Rearrangement of Coordinate Selection for Triangle Features Improvement in Digit Recognition

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***Abstract*— Triangle geometry feature demonstrated as useful properties in classifying the image. This feature has been implemented in numerous recognition field such as biometric area, security area, medical area, geological area, inspection area and digit recognition area. This study is focusing on improving triangle features in digit recognition. Commonly, triangle features are explored by determining three points of triangle shape which represent as A, B and C to extract useful features in digit recognition. There is possibilities triangle shape cannot be formed when chosen coordinate are in line. Thus, a prior study has proposed an improvement on triangle selection point technique by determining the position of coordinate A, B and C use gradient value to identify the triangle shape can be modelled or vice versa. The suggested improvement is based on the dominant distribution which only covers certain areas of an image. Hence, a method named Triangle Point using Three Block (Tp3B) was proposed in this study. The proposed method proposes the arrangement of selection coordinate point based on three different blocks which where all coordinates points of an image were covered. Experiments have developed over image digit dataset of IFCHDB, HODA, MNIST and BANGLA which contains testing and train data of each. Features classification accuracy tested using supervised machine learning (SML) which is Support Vector Machine (SVM). Experimental results show, the proposed technique gives a promising result for dataset HODA and MNIST**

***Index Terms*— Digit Recognition; Triangle Feature**.

I. INTRODUCTION

Recognition related studies and activities became popular and gave significant impact in supporting our real-life activity since many of our routine activity has been supported by the system these days. Recognition area is a part of image processing fields which has been evolved and grows to be imperative in various expanses such as in intrusion detection[1], medical area [2], geological area [3] , inspection area [4] and digits recognition [5]. Advancing many real-world application in understanding natural handwritten and language, improving maps and navigation, accessing knowledge, identifying the origin of the document or manuscript, efficient and accurate registration plat number and many others have bringing digit recognition is among favorite topic chosen by the researcher. In 2013, [6] has to recognize that research in English handwritten words and digits is started from about 50 years ago and Arabic and Persian handwritten words and digits are started from about 28 years ago.

Feature extraction is an important activity in recognition applications as a part of crucial steps to determine and classify an image. There are many studies brings verity of feature extraction methods and keep progressing because the successful degrees of each method will be varied depends on specific recognition problem and available data [5]. Numerous methods and technique has been proposed and improved by the image processing researcher in digits recognition features extraction to evaluate the classification accuracy and performance such as hamming distance neural networks [7], local binary pattern and K-Nearest neighbor [8] , Change Code Histogram (CCH) using SVM [9], biologically inspired model [10] and triangle features [11]–[14]. Each method suggests an improvement of earlier methods depends on dataset chosen.

Triangle geometric shape formed by identifying three coordinate points to represent each triangle edges. Selection of point methods will determine triangle edges which useful in features extraction to recognize a pattern in image processing. [14] has highlighted the problem in triangle features in digit recognition when three coordinate is chosen avoiding triangle shape to be modelled. The researcher has proposed the improvement method of point selection by identifying three inline coordinates from [15] to solve this problem. However, enhancement of triangle geometry formulation proposed by [14] only discovers a part of an image that produces straight line problem and concentrating on neighborhood pixel using dominant distribution. Besides that, analysis of this approaches found that triangle shape formed is very tiny that may not signify for complex digit image classification.

Therefore, it led to a new investigation and motivating this study to be carried out in order to propose a new enhancement

of triangle coordinate selection method. The proposed triangle coordinate selection technique will consider the whole of an image coordinate using three (3) block selection point which expected will produce larger size triangle shape compared with shape generated proposed in earlier studies [14], [15]. Besides, proposed method predicted will improve classification accuracy rate for digit image classification. Digit dataset HODA, BANGLA, MNIST and IFCHDB will be used to evaluate the effectiveness of proposed methods to classify digit image. The images will be processes and converted into binary form before triangle coordinate can be plotted over the digit images. The completeness of dataset will influence the experimental results. Thus, dataset completeness can be measured using the technique as proposed in [16].

