placed on objects
- Depth camera locates and identifies AprilTags
- AprilTags allow for dynamic interactions

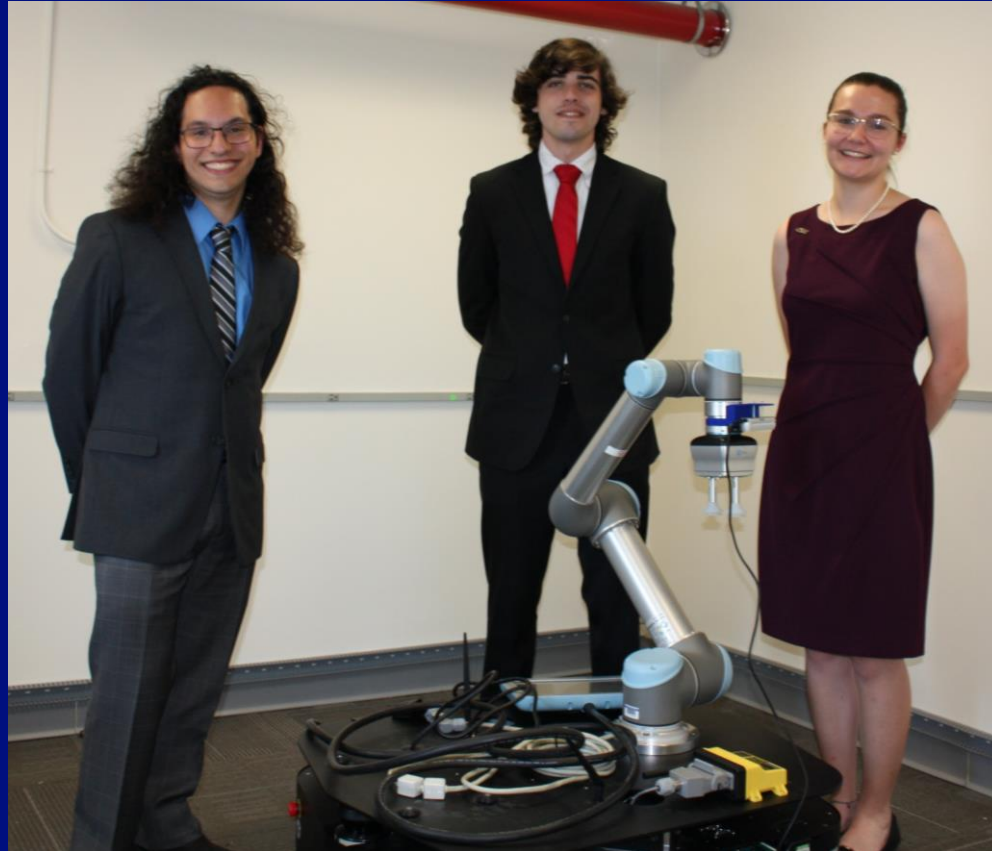


Vision Model

- Locate and identify metal sphere
- Inspect for dents and scratches
- Image processing to create mask
 - Using depth data
- Trained AI model
 - Transfer learning to retain the final layer of a resnet18 model to identify the 2 classes
 - Classes: Pass/Fail



Questions?



Questions?

