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# Multi Model Biometric Identification System: Finger Vein and Iris

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***Abstract- Personal identification process is a very important process that resides a large portion of daily usages. Identification process is applicable in work place, private zones, banks …etc. Human is a rich subject having many features that can be used for identification purpose such as finger vein, iris, face …etc. In this paper, a personal identification system with multi model architecture have been proposed. The proposed system fuse personal finger vein and iris which utilizes a vein feature matcher for finger vein and Hamming Distance Matcher for iris with matching score level to provide higher accuracy of 92.4%, with FAR and FRR of 0% and 7.5%, respectively. It has been more secure than a framework used a single identification of personal feature.***

***General Terms- Multi-model System, Biometric, finger vein, Iris, Identification, Recognition.***

***Keywords- Biometric Computing, finger vein Recognition, IRIS Recognition, Minutiae Extraction, FAR, and FRR.***

## I. INTRODUCTION

Riometric identifiers are classified as physiological and behavioral characteristics. Biometrics is defined as the identification of individuals by their characteristics or traits. Biometric identifiers are the unique, measurable characteristics used to describe individuals. Physiological characteristics are related to the shape of the body. Examples finger vein, face recognition, DNA, Palm print, hand geometry, recognition and retina . Behavioral characteristics are related to the behavior of a person like typing rhythm, gait, and voice. Many different aspects of human physiology, chemistry or behavior can be used for biometric authentication. The selection of a particular biometric for use in a specific application involves a weighting of several factors such as universality; means that every person using a system should possess the trait, uniqueness means the trait should be sufficiently different for individuals such that they can be distinguished from one another, permanence; relates to the manner in which a trait varies over time. A trait with 'good' permanence will be reasonably invariant over time, measurability; relates to the ease of acquisition or measurement of the trait. And, acquired data should be in a form that permits subsequent processing and extraction of the relevant feature sets, performance; relates to the accuracy, speed, and robustness of technology used, acceptability, relates to how well individuals in the relevant population accept the technology such that they are willing to have their biometric trait captured and assessed, circumvention; relates to the ease with which a trait might be imitated using an artifact or substitute. Biometrics systems were mostly used in forensic sciences, but nowadays it is mainly due to civilian applications such as controlling physical access to facilities, controlling logical access to software, and controlling voters during elections. A key component in fingerprint recognition systems is the fingerprint matching algorithm [1]. No single biometric will meet all the requirements of every possible application. But, the most new pattern used in the identification method is finger vein [2]. Finger vein recognition had been researched [6]. In [7], they proved that each finger has unique vein patterns so that it can be used in personal verification. Finger vein based biometric system has several benefits when compared with other hands based biometric methods. First, the finger vein pattern is hard to replicate since it is an internal feature. In addition, the quality of the captured vein pattern is not easily influenced by skin conditions. Moreover, as compared with palm vein based verification system [8], the size of the device can be made much smaller. Lastly, finger vein recognition does not require contact between the finger and sensor, which is desirable for a hygienic viewpoint. The iris is unique pattern which remains stable throughout adult life which makes it very as a biometric for identifying individuals. The unique iris pattern can be extracted from a template image of the eye. This biometric template contains a representation of the unique information stored in the iris which could be compared with other templates [4]. Image processing techniques used to convert iris pattern to unique code which can be stored in a database and allows comparisons between templates.

The overall process for acquiring and storing iris features with iris images can be listed as follow [5]:

1. Image acquisition: take photo of iris with good resolution and quality.
2. Segmentation: process the acquiring image for separation of iris from eye image.
3. Normalization.
4. Feature extraction and feature encoding,
5. Storing extracted codes in database and comparing acquiring iris images with codes in database.

Multiple sensors could be used as a Multimodal biometric system to overcome the limitations of uni-model biometric systems. Because of uni-model system limited to one identifier which may have some limitations as if iris recognition systems are used, the features can be changed by aging iris and vein scanning systems by worn-out, wet or cut finger vein. Multimodal system can get more information rather than a single biometric or information from different biometrics. Organization: This paper is organized into the following sections. Section 2 is an overview of the related work, in section 3

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the atomic concepts and tools that have been used. Section 4 describes the proposed model. In section 5 performance analysis and results are discussed and finally in section 6 give the conclusions.

## II. RELATED WORKS

Due to gently importance and impact of biometrics techniques in security field, there is many, today, researchers attempt to build robust and stable technique that are compatible and applicable in recognition restricted environment. In 2010, K. R. Park et. al. have proposed a new algorithms for finger vein recognition that have three advantages and contributions compared to previous works. First, we extracted local information of the finger veins based on Local Binary Pattern (LBP) without segmenting accurate finger vein regions. Second, the global information of the finger veins based on Wavelet transform was extracted. Third, two score values by the LBP and Wavelet transform were combined by the Support Vector Machine (SVM) [June 2010]. N. Miura et. al. have achieved robust pattern extraction for finger vein. They have proposed a method of personal identification based on finger-vein patterns. In which finger vein image is captured under infrared light contains not only the vein pattern but also irregular shading produced by the various thicknesses of the finger bones and muscles. The proposed method extracts the finger-vein pattern from the unclear image by using line tracking that starts from various positions [12]. Ghazvini, Met. Al. proposed a fingerprint matching method based on genetic algorithm. Then use the local properties of minutiae. Also there is a new kind of triangle descriptors are proposed, which uses these descriptors properties, the approximated value of transfer parameters for alignment and similarity between two fingerprints can be attained [7]. Prabhakar, S et. al. discussed the signal acquisition aspects of fingerprint and iris biometrics-two of the most widely used biometric traits. Personal recognition of people is necessary to conduct many social and economic activities. Besides visual recognition of acquaintances, checking a person's government issued photo ID is the most common procedure [9]. Hoyle et. al. proposed methodologies use minutiae triplet-based features in a hierarchical fashion, where not only minutia points are used, but ridge information is used to help establish relations between minutiae[8]. Miguel Angel Medina-P´erezet. al. proposed Improving Fingerprint Verification Using Minutiae Triplets This algorithm contains three components: a new feature representation containing clockwise-arranged minutiae without a central minutia, a new similarity measure that shifts the triplets to find the best minutiae correspondence, and a global matching procedure that selects the alignment by maximizing the amount of global matching minutiae[6]. Anil K. Jain et. Al. proposed a system for matching latent images with full fingerprints that uses minutiae as well as ridge information as the discriminative features. Also, developed a minutiae-based fingerprint matcher is considered besides the specific characteristics of the latent matching problem [10]. HimanshiBudhirajaetet.al. proposes a biometric personal authentication system using a novel combination of iris and fingerprint. For system deployment the combination is found to be useful as one needs a close up system and other needs contact. One modality is used to overcome the limitations posed by the other [11].

## III. UNI-MODAL STRUCTURE

### 1.1 Finger Vein Recognition

In finger vein recognition, the finger vein image is captured and localized the finger region in the captured image. The shape of each finger was found to be different so normalizations is performed to the localized finger region which was defined and stretched towards the X and Y axes, respectively. Then, the localized image was sub-sampled. After that, the finger vein feature are extracted and enrolled in the back store so that it can be matched in a later during matching process [2011]. For robust extraction of the finger-vein patterns from the non-uniform images, the used method includes the repeated tracking of dark lines in the images. Extraction process of the patterns depends on the number of times the tracking lines pass through the points.

#### 1.1.1 Feature Extraction

The used method is based on the use of line-tracking operation which starts at any pixel in the captured image. "Current tracking point" is the title of the current pixel position, and it is moved pixel by pixel along the dark line. The depth of the cross-sectional profile is checked around the current tracking point. Pixel *p* is a neighbor of the current tracking point in the upper-right direction. Cross-sectional profile *s*-*p*-*t* looks like a valley. Therefore, the current tracking point is on a dark line. The direction of this dark line can be detected by checking the depth of the valley with varying $\theta i$. After that, the current tracking point moves to the pixel closest to this direction, pixel *p*. If the valley is not detectable in any direction $\theta i$, the current tracking point is not on a dark line and a fresh tracking operation starts at another position. The current tracking point may track a region of noise by chance. Statistically, however, the dark lines are increasingly tracked more often with repeated operations. This makes for the robust extraction of patterns of finger veins. "Locus space" is a matrix used to hold the number of times that each pixel has become the current tracking point. The size of the locus space is the same as the number of pixels in the captured images. The total number of trials on which each pixel has become the current tracking point is recorded in the corresponding matrix element. Therefore, an element of the locus space that is more frequently tracked has a higher value [12]. For smooth line tracking, an attribute, "the moving-direction attribute", which restricts increases in the global curvature of the locus is added to the tracking point. In concrete terms, this restricts selection from among the eight neighboring pixels of the next tracking-point position. If only a single line-tracking operation is conducted, only a part of veins within the image will be tracked. To solve this problem, vein-tracking sequences are started at various positions that are determined so that the line-tracking trials are conducted evenly across the image [12]. Because of positions in the locus space with high values are stored which are tracked frequently in the line-tracking procedure also, they have high probabilities of being the positions of veins. So, the paths of finger veins are obtained as chains of high-value positions in the locus



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space. In order to eliminate unnecessary tracking operations of repeated line tracking, when tracking begins from tracking points near each other, tracking follows similar paths. Therefore, line tracking from all pixels in the finger region is not required. Eliminating some start points for line tracking reduces the computational costs while retaining accuracy in extraction. Whereas for reducing the size of the pattern, a smaller template, is used to faster the computation keeping all information required for personal identification. Next figure summarize a context pseudo code of finger vein extraction algorithm.

### 1.1.2 Matching

Because of the pattern is converted into matching data, which can be compared with recorded data. There are two common methods that are used for matching line shaped patterns:

1. Structural matching, that require extra information to be extracted such as line endings and bifurcations. [19].
2. Template matching [14, 17], the conventional template-matching technique is not robust against pattern distortion. Robust template-matching is can be achieved by some modifications and work around including identification of the “ambiguous regions” and the slight misalignments between vein patterns in these regions are ignored.

Because of the finger-vein pattern has few of the extra information required by the structured method, template matching is considered the suitable for comparison of pixel values in more appropriate for finger-vein pattern matching.

The used method has proposed a matching process that can be concluded in short steps as follows [12]:

1. Labeling of the locus space

In which, Pixels in the locus table with values smaller than a predefined threshold are labeled as parts of the background, and those with values greater than or equal to that threshold are labeled as parts of the vein region. In turn the image is binarized using a threshold.

2. Spatial reduction and relabeling of the locus space

In order to retain veins as small as about 3 pixels in the image, the locus space is reduced to one third of its original size in both dimensions. This reduction is performed based on taking averages of all no overlapping 3 × 3 pixels. The binarized (0 or 255) image of the locus space is turned into a smaller grayscale image. At that moment, new locus space is rebinarized by simply setting the threshold to 128, aliasing appears around the borders between the background and the veins. Therefore, the thin lines that have the same shape tend to be misaligned with each other which have intermediate range value and considered as ambiguous regions that are not necessarily part.

3. Matching of data

In this step, a mismatch ratio *Rm* is calculated to examine whether or not two sets of data have a correlation with each other. The ratio *Rm* is defined as the difference between two sets of data to be matched. *R*(*x, y*) and *I*(*x, y*) are the values at position (*x, y*) of the registered and input matching data, *w* and *h* are the width and height of both sets of data, *cw* and *ch* are the distances in which motion in the vertical and horizontal directions, respectively, is required to adjust the displacement between the two sets of data, and the template data are defined as the rectangular region within *R*(*x, y*) whose upper-left position is *R*(*cw, ch*) and lower-right position is *R*(*w* − *cw, h* − *ch*).

Step 1:
Determination of the start point for line tracking and the moving-direction attribute

Step 2:
Detection of the direction of the dark line and movement of the tracking point

1. Initialization of the locus-position table *Tc*
2. Determination of the set of pixels Nc to which the current tracking point can move
3. Detection of the dark-line direction near the current tracking point
4. Registration of the locus in the locus-position table Tc and moving of the tracking point
5. Repeated execution of steps 2 to 4

Step 3:
Updating the number of times points in the locus space have been tracked where Values of elements in the locus space *Tr*(*x, y*) are incremented ∀(*x, y*) ∈ *Tc*.

Step 4:
Repeated execution of step 1 to step 3 (*N* times) in which care about repetition that if the number of repetitions *N* is too small, insufficient feature extraction is performed. If, on the other hand, *N* is too big, computational costs are needlessly increased.

Step 5:
Acquisition of the finger-vein pattern from the locus space. Because the total number of times the pixel (*x, y*) has been the current tracking point in the repetitive line tracking operation is stored in the locus space, *Tr*(*x, y*). Therefore, the finger vein pattern is obtained as chains of high values of *Tr*(*x, y*).

**Fig 1 Finger Vein Extraction Pesudo Code [12]**

The value of mismatch *Nm*(*s, t*), which is the difference between the registered and input data at the positions where *R*(*cw, ch*) overlaps with *I*(*s, t*), is defined as follows:

$$N_m(s,t) = \sum_{y=0}^{h-2ch} \sum_{x=0}^{w-2cw-1} \{\emptyset(I(s+x,t+y)), R(cw + X, ch+y)\}, Equation\ (1).$$

where *w* = 66 and *h* = 44 in consideration of the finger size in the captured image, *cw* and *ch* are set at *cw* = 8and *ch* = 7 in order to adjust the finger position in the captured image by up to about 1 cm, and *φ* in Eq. 1 is a parameter that indicates whether a pixel labeled as part of the background region and a pixel labeled as part of a vein region overlapped with each other.

### 1.2 IRIS Recognition

The iris formation happens in the third month of early life and unique patterns are formed during the first year of life. These patterns are random and don't depend on genetic factor and the only characteristic that is dependent on genetics is the pigmentation. Iris recognition systems focus on analysis many irises features; e.g. rings, furrows, and freckles. Such features are being existed in the colored tissue surrounding the pupil. One of the most common and powerful tool used for such analysis is image processing techniques. Image processing can be used for formulation an iris pattern to unique code which can be stored in a database and used in later for comparisons purposes between templates and queries. In turn, the iris systems have a very low False Accept Rate (FAR) compared to other biometric traits that can be rather high [16].

#### 1.2.1 Iris Localization

Circle detection algorithm is used to increase the overall speed of the system. Circle detection is used because of many benefits. Circle detection algorithm has enough recognition performance and speed level. Also, it has great ability for accurately detection with high precision although partially occluded circles. Circle detection is simpler, efficient, optimum memory consumer and low burden processing method than others [18].

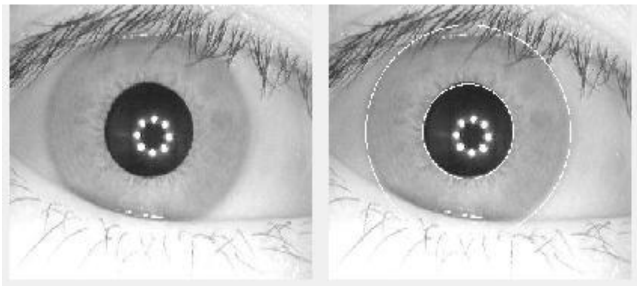

**Fig. 2 Iris Localization**

#### 1.2.2 Iris Segmentation

Generate, first, edge map by employing a powerful edge detection operator; e.g. Canny Edge Detection. Process the image for separation of iris from eye image.

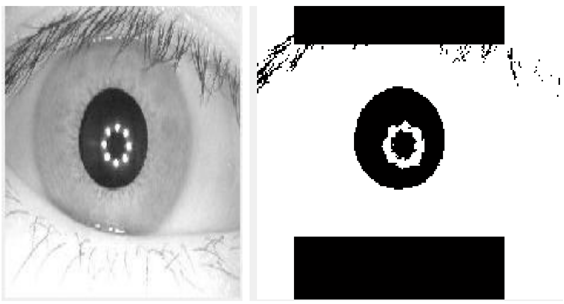

**Fig. 3 Iris Segmentation**

#### 1.2.3 Iris Normalization

Normalization process is responsible for producing irises with same fixed dimensions, in turn, for a given two photographs of the same iris under different lighting conditions will have the same characteristic features. In turn, after eye region segmentation, segmentation for iris extraction is required to allow comparisons between different irises. Each iris that is extracted is transformed so that it has a fixed dimension, and hence removing the dimensional inconsistencies between eye images due to the stretching of the iris caused by the pupil dilation from varying levels of illumination [18].

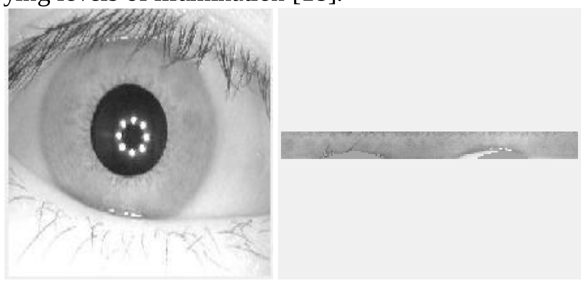

**Fig. 4 Iris Normalization**

#### 1.2.4 Iris Feature Extraction and matching:

For every biometric system, feature extraction phase holds the highest weight for accuracy and system performance. Iris feature extraction is the most principle component of any iris recognition system. Iris recognition system is stable and trusted when it extract the feature vector from query image and compare it carefully with stored template feature patterns [18]. Features are the attributes or values extracted to get the unique characteristics from the image. Features from the iris image are extracted using hamming distance algorithm.

## IV. THE PROPOSED MULTI-MODEL STRATEGY

The purpose of the proposed model is to achieve higher performance that may not be possible using a single biometric indicator alone. The proposed model is a fusion of iris and finger vein biometrics as shown in Fig 5. Feature vectors are created independently for each sensor and are then compared to the enrollment templates which are stored separately for each biometric trait. Based on the proximity of feature vector and template each subsystem computes its own matching score. These individual scores are finally combined into a total score which is passed to the decision module. The proposed integrated system also provide anti spoofing measures by making it difficult for an intruder to spoof multiple biometric traits simultaneously. Scores generated from individual traits are combined at matching score level using weighted sum of score technique.

## V. EXPERIMENTAL DISCUSSION

Experiments are done out on windows 7, processor core i7 and RAM 8 GB to obtain high accuracy and performance. The experiments reported in this paper has been conducted on the finger vein images , containing finger vein images of size (320 *240) pixels and the iris database images is CASIA iris image database version 1.0[14] [20].The results are tested on iris and fingerprint images given to us by our guide. The database consists of seven iris images (50×7) and six finger vein images (50×7) per person with total of 20 persons. For the purpose allowing comparisons two levels of experiments are performed. At first level iris and finger vein algorithms are tested individually. At this level the individual results are computed. The performance indicators computed in this experiment are FMR and FMR. These measures are useful to characterize the accuracy of finger vein based systems, which are often operated far from the EER point using thresholds which reduce FMR at the cost of higher FNMR.



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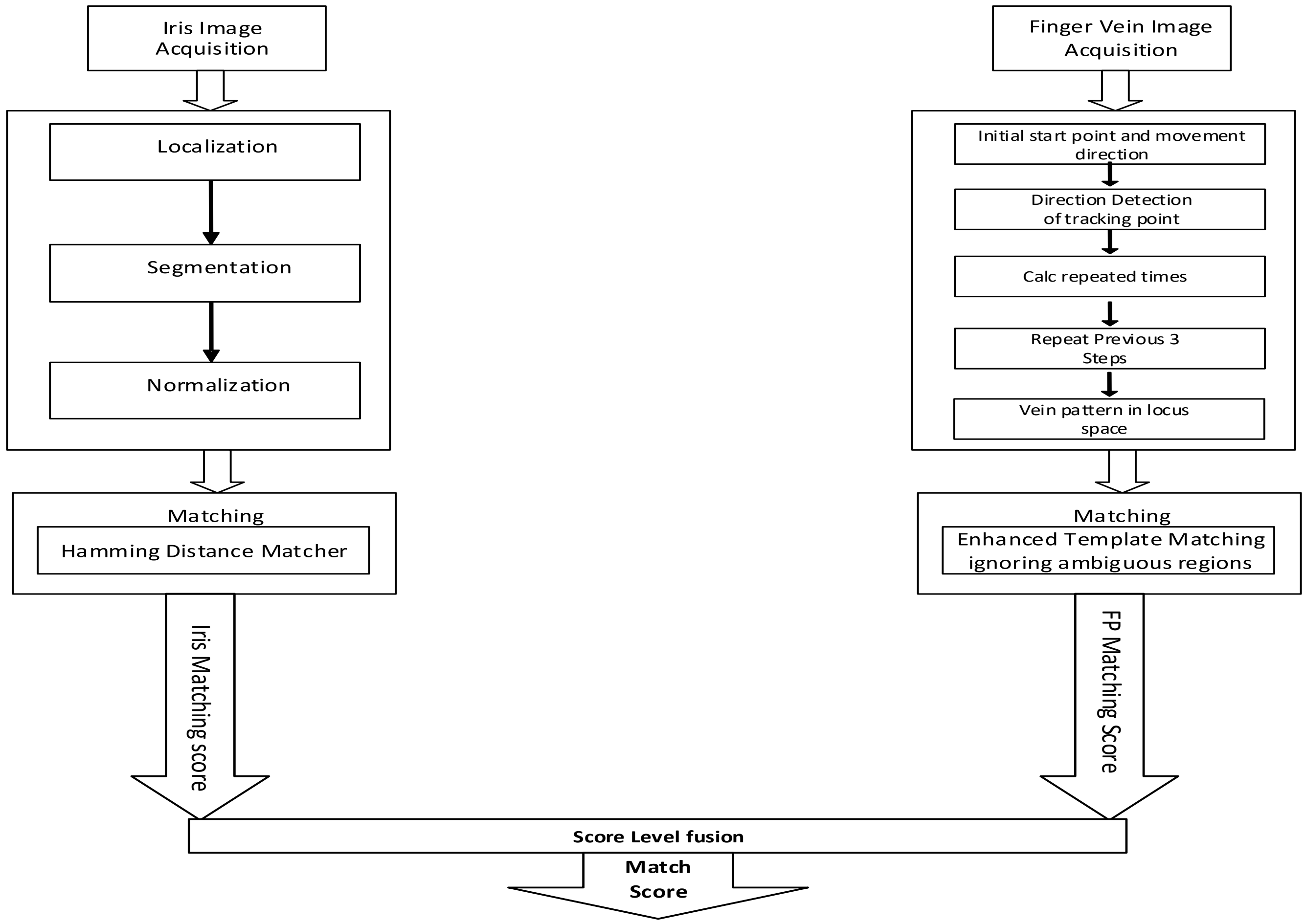


**Fig. 5 The Proposed Fusion Multimodal Personal Identification System**

False match rate (FMR): The probability of invalid inputs which are incorrectly accepted.

$$\text{FAR (or FMR)} = \frac{\text{Number of Falsely accepted images}}{\text{Total number of persons out the database}}$$

False non-match rate (FNMR): the probability of valid inputs which are incorrectly rejected.

$$\text{FRR (or FNMR)} = \frac{\text{Number of Falsely rejected images}}{\text{Total number of persons in the database}}$$

After a set of experiments have been conducted, the results is are listed a table which are derived and listed; see table 1.

**Table 1 Experimental Results**

| System Type | FAR | FRR | Threshold | Accuracy |
|---|---|---|---|---|
| Finger Vein | 0.122 | 0.008 | 0.85 | 86.6 |
| Iris | 0.24 | 0.002 | 0.95 | 75.1 |
| Fused System | 0 | 0.075 | 0.95 | 92.4 |

The accuracy of the finger vein module individually is 86.6% with FAR of 12.2% and FRR of 0.08%. Whereas iris accuracy individually is 75.1% with FAR of 24% and FRR of 0.2%. The accuracy of the proposed model is 92.4 % which proved that the multimodal system has higher performance and accuracy that may not be possible using a single module alone. The accuracy of the proposed model is inversely proportional to the threshold as when the threshold increases the accuracy decreases and vice versa. And at the middle of the range reach has highest values with maximum of 92.4 at threshold of 0.6.

## VI. CONCLUSIONS AND FUTURE WORKS

Biometrics is a very promising technology, challenges are slowing its development and deployment. Finger vein images and Iris images are chosen due to their unique physiological traits. The proposed multimodal biometric identification and authentication system is considered a robust combination of finger vein and iris that have matching score level with accuracy of 92.4% with FAR and FRR of 0% and 7.5% by threshold (0.6). The proposed system is a gentle secure and robust stable identification and recognition system. The proposed system is a new combination to the biometric research that can be extend and enhanced during times.

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