A Novel Approach For Pick and Place Robot in Real Time Embedded System

M. S. Chelva, S. V. Halse

Research Scholar, SRTM University, Nanded, Maharashtra, India
Karnataka States Women’s University, Vijaypur, Karnataka, India

mschelva@gmail.com, drsvhalse@rediffmail.com

Abstract— In many industries, there are some tasks which pose life risk for human workers. The trend is to replace the human worker by robots. These intelligent machines do a task with precision and suit for repetitive tasks. One typical task in an industry is to pick up a load (object) and place it elsewhere. The goal is to identify (locate) the correct load and pick it up to transport. In this paper, we propose a soft computing approach for an industrial robot to detect the load or object in its vicinity and move closer to the load. The robot optically recognizes the objects with an efficient image processing algorithm that uses mask template of dynamic size to detect the object. The results are promising on real time embedded system.

Key Words—Object Detection, Template Matching, Hue Saturation Value (HSV), Gamma Correction, Dilation

I. INTRODUCTION

Electromechanical machine guided by an electronic circuitry or computer program is called as a robot. Robots are replacing humans to perform the same job at high speed and with more accuracy in every field. Heavy tasks which require objects to be moved from one place to another are being done by a ‘Pick and Place robot’. For pick and place robot, one can use text command or voice commands. For real time interface hand gesture gives most interactive way but this requires human intervention. Development of efficient algorithms is a challenge to handle low-level tasks as it influences the performance of all higher levels of various applications. So, to automate this task of robot, the advanced way is to provide vision to robot and get real time feedback from the surrounding. Detecting and tracking of moving objects are widely used as low-level tasks of computer vision applications.

Vision based control of the robotic system is the use of the visual sensors as a feedback system to control the operation of the robot. Integration of the vision based algorithms with visual sensors can enhance the performance and the efficiency of the system.

To mock human visual sensors vision based system have been implemented. For successful object recognition image processing algorithm take time in processing the image frame and object tracking is important component in majority of the computer vision applications [7]. Given the initial state of a target object in a frame of a video, the goal of tracking is to estimate the states of the target in the subsequent frames. Although object tracking has been studied for several decades, and much progress has been made in recent years still it remains a very challenging problem [14, 15, 16]. The most common problems in object detection and tracking are illumination variation, occlusion, background clutters etc. There exists no single tracking approach that can successfully handle all scenarios as numerous factors affect the performance. Therefore, it is crucial to evaluate the performance of object detection and tracking algorithms in terms of their strength and weakness and design more robust algorithms.

In section II, we analyze various methods for pick & place robot and the related work on the techniques. In section III, our approach is presented. Section IV discusses the results and section V provides the conclusion of the paper.

II. RELATED WORK

The hand gesture technique is used control the robot to recognize object, and pick & place them in appropriate place. A video camera is used for capturing the image of the object and processed using open CV. The output of the processing controls the movement of the arms to pick and place the object. Gesture commands provide the user an interactive and easy way to control the robot [1]. To detect and track the moving objects quickly one approach is contour based method. This method uses lines computed by a gradient-based optical flow and an edge detector where the edges extracted are restored as lines. The outdoor-scenes show fast and robust results of this method [2]. To detect the object in a sequence of color images taken from a moving camera, Bernd [3] has implemented an algorithm in which first step is to estimate motion in image plane i.e. to determine the motion of cluster built by grouping of pixels in color or position feature space. Kalman filter is used to predict dynamic changes in cluster positions. Motion based segmentation is second step where adjacent clusters with similarity are combined to build object hypotheses. The approach was tested in real time to track traffic scenes;
and it successfully segmented various types of moving objects, such as cars, motorcycles, and even pedestrians. For multiple object detection SIFT approach is used to obtain a set of correspondence between object model and current image. Clustering of correspondence is done to segment multiple instances. SIFT have two modules: Feature extraction & matching and segmentation. In Feature extraction features are extracted from the model object and the current image, subsequently matched using similarity measures and the best matched are hold off [4]. Another method is directed towards development of the image processing algorithm which is a pre-requisite for the full operation robotic for object task. For this type of task, first the feature extraction algorithm detects the object [5]. Then image is sent to the classifier to recognize what object it is and once this is finalized, the output specifies the type of the object along with coordinates to be ready for the Robotic Arm to execute the task. But the challenge was to develop image processing algorithm with classifier parameters, resizing of the images conceded in the loss of pixel data [5].

For industry robot there is autonomous system along with image processing. The color detection is done by using high speed processor and camera [6]. MATLAB is used for GUI and for image processing. RoboCIM software is used which have inbuilt program to control robot. The co-ordinates of the object are acquired through the camera and edited in the program. Then this software sends signals to the robot and the robot then moves toward the object, picks it and places it in the desired location [6]. One of the most important components in various applications in computer vision, such as human computer interaction (HMI), surveillance, and medical imaging is object tracking. One common issue in assessing tracking algorithms is results are based on some sequences with different initial conditions or parameters. Thus, the results do not provide the view of these algorithms [8]. ABB developed a line follower robot for material handling purpose [9]. The ABB robot used for this project is the IRB1410 with 6-axis therefore having 6 degree of freedom. It follows a specific path on the ground and follows a black line while conveying the object placed on it by the ABB robot. PIC 16f873 micro controller controls it. The robot is taught each position of the sequence manually for the pick and place program [9].

In a RoboCup without using color information real time, the robot can track and detect of ball. To get a colorless representation of the ball Haar-like features trained by an Adaboost algorithm [10]. Tracking is performed by a particle filter. Algorithm is able to track the ball in real-time with 25 fps. The results of the Adaboost feature learning algorithm are integrated into a condensation tracking framework [10]. In bin picking applications robots are required to pick up an object from a pile of stacked or scattered objects placed in a bin. Vision system is used for performing such tasks, identification of the objects to be picked. In this system top most object from pile of occluded objects and computes its location. There are two modules in this system namely object segmentation and object localization. For segmentation ‘Acclimatized Top Object Threshold’ [ATOT] algorithm is proposed [13]. In the module the object’s location is calculated by s’x’, ‘y’, ‘z’ co-ordinates of the object midpoint using a unified stereo imaging algorithm. Object location co-ordinates, the validity of the algorithms is experimentally verified for object pick and place operations. [13].

### III. METHODOLOGY

The robots in industry are used to grab heavy loads and transport to other area. The methodology here helps robotic machine to detect the object and move closer to the object to grab it. The algorithm has following two major steps: Image Processing and Robot locomotion. The image processing include image capture which uses an USB camera with 0.3MP resolution. The camera provides output in encoded and compressed format which is then converted to raw data format. The next stage is image pre-processing to enhance the quality of the image. At this stage we perform gamma correction on the color input image, this compresses the higher pixel intensities and expands the lower pixel intensities.

\[
\text{newImg}(i,j) = \left( \frac{\text{RGBImg}(i,j)}{255} \right)^{\text{gamma}} \times 255
\]

The image is then converted to HSV image that is the hue saturation value color space. Hue indicates an angle in the range [0,2π], where the color red is represented by Hue value of 0 degrees and hence the angle for other colors is indicated with respect to red color i.e. green at 2π/3, blue at 4π/3 and red again at 2π. Saturation value in HSV color space is the radial distance between the centre and the point on the surface, this is also referred as the depth and the value indicates the intensity.)
The HSV color space calculations are shown in the box above. The value component from the HSV image is extracted and normalized with respect to 255. The next we convert the image to binary image.

**Binary Image Conversion**

\[
\text{BinaryImg}(\text{row, col}) = \begin{cases} 
0, & \text{inImg}(i, j) \geq \text{threshold} \\
1, & \text{inImg}(i, j) < \text{threshold}
\end{cases}
\]

Now, to thicken the object we perform morphological operation of dilation with a structuring element of 5x5 square.

**Dilation Operation**

\[
\text{ImgOut} = \text{Img} \oplus \text{Se}
\]

Where,

- \(\text{Img}\) – Input image
- \(\text{Se}\) – Structuring element

The last step in image processing is object localization which uses the template matching approach to detect the location of object. We define a mask of size smaller than that of the object and determine the coordinates of the object.

The next important step is locomotion of the robot towards the object. Once we get the coordinates of the object, the locomotion is performed with respect to position of object in the frame.

The image frame is logically divided into three regions viz. centre, right and left to drive the robot. If the load to be picked lies in central region, the robot would drive straight else if object lies in left region, the robot is driven towards left and the angle of turn is proportional to the distance of object from the centre.

Turn Speed = base speed \(\times\) (distance of object from image centre)

Similarly, the right drive is applied to the robot depending upon the object location. Now, as the robot
moves forward, the proportion of object in the image frame increases and the distance between object and robot decreases. As shown in Figure 2A, the robot is far away from the object and hence object appears small compared to the frame size whereas in Fig.2D, the object size is much larger compared to the size of frame. In order to get proper object location, the size of mask used in template matching stage is increased proportionally as the robot moves forward. The algorithm stops after the mask size exceeds certain threshold size of object. The flowchart of the algorithm is shown in fig.3.

IV. RESULTS

The algorithm described above is implemented on ARM9 embedded processor which uses an USB CMOS optical sensor and port pins are used to send commands to motor driver circuit. The results at every stage of algorithm are shown in Figure 4 and Figure 5. The Fig.4A is the input image captured by the camera; Fig.4B is the Hue saturation Value (HSV) color space image generated after gamma correction with a factor of 4; Fig.4C shows the V-component image extracted from the HSV image and the Fig.4d is the image obtained after applying morphological operator of dilation on the binary image. The binary image is generated by applying threshold to the V-component image in Fig.4C. The object template is matched with the Fig.4d and the location of object is detected. Similar results are shown in Fig.5 but the object in Fig.5A appears to be larger than the object in Fig.4A as the robot has moved forward towards the object and therefore, the size of template used to detect object in Fig.5d is larger than that for frame shown in Fig.4d.

V. CONCLUSION

The paper presents a novel approach for robots to detect and follow a still object in real time embedded system. The use of gamma correction and Hue Saturation Value color space image reduces the probability of false detection of the object. The template matching is carried out by subtracting template from processed the image frame by spatial filtering technique. The use of dynamic template size also reduces the probability of false detection and helps to get the location of object which is almost near to the object centre. The morphological operation is computationally expensive and hence the algorithm processes nearly 18 frames per second. The algorithm works well in real time embedded system and Promises practicability results.

REFERENCES


Processing For An Industrial Robot" International Journal of Advanced Computational Engineering and Networking, ISSN: 2320-2106 Sept 2013


