



**NANYANG  
TECHNOLOGICAL  
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**SINGAPORE**

# **Visual Marker-Guided Mobile Robot Solution for Automated Item Picking in A Warehouse**

*presented by*

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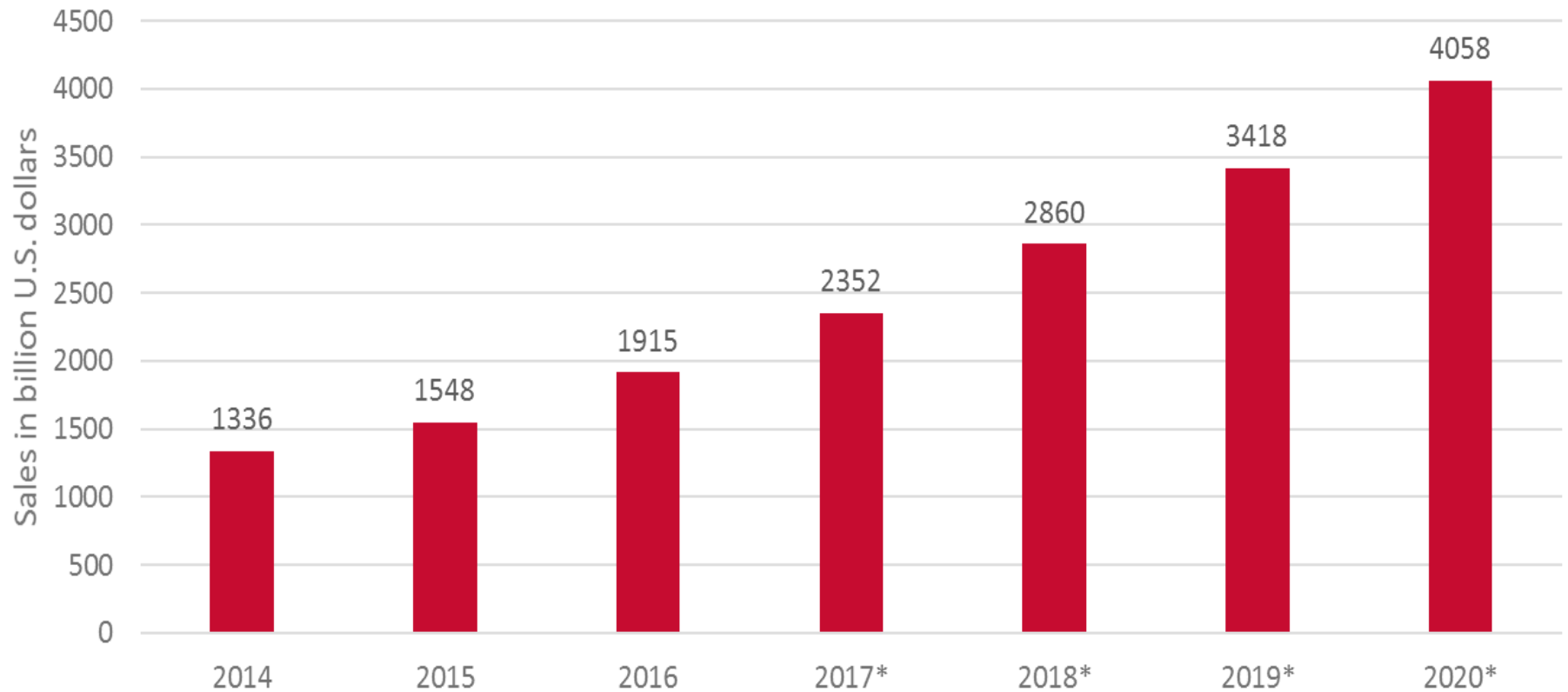
*Research Associate*

*School of Mechanical and Aerospace, Robotics Research Centre*

*26 May 2017*

# Retail E-Commerce Sales Trends

Retail e-commerce sales worldwide from 2014 to 2020 (in billion U.S. dollars)



Statista. (2016). Global retail e-commerce sales 2014-2020.

