Improvement On Triangle Features Based Grouping Features for Offline Digit Handwriting

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***Abstract*— An offline digit handwriting recognition is one of an active studied that has been explored in the field of pattern recognition. In this paper, an improvement on triangle features based grouping features is proposed. It uses to overcome the problem of processing data where the performance is slow based on time training. This problem occurred due to the huge size of the number of triangle features are used. The grouping features are focused on triangle properties of ratio and gradient where the outcome of this grouping features will produce five triangle features which are gRatio-ABC, gGradient-ABC, angle point A, angle point B and angle point C. Then, the converting process using the absolute value function is applied to increase the classification accuracies for digit dataset of IFCHDB, HODA, MNIST and BANGLA. A classifier of Support Vector Machine was used to measure the accuracies.**

***Index Terms*— Digit Handwriting; Support Vector Machine; Triangle Geometry; Triangle Features.**

I. INTRODUCTION

Offline handwriting recognition involves a process of converting the person handwriting into an image by representing them in letter codes that can be used within the computer and other image applications. In other words, the offline handwriting is captured optically using the scanner and presented them as an image [1]. The study of offline handwriting recognition especially an ancient manuscript such as Arabic [2]–[4], Chinese [5]–[7], Hebrew [8]–[10], Indian and Roman has been actively explored since over four decades ago. Most of the ancient manuscripts have their own difficulty in recognizing the style, pattern, type, the number of authors, date and the origin of the manuscript itself. An offline handwriting recognition becomes a challenging task due to a variety of reasons such as most of the approaches require accurate segmentation of text but not perform well on text handwriting [11]. Thus, various methods and techniques have been proposed from date to date in order to recognize the handwriting.

According to [1], the most common approaches in recognizer system are Hidden Markov (HMMs), Artificial Neural Networks (ANNs) and Support Vector Machine (SVM). Besides that, M. Abaynarh and L. Zenkouar [12] also has stated that ANNs and HMMs are most used amongst the techniques of handwriting recognition. R. Radika et. al [13] has implemented HMMs technique for recognizing Jawi word. The result of the experiments has shown improvement in recognition rate. Besides that, Jawad et. al [14] also has used HMMs for offline handwritten Arabic cursive text recognition. Besides that, the SVM technique also has been widely applied in handwriting recognition. Arbain et. al [15] has applied SVM technique to measure the accuracies for digit recognition. Azmi et al. [16] also have applied the libSVM technique for defining the best cost and gamma of the dataset. The best cost and gamma was used to obtain the highest accuracy for the dataset.

However, some of the studies have proposed the hybrid techniques for some reasons whereas the results proposed can improve the accuracies and performances. H. Zhang et al. [17] proposes a hybrid of two methods which are SVM and K-nearest neighbor (KNN). This hybrid method was proposed as their compatibility in dealing with the computational complexity for both training and at run-time.

This paper focuses on improving the triangle features based grouping features for an offline digit handwriting recognition. The proposed method was adapted from triangle nature. This paper is organized as follows. In Section II, a brief of a literature review about related work is discussed. In Section III, the proposed method is explained. The result and discussion are covered in Section IV. Finally, in Section V, we conclude the paper.

II. LITERATURE REVIEW

The geometry method such as a triangle has been applied in [15], [16], [18] to recognize the digit handwriting. The author of [18] uses triangle geometry properties such as ratio, angle, and gradient for each of triangle's point as the features. Then, the author of [18] has applied zoning method to generate more features. There are 297 features has been generated through four types of zoning method in [18].

Next, the same method (triangle geometry) has been applied by [16] to improve the classification accuracy result through data normalization. The study in [16] has reported that the data normalization method is suitable to be used in their feature extraction that uses triangle geometry features.

