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REVIEW ARTICLE

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A Review of Computer Vision based Algorithms for accurate and efficient Object Detection

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Abstract: In this paper two vision-based algorithms are adopted to locate and identify the objects and obstacles from the environment. In recent days, robot vision and navigation are emerging as essential services especially in hazardous environments. In this work, two vision based techniques such as color based thresholding and template matching – both correlation based similarity measure and FFT (Fast Fourier Transform) based have been adopted and used for object identification and classification using the image captured in CCD camera attached to the robotic arm. Then, the robotic arm manipulator is integrated with the computer for futher manipulation of the objects based on the application.

Keywords: Object detection, Template matching, Thresholding, Fast Fourier Transforms, SSD,

I. INTRODUCTION

In recent times quite a significant amount research in the field of computing has been directed into computer vision. What has drawn so much interest into the subfield is perhaps the inexplicable ease and immaculate accuracy with which the human brain accomplishes certain tasks related to vision. Object recognition is one of the most fascinating abilities that humans easily possess since childhood. With a simple glance of an object, human beings can identify and categorize an object inspite of the variation in various parameters like illumination, texture, deformation and partial obstruction. The human eye can easily classify a new object into one of the existing categories. For example, kids are able to generalize the concept of “chair” or “cup” after seeing just a few examples of the same. As a result, object detection is one of the most researched topics in computer vision. These systems find wide applications ranging from medical image processing, defence applications, mining, scene interpretation, security, underwater robotics, space applications and many more. However, it is a daunting task to develop autonomous computer vision-based systems that match the cognitive capabilities of human beings. This is because the development of such systems would need extensive and exhaustive machine learning exercises and even then, the chances of a system being able to classify unknown or unseen objects are difficult to predict. While the performance maybe highly satisfactory at certain times, at other times the entire exercise may fail. This is especially a high risk factor in the case of robots deployed on defence missions. Many a time it has been reported that robots mistake the country’s soldiers to be the enemy soldiers. The key to robust object recognition systems are how the regularities of images, taken under different lighting and pose conditions, are extracted and recognized. In other words, all these algorithms adopt certain representations or models to capture these characteristics, thereby facilitating procedures to tell their identities. In addition, the representations can be either 2D or 3D geometric models. The recognition process, either generative or discriminative, is then carried out by matching the test image against the stored object representations or models.

This work is aimed at developing an accurate and robust object detection based system which can be used for robot vision. In the next section, a detailed discussion of the vision-based techniques used for object detection follows. Experimental results will be given in the last part of the paper.

II. PREVIOUS WORK

Object recognition in computer vision is a two stage process which involves the task of detecting and classifying a given object in an image or a video sequence. The classification requires building a knowledge base of all classes against which an input object is matched. Humans can recognize objects even when they are partially obstructed from view. This task is still a challenge for computer vision systems in general.

Obstacle detection is defined as “the determination of whether a given space is free of obstacles for safe travel by an autonomous vehicle”. Obstacle detection is one of the most renowned problems within the subfield of computer vision in terms of the amount of research it has attracted and the number of uses it has. Together with research into other subfields of artificial intelligence, obstacle detection is crucial in order to perform many basic operations for mobile robots such as avoidance and navigation. A good obstacle detection system must be capable of the following:

- To detect obstacles in a given space in good time
- To detect and identify correct obstacles
- To identify and ignore ground features that may appear as obstacles

In current robot navigation systems, snap shots of the real scene are taken using cameras, laser scanners, sonars, odometry, etc. and the data is processed by a computer which ultimately performs obstacle detection. Since most of these devices can only take a limited number of shots of a scene in a given time and since an enormous amount of data needs to be processed, obstacle detection can often be quite slow for some real time applications, e.g. navigation of high-speed vehicles. Very sophisticated sensors and processors used to perform obstacle detection so far have been able to accommodate navigation at speeds of only a few metres per second.

These algorithms are unique in the fact they are uncalibrated, that is the internal parameters of the camera are not required for these computations.