<https://www.statista.com/statistics/379046/worldwide-retail-e-commerce-sales/>

# State-of-Art Warehouse Robotics



Human Picker

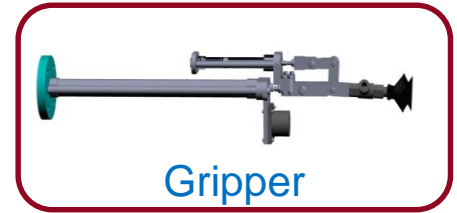
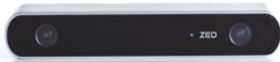
Kiva Robot

# RedMart, Singapore



# Autonomous Mobile Robot Picker

ZED



Gripper



Onboard PC



## Software Modules Included:

- Task Planning
- Motion Planning
- Path Planning
- Collision Avoidance
- Grasp Planning
- Item Identification
- Item Pose Estimation
- Error Recovery

UR 5



Hans Mobile Platform

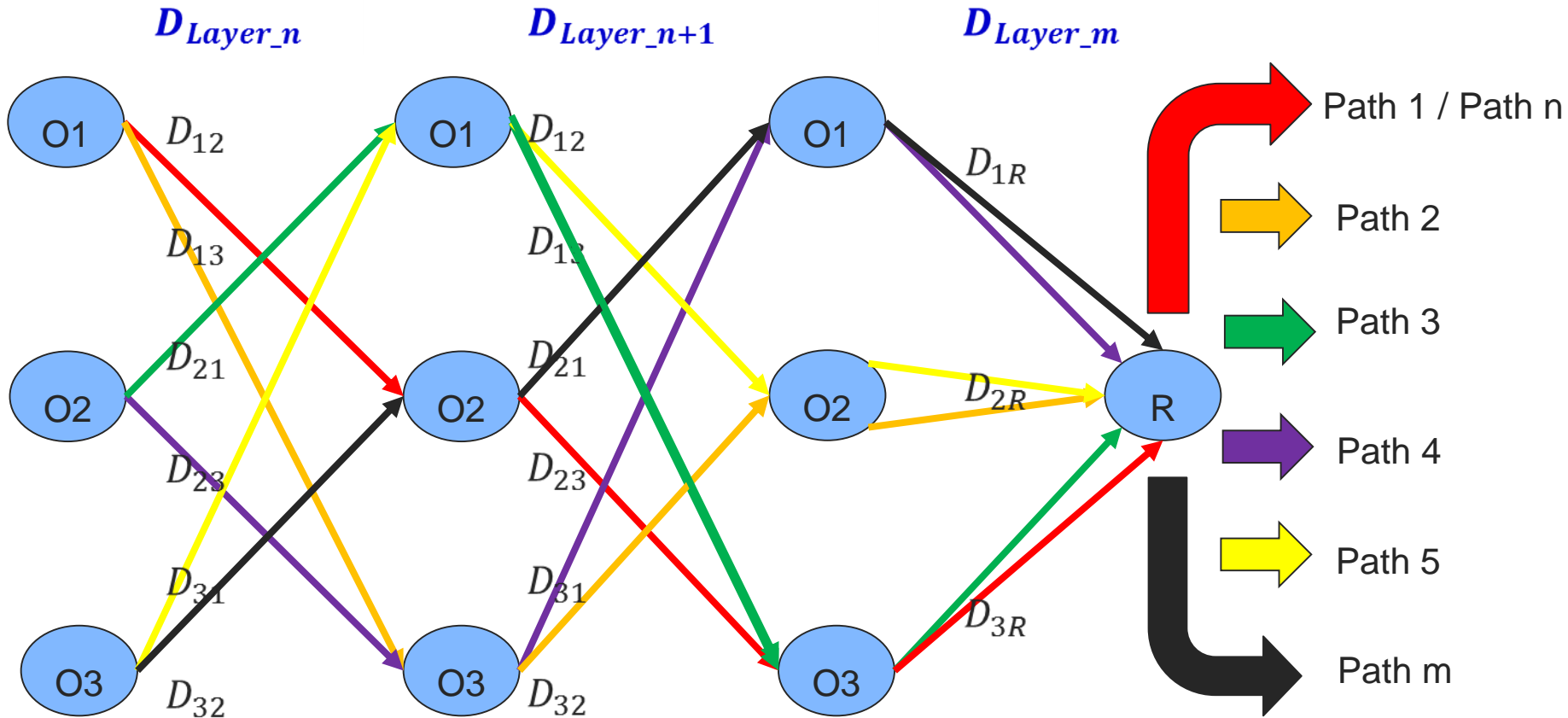


# Warehouse Management Software

The screenshot displays the RViz interface for a warehouse management simulation. The main view is a 2D top-down floor plan of a warehouse. A red robot icon is positioned on the left side. Three objects are marked with red stars and labeled: 'Object 3' in the upper-middle section, 'Object 2' in the middle-right section, and 'Object 1' in the lower-middle section. A purple square labeled 'Loading Point' is located on the right side. The floor plan includes various elements like shelves, doors, and a grid. A legend in the bottom right corner identifies symbols for 'Standard shelf', 'Loading dock', 'Dumpeater', 'Parking stall', and 'Staging area'. The top menu bar includes 'File', 'Panels', and 'Help'. Below the menu, there are several tool icons: 'Interact', 'Move Camera', 'Select', 'Focus Camera', 'Measure', '2D Pose Estimate', '2D Nav Goal', and 'Publish Point'. At the bottom, a 'Time' panel shows 'ROS Time: 1590.40', 'ROS Elapsed: 5.45', 'Wall Time: 149516558.85', and 'Wall Elapsed: 76.90'. There is also a 'Reset' button and a checkbox for 'Experimental'.