The author of [15] has proposed a detection on straight line problem that occurred during triangle geometry formation. The four digit datasets from HODA, IFCHDB, BANGLA, and MNIST have been used to be tested in the experiment. The studies in [15] have applied same triangle features that used in [18]. The results in [15] have shown improvement for SVM technique but less for MLP technique. However, the proposed method in [15] has been successfully applied to overcome the straight line problem in triangle geometry formation.

The exploration in offline handwriting is not only focused on digit handwriting but also on character handwriting. A haar wavelet-based zoning method has been used by [3] to compute the 1 level Haar Wavelet Transform for binary character images. The author of [3] divides the wavelet space into eight zones where each zone will be extracted three types of features which are mean, standard division and skewness. Then, the Mahalanobis distance was used by [3] to obtain the recognition accuracy result. It resulted in 73% for recognition accuracy after applying the proposed method [3]. The proposed method by [3] has been tested on offline Arabic characters.

III. Proposed Method

In this section, the proposed method is discussed. The proposed method consists of two main stages. In the first stage, the selecting triangle features are performed. The next stage is applying absolute value function to the triangle features' value to obtain the positive value for the result. A schematic diagram of the proposed method is shown in figure 1.

A. Stage 1: Selecting triangle features for grouping features

In stage first, the geometry properties used by [18] is investigated. There are three main geometry properties used by [18] which are ratio, angle and gradient. For constructing triangle shape, three points are required where the triangle features are generated based on triangle points' ratio, angle and gradient. Thus, nine triangle features are produced. The selection of triangle features was performed based on the characteristic of the triangle properties itself. Among three triangle properties, only two properties were fit to be grouped. The triangle properties of ratio and gradient were chosen based on their independent characteristic that not reliant on to any number. This can be explained based on the characteristic of angle where the total angle of triangle shape is 180 degree which caused the angle is not reliable to be the independent features as well as ratio and gradient. The grouping features were performed by grouping the same properties from each of triangle points as shown in Figure 3. Then, the values of the ratio for triangle points of A, B and C will be combined by adding the values between points A, B and C which is producing a new feature namely gRatio-ABC. This method was also applied to the gradient feature which is producing a new feature namely gGradient-ABC. Thus, the outcome of grouping features, it has produced five features which are gRatio-ABC, gGradient-ABC, the angle of point A, the angle of point B and angle of point C.

B. Stage 2: Converting triangle features' values using absolute value function

In this stage, all the values of triangle features were converted into positive value using absolute value function. For example, the value would be written $|-7.598| = 7.598$ and $|7.598| = 7.598$. The process of converting was applied after the process of grouping features were performed as shown in figure 2.

