

Automation in Material Inspection and Handling

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Welcome



- Maggie Fontaine
 - Undergraduate Intern
 - Georgia Institute of Technology
 - Mechanical Engineering
 - Project Focus: Mechanical
- Adam Garsha
 - Undergraduate Intern
 - Texas A&M University
 - Mechanical Engineering
 - Project Focus: Software
- Hersch Nathan
 - Undergraduate Intern
 - University of Kentucky
 - Electrical Engineering
 - Theater
 - Project Focus: Electrical

I. Introduction



UR5 robotic arm on top of
Ridgeback Mobile Robot

- Two systems integrated together to meet lab requirements
 - Universal Robotics UR5 Robotic Arm
 - Clearpath Ridgeback Mobile Platform Robot
- Demonstrate capabilities in handling and inspection
 - Adapt robotic systems to pre-existing environments

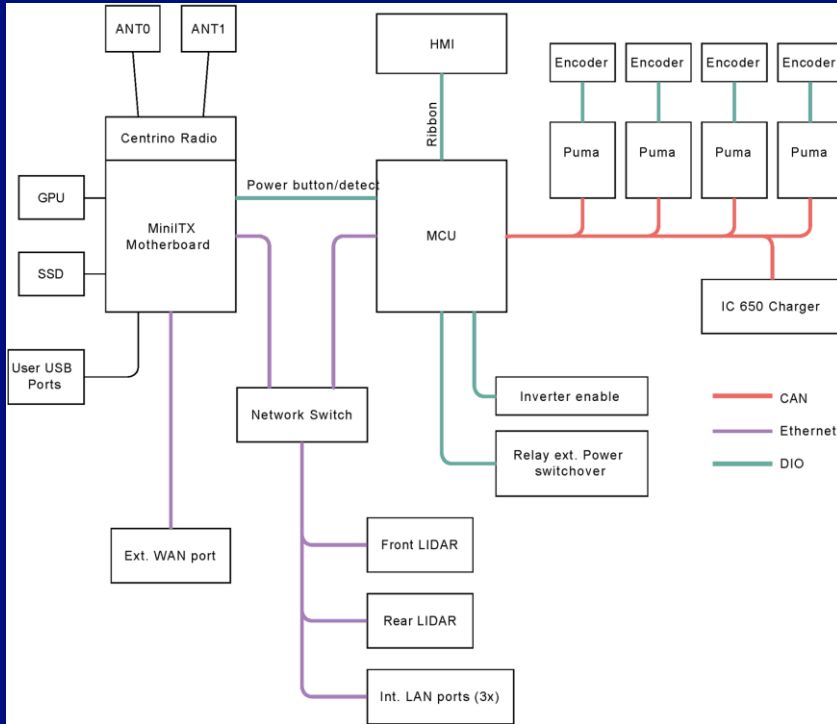
Mechanical



UR5 robotic arm with D435i and Vacuum End Effector

- UR5
 - OnRobot VGC10 Vacuum End Effector
 - Stationary mounting system
- Ridgeback
 - Omnidirectional wheels and LiDAR sensor
 - Supplements UR5 stationary limitation
- Intel RealSense D435i Camera
 - Incorporate environmental information

Electrical: Communications & Safety



➤ UR5

- Controlled by Universal Robotics CB3
- Actuators via serial communication
- Has PLC like I/O module
 - Safety I/O
- E-stop on teach pendant