- Items location
- Images of the Item
- 3D Point Cloud Data

# Order Planning



R : Robot current Position

O : Object

D : Distance

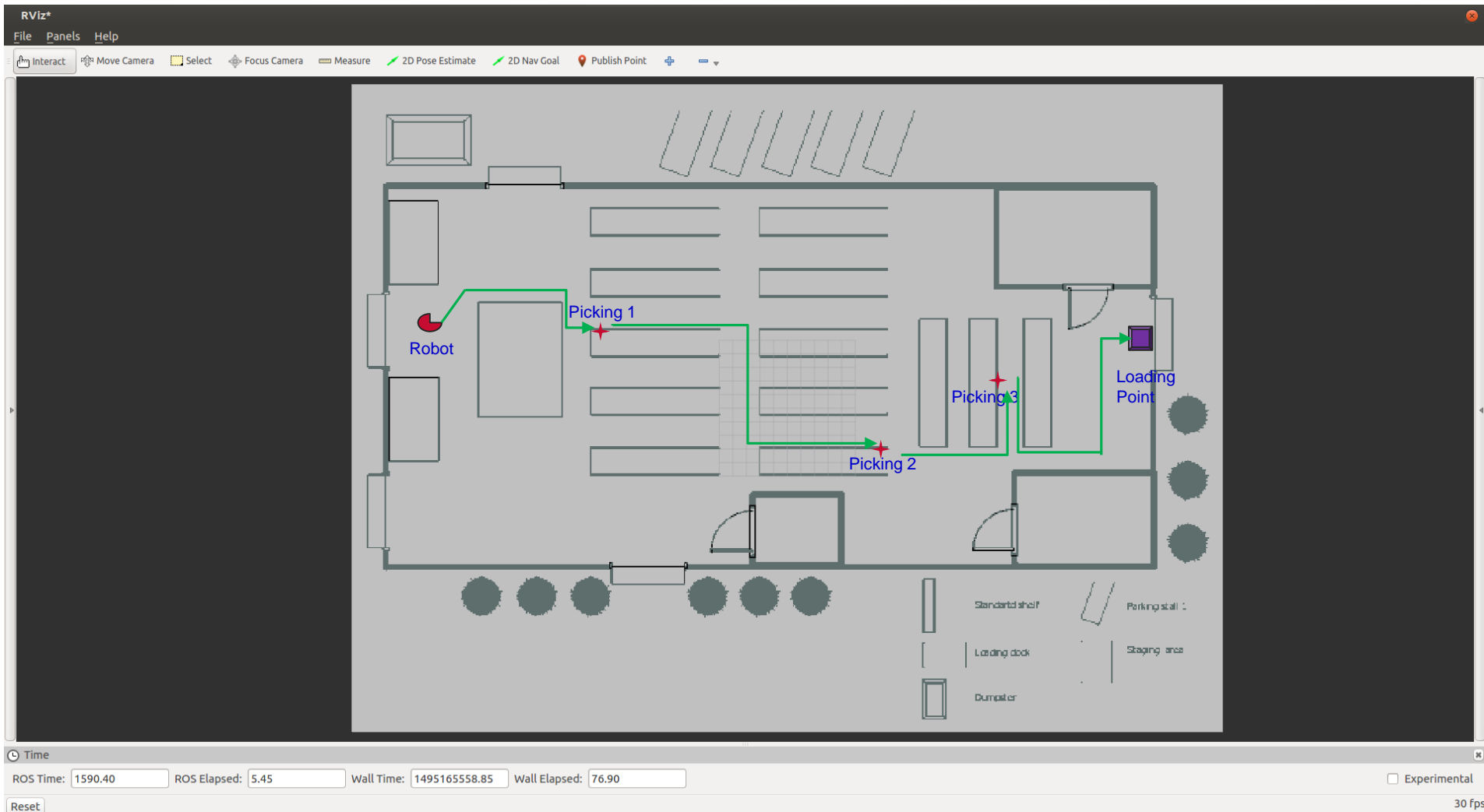
Layer : Picking Step

r

$$D_{i\_Total} = \sum_{i=n}^m D_{Layer\_i} = D_{Layer\_n} + D_{Layer\_n+1} + D_{Layer\_m}$$

$$Path_{chosen} = \text{Min}(D_{Total\_n}, D_{Total\_m})$$

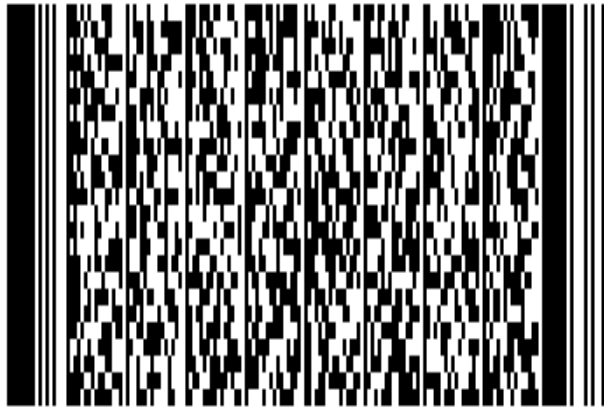
# Picking Plan





# Comparison of Markers

PDF417



616 x 36 pixels  
FedEx

QR



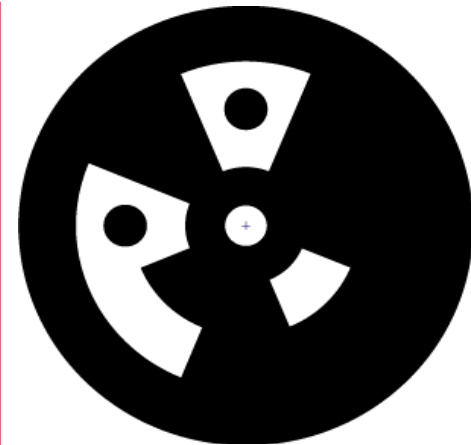
37 x 37 pixels  
In-Store Product Labeling