III. VISION BASED POSITIONAL DETECTION

The purpose of the vision system employed is to measure the area and position of the obstacle and alert the observer who may be controlling the system from a distance. Depending upon the application, the object would then be either picked up for further examination or avoided to prevent collision. Until quite recently these measurements were typically performed by coarse mechanical methods often having low resolution and repeatability. We have addressed this problem by applying computer vision analysis methods to determine the positional measurement of various obstacles that may be encountered in different applications. Although this initial study was limited to the use of only simple thresholding and color-based techniques, it is demonstrated that in principle the computer could be used to determine the object size accurately.

Certain objects like a biological cell in the case of medical image processing are difficult to analyze because its surface tends to have large spatial variations in both gray level and light reflectance. Therefore in the present study we have introduced an entirely new approach to the measurement problem.

In some cases like in the case of metals or droplet images, certain regions appears brighter than background, the boundaries are not clear and there is considerable variation in the intensity. In the next section, we will discuss the basic concepts of the three algorithms. Experimental results will be given in the last part of the paper.

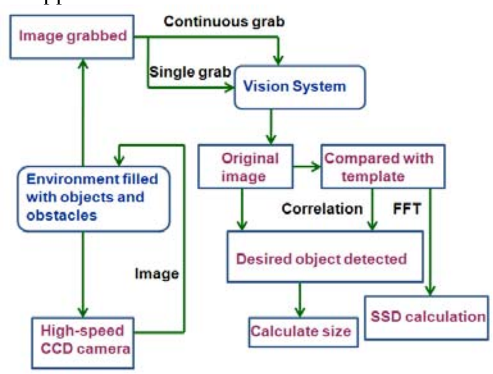
IV. OBJECT DETECTION ALGORITHM

The system has been implemented on IBM PC/AT system on the MATLAB interface. The image captured by the camera is fed as input to MATLAB where further processing is done for detecting the position coordinates of the object.

We proposed three approaches for doing the same. The first one involves identifying the object based on shape and then generating its coordinates (by comparison with a template image). Second is based on identifying the objects based on color and texture and thereafter the coordinates are generated. The third algorithm measures the hamming distance and use it as a similarity measure to identify the object. These algorithms are quite generic and find applications ranging from medical image processing to material handling robots to underwater robots. Fig. 1 shows the environment filled with objects and obstacles from whoch the desired object is to be identified and picked up by the robot arm. Fig. 2 shows a schematic of the actual set up made to detect the object and then pick it up with the help of a robot manipulator.

A. Object Detection by Correlation based Similarity Measure:

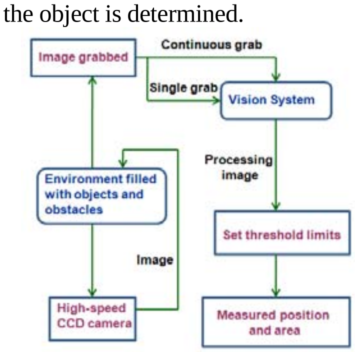
Correlation based matching typically produces dense depth maps by calculating the disparity at each pixel within a neighborhood. This is achieved by taking a square window of certain size around the pixel of interest in the reference image and finding the homologous pixel within the window in the target image, while moving along the corresponding scan-line. The goal is to find the corresponding (correlated) pixel within a certain disparity range d, that minimizes the associated error and maximizes the similarity. In brief, the matching process involves computation of the similarity measure for each disparity value, followed by an aggregation and optimization step. Detecting the isolated cell through this approach requires the selection of the cell template, which is then correlated with the original image and similarity value between the template and original image is calculated. The similarity measures computed in our algorithm are- SSD (Sum of Squared Differences), SHD (Sum of Hamming Distances), NCC (Normalized Cross Correlation).The three different measures are in the order of decreasing algorithmic complexity. These parameter values indicate the maximum degree of similarity between the cell, the image obtained through the fluorescence microscope. The cell present in the image is highlighted and thereby its positional coordinates are generated. Template matching was done by both normalised cross correlation and Fast Fourier Transforms (FFT). While both yield similar results, computational time is highly reduced in the case of FFT makng it more suited for realtime applications.



