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Comparative Analysis of Image Detection Techniques

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Abstract: Image detection is a sub field of image processing. It is used for detection of images of real world. This field has gained huge importance in last two decades because of its increasing demand especially in fields of Security, Medical, Industries, & Biometrics. This paper presents the detailed comparison & experimental analysis of six different image detection techniques (i.e., SURF, FAST, BRISK, HARRIS, MinEIGEN& MSER). Their performance is analyzed on MATLAB (2015a). For their analysis, three different Scenarios (Single image, 3-card Image & Cluttered Scene) are considered along with four cases (Simple, Rotation, Scaling, & Illumination. The accuracy of these techniques have been analyzed in each scenarios using four cases in terms of their Detected Feature Points.

Keywords: Image Detection, SURF, FAST, BRISK, HARRIS, MinEIGEN, Accuracy, Detected Feature Points

1. INTRODUCTION

Image detection is the process of detecting the Images of 3-D world such as human, trees, cars, houses etc. via machine using some techniques. Image detection techniques perform two major tasks: to extract the features, and to recognize the objects. It has become hot area of research from past few years due to its use in real time applications such as surveillance, image retrieval, automated parking systems etc. In today's world surveillance cameras are installed everywhere especially in public places for the security purpose[24]. It is widely acknowledged that object detection plays vital role in surveillance system, because the system does not require any sort of Human or machine (ROBOT) cooperation to perform their task. As face or object detection is easy task for any human but still very challenging for computer vision technology due to wide variety of pose and position changes. In this field accuracy and correct identification is main issue.

Several image detection techniques have been proposed yet along with some advantages and limitations too. Our objective is to perform analysis of existing image detection techniques and compare their results in terms of their accuracy in order to analyze their efficiency of detecting the image or any particular object.

Section 2 discusses Six image detection techniques in detail. Section 3 presents performance Analysis and highlights the advantage and limitations of discussed techniques. Section 4 gives results and discussion. Section 5 concludes the paper gives the future works.

2. RELATED WORK

A. *SIFT (Scale Invariant Feature Transform):*

This technique was proposed by David G. Lowe in 1999 called as (SIFT, 1999), .It forms the Scale Space Representation by continuously down sampling the image and arrange (Down Sampled Images) them in Octaves and Intra-Octaves. After that, it finds the key-points and eliminate all points at margins and low contrast points, then computes the magnitude and gradient across key points. For orientation assignment, it splits the 16 x 16 input window into 4 x 4 sub-windows, spread 8-bit Histogram evenly over all sub windows, and weight that histograms by previously calculated magnitude andorientation values. In this it forms 128 directional Feature Vectors which are invariant to Rotation, Translation, Scaling and illumination.

B. *SURF (Speeded-Up Robust Feature):*

This Image Detection Algorithm was proposed by Herbet Bay in 2008 (Herbert 2008). (Jurie, 2004) (Lowe 2004), This technique was proposed in an attempt to increase the efficiency of SIFT by decreasing its performance time, retaining all other capabilities of SIFT in its actual form for compact Image Detection. For robust detection it converts the image into integral image. This method is helpful in finding relevant features quickly. Like SIFT, it also forms Scale Space Representation, then computes the key-points and eliminate all irrelevant or useless points. It splits 16 x 16 window into 4 x 4 sub- windows like

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SIFT. For orientation assignment it further splits the 4 x 4 window into 5 x5 sub- regions and computes the HAAR wave-let response on all 25 regions in each 4x4 window separately. Then, add the responses of all sub-windows and form Single large directional vector which will ensure the rotation invariance. This technique is invariant to rotation and scaling while partially to illumination.