Barcode



380 pixels  
Retail, Industries

InterSense

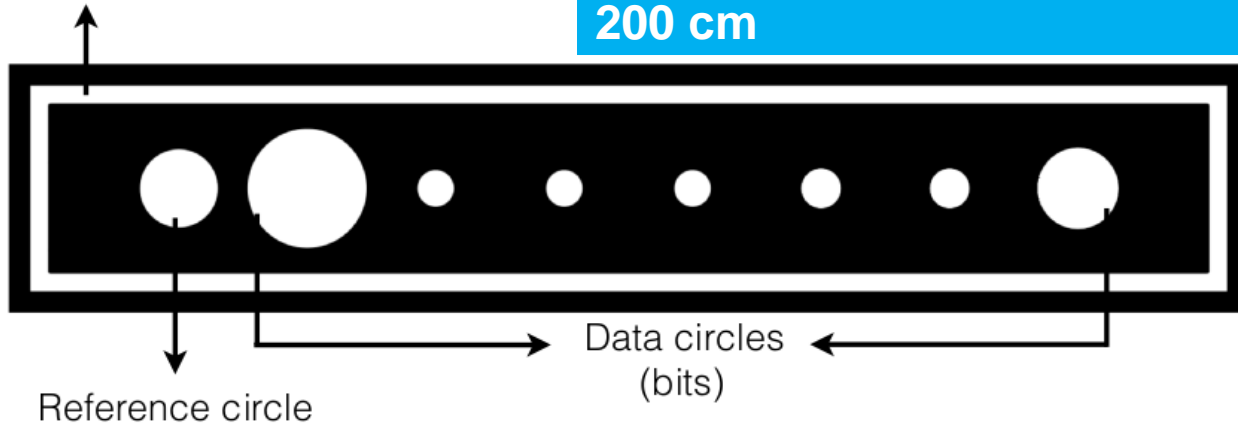


30 x 30 pixels  
Motion Tracking

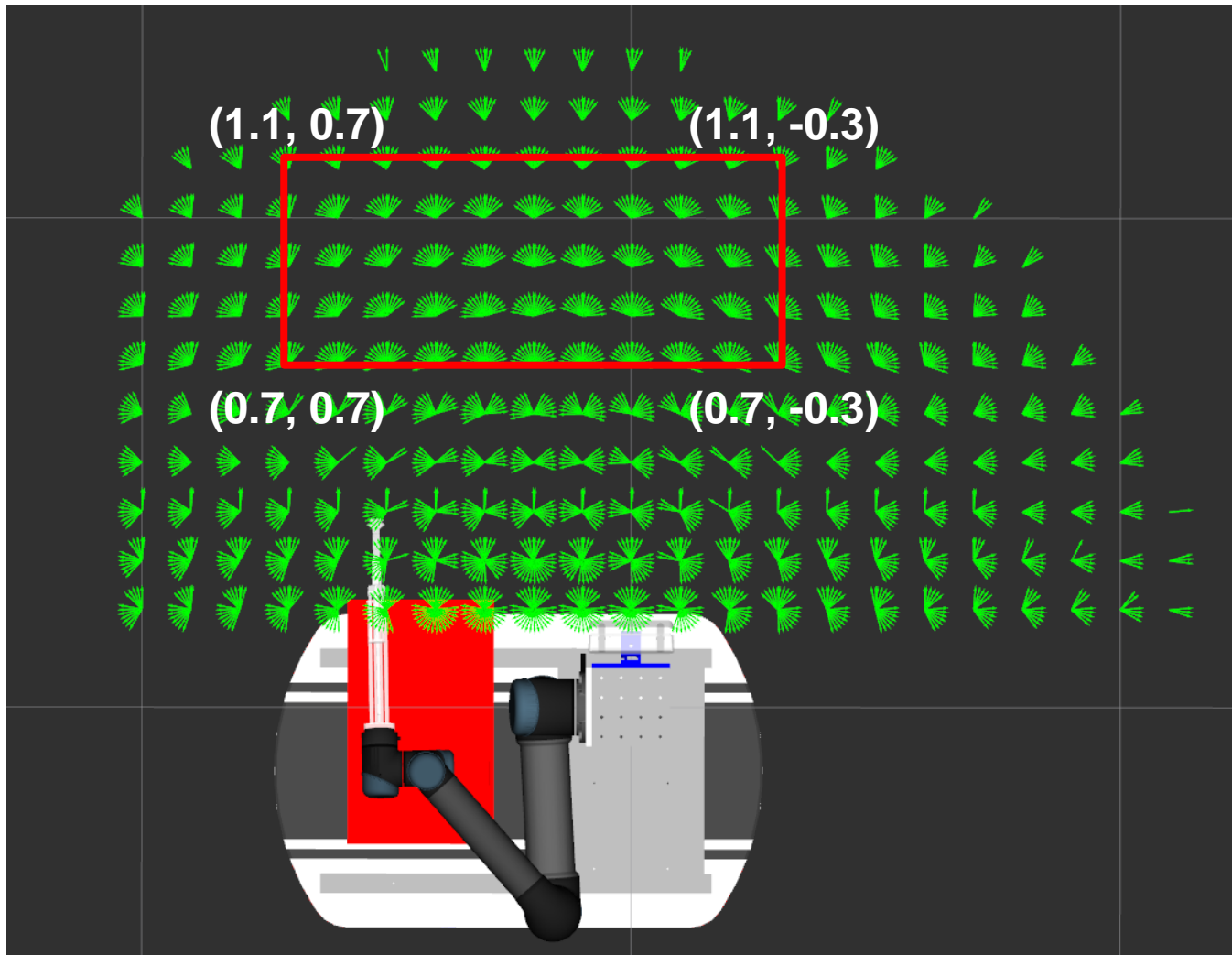
# View-Invariant tag (VITag)

