Methods for Improving Performance of Robotic Pick & Place System for ARC 2017

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May 29, 2017

ICRA Workshop on Warehouse Picking Automation 2017, Singapore
Overview

- Object Recognition System
- Hybrid Gripper Design
- Grasping Algorithms
- Automatic Data Generation
- Motion Planning
- Packing
Object Recognition

- Scene Parsing network (PSPnet)
- Single Shot Detection Network

Work by Anima, Ashish, Siddharth and Chandan
Learning Architecture for detecting Unknown Objects

- Labeled Data
  - Category 1 data
  - Category 2 data
  - Category 7 data
- Category / ROI Training (RCNN/RFCN)
- ImageNet Features (VGG16)
  - ROI Cropped Images & Labels
  - ROI Cropped Images & Labels
- Trained Model For 7 classes
  - Classifier training (Random Forest) for category 1
  - Classifier training (Random Forest) for category 2
  - Classifier training (Random Forest) for category 7
  - RF Model For category 7
  - RF Model For category 2
  - RF Model For category 1
ROI and category obtained from a trained RCNN network
Testing with Unknown Objects

Unknown objects were similar to the ones which were used for training – different brand, different colour etc.
Identification using Scene Parsing Networks (PSPNet)

Test Images

PSPNet (6 Hours)

Modified PSPNet (30 minutes)
Automatic Data Generation

- Deep Network training requires large training datasets which are usually generated through laborious manual process.
- The process could be made efficient and fast through automation.
- Challenges
  - Samples generated in a controlled environment needs to take into account the real-world variations – Data augmentation / Domain adaptation.
  - Outlier rejections, eliminate redundancy, reduce noise.

Work done by Harsh Vardhan
Data Augmentation

Platform for automatically generate templates

Synthetically Generated Clutter
Effect of Data Augmentation

Table 1: Effect of various augmentation schemes on mean average precision of Faster-RCNN and R-FCN

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Name</th>
<th>Label</th>
<th>Sample Size</th>
<th>Test Set 1 RCNN</th>
<th>Test Set 1 RFCN</th>
<th>Test Set 2 RCNN</th>
<th>Test Set 2 RFCN</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Varying Illumination</td>
<td>SET1</td>
<td>14000</td>
<td>0.77±0.18</td>
<td>0.82±0.22</td>
<td>0.80±0.20</td>
<td>0.85±0.22</td>
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<tr>
<td>2</td>
<td>Blurring dominant</td>
<td>SET2</td>
<td>14000</td>
<td>0.71±0.18</td>
<td>0.81±0.23</td>
<td>0.83±0.18</td>
<td>0.86±0.22</td>
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<tr>
<td>3</td>
<td>Sharpening dominant</td>
<td>SET3</td>
<td>14000</td>
<td>0.74±0.21</td>
<td>0.85±0.19</td>
<td>0.86±0.16</td>
<td>0.89±0.14</td>
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<tr>
<td>4</td>
<td>Only sharpening</td>
<td>SET4</td>
<td>14000</td>
<td>0.79±0.15</td>
<td>0.82±0.19</td>
<td>0.91±0.10</td>
<td>0.87±0.15</td>
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<tr>
<td>5</td>
<td>Color casting</td>
<td>SET5</td>
<td>14000</td>
<td>0.65±0.27</td>
<td>0.76±0.16</td>
<td>0.76±0.15</td>
<td>0.88±0.12</td>
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<tr>
<td>6</td>
<td>Vignetting</td>
<td>SET6</td>
<td>14000</td>
<td>0.79±0.18</td>
<td>0.77±0.23</td>
<td>0.75±0.22</td>
<td>0.83±0.20</td>
</tr>
<tr>
<td>7</td>
<td>SET3 + SET7 + SET10</td>
<td>SET7</td>
<td>14000</td>
<td>0.77±0.18</td>
<td>0.80±0.22</td>
<td>0.83±0.19</td>
<td>0.85±0.20</td>
</tr>
</tbody>
</table>
Hybrid Gripper Design

Linear Actuators

0 to 90 degree rotation for suction end-effector.

Retractable two-finger Gripper

Work done by Venkat Raju
Scissor type CAM mechanism for gripper Retraction

- Payload = 2 Kg
- Weight = 2 Kg
- Clearance between fingers = 4.5 cm
- Dimension: 42 x 100 x 90 mm
Video Demonstration

A Geometry-based Grasping Algorithm for a Warehouse Pick and Place Robot

February 25, 2017

Olyvia Kundu

TCS Research
Tata Consultancy Services
Some more modifications

Curved support for elliptical retraction

New CAM for Gripper Retraction

Smaller length = 38 mm

Smaller cross sectional work area = 7 x 7 cm. Higher clearance between fingers.
Weight = 1 ~ 1.5 Kg.

Curved support for elliptical retraction

Reduced Cross Sectional work Area

Inside protective Mesh

7 mm
Grasping Algorithm

Input Point Cloud (RGB-D) -> Object Recognition Using RCNN -> Region Growing in The detected window

Shape Primitive Fitting

Axis Detection Using PCA

GMM based Object Segmentation

Localize Grasping Region
Salient Features

- Inaccuracy of RCNN (due to less training data) is compensated by the Grasping algorithm.
- The object within the RCNN bounding box is localized using a GMM based clustering algorithm that uses Color + depth curvature information.
- Primitive shape, graspable affordance and grasp pose is detected without any apriori shape information in real-time.
Identifying multiple surfaces for a given object.

GMM clustering with Color

GMM Cluster with Color + Depth Curvature

Primitive Shape Identification

Under Review At IROS 2017
New Results

Identifying precise graspable affordance for irregular objects.
Video Demonstration

Hybrid Gripper Design

Version 2.0

Venkat Raju

Tata Consultancy Services
Grasping using Deep Networks

- Validation accuracy = 82.39%
- Correct predictions

A pre-trained ResNet V2 tensorflow model is fine-tuned with Cornell Grasping dataset.

- Incorrect predictions

- Ambiguous predictions: Predicted as correct, but do not look like
  (Need to look into this!)

The current State-of-the-art

<table>
<thead>
<tr>
<th>Paper</th>
<th>Method</th>
<th>Accuracy (image-wise split)</th>
</tr>
</thead>
<tbody>
<tr>
<td>[1] Redmon et al.</td>
<td>Direct regression (25 epochs)</td>
<td>84.4%</td>
</tr>
<tr>
<td>ICRA 2015</td>
<td>Regression + classification (25 epochs)</td>
<td>85.5%</td>
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<tr>
<td></td>
<td>MultiGrasp Detection (25 epochs)</td>
<td>88.0%</td>
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<tr>
<td>[2] Kumra et al.</td>
<td>Uni-modal grasp predictor (30 epochs)</td>
<td>88.84%</td>
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<tr>
<td>CVPR 2017</td>
<td>Multi-modal grasp predictor (50 epochs)</td>
<td>88.53%</td>
</tr>
</tbody>
</table>

Work done by Ankita
Motion Planning with Moveit, Octomap etc.

Gazebo Simulation Environment

Waypoint generation using RRT

Collision avoidance using Octomap

3D Model generation

Work by Sharath and Manish
Packing into Boxes

Work by Soumyadeep and Olyvia
Thank you

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URL: https://sites.google.com/site/swagatkumar/iitk-tcs-arc-2017