➤ Ridgeback

- 4 Hardwired E-stops on corners

➤ VGC10

- Controlled by On Robot Compute Box

Ridgeback Communication
Diagram

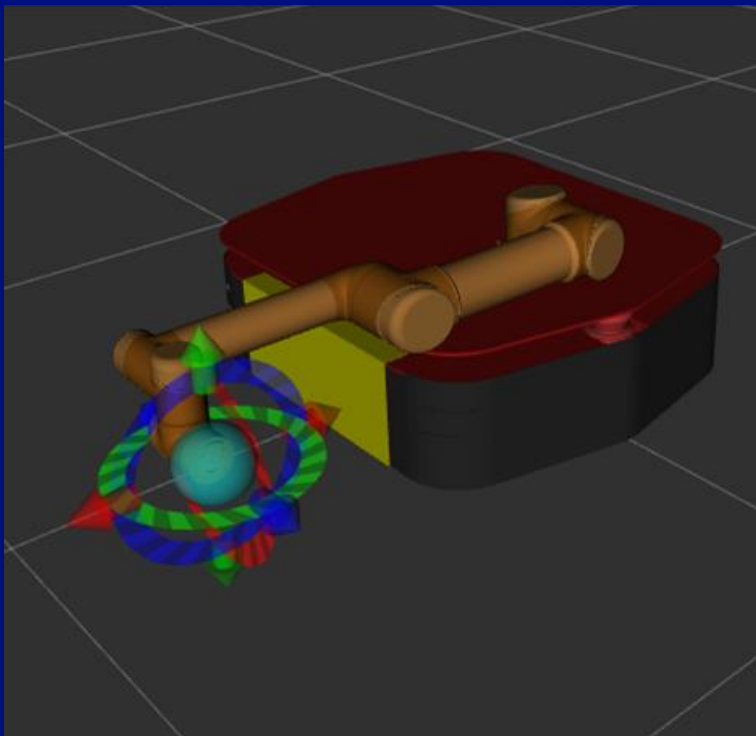
Electrical: Power



Ridgeback Estop

- UR5
 - 120 V AC Input then step down
 - 12 V DC
 - Safety Control Board, Motherboard, Teach Pendant
 - 48 V DC
 - Joints on Arm
- VGC10
 - 120 V AC to 48 V DC wall adapter
- Ridgeback
 - 24 V DC from batteries
 - Through converters powers the system
 - Integrated battery charger