Rectangular border for candidate detection

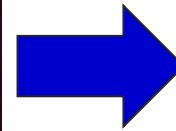
Detectable Range : 20 – 200 cm



# Pickability Constraints (Top View)



# Identification Target & Estimating Suction Pose



PCL Data within ROI is segmented using Voxel Cloud Connectivity Segmentation (VCCS)



SIFT and FPFH extract features for RGB Image Segment and PCL segments respectively



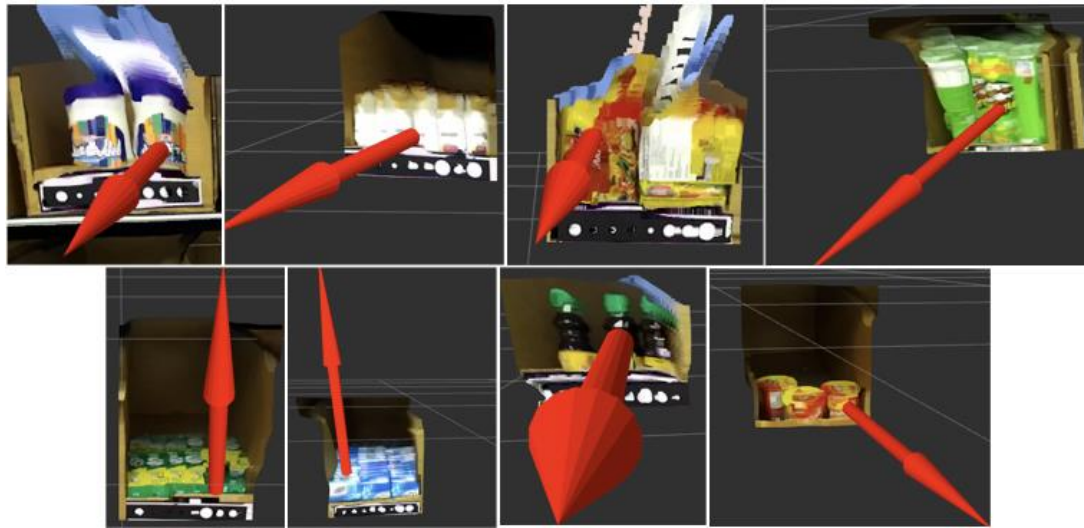
FLANN-based matcher were used to match the extracted features

