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A COMPARISON OF SIFT and SURF ALGORITHM FOR THE RECOGNITION OF AN EFFICIENT IRIS BIOMETRIC SYSTEM

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Abstract: The recognition of iris has the potential for high level of accuracy due to its uniqueness and stable feature. In this paper a comparison of SIFT (Scale Invariant Feature Transform) and SURF (Speeded Up Robust Features) algorithm is used to analyse the speed and accuracy of the Iris Recognition system. SIFT and SURF method will extract the local feature points of the iris and then determine the scale invariant key points in the iris image and then express these key points using the local patterns around the key points. The K-nearest neighbour algorithm is used for classification. The experimental result proved that SURF algorithm works faster, efficient and reliable than SIFT.

Keywords: SIFT, SURF, Feature Extraction, K-nearest neighbour.

I. INTRODUCTION

Iris biometrics is considered to be one of the unique and stable modality, which is secured from external environments behind the cornea, and the eyelid, and also the iris pattern of left as well as the right eye of a person is different. Due to this reason the Iris is claimed to be strong candidate especially when it comes to the authentication of a legitimate user. The different approaches to check the genuineness of an input image against the image stored in the database are global feature matching and the local feature matching [1]. Majority of the iris recognition systems have been implemented by using Daughman's patented algorithms which uses mainly iris-codes. The main difficulties faced in these types of feature based iris recognition is that the matching performance is influenced significantly by a number of parameters during the feature extraction process, such as spatial position, orientation, centre frequencies and the size parameters for 2D Gabor filter kernel. In order to overcome the above mentioned problem, another algorithm is proposed by Kazuyuki Miyazawa et. al. using phase-based image matching technique, which uses only the phase-component in 2D-DFTs, where there there exist a problem in which, the sub-pixel image estimation is the major concerned. Studies showed that global feature matching gives less accuracy due to its inability to handle invariance in image scale and rotation. Scale Invariant Feature Transform (SIFT) and Speeded Up Robust Feature (SURF) are two local feature matching algorithm which proved to be most promising due to high performance and have been used in many applications. In SIFT it will identify the keypoints which are invariant to scale, illumination, and rotation, then for each keypoints corresponding feature vectors are computed[2]. According to H. Bay [3] SURF algorithm operates very similar to SIFT but it follows a different approach for processing in all the steps. Also his study claims that SURF is an enhanced version of SIFT. In SURF algorithm it has three main operations like interest point detection, local neighbourhood description and matching. SURF uses a blob detector based on the Hessian matrix to find points of interest. The determinant of the Hessian matrix is used as a measure of local change around the point and points are chosen where this determinant is maximum. The different classes of keypoints are then undergoing nearest neighbour algorithm for classification.

II. SIFT FOR IRIS FEATURE POINTS EXTRACTION

A natural phenomenon of a pupil is that it will expand and contract. Due to this reason a linear deformation occurs on the texture pattern of the iris. So an improved version of keypoint descriptor is essential that can perform scale invariance along with other transformations. A large number of methods for extracting the keypoint of an iris have been studied and proposed. In this paper SIFT is used as one of the local feature descriptor that provides features which are less sensitive to image distortions. Using SIFT will reduce the iris pre-processing steps and also it can describe iris local properties effectively.

The four major steps used for the computation of the feature extraction using SIFT are Scale Space Extrema Detection, Keypoint Localization, Orientation Assignment and Keypoint Descriptor, which are detailed as follows.

A. Scale Space Extrema Detection
This computation step will searches the entire scale and image location. The Difference of Gaussian function is used to identify the keypoints from annular iris image. By using cascade filtering approach, it will search all the stable features in the image. The scale space of an input iris image I(x, y) is defined as a function of L(x, y, σ) which is convolved with Gaussian kernel G(x, y, σ) and defined as

$$L(x, y, \sigma) = G(x, y, \sigma) * I(x, y)$$

where * is the convolution operation in x and y. σ defines the width of the Gaussian filter. The Difference of Gaussian images are computed from the difference of two nearby scales separated by a constant multiplicative factor k.

$$D(x, y, \sigma) = L(x, y, k\sigma) - L(x, y, \sigma)$$

B. Keypoint Localization
Once the candidate keypoint has been found by comparing two nearby pixel, then the next step is to perform the detailing to the candidate keypoint to eliminate the points which are poorly localised. For that the Difference of Gaussian images are used to detect the interest points using local maxima and minima at different scales.

C. Orientation Assignment
This stage assigns the orientation to the each selected keypoints which will result rotation invariance [4]. Direction of the gradient and the magnitude of each keypoints are collected and the most prominent orientation is a taken as the keypoint in that region. Then the keypoint orientation is determined by computing the gradient orientation histogram. Then select the Gaussian smoothed image from the scale of keypoint. For each Gaussian smoothed image L(x, y), magnitude (m (x,y)) and orientation (θ (x,y)) are computed as

$$m(x,y)= \sqrt{(L(x+1,y)-L(x-1,y))2+(L(x,y+1)-L(x,y-1))2}$$

$$\theta(x,y)= \tan^{-1}\frac{L(x,y+1)-L(x,y-1)}{L(x+1,y)-L(x-1,y)}$$

An orientation histogram is formed for all pixels around the keypoint, in which 360 degrees of orientation are split it into 36 bins and each sample is weighted by gradient magnitude and Gaussian weighted circular window with σ = 1.5 times of scale of keypoint before adding it to histogram. Histogram peaks corresponds to the orientation and any other local peak that is within 80% of the highest peak is used to create keypoint with that orientation. Thus for location with multiple peaks of similar magnitudes will have multiple keypoints created at the same location and scale but with different direction. This will contribute to increase the stability during the matching.

D. Keypoint Descriptor Computation
Once the orientation has been selected, the feature descriptor is computed as a set of orientation histogram on 4×4 pixel neighbourhoods. For that a 16×16 neighbourhood around the keypoint is taken, which is divided into 16 sub-blocks of 4×4 size. For each sub-block, 8-bin orientation histogram is created. So a total of 4×4×8=128 bins values. These 128 numbers form the feature vector and the keypoint is uniquely identified by this feature vector. This feature vector is invariant to rotation, scaling and is immune to illumination changes.

III. SURF FOR IRIS FEATURE POINTS EXTRACTION

Speeded Up Robust Feature is found to be computationally simpler and faster than SIFT without sacrificing the performance. The integral image helps in computation of a box type convolution filters. Compared to existing keypoint detectors SURF is more robust because of the Hessian based detectors which are more stable and repeatable than their Harris-based counterparts [5,6].

The two main advantages of SURF over SIFT is that SURF uses Laplacian of Gaussian so as to have a distinction between background and foreground features, and secondly, SURF uses only 64 dimensional vector compared to 128 dimensional vector for SIFT[7]. This helps in fast feature computation and also the quick matching capability.

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The two different steps used by SURF to determine the local descriptor vectors are A. Keypoint Detection B. Keypoint Descriptor, which are explained below.

A. Keypoint Detection

In this step instead of using Difference of Gaussian as in SIFT; the SURF keypoints are detected using Hessian Matrix approximation. The location where the Hessian determinant is maximum gives rise to the interest point.
For an image I with a given point P = (x, y), the Hessian matrix
H = (P, σ) in P at scale σ is defined as follows:

$$H(P, \sigma) = \begin{bmatrix} L_{xx}(P,\sigma) & L_{xy}(P,\sigma) \\ L_{xx}(P,\sigma) & L_{yy}(P,\sigma) \end{bmatrix}$$

where $L_{xx}(P, \sigma)$ in equation is the convolution of the image with the second order derivative of the Gaussian. Approximate Gaussian second order derivatives can be evaluated using integral images at very low computational cost. The use of integral images makes calculation time independent of filter size. So in SURF scale space is built by keeping the same image and only the filter size is varied. The 9×9 box filters shown in Fig. 1 are approximations of Gaussian with σ=1.2 and this represents the lowest scale space[8].

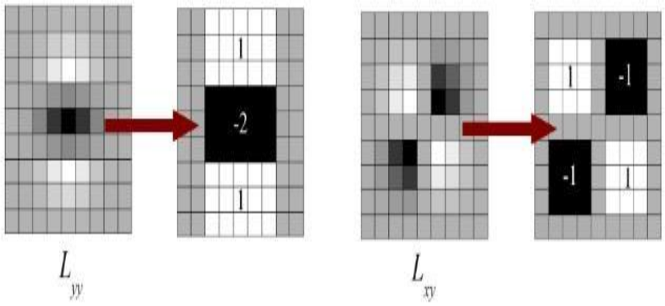

Figure 1: Gaussian second order derivatives in y and xy direction

The approximated LoG is represented as D_{xx}, D_{xy} and D_{yy}. [8] So the determinant of the Hessian matrix is given as:
$Det(H_{approx}) = D_{xx}, D_{xy} - (0.9D_{xy})^2$

B. Keypoint Descriptor

The keypoint descriptor is to provide a unique and robust description of a feature, a descriptor can be generated based on the area surrounding an interest point. The SURF descriptor is based on Haar wavelet responses and can be calculated efficiently with integral images with 64 dimensions for speed.

As a first step it finds the orientation using circular window around the interest point. To achieve image rotation invariance the orientation is identified for each keypoint. For that Haar wavelet responses are calculated in x and y directions circular window of size 6s. The wavelet responses in x and y direction of the points in the circle about the interest points are calculated. The wavelet size is scale dependent and set to side length of 4s. Once the wavelet responses are calculated and then weighed the responses with Gaussian kernel.

After finding out the orientation of all interest point a square window of size 20s centred around the interest point and oriented along the direction found prior to this. The region is split into smaller 4×4 sub-regions to preserve spatial information.

Haar wavelet responses are obtained in horizontal (d_x) and vertical direction (d_y) for each sub-regions[9]. The d_x and d_x along each sub-regions are summed up to form elements of feature vector.

Then calculated Σ|dx| and Σ|dy| are to have information about the polarity changes in intensity.

So each sub-region resulted in a descriptor vector of 4 dimensions viz. v=(Σdx, Σ|dx|, Σdy Σ|dy|). Doing this for all sub-regions, a descriptor vector with 64 dimensions will be obtained. This 64 dimensional feature vector corresponds to each keypoint.

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Nearest Neighbor Feature Matching

The image matching algorithm in biometrics ranges from simple nearest neighbor to more sophisticated methods like support vector machines[10]. Accurate authentication of an individual is found out by using the total number of keypoint pairs in local feature matching. In image matching for each element in D_m, which is the set of all keypoint descriptors for each keypoints in K_m, (where 'm' is the stored image in the database and 'n' is the probe image) the Euclidean distances are measured with every element in D_n which is the set of all keypoint descriptors for each keypoints in K_n. The images to be matched and find out matched pair of keypoints by the method of comparing with a given threshold.

IV. COMPARISON OF SIFT AND SURF FOR IRIS RECOGNITION SYSTEM

The experimental results in the table.1 shows the performance and accuracy of feature matching in terms of speed when we combine both SIFT and SURF algorithm together for iris recognition.

TABLE : 1 COMPARISON RESULTS OF SIFT AND SURF

	Detected Feature point	Matching feature point	Feature matching Time
SIFT	44	7	0.796145 seconds
SURF	11		0.000001 seconds

Based on the methodological analysis the characteristics of SIFT and SURF are briefly summarized in the table 2.

TABLE: 2 COMPARISON OF SIFT AND SURF

	SIFT	SURF
Keypoint Detection	Different scale image convoluted with Gaussian function	Original Image is convoluted with Different scale box filter
	Candidate keypoint detect extrema in Difference of Gaussian space	Candidate keypoints are determined using Hessian matrix
Keypoint Description	Gradient amplitude of a square area is calculated with maximum gradient strength as the main direction	A Haar wavelet response is used to calculate each sector in a circular area
	Feature Extraction by dividing a 16×16 region into 4×4 subregion, for each subregion a gradient histogram is created.	Feature Extraction by dividing a 20×20 region into 4×4 subregion and a Haar wavelet response is calculated.
Dimensions	128	64

V. KEYPOINT CLASSIFICATION AND MATCHING APPROACH

The two keypoint detection methods are being used for authenticating both the probe image and the stored database image [11,12]. They are Difference of Gaussian keypoint detection by SIFT fig.2 and Hessian matrix keypoint detection by SURF. fig. 3 on a sample iris image from UBIRIS database.

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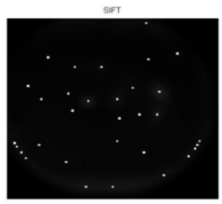

Fig.2 Keypoints detected by SIFT

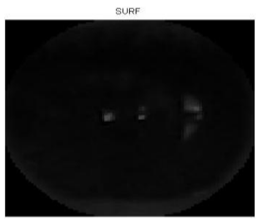

Fig.3 Keypoints detected by SURF

The approach used for matching the keypoints is by the most commonly used nearest neighbor approach [13,14]. First check the images to be compared have same number of keypoints. For that we considered a keypoint in the first image and then found out the Euclidean distance between this keypoint and another keypoint in the second image. After having found out the Euclidean distance between keypoint '1' of first image and all the keypoints of second image, it will be stored in an array. Then to find out matching for the first keypoint in the second image we go for a 'hit and trial' method where we set a threshold value. Then compare each of the obtained distance with the threshold, thus obtain the distance which is less than or equal to the threshold. Thus we found out the matched keypoint in the second image. In case of multiple keypoints satisfy the above criteria, we choose the keypoint which gaves the minimum Euclidean distance. The block diagram shown in fig. 4 detailed the steps we adopted.

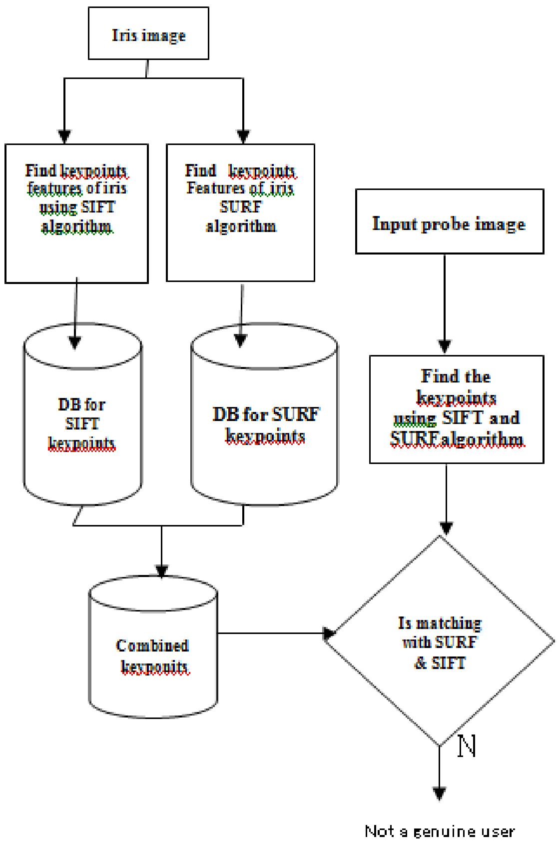

Fig .4 Block diagram of keypoint classification and authentication

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VI. CONCLUSION

In this paper a comparison of SIFT and SURF feature matching algorithm for the recognition of iris were presented. Iris keypoints were extracted and matching has been done using both SIFT and SURF. The proposed method reduce the iris pre-processing and describe the properties of iris with local features effectively. By combining both SIFT and SURF algorithm helps to found out matching keypoints much faster than using SIFT algorithm alone.

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