Berner Fachhochschule
Haute école spécialisée bernoise
Bern University of Applied Sciences

Rob 195 - Automated Object Detection in a Collaborative Robot Workspace

Bachelor Thesis Defence

Dario Aeschlimann

Introduction

- Introduction
- Current safety systems and thesis goal
- Tools
- Methods
- Results and Outlook
- Questions
- Demonstration

Current safety systems and thesis goal

- Three different workspace monitoring systems:
  - Safety monitored stop
  - Speed and separation monitoring
  - Power and force limiting

- Create an additional safety layer by implementing a vision system:
  - Monitor robot workspace
  - Detect objects
  - Simulate robot movements and detect collisions
  - Avoid collision

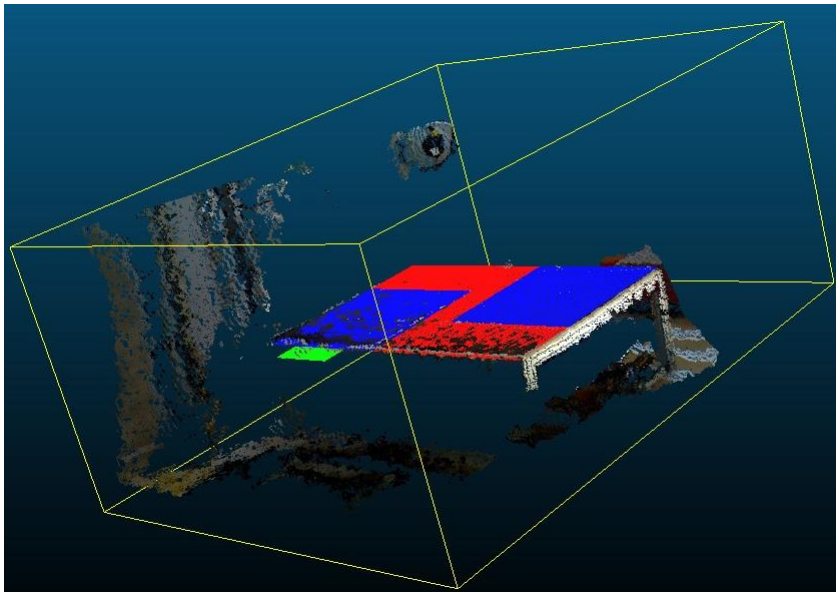
