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Review Paper on Offline Signature Verification

ZuraidasahanaZulkarnain Mohd Shafry Mohd Rahim and Rosely Kumoi

Abstract—Signature verification is an important research area in the field of personal authentication. The objective of the signature verification system is to discriminate between two classes: the genuine and the forgery, which are related to intra and interpersonal variability. The most important stage in signature verification system is feature extraction process. As several signatures have similar strokes and sizes, it will make them much more complicated. In this paper, we are conducting the study of global and geometric centerapproaches that related to offline signature verification systems. Besides, this paper also provides the comparison of those approaches along with the features used, to help the researchers working in this field.

Index Terms—Enhancement, Feature representation, Segmentation,.Verification

1 Introduction

BIOMETRICSrefer to automated techniques of recognizing an individual based on physiological or behavioral characteristic. Physiological biometrics involve data derived from the direct measurement of some part of the human body. Examples of physiological biometrics include fingerprint, face, palm print and retina-based verification. Whilst, behavioral biometrics involve data derived from an action taken by a person. Examples of behavioral biometrics are speech, keystroke dynamics and signature-based verification [1]. Since the biometric identifiers are inherent to an individual, it is more difficult to manipulate, share or forget these traits. Hence, biometric traits constitute a strong and reasonable permanent link between a person and his identity.

There are basically two types of system in signature verification which are on-line system (use dynamic features, the time series) and off-line system (use static features, the signature image). On-line signature verification uses signatures that are captured by pressure-sensitive tablets that connected to a computer to extract information about a signature and takes dynamic information like pressure being applied on pen, the speed at which the signature being put, etc. On the other hand, offline method uses an optical scanner to obtain handwriting data from a signature system [2]. However, offline signature verification is more difficult than online as dynamic information are not available and it is difficult to recover them from the offline images.

The subject of interest in this research is signature verification. Signature verification is defined as a biometric identification method using a person's signature characteristics. Each person has a unique handwritten signature. The way a person signs their name or writes a letter can be used to prove a person's identity [3]. Signature verification is dissimilar from character identification, because signature is regularly illegible and it is often a representation with several particular curves that correspond to the writing style of the person. Signature is just a unique case of handwriting and regularly is just a symbol [4]. Therefore, it is essential to deal with a signature as a complete image that signifying a particular writing style and not as a compilation of letters and words.

2 Feature Approaches in Offline Signature Verification

There are two approaches to be discussed in this paper which are global feature approaches and geometric center feature approaches. A global feature is defined as the signature viewed as a whole and features are extracted from all the pixels confining the signature image [5]. Based on the style of the signature, different types of global features are extracted. Following global features are found in literatures [6],[7],[8],[9],[10],[11],[12].

As for geometric feature, it describes the characteristic geometry and topology of a signature and preserves their global as well as local properties [5]. Geometrical features have the ability to tolerate with distortion, style variations, rotation variations and certain degree of translation [13],[14],[15].

2.1 Global Feature Approaches

According to [6], he implemented combinations of Gabor filter, XGabor filter and gravity center point as a novel feature extraction algorithm for an offline signature verification system in order to validate the originality of the test signature images and distinguish the skilled and random forgery from genuine. The proposed feature extraction method can be separated into 2 parts.Firstly, Gabor and XGabor filters were used to extract textural features.Secondly, the angle of inclination of each filtered image gravity center point was collected in the lower

- *ZuraidasahanaZulkarnain is with the UTM VicubeLab, UniversitiTeknologi Malaysia, Malaysia, Johore 81310. E-mail: zurai.sahana@yahoo.com*
- *Mohd Shafry Mohd Rahim is with the UTM-IRDA Digital Media Centre, Universiti Teknologi Malaysia, Malaysia, Johore 81310. E-mail: shafry@utm.my*
- *Rosely Kumoi is with the UTM VicubeLab, Universiti Teknologi Malaysia, Malaysia, Johore 81310. E-mail: rosely@utm.my*

right corner of the image. It should be normalized with the summation of intensified pixels in transforming image as the feature of the signature image. For classification phase, he used Feature Relation Graph (FRG) classifier, where it achieved an equal error rate of 7.66%.

Based on [7], they proposed an offline signature verification and recognition systembased on a combination of features extracted such asglobal features and alsotransition features.These features were geometrical features,which mean they were based on the shape anddimensions of the signature image. A centroid feature vector was obtained from a set of genuine samples using the features thatwere extracted earlier. The centroid signature was then used as a template to verify a claimed signature. In order to compute the result, they used the Euclidean distance toobtain a satisfactory measure of similarity between their template signature and the claimed signature.

In [8], they presented an image pre-possessing, geometric feature extraction and neural network training with extracted features and verification. The features that were extracted in this phase were used to create a feature vector. A feature vector of dimension 24 has been used to distinctively describe a person signature. These features were extracted as follows: a) Maximum horizontal and vertical histogram, b) Center of mass, c) Normalized area of signature, d) Aspect ratio, e) Tri surface features, f) Six fold surface features, and g) Transition features. Later, the extracted features of test signature were verified to a trained neural network which classified it as a genuine or forged.

