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Multimodal Biometric Identification using DWT, Harris Corner and Support Vector Machine Classifier

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Abstract – Biometric recognition systems use certain human characteristics such as voice, facial features, fingerprint, iris or hand geometry to identify an individual or verify their identity. These systems have been developed individually for each of these biometric modalities until they achieve remarkable levels of performance. Multimodal biometric systems combine different modalities in a unique recognition system. The multimodal fusion allows to improve the results obtained by a single biometric characteristic and make the system more robust to noise and interference and more resistant to possible attacks. The fusion can be carried out at the level of the signals acquired by the different sensors, of the parameters obtained for each modality, of the scores provided by unimodal experts or of the decision taken by said experts. In the fusion at the level of parameters or scores it is necessary to homogenize the characteristics coming from the different biometric modalities prior to the fusion process. This paper presents development of a multimodal biometric identification system based on two biometrics namely, the fingerprint and finger knuckle. Feature extraction is done using Harris Corner and DWT method and classification is accomplished using Support Vector Machine (SVM) classifier.

Keywords – DWT, Harris Corner, Multimodal biometrics, SVM.

I. INTRODUCTION

The identification of individuals corresponds to the search for the identity of the person who appears in a database. It can be used to authorize the use of services, for example to control access to a highly secure area for which only a limited number of people (registered in a database) have access authorization, as it can be used to recognize criminals and terrorists.

To meet these needs, biometrics seems to be a practical, effective solution whose cost in effort and money is constantly decreasing. In fact, biometrics is developing rapidly. This infatuation leads to the growth of a wide variety of biometric methods: from the classical ones, such as the study of fingerprints [1] or iris [2], to more exotic ones like the recognition of the gait [3], recognition of the shape of the ear [4].

In order to develop the means of recognition, the research has been in recent years a spectacular revival and has a major interest in "biometric" data, that is to say the characteristics of each person: his voice, fingerprints, and features of his face, the shape of his hand, his signature and even his DNA.

Biometrics has its origins in anthropometric recognition processes, the oldest being fingerprint analysis. The thumbprint was already used as a signature in Babylonian trade in ancient times and in China in the 7^{th} century. In a much nearer time, in the 19^{th} century, Alphonse Bertillon, a great French criminologist, invented a scientific method called "judicial anthropology" allowing the identification of thugs according to their physiological measurements.

The first question we need to answer is: what is biometrics? The word biometrics refers in a very broad sense to the measureable study of living things [5]. Biometry is the science that uses mathematics to study biological variations within a given group.
Biometric features cannot be easily stolen, falsified, or shared. Thus, they are more trustworthy and secure for person recognition than traditional methods based on knowledge or possession. However, these physical and behavioural features must satisfy several constraints for a high reliability of the biometric systems. Indeed, the objectives of the biometric recognition are the ease of use by a recognition without card or PIN, the increased security which is translated by the difficulty to circumvent the access control as well as the greater performance with the precision and the speed of processing [6].
Biometric techniques are divided into two groups according to the cooperation or not of the individual:

- Intrusive Techniques: These techniques require physical contact with the individual to identify him or her, such as fingerprints, retina, laughing or the shape of the hand. Their use is generally poorly accepted.
- Non-intrusive Techniques: These techniques do not require the cooperation of the individual in question, their application can be done remotely using sensors that do not require direct contact with the user (face, gait).

This paper uses two biometric modalities:

A. Fingerprint Recognition

Fingerprint recognition is a mature biometric technique for any individual identification or verification application. A fingerprint recognition system is an automatic pattern recognition system that consists of the three main steps [7-9]:

- Acquisition: Fingerprints are captured and stored as images.
- Feature Extraction: the essential features are extracted from the images.
- Decision making: The features acquired are compared with the features stored in a database and from the result of this comparison a decision is made.