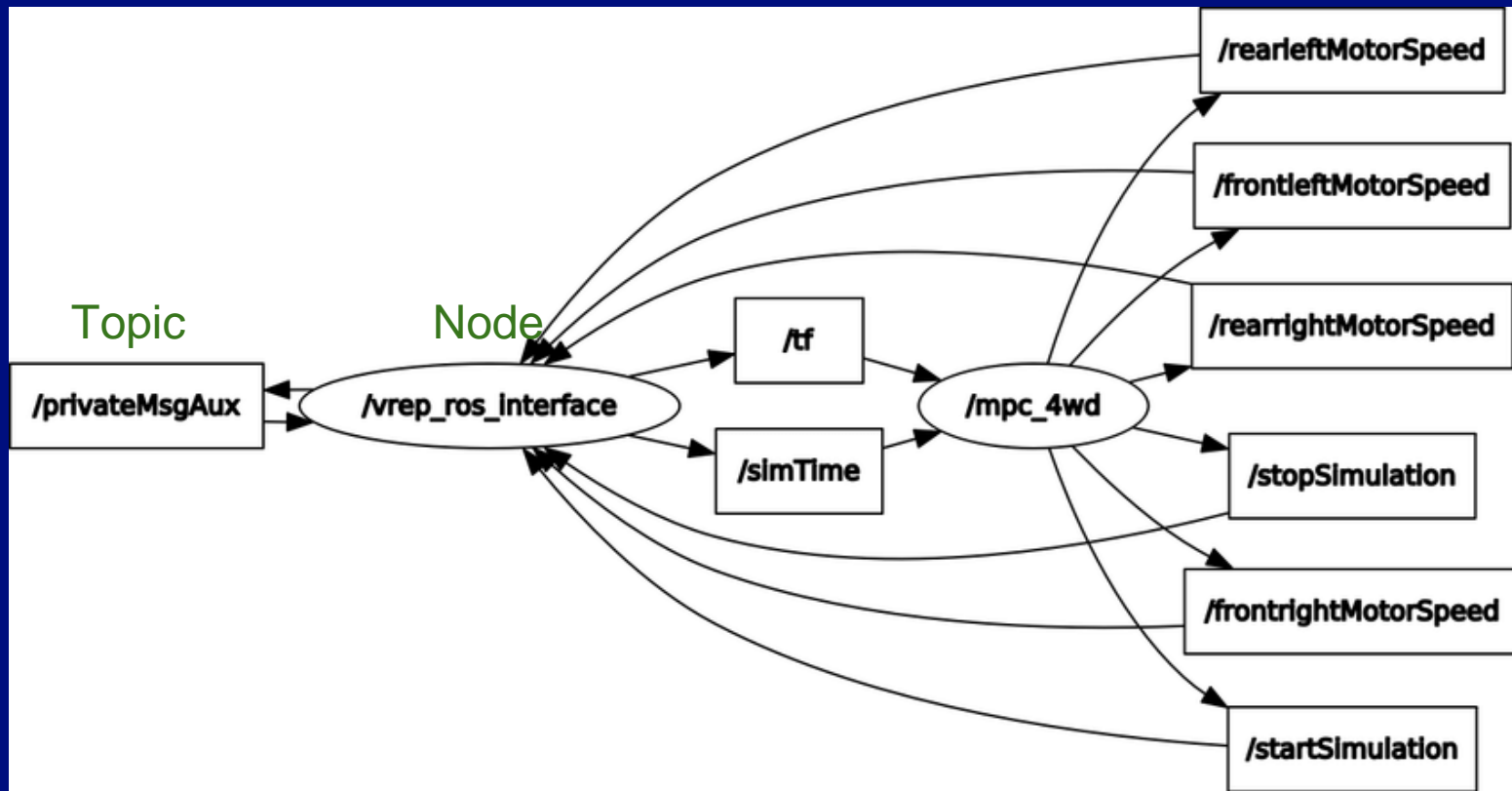
Software



Simulated Robot

- ROS
 - Nodes, topics, services
 - Publish/subscribe model
 - Request/response model
- Communication between robots
 - Packages for each system
 - Ridgeback
 - UR5
 - Intel RealSense
- Simulation
 - Test planning algorithms
 - Prevent hardware damage

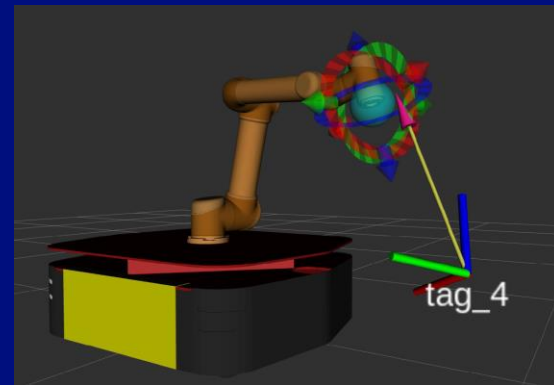
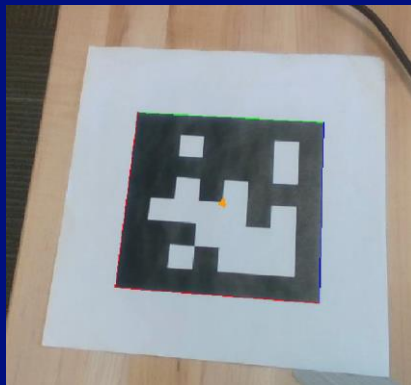
Software



II. System Description

Navigation

- 2D LIDAR sensors
 - Combined 360 degree range
 - Mapping capabilities
 - Real-time sensing
- Intel Realsense Camera
 - Apriltag Detection
 - Vision



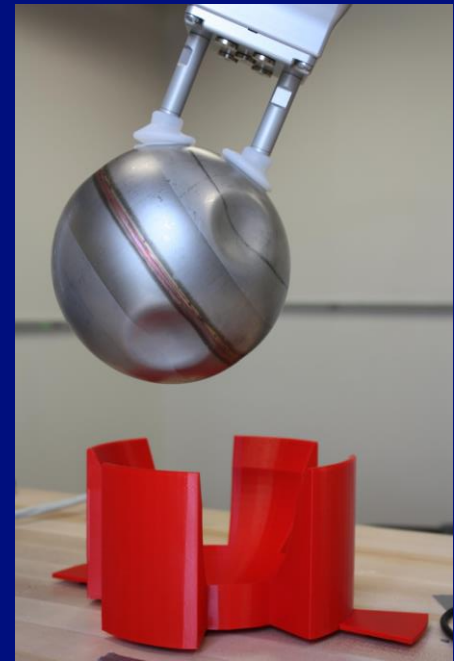
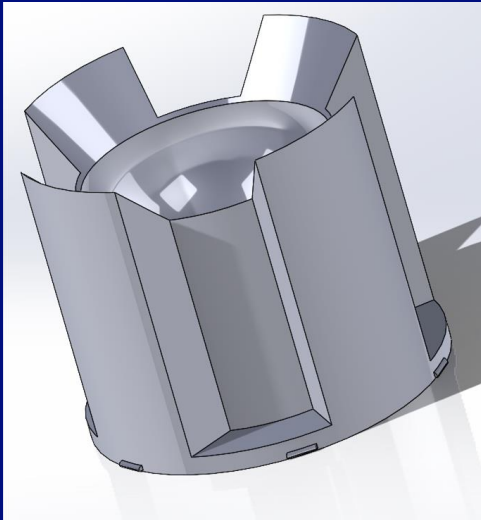
Inspection



