In hand object modeling center for robotic perception

Diploma thesis

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Objectives
Introduction
Software and hardware tools
Implementation
Objects detection and recognition
Conclusions
Objectives

- model of an object based on the data collected with an RGB camera
- acquisition of the models for textured objects
robots are starting to be more capable and flexible

robot truly autonomous = to learn “on the fly” and possibly from its own failures and experiences

the robots have to be equipped with the robust perception systems that can detect and recognize objects
Personal Robot 2 is equipped with 16 CPU cores with 48 Gigabytes of RAM. Its battery system consists of 16 laptop batteries.

- ROS system - libraries for perception, navigation and manipulation.
- Open Source Computer Vision Library
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System overview

- The top-left image is the input image, the data generation from PR2,
- The top-right image is the final one, the region of interest extracted,
- The bottom-left is the URDF robot model in openGL and
- The bottom-right image is the image with the mask part of the robot.
Service Client program visualization

- OpenGL visualization
- URDF - Unified Robot Description Format
- TF – Transform Frames

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Masking of robot parts

- to prevent feature detection on the robot’s gripper
- enables robot-noise-free object recognition
Mask dilution

- detect transitions between black and white through comparing of pixel values.
- add padding, that is color black 15 pixels on the each side of the detected borders.
NNS (Nearest Neighbor Search)

Radius Search and KNN Search method

- Images contain a considerable number of outliers
- Radius search - check the nearest neighbors in a specified radius (20-30 pixels)
- KNN search – check the nearest neighbors for a specified number of neighbors (2 - 5 neighbors)
- removing the outlier features
- extract the region of interest by computing a bounding-box rectangle around the inlier features.
compute the bounding box around all the inlier keypoints filtered by either radius- or KNN-based search.

~100 ROI for each object
The user manually annotate the top-left and bottom-right corner of the object. All features lying outside thus obtained bounding box are considered as outliers.
Object detection and recognition

- Detectors
  - finds some special points in the image like corners, minimums of intensities

- Descriptors
  - concentrate of keypoint neighborhood and finds the gradients orientation

- Matchers
  - for each descriptor in the first set, the matcher finds the closest descriptor in the second set by trying each one
SIFT-detector & descriptor
Scale Invariant Feature Transform

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Image correspondences in hand based modeling

- Read images
- Compute keypoints
- Visualize the keypoints
- Calculate descriptors
- Find and extract the matchers
- Run homography calculation with ransac
- Create and draw a set of inlier matches
The acquisition of templates for 1 object took approximately 1 minute.
run the recognition benchmark using the ODUfinder system to evaluate the quality of the acquired templates.

a document for storing all the detection and recognition results.

the file contained the first 5 objects that were supposed to be the result of object identification.
Experiment results

- First row: number of all templates per object (ALL),
- Middle row: number of true positive measurements (TP),
- Bottom row: ratio between TP/ALL

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objects are commonly found in home and office environments.

good detection for many objects in the dataset, but is still problematic for small boxes.
Shopping project

1. Detection of shopping basket using Kinect sensor and box fitting algorithm
2. Alignment of basket using fingertip sensors
3. Checking gripper aperture to verify successful grasp of basket’s handle

4. Using URDF model of storage rack to detect objects
5. Verification of objects pose using plane and cluster extraction from projected stereo
6. Robot holding the basket in the hand while standing

7. Alignment of basket using fingertip sensors measurements
8. Pre-recorded trajectory to topple the handle
9. Bi-manual basket emptying using synchronized arm motions

10. Recognition of object using vocabulary trees and SIFT features extracted on the face of the milk the robot is looking at

11. Detection of handles and opening of fridge using incremental controller
12. Finding biggest plane inside fridge and putting the object in the center of the plane
13. Closing the fridge using the opening trajectory

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Conclusions

- Extract the right region of interest to improve the performance and reduce computational cost.
- Remove the outlier features through 3 methods.
- Use of the Kinect data acquisition to take the data from robot instead of stereo cameras;

- More information:
  - http://www.ros.org/wiki/model_completion
  - http://monica-opris.blogspot.com/
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Questions & Answers!!!