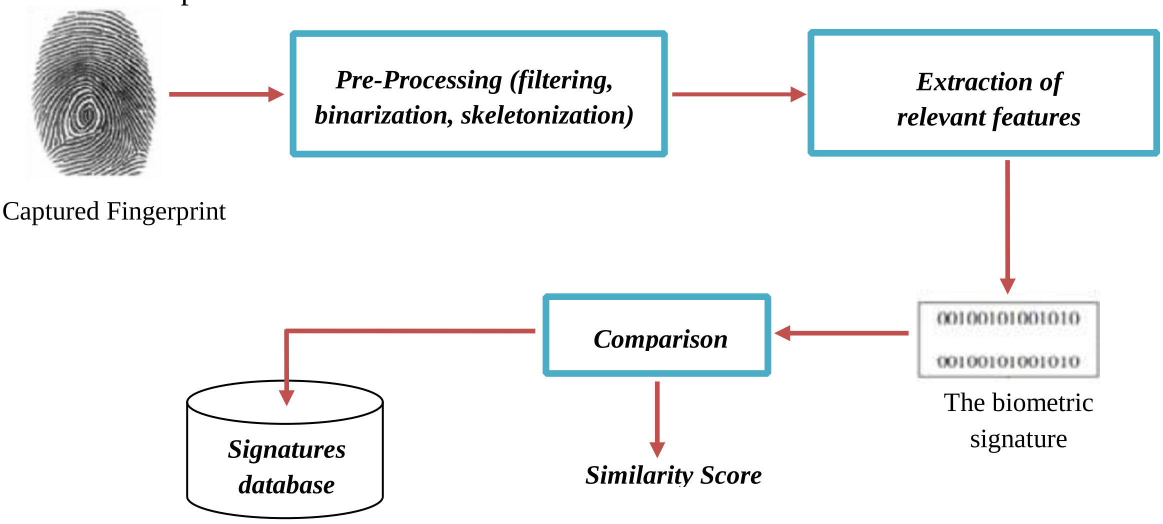

Figure 1: Design of a biometric system based on fingerprints

B. Finger Knuckle Print

The finger knuckle print (FKP) is a new type of biometric modality, which can be used successfully to recognize people based on lines and textures in the outer surface of the finger as shown in Figure 2. These linear structures and textures are highly effective at discriminating different individuals because they are relatively stable and remain unchanged during a person's life [53-56].

The FKP modality can be used by biometric systems because of certain advantages. First, the acquisition of data is relatively easy and economical via low resolution commercial cameras. Secondly, FKP based access systems are very suitable for indoor and outdoor use, and can work well in extreme weather conditions and poor lighting conditions. Third, FKP characteristics in adults are more stable over time and are not subject to major changes. Finally, biometric information based on FKP is very reliable and can be used successfully to recognize multiple individuals [10].

Figure 2: Some images of the finger joints fingerprints [11]

The aim of this paper is the development of a multimodal biometric identification system based on two biometrics; and finger knuckle. Section two presents the proposed methodology and section three represents the simulation results trailed by the conclusive remarks in the section four.

