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A study on image detection techniques

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Abstract: -This paper presents the detailed study of image detection techniques such as SIFT, SURF, FAST, BRISK, HARRIS, & Min.Eigen. Image detection techniques are widely used in today's world for various applications such as monitoring and security purpose. These techniques allow image detection in the simple, cluttered, rotated, and scaled by retaining some useful or most important features. Feature extraction is used to find the correspondence between two images of same scene. In this way, the technique can detect the image properly even in case of rotation, scaling, translation & illumination changes. This paper will help new researchers to understand image detection techniques and propose new image detection technique.

Keywords: - Image detection, SIFT, SURF, FAST, BRISK, HARRIS, Min.Eigen.

I. INRODUCTION

Image detection is process of detecting the images of real world like images of tree, car etc. Image detection systems playing vital role in this era especially in field of security. One of the most practical example is surveillance camera. Surveillance cameras are installed especially in malls & public places to record the activities of layman in public places. The main advantage of these cameras is to reduce human intervention by using new technology to perform different tasks.

In the literature, different image detection techniques have been proposed yet. These techniques extract the images with respect to their feature types. Features are the structure or pattern that found different in image in sense of colour, intensity or texture from their immediate surroundings or neighbourhood. These local features help algorithm to handle the rotation, translation, scaling, & view point changes well. Broadly, we can classify image detection techniques in three classes based on their local features: Corner, Blob & Edge pixels.

Corner detection: Term corner in detection does not mean to detect the physical corner such as corner of table or chair, but these are points in images with high curvatures. Corner means a point in image whose gradient direction changes rapidly. The techniques of this class select the portion of image which possess the distinct properties from their immediate surroundings. Then, computes the key points or features which remain locally invariant or constant. Using these features, image can be detected in different scenarios: rotation, scaling, translation & occlusion. Corner detection techniques are used for image recognition, detection, and analysis. [1]

Blob detection: In this class, proposed Techniques select small regions possessing distinct features or properties from their surrounding as key points. The pixels within the region shares the same properties or similar to each other, or approximately constant. These techniques are further classified in two classes i.e., (i) Differential Methods which are based on finding the derivative of function with respect to their position, and (ii) local Extrema method in which the algorithm has to find the local minima or maxima of the pixels. [2]

Edge detection: This method is called as Edge because the points where brightness conditions changes rapidly are arranged as a set of curved lines [3]. In this class, proposed techniques extract the image with the help of key points. This method selects the points brightness changes sharply or rapidly or formally (Brighter than surrounding or darker then surrounding) for key point localization.

Section II discusses image detection techniques in detail. Section III highlights the advantage and limitations of discussed techniques. Section IV concludes the paper and describe the future work.

II. IMAGE DETECTION TECHNIQUES

A. Scale Invarient Features Transform (Sift)

David G.Lowe have proposed the image detection technique called as SIFT [4][5]. Figure.1 illustrate the entire working Cycle of SIFT. SIFT uses following steps for image detection.

1. It sets some threshold.
2. Select a pixel satisfying the threshold.
3. Compare its intensity with pixels surrounding it.
4. For key point, the point should be minima or maxima (brighter or darker then all pixels surrounding it).
5. After key point localization, it starts to eliminate low contrast pixels & the corner pixels not surrounded by required number of pixels.
6. This algorithm calculates the magnitude and orientation along all key points for orientation invariance.

7. This algorithm uses 16 x 16 detection window, it splits the window in 4x4 sub windows & spread 8 bin histogram in all windows and weight that histogram by magnitude and orientation values calculated across key points.
8. Finally, it generates Feature vectors, which are invariant to rotation, translation, scaling changes & partially to shadowing and illumination changes.

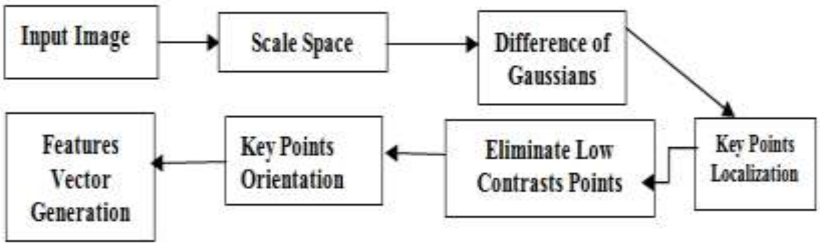

Figure.1 Working Cycle of SIFT

B. Speeded-Up Robust Features (Surf)

Herber Bay et.al have proposed a modified version of SIFT technique called as SURF [6]. This is roughly 3 to 5 times faster than SIFT. The entire working Cycle of SURF is illustrated in Figure.3. Following steps are used in SURF for image detection.