II. TRIANGLE FEATURES

Triangle geometry features are the main interest of this study. Triangle features method broadly adapted to numerous field of recognition study. Determining three points of triangle coordinate is the highest focus in the triangle features extraction for digit recognition since it will influence to features extracted and classification results.

The adaptation of triangle features in digit recognition applied in [13] by extracting triangle features from scalene triangle shape. The motivation of the study is to portray real and hidden information of Malay manuscript such as the origin of the paper and when it been published. The scalene triangle shape has constructed by determining point A, B and C and it produces six different triangle block. The triangle block represents by shape A, B, C, D, E and F. Each shape determined by evaluating the position of *y*-coordinate for points A, B and C. Table 1 presents scalene triangle shape formation formula. Thus, Twenty-one (21) features extracted and presented including the produced six block for image classification.

Table 1
Position y-coordinate in determining triangle shape [13]

Shape	Coordinate of y
A	$yA \geq yC \geq yB$
B	$yA \geq yB \geq yC$
C	$yA \leq yC \leq yB$
D	$yA \leq yB \leq yC$
E	$yA \geq yB \geq yC$
F	$yA \geq yC \geq yB$

Later in 2013, [15] has to exploit tringle features in the classification of digit dataset. The main problem addresses in the study is to determine the location of point A, B and C. They proposed coordinate C be as the centroid of the image based on black pixels. Then, the location of coordinate A and B will be determined using formula (1).

$$B_x = 0 \text{ until } B_x <= C_x \; ; \quad Ax = C_x \text{ until } A_x <= N\text{-}1 \qquad (1)$$

However, using formula (1) had triggered the formation of a straight line when point A and B generated results in the same gradient which it led to false features extraction. [15] has extracted digit dataset using zoning method which location of A and B were identified. Next, the enhancement of this method has been proposed to solve straight line problem by detecting the occurrence of formation straight line and divided each main zone into four fragments [11], [14].

Table 2 presented the mathematical formula in constructing zone fragmentation. Figure 1 illustrates isolation of Zone A into four fragments. Point A and point B in figure 1 show the straight line occurrence sample in the coordinate image. Proposed enhancement by [14] only happens when the straight line was detected. Thus, to solve this problem, the researcher has proposed to add the value of one for each coordinate *x* and *y* when the total number of the fragment is the highest. Otherwise, the coordinates of *x* and *y* for the selected point of the corner was minus by one.

III. PROPOSED METHOD

Proposed method in this study focus in triangle selection point technique using three blocks of overall image coordinate in order to recommend triangle features enhancement in digit recognition.

Table 2
Fragments for each of corner [14]

Point of Corner	Involved Fragments	Comparison
A	Fragment I (*f1*) and 3 (*f3*)	$f1 \geq f3$
B	Fragment 2 (*f2*) and 4 (*f4*)	$f2 \geq f4$
C	All fragments	$(f1 + f3) \geq (f2+f4)$

This technique name Triangle Point using Three Block (Tp3B). Tp3B developed by rearranging digit image coordinate prepared in [15]. This original triangle coordinate is constructed based on 297 features that have been extracted via zoning method in features extraction phase. Coordinate selection applied in Tp3B is to divide whole image coordinate into three (3) main block and coordinate A, B and C will be chosen in a different block to produce huge triangle shape. This technique maintains an original number of features which is 297 features for digit recognition.