Tools

Fanuc CR-35iA Robot
Roboguide

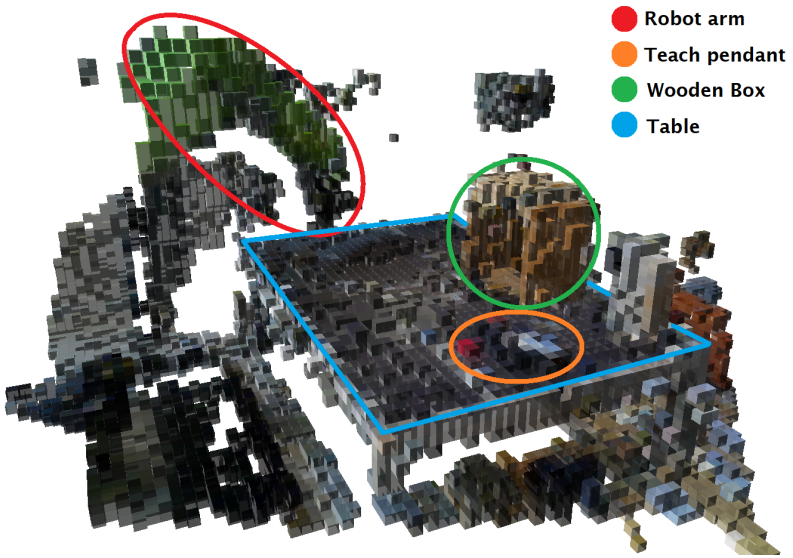
Asus Xtion PRO LIVE

Tools

Point Cloud Library (PCL)
CloudCompare



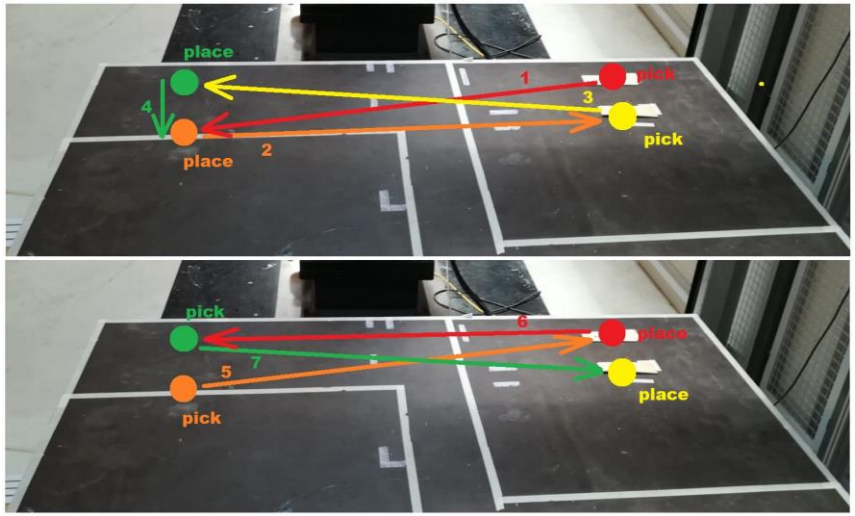
Octomap library



Methods

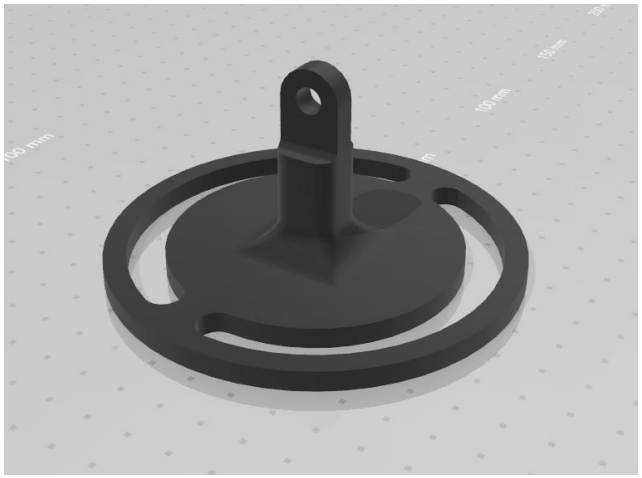
Robot communication

- Socket messaging
- Sequential robot communication
- Telnet for gripping commands
  - Fieldbus alternative
- Pick and Place application written in C++

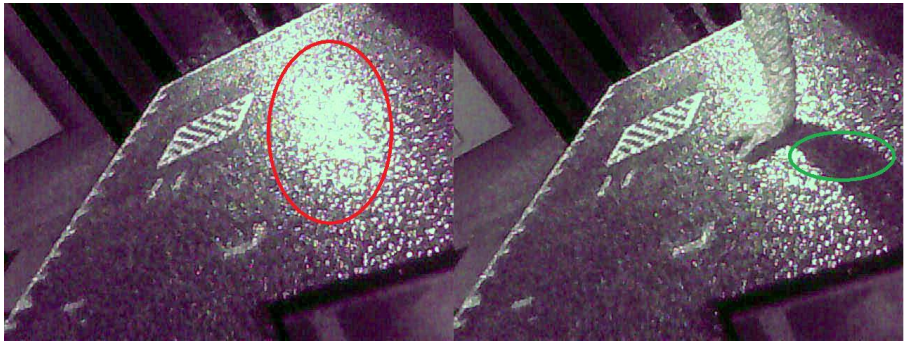


Methods

Camera positioning



- Designed and 3D printed camera fixation
- First mounting position directly at the table
- Interference of infrared structure resulted in data loss
- Maximized Distance between cameras to reduce interference



