Comau Robotic 3-D
Tetris

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12/21/2020
About Me
Problem Overview
The Potential for Saving Time and Money
The Two Subproblems

- We were responsible for addressing two primary problems:
  - The online bin packing problem in a three-dimensional space
    - Goals:
      - Fill the bin to at least 85% capacity
      - Place each item within 10 seconds
  - Determining the incoming objects dimensions
    - Goal:
      - Determine the dimensions of every object to within 2.5% margin of error
Division of Labor

**Camera System**
- Develop a system that can detect an incoming object
  - Integrate camera/hardware into system
  - Generate a point cloud from camera

**Segmentation**
- Segment data from object detection system into usable information
  - Segment out the object from the pointcloud
  - Identify the dimensions of the object

**Bin Packing Algorithm**
- Code an algorithm that optimally places objects into a bin
  - Devise bin packing heuristic
  - Consider edge cases of different objects and scenarios
  - Document system

**Front End Interaction**
- Create a Graphical User Interface
  - Show human user bin placement process
  - Notify when the system requires human intervention
Our Solution

Computer Architecture of System

- **Linux Space**
  - **Point Cloud Generation**
    - `pointcloud.cpp`
    - Intel RealSense SDK Library
    - Extracts point cloud file from camera
    - Stitches streams from multiple cameras
  - **Segmentation Algorithm**
    - `object_id.cpp`
    - Point Cloud Library
    - Segments object from point cloud

- **Graphical User Interface**
  - `basic_gui.pde`
  - Processing
  - Visual output of bin and boxes

- **Bin Packing Algorithm**
  - `Box.cpp`
  - `Bin.hpp`
  - `Prism.hpp`
  - Determines object placement within the bin

- **Robot**
  - From Comau
  - Out of scope

**KEY**
- Completed
- In Progress
- Not Completed
Results
Point Cloud & Segmentation Results

Point Clouds from Varying Angles

Merged Point Clouds

Segmented Image with Bounding Box
Bin Packing Results

123 of 140 items placed
Fill Percentage: 75.328%

Left View

Right View

Top View
Full System Results
Implication and Conclusion

<table>
<thead>
<tr>
<th>Goal</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fill bin to 85% capacity</td>
<td>Currently at 73% capacity</td>
</tr>
<tr>
<td>Place each item in under 10 seconds</td>
<td>Technically Complete, unable to test</td>
</tr>
<tr>
<td>Determine the dimension of every object to within 2.5% margin of error</td>
<td>Complete</td>
</tr>
<tr>
<td>Display results on graphical user interface</td>
<td>Complete</td>
</tr>
</tbody>
</table>
Thanks for Listening!
Q&A

1) How did you get involved in this project?
2) How did you connect with your capstone advisor, lab, team?
3) What hurdles were most difficult or least anticipated?
4) How do you hope to use what you learned from this project in your future career?
Goals and Project Scope

- The specific code for directing the robot where to go
- Only looked at rectangular prisms of varying shapes
- What we did consider (and goals)
  - Varying shaped items
  - Segment item to within 2.5% margin of error
  - 85% fill capacity
  - Whole placing under 10 seconds