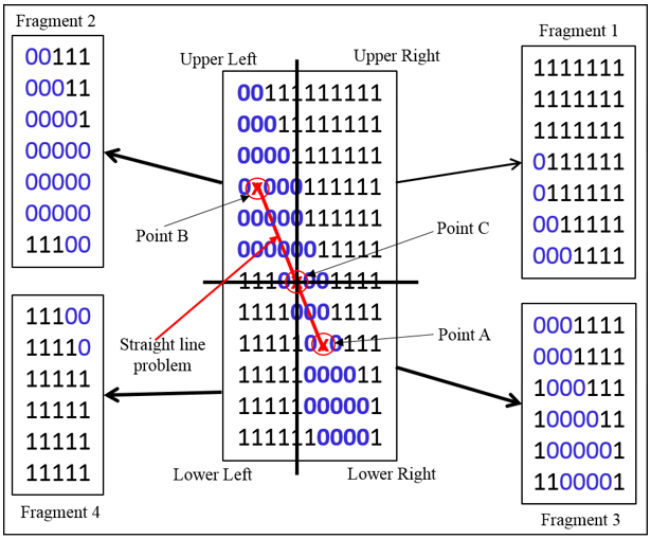

Figure 1: Straight line problem and the zone fragmentation method [14]

In this paper, Tp3B will be applied to classify the digit dataset of HODA, MNIST, BANGLA and IFCHDB. Then, the classification accuracy rate will be evaluated using supervised virtual machine library tools (LibSVM). Besides, the performance of Tp3B will be measured by comparing the results with benchmark results.

A. Development of Tp3B

The development of Tp3B technique is by dividing the whole coordinate of digit image into three (3) main block to

a formed triangle shape. Each of Point A, Point B and Point C will be chosen from different block 1, 2 and 3 consecutively. Figure 2 presents pseudocode of Tp3B.

After Tp3B has done the proses, those new coordinate of each dataset will be recorded into CSV files for feature extraction. Then, features extraction of Tp3B also recorded in CSV files as an input to the next process which is features classification.

```
Start
Initialize counter, counterB, counterC,
new_coordinate
Read file and get original point set data
Get total point  → total_point
Get counterB ← total_point/3
Get counterC ← counterB*2

while original_point <> 'EOF'
for counter = 1, counter < counterB
     A ← original_point (counter)
     B ← original_point (counter + counterB)
     C ← original_point (counter + counterC)
     add to new_coordinate (A,B,C)
   counter++
end for
end while

Write into file new_coordinate
End
```

Figure 2: Tp3B Pseudocode

IV. IMPLEMENTATION

Experiment approach was applied in this study to measure proposed technique efficiency in digit recognition classification. Experimental design carried out in this study presented in figure 3.

A. Development of experiment

The experiment implemented to coordinate image of digit dataset BANGLA, HODA, IFCHDB and MNIST as established in [15]. Each of them contains two files which are testing data and train data. As stated in experimental design, it starts with reading original coordinate digit image of each dataset. Then, each coordinate will be rearranged using the Tp3B technique to produce a new set of triangle coordinate. Those new coordinate will be recorded into CSV files with given name new_&inputfilename. Image file name and data type also recorded to ensure it will be meaningful input for features extraction phase.

Then, features extraction will be conducted on each of the new coordinate files formed using the Tp3B (new_&inputfilename) above using scalene algorithm [15] with small modification as error handling purposes established. Feature extraction in the scalene algorithm has covered straight lines problem and enhance using object point selection technique by [14]. Each new features extracted has been recorded into a new csv file with naming NF_&inputfilename.

Triangle features proposed by Tp3B in classifying digit image dataset measured using SVM. It will be described in details in next section.