II. PROPOSED METHODOLOGY

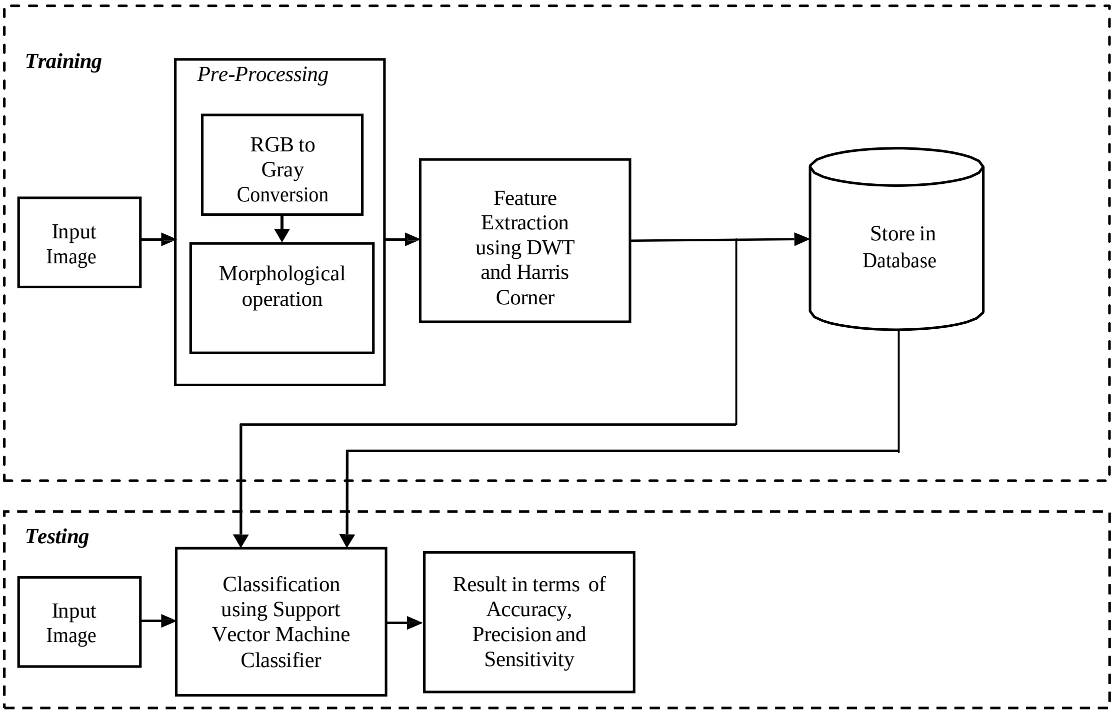

Figure 3: Proposed block diagram

A. System Model

There are two input patterns for proposed multimodal biometric identification i.e. fingerprint and finger knuckle images. Figure 3 shows the proposed system modal containing training and testing modules.

B. Pre-Processing

After resizing, the RGB image is transformed to a gray scale image using rgb2gray function.

C. Morphological Operations

Mathematical morphology is a branch of mathematics based on the study of sets for analyzing geometric structures. This method was born in between 1964 and 1968, under the leadership of G. Matheron and J. Serra [12], has since given rise to many developments [13].

The development of mathematical morphology was inspired by image processing problems, which is its main field of application. In particular, it provides tools for filtering, segmentation, quantification and image modeling.

In what follows, we present the basic elements of mathematical morphology.

We will study the mathematical morphology applied to binary images (two levels of gray) because this corresponds to our use of this method. However, the approach can also be applied to images in several gray levels.

1. Tools of Mathematical Morphology

The mathematical morphology is known by its set elements; where X is the set to be analyzed and S a structuring element that one chooses according to the needs of the analysis.

These relationships are indeed based on basic morphological operators that are erosion and dilation.

On a binary image, X can be the set of white pixels or any subset of the latter, and S any subset of all the sites [14].

$X_t = \{x_t, x \in X\}$, translated from X

$\check{S} = \{-s, s \in S\}$, the symmetric of S with respect to the origin.

Subtraction of Minkowski

The Minkowski subtraction of the set X by the set Y is defined by [14]:

$$X \ominus Y \cap X_y \qquad (1)$$

Addition of Minkowski

The addition of Minkowski of the set X by the set Y is defined by [14]:

$$X \oplus Y = \{x + y, x \in X, y \in Y\} \qquad (2)$$

Erosion

The mathematical erosion by a structuring element is a subtraction of Minkowski in such a way that: An erosion operation on a binary image containing labels 0 and 1 (1 and 0 respectively represent white and black), by a structuring element, consists of a convolution of S with I, centered i. If this convolution is less than a predetermined value (usually the area of, the number of pixels that are 1 in the structuring element itself), the value of the pixel is changed from 1 to 0.

The structuring element (erosion kernel) determines how erosion tinges borders in an image [14].