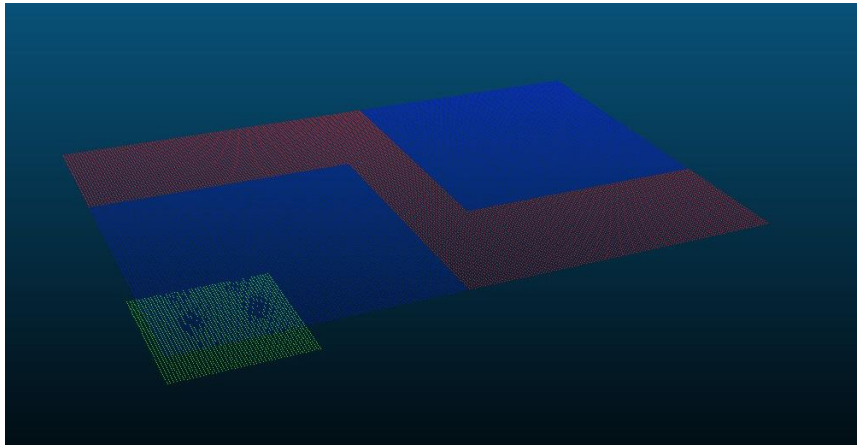
Methods

Camera positioning

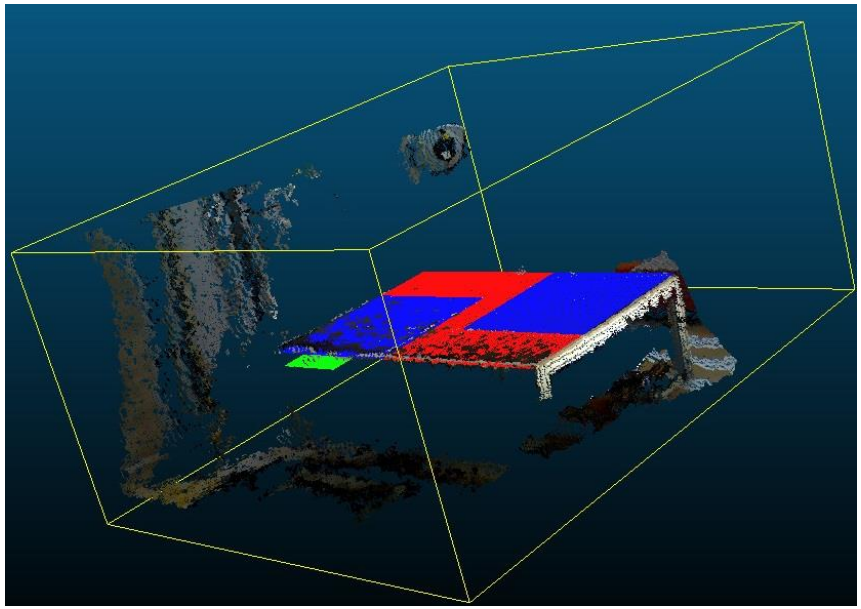
- Diagonal camera positioning
  - Provides object detection from all sides
  - Cameras are mounted out of reach of unintended shifting

Methods

Camera calibration



- Create a reference cloud of the table
- Align point clouds
- Save the transformation matrix
- Transformation matrix will be read at system start-up



