

ROS-INDUSTRIAL DEVELOPERS MEETING (ASIA)

Features in
`easy_manipulation_deployment`

8th December 2020

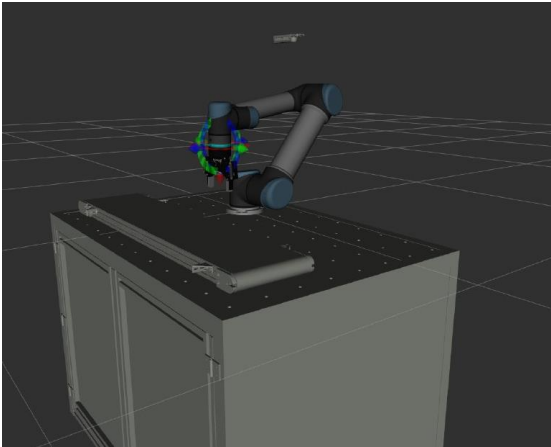
easy_manipulation_deployment



An easy to use ROS2 manipulation package that uses the easy_perception_deployment output to provide a **modular** and **configurable** manipulation pipeline for pick and place tasks

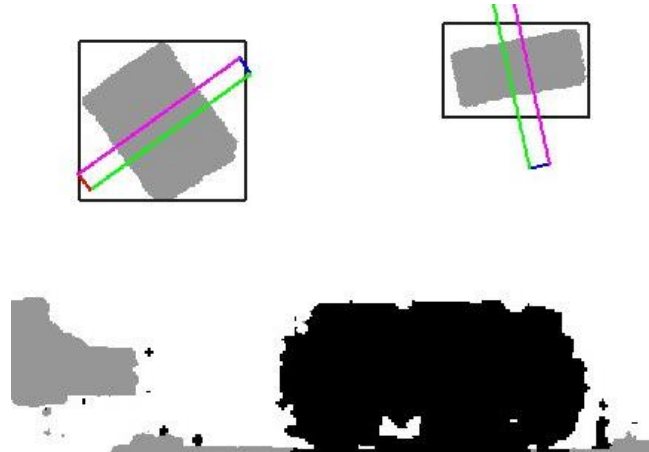
Easy_manipulation_deployment

Manipulation pipeline



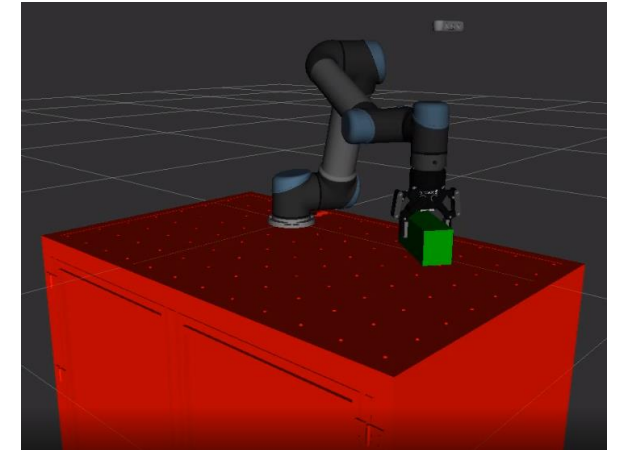
Workcell builder

Quick and Intuitive GUI for users to create a representation of the elements in a workcell



Grasp Planner

Modular and Flexible Grasp Planner that generates a (3+1) DOF End Effector specific Pose from the easy_perception deployment output