The MATLAB command is given by:

$$g = im(f, se)\,; \qquad (3)$$

Dilation

The mathematical dilation by a structuring element is an addition of Minkowski by $\check{S}$ such that:

$$X \oplus \check{S} = \{x, S_x \cap X \neq \emptyset\} \quad (4)$$

As for erosion, an expansion on an image containing the labels 0 and 1, by a structuring element changes the value of the pixel in from 1 to 0, if the result of the convolution of with, centered at, is greater than a predetermined value. This value is usually zero. The structuring element (kernel expansion) determines how expansion expands the boundaries in an image [14].

The MATLAB command is given by:

$$g = imdilate\ (f, se); \quad (5)$$

D. Feature Extraction

Harris corner and discrete wavelet transform are used for feature extraction of pre-processed images.

1. *Harris Corner Method*

Harris corner detection is a post-processing technique used for smile recognition by the lip corner data, eye detection and many more [15]. Harris corner detector has to detect the corners in the input image I_I. Going stepwise, firstly I_I is used to create gradient image through filtering it with Gaussian Mask and then the Harris corner method is imposed [16].

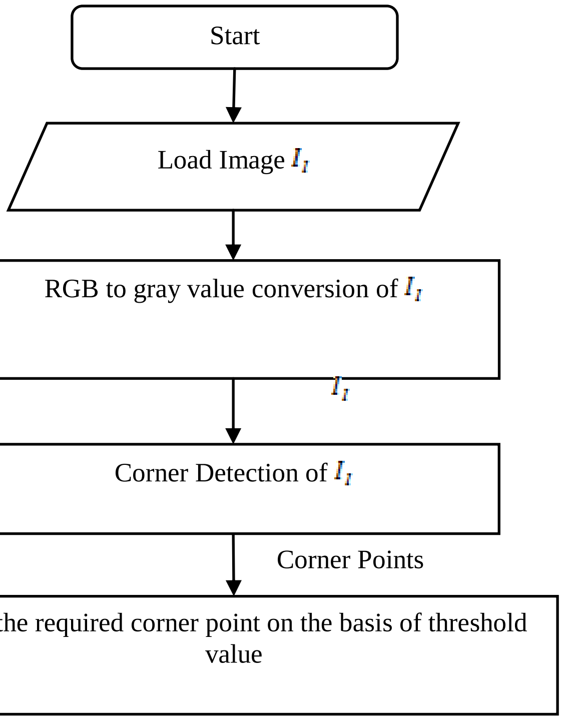

Figure 4: Flow diagram of Harris Corner detection

2. *Discrete Wavelet Transform*

The wavelet analysis was introduced by Morlet to improve the windowing solution that Gabor had proposed to overcome the limitations of Fourier transformation.

In fact, the Fourier transformation has some disadvantages that can be summarized in three points:

- It does not allow precise characterization of a signal simultaneously in the frequency domain and the spatial domain [17];
- The result obtained by transformation eliminates all information concerning the spatial domain: the beginning or the end of a component of the signal are no longer localizable in the parametric model;
- The spatial frequency of a signal being inversely proportional to its period, if we want to obtain information on a low frequency signal, the observation interval must be large (and vice versa).

The advantage of using wavelets is their greater similarity with real signals, which are generally used, which vary in a wave form and which concentrate a large part of their information load in certain places and not in uniform way; In this sense, they become much more efficient at the moment of wanting to extract certain characteristics of an image thanks to their translational and dilatational capacity that allows them to be similarly shaped to the forms that we want to determine, discriminated against the others. If we wanted to locate a certain figure it would be enough to choose a mother wavelet that resembles it as much as possible, and apply with this wavelet the two-dimensional transform to the image [18].

$$\psi_{\tau,s}(t) = \frac{1}{\sqrt{|s|}}\psi\left(\frac{t-\tau}{s}\right) \tag{6}$$

Where s is the scale and τ is translation.

