Improving Human's Finger Knuckle Identification using High Order Zernike Moments

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Received: August 2019 Revised: November 2019 Accepted: December 2019

ABSTRACT:
Identification systems based on biometrics have been conventional more than traditional identification systems in the last two decades. Many biometrics have been provided such as fingerprint, palm, iris, the vein of palm and veins of fingerprint and such. One of the challenges discussed in biometrics is physical damages. The biometric of fingers knuckles is one of the biometrics less exposed to the physical damages. Several methods have been suggested for identification with various weak points such as high mathematical complications and a very low rate of identification. The present study suggests a new method for identification which is based on Zernike Moment. Zernike moment extracts the features of the picture several times. What distinguishes this algorithm from its counterparts is that it has got high accuracy in demarcating similar pictures of different classifications. In addition to its logical calculating complications, this method was able to record a very appropriate rate of identification facing some challenges such as noise, rotation, and transition.

KEYWORDS: Identification, Zernike, Moment, Finger Knuckles, Recognition Rate.

1. INTRODUCTION

For more than two decades, biometric-based authentication systems have replaced traditional identity-based systems such as ID cards, passwords, and more. During this time, many features of the human body have been identified as being unique, and much research has been done to improve the methods of identity identification using these features. Famous features include fingerprint, face, and iris [1]. Each of these features had its own challenges. Fingerprints and palm lines were always exposed to physical damage, which eventually led to changes in the pattern of these lines and increased system error rates. Face-based systems were considered as one of the most challenging identity-recognition systems because of factors such as aging, facial hair growth, wearing face glasses, etc. which greatly reduced the error rate of these systems [4]. Iris-based systems were considered to be very sensitive systems with very low error rates, but there are still challenges because of the very fine texture of the iris-based imaging systems. Iris was very costly and of high computational complexity [5], considering all the factors have been discussed above, the researchers inclined to introduce systems that at the first step are not subjected to such destructions and their change rate is low, at the second step, systems that have the lowest complications in their imaging process and calculations. Therefore, the patterns of the lines of the knuckles caught the attention of researchers since utilizing this pattern, due to fewer complications in imaging as well as operation, is assumed to be likely.

Since this feature was recognized as a biometric feature for the first time in 2010, various researches used this solution to recognize and overcome the challenges of this biometric. The present study intends to carry out a comprehensive investigation on these researches and also proposed a new method with its exceptional characteristics. Among the introduced biometrics such as iris, fingerprint, voice, gait, and DNA, knuckle have appropriate properties and applications. The lines of the knuckles have got a great collection of features such as the mainline and the miniature lines. The lines and raffles of knuckles with their individual edges and angles help to identify people [7]. Employing this biometric has been suggested due to its simplicity in usage and availability, but the identification process through the images of the palm is a very complicated task due to the different quality, size, form, scale, and angles of vector images [8].

To address some challenges such as the change of image scale and angle of the image, several studies need to be carried out for the identification to be done with the lowest rate of error using the images of palm with any angles and any scales. This study aims to provide a new method for identification through images of finger knuckles. Identification systems with the potential to overcome this challenge can do the identification with high accuracy and low errors. However, the number of studies addressing the different challenges of these images is very low. In 2018, Bahatachriand et al [9], increased the recognition rate by up to 93%, using the Gbour filtering technique, but this study only discusses the identification using the fingers knuckles and neglect the challenges faced in the identification process. Although a proper recognition rate is achieved in this study, it is still far from an ideal recognition rate. This research intends to provide a new method in identification using high order Zernike Moments. Shoyangi et al. [11] used Principal Component Analysis (PCA) Knearest neighbor to identify and confirm the identity of the lines of the fingers knuckles. In this proposed method, the FKP pattern is generated and, various features are extracted using PCA. Thereafter the final classification will be done through the classification of the closest neighborhoods. The obtained results indicate its high efficiency compared to the other similar methods. Moreover, a review on other identification methods using other biometrics has been done in this study. In the case of FKP, the usage of the coalition at the decision level has been proposed [12]. At first, features considered for identification in FKP are extracted, then, the final decision is made by a different algorithm such as the decision trees, support vector machine, etc, and at the end, the best decision will be made based on the decision rule in coalition at the decision level. Another method of interest in this particular area is competitive coding, the Gabor filters are usually utilized to produce competitive codes POC due to their two-dimension ability [13]. The BLPOC and also the POC algorithms are some of the other renowned methods in this research [14]. The SFIT (Scale Invariant Feature Transform) [15] and the SURF (Speeded Robust Feature) and also MS (Matching Score) are of other useful algorithms in the identification process.

In the suggested method by Shubhangi at first, the PCA will be applied to FKP images as a suitable algorithm, to extract their features. Elimination of the repetitive information, as well as the production of components full of information and details, are of important advantages of PCR [16]. On the other hand, the mean-based classification is a well-known classification process and the combination of these two categories has turned out to be an attractive approach. Kale et al. [15], have proposed another new method in addition to reviewing other identification methods using finger knuckles. The proposed systematic method is automatic and consists of ROI classification, normalization of the image, and reliable improvement and adaptation. He suggests the usage of phalanx and pattern of pinkie for identification. In this method, an image preprocessing was done, then features were extracted and saved in the feature matrix. Then the images will be imported for identification. These images will be prepared for their features to be extracted in the preprocessing phase. At the end, the matching task will be performed in the database. If the required score is achieved by the image as well as the input feature in matching, the imported image will be identified as one of the images available in the database. Zhang et al [15], have proposed the usage of coding methods for identification through one phalanx. The proposed method employs the localized Radon Transform LRT which effectively shows the random curved lines and wrinkles. The similarity between the two knuckle codes would be calculated through the lowest matching distance that could be used as the results obtained from the changes and transformation of the knuckles lines. The method proposed by Zhang et al. consists of 158 operated samples in the database and declares 81% of ERR stimulation and 98.6% of the recognition rate. The block diagram of the proposed method is shown in Fig. 8. What is interesting in this proposed method is applying simple but effective techniques, such as Histogram Equalization. In the production phase of knuckle code, local directions would be estimated and then the orientation map of errors is developed for production and encoding. A sample of biometric lines of the knuckle belonging to the data base poly U is shown in Fig. 1.

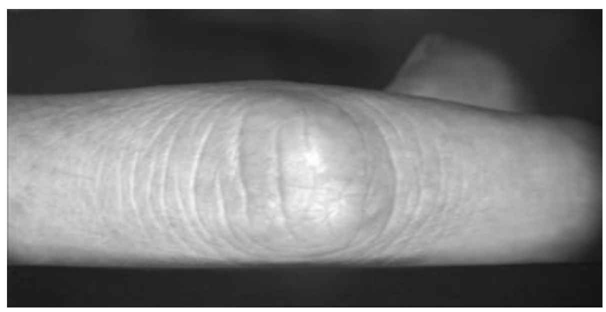

Fig. 1. A sample of biometric lines of the knuckle belonging to the data base poly U [6].

Identification based on the knuckle line consists of four main processes: segmentation, feature extraction, feature selection, and classification. Prior to the segmentation process, pre-processing is performed to correct distortions, such as noise removal from the image, through the segmentation phase, all the knuckle lines will be coordinated by an identical coordinate system in order to be able to extract features of a desired and ideal part of each finger. Therefore, the segmentation process is of great importance as the first and main step in the identification systems based on the lines of the knuckles. In most algorithms which are for identifying individuals and are based on this biometric, a specific part of the knuckle with a constant size is utilized to extract the features and a lot of information is neglected. Fig. 2 shows how the image of a fixed area of knuckles is taken from an invariant distance and with a specific resolution.

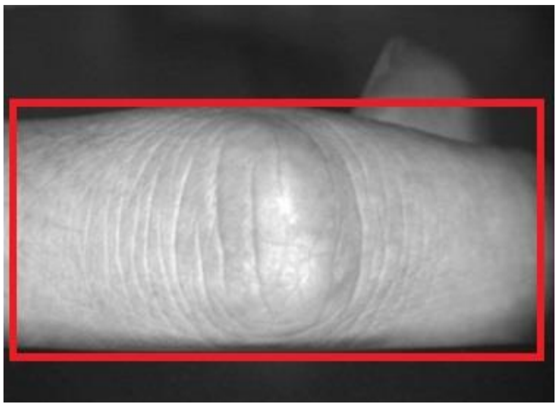

Fig. 2. An example of a processing area of knuckle.

In this section, the current method is used to extract the features of a rectangle-shaped part of the knuckle with a fixed size.

2. PROPOSED METHOD

Most of the conducted studies have been operated in a common frame, and in the most ideal state, only carry out the identification process but the real world is a world of errors. The existence of these errors shows the importance and necessity of implementing methods concerning these errors. For example, error in the correct identification of the ROI zone throughout the segmentation algorithm can result in the image generated from ROI to be with a little bit of rotation, transition, scale charge, etc. or the scanner device has got technical problems and scanned images have noise. If all the aforementioned issues are put together with the human errors in using security systems, it would be crystal clear that the real situation is never close to the ideal one. The main purpose of this research is to define some of the challenges that are inevitable to occur in the real systems so as to investigate the stability of the proposed method against these changes. These challenges are; noise, scale change, transition, and rotation. Fig. 3 shows an example of these challenges. The proposed method in the educational phase is shown in Fig. 4.

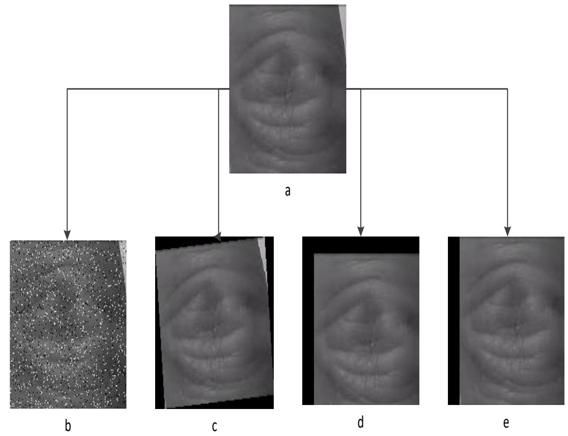

Fig. 3. A sample of investigated challenges in this research a) original image, b) noise challenge, c) transition challenge, d) scale change challenge, e) rotation challenge.

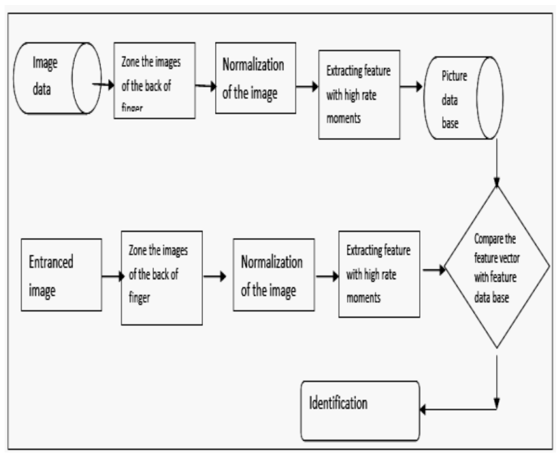

Fig. 4. The proposed method in the educational phase.

As it is shown in Fig. 3, two types of changes have occurred in images. The first change is in the brightness and clarity of the pixels. That is to say, the brightness of all the pixels would drastically change by applying rotation, transition and scale change and the brightness of a large number of pixels would change by applying noise. The second change is losing a part of the image. Some pixels of the margin of the image are lost after the transition. Thus, the main purpose of this study is to provide a method to generate distinct feature vectors for images to be classified properly despite general alterations in the image. In order to do so, the Zernike moments are employed for extracting features from the image. This method makes use of a neighborhood to generate features of each pixel instead of extracting the feature from a large number of pixels. This will make fewer changes in the features vectors which leads to sufficient stability of vectors against the changes.

3. RESULTS AND DISSCUTIONS

There are different parameters and many variables in this research that highly influence the recognition rate. The important parameters of this research are divided into two categories: the algorithm parameter used in this research and the challenge parameters considered for the research. The assessment of the parameters of the challenges is done in the performance evaluation section and the efficiency of the proposed method is evaluated by each input parameter of the challenges. The best algorithm parameters applied in this research have been identified through trial and error and are shown in Table 1.

Table 1. A comprehensive explanation of the three compared methods. These parameters will be fixed in all phases of the test.

	Parameters details
The best parameters that are used in proposed method	The level of Zernike moments the radius of neighborhood is defined as 1 (K=1)
Evaluated parameters for investigated challenges in this research	*In noise challenge, in the rate of 0 to 0.32, the test of grizzly noise has been applied *In rotate challenge, the under tested images are evaluated between 0-6 degree *In transition challenge issued moved between 0-12 pixel on y-vector *in scale challenge, the issued images will have a scale change between 0-88, and Images are positive direct.

3.1. Evaluation of the Accuracy of the Proposed Method

Several issues should be taken into consideration in explaining the details of the proposed and evaluated methods. The sampling process of the educational images and the test have been random in all the phases, and from each 5 images of the hand, 3 of them are chosen for educational purposes and one of the images would be selected randomly for the test after applying the challenges of the rotation, transition, scale change and noise. In the suggested method, the collection of images utilized for the identification of the best-applied parameters will be omitted from the main image collection of the test. The total number of the data used in these tests were 2517 image from 503 people. (3 images of each person for education, and 2 images as the test samples). The introduced method and the compared method were repeated 10 times with random sampling for education and test collection, and the accuracy of the identification is calculated and recorded each time. The accuracy of identification recorded in the result table is the average result obtained from performing the test 10 times. Furthermore, the confidence interval for all tests was calculated regarding the accuracy of identification obtained from 10 repetitions of each test and a confidence level of 95%. Tables 2 and 3 display the results achieved from 2 aforementioned challenges.

3.2. Study of the Suggested Method with Noise Challenge

In Table 2, the results achieved from the calculation of the recognition rate of the image under the influence of grizzly noise in the zone of 0 to 0.32 are shown. As it could be understood from the results of this challenge, the rate of identification under the effect of grizzly noise is not damaged very much. When the noise passes the zone of 0.16, the decrease of the rate of identification will be more sensible, but to have a better recognition of the main reason of this stability, we should pay more attention to the Fig. 2. In this figure, you can see that several graphs will be extracted for each image. In addition, the feature extraction from a relatively expanded segment will cause the damage of a small part to have a little effect on the quality of extracted features. Fig. 5 displays the comparison of the recognition rate of the present research under the influence of the noise challenge.

Table 2. The results of recognition rate with the challenge of salt chili noises.

Noise Level	Average –Poly U	Confidence interval – Poly U
0	98.6	98.1-99.1
0.02	95.1	94.7-95.5
0.04	94.3	93.6-95.0
0.08	92.5	91.6-93.4
0.16	91.3	90.5-92.1
0.32	90.1	89.0-91.2

3.3. Study of the Suggested Method with Rotation Challenge

In Tables 4, 5, the results of identification with the rotation challenge between 0–6 degrees are presented.

As it can be seen, the suggested method has got relatively sufficient stability against the rotation, but the reason behind this stability is that feature extraction is done for one pixel in 4 round-shaped zones. Rotation of the image only changes zones of selected graphs which cannot have a serious effect on the rate of identification. Fig. 6 shows the recognition rate of two databases used in this research under the effect of rotation challenge. The output value is based on a constant number of users in 50-time divisions.

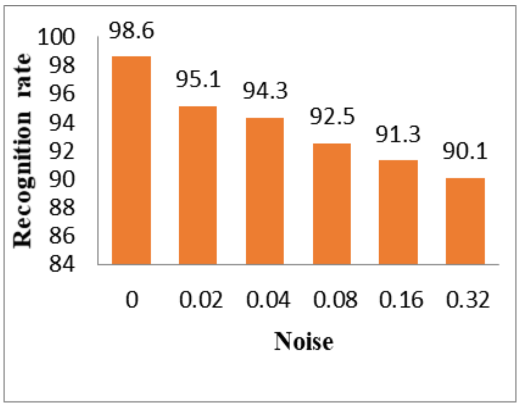

Fig. 5. Comparison of recognition rate under noise challenges.

Table 3. The results of recognition rate with the rotation challenge.

Spin Rate	Average – Poly U	Confidence interval – Poly U
0	98.60	98.1-99.1
2	94.40	93.7-95.1
3	93.50	92.8-94.2
4	92.60	91.7-93.5
5	91.70	90.7-92.7
6	89.90	88.8-91.0

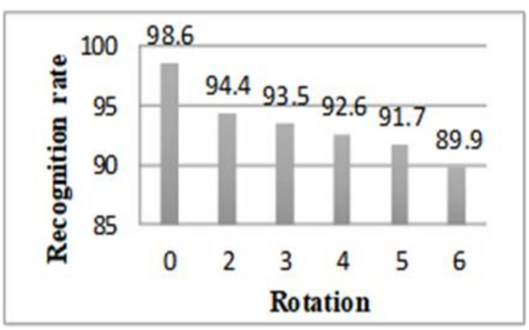

Fig. 6. Comparison of the recognition rate under the influence of the 0 to 6 degree of rotation challenge.

3.4. Study of the Suggested Method with Transition Challenge

In Table 4, the results of the suggested method within the challenge of transferring the pixels of the image in a zone of 0-12 pixels in the direction of the x-vector are compared. The results obtained from calculating the recognition rate of the suggested method in this challenge also show the stability of the suggested method against transforming the image. The reason for this stability is that only a part of the margin of the image would be cut off from the main image while transferring, and the suggested method would extract required features from the remaining parts of the image. Fig. 7 shows the recognition rate under the influence of transition challenges.

Table 4. The results of recognition rate with the challenge of transition rate.

Transition rate	Average –Poly U	Confidence interval – Poly U
0	98.60	98.1-99.1
1	94.90	94.2-95.6
3	94.10	93.2-95.0
6	93.20	92.4-94.0
9	91.50	90.3-92.6
12	88.70	87.6-89.8

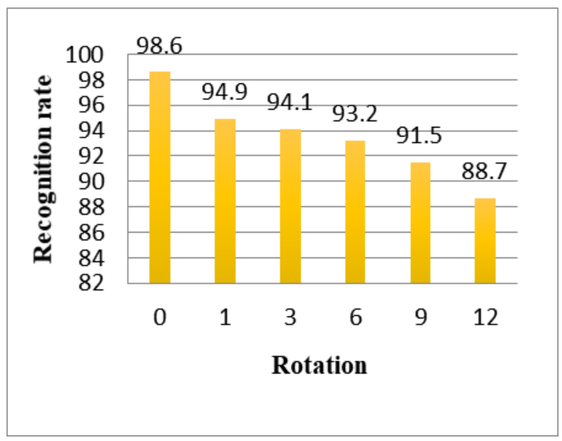

Fig. 7. Comparison of the recognition rate under the influence of transition challenge from 0 to 12 pixels.

3.5. Study the Suggested Method with Scale Change Challenge

At the end of this section, the results of the scale change challenge are shown in Table 5. This challenge makes the image smaller and destroys the texture of the image, but again the suggested method produces authentic feature vectors from the remaining of the image in each classification which prevents the rate of identification of the image to be decreased. Fig. 8 shows the recognition rate under the influence of the transition challenge.

Table 5. The results of recognition rate with scale challenge.

Scale rate	Average – Poly U	Confidence interval –Poly U
0	98.60	98.1-99.1
2	95.10	94.4-95.8
3	94.20	95.3-95.1
6	92.50	91.5-93.5
9	90.20	88.8-91.6
12	77.70	75.2-90.2

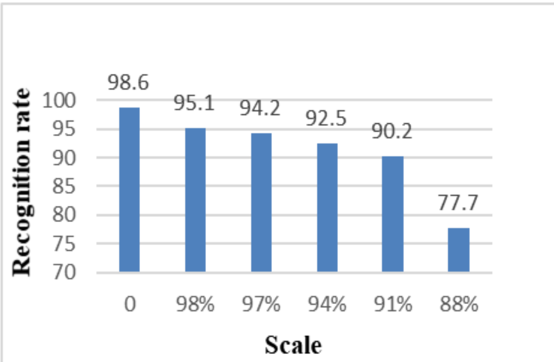

Fig. 8. Comparison of the recognition rate under the challenge Scale from 0 to 88 percent

3.6. Comparison with Other Methods

The proposed method is compared with the proposed method in [11] and [21] and [22] that uses the principal component analysis for recognition. There is no investigation on challenges in recognition like noise or rotation on images in dataset. Table 6 shows the comparison of results of the proposed method and the method presented in [11]. As Table 6 shows, the proposed method with the NO challenge has the better result, but with scale rate of 2 and noise ratio of 0.02 and the transition rate of 1, the recognition rate of the proposed method is similar to the [11], but with the comparison with tables in the paper, the results are acceptable. Results in paper [21] and [22] were not based on any challenges, and recognition was done in normal position of finger. For a better illustration, Fig 9 shows the results. As Fig. 9 shows, the proposed method has the best results even in challenges, due to using the invariant moments.

Table 6. The recognition rate of the proposed method and references [11], [21] and [22].

Methods	Average – Poly U
Proposed method with no challenge	98.60
Reference [11]	96
Reference [21]	86
Reference [22]	91
Proposed method with scale change	94.20
Proposed method with noise of 0.02	96.50
Proposed method with transition rate	94.90
Proposed method with rotation of 2	94.40

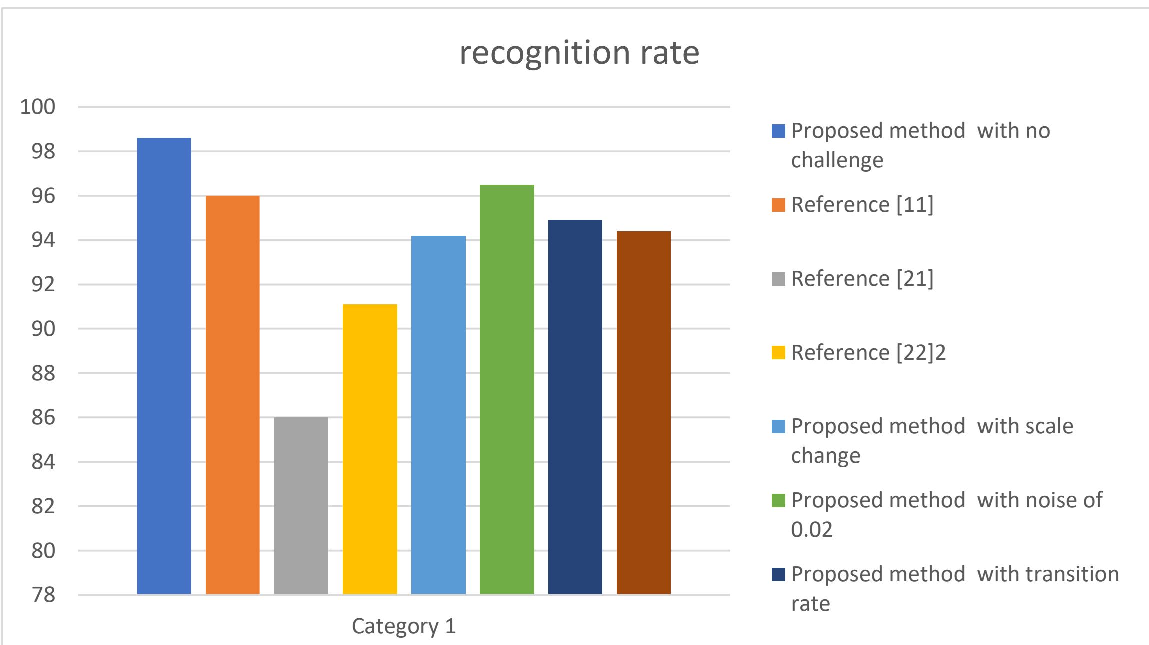

Fig. 9. The recognition rate of the proposed method and reference [11], [21] and [22].

4. CONCLUSION

Regarding results obtained in this essay, it can be concluded that the suggested method has got sufficient stability against the discussed challenges, and also this method can be useful for two reasons. First, the present method makes an effort to enter the most recent challenges into the research structure and also meet the up-to-date needs and requirements of the real world and second reason is that this study presents a stable method against the changes, which can be implemented in palm-based identification systems and fulfill the needs and expectations of an identification system.

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