1. This algorithm first converts the input image into integral image. This new representation of image is helpful in selecting the relevant features rapidly.
2. It also uses Scale Space Representation by continuously down sampling the images like SIFT.
3. For interest points localization, this algorithm uses Hessian matrix (2D matrix). The determinant of Hessian matrix reports the local changes (change in intensity, color or texture) across the point. The point with maximum determinant is known as key point. The key point is one, which has highest determinant value or maxima in 8 neighbors. The selection of key point is done by comparing 2 x 9 pixels in its above & below layers (in scale pace representation) as shown in Figure.2.

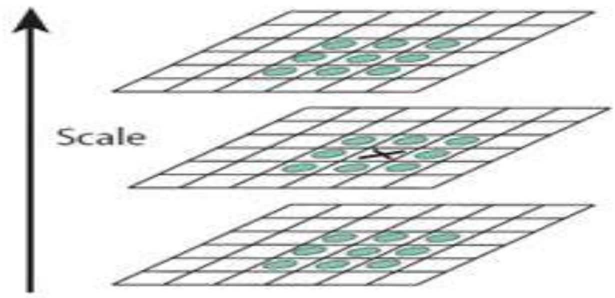

Figure.1 Key point localization

Then it starts feature description which is required for robust and unique description of local features. It splits 16 x 16 window n 4 x 4 sub windows, for feature description. This algorithm further splits 4 x 4 sub windows into 4 x 5 sub windows & computes the HAAR wavelet response in both direction x & y. These responses are computed to ensure the rotation & orientation invariance.

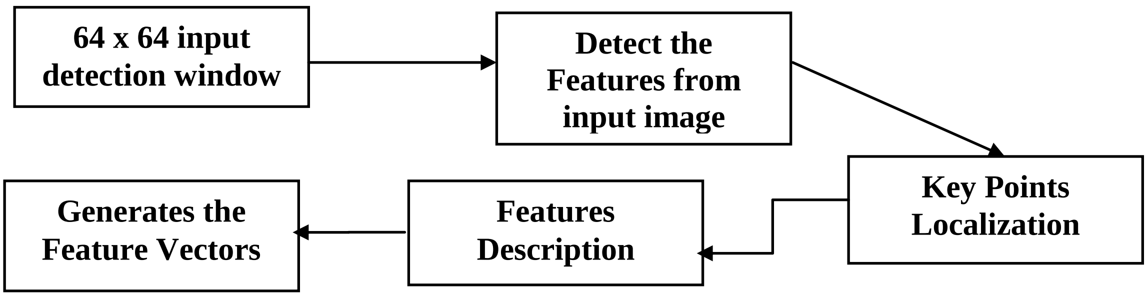

Figure.3 Working Cycle of SURF

C. Features From Accelerated Segmented Test (Fast)

Edward Rosten and Tom Drummond have proposed a new algorithm to find the interest points from an input image [7] [8]. Below mentioned steps are used by FAST Algorithm to detect the image:

1. It sets a threshold.
2. Selects a pixel. Compare its intensity with 16 pixels surrounding it in circular manner. Write 1 for pixels whose intensity equal to the center and 0 for otherwise (above or below).
3. For key points, it is important that maximum number of pixels possess same intensity as that of center otherwise it's not key point (e.g. out of 16 at least 12 satisfy the threshold).
4. Repeat this procedure on all pixels in image & find all key points.
5. It stores the pixel's P information in vector form. There will be three states of vector, brighter, similar or darker ($\mathbf{I_b}, \mathbf{I_s}, \mathbf{I_d}$). It sets bit 1 when equal or similar to threshold & 0 otherwise.
6. Sometimes several key points are found at a time which creates the problem in deciding the actual key point. This problem can be eliminated by NON-MAXIMAL SUPRESSION technique, in which pairs of pixels are compared and finally the pixel with highest intensity is selected as key point and other will be rejected.