Besides, [9] had presented an off-line signature verification system based on combination of extracted features such as grid feature, mask feature and global feature. From the signature samples taken from each person, four features were extracted for all the samples; centroid, tri-surface, six-fold surface and shape number feature. Three of the features used by the author which are centroid, tri-surface and also six-fold surface were slightly the same as the features that were proposed by [8]. But in this case, [9] had added another feature which is the shape number feature.To verify the similarity between trained signatures, the Euclidean distance and a specific threshold were used.

According to [10], they proposed Concatenation of Spatial and Transformation features for offline Signature Identification (CSTSI) method to distinguish genuine signature from skilled forgery signatures.The transform domain and spatial domainfeatures were concatenated to obtain a final set of features.The transform domain was applied on signature to derive the DWT sub bands such as approximation, horizontal, vertical and diagonal bands. On the other hand, global features were extracted which led to spatial domain features. To get the final results, the test signature features were compared with database signature features by using correlation technique.

Based on [11], they presented anoffline signature recognition and verification by using neural network. Signatures were verified based on parameters extracted from the signature using various image processing techniques. In this paper, all of the features used are the same as the features proposed by [8]. A feature vector of size 24 was formed by combining all the extracted features. Later, all of the 24 extracted feature points were normalized to bring them in the range of 0 to 1.These normalized features were then applied as input to the neural network.

According to [12], they recommended two systems for offline signature verification based on a local and a global feature correspondingly that includes variety of geometrical, statistical and structural features. In local features, “outer” and “inner” contours were exploited. The beginning spot of each curve was set as the pixel linked with its farthest left, and these points were followed in clockwise direction. Every curve was then divided into strokes that were classified by two significant points; correspond to alter of path alongside the x-axis or y-axis or to high alters of slope paths. In order to evaluate the performance of the systems, the Equal Error Rate (EER)functioning point was reported.

2.2 Geometric Center Feature Approaches

According to [13], they proposed an offline signature verification system by segmenting signature image into different parts based on depth. Then, geometric center for each segment was set as the feature point for that segment. The number of feature points extracted from signature image is equivalent to the number of the segmented signature image that was produced by specifying the value of depth. The geometric elements were based on two sets of points in 2-dimensional plane; vertical and horizontal splitting. The vertical and horizontal splitting of each image has 30 feature points (v1, v2, v3,…,v30) and (h1, h2, h3,….,h30). These feature points were attained with relation to the image’s geometric center point. Then, Euclidean distance was applied to those tested signatures to classify either it is genuine or forgery.

In [14], they presented a new technique for the analysis of stability in static signature images.The technique used an equimass segmentation approach to non-uniformly split signatures into a standard number of regions. A multiple matching technique was adopted to estimate the stability of each region, based on cosine similarity. In the feature extraction, for each region of the signature image, five equally-spaced parallel segments were considered for each one of the four main directions (horizontal, vertical, +45°, -45°) and the total number of black pixels intercepted by the segments in each direction were then counted. From each region, a vector of four components (one for each direction) was extracted. The colors of each regionindicate the degree of stability of that region.

Based on [15], they presented a method that consists of image pre-processing, geometric feature extraction, neural network training with extracted features and verification. In feature extraction phase, a feature vector was created from the extracted features. They had used a feature vector of dimension 60 to distinctively distinguish a person signature. The feature used was geometrical features; they were based on the shape and size of the signature image. These features were extracted as follows: a) Geometrical center, b) Feature extracted using vertical splitting, and c) Feature extracted using horizontal splitting.

3 RESULTS

In order to determine the effectiveness of the signature verification based on the previous works, a comparison between global feature approaches and geometric center feature approaches had been made as shown in table 1. False Acceptance Rate (FAR) and False Rejection Rate (FRR) are the two parameters used for measuring the performance of any signature verification method. The FAR is given by the number of forged signatures accepted by the system with respect to the total number of comparisons made, whereby FRR is the overall amount of genuine signatures discarded by the system with admiration to the overall amount of evaluations made The purpose of verification is to reduce FAR and FRR.

TABLE I. COMPARISON BETWEEN GLOBAL APPROACHES AND GEOMETRIC CENTER APPROACHES

GLOBAL FEATURE APPROACHES

Features	Classifier	Database	Results
- Gabor filter - XGabor filter - Center of gravity [6]	Feature Relation Graph (FRG)	GPDS	FAR – 9.08% FRR – 6.25%
- Normalized area of signature - Aspect ratio - Maximum histograms - Centroid - Trisurface - Sixfold surface - Number of edge points - Transition [7]	Euclidean distance	GPDS	A success rate of 84.1% was achieved using a localized threshold
- Maximum horizontal and vertical histogram - Center of mass - Normalized area - Aspect ratio - Three surface features - Six fold surface features - Transition feature [8]	Neural Network (NN)	GPDS	FAR – 14.7% FRR – 20.0%
- Centroid - Trisurface - Six-fold surface - Shape number [9]	Euclidean distance	GPDS	FAR – 43.6% FRR – 38.1%
- Height - Width - Diagonal distance - Aspect ratio - Center of gravity - Area of black pixel - Middle zone - Energy features [10]	Correlation technique	GPDS	FAR – 6.67% FRR – 36.67%
- Maximum histogram and vertical histogram - Center of mass - Normalized area of signature - Aspect ratio - Tri surface feature - Six fold surface feature - Transition feature [11]	Neural Network (NN)	GPDS	The correct classification rate of the system is 82.66% in generalization
- Outer and inner contour - Slope of different strokes - Angle between two consecutive strokes [12]	Mathematical Morphology	GPDS	EER (local) – 32.8% EER (global) – 25.2%

GEOMETRIC CENTER FEATURE APPROACHES

Features	Classifier	Database	Results
- Depth - Vertical splitting - Horizontal splitting [13]	Euclidean distance	GPDS	FAR – 6.8% FRR – 14.0%
- Horizontal splitting - Vertical splitting [14]	Degree of Stability	GPDS	Middle Area of the signature is more stable than Bottom and the Top areas
- Geometric center - Vertical splitting - Horizontal splitting [15]	Neural Network (NN)	GPDS	FAR – 12.0% FRR – 16.7%

4 DISCUSSION

Based on Table 1, geometriccenter approaches give lower percentage of FAR and FRR than the global approaches as a whole. Althoughglobal features are easily extractable and insensitive to noise,they are dependent upon the position alignment and highlysensitive to distortion and style variations. Unlike global features,geometric featurespreserve both global and local properties of signature. Geometrical features have ahigh tolerance to distortion and style variations, and they canalso tolerate a certain degree of translation and rotationvariations.In addition, the performance by using global center approaches is not impressive since it is less accurate due to the use of too many features. With modern computers, there is a need to develop fast and accurate algorithms for signature verification.

Geometrical approaches are broadly used in Image Processing areas such as Computer Vision, Pattern Recognition, and Segmentation. In the area of handwritten signature verification, especially offline signature verification, different technologies have been used and still the area is being explored. Future works will be focused on adapting the classification function dynamically to the signature for authentication, and thus combining the advantages of both approaches. Future direction in this study is classifying the skilled forgeries correctly.

5 CONCLUSION

In this paper, we have reported on the experiments conducted to evaluate the performance of global and geometric center features for the off-line signatures verification. Results from both features are compared on benchmark database which is GPDS.In conclusion, results show that the best performance of signature verification was achieved by geometric centerfeatures, as an overall.

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ZuraidasahanaZulkarnainobtained her bachelor degree in Computer Graphics and Multimedia from UniversitiTeknologi Malaysia, Currently; she is a Masters student at the Faculty of Computing, Universiti Teknologi Malaysia. She is a member of UTM VicubeLab research group at Faculty of Computing, Universiti Teknologi Malaysia. Her research interests include image processing and computer vision.

Mohd Shafry Mohd Rahim is an Associate Professor of Computer Graphic and Image Processing at Universiti Teknologi Malaysia. He received his B. Sc. (Hons.) in Computer Science (1999) and his MSc. in Computer Science (2002) from Universiti Teknologi Malaysia. Then, he obtained his Ph. D. in Spatial modelling from Universiti Putra Malaysia at 2008. The rapid development in the field of Computer Graphics caused him eagerly want to share his acquired knowledge. To realize his desire, he has started his career as a lecturer at CITI College, Taiping, Perak in early 1999 and continued his work at Universiti Teknologi Malaysia. He was appointed as a Senior Lecturer at the age 32 years during his early involvement with UTM and as an Associate Professor 4 years later. Now, he focused his research together with his research group, UTM ViCube Lab under Faculty of Computing, UTM. He is expert in research area of computer graphic and image processing. His passionate with his research area make him published more than 70 papers for journals and conferences. He appointed as Deputy Director of Centre for Joint Programme, UTMSPACE. He is also a member of UTM-IRDA Digital Media Centre, Universiti Teknologi Malaysia. In addition, he experienced as ICIDM 2012 conference's chair and has appointed as Chief Editor for International Journal in Interactive Digital Media.

Rosely Kumoi is a lecturer in Department of Graphic and Multimedia, Universiti Teknologi Malaysia. He received his B.Sc Comp. Ed. In Chemistry (1996) from Universiti Teknologi Malaysia and continued with M.Sc. in Distributed and Multimedia Information Systems (1998) from Heriot-Watt University, Edinburgh Scotland, UK. Until now, he is working on his PhD at Universiti Teknologi Malaysia. His research area is in Web-based system/application development (web engineering), E-Commerce, Distributed systems / applications, Java technology, Web based knowledge/information management – structuring, storing, integration and extraction, XML technology, GRID Computing and Bioinformatics. He is a member of UTM ViCubeLab Research Group under Faculty of Computing, Universiti Teknologi Malaysia, Skudai, Johor.