# Identification Target & Estimating Suction Pose

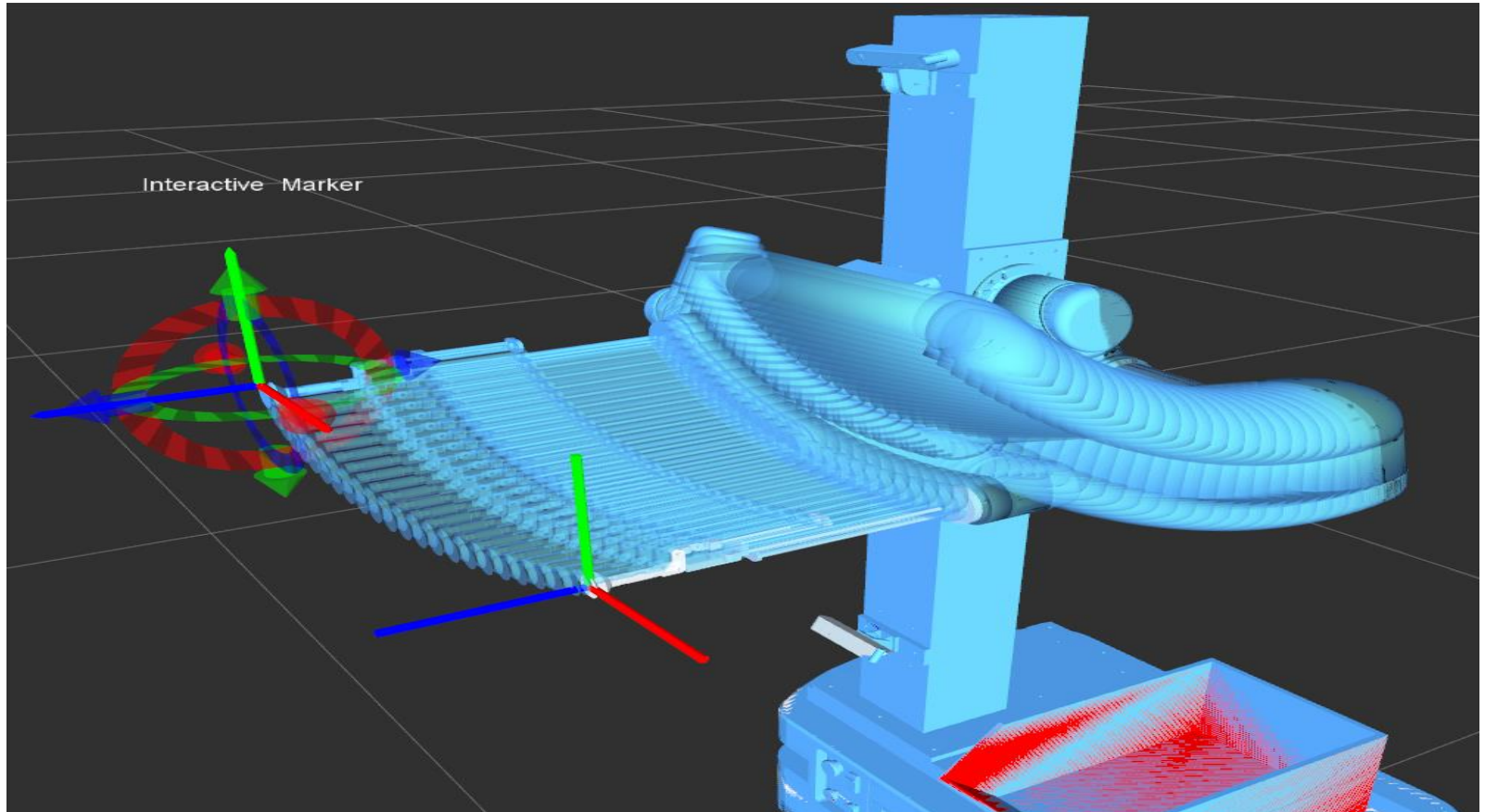
Camera View



Point Cloud Data

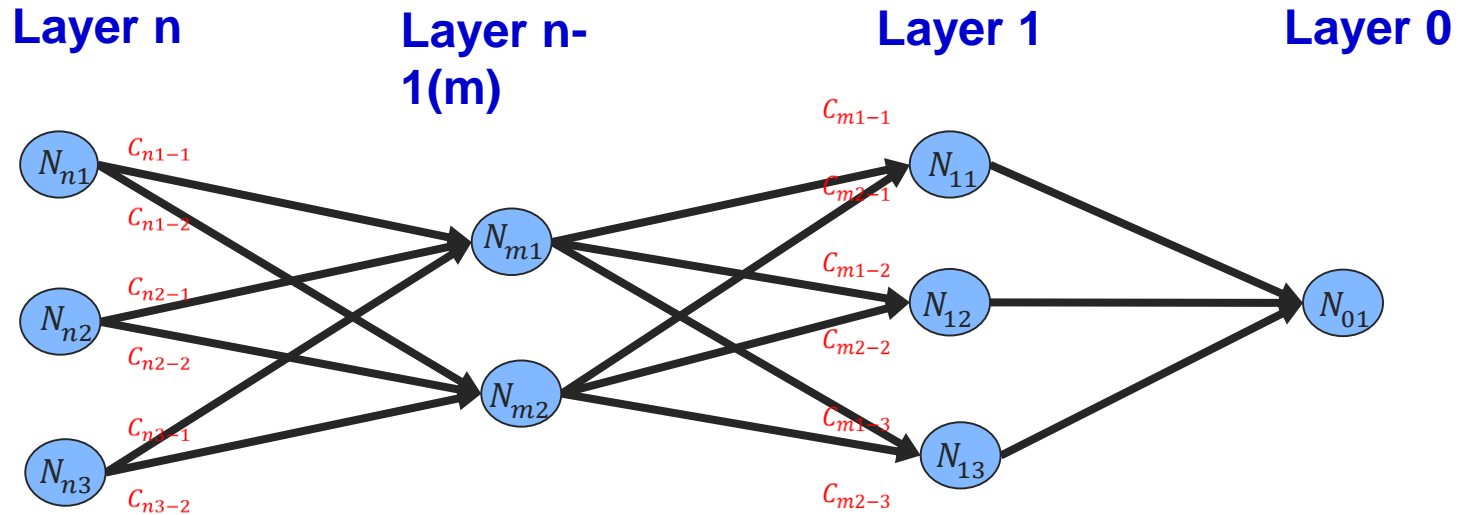


# Manipulation Planning



- System generates a sequence of trajectory points in free movement space