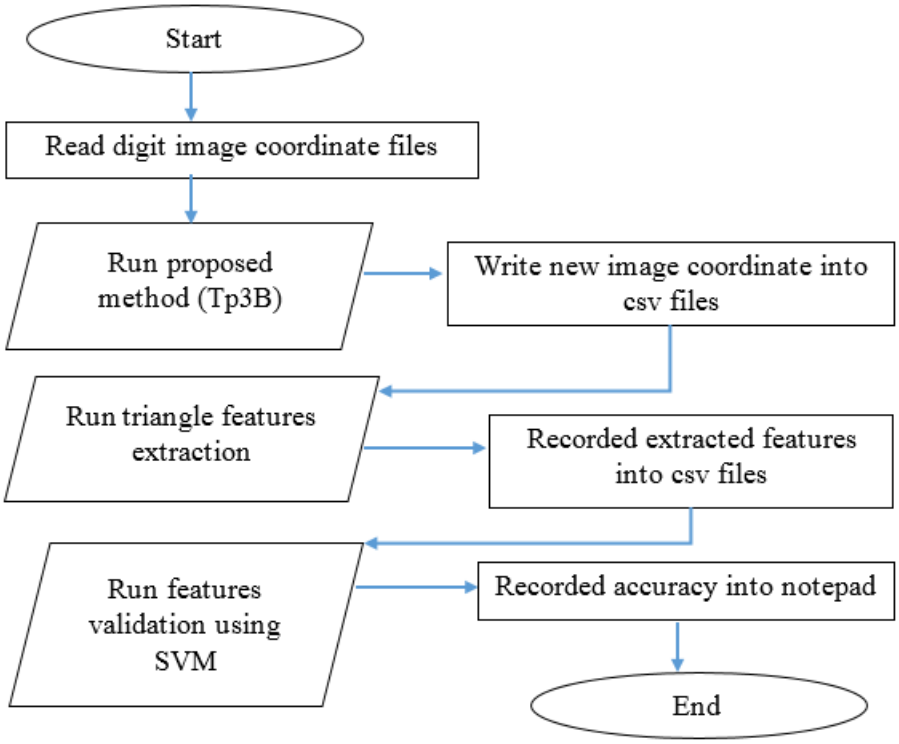

Figure 3: Experimental Design

B. Classification Accuracy

Classification accuracy of Tp3B is handled using support vector machine (SVM) which is supported by Weka 3.8 tools with LibSVM function. This is a stable version of open source SVM. This tools also has been adapted by the previous researcher, so that their results can be benchmark result to evaluate classification accuracy performance of Tp3B.

To determine the best gamma and cost value to be applied by LibSVM Weka tools for features extraction on Tp3B, LibSVM Grid search tool has been implemented. The result

from grid search obtained cost value is 128.0 and gamma value is 3.0517578125e-05 for all dataset. Figure 4 shows LibSVM grid search result in obtaining best value of cost (c) and gamma (γ) for BANGLA dataset.

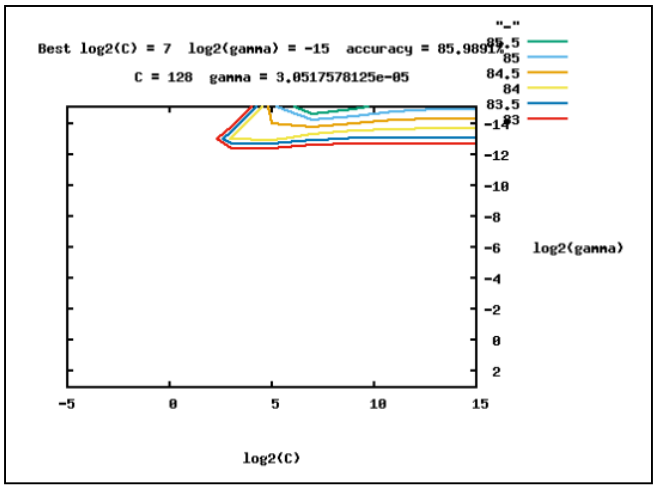

Figure 4: Grid search result over Bangla dataset

This c and γ value will be vary depends on input features in our study. Table 2 presented best c and γ value over method proposed in [14] and Tp3B. Experimental results may obtain fair result if not use suitable c and γ value.

V. Result And Discussion

After value c and γ has been determined, which are 128.0 and 3.0517578125e-05 respectively, triangle features classification accuracy measured using Weka LibSVM. Tp3B accuracy results and the Tp3B performance evaluation results will be discussed shortly.

A. Accuracy Results

Tp3B methods show promising result over digit dataset BANGLA, HODA, IFCHDB and MNIST which all of them obtain more than 80 percent accuracy. Table 3 shows the experimental results achieved from this study.