Grasp Execution

Robust Path planning process to navigate robot to the object for grasp

Workcell Builder



Workcell Builder

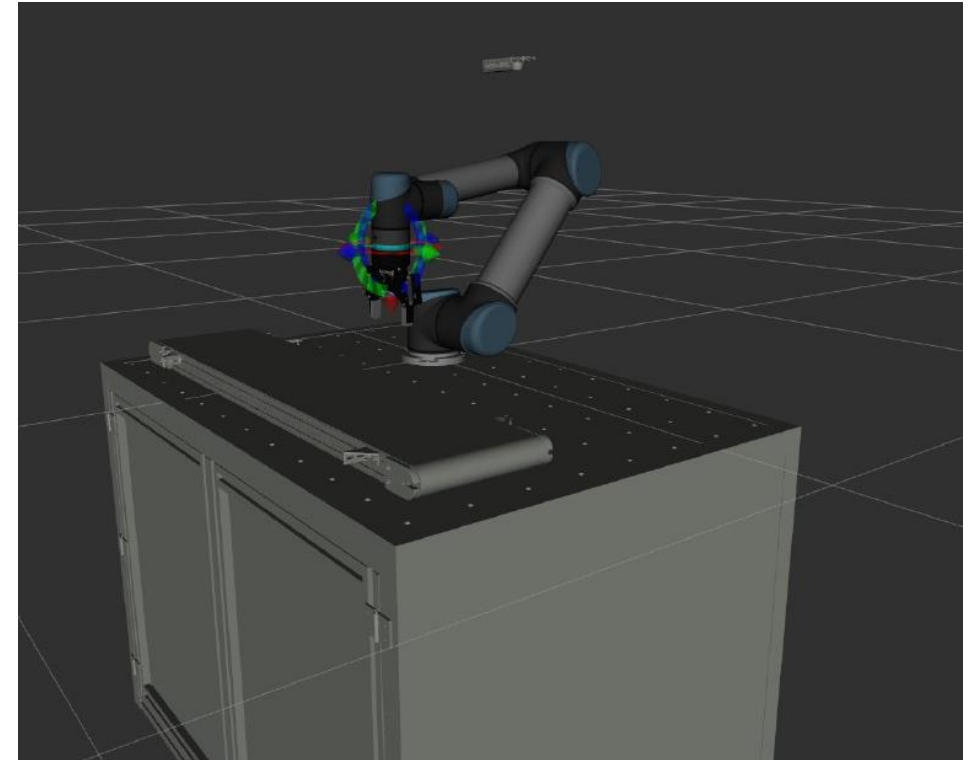
Rationale

Problem Statement:

For new users to ROS and to robotic workcell generation, it is **knowledge and time intensive** to generate the required files to prepare an environment that represents a workcell for robot manipulation

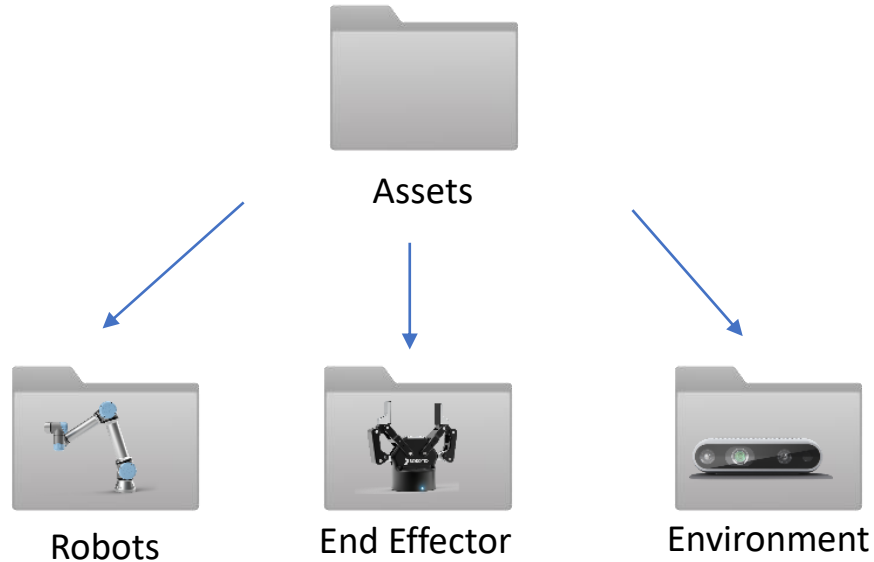
Solution:

A **simple to use Graphical User Interface** that allows the user to determine and create objects required in a robotic workcell, which generates a file that provides an easy to understand representation of the workspace. Relevant files and folders will then be generated and organized to provide an immediate simulation model for path planning.



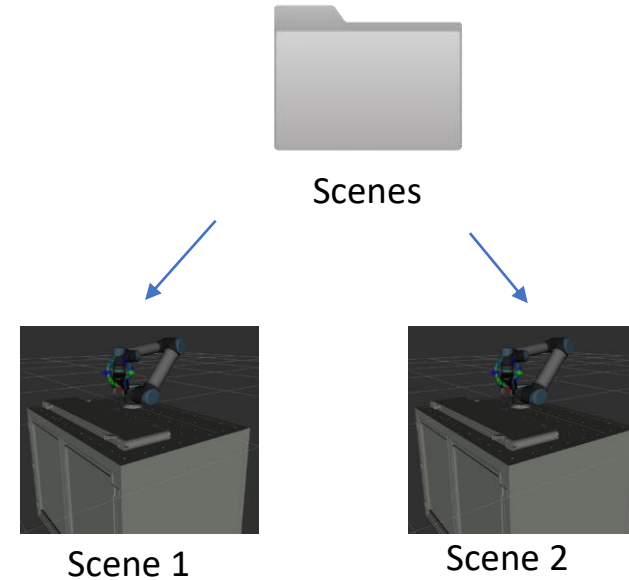
Workcell Builder

Standardization



Folder structures

- Folder standardization has been determined to ensure:
 - Clear delineation between user's custom generated folders and pre downloaded asset packages
 - Clear segmentation of types of assets to increase user understanding and easier folder navigation



Naming Convention

- Naming convention has been established for:
 - End Effector description and moveit configuration folder
 - Robot description and moveit configuration folder
 - URDF and SRDF files

Workcell Builder

Scene building

Create New Scene

Custom environmental Objects

table

Add Object

Load Existing Object

Delete

☒ Include Robot

Robot

Robot Brand: universal_robot

Robot Model: ur5

Edit Robot

Remove Robot

Robot Loaded!