Methods

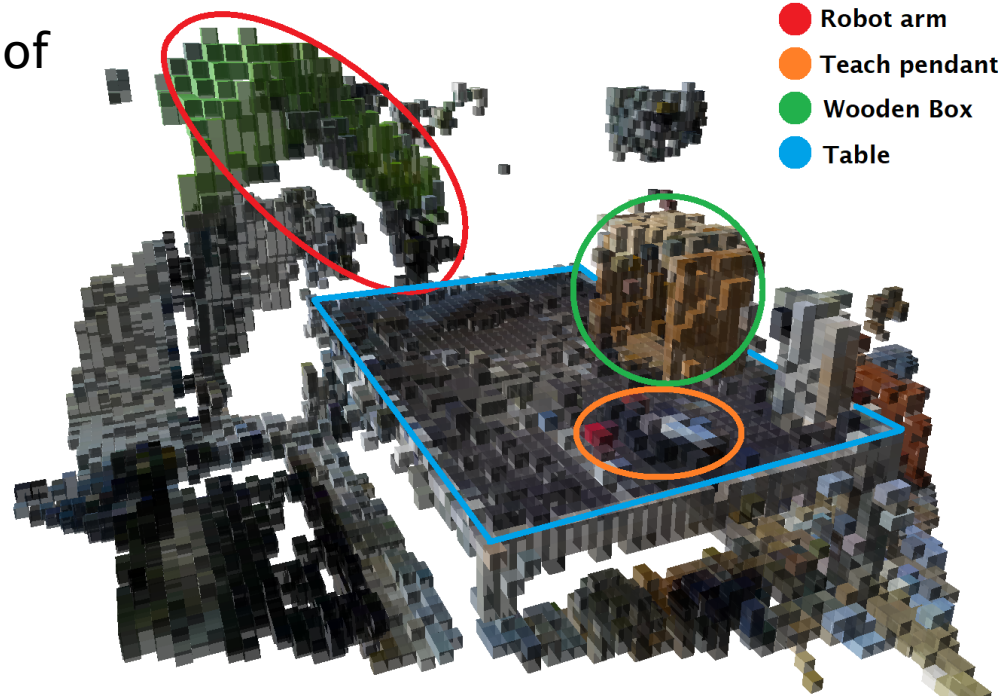
Data acquisition

- Stream camera data and save data as point cloud
- Applying filters
  - Range filter
  - Octree downsampling
- Transform point clouds based on matrix from calibration.
- Merge point clouds to single entity.

Methods

Mapping

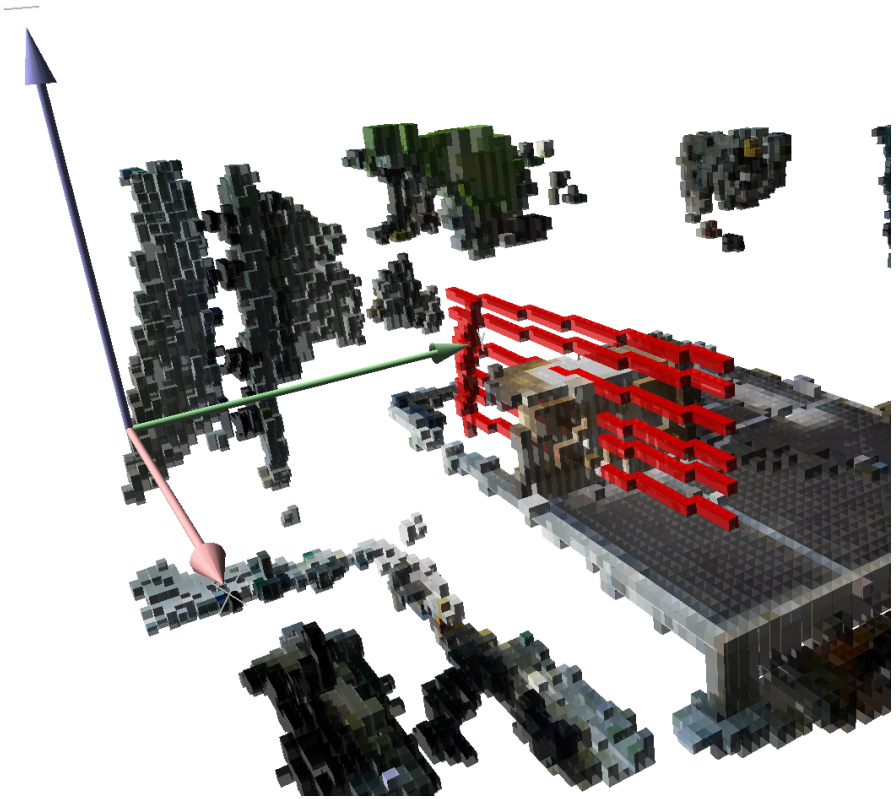
- Generate occupancy grid out of point cloud.
- Downsampling merged point cloud to desired leaf size.
- Defined leaf size is 4cm.
  - Bigger leaf size too inaccurate
  - Lower leaf size too slow



Methods

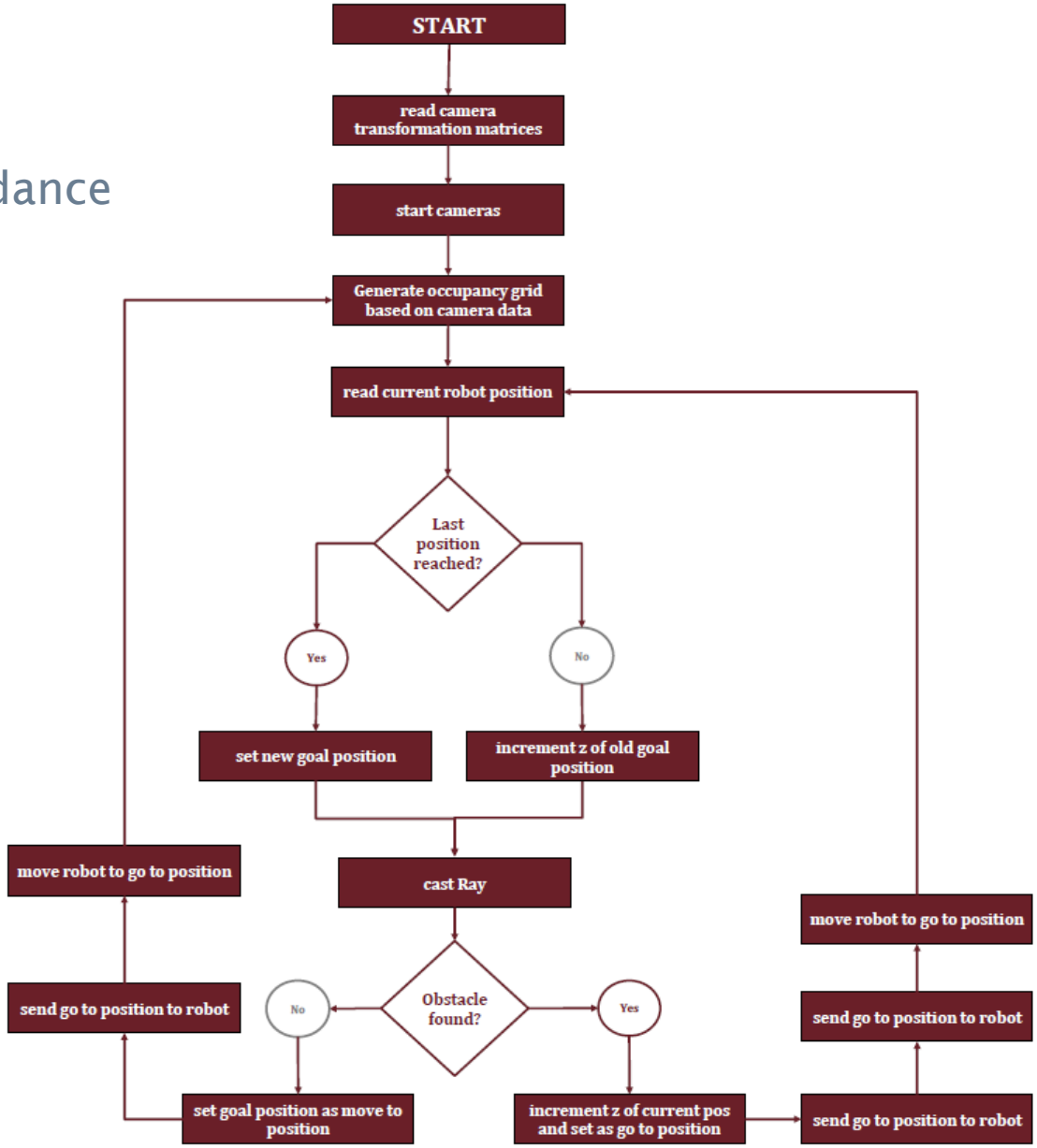
Collision Avoidance

- Raycasting inside occupancy grid.
- Calculate direction and distance from start to end point.
- Check if ray arrives at end position without traversing any occupied cell.



Methods

Collision Avoidance



Results and Outlook

Robot communication and movements

- Sequential communication
  - Read and write cartesian positions
- Upgrade to more dynamic communication by enhancing communication data with flags for read, write and move commands
- Robot movements controllable from the C++ program
  - limited to linear movements due to raycasting
  - Sectioning the path in smaller parts could allow joint movements

Results and Outlook

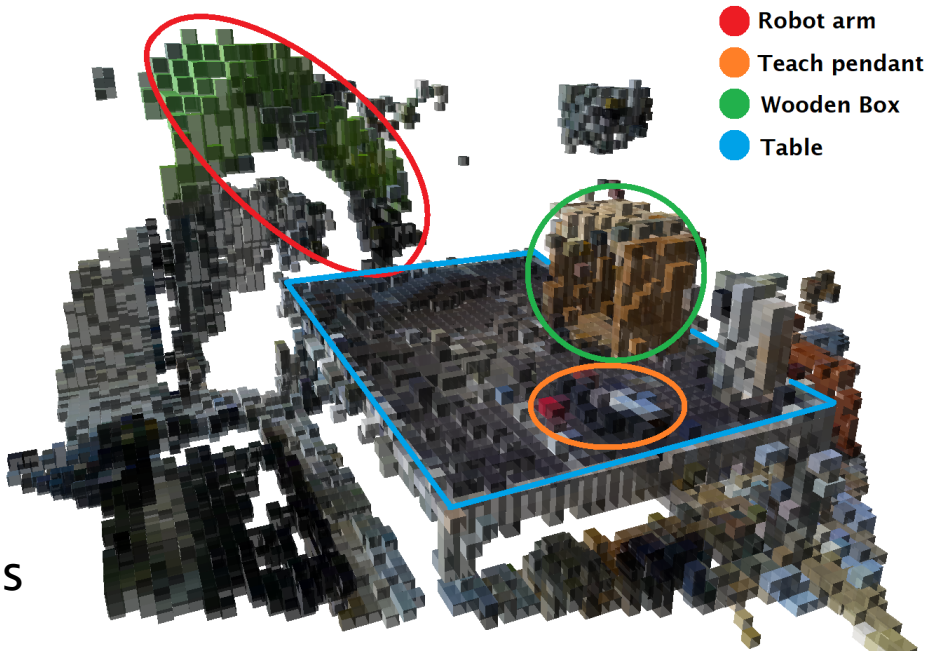
Cameras and data acquisition

- More than two cameras needed
  - Shadows on certain robot positions
  - Data loss
- Different cameras due to
  - Long USB cable
  - Interference
- Segmentation of camera data to avoid having an external calibration step.

Results and Outlook

Mapping

- Map includes robot body as occupied cells
  - Leads to faulty collision predictions with the robot itself
- Removing robot from maps would allow collision predictions in all directions.



Results and Outlook

Collision avoidance

- Collision avoidance implemented for straight line between two points.
  - Only regards end-effector.
  - Collisions with robot body are not detected.
- Collision avoidance for whole robot body necessary for industrial use.

Questions