*C. FAST (**F**eatures from **A**ccelerated **S**egmented **T**est)*

This method of image detection is proposed in 2006 by Edward Rosten and Tom Drummond. (Drummond. 2006) This technique detects the image with the help of key-points. For key points localization, it selects the pixel compare its intensity with 16-pixels surrounding it (12 out of 16 should satisfy center pixel). In this way it finds all key-points and eliminate all other irrelevant points. It stores the relevant feature information in vector form. There are three vector states (I_s, I_d, I_b) similar, darker and brighter. It stores the information according to the state of pixel. Sometimes several points are detected by algorithm as relevant point. FAST algorithm solves it by NON MAXIMAL SUPRESSION in which the points are compared in terms of their Score Function. The point with maximum score function is selected as actual relevant point. This technique is invariant to rotation and partially illumination, but not supports Scaling.

*D. BRISK (**B**inary **R**obust **I**nvariant **S**calable **K**eypoints)*

BRISK approach is proposed by Stefan Leutenegger (2011) This technique first forms Scale Space representation of input image like SIFT and SURF. Then, it computes the key-point using same method as that of FAST but unlike FAST it forms 9-16 mask means at least 9 out of 16 should satisfy center pixel. For key-points description, it forms short pairs and long pairs by point to point comparison intensities, where long pairs are used to determine the orientation. This technique is invariant to rotation, scaling and partially to illumination.

E. Harris

This corner detection method was proposed in 1988 Harris, (1988).Stephens (2004), . It extracts the image with corner points (the points with high curvature). This image detection technique is based on function R, where R is "Measure of Corner Responses". First computes the corner responses on entire image. Then find out the large corner responses, means at the corners only where R > Threshold. Good corners are those, which possess noticeable change in intensity in all directions. Finally, it computes the local maxima's, points brighter than the surrounding pixels, for compact detection of image.

F. MinEIGEN

Shi and Tomasi have proposed the modified version of Harris corner detector [(1994) (2004) . 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.

*G. MSER (**M**aximally **S**table **E**xternal **R**egion)*

In 2002 Matas proposed a new detection algorithm known as MSER (Maximally Stable Extremal Region). It was developed to find the correspondence between two images of same scene. The main advantage of this technique is, it supports Multiscale detection without any smoothing or filtering (Scale Space Representation) unlike SURF, SIFT or BRISK. This algorithm depends upon extremal regions (pixels with intensity either brighter or darker then surrounding pixels), it computes the stable extremal region of image for robust image detection.

3. PERFORMANCE ANALYSIS

In this section, we present the performance analysis of six image detection techniques: SURF, FAST, BRISK, HARRIS, MinEIGEN, and MSER. To simplify the analysis, 3 different Scenarios (**Scenario 1: Single Image, Scenario 2: 3-Card Image, Scenario 3: Cluttered Scene**) along with four cases (**Case 1: Simple Case, Case 2: Rotated Case, Case 3: Scaling Case, Case 4: Illumination Case**) are considered. These cases will be used in scenario 1, 2 and as well as in 3 to analyze the performance of each technique in all scenarios.

In Scenario 1 and 2, the whole image is considered to be detected by the technique, while in scenario 3, the specific object from the cluttered image to be detected by the technique. The Accuracy of each technique in terms of detected feature points is analyzed.

Case 1 (Simple Case): We take two images reference image and expected image of same size and position, then analyze the performance of all techniques in all scenarios in Simple Case.

Case 2 (Rotated Case): We take the reference image in its actual form while rotate the expected image and analyzed the accuracy of all techniques.

Case 3 (Scaling Case): We take the reference image in its original form but scale the expected image and analyzed the accuracy of all techniques.

Case 4 (Illumination): We take two image reference and expected image of same size and position but with some illumination changes, and check the accuracy of each technique.

