A development of visual-feedback automatic control for robotic manipulator

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Abstract: In this work, an automatic robotic manipulator control based on visual information for object tracking is presented. The tracking process employ Recurrent Neural Network technique to predict the location of target object which is used to calculate movement of the robot. We also propose an object analysis based on image processing technique for object width estimation. We implemented the proposed system with an actual robotic manipulator with a gripper for experiments. The experiments shown that object size estimation method results the maximum accuracy at 1.13% and the tacking process can effectively keep the target object in the position suitable to perform grasp.

Keywords: Automatic robotic manipulator, Recurrent Neural Network, Object tracking, Object Analysis

1. Introduction

Robotic manipulators are being used in wide variety of applications such as manufacturing process, home use, and medical. One of the major function of robotic manipulator is to pick up an object to move it by using a gripping tool as an end-effector. However, the process of moving the end-effector is complicate due to the multiple dimensions have to be controlled consistently based on the number of movement joint of the robot. This complexity pose the difficulty to an operator in case of manual or semi-auto control operations. Thus, in this work we present an automatic robotic manipulator controller method based on computer vision techniques to facilitate manual or semi-auto control operations. The proposed method takes a user selected target object image then tracks the object. The tracking process consists of image tracking task and manipulator joints control task. The proposed method has been implemented in an actual robotic manipulator with a 3D-camera installed at the end-effector of the robot. A Neural Network based object tracking tecnique was occupied for tracking process. Also, we present an object analysis method based on image processing technique to estimate the size of the object. The experiments shown that object size estimation method results the highest accuracy at 1.13% and the tacking process can effectively keep the target object in the gripping position.

2. Proposed method

The proposed object tracking process is actually a closed-loop control process as shown in Fig.1. The aim of the process is to keep the target object image in the center of camera frame which is the position of the end-effector to perform gripping task. The target image information i.e. cropping box location on the camera frame, is given to the control process as set point. Thus the controller manipulates all robotic manipulate joints based on the deviation of target image information to the center of camera frame.

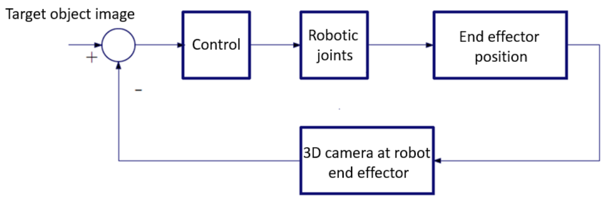

Figure.1 Structure of the proposed system

2.1 Object Tracking by Recurrent Neural Network

The object image tracking process implemented in this work is based on Recurrent Neural Network technique. There are multiple layers constructed in an Recurrent Neural Network prediction mode as illustrated in Fig.2. The Region of Interest (ROI) is used to choose the area of the target object image in the camera frame as raw input information for prediction process. The Convolutional layers performs feature extraction task to obtain meaningful information of the raw input. The motion behavior and characteristic are learned and will be used to predict upcoming motions. At the regression layer, the prediction results from the recurrent layer are interpreted to the coordination of the object in the camera frame.

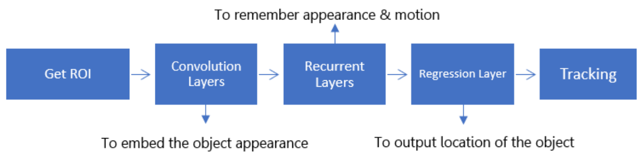

Fig.2 Recurrent Neural Network for object tracking

2.2 Object Analysis

In order to perform correct action of grasping, object shape information is needed. One of the vital object

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parameters is the object size which is importance for correct gasping action and to avoid a collision of end-effector and the object. In this work, Hough's transformation based line detection method is occupied in the proposed object size estimation process as shown in Fig.3. Canny edge detection algorithm is used to transform original image into binary type image which is required for Hough's transformation process. The lines detected from Hough's transformation are then selected by the allowance angle to accept only vertical lines of the object shape. The angle was experimentally set at 75°

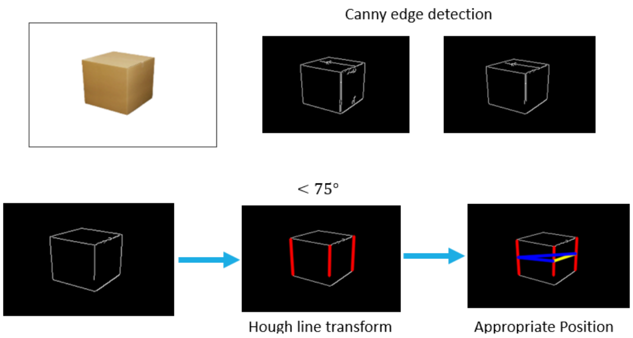

Fig.3 Object shape line detection process

The selected lines are then used to calculate the object width based on trigonometry calculation as explained in Fig.4. The importance information for the calculation is the distance between end-effector and object. We employ a 3D-camera that provides depth information that can be used in the calculation.

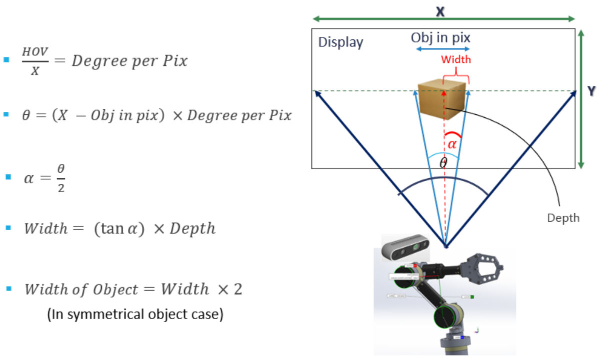

Fig.4 Object width estimation algorithm

3. Experimental Results

The experiments were conducted with an actual robotic manipulator with a robotic gripper is used as end-effector. A 3D-Camera installed at the gripper is used to obtain image for object tracking process and also provide depth information for object width estimation. Four example object with different size shape were used as target object in each experiment trial. The tracking process shown effective performance as the manipulator can reach object target location (center of camera frame) at all experiment trails. The object width estimation experimental results shown in Fig.5. The highest accuracy is at 1.13% and the accuracy is less than 5% for cylindrical-shape objects while error increased in the rectangle-shape box due to confusion of multiple detected lines.

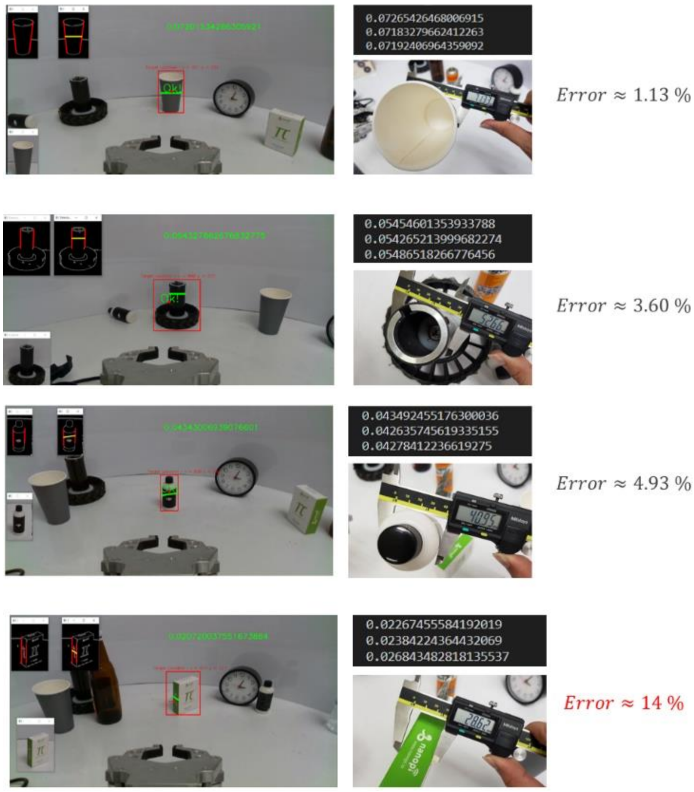

Fig 5 Object width estimation experiments

4. Conclusion and Future Development

A Visual-based robotic manipulator control method for object tracking is presented and implemented in this work. The image tracking employing Recurrent Neural Network is used to predict the location of the object. We also proposed an object analysis method to estimate object width. The experiment shown that the tracking process has performed with effective performance. The highest accuracy of the proposed object width estimation is at 1.13%. In future, we will conduct addition experiments to quantitatively evaluate the performance of the object tracking method. Several improvements will also be performed such as using Kalman-filter to deal with uncertainty situations.

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