☒ Include End Effector

End Effector

End effector Brand: robotiq_85_gripper

End effector Model: robotiq_85

Edit End Effector

Remove End Effector

Robot and EE connected!

Object	Parent Object	Parent Link
table	world	world

Scene Name: new_scene

Errors

ok

Scene Overview

Add New Environmental Object

Link	Joint Name	Joint	Child Link
All Links in object		Parent Link	

Add New Link

Add New Joint

Delete

Delete

Object Name*:

Adding static objects

Load a Robot

Origin

Position

x

y

z

Orientation

r

p

y

☒ Include Origin!

Robot Brand: universal_robot

Robot Model: ur5

Robot Base Link: base_link

Robot End Effector Link: tool0

Parent Object: World

Child Link: world

Error Check

Adding Robots

Load End Effector

Origin

Position

x

y

z

Orientation

r

p

y

☒ Include Origin!

End Effector Brand: robotiq_85

End Effector Model: robotiq_85

End Effector Link: gripper_base_link

End Effector Type: finger

Fingers: 2

Parent Object: ur5

Parent Link: tool0

Error Check

Adding End Effectors

Workcell Builder

Static object building

New Joint

Position **Orientation**

x r Origin
y p
z y

☒ Include Origin

Joint Name * **Position**

Joint Type* **Revolute** x Axis
Parent Link* **link1** y
Child Link* **link2** z

☒ Include Axis

Error Check

Ok

Joint Creation

New Link

Link Name *

☒ Enable Visual
Create Visual Edit Visual Delete Visual

☒ Enable Collision
Create Collision Edit Collision Delete Collision

☒ Enable Inertial
Create Inertial Edit Inertial Delete Inertial

Ok Exit

Link Creation

Add Visual

Visual Name

Geometry* ☐ Using STL
☒ Using Geometry

Load File

Scale x y z

Box Length Breadth Height

Position Orientation

x r
y p
z y

☒ Include Origin

Material ☐ Using Texture File Material Name
☐ Using Color R G B A

Load File

☒ Include Material

Ok

Visual Component

Add Inertial

ixx iyy
Inertia ixy iyz
ixz izz

Mass

Position **Orientation**

x r
y p
z y

☐ Include Origin

Ok

Inertial Component

Add Collision

Collision Name

Geometry* ☒ Using STL
☐ Using Geometry

Load File

Scale X Y Z

Box Length Breadth Height

Position **Orientation**

x r
y p
z y Origin

☐ Include Origin

Ok

Collision Component

Workcell Builder

YAML files

Robot

```
robot:
  name: ur5
  origin:
    x: 0
    y: 0
    z: 0
    roll: 0
    pitch: 0
    yaw: 0
  links:
    - base_link
    - shoulder_link
    - upper_arm_link
    - forearm_link
    - wrist_1_link
    - wrist_2_link
    - wrist_3_link
    - ee_link
    - base
    - tool0
```

End effector

```
end_effector:
  name: robotiq_85
  origin:
    x: 0
    y: 0
    z: 0
    roll: 0
    pitch: 0
    yaw: 0
  links:
    - gripper_base_link
    - gripper_finger1_knuckle_link
    - gripper_finger2_knuckle_link
    - gripper_finger1_finger_link
    - gripper_finger2_finger_link
    - gripper_finger1_inner_knuckle
    - gripper_finger2_inner_knuckle
    - gripper_finger1_finger_tip_link
    - gripper_finger2_finger_tip_link
```