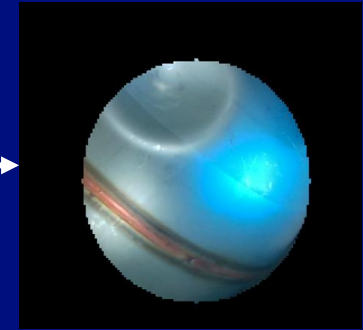
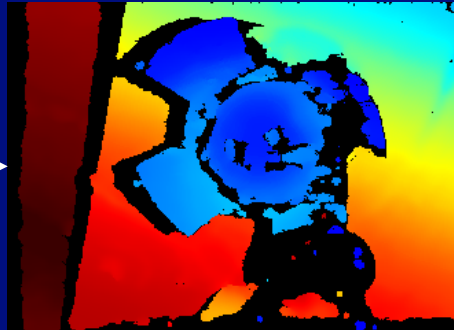
- Goal:
 - Approach, Inspect, Handle objects
- Metal spheres
 - 5 and 6 inch sizing
 - Weight 0.98 and 1.375 lbs
 - Interacted object
 - Simulate material handling
- Sort based on damage

Hardware Environment

- Stand-ins for controlled locations or conditions
 - 3D Printed from PLA with adhesive rubber support
 - E.g. Points of overlap between distinct autonomous systems
- Simple modification for application expansion



Inspection: Pipeline

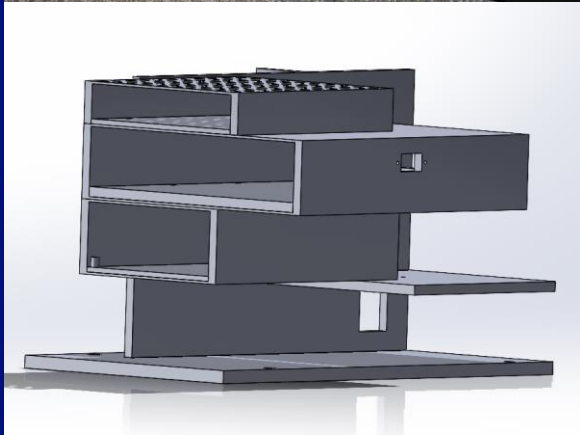
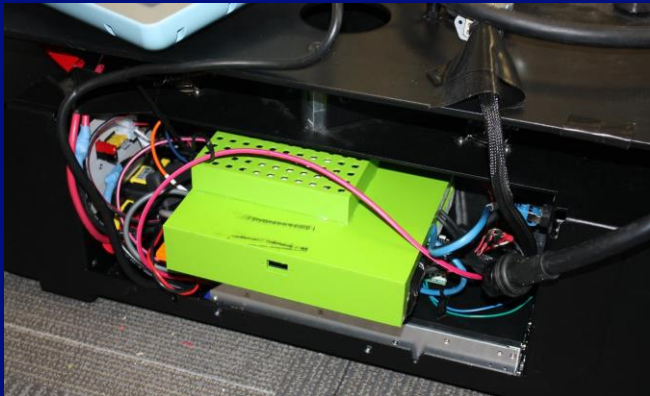


- Fixtures located
- Depth and color images taken

- Depth data topographical map
- Mask about the sphere

- Mask applied to a grayscale color image
- Color image sent through Neural Network classification model
 - Transfer learning from RESNET-18