E. Classification using SVM

Consider the training set $\{x_1, y_1\}, \ldots, \{x_\ell, y_\ell\}$, where $x \in X$ and $y \in \{-1, 1\}$, where ℓ is the number of observations and X is a distribution in space $\Re^n$. In the classification problem, the goal is to find an efficient method to construct the optimal separator hyperplane, i.e., with the greatest margin. To do this, one must find the vector w and the constant b, which minimize the norm $|w|^2 = w^T w$ (since it is inversely proportional to the margin), under the constraints [19]:

$$w^T x_i + b \geq 1, \quad if\ y_i = 1 \tag{7}$$

$$w^T x_i + b \leq -1, \quad if\ y_i = -1 \tag{8}$$

Because one can accept some errors, one relaxes the constraints (8) & (9) and introduces an additional cost related to this relaxation, so that one arrives at the quadratic problem, QP, following:

Minimize $\quad \frac{1}{2}(w^T w) + C\left[\sum_{i=1}^{\ell} \xi_i\right]$

w

Under the constraints $\quad y_i(w_i^T x + b) \geq 1 - \xi_i,$

$$\xi_i \geq 0 \qquad i = 1, \ldots, \ell \tag{9}$$

The problem (9) can be solved in the primal space (the space of parameters w and b). In fact, one solves the QP in the dual space, equation (10), (the Lagrange multiplier space) for two main reasons: 1) The constraints (8) and (9) are replaced by the associated Lagrange multipliers, and 2) We obtain a formulation of the problem where the training data appear as an internal product between vectors, which can then be replaced by kernel functions, then construct the hyperplane in the feature space and obtain functions Non-linear in the input space [20].

Maximize $\quad L_D(\alpha) = \sum_{i=1}^{\ell} \alpha_i - \frac{1}{2}\sum_{i,j=1}^{\ell} \alpha_i \alpha_j y_i y_j (x_i^T x_j)$

α

Under the constraints $\quad \sum_{i=1}^{\ell} y_i \alpha_i = 0,$

$$0 \leq \alpha_i \leq C \qquad i = 1, \ldots, \ell \tag{10}$$

Where, α_i is the Lagrange multiplier, associated with constraints. Parameter C controls the level of error in the classification.

The SVM evaluation function is defined as [19]:

$$f(x) = \sum_{i=1}^{\ell} \alpha_i y_i k(x_i, x) + b \tag{11}$$

The examples x_i associated with the Lagrange multipliers α_i larger than zero correspond to the support vectors, and have a significant contribution to equation (11). Geometrically, these vectors reside in the margin defined by the separating hyperplane. The constant b represents the threshold of the hyperplane learned in the characteristic space. It can be calculated by the mean of the function (11), evaluated using the support vectors.

III. SIMULATION RESULTS

The confusion matrix represent the results obtained:

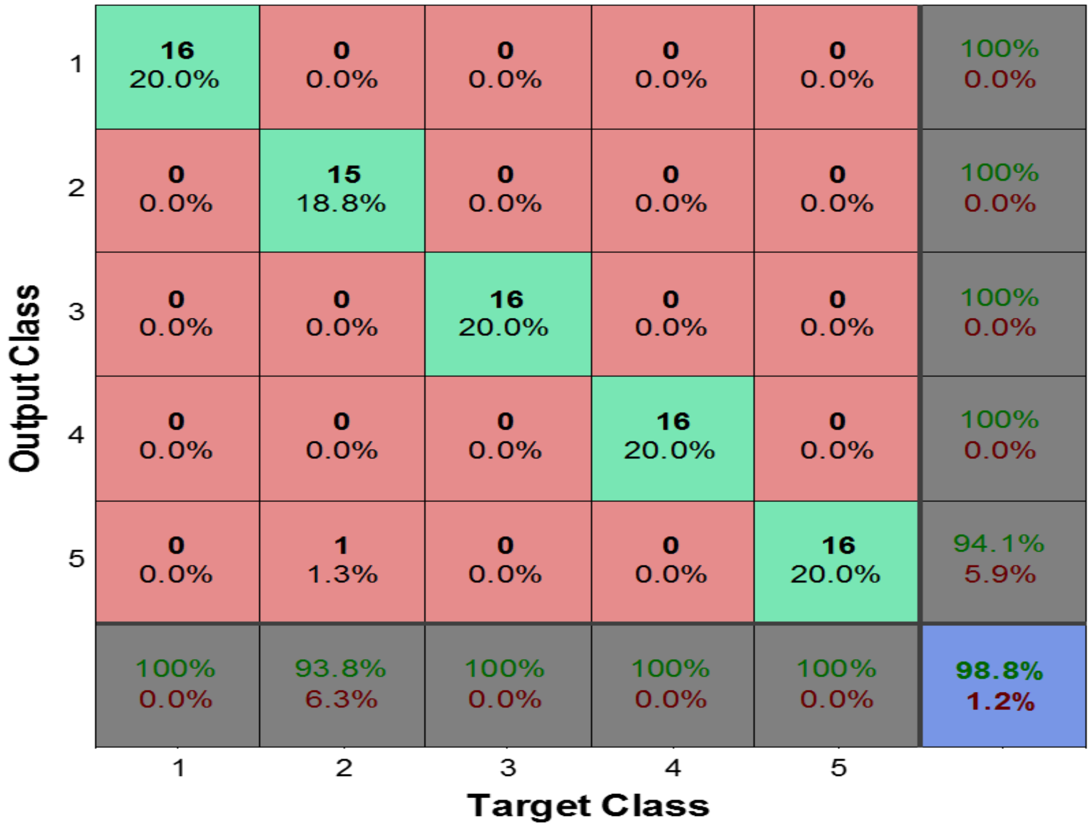

Figure 5: Confusion matrix plot for proposed hybrid approach

Figure 6: Accuracy graph for proposed hybrid approach

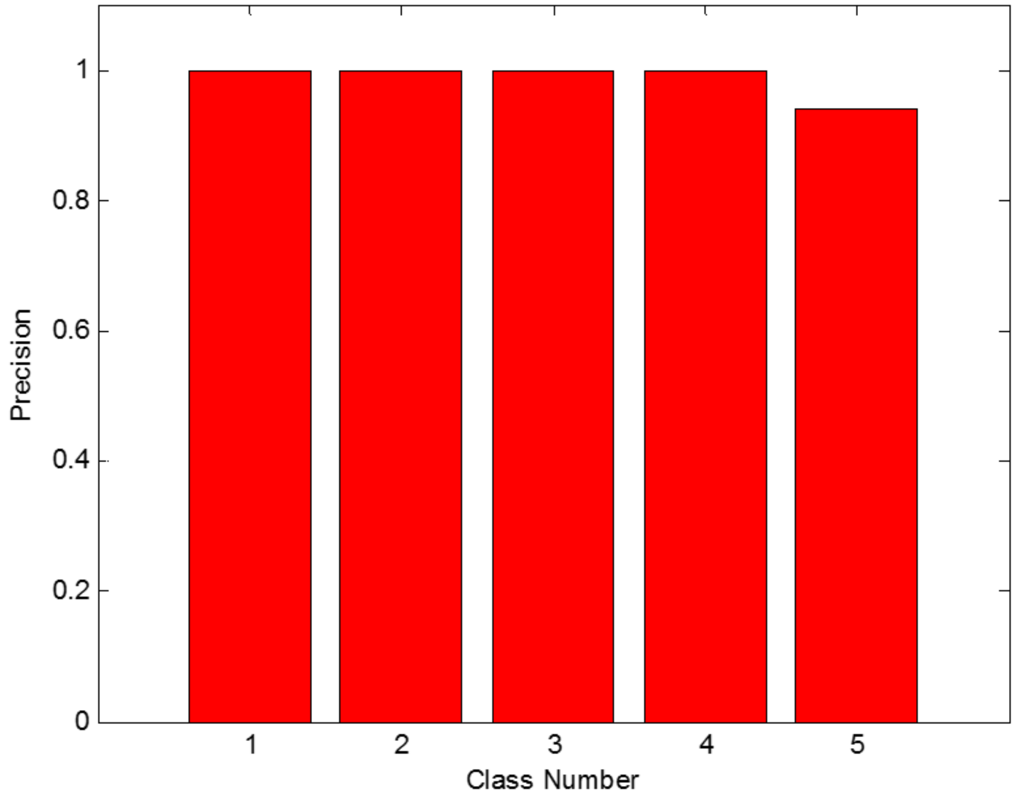

Figure 7: Precision graph for proposed hybrid approach

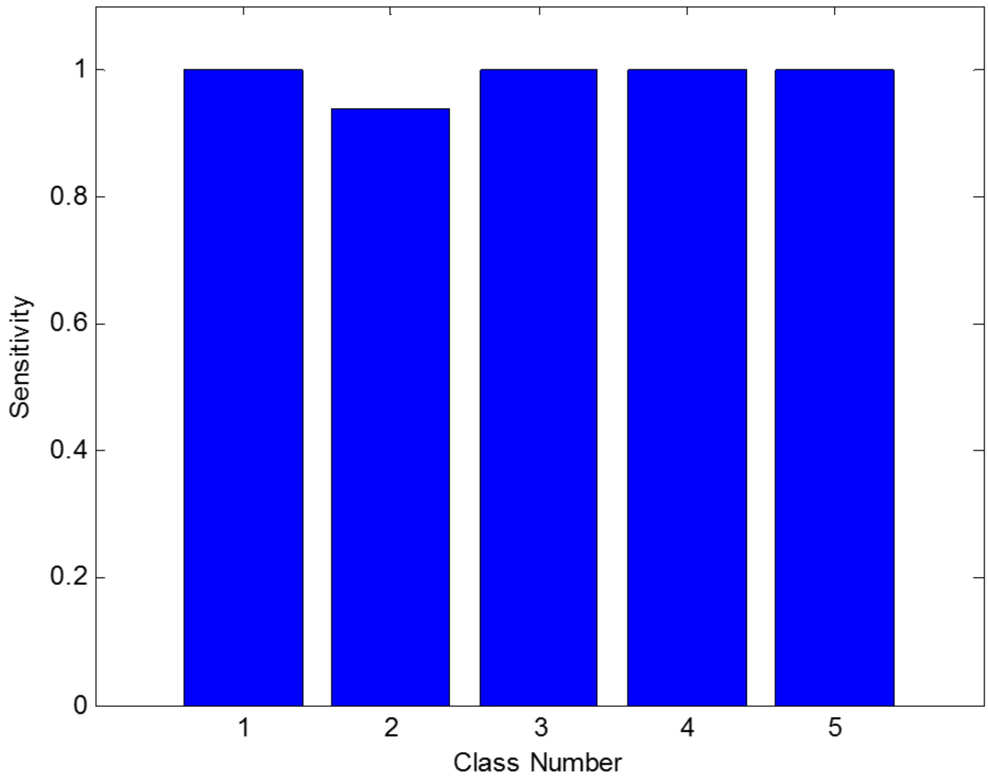

Figure 8: Sensitivity graph for proposed hybrid approach

IV. CONCLUSION

Biometrics is an expanding field with a growing body of research that aims to achieve an effective, reliable and timely way of identifying people. The two proposed biometric modalities are the iris and the fingerprint. This paper presented the process of identifying individuals by multimodal biometrics.

The main goal is to implement a multimodal biometric system for the identification of individuals where information from two biometric scores (fingerprint and finger knuckle) are combined. The quality of a unimodal identification system depends on several parameters (the capture environment, the variability of behaviour depending on the individual, etc.) which hampers the proper functioning of the identification. However, we can make the performance of the biometric system reliable by simultaneously using several different modalities.

The multimodal recognition process improves the performance of single-mode systems. Indeed, the tests that we carried out showed the interest of the fusion at the level of the scores.

The performance of the score fusion system can be degraded by the weakness of one of the unimodal systems. In general, to increase the performance of the system it is necessary to fuse modalities with similar performances. The integration of the data at the level of the correspondence scores by the weighted sum method gives the best result and makes it possible to significantly improve the performance of the multimodal system. This paper shows a maximum accuracy of 98.8%. The proposed multimodal biometric identification approach may utilize other biometric methods such as palm-print/iris to achieve better time complexity.

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