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ROBOTIC ARM FOR PICK & PLACE OPERATION USING MATLAB BASED ON OFFLINE SURFACE CLUSTERING ALGORITHM

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A B S T R A C T

The industry is moving from current state of automation to Robotization, to increase productivity and to deliver uniform quality. The main objective of this paper is to perform an object detection and its pose estimation for robotic pick and place operation using offline surface clustering algorithm. The pick and place robot is a microcontroller based mechatronic system that detects the object, picks that object from source location and place it at desired location. RGBD Sensor provides depth information beyond visual data. In the present situation the detection part is mainly based on the recent template-based linemod approach for object detection. Offline surface clustering algorithm was introduced to overcome the difficulties that occur in present situation and it improves the correct detection rate compared to linemod approach, hence suitable for robotic applications. Object detection by image processing algorithms is done using MATLAB software. Hardware implementation of robotic pick & place task for detected object is done using PIC microcontroller.

INTRODUCTION

Image processing is a method to convert an image into digital form and perform some operations on it, in order to get an enhanced image or to extract some useful information from it. It is a type of signal dispensation in which input is image, like video frame or photograph and output may be image or characteristics associated with that image. Usually Image Processing system includes treating images as two dimensional signals while applying already set signal processing methods to them. It is among rapidly growing technologies today, with its applications in various aspects of a business. Image Processing forms core research area within engineering and computer science disciplines too. Image processing basically includes the following steps: Importing the image with optical scanner or by digital photography, Analyzing and manipulating the image which includes data compression and image enhancement and spotting patterns that are not to human eyes like satellite photographs, Output is the last stage in which result can be altered image or report that is based on image analysis.

The modern world is enclosed with gigantic masses of digital visual information. To analyze and organize these devastating oceans of visual information image analysis techniques are major requisite. In particular, useful would be methods that could automatically analyze the semantic contents of images or videos. The content of the image determines the significance in most of the potential uses. One important aspect of image content is the objects in the image. So, there is a need for object recognition techniques. Object recognition is an important task in image processing and computer vision. It is concerned with determining the identity of an object being observed in an image from a set of known tags. Humans can recognize any object in the real world easily without any efforts; on contrary machines by itself cannot recognize objects[2]. Algorithmic descriptions of recognition task are implemented on machines; which is an intricate task. Thus, object recognition techniques need to be developed which are less complex and efficient. Many successful approaches that address the problem of general object detection use a representation of the image objects by a collection of local descriptors of the image content. Global features provide better recognition. Color and shape features can also be used. Various object recognition techniques are available. Difficulties may arise during the process of object recognition, and they are lightning, positioning, rotation, mirroring, occlusion, scale.

The robust and efficient object recognition technique using image processing algorithm can be developed by taking into account these difficulties and overcoming them. The image processing algorithms used in this system are linemod algorithm and offline surface clustering algorithm which can detect an object efficiently and accurately for robotic pick & place operation.

System Model

This system consists of image acquisition phase, image processing phase and image transmission using communication protocol.

1. The image is acquired by means of a camera and this phase is known as image acquisition phase.

2. This captured image is processed in the Personal Computer by efficient image processing algorithms. Thus, the objects can be detected at this phase and this phase is known as image processing phase.
3. Finally, the detected objects are transmitted towards the microcontroller unit using the communication protocol Zigbee for performing robotic arm pick & place task.

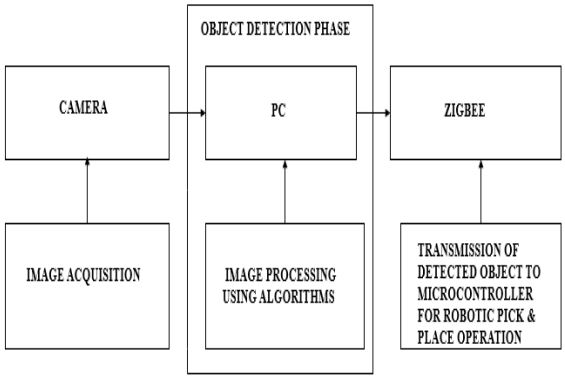


Fig 1 Block diagram for Object Recognition

Object Recognition Using Image Processing Techniques

In this process image processing algorithms are used to detect an object. The two image processing algorithms used in this paper for object recognition are:-

1. Linemod algorithm.
2. Offline surface clustering algorithm.

Linemod Algorithm

Linemod is an object detection and pose estimation pipeline which receive input as 3D mesh object model[5]. From the model, various viewpoints and features from multiple modalities (RGB gradients, Surface normal) are sampled. The features are filtered to a robust set and stored as a template for the object and the given viewpoint. This process is repeated until sufficient coverage of the object is reached from different viewpoints.

The detection process implements a template matching algorithm followed by several post processing steps to refine the pose estimate. The approach was designed specifically for texture-less objects, which are notoriously challenging for pose estimation methods based on colour and texture. Linemod uses gradient finding in template matching algorithm. Linemod algorithm fully depends on the template matching Strategy. The flow chart of linemod algorithm is given below for object recognition.