Based on results achieved, lowest accuracy evaluation recorded for digit dataset Bangla with only earned 83.8 accuracies. Followed by MNIST with 91.7726% classification accuracy. While IFCHDB shows the good result with recorded accuracy percentage 92.369%. HODA dataset illustrates the highest percentage with 95.83% accuracy with the number of instances correctly classified is 19166.

B. Performance Analysis

The Tp3B performance analysis will be determined by comparing achieved accuracy results in this paper with accuracy results obtained by [14], [15] as a benchmark performance. Table 4 presented the comparison of said results.

Refers to the performance of the proposed technique as tabulated in table 4, Tp3B has lower accuracy rather than MSA and TD^{2}FI for all datasets in this experiment. Result recorded by Tp3B slightly better than TSGR and EFTA achievements for dataset HODA. HODA accomplish 95.83% using Tp3B while TSGR and EFTA achieve 95.335% and 95.515 respectively. Against of MNIST data, an average of improvement classification accuracy by Tp3B recorded almost 1% better than TSGR and EFTA. It demonstrates that Tp3B can be measured as suitable to classify HODA and MNIST dataset, but not for IFCHDB and BANGLA.

Table 3
Comparison Best Value of c and γ

Dataset	Tp3B		TD^{2}FI [14]		TSGR [14]		EFTA [14]	
	c	γ	c	γ	c	γ	c	γ
IFCHDB	128.0	3.0517578125e-05	8.0	0.00048828125	32.0	0.00048828125	32.0	0.00048828125
HODA	128.0	3.0517578125e-05	8.0	0.0078125	8.0	0.001953125	32.0	0.001953125
MNIST	128.0	3.0517578125e-05	8.0	0.0078125	8.0	0.0078125	8.0	0.0078125
BANGLA	128.0	3.0517578125e-05	8.0	0.001953125	32.0	0.001953125	32.0	0.001953125

Table 4
Tp3B Classification Accuracy Result

No.	Dataset	Total Instances	Correctly Classified	Incorrectly Classified	Accuracy Result (%)
1	IFCHDB	5268	4866	402	92.369
2	HODA	20000	19166	834	95.83
3	MNIST	9991	9169	822	91.7726
4	BANGLA	4000	3352	648	83.8

Table 5
Comparison of Accuracy Results

Method \ Dataset	IFCHDB	HODA	MNIST	BANGLA
MSA [15]	94.856%	99.695%	94.06%	88.775%
TD^{2}FI [14]	94.1913%	96.375%	93.58%	89.2%
TSGR [14]	93.3371%	95.335%	93.58%	86.325%
EFTA [14]	93.7547%	95.515%	90.29%	87.45%
Tp3B	92.369%	95.83%	91.773%	83.8%

VI. Conclusion

Triangle geometry features have given a significant contribution in various recognition field. [15] has proven the successfulness triangle features in classifying digit image. [14] has improved triangle features by focusing in straight line problem which avoids false triangle classification and proposed an enhancement of triangle features extraction technique. Since the improvement carried out by [14] focus in straight line problem in a specific zone of the image, this study has expanded prior study to discover enhancement of triangle features which cover overall of an image.

Triangle Point using Three Block (Tp3B) has introduced fresh triangle point selection technique in forming triangle shape in order to improve triangle features for digit recognition. Experimental results discover that Tp3B has suggested a good alternative to extracted triangle features in order to recognize digit image. The tp3b technique suggested new triangle coordinate selection approaches which cover overall of digit image. Triangle shape formed by Tp3B is wider rather than triangle shape produced in the previous study. Thus, Tp3B predicted will give high accuracy for large digit image.

Accuracy evaluation results show Tp3B give promising result over dataset HODA and MNIST with achieving 95.83% and 91.773% respectively which better compared to TGSR and EFTA. Thus, this technique has enhanced triangle features extraction to classify the digit image.

Recommendