IJCSE International Journal of Computer Sciences and Engineering Open Access
Research Paper Vol.-7, Issue-2, Feb 2019 E-ISSN: 2347-2693

Recent Advancement in Feature Extraction tools for Biometric System: Comparative Analysis

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DOI: https://doi.org/10.26438/ijcse/v7i2.4650 | Available online at: www.ijcseonline.org

Accepted: 12/Feb/2019, Published: 28/Feb/2019

***Abstract*—** Biometrics is the new technology for body measurements and calculations that is use to identifying a person. It signifies to metrics related to human physiological or behavioral characteristics. Many specific physiological and behavioral parts, personal characteristics have been suggested and used for biometric security scheme [1]. Any Biometric system comprises of four modules: sensor module, feature extraction module, database module and matching module. Out of all these module feature extraction module of any recognition system plays an important role in recognizing the particular objects with same set of images [3]. This paper presents an analysis on the use of the newly introduced modern and popular key-points feature extracting tools and methodologies that can be applicable in the biometric domain. The implementation is carried out using MATLAB programming environment and tested on CASIA database for Iris and FVC2004 DB3_A for Fingerprint.

Keywords— Biometric; Iris; Fingerprint; Feature;Templte; Matching**.**

I. INTRODUCTION

A Reliable authentication system has long been in demand. Since its inception various models and technologies implementing these models have come up in the market and are in use for different application in different areas [2]. Among the most popular and widely accepted worldwide means of authentication is password. But there are some limitations with traditional way of authentication, as Passwords may be forgotten, PIN may be guessed, and Id-Card may get misplaced or lost. Looking forward to overcome the problems with traditional solution, it is found that Biometric on the other hand proves to be very useful and efficient way of authentications [1].

The use of Biometrics for authentication and recognizing individuals from the mass has emerged as one the most convincing and reliable method. Biometric system is a kind of authentication system. The term biometric has originated from the Greek word bio which means 'life' and metrikos meaning is 'to measure'. Today in this modern era, the term biometrics refers to technologies that analyze and measure human physiological and behavioural characteristics. Physiological characteristics are (fingerprint, iris, face etc.) and behavioural characteristics include (voice patterns, signature, writing styles, gait etc.) for the authentication purposes [3]. The Biometrics data are not easy to duplicate or steal. For any system to recognize accurately it must have capability to minimize intra-class variability and limit the inter-class variability. It's become easy for a system to reliably classify one object from the group of objects, if and only if when the variability among different instances of a given class is less than the variability between different classes.

The paper presents a complete analysis about the various well known methodologies for key-points extraction at enrolment phase. The multiple methods such as SURF, SIFT, FAST and DWT have been used to see how well they work with authentication system. Among these methodologies, the one that gives an optimal result when implemented using Matlab on CASIA iris database and FVC2004 database for fingerprint is analysed. The robust feature extraction tool speeds up the overall performance of the system.

II. BIOMETRIC TRAITS

Among the various traits, Iris having the most discriminant texture and fingerprint being the most popular is used as input for sensor to analyse the efficiency of the different feature points extracting tools.

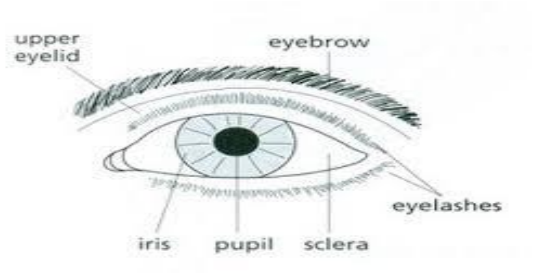

Fig. 1a

Iris as a biometric trait helps the system in recognizing the person by extracting ones iris patterns from the images of the person eye and then matching with the templates stored in the system for that person (Fig. 1a). Iris being the internal part of eye but externally being visible is well protected from the environment. It remains stable throughout the life span.

Fig. 1b

Fingerprint is another very important and popular trait among the other modal. Most of the traditional and modern technologies are design and implemented using fingerprint for verification and identification of person identity. Fingerprint is very rich in patterns such as whorl, left loop, right loop, bifurcation, delta and many more thus it makes fingerprint more popular among researcher to be a first preference (Fig. 1b).

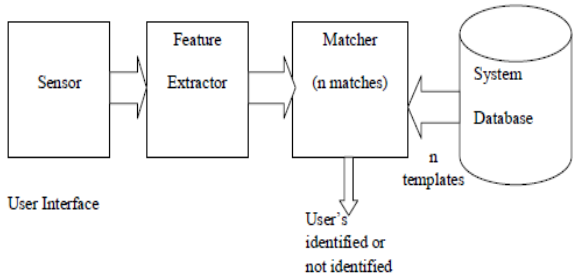

Fig. 2 Block Diagram for Biometric System [1]

III. FEATURE EXTRACTION

The object that needs to be verified and authenticated has to be mapped accurately with the templates stored in the database. The database of templates is created during enrolment phase.

Feature extraction is the process of extracting the relevant key-points or features from the patterns available on the objects. These points form a feature vector and are then used by classifiers to identify the input credentials with templates stored in the database (Fig. 2 given above). The classifier makes it easy to classify the object from the existing list of population (templates in database).

Feature selection itself is one of the most important factors to contribute high performance and high accuracy in recognizing the objects or traits by the system. Researchers have contributed various techniques and tools for feature extraction. Among these tools and techniques, the recent and perhaps the interesting algorithms are Scale Invariant Feature Transformation (SIFT), Speedup Robust Feature (SURF), and various versions of FAST.

A. Scale Invariant Feature Transform (SIFT)

SIFT is a blissful approach to texture based feature (key-points) detection introduced by Lowe in 2004. It transforms image points or data into scale-invariant coordinates relative to local features. The key-points obtained are invariant to scaling and rotation. They are partially invariant to change in illumination too. They can be well localized in the space and time domains both, reducing the chance of getting interrupted by interference, clutter or noise due to presence of unwanted salt and pepper.

SIFT helps in extracting large numbers of features or key points from a typical image efficiently [2, 4]. The features obtained are unique and distinctive. As a result it increases the probability of correctly matching a single feature to a large set of features from the database templates. It forms the basis for each object and image recognition easy and efficient. The major stages in SIFT are:

- Scale Space Extrema Detection: This is a first stage for key-points detection which uses a Difference of Gaussian (DoG) to identify the locations and points that are invariant to change in scale and orientation of the image data.
- Key point Localization: In this stage at each candidate location, a detailed model is fit to find a correct location and scale. Key points are selected based on correctness and stability in points at that location.
- Orientation Assignment: One or more orientations are assigned to each key-point location based on local data such as gradient directions.
- Description Generation: Finally the computation of a descriptor is carried out for the key-point locations that are invariant to scale or change in illumination.

B. Speeded Up Robust Features (SURF)

Surf is a novel approach to interest point detector and descriptor that are invariant to scale and rotation introduced by Bay and Tuytelaars in 2006. It approximates or even outperforms the existing algorithms such as SIFT and FAST

with respect to invariability, distinctiveness, and robustness. Here the key-points are computed and extracted at much faster rate in comparison to SIFT because of the use of integral images for convolutions, a Hessian matrix for detector and distribution of Wavelet responses as descriptor [4, 5]. The two main steps in SURF are:

- Interest Point Detection: The detection is carried out using Hessian matrix based measure to detect interest points in an image which are invariant to scale and rotation.
- Interest Point Descriptor: A distribution of Haar-wavelet responses within a local region are used as descriptor.

C. FAST

FAST is a feature-based algorithm in comparison to SIFT and SURF (which are texture based descriptor). After a decade, the Harris Detector was published; a new corner detector algorithm called FAST was introduced by Trajkovic and Hedley in 1998. The use of FAST gives a priority to corners detection over edges. They claimed that it is the corners which can provide most distinctive and intuitive types of features as it clearly reflects changes in intensity between neighbouring points. The important fact behind publishing of FAST was to enhance the computational speed required in the detection of corners [7, 8].

D. Discrete Wavelet Transform (DWT)

The technology is based on sub-band coding; it can perform a fast computation of Wavelet Transform. Discrete Wavelet Transform is easy to implement and has been seen that it reduces the computation time at great level for finding approximation and other details.

According to S. Mallet [12], the Discrete Wavelet Transform (DWT) can be implemented using filter banks involving Low-Pass (LP) and High-Pass (HP) filters as shown in the fig. 4. The DWT is carried out on rows first (i.e. row by row) and then column by column. As a result, four sub images are generated.

- The top left section corresponds to sub image which gives an approximation of the original image.
- The top right section corresponds to sub image which gives the horizontal details.
- The bottom left section corresponds to sub image which gives the vertical details.
- The bottom right section corresponds to sub image which gives the diagonal details.

The decomposition procedure is further iterated on the resulting approximation sub image as shown in fig. 3a. Fig. 3b and fig. 3c shows a two-level decomposition of the colour image for iris and fingerprint.

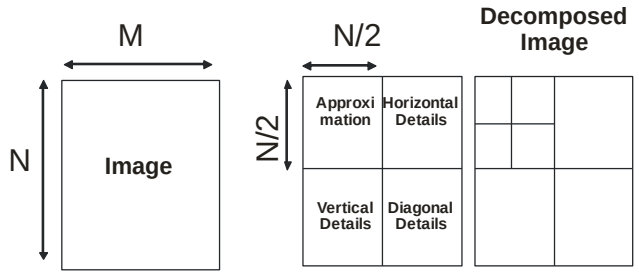

Fig. 3.a

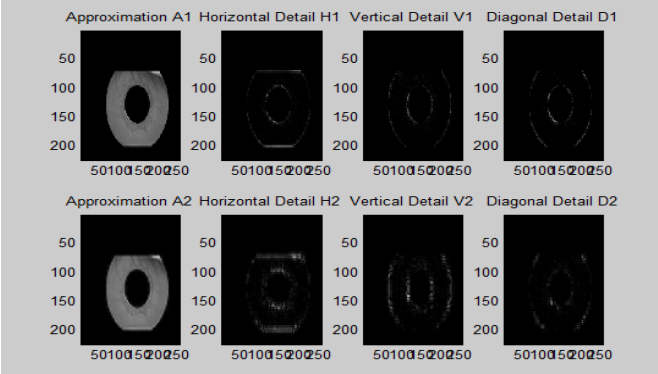

Fig. 3.b

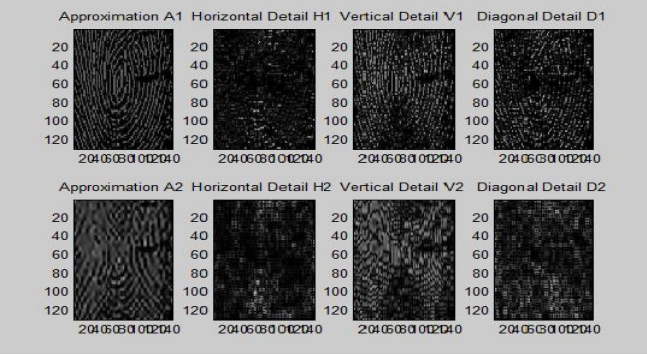

Fig. 3.c

IV. EXPERIMENTAL RESULTS

The result has been derived by comparing one algorithm against the other algorithm using the same data sets of images. The results in the tables are part of the implementation of different methodologies that are popular in the field of computer vision. The comparison is done using different sets of eye images and finger print images from cassia database. In the table given below shows that the Discrete Wavelet Transform (DWT) performs very fast feature extraction. It takes on an average of 0.6078ms. Next is SURF, it takes around 2.5617ms. Third is FAST which takes around 6.7058ms. Finally SIFT as stated in many paper, it is very slow in detecting important features from images, it takes around 19.6874ms which seems to be very high value compared to SURF, FAST and DWT.

Table 1 Comparative Result Analysis

Id	Elapsed Time	Enrolment (y/n)	Algorithm (Methodologies)	Matching		Identification
				Image1 (eye)	Image2 (finger)	
1	2.6820	Y	SURF	Y	Y	Y
2	2.5617	Y	SURF	Y	Y	Y
3	2.1000	Y	SURF	Y	Y	Y
4	2.1000	Y	SURF	Y	Y	Y
5	19.7440	Y	SIFT	Y	Y	Y
6	19.6478	Y	SIFT	Y	Y	Y
7	18.5141	Y	SIFT	Y	Y	Y
8	19.5424	Y	SIFT	N	N	N
9	10.9789	Y	FAST	Y	Y	Y
10	6.7058	Y	FAST	Y	Y	Y
11	6.7377	Y	FAST	Y	Y	Y
12	6.8532	Y	FAST	Y	Y	Y
13	1.2204	Y	DWT	Y	Y	Y
14	0.6738	Y	DWT	Y	Y	Y
15	0.5664	Y	DWT	Y	Y	Y
16	0.6078	Y	DWT	Y	Y	Y

The elapsed time in the table shows the feature extraction time in total for both the image (eye and finger). Once the feature was successfully extracted it is given to matching module where it is compared with existing templates feature already enrolled in the database. The result was surprising when it was found that SIFT being one of the popular tool to deal with image, it is observed that it fails to recognize some of the images, in contrary other tools performed well without missing the target.

A. Chart

Here from the chart (Fig. 4) we can analysis the performance of individual algorithm on the basis of time consumed (i.e. elapsed time) while extracting the most relevant and interesting points (key-points) from the given images of eye and fingerprint at the time of enrolment in the database of templates. The long bars in the chart represents that there is huge difference in consumption time between the algorithms though they operate on same set of data/images.

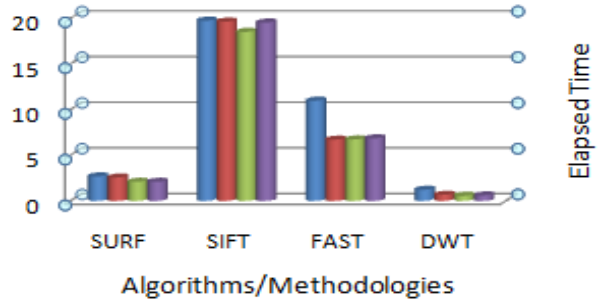

Fig. 4

V. CONCLUSION

The robustness of various techniques has been examined using a CASIA database for Iris as well as on FVC2004 database for Fingerprint. It is observed that the DWT and SURF technique employed for feature extraction module outperforms the various limitation of SIFT and FAST. The resultant analysis is an outcome from an implementation of various stated feature extraction tools on two different biometric traits (eye, fingerprint). The implementation also showed that SIFT being powerful tools fails in some cases in extracting the relevant features compare to SURF. Our future scope is to make fusion of the matching scores obtained using these algorithms at the time of enrolment of images.

ACKNOWLEDGMENT

The Authors of this paper are thankful, to Libor Masek, for making available of open source code on various Projects and to the seniors for their blissful support in implementing the method successfully.

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