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Object Recognition Approaches

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ABSTRACT
Every Field of Computer Science from Robotics to Artificial Intelligence demand the system which have the ability like we human being have to recognize different things basis on certain properties of objects such as color, texture, shape etc. In this direction various algorithms have been implemented. The main motive of present work is to classify and analyze different object recognition techniques in an image for feature detection & extraction. The SURF (Speed Up Robust Feature) technique which rely on Integral images and Hessian Matrix for feature detection & extraction and ORB (Oriented Fast and Rotated BREIF) which is a combination of two major techniques: FAST (Features from Accelerated Segment Test) & BRIEF (Binary Robust Independent Elementary Features), both are best known technique for computer vision systems. Keeping this as a focal point, the work proposed aim at analyzing performance of the algorithms, which is particularly useful in mobile robots & Real world applications where it may encounter situations in which it has to recognize objects which may be at different orientations than the trained images
Keywords: Object Recognition, SURF, ORB, SIFT

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I. INTRODUCTION

As Humans have a capability to recognize a wide range of objects with little effort despite of the fact they may vary in attributes such as shape, color, texture, etc. The field of Object Recognition performs similar as human recognition, so it can be defined as task for Identifying and recognizing an Object in a particular Image like Human beings do. The application of object Recognition has become popular in wide range of areas. As we know objects can be recognized in many different places, from many different viewpoints, and of different sizes and

Sometimes, they may even be partially obstructed from view point. Thus, we require an object recognition system which is invariant with respect to changes in the size, translation and rotation of the object. Object recognition in images is a Computer Vision problem that has not been completely solved from past five decade. The object recognition system aims at recognizing the objects in the image in a similar way as human being recognizes the various objects by seeing an image and matches it with the similar image. But, the task of Object Recognition is still challenging due to the various problems encountered in images such as varying illuminations, partial occlusions, viewpoint changes, appearance variations, cluttered backgrounds etc. Therefore, a good object Recognition approach is required that overcomes these types of problems and has also the ability to recognize the objects in these scenarios. The approach of Object recognition includes a good algorithm in terms of speed & accuracy for Feature Detection & Extraction. The Approach of Object Recognition can be divided into three main steps. In the first step, the key-points are detected at distinctive locations in image as corners and junctions. In a second step, the neighbourhoods of the key points are represented by feature vector and they are known as descriptors. The descriptors must be robust to noise and distinctive in nature for efficient recognition and the Final step is to match these descriptor vectors across the images so as to recognize the object.

In this direction, the Paper aims at analyzing the various algorithms in this context which are best known algorithms for the purpose of Object Recognition in images.

The rest of paper consists of is organized as follows: In section II, mention various Difficulties encountered while recognizing an object from the image, Section III Speeded up robust features and ORB, SIFT and various object recognition techniques are introduced, then comparative analysis results are shown,. SectionV includes the application of these techniques on a standard dataset with study of object recognition approaches. Finally, Conclusions are drawn in Section VI.

II. OBSTRUCTIONS IN OBJECT RECOGNITION UNDER VARIED SITUATIONS

1) Brightness: The brightness or lightning may differ during the course of the day and the weather conditions also may influence the lighting in the image. In lightning, In-door & outdoor images can have varying object for the same image. The Shadows may also influence light in the image. Therefore whatever the lightning occlusion occur in image,the system must be sufficient enough to recognize the object in the image.

Fig: 1

2. Positioning: The object positions may get altered in the image,If template matching is used the system has to tackle such images uniformly.

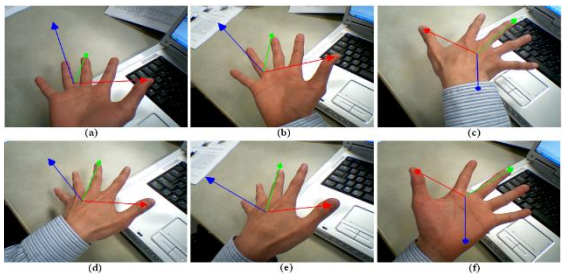

Fig: 2

3. Rotation: The image can be provided in rotated form to the system so it must be able to handle such difficulty. As shown in fig.3, the character 'A'can appear in any of the form. But the orientation of the letter or image must not affect the recognition of character "A" or any object in the image.

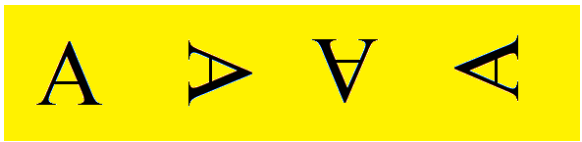

Fig: 3

4. Mirroring: The mirrored image of any object must be identify by the object recognition technique.
5. Occlusion: The condition when object in an image is not completely visible is referred as occlusion.
6. Scale: Change in the size of the object must not affectthe correctness of the object recognition system.

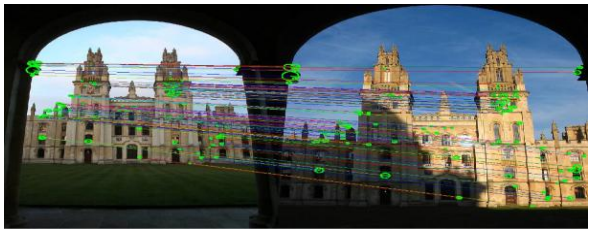

Fig: 4

Above stated are some of the difficulties that may arise during object recognition. An efficient and robust object detection system can be developed by conquering theabove stated difficulties.

III. OBJECT RECOGNITION METHODS

Template Matching

Template matching is a technique for finding small parts of an image which match a template image. 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.

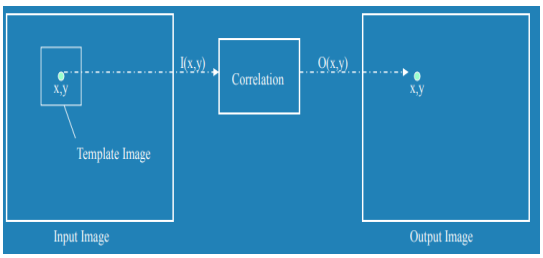

Fig: 5

Toshio Modegi [2] used the approaches of template matching algorithms for object recognition in high resolution satellite images. The author considered the problem of resolution of optical sensors installed in the current earth observation satellites that pixel resolution is not enough for identifying each small object such as an automobile by the currently available pattern matching techniques and it overcomes that by using notion of template matching.

Wiedo Hu [5] applied the template matching technique so as to detect the ground objects. As template matching technique considered as good for target detection applications, that's why author used the hit-or miss template matching technique to identify the objects. The proposed technique improves the precision in detecting

ground objects. This technique is generally immune to noise and illumination effects in the images, but having problem of high computational complexity that is caused by summations over the entire template.

Color and Shape Based

A simple and effective recognition scheme is to represent and match images on the basis of color histograms as proposed by Swain and Ballard [1]. But, it has the disadvantage that when the illumination circumstances are not equal, the object recognition accuracy degrades significantly.

In the object detection, the shapes of the objects are widely used for identification, because the shaped images are easy to cluster and to perform the segmentation for finding an object in an image.

As shown in Figure 5, shape is generally used for the describing the boundary of an image. Comparing with the texture and gradient based representation, the shape based representation is more descriptive on larger images4.

In this image (Figure 5.) the shape of the object is measured, this technique input image will be compared the existing image shape and the required object will be detected.

Feature Based Approaches

In this section object recognition approach based on Feature based techniques will be discussed. The steps are given in:

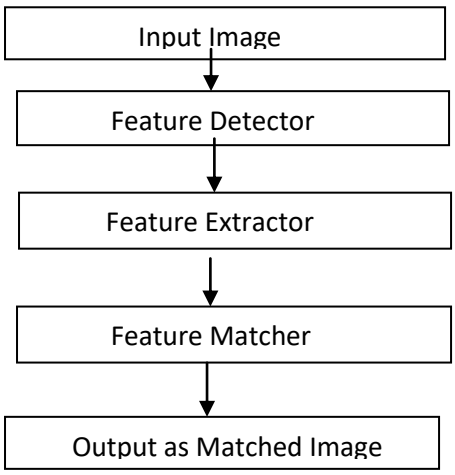

Fig 6: Block diagram of Object Recognition using Feature Based approaches

Features Detection

Feature detection can be defined as to detect some interesting points or features in the image. For an example finding a corner or junction in an image. Corners are considered as a good interest points to detect an object because it shows abrupt changes in the intensity. There are many Corner detection algorithms are as follow FAST Algorithm, Harris Corner Detection, LOG, DOG, DOH, SUSAN.

Features Extraction

In object recognition and image processing field, if the Input data to an algorithm is too large to be processed then the input data will be changed into a reduced representation set of features that are known as Feature vector and changing this input data into the set of feature vector is called as feature extraction.

There are many algorithms for Feature Extraction which is as follows: SIFT, SURF, ORB.

A) Speeded Up Robust Features (SURF) Technique

SURF is a scale and rotation invariant interest point detector and descriptor [12].In 1998 SURF Algorithm was first proposed by Lindeberg [1] for object Recognition in images. The main advantage of SURF is that it is three times faster in speed in comparison to other feature extraction. Algorithms and it is good at handling blurring of images & image rotation but it is poor in handling illumination change.

Algorithm

The steps involves in the algorithm are as follows [13]:

Input: Interest points

Output: Key point Descriptor

Step 1: Integral Image

The concept of Integral Images was introduced in 1984 in the image processing domain for fast calculation of sum of pixel values in the given image and it is also known as Summed area table. The Main purpose for computing Integral image is to find average intensity in a given image that speeded up the further computations. The value at any point (x, y) in the image can be computed as with the given formula.

$$I(x,y) = \sum_{\substack{x' \le x \\ y' \le y}} i(x',y') \quad (1)$$

Step 2: Interest Point Detection using Hessian Matrix

The SURF feature detector is based on the Hessian matrix because of its accuracy in terms of performance. The Point is considered as corner if the determinant of the matrix is maximum. The determinant of the Hessian matrix is used to determine the location and scale of the descriptor. For a given point (x, y) in image I, the Hessian matrix is defined as H(x, σ)

$$H(\mathbf{x}) = \begin{bmatrix} L_{xx}(\mathbf{x}) & L_{xy}(\mathbf{x}) \\ L_{xy}(\mathbf{x}) & L_{yy}(\mathbf{x}) \end{bmatrix} \quad (2)$$

Step 3: Interest Point Descriptor

After constructing Scale space Pyramid using Gaussian filter, it find the extreme values of hessian matrix determinant values by comparing it in a neighborhood of 3*3*3 similar to that in SIFT. This gives the result of Key points along with their scale information. After getting key points, a square region centered on the key point is formed, and point of interest is split into 4*4 square sub-regions. Then, haarwavelet response is calculated along vertical dx and horizontal Dy locations for computing the orientation and they are summed up over each sub-region to form a set of entries in feature vector.

B) ORB Algorithm

In 2011, Ethan Rublee, Vincent Rabaud, Kurt Konolige and Gary R. Bradski Proposed this algorithm in their paper "ORB: An efficient alternative to SIFT or SURF [16].ORB is basically a fusion of FAST, The FAST Algorithm was introduced by Rosten Drummond [16] in their paper "Machine learning for high-speed corner detection" in 2006 for detecting the interest points or corners in an image key point detector and BRIEF feature descriptor. ORB is at two orders of magnitude faster than SIFT.

Algorithm

There are mainly two steps involved in ORB algorithm which are as follows:

Input: Interest points

Output: Key point Descriptor

Step 1: Key point Detection

In this Step key points are detected using FAST along with Rosin's corner intensity [16]. The FAST in ORB uses a technique of intensity centroid so as to add orientations to the detected corners. The intensity centroid of a patch of pixel computed using:

$$m_{pq} = \sum_{x,y} x^p y^q I(x,y),$$

$$C = \left(\frac{m_{10}}{m_{00}}, \frac{m_{01}}{m_{00}} \right) \quad (3)$$

Step 2: Key point Descriptor

Using BRIEF technique it implements the descriptors for key point's basis on pixel intensity comparison on location pairs(x, y). Assume the location pairs as p and q and binary test on them will yield:

$$T(p;x,y) := f(x) = \begin{cases} 1, & p(x) < p(y) \\ 0, & p(x) \geq p(y) \end{cases} \quad (4)$$

If intensity of I (p) <I (q) then the result is 1 or else the result is 0. The hamming distance is applied on bit strings so as to match them.

C) SIFT Algorithm

In 2004 Lowe proposed SIFT algorithm [6] to resolve the image affine deformation, scaling, illumination changes.

Algorithm

There are mainly four steps involved in SIFT algorithm which are as follows:

Input: Interest points

Output: Key point Descriptor

Step 1: Find Scale-Space Extrema

Step2:Key point Localization & Filtering

The Laplacian of Gaussian is great for finding interesting points (or key points) in an image.Harris Corner Detector is used toget rid of bad key points Edges and low contrast regions (outliers) elimination of these makes the algorithm efficient and robust.

Step 3: Orientation Assignment

Compute Gradient histogram by Calculating gradient magnitude and orientation using finite differences so as to remove effects of scale and rotation.

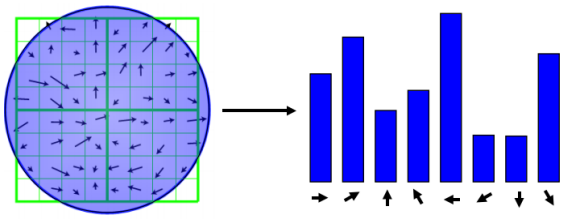

Fig: 7

Step 4: Create descriptor

In this step key point descriptor is generated, 16x16 neighborhoods of pixels around the key pointare considered. And then it is divided into 16 sub-blocks of 4x4 sizes. For each sub-block, 8 bin orientation histogram is created. Therefore a total of 128 bin values are obtained.Key point descriptor is represented as form of vector. They are matched using distance measure calculation so as to match the images.

IV. COMPARATIVE ANALYSIS OF OBJECT RECOGNITITON METHODS

Techniques	Accuracy	Usage
Template Matching	Moderate	It is used mainly in the context of Face Recognition & medical image analysis.
Color and shape Based	Low to Moderate	It is used mainly in the context of

		contentimage retrieval
Feature Based	High	Most widely used approach for object detection.

Table I

Comparative Analysis of Appearance based Methods

Feature Based Techniques	No. of key points Detected	Execution Time taken
SURF	Every corner is considered as Key points, so many outliers in this approach	Take much time for execution as more key points are considered.
SIFT	Less as compared to SURF	Take Less time
ORB	Only relevant point is considered as key points, so less number of outliers are found	Take Less time

Table II

IV. APPLICATION OF OBJECT RECOGNITION

1. Biometric recognition: Biometric Recognition utilizes human physical or behavioral characteristics to perceive any person for security and validation [4]. Biometrics is the Identification of an individual in light of recognized organic highlights, for example, fingerprints, hand geometry, retina and iris designs, DNA, and so forth. For biometric investigation, question acknowledgment systems, template matching can be utilized.

2. Surveillance*:* Objects can be recognized and tracked for various video surveillance systems. Object recognition is required so that the suspected person or vehicle for example be tracked.

3. Industrial inspection: Various Parts of machinery can be identifiedvia object recognition and can be observed for faults or damage.

4. Content-based image retrieval:At the point when the recovery depends on the picture content it is called as CBIR. A regulated learning framework, called OntoPic, which gives a mechanized keyword phrase explanation to pictures and content– based picture recovery is introduced in [5].

5. Robotic*:* The examination of autonomous robots is a standout amongst the most critical issues as of late. The humanoid robot soccer rivalry is extremely famous. The robot soccer players depend on their vision frameworks vigorously when they are in the dynamic conditions. The vision framework can help the robot to gather different condition data as the terminal information to complete the elements of robot restriction, robot strategy, boundary keeping away from, and so forth. It can diminish the figuring endeavors, to perceive the basic objects in the challenge field [7].

6. Medical analysis:Tumour detection in MRI images, skin cancer detection can be some examples of medical imaging for object recognition.

7. Optical character/digit/document recognition: Characters found in scanned documents can be identified by object recognition techniques.

8. Human computer interaction:Human gestures can be stored in the system, which can be used for recognition in the real-time environment by computer to do interaction with humans. The framework can be any application on cell phone, intuitive amusements, and so on.

9. Intelligent vehicle systems: Intelligent vehicle systems are usedfor movement sign identification and acknowledgment, particularly for vehicle location and following. In [6], such a framework is created. In identification stage, a shading based division technique is utilized to check the scan the scene inOrder to quickly establish regions of interest.

V. CONCLUSION

This paper aimed at analysis of various algorithms for the purpose of Object recognition. All the main terminologies used in the context of object recognition has been addressed. Most generally utilized and all around perceived strategies for different stages of object recognition have been clarified in points of interest. Most commonly used techniques are Feature based Methods which basically includes key point detection and key point descriptor matching phases.Among many methods of appearance basedidentification most ofthe researchers uses SIFT Or ORB techniques because of their good performance in terms of accuracy for object detection in the image. ORB provides better results in terms of execution time and good stability and less number of good key points when compared to SURF and SIFT. The Key Point detection in ORB is much faster due to the intensity centroid technique as compared to SURF& SIFT. Apart from this, the template matching approach mostly used for face detection systems and it is less complex as compared to other techniques whereas Color and shape based methods lacks when the illumination circumstances are not equal in the image.

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