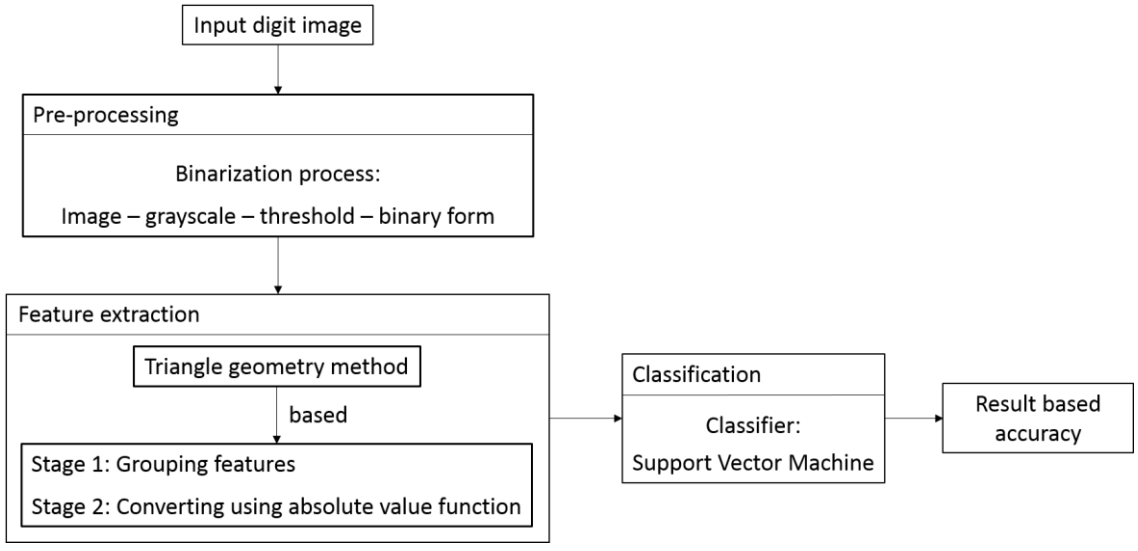

Figure 1: A schematic diagram of the proposed method

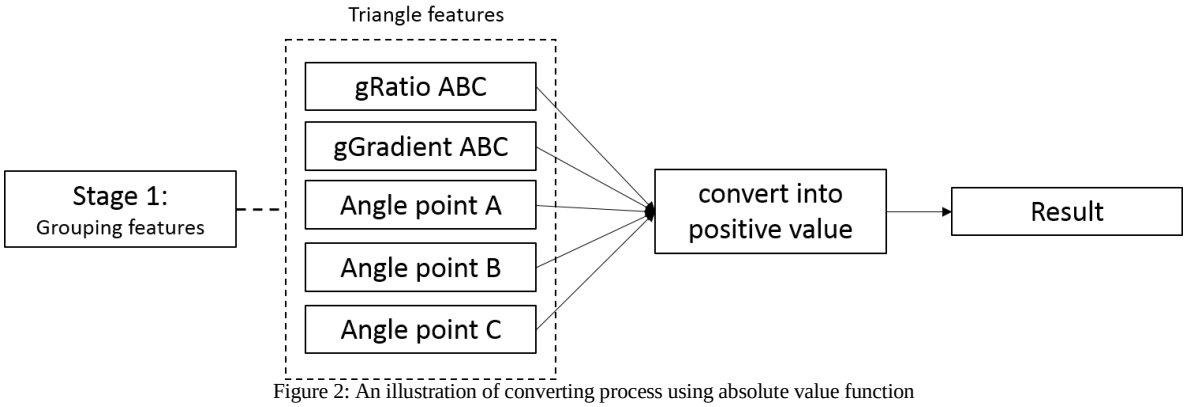

Figure 2: An illustration of converting process using absolute value function

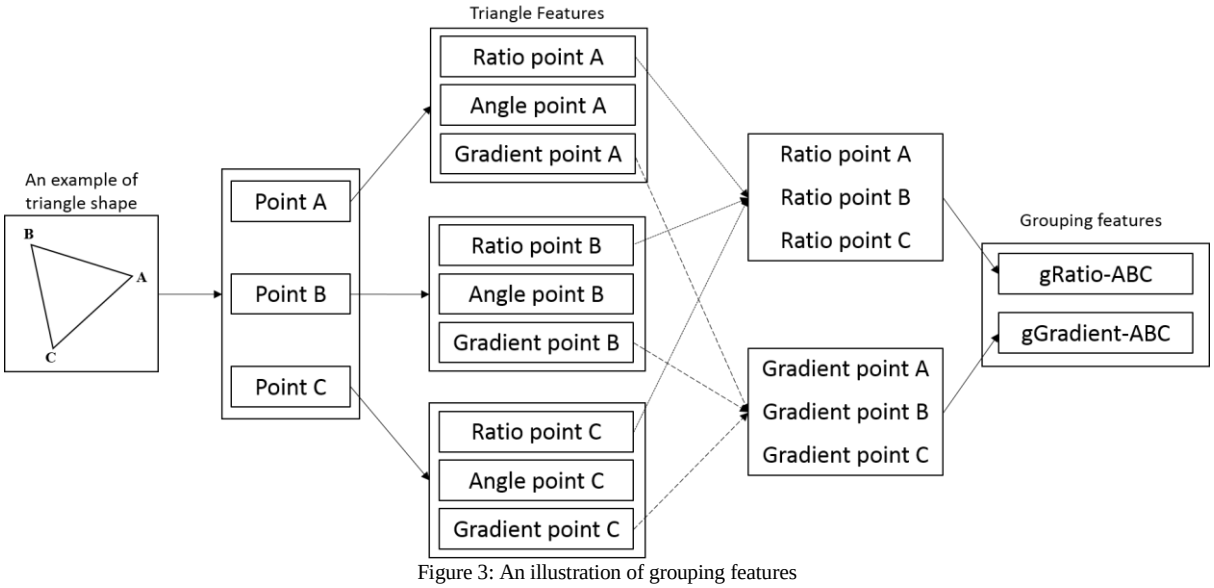

Figure 3: An illustration of grouping features

IV. Result and Discussion

There are four types of digit datasets were tested in the experiments namely IFCHDB [19], HODA [20], MNIST [21] and BANGLA [22]. Both datasets of IFCHDB and HODA are from Arabic handwriting. The MNIST dataset is from Roman handwriting while BANGLA dataset is from Indian handwriting. The classifier of SVM was applied to measure the accuracy of tested digit datasets. However, the accuracy result using SVM is reliable on the best value of both parameters which are cost and gamma. Based on [23], LIBSVM is a library for SVM. The LIBSVM obtains cross-validation (CV) accuracy. Thus, the LIBSVM was used to check a grid of parameters. Table 1 shows the results of best cost (c) and gamma (γ) for each of dataset.

The comparison was made between Mohd Sanusi Azmi's study [24] and our present proposed method. The author of [24] proposes 297 triangle features based on triangle properties of ratio, angle and gradient. Meanwhile, our present proposed method had used the same triangle properties but proposes a different approach by grouping the features from the original triangle features proposed by [24]. The result of comparison between the previous study with presently proposed method was illustrated in table 2. Based on table 2, the training time taken for datasets of IFCHDB, HODA and MNIST have shown improvement compared to the result training time taken from the previous study. The improvement result based training time taken had achieved based on the reduction size of triangle features from 297 to 166. However, the improvement based accuracy result has only achieved for IFCHDB dataset. Even though there was no improvement based on accuracy results for a dataset of HODA, BANGLA and MNIST but the significant value has shown slightly value between previous study and presently proposed method.

