Automatic Approximation of Primitive Shapes using Point Clouds

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Abstract

This paper proposes a method to estimate appropriate primitive shapes by automatically using a point cloud of objects. The process is as follows. First is to estimate a rotation angle of the object and, then place a primitive shape (i.e., cylinder or sphere) in the center of the object. The primitive shape is either stretched or compressed to fit the object. The distance between all the point cloud of the object and the primitive shape are measured. We apply these methods with various primitive shapes and find the most suitable primitive shape. We show that objects like apples and chikuwa can be recognized with primitive objects, such as spheres and cylinders.

Keywords: Primitive Shape, Point Cloud, Bulk Picking

1. Introduction

Bulk picking is one of the fundamental tasks of industrial robots[1]. In this task, the robot is tasked to picks up an object from a case containing several objects. To achieve this task, the robot required to estimate a grasping point of the object. However, this is a difficult task for the robot to estimate the proper grasping point without knowing the hiding point or occlusion of the object. To understand the occlusion of the object, it is necessary to teach shapes of the object to the robot with CAD data. However, with unknown objects, the robot must investigate the shape of the object by itself. One of the methods to determine the object shape is to approximate it with primitive shapes. The primitive shapes are defined simple shapes, for instance a sphere or a rectangle.

In this study, we propose a method for estimating primitive shapes in a situation where a robot observes a part taken out of an enclosed case. Our method is to calculate the likelihood of shapes by stretching and shrinking several kinds of primitive shapes and compare to the object. With this we able to determines the closest primitive shape to the object. In this research, we evaluate our method with two types of objects: apples and bananas. Our result shows that we were able to find an appropriate primitive shape for each object.

2. Importance of Understanding Occlusion

Occlusion is a part of an object that is not visible with the observer point of view. The example of occlusion is shown in Fig. 1. Figure 1 displays a case where an understanding of the shape occlusion is necessary to pick the object. In this situation, a robot arm is tasked to carry fried food from the enclosed box. If the robot does not understand the object's occlusion, the robot may fail to find an optimized location (center of gravity) of the object to grasp and fail the task. To prevent this situation, the robot must understand the shape of the object.

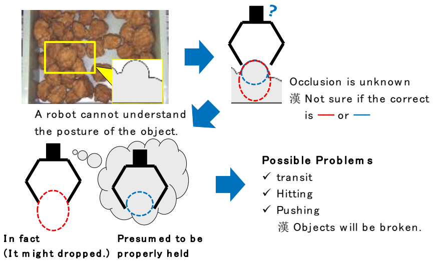

Fig. 1. Importance of understanding occlusion

3. Proposed Methods

The overview flow of our proposed method is shown in Fig. 2. In general, the system works as follows:

1. Capture the object point cloud from an interested object with the RGB-D camera.
2. Restrict the area.
3. Detect and remove the planes.
4. Estimate the orientation of the object.
5. Place each primitive shape at the estimated orientation and Cartesian coordinate of the object, and scale each shape according to the size of the object point cloud.
6. Measure the distance between the point cloud and the primitive shapes, and detect the object with the shortest distance.
7. Steps 4 to 6 are applied several times to decide the most appropriate primitive shape.

The object with the shortest distance is considered the object with the best match. In following sections, we further describe important steps in our proposed method.

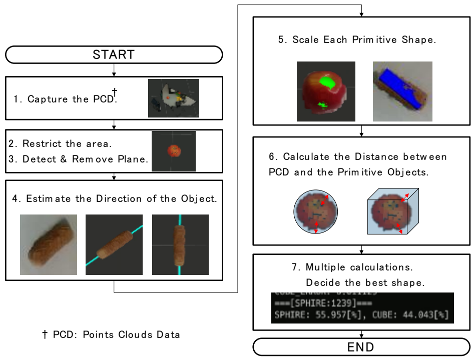

Fig. 2. Overview pipeline of our proposed method

3.1. *Step 4. Estimate the direction of the object.*

In step 3, we divide the process into XY and XZ planes. In the XY, the yaw angle of the object is calculated, and in the XZ, the pitch angle of the object is calculated. These are calculated using the least-squares method.

3.2. *Step 5. Scale each primitive shapes*

In step 5, primitive shapes are placed in the point cloud of the object and stretch. First, the system finds a center of gravity of the object point cloud. Next, it places a primitive shape at the location of center of gravity. Finally, the primitive shape is stretched and contracted.

3.3. *Step 7. Decide the best shape*

These process from step 4 is repeated several times, in each time, voting for each object that is estimated to be appropriate. After a predefined threshold number of votes, the shape with the highest vote rate is decided.

4. Experimental results

The experiment was conducted to evaluate our method using objects like apples and chikuwa. For apples, the voting score for spheres was 57%, and for chikuwa, the voting rate for cylinders was 62%. This indicated that appropriate primitive shapes can be voted.

5. Conclusion and Future Work

We proposed a method for estimating primitive shapes that adequately approximate objects for bulk picking industrial robots. We conducted an experiment with apples and chikuwa. We found that our method can recognize the approximate primitive shape objects properly. In the future, we will increase the number of primitive shapes and construct a system to apply the approximated primitive shapes to objects stacked together. In addition, we will integrate with a system that performs highly accurate object recognition using RGB and Depth images[2].

References

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