D. Binary Robust Invarient Scalable Key Points (Brisk)

Stefan Leutenegger et al have proposed the new approach for image detection called as BRISK [9]. This algorithm performs keypoint detection, description & matching as follows:

1. It computes all keypoints not only in image plane but also in scale space using same method like FAST. But it uses 9 – 16 mask, which means 9 out of 16 pixels must be brighter or darker (maxima or minima) to center pixel (threshold satisfying pixel). It applies 9-16 detectors on all octaves & intra-octaves to figure out all regions of interest then subjected them into non-maximal suppression to find actual interest points.
2. For keypoints description it performs point to point comparison of intensity. This descriptor is composed of binary string. It compiles the results of simple brightness comparison test and forms the binary string. It sets bit 1 when intensity of first pixel is higher than second & 0 otherwise.
3. It computes the local gradients (magnitude, orientation) across each interest point for orientation & rotation invariance.
4. It forms long pairs & short pairs. Long pairs are those whose distance is above threshold & short pair's distance will below the threshold. Long pairs are used for orientation determination & short pairs used for intensity comparison that build the descriptor.

E. Maximally Stable Extremal Region (Mser)

Matas et al**,** have proposed an image detection technique known as MSER (Maximally Stable Extremal Region) [12]. This technique is developed to compute the correspondence between image elements from two images of same scene possessing different view point. This algorithm works in following manner:

1. It first sets the threshold.
2. Then convert whole image into white or black color.
3. Calculates extremal regions.
4. Extermals are those pixels whose intensity is either brighter or darker then surrounding pixels.
5. Extremal regions start to appear as black dots if image is converted into white or white if image is black as shown in Figure.4.

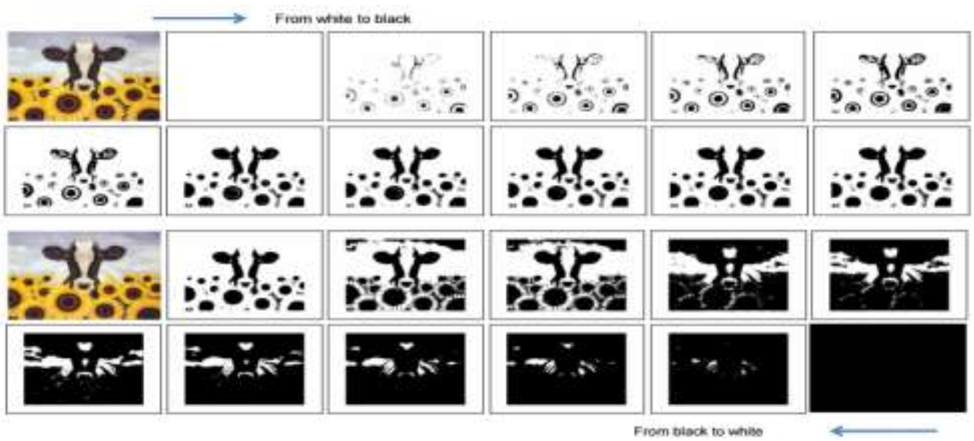

Figure.4. Maximally Stable Extremal Region (Mser)

F. Harris Corner Detector

C.Harris, M.Stephens have proposed new technique for image detection called as corner detection method [10]. This image detection technique is based on function R, where R is "Measure of Corner Responses". As R varies from region to region such as, at corners R is greater than thresholds; at edges R is less than threshold; at flat regions R is small. This is illustrated in Figure.5.

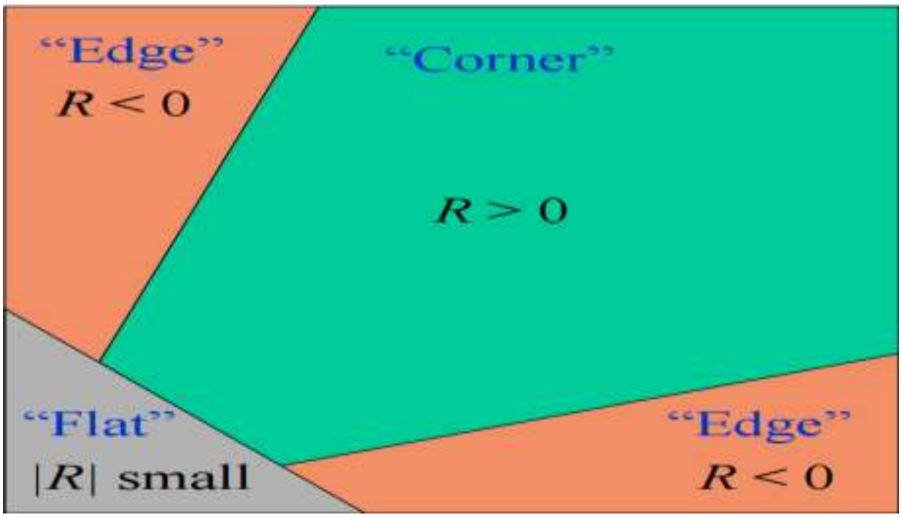

Figure.5. Harris Corner Detector

This algorithm performs following steps for image detection:

1- First computes the corner responses on entire image.
2- Find out the large corner responses, means at the corners only where R > Threshold.
3- Good corners are always with the noticeable intensity change in all directions.
4- Finally, it computes the local maximas, points brighter than the surrounding pixels.

