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Triangular Geometric Feature for Offline Signature Verification

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***Abstract*—**Handwritten signature is accepted widely as a biometric characteristic for personal authentication. The use of appropriate features plays an important role in determining accuracy of signature verification; therefore, this paper presents a feature based on the geometrical concept. To achieve the aim, triangle attributes are exploited to design a new feature since the triangle possesses orientation, angle and transformation that would improve accuracy. The proposed feature uses triangulation geometric set comprising of sides, angles and perimeter of a triangle which is derived from the center of gravity of a signature image. For classification purpose, Euclidean classifier along with Voting-based classifier is used to verify the tendency of forgery signature. This classification process is experimented using triangular geometric feature and selected global features. Based on an experiment that was validated using Grupo de Senales 960 (GPDS-960) signature database, the proposed triangular geometric feature achieves a lower Average Error Rates (AER) value with a percentage of 34% as compared to 43% of the selected global feature. As a conclusion, the proposed triangular geometric feature proves to be a more reliable feature for accurate signature verification.

***Keywords*—**Biometrics, euclidean classifier, feature extraction, offline signature verification, VOTING-based classifier.

I. Introduction

BIOMETRICS are technologies used for measuring and analyzing a person’s unique characteristics. There are two types of biometrics; behavioural and physiological [1]. To obtain data on a physiological biometric trait, some part of the human body is measured, such as fingerprint, face, retina or palm print. On the other hand, to obtain data on a behavioral biometric trait, a person’s resulting action is measured such as his or her signature [2]. Since the biometric identifiers are inherent to an individual, it is difficult to be modified, shared or forgotten. Therefore, a strong and reasonable linkage between a person and his or her identity is formed from these biometric traits.

Generally, two types of systems based on signature verification can be found in literature; online system (use dynamic features - the time series) and offline system (use static features - the signature image). Signatures taken by using pressure-sensitive tablet in order to extract information about that signature such as pressure applied on pen and speed of writing of the signature is defined as online signature verification. Conversely, an offline method uses a simpler technique where data of the signature is captured by using an optical scanner [3]. Signatures in offline system usually may have noise, due to scanning hardware or paper background and contain less discriminative information since only the image of the signature is the input to the system. While genuine signatures of the same person may slightly vary, the differences between forgery and a genuine signature may be unnoticeable, which makes automatic offline signature verification a very challenging pattern recognition problem [4].

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II. Related Works

The achievement of a signature verification system significantly relies upon the features extraction. An excellent feature extraction technique extracts a minimum feature set that gets the most out of interpersonal (different person with similar signature) while minimizing intrapersonal (same person with different signature) factor. Generally, there are three main categories of features based on offline signature verification: global, local and geometric features.

Research conducted by [5] described a usage of global features based on the boundary of a signature and its projection for enhancing the process of automated signature verification. The first global feature was derived from the total ‘energy’ a writer used to create a signature. The second feature employs information from the vertical and horizontal projections of a signature. These two features are then combined with the Modified Direction Feature (MDF) and the ratio feature. Their research results obtained an Average Error Rate (AER) of 17.25%. However, in the work of [6], stroke endpoint and stroke orientation of signature was used as the feature. Results obtained from the experimentation claimed that trade-off between response time and accuracy of recognition is quite impressive, which is around 95% with an AER of 5%.

In the research conducted by [7], an offline signature verification based on local parameter feature extraction was used. There are basically two types of local parameters which are component oriented (contour based, geometry based) and pixel oriented (grid based, intensity based). Experimental results show that False Acceptance Rate (FAR) is reduced to 11-20% while False Rejection Rate (FRR) is reduced to 7-19%. This results in AER of 14.25%. Research carried out by [8] proposed signature image verification based on time series data. Experimental results of this work show that the method has great reduction in AER with a percentage of 5.8%. On the other hand, [9] had evaluated energy of signature on grid-level as features for verifying the offline signature. The energy on grid-level method gave moderate FAR (2.25%) and FRR (2.25%) values and produced an AER of 2.25%.

The research study by [10] proposed a new approach for symbolic representation of offline signatures. The symbolic representation is a geometric feature that is formed by finding the distances between geometric centroids of the signature image. This proposed approach shows lower AER which is 21.6%. In a research conducted by [11], lower AER with a percentage of 6.75% was obtained by using vertical and horizontal splitting together with angular feature. The vertical and horizontal splitting feature were also used in [12] but the percentage of AER is higher than [11] which is 16%. Another research that opted geometric feature is [13], where unlike other researches, the splitting of the signature image is done by partitioning the image into rectangular cells at moderate resolution to acquire complete gradient information of the signature strokes. AER obtained from this research is 0.75%.

Based on the review conducted, this paper found that the geometric features have the potential to further stabilize the accuracy of signature verification. Geometric features are able to preserve both global and local properties of the signatures besides having a high tolerance to distortion and style variations. Furthermore, this feature can tolerate a certain degree of translation and rotation variations. Thus, based on these findings, this paper introduces new proposed feature based on the triangular geometric feature in order to increase accuracy of verification.

III. Triangular Geometric Feature

Based on the previous works, inability to extract robust features from a static image of signature contributes to higher verification error rates [14]. In this paper, three new feature sets are proposed based on the characteristic of the triangle shape feature: Triangle's Sides, Triangle's Angles and Perimeter, as shown in Fig. 1.

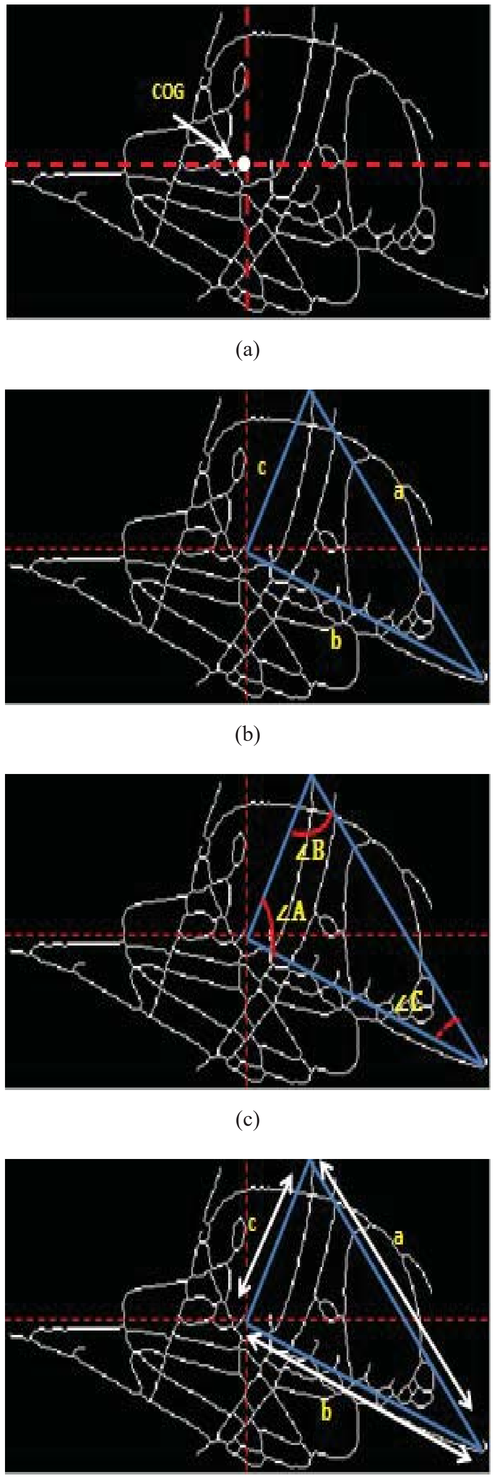
The idea to propose the new features is based on the geometrical state of the triangular feature itself. Based on Fig. 1, the features of the triangle are derived from the center of gravity (COG) of the signature image. Here, the COG of the signature image is shown by the intersection point of the two dotted lines (refer Fig. 1 (a)). This COG point is chosen because it holds a stable value for that corresponding signature image. Based on [15], every person's signature has a unique COG, hence it will lower the dependencies of the intrapersonal and interpersonal factor. Therefore, it is believed that these new features may have the potential that might increase the accuracy of signature verification.

Following are the descriptions of the new triangle features:

i. **Triangle's Sides**: consists of three lines; side a, side b and side c, which connect to each other at the vertex point and then form a triangle shape (refer Fig. 1 (b)).

ii. **Triangle's Angles**: consists of three angles; ∠A, ∠B and ∠C on the inside of a triangle at each vertex (refer Fig. 1 (c)).

iii. **Perimeter**: length of the outline of the triangle as in Fig. 1 (d).



(a) (b) (c) (d)

Fig. 1 Triangle features (a) Center of gravity (b) Triangle's Sides (c) Triangle's Angles (d) Perimeter

IV. Classification

Two stages of classification based on Euclidean classifier and Voting-based classifier are used in order to validate the input testing signature. In the first stage of classification, each feature is passed through Euclidean classifier to determine whether the signature is genuine or forgery. Two statistical features, mean and standard deviation, were calculated for each of the feature in every signature samples. The calculated standard deviation value is then used to define the threshold value of each feature. Afterwards, the calculation of distance vector is conducted by finding the Euclidean distance between the input testing datasets with their corresponding mean value.

Finally, the distance vector is compared against the threshold value to determine whether it is genuine or forged. The decisions of the previous stage are then fed into the Voting-based classifier to produce the final output. At this stage, the final decision of whether the signature is genuine or forged is made for the overall registered signature. In this case, if the total genuine is larger than the total forgery, then the signature is verified as genuine, else it is verified as forged.

V. Results

For experimentation purpose, two experiments are carried out in order to verify the testing signature dataset. The first experiment is conducted using the new proposed feature which is the triangular geometric feature. Whilst for the second experiment, four selected global features are used which consist of aspect ratio, pure height, maximum horizontal value and number of strokes found in the signature image. These two experiments are carried out using Grupo de Senales (GPDS-960) standard database. From these experiments, three error rate values: False Rejection Rate (FRR), False Acceptance Rate (FAR) and Average Error Rate (AER) are computed. Comparison between those error rates is made in order to quantify the performance of the two compared features. In this case, the lower the error rate value, the better is the performance of the system. Table I shows the performance of the two feature sets applied on GPDS-960 database.

TABLE I
Final Evaluation of the Two Features Set by Using GPDS-960 Database

Database	Features Set	Error Rates		
		FRR	FAR	AER
GPDS-960	Triangular Geometric Feature	32	36	34
	Selected Global Feature	58	28	43

Table I shows the final evaluation of the triangular geometric features and the selected global features towards GPDS-960 database. In this table, the triangular geometric features recorded FRR of 32% and FAR of 36%. From these percentages, an AER of 34% was opted. Meanwhile, the selected global features recorded FRR of 58% and FAR of 28%. The selected global features opted an AER of 43%, which is 9% higher than the triangular geometric feature. As mentioned earlier, the lower the AER value, the better the performance of the feature. So, based on the AER results of both sets, the triangular geometric features achieve better results as compared to the selected global features.

VI. Conclusion

In this paper, the proposed feature is based on the triangular geometry was discussed. Results are compared with selected global features and performance of the proposed method is carried out. As a lower AER value shows better performance of the system, likewise, in this research, a low AER value is achieved. By using the proposed triangular geometric feature, the value of AER is 34%, which is lower than the selected global features. Therefore, it is concluded that the new proposed feature, the triangular geometric feature, proves to be a more reliable feature for an accurate signature verification.

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