Modifications

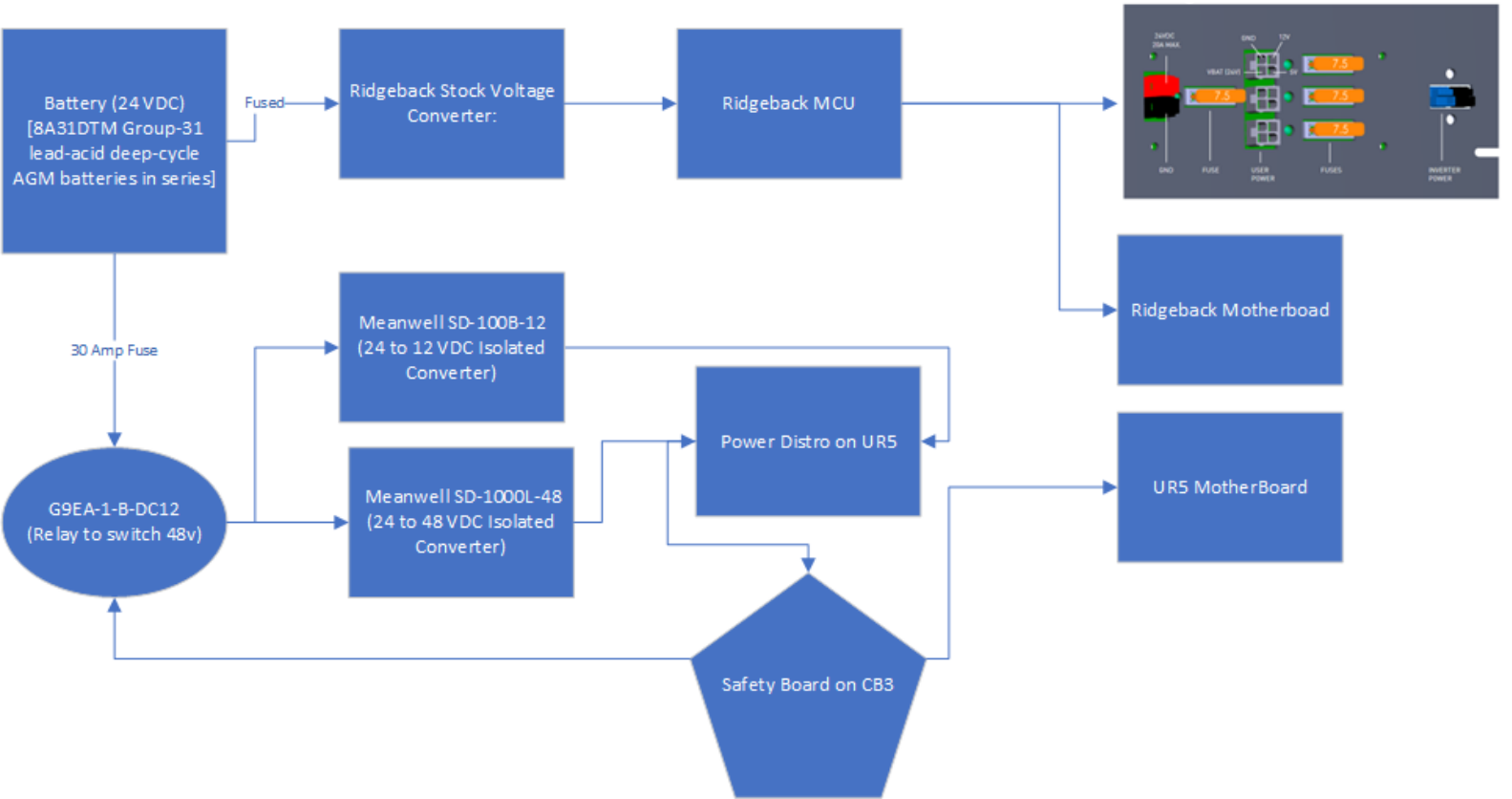


Top: Ridgeback Cavity, Bottom
Custom mounting for UR
electronics

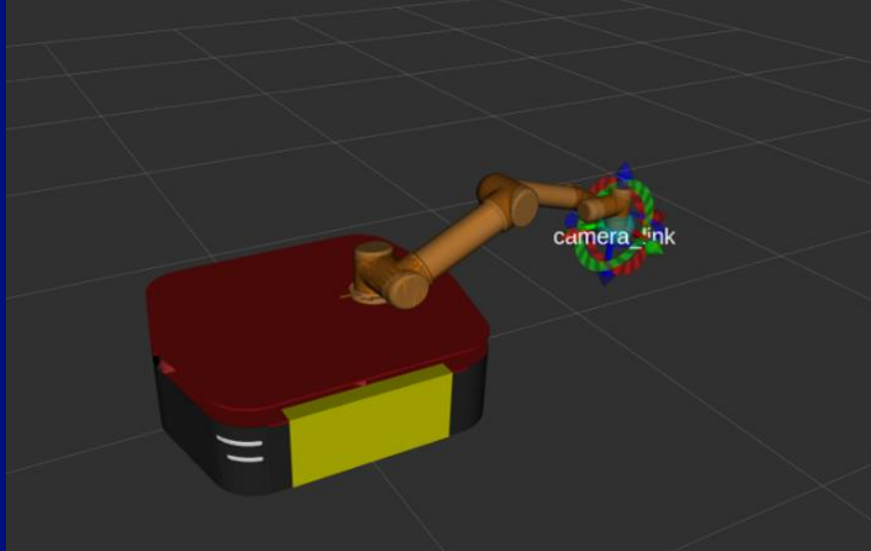
- Empty Ridgeback cavity
 - Removed proprietary IndoorNav navigation computer
- Developed custom mounting
 - CB electronics
 - Power modification components
- E-Stops connected across UR5 and Ridgeback

Modifications: Power

Ridgeback User Power Ports



System Control



Simulated System

- Disable E-stops
- UR5 Computer
 - Start ROS External Control
- Ridgeback Computer
 - Start LIDAR Node
- External Computer
 - Other nodes
 - Run main program

III. Discussion

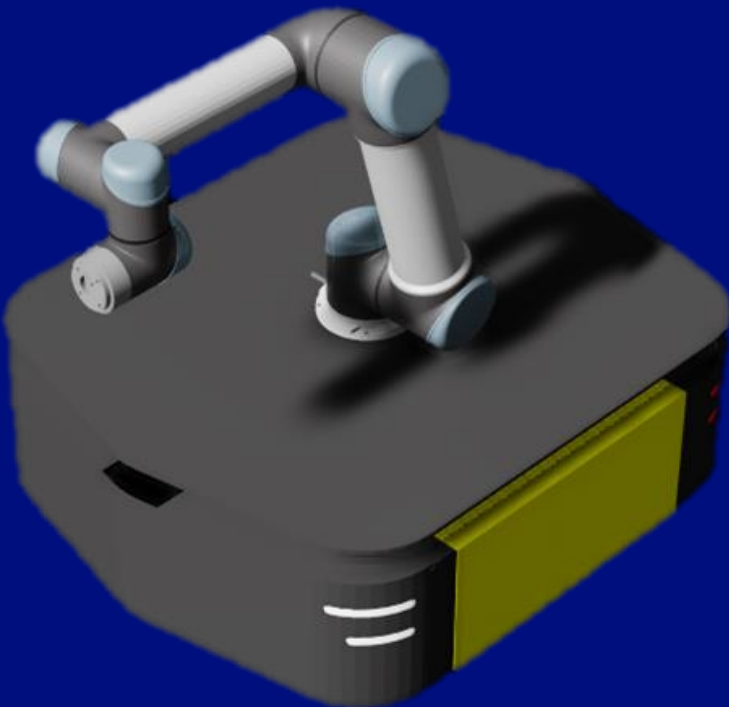
Results



Fully integrated robot

- Navigate unknown environment
 - Ridgeback's LiDAR
 - D435i's AprilTag identification
- Manipulate Objects
 - Vacuum grip for handling
 - Software constraints ensure object remains level
 - D435i and AI for damage inspection

Overall Integration



- CB3 Electronics
 - Mounted via custom enclosure
- UR5 arm mounted
 - Wireless E-stop system across UR5 and Ridgeback developed
- VGC10 End effector
 - Adaptor plate for D435i developed
- ROS packages
 - Installed to control everything

Top: Robotic System Simulated image, Right: Portion of Ridgeback



IV. Conclusion



Spheres for the robot to interact with

- Inspection and Navigation System
- Combined UR5 and Ridgeback
 - Integrating the robots together leads to more capabilities
 - Waste handling
- Future Work
 - Expand physical capabilities
 - Improve Recognition system
 - Octomap system for collision avoidance
 - Adapt to further applications