# Manipulation Planning



Trip Cost

$$C_i = \sum_{x=0}^n [q_x - q_{x-1}] [\omega]$$

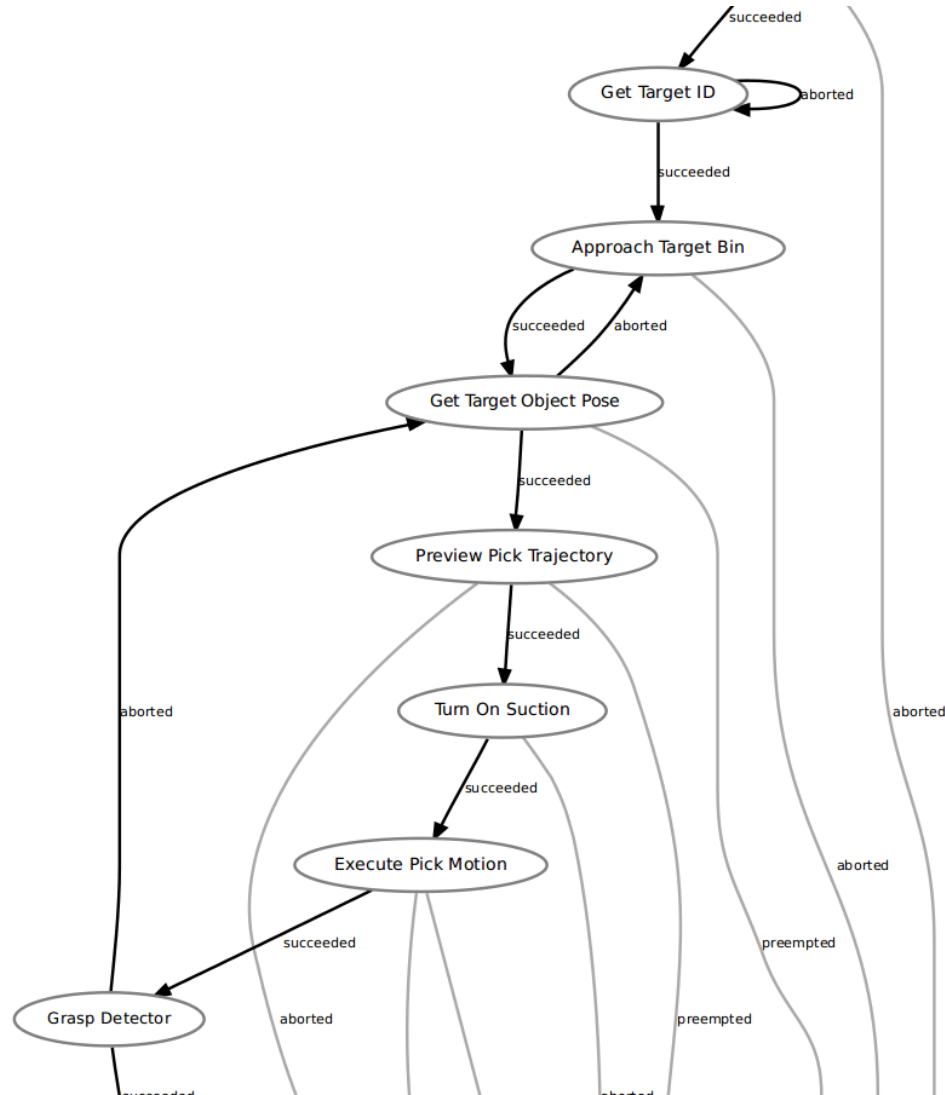
Joint positions

Joint weights

Path No.

$$Path_{Chosen} = \text{Min}(C_1, C_n)$$

# State Machine Integration





# Demonstration Video



## Demonstration of Automated Robot Item Picking System

*presented by*

*Robotics Research Center  
School of Mechanical and Aerospace Engineering*

*07 April 2017*



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