G. Min Eigen

Shi and Tomasi have proposed the modified version of Harris corner detector [11]. This algorithm works in almost same way like HARRIS but with a little change. Harris uses corner selection criteria with the help of Response function R, if the score of R greater than certain value, then the point will be called as corner, where the score function computed by using two Eigen values. Shi & Tomasi have used Eigen values to decide corners instead of using score function as shown in Figure.6.

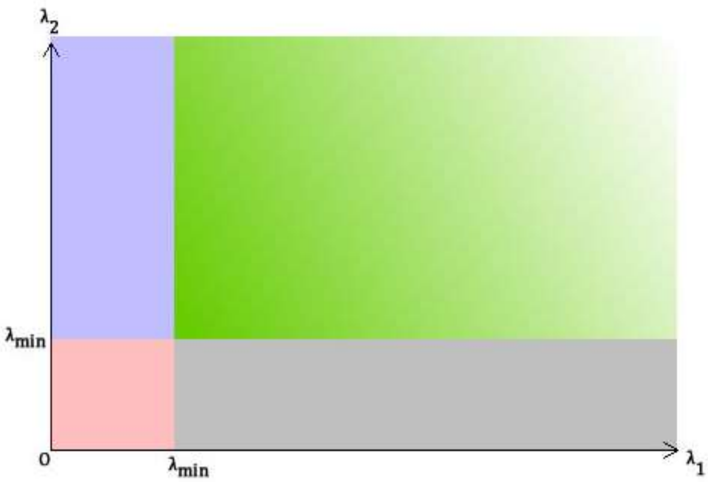

Figure.6. Min EIGEN

Green region shows that the values are above or greater than required certain value. Means pixels in this region can be called as Corners. Where gray blue & pink regions show value is smaller than required minimum, so they can be flat or edge regions.

III. Advantages And Limitations Of Image Detection Techniques

FEATURES	ADVANTAGES	LIMITATIONS
SIFT	• Invariant to rotation. • Invariant t scale changes. • Invariant to illumination changes	• Slower • Complex
SURF	• Invariant to rotation. • Invariant t scale changes. • 3-5 times faster than SIFT	• Still not suitable for application which require faster detection rate. • Sensitive to illumination
FAST	• Very fast detection rate. • Invariant to rotation • Good for: 1. Real time applications (video processing) 2. For low power devices	• Poor in handling scale & illumination changes.
BRISK	• Invariant to rotation • Faster than SIFT/SURF • Dramatically decreases computational complexity. • Invariant to scale changes • Especially suited for: 1. Real time requirements. 2. Low power devices (smart phones).	• Not support illumination changes .
MSER	• Invariant to affine transformation. • Multiscale detection is possible without any smoothing or filtering. • Stable because it chooses most stable regions of image. • Invariant to rotation, scaling, illumination changes	• Slow
HARRIS	• Invariant to rotation	• Improper detection in case of scaling & illumination
Min-EIGEN	• Invariant to rotation	• not support Scaling & illumination changes

IV. CONCLUSION & FUTUREWORK

This paper presents the detailed comparison of different image detection techniques in terms of their advantages & limitations. Among all detection techniques, which are described above, the HARRIS corner detection technique was first developed, it was invariant to rotation but sensitive to scaling & illumination changes. After that Shi Tomasi introduced the modified version of HARRIS known as MinEIGEN but the problem of scaling & illumination in HARRIS was not considered MinEIGEN. Then novel technique SIFT was developed, this techniques was invariant to rotation, scaling & illumination. But, SIFT was slow in terms of performance time. Later, SURF technique was developed with an aim to decrease the processing time of SIFT while retaining all capabilities of SIFT for robust & compact image detection, but this technique was illumination sensitive. Then another technique introduced in the world of image detection known as MSER. This technique is invariant to the rotation, scaling & illumination. But MSER was also noticeably slow in terms of detection time. The more recent methods are BRISK & FAST both techniques perform image detection in average time but are illumination & scaling sensitive.

Our ongoing work is to analyse these techniques experimentally using MATLAB. As from our theoretical analysis, we found MSER performing well in all scenarios but their detection time noticeably high then other techniques. In future, we are interested to propose the modified version of MSER overcoming the problem of detection time.

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