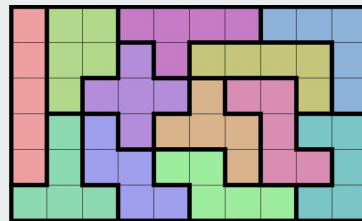




Pentominoes Puzzle solving with Kuka Miiwa

Final Project

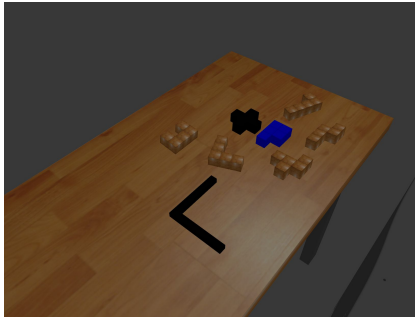


Diogo Marques 83631

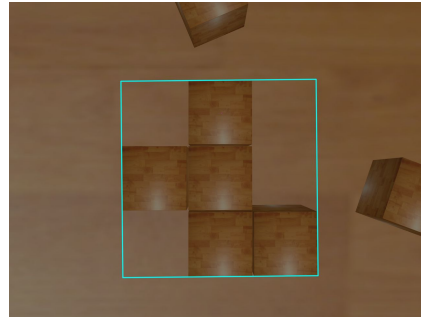
Marco Silva 84770

Implementation

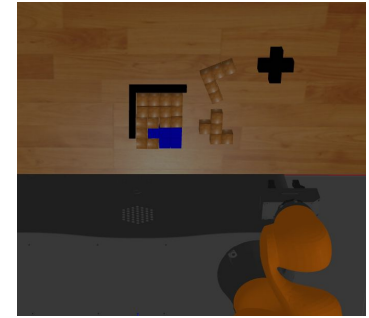
- The implementation was divided into 3 distinct phases:



1 - Location of pieces and play frame



2 - Recognize and Categorize



3 - Puzzle Solving

Phase 1 - Location of pieces and play frame on the table

1. Look for pieces on the right side of table with the help of the Right Template, using the Pan Tilt camera
2. Using that same template determine the Top Left corner of the play area
3. Change the Pan Tilt camera to match the Left Template and look for pieces in that area
4. Use the TCP Camera in the arm to get a top view each location obtained from Pan Tilt Camera and get each piece center
5. Use that same camera to capture a closer view of each piece



Left Template



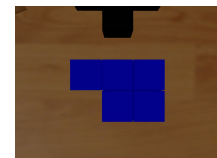
Right Template



Pan Tilt
Capture



TCP Top View
Capture



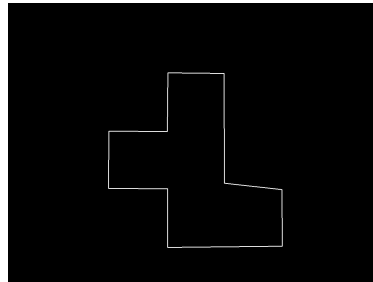
TCP Close View
Capture

Phase 2 - Recognize and Categorize each piece

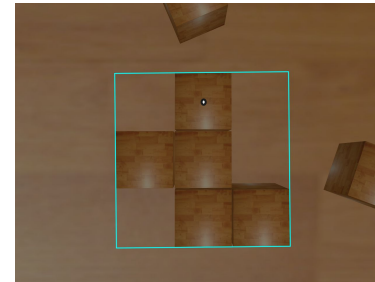
1. Get a close up image of the piece;
2. Apply filters and get the piece's contours;
3. Compare piece parameters with the various templates (number of vertices, perimeter and area of the outer smallest rectangle) and categorize the piece;
4. Detect the rotation angle and calculate the position of the cube that the robot will grab.



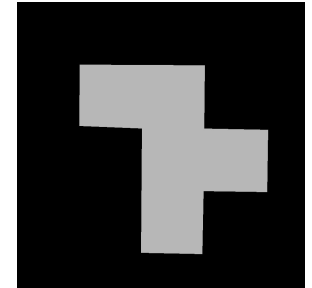
TCP Close View Capture



F contours



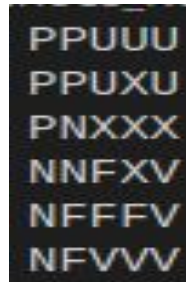
minAreaRect() and point
to grab



F Template

Phase 3 - Grab the pieces and solve the puzzle

1. From the solution file and the template files, the position and orientation of each piece in the puzzle is calculated;
2. The robot will pick up the piece closest to the game frame;
3. And places the piece at the calculated coordinates;
4. After all pieces are placed the puzzle is assumed to be solved.



6 piece solution



4 piece solution

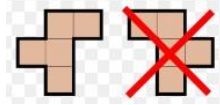


F template

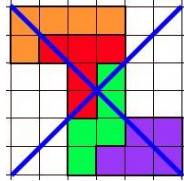
Constraints



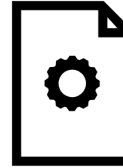
Arm doesn't
reach every point
of the table



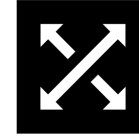
Pieces are not
flipped



All pieces are
clearly separated
so that the top
view camera can
isolate each one



Static templates
for both table
and pieces



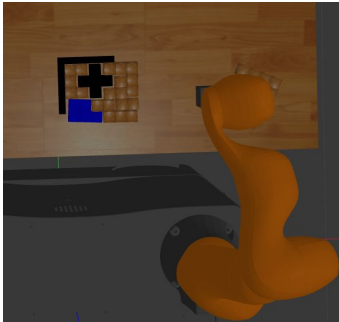
Play area must
be free of pieces



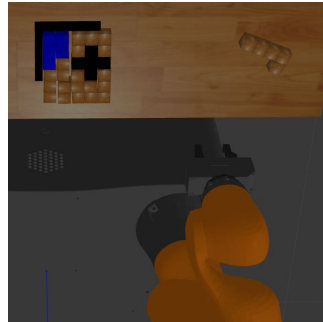
Puzzle solution is
given

Results

- The robot is able to complete several puzzles with different number of pieces as long as it meets the previous restrictions.
- The main reason why the robot fails to solve the puzzle is because it cannot grasp the piece even though it is between the handles.
- Note: Some changes have been made in the simulator in order to resolve some errors.



6 piece solutions (U, X, V, F, N, P)



4 piece solutions (U, N, P, L)



DEMO