Table 1
Results of cost and gamma for each dataset

Dataset	Cost (c)	Gamma (γ)
IFCHDB	32.0	0.00048828125
HODA	32.0	0.001953125
BANGLA	32.0	0.001953125
MNIST	8.0	0.0078125

Table 2
Results of classification accuracies (%) and training time (s)

Method		IFCHDB	HODA	BANGLA	MNIST
Mohd Sanusi Azmi (2013) (297 features)	**Classifier SVM**	**93.58 %**	**97.30 %**	**90.28 %**	**95.35 %**
	Training time	112.87s	1223.82s	231.77s	3703.21s
Proposed Method (166 features)	**Classifier SVM**	**94.48 %**	**96.37 %**	**89.85 %**	**92.85 %**
	Training time	19.77s	167.23s	236.54s	1860.49s

V. CONCLUSION

This paper presents the proposed method to increase the result of classification accuracies through improvement on triangle features based on grouping features. There are two important stages in the proposed method of this paper. In the first stage, the grouping features are applied to reduce the size of a number of triangle features from nine to five features where the outcome of total proposed features is 166 features compared to 297 features. In stage two, the converting process for triangle features' values into positive value using absolute value function was applied to increase the accuracy results for IFCHDB, HODA, MNIST and BANGLA. In this paper, the results of training time taken were recorded as the proven for improvement made to increase the result. The improvement based on training time took using SVM classifier was successfully applied on IFCHDB, HODA and MNIST. Further research is needed to increase the accuracy result by selecting appropriate features using feature selection technique.

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