4. RESULTS AND DISCUSSION

A. RESULTS

4.1 *Scenario 1 (Single Image)*

4.1.1. Case 1 (Simple Case)

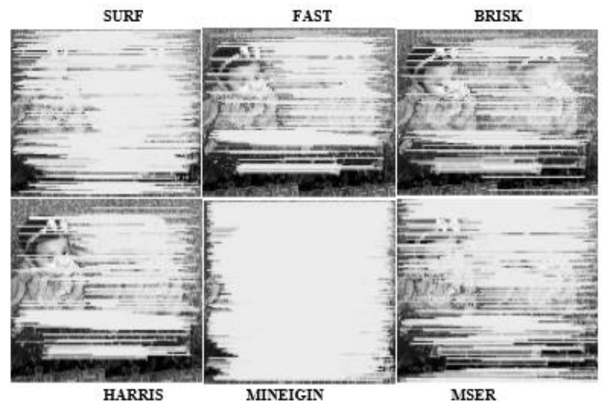


Fig.1: Scenario 1 (Single Image): Simple Case

4.1.2 Case 2 (Rotated Case)

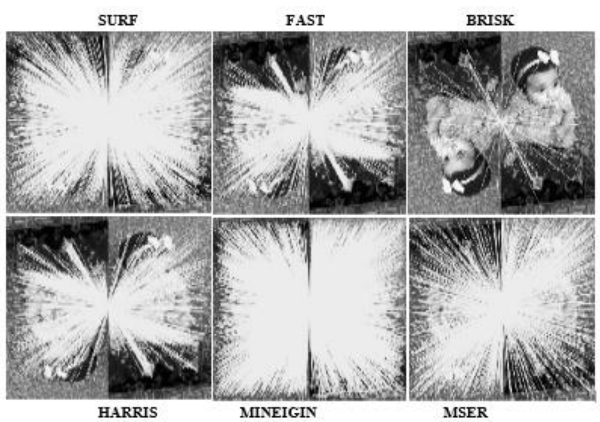


Fig. 2: Scenario 1 (Single Image): Rotated Case

4.1.3 Case 3 (Scaling Case)

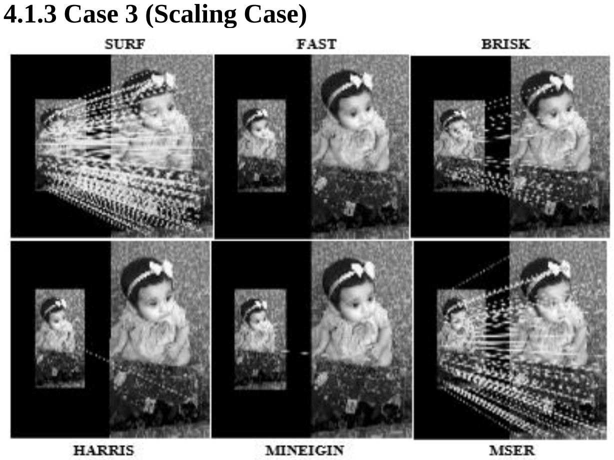


Fig. 3: Scenario 1 (Single Image): Scaling Case

4.1.4 Case 4 (Illumination)

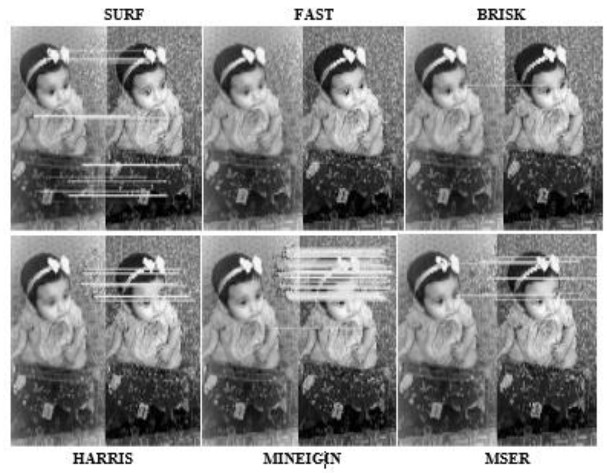


Fig. 4: Scenario 1 (Single Image): Illumination Case Case

4.2. Scenario 2 (3-Card Image)

4.2.1.Case 1 (Simple Case)

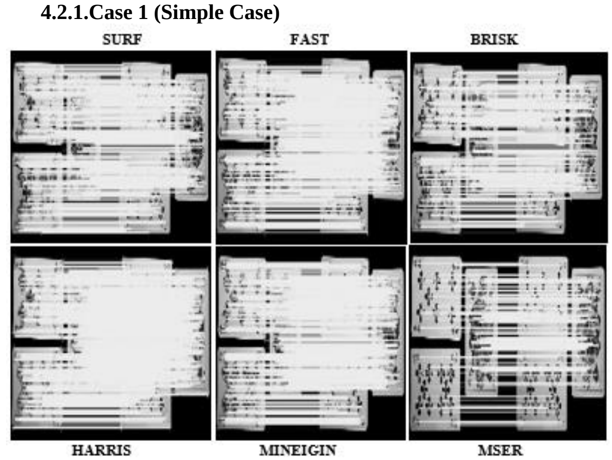


Fig. 5: Scenario 2 (3-Card Image): Simple Case

4.2.2. Case 2 (Rotated Case)

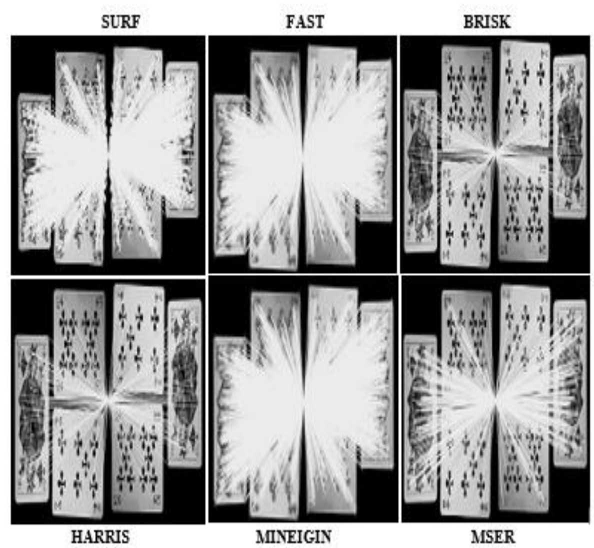


Fig. 6: Scenario 2 (3-Card Image): Rotated Case

4.2.3. Case 3 (Scaling Case)

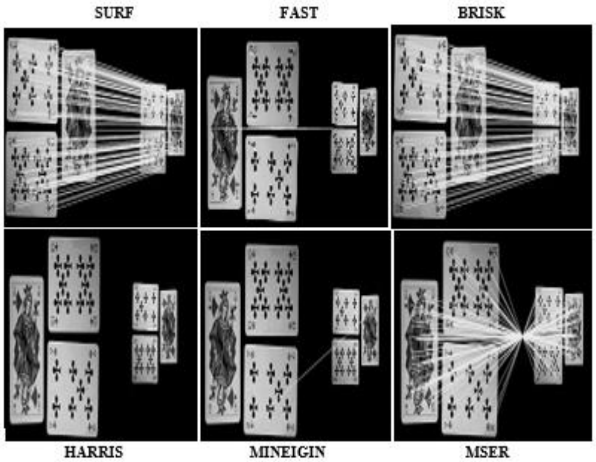


Fig. 7: Scenario 2 (3-Card Image): Scalling Case

4.2.4. Case 4 (Illumination Case)

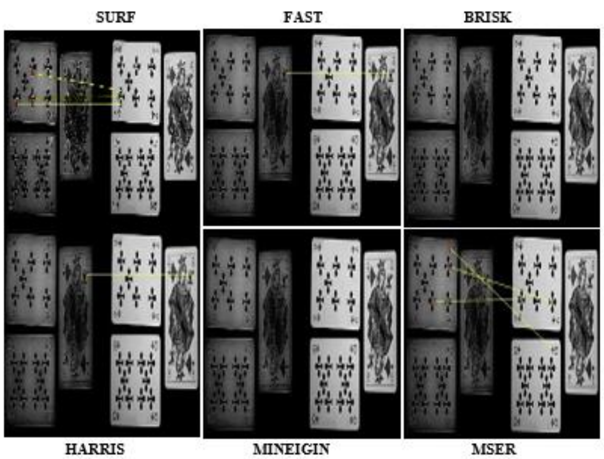
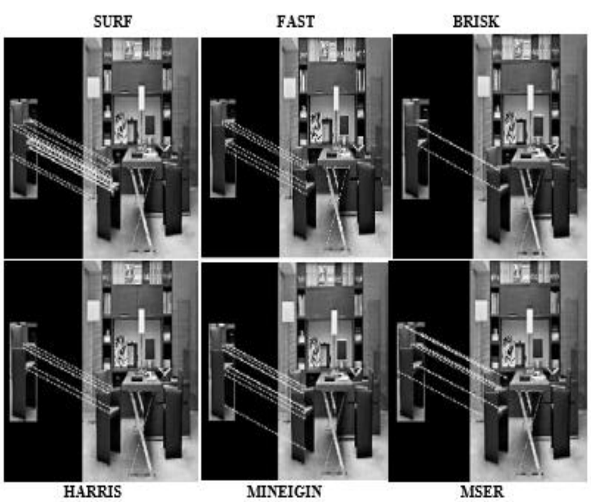


Fig. 8: Scenario 2 (3-Card Image): Illumination Case

4.3. Scenario 3 (Cluttered Scene)

4.3.1. Case 1 (Simple Case)



Fig/ 9: Scenario 3 (Cluttered Scene): Simple Case

4.3.2. Case 2 (Rotated Case)

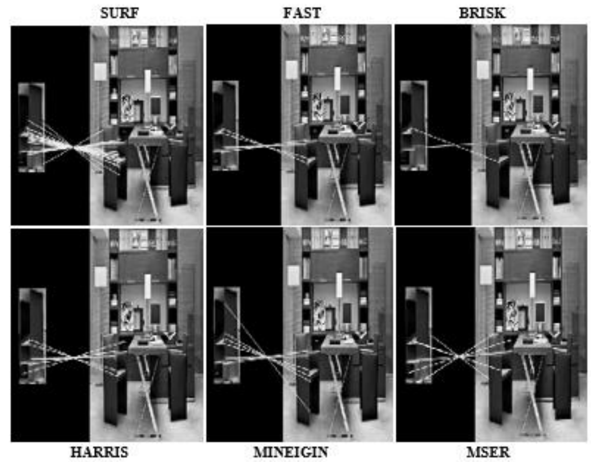


Fig.10: Scenario 3 (Cluttered Scene): Rotated Case

4.3.3 Case 3 (Scaling Case)

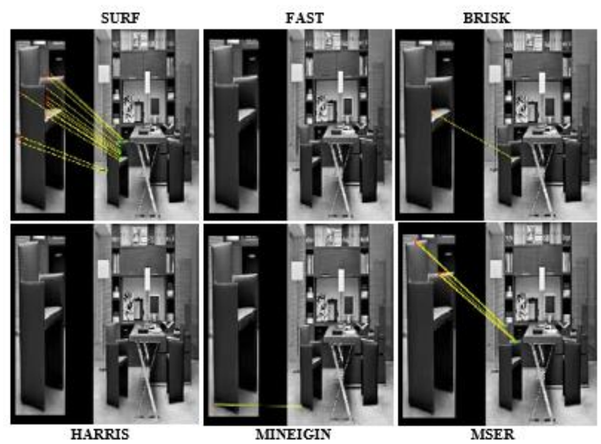


Fig. 11: Scenario 3 (Cluttered Scene): Scaling Case

4.3.4. Case 4 (Illumination case)

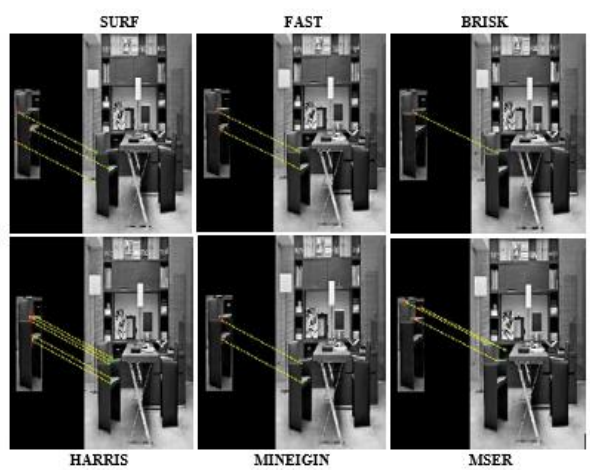


Fig. 12: Scenario 3 (Cluttered Scene): Illumination Case

Table 4.1. Accuracy In Terms of Detected Feature Points (Scenario 1. Single Image)

Techniques	Simple	Rotation	Scaling	Illumination
SURF	22%	30%	13%	3%
FAST	6%	6%	0%	2%
BRISK	3%	2%	1%	1%
HARRIS	6%	7%	0%	5%
MinEIGEN	11%	8%	1%	2%
MSER	10%	8%	9%	3%

Table 4.1 represents the accuracy of the techniques in terms of detected feature points for the Scenario 1 (Single Image). From the table 4.1 it is found, that in Scenario 1 (Single Image), MinEigen is giving maximum performance in first two cases (Simple, Rotation) while all other techniques (SURF, FAST, HARRIS, MSER) were also performed well. Whereas, BRISK performed average in both cases. In case of Scaling and Illumination SURF and MSER gave average performance whereas, the efficiency of other techniques was almost negligible.

Table 4.2. Accuracy In Terms Of Detected Feature Points (Scenario 2. 3-Card Image)

Techniques	Simple	Rotation	Scaling	Illumination
SURF	95%	93%	52%	33%
FAST	86%	87%	0%	0%
BRISK	76%	60%	30%	2%
HARRIS	82%	88%	2%	18%
MinEIGEN	98%	96%	1%	30%
MSER	92%	90%	43%	22%

Table 4.2 represents the accuracy of the techniques in terms of detected feature points for the Scenario 2 (3-Card Image). In Scenario 2 (3-Card Image) almost same performance trend was observed, that in cases of Simple and Rotation MinEigen, HARRIS, FAST were best in terms of performance, MSER performed good, whereas SURF and BRISK performed average in case of rotation. In case of scaling SURF, BRISK and MSER performed satisfactory with the efficiency of more than 70% but in case of Illumination, again, like Scenario 1 the performance of all techniques was almost negligible.

Table 4.3. Accuracy In Terms Of Detected Feature Points (Scenario 3. Cluttered Scene)

Techniques	Simple	Rotation	Scaling	Illumination
SURF	92%	60%	80%	3%
FAST	96%	92%	1%	1
BRISK	79%	65%	76%-	0%
HARRIS	98%	96%	1%	1%
MinEIGEN	93%	98%	0%	0%
MSER	78%	70%	71%	4%

Table 4.3 represents the accuracy of the techniques in terms of detected feature points for the Scenario 3 (Cluttered Scene). In Scenario 3 (Cluttered Scene), SURF performed somehow better than other techniques (FAST, BRISK, HARRIS, MinEigen, MSER) in all cases (Simple, Rotation, Scaling, and Illumination) but its performance is not acceptable too for real time applications.

4 CONCLUSIONS

In this paper, Accuracy in terms of detected feature points for Six Image Detection Techniques i.e., SURF FAST, BRISK, HARRIS, MinEigen, MSER have been analyzed. From their analysis on Matlab 2015a, it is observed that all techniques performed good in cases of Simple and Rotation while in cases of Scaling and Illumination their performance was not satisfactory. Indeed, they were supporting Scaling and Illumination changes but their performance is not acceptable for real time applications. These techniques were also not suitable for specific object detection as in the Scenario 3, their efficiency was not more than 30% which is almost negligible. So in future work, we are interested in proposing new technique (or modify existing technique) considering Scaling and Illumination cases.

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