Environment Objects

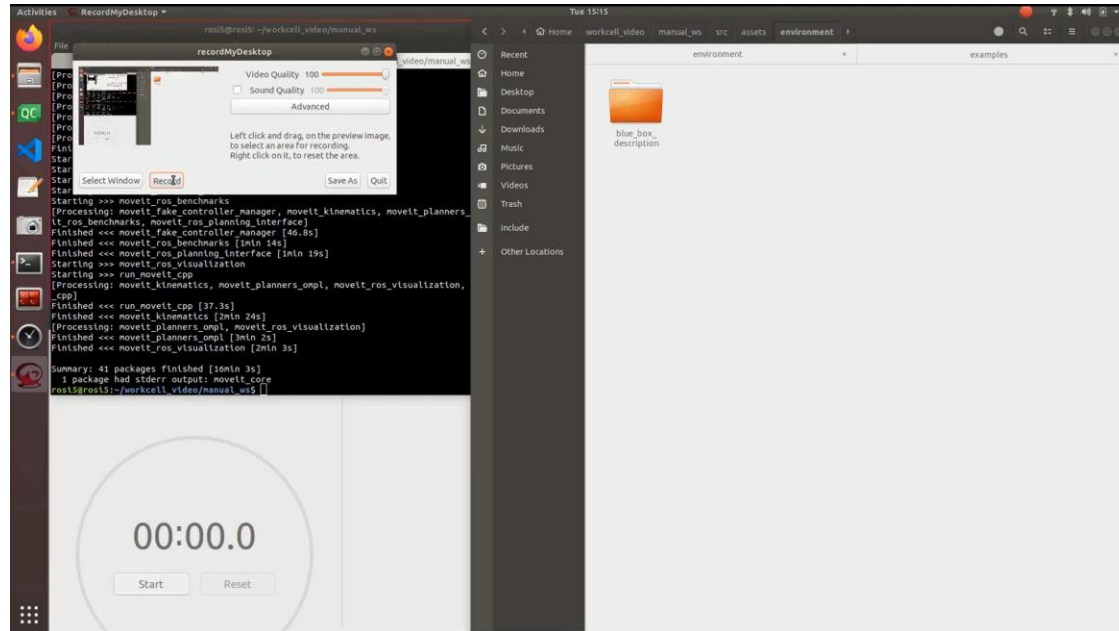
```
objects:
  table:
    links:
      table:
        visual:
          name: None
          geometry:
            filepath: /home/rosl5/rect
            scale:
              scale_x: 0.001000000005
              scale_y: 0.001000000005
              scale_z: 0.001000000005
          material:
            name: aluminum
            r: 0.5500000012
            g: 0.5600000002
            b: 0.5299999971
            a: 1
        collision:
          name: None
          geometry:
            shape: Box
            length: 2
            breadth: 2
            height: 0.00999999978
```

External Joints

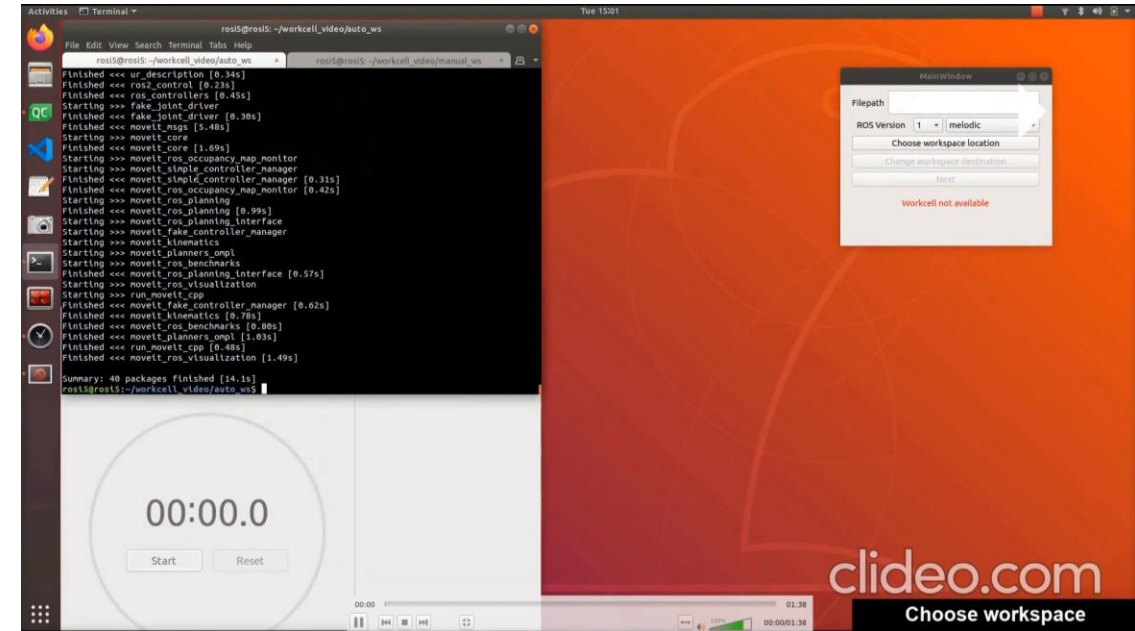
```
external_joints:
  robot_to_table:
    type: fixed
    parent: base_link
    child: table
    origin:
      x: 0
      y: 0
      z: 0
      roll: 0
      pitch: 0
      yaw: 0
```

Workcell Builder

Benchmarking



Without Workcell
Builder



With Workcell Builder

Benchmarking of workcell building process between using the Workcell Builder (**1:36**) and without (**19:51**) shows the potential time reduction and the reduction of knowledge gap faced by users

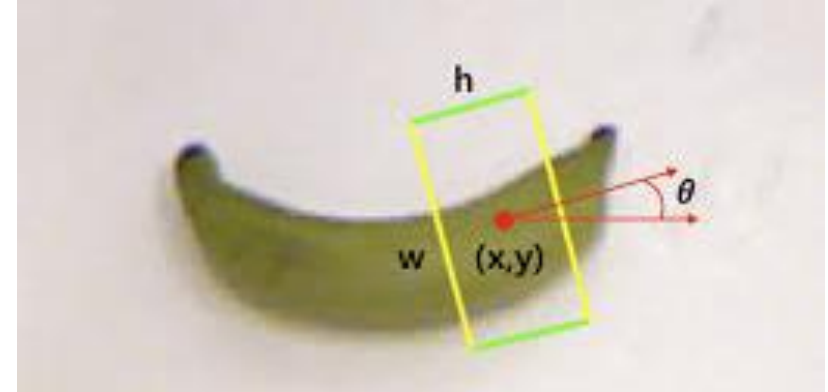
Grasp Planner



Grasp Planner

Rationale

Most grasp planners are Machine Learning based, which means that a **completely different training dataset is needed if a specific end effector is required**, leading to difficulties in implementing new models for new grippers.



Solution:

An **Algorithmic, depth based grasp planner** that uses depth values to generate valid grasp poses, accounting for finger collision and stability (Assuming objects with center of mass at the object centroid)

A **flexible representation of an end effector** to allow for extension of capabilities to other end effectors with minimal effort needed from the user

Grasp Planner

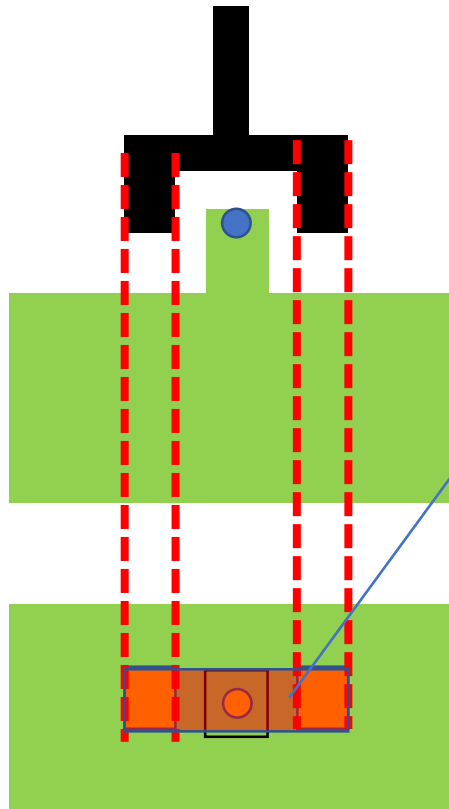
User Configuration

```
end_effector:  
  type: finger  
  attributes:  
    fingers: 2  
    distance_between_fingers: 250  
    longest_gripper_dim: 40  
    table_height: 570  
  parameters:  
    min_zero_angle: 0.01  
    min_height_diff_to_grip: 5  
    min_gdi_diff_for_comparison: 5
```

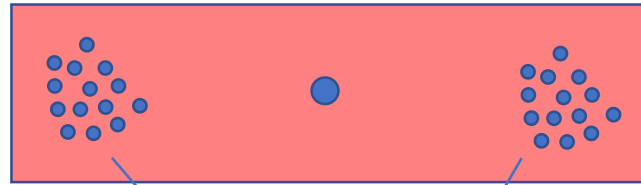
- Easy to understand configuration file for users to customize the parameters to their specific end effector

Grasp Planner

Algorithm – Finger collision avoidance



Grasp option

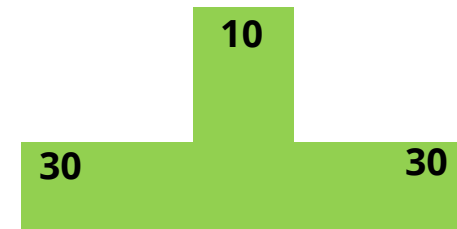
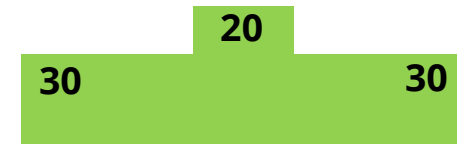


Depth values are sampled from the sides of the grasp option, and compared to the centre depths. **Grasp finger collision is minimized if the centre depth value is significantly lower than the sides**

The **more points** that satisfy this condition, and if the **difference is greater**, the greater the quality of grasp.

Finger Gripper

Depth camera

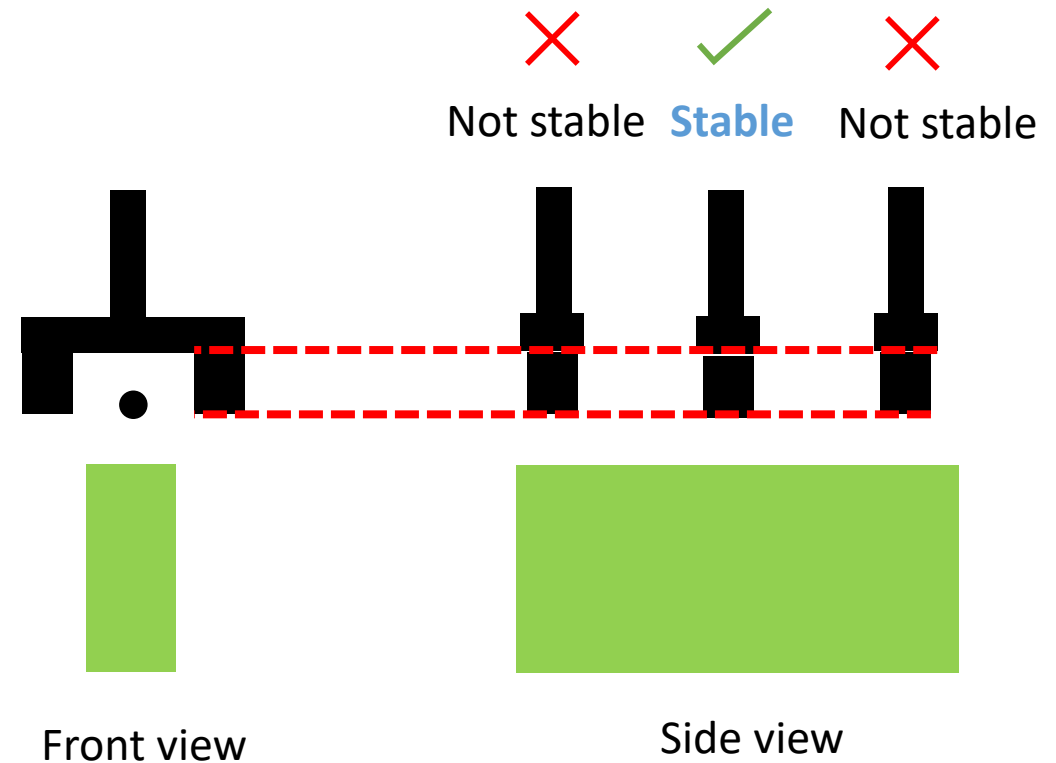


Grasp Planner

Algorithm – Grasp stability

Current assumption that the Centre of Gravity is at the centroid of the object, so we also **value grasps closer to the centroid IF the first condition of graspability is satisfied**

This additional condition allows for faster computation of grasp samples, and increased stability for regular objects



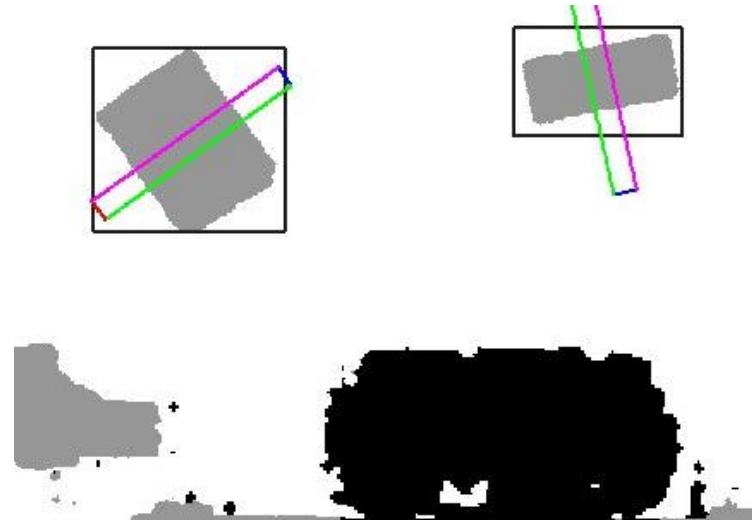
Grasp Planner

Results

Current implementation of grasp planner shows that it is possible to have a **non Machine Learning** based, **unsupervised learning grasp planner** to find **grasp poses for novel objects**



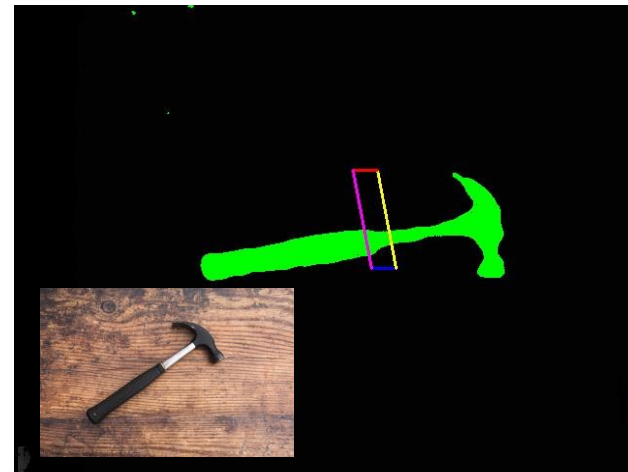
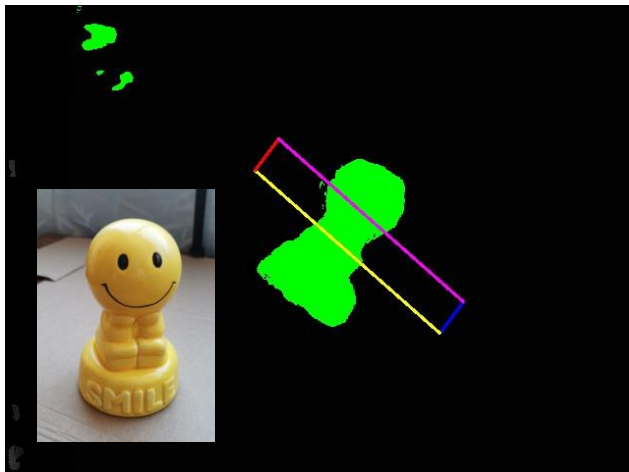
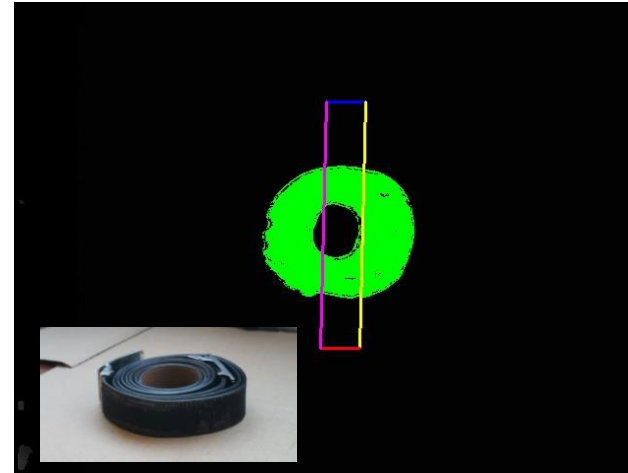
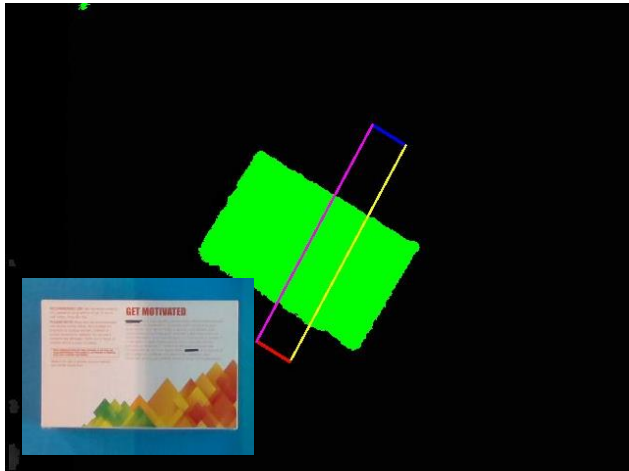
Cornell Grasping dataset output. **Requires training of Neural Network with object specific dataset to get high accuracy of grasp**



Work Package output, done with depth based grasp pose planning **without need for training.**