B. Object Detection by Color-Based Coding

This technique is specially useful for applications where the objects maybe classified based on colour. For example in mining applications, fruit sorting applications, etc., the robot manipulator can decide the object to pick up based solely on the color of the object. It also takes into consideration various properties like the texture of the object. In this algorithm thresholding is done for a particular range of colors in which the object is supposed to be identified and avoided or picked up as the case may be.

First the image is segmented into object region and background using simple gray level thresholding, and in the second, some misclassified regions are smoothed by morphological filters. Although the automatic determination of the threshold turned out to be difficult because of the input characteristics, we found that gray level thresholding followed by an adequate smoothing operation is quite appropriate. The image thereby turns into a gray scale image where the desired object alone is highlighted in its natural color. Thereafter the position of the object is determined.



V. FIGURES AND RESULTS

Fig.1 Original Image

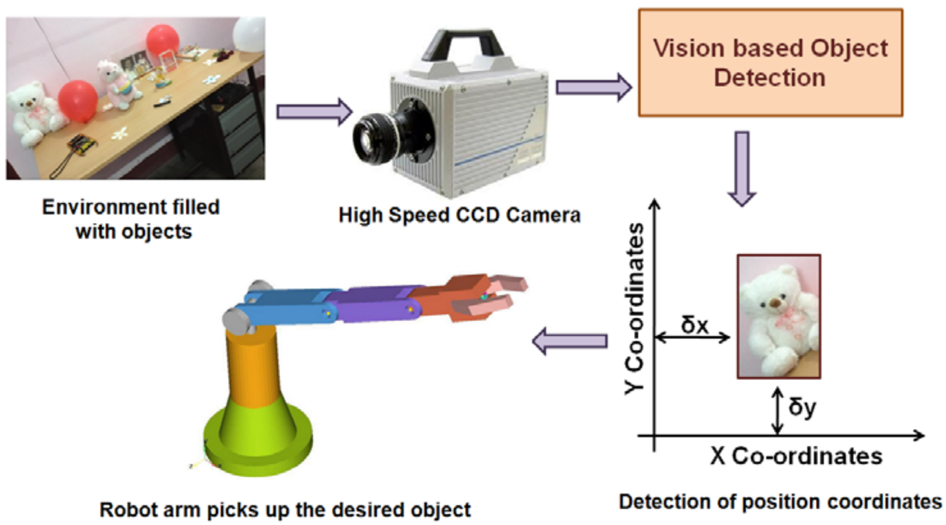
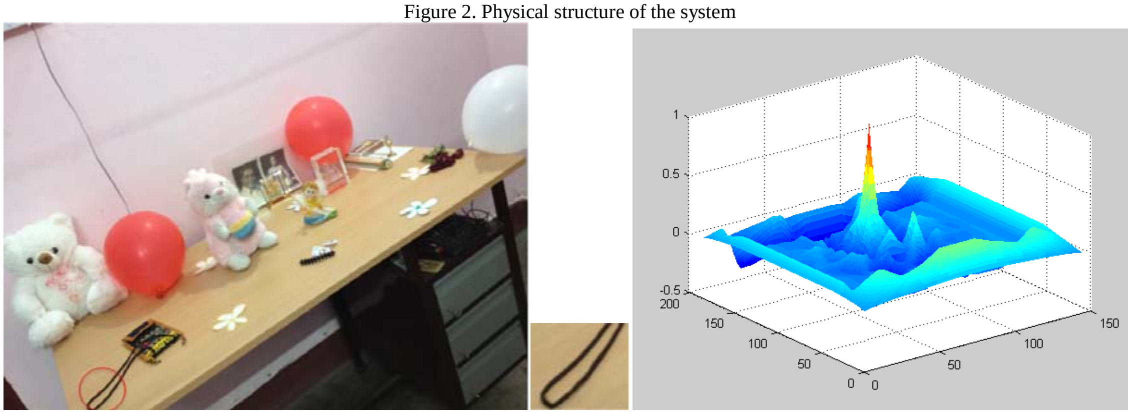


Figure 2. Physical structure of the system



(a) Object identified in the environment (b) Template (c) Normalized Cross-Correlation and Find Coordinates of Peak