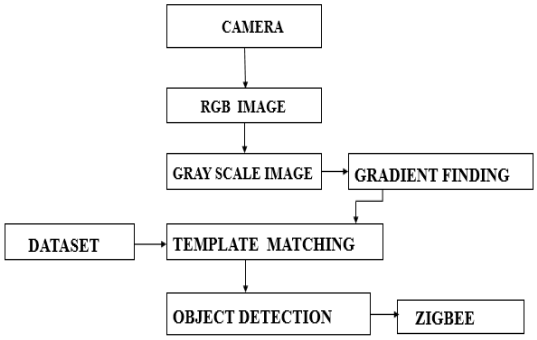


Fig 2 Flowchart of Linemod Algorithm

Camera

Image which is to be processed for object recognition is captured using a camera. This is the image acquisition phase.

RGB Image

An RGB image, sometimes referred to as a truecolor image, is stored as an m-by-n-by-3 data array that defines red, green, and blue color components for each individual pixel. RGB images do not use a palette. The color of each pixel is determined by the combination of the red, green, and blue intensities stored in each color plane at the pixel's location. Graphics file formats store RGB images as 24-bit images, where the red, green, and blue components are 8 bits each. This yields a potential of 16 million colors.

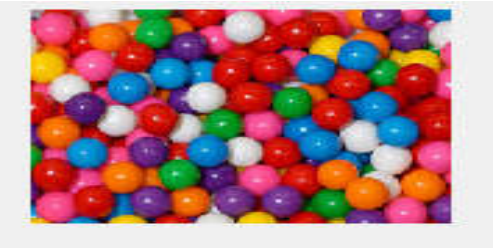


Fig 3 RGB Image

Grayscale Image

In photography and computing, a grayscale digital image is an image in which the value of each pixel is a single sample, that is, it carries only intensity information. Images of this sort composed exclusively of shades of gray, varying from black at the weakest intensity to white at the strongest.

Gradient Finding

An image gradient is a directional change in the intensity or color in an image. Image gradients may be used to extract information from images. Each pixel of a gradient image measures the change in intensity of that same point in the original image, in a given direction. One of the most common uses is in edge detection.

Template Matching

Template matching is a technique for finding small parts of an image which match a template image [2]. It is a straightforward process. In this technique template images for different objects are stored. When an image is given as input to the system, it is matched with the stored template images to determine the object in the input image. Templates are frequently used for recognition of characters, numbers, objects, etc. It can be performed on either color or gray level images. Template matching can either be pixel to pixel matching or feature based. In feature based the features of template image is compared to features of sub-images of the given input image; to determine if the template object is present in the input image. Dataset consists of collection of images stored as template and the captured image is compared with that stored template and by this technique object is detected in linemod algorithm. Thus, the matched object is detected and transmitted to microcontroller unit for performing pick & place operation using zigbee. The template matching technique requires large database of image templates for correct object recognition. Hence it must be used only when limited objects are to be detected and it will not provide accurate results in detecting curved objects hence offline surface clustering algorithm is used.

Offline Surface Clustering Algorithm

This section describes the offline clustering method of the polygon models of the object and the environment [1]. We will briefly explain the overview of the basic algorithm of the clustering method. In the clustering algorithm, we first calculate the initial set of clusters where each cluster is composed of a few triangles. Then, we consider iteratively merging a neighbouring cluster as far as the cluster can be approximated by a planar region. When searching the object posture, we consider that the surface of the object maintains contact with the surface of the environment.

Cluster Analysis

Cluster analysis or clustering is the task of grouping a set of objects in such a way that objects in the same group called a cluster are more similar in some sense or another to each other than to those in other groups clusters. Cluster analysis itself is not one specific algorithm, but the general task to be solved. It can be achieved by various algorithms that differ significantly in their notion of what constitutes a cluster and how to efficiently find them.

Clustering algorithms can be categorized it will only list the most prominent examples of clustering algorithms, as there are possibly over 100 published clustering algorithms. Not all provide models for their clusters and can thus not easily be categorized. An overview of algorithms explained it can be found in the list of statistics algorithms. There is no objectively "correct" clustering algorithm, but as it was noted, "clustering is in the eye of the beholder." The most appropriate clustering algorithm for a particular problem often needs to be chosen experimentally, unless there is a mathematical reason to prefer one cluster model over another.

It should be noted that an algorithm that is designed for one kind of model has no chance on a data set that contains a radically different kind of model. The flow chart of Offline surface clustering algorithm is given below for object recognition.

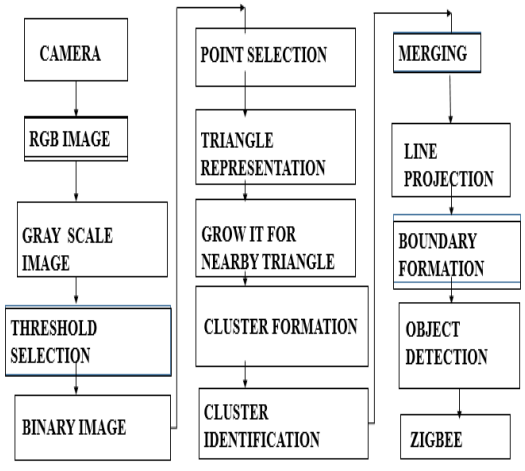


Fig 4 Flowchart of Offline Surface Clustering Algorithm

Binary Image

A binary image is a digital image that has only two possible values for each pixel. Typically, the two colors used for a binary image are black and white, though any two colors can be used. The color used for the objects in the image is the foreground color while the rest of the image is the background color. A point is selected for the binary image and the triangular representation is made from that point to boundaries of the image. The triangle is further extended with neighbouring triangles and the cluster is obtained. Now identify the number of individual cluster obtained. Then project the line and merge the similar cluster pixels together to form a boundary. This boundary formation provide efficient object recognition and the detected object is transmitted towards the microcontroller through zigbee unit. By means of forming the cluster through generating centroid for represented triangles using region props property this algorithm ensures accurate object detection even for curved objects.

Robotic Arm Pick & Place Task

The objects that are detected by image processing algorithm are transmitted towards the microcontroller unit through zigbee for performing Pick and place task. The microcontroller unit consists of the handmodule motor unit for performing pick and place task and another motor unit for front and back movement of robotic arm. when the microcontroller receives the detected object it signals the motor unit to perform the robotic arm pick & place task.

Application

- Biometric recognition
- Surveillance
- Industrial inspection
- Content-based image retrieval
- Robotics
- Medical analysis
- Optical character recognition
- Document recognition
- Digit rnecognition
- Warehouse applications

RESULTS AND DISCUSSION

The object recognition is done by using image processing algorithms in MATLAB software. The image processing algorithms used are linemod algorithm and Offline surface clustering algorithm.

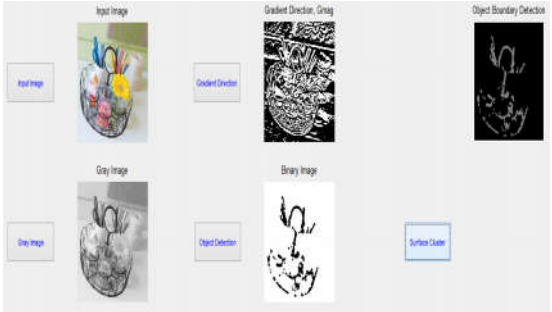


Fig 5 Image Captured and Converted for Object Detection

The above figure shows the input image and its required conversion required for object detection. The below snapshots show the object detection using template matching and clustering.

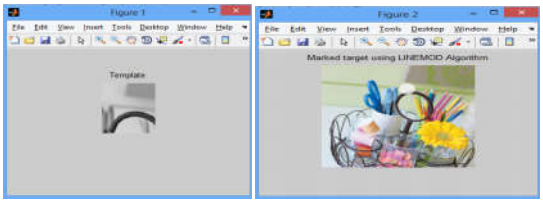
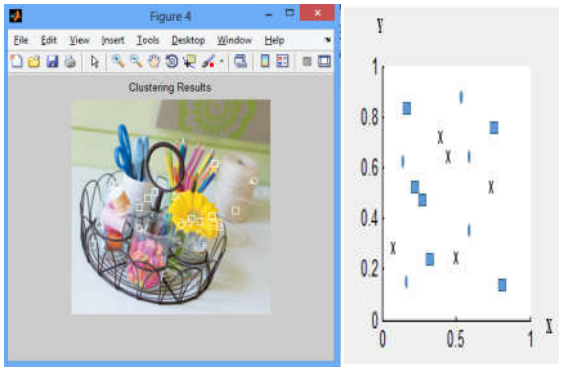


Fig 6 Object Detection Using Linemod Algorithm

Fig 7 Binary Image Conversion for Clustering



-cluster 1, x **-cluster 2,** **-cluster 3**

Fig 8 Clustering Results for Object Detection Using Offline Surface Clustering Algorithm

Comparison of Algorithms

Table 1 Comparison of Linemod and Offline Surface clustering Algorithm

OBJECTS	DETECTION TIME USING LINEMOD ALGORITHM	DETECTION TIME USING OFFLINE SURFACE CLUSTERING ALGORITHM
BALLS	4.594946 Sec	0.323920 Sec
CRUSHED PAPER	4.500668 Sec	0.422721 Sec
CAPACITORS	4.657103 Sec	0.462354 Sec
COINS	4.478226 Sec	0.413752 Sec
IC	4.500176 Sec	0.397946 Sec
BOOKS	4.586559 Sec	0.456106 Sec
PEN	0.673561 Sec	0.321678 Sec
TOYS	4.583811 Sec	0.381830 Sec
BOX	4.605255 Sec	0.482442 Sec

CONCLUSION

This paper proposed a method for object detection using image processing algorithms, required for performing robotic arm pick & place operation. The image processing algorithms that are used in this paper are Linemod algorithm and Offline Surface Clustering algorithm. The objects were detected by image processing algorithm and the outputs from both the algorithms were noted. It is found that the offline surface clustering algorithm can detect more objects properly when compared to Linemod algorithm within shorter duration.

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