Grasp Planner

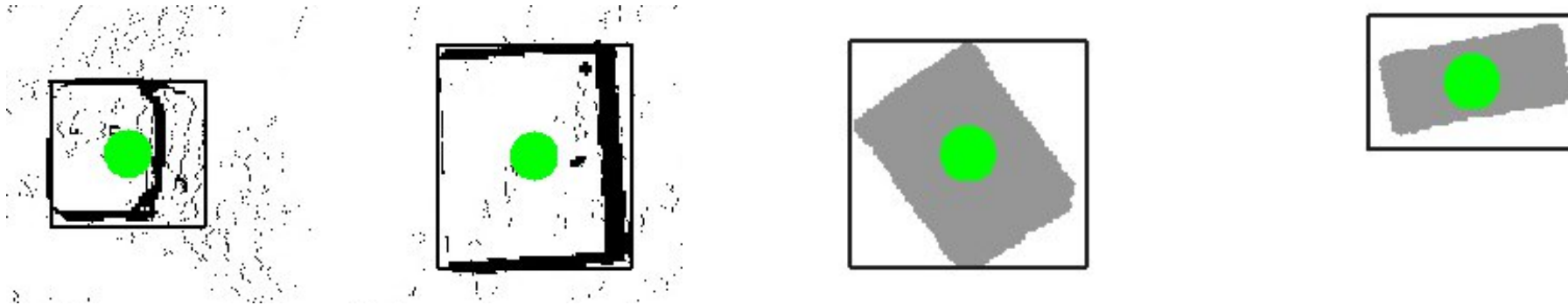
Further testing



Grasp Planner

Multi-gripper support

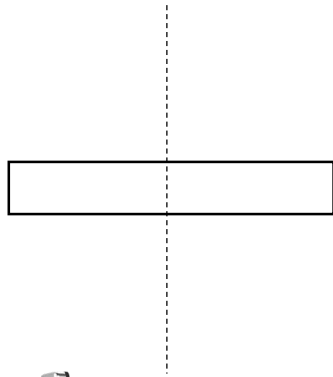
Support for suction type grippers has been added, but current functionalities only include single cup grippers.



Average grasp planning time: 0.25s

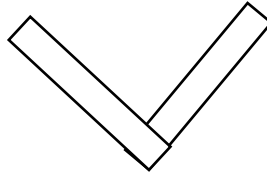
Grasp Planner

Extrapolation of fingered end effectors

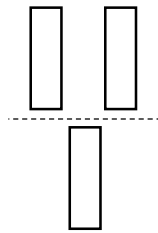


2 Finger Gripper

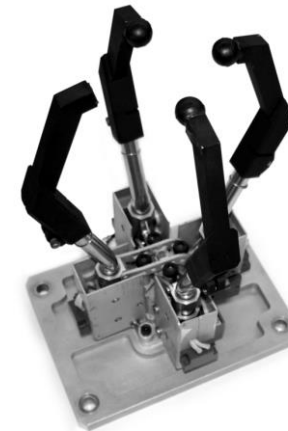
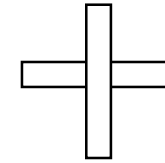
Spherical Mode



Cylindrical Mode



3 Finger Gripper



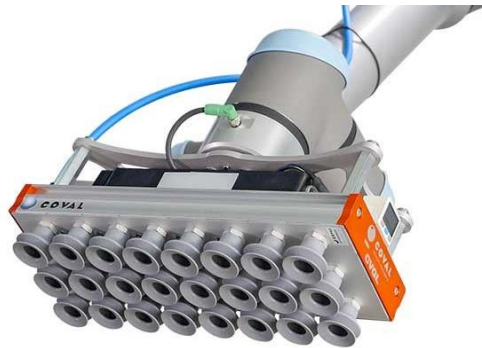
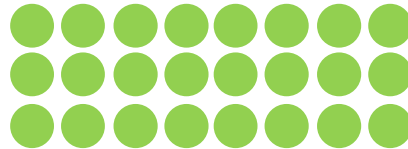
4 Finger Gripper

Grasp Planner

Extrapolation of suction end effectors



Single suction cup



Suction Cup array



Irregular suction cup array

Grasp Planner

Benchmarking

- Current grasp planning solution was run on CPU (i7-7700HQ, 4 cores) using a single thread, thus in terms of processing power there is **still significant opportunity for further improvement** in detection speeds by harnessing GPU and running multi-thread processes. Current results however, already indicate the **low hardware specifications needed for the package, which is a common problem for Machine Learning methods**
- Actual improvement in grasp times vary depending on the size of object and the profile of the object.

Solution	End Effector Supported	Grasp Planning times (s)	Training needed?
Grasp Pose Detection (GPD)	2 Finger Gripper	2.1	Yes
Superquadratic Grasping	5 Finger Gripper	1.78	Yes
<u>ROS-I Grasp Planner</u>	<u>2 Finger Gripper</u> <u>Single Suction Gripper</u>	<u>~0.42</u> <u>~0.25</u>	<u>No</u>
GQ-STN	2 Finger Gripper	0.024	Yes



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