Optimization of Human Finger Knuckle Print as a Neoteric Biometric Identifier

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Abstract – *Among the several biometric measures developed, the figure knuckle surface is becoming a eminent choice of researchers due to its natural ease of reproducibility and verification. For any purpose of personal identification or crime analysis, figure knuckles surface do not need to be a voluntarily presented, they get exposed naturally. Specific lines, creases, folds and texture pattern on the figure knuckle surfaces can be used as effective biometric measure on their own or in combination with other biometrics. This paper proposes the development of a figure knuckle based biometric identification system. The system incorporates principal component analysis (PCA) for feature extraction after pre-processing and enhancing input image extracted from knuckle surface from video input capture. Secondly the system employs k-nn classifier as a matching classifier for personal identification algorithm. Not only the principal component but Local Binary Pattern is also tested, also various parameters are extracted from the training and testing data. The system implementation is tested, verified and validated with real time data sample test experiments.*

Key Words: finger knuckle print, pca, K-NN classifier, biometric identifier ,feature extraction, classification, feature matching

1. INTRODUCTION

In the developing in digital world, concept of biometric plays an imperative role in security systems, surveillance systems, national ID systems, ecommerce, forensics, information technology and also banking where authentication is vital. Such systems require authentic identification for their system to work flawless. With growth in the population of world, it is presently exceptionally hard to maintain records using traditional ways such as signature, photo identity card. Thus, maintaining digital data records of the individual and using them for identification procedure is very important. Many countries including India (aadhar card i.e. Unique Identity Card) are opting biometric parameters for providing more security and unique identity for the citizens.

Identification of humans utilizing their different anatomical and physiological characteristics has been increasingly researched for their variety of applications. There are number of organizations which require precise, on the web and high scale automated personal identification. This has introduced new difficulties for the biometrics technologies. So there is a necessity of introducing and researching on very much simple and robust identification methods. For this, biometrics, described as the unique physiological and in addition behavioral qualities of human beings, will be utilized for differentiating between individuals. In the previous couple of decades, analysts have precisely examined the utilization of different biometric characteristics.

Biometrics refers to metrics associated with human characteristics. Biometrics validation is utilized in computer science as a kind of kind of identification and access control. It also can be additionally utilized to find person in gatherings that are under surveillance.
Biometric identifiers are the unmistakable, quantifiable characteristics utilized for labeling and depict people. Biometric identifiers are regularly classified as physiological against behavioral attributes. Physiological features are identified with the buildup of the body. Cases fuse, however are not confined to fingerprint, palm veins, face recognition, DNA, palm print, hand geometry, iris recognition, retina and odor/scent. Behavioral characteristics are identified with the example of conduct of a person, having be that as it may, not constrained be that as it may, not confined to typing rhythm, gait, and voice. Some specialists have begun the term behavior measurements to depict the last class of biometrics.
More customary method in the vein of verification are token-based identification frameworks, for example, a driver's license or passport, and knowledge-based or memory depending on distinguishing proof frameworks, like, a password or personal identification number. Since biometric identifiers are one of a kind to people, they are extremely much dependable in checking identity than token and knowledge based techniques; be that as it may, the accumulation of biometric identifiers maximizes security worries about an absolute utilization of this data.
The biometrics derived from Greek, where bio implied lively likewise metric implied measure. There are couple of standard rules for biometrics. These are universality, permanence and measurability. Firstly, it is its universality in nature. All universality implies each ordinary person

possess the biometric. Like the generally used biometrics, e.g. iris, fingerprints, ear surfaces etc. are recognized to be with any typical human personality. Secondly, the permanence implies the time invariance of biometric feature. For example, the fingerprints stay unaltered over the time or by growing age of the person. So one can utilize them for identification or verify regardless of age of the subject. In conclusion, it is the quantifiably of the biometric. Measurability, the biometric can be removed by method for a framework, in a sort of data which can be further prepared, looked at or stored as and when needed. For example the personal iris coloured structure can be verified with the stored one then again finger knuckle print can be put away and later verified for identification.

2. RELATED WORK

In paper [1] authors made use of 2D FKP as a biometric identifier for personal authentication. A cost-effective FKP system, having the image acquisition device as well as the associated FKP image processing algorithms is implemented. The database known as FKP which has 5,760 images of 480 different fingers is created. According to authors the system is user friendly, has no remains also moderate size and cost-effectiveness. Authors stated that the system can be improved and employed in real applications.

In paper [2], authors developed a system for personal authentication by making use of the finger knuckle surface for feature extraction. The developed FKR method is evaluated utilizing database of all categories of Finger Knuckle samples. They also stated that pre-processing of the database eliminates the noise and also enhances the FKP image that improves the accuracy of the system. Authors stated that the proposed technique has accuracy of 89.99 % and EER of 10.01%.

In paper [3], authors proposed a reconstruction based FKP verification technique which minimizes the false rejections generated by finger pose variations in data collection process. For an input query image whose matching distance falls into the uncertain interval, authors reconstructed a novel case of it by using a dictionary learned from the gallery set. Also an adaptive binary fusion (ABF) rule is developed to fuse the two matching distances for the last decision making. The given reconstruction based FKP verification with ABF, denoted by R-ABF, can effectively reduce the false rejections without increasing much the false acceptances.

In paper [4], authors have proposed a model which works in two steps. At first stage they investigated the data fusion in single modal, which is the FKP biometric. For fusing the information of each FKP, two different representation of every image is utilized. On the other hand, two different subsets of feature vectors are extracted from each image. In second stage, the data of every finger at two different fusion levels is fused: feature and matching score level. Also used fusion rules in different levels, by which recognition rate is improved.

In paper [5] authors concentrated on multimodal biometrics based personal authentication. Two efficient as well as distinct biometric identifiers like palm print as well as inner knuckle print has selected. Novel approach known as Monogenic Binary Coding (MBC) has been used for palm print recognition also Ridgelet transform and SIFT has been used for extracting the features of inner knuckle print.

3. SYSTEM IMPLEMENTATION

3.1 Proposed System

The execution of the framework is described using the figure 1. The system uses real time database, which has to undergo training first and then testing, later which gives real time output for identification. Here, feature extraction for the testing dataset plus the training dataset is performed. The system architecture is as follows,

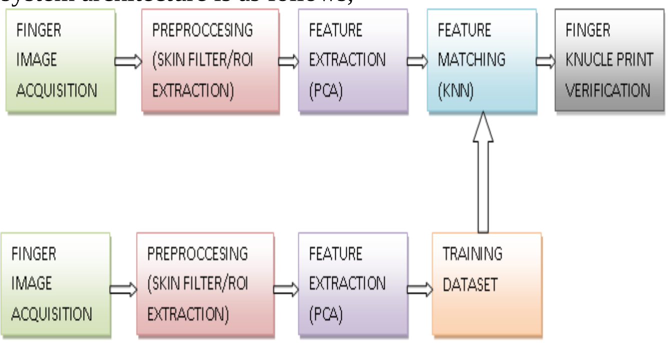

Fig. 1: System architecture for Finger Knuckle Identification System

The web video input camera send frames of input image to the pre-processing and feature extraction. The values from the features extracted during testing and also training are compared using classifier. In this system Principal Component Analysis (PCA) for feature extraction, it also reduces multi-dimensional data in to lower dimensional data with very less or zero loss of information. Also Local Binary Pattern is used for feature extraction. (LBP- only for testing and comparision) Proposed system has a preprocessing step which is developed in order to maximize the image features. Various features like as mean, standard deviation, entropy, smoothness, skewness, contrast, kurtosis, homogeneity, variance and correlations are extracted. At last KNN classification technique is employed to classify knuckle images. Accuracy for LBP and PCA testing are compared in the results.

3.2 Algorithms:

Generic steps involved in algorithm of PCA :

1. Acquisition of data
2. Subtract the mean from each data dimension. This produces a data set whose mean is zero.
3. Calculate the covariance matrix
4. Calculate the eigenvectors and eigenvalues of the covariance matrix
5. Choose components and form a feature vector and form a new dataset.

Feature vector = (eig1, eig2, …., eign)

Here, PCA algorithm extracts relevant information from a knuckle image [Principal Components] and encodes that information in a suitable data structure.

3.3 Mathematical Equations

1. Mean is given:

$$\overline{X}=\frac{\sum_{i=1}^{n} X_i}{n}$$

Where $\overline{X}$ the meanand is n is the no of elements.

2. Standard Deviation (SD):

The Standard Deviation (SD) of an information set is a measure of how the information is spread out.

SD is calculated as,

$$\sigma^2 = \frac{\sum_{i=1}^{n}(X_i-\overline{X})^2}{(n-1)}$$

Where, σ is the standard deviation of a sample.

3. The formula for variance could also be written like this,

$$var(X) = \frac{\sum_{i=1}^{n}(X_i-\overline{X})(X_i-\overline{X})}{(n-1)}$$

4. Covariance:

Standard Deviation and variance is measured in one dimensions but covariance is measured in two dimensions.

The formula for covariance is given as

$$cov(X,Y) = \frac{\sum_{i=1}^{n}(X_i-\overline{X})(Y_i-\overline{Y})}{n-1}$$

5. Skewness: Skewness is a measure of symmetry, or more precisely, the lack of symmetry.

$$skew(X) = \frac{E[(X-\mu)^3]}{\sigma^3}$$

6. LBP:

A local binary pattern encoding acquires local knuckle patterns and also represent multi-scale texture patterns. The binary pattern for every pixel centred at z_c with neighbouring pixel z_p is computed as [6]

$$h(z_p - z_c) = \{1, z_p - z_c >= 0, 0\ otherwise\}$$

LBP code for corresponding pixel is z_c is generated by assigning binomial weight 2^p to the above *equation 5.1*.

$$LBP(z_r) = \sum_{p=0}^{p-1} h(z_p - z_c)2^p$$

Where p is the total number of pixels in a local region and p *=0,1,2,...p −1*. The LBP encoded knuckle images are used to generate LBP descriptors using local histograms. The histogram information from each of the local regions is concatenated to extract the LBP descriptors. The similarity between two LBP descriptors is computed by comparing histogram intersection similarity measure as follows

$$S^{1,2}, G = \sum_{i=1}^{w} \min(g_i^1, g_i^2)$$

where w is the number of histogram bins while g^1 and g^2 represent LBP descriptors from the enhanced knuckle images

7. KNN classifier

$$d(a_1,a_2) = \sqrt{\sum_{j=1}^{k}(a_1,j - a_2,j)^2}$$

where a_1 and a_2 are two different points between the distance to be calculated

4. RESULTS AND ANALYSIS

4.1 Database Collection

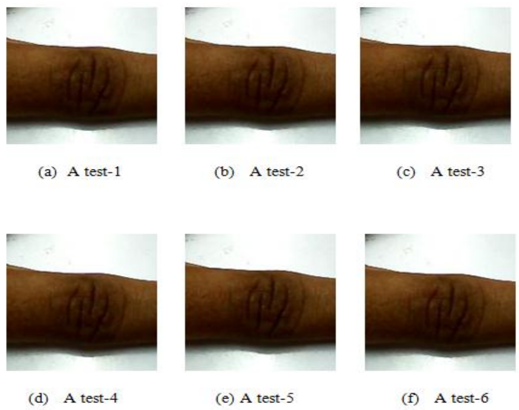

Fig.2: Database collected of a person A

The fig.2 shows database collected of an individual for six times by using a video camera. In this way database can be collected for n number of persons and can be stored

4.2 Testing And Results Validation

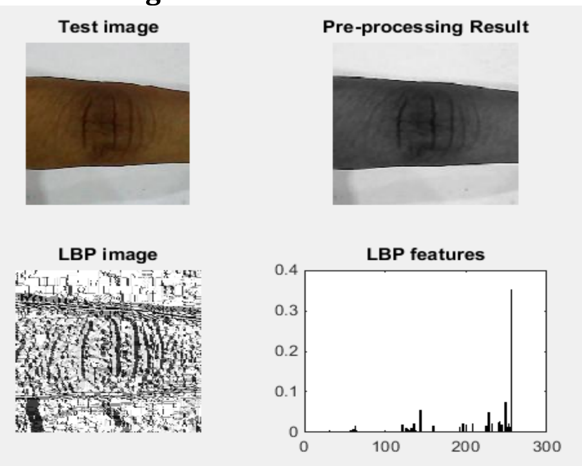

Fig.3 : Testing of image with pre-processing result and LBP feature extraction

The fig. 3 shows the testing of image acquired from person A . The LBP feature extraction method is applied for the same . it shows the features extracted in the graphical form too. The same image is processed using PCA and the following fig.4 shows the results for the mentioned system

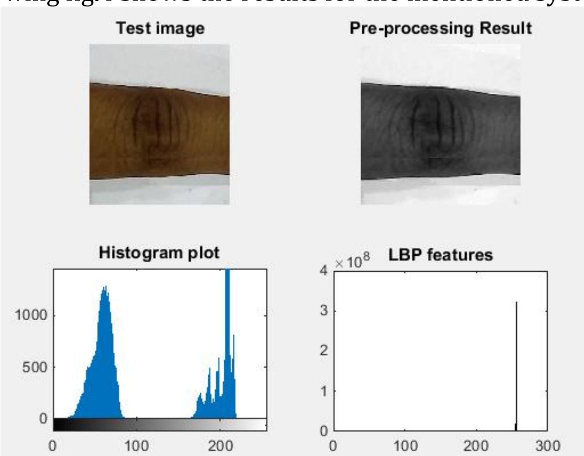

Fig.4 Results For PCA Feature Extraction

Table 1 Testing database.

Total no of Test image : 10
Total no of training image : 20
Total no of person : 5

Table 1 shows the number of testing and training image samples and the no. of individuals tested.

Table 2: Result for testing with LBP+KNN

Method: LBP+KNN			
Person	**Image name**	**Expected Result**	**Our Result**
1	A-test1.jpg to A-test4.jpg	Person A	Person A
	A-test5.jpg	Person A	Person A
	A-tes65.jpg	Person A	Person A
2	B-test1.jpg to B-test4.jpg	Person B	Person B
	B-test5.jpg	Person B	Person B
	B-test6.jpg	Person B	Person A
3	C-test1.jpg to C-test4.jpg	Person C	Person C
	C-test5.jpg	Person C	Person C
	C-test6.jpg	Person C	Person A
4	D-test1.jpg to D-test4.jpg	Person D	Person D
	D-test5.jpg	Person D	Person D
	D-test6.jpg	Person D	Person E
5	E-test1.jpg to E-test4.jpg	Person E	Person E
	E-test5.jpg	Person E	Person C
	E-test6.jpg	Person E	Person E

Table 3: Result for testing with PCA+KNN

Method: PCA+KNN			
Person	**Image name**	**Expected Result**	**Our Result**
1	A-test1.jpg to A-test4.jpg	Person A	Person A
	A-test5.jpg	Person A	Person A
	A-tes65.jpg	Person A	Person A
2	B-test1.jpg to B-test4.jpg	Person B	Person B
	B-test5.jpg	Person B	Person B
	B-tes65.jpg	Person B	Person B
3	C-test1.jpg to C-test4.jpg	Person C	Person C
	C-test5.jpg	Person C	Person C
	C-test6.jpg	Person C	Person E
4	D-test1.jpg to D-test4.jpg	Person D	Person D
	D-test5.jpg	Person D	Person D
	D-test6.jpg	Person D	Person A
5	E-test1.jpg to E-test4.jpg	Person E	Person E
	E-test5.jpg	Person E	Person E
	E-test6.jpg	Person E	Person E

4.3 Accuracy Calculations:

Table4: Accuracy for LBP+KNN Method

Total no. images : 30
Accuracy = (correctly classified image / total no. of image)
Accuracy=(26/30)*100
Accuracy = 86.67%

Table5: Accuracy for PCA+KNN Method

Total no. Images: 30
Accuracy = (correctly classified image / total no. Of image)
Accuracy=(28/30)*100
Accuracy = 93.33%

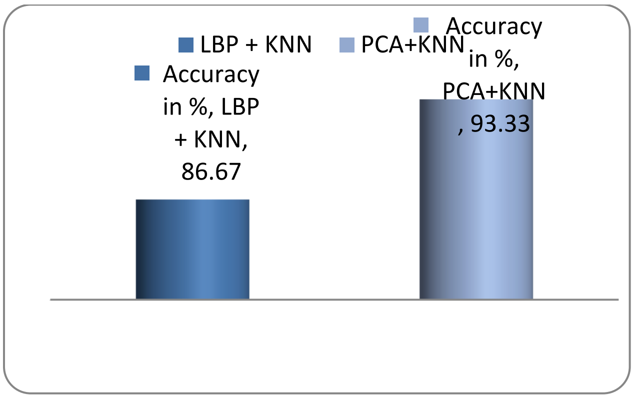

Fig.5 Accuracy calculated for database for both the methods.

Table 6. statistical feature values extracted for person A

Sr. No.	Featured extracted	Values extracted for training image	Values extracted for testing image
1.	Mean	129.5216	129.5101
2.	Standard deviation	73.3174	73.3304
3.	Entropy	-0.4856	-0.4605
4.	Smoothness	.-0.0827	-0.0787
5.	Skewness	-0.0025	-0.0030
6.	Contrast	1.0000	1.0025
7.	Kurtosis	0.2070	0.2180
8.	Homogeneity	0.0403	0.0325
9.	Variance	0.5362	0.5222
10.	Correalation	16.1904	16.2508

4.4 Output Result

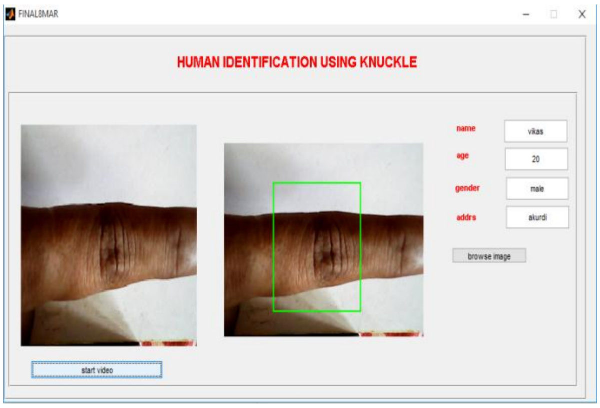

Fig. 6 Output window with the person identified

The fig. 6 shows when the finger knuckle is placed on the surface under a camera i.e. Input device, the person gets identified by classifying with stored data in the system.

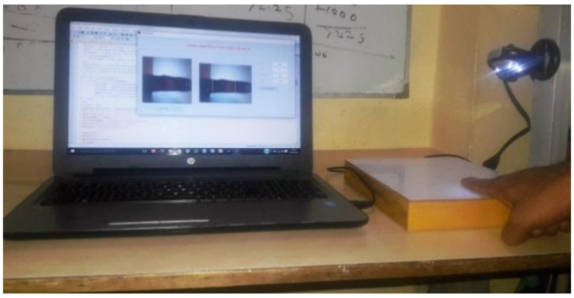

Fig.7 experimental setup

4.5 Graphs

The following images are of the graphs plotted for the features extracted during the training period of the system. The same graphs are plotted during the testing of the image having continuous output since, the input frames are continuously acquired from the video input camera. Also the accuracy graphs for the PCA+KNN and LBP+KNN are shown with rate of person identified.

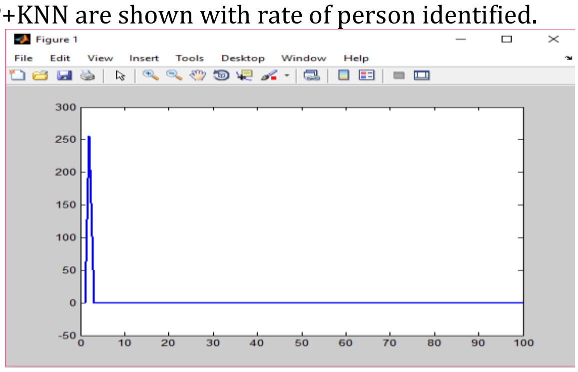

Fig. 8 Graph for Skewness

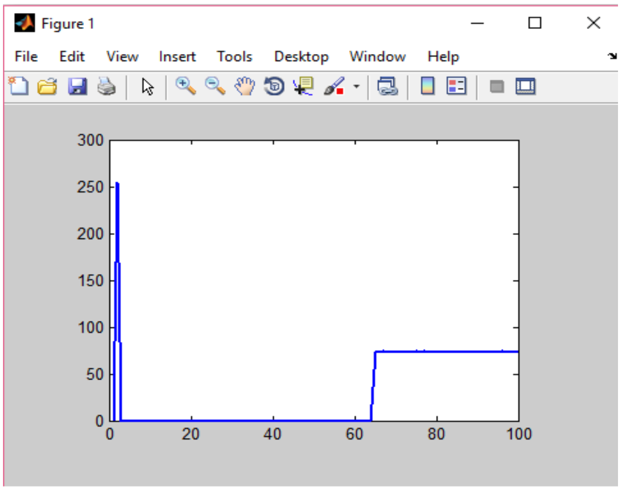

Fig. 9 Graph for Standard Deviation

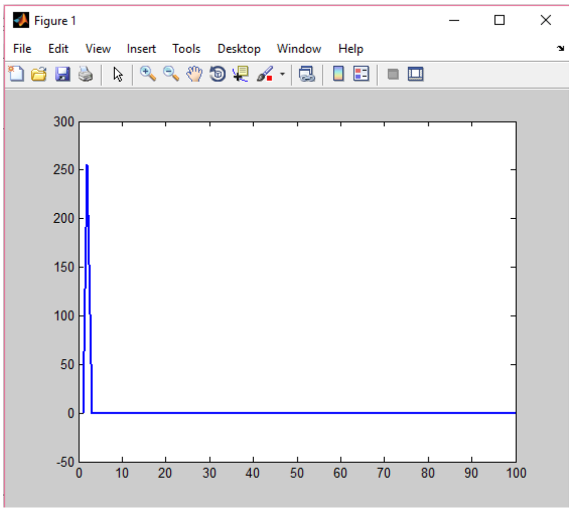

Fig. 10: Graph for Covariance

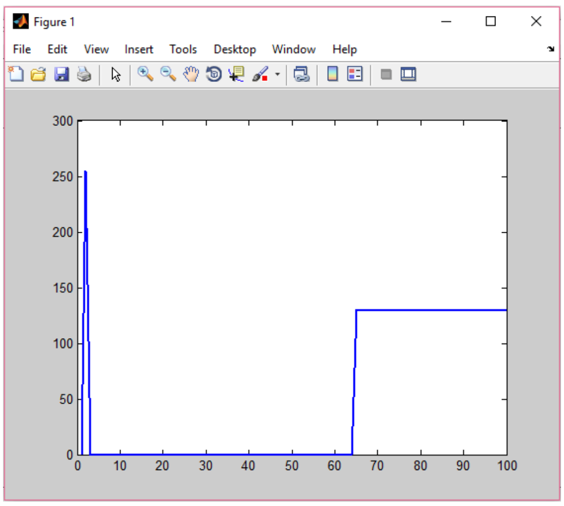

Fig. 11 : Graph for Mean

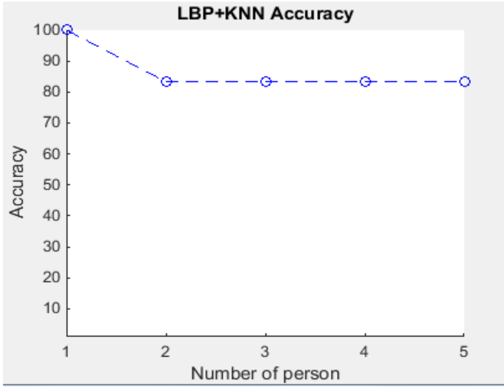

Fig.12 Results For LBP+KNN Method For Person A

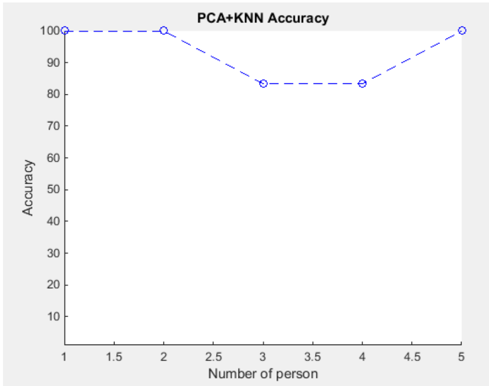

Fig.13 Results For PCA+KNN Method For Person A

5. CONCLUSION

This paper proposes the method for personal identification using finger knuckle print image. This work presented the finger knuckle print image acquisition and database collection, further the image preprocessing, feature extraction, various features, and their matching using K-NN classifier is mentioned. Also the proposed method was compared and validated with the existing techniques. This work concluded that finger knuckle print identification using PCA and K-NN classifier gives quite effective results and achieves high performance in knuckle identification. Thus , finger knuckle print can be used as neoteric biometric identifier.

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