Fig 3. Object detection by template matching - Cross Correlation

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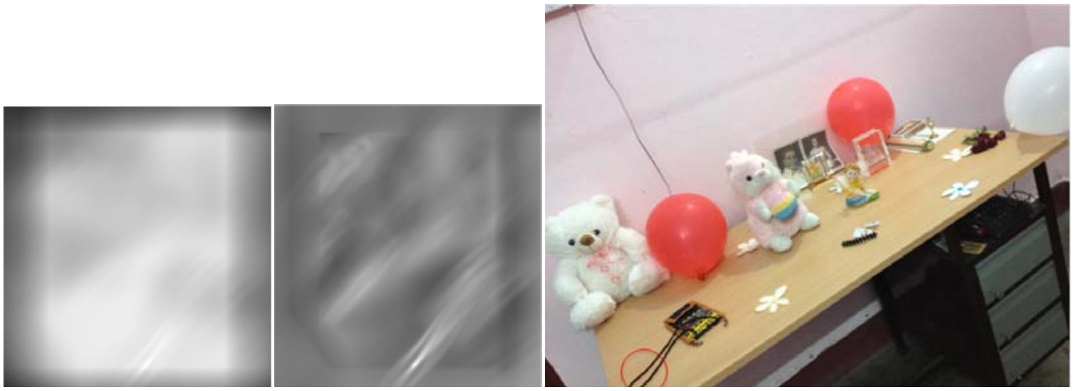

SSD Matching   Normalised Cross Correlation   Object identified in the environment

Fig 4. Object detection by template matching - FFT

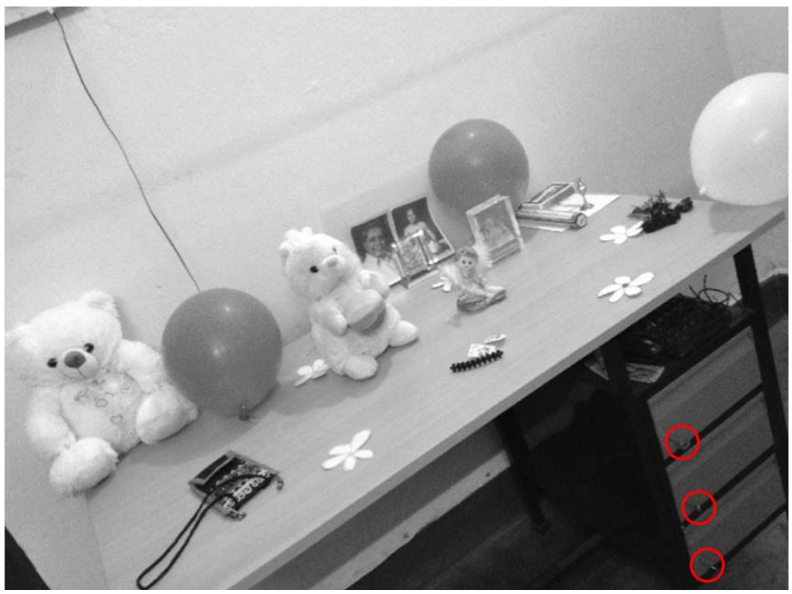

Figure 5. Isolated CTC by Color Based Coding

VI. CONCLUSION

The template matching approach is particularly helpful when the set of obstacles is small as computational time is heavy if the set contains many objects. However if FFT based template matching is done thenit is suitable for real time applications. Though all the algorithms yielded accurate results, the best algorithm has to be chosen based on the application. Experimental results obtained from processing the captured images support the efficacy of these approaches as well as thei reliability. Also, the process of isolating cell by filtering them out of the micro cavity channel produces desirable results. This will provide us with a new tool to recover diseased cell and analyze them molecularly to dissect the steps between primary and secondary tumor development. The early detection of diseased cell by employing a vision system will play a vital role in the process of understanding the process of metastasis, disease staging, predicting prognosis, monitoring patients during therapy and improving therapy design. The performance of the three algorithms can be evaluated by measuring the degree of similarity between the actual position and size of the cell to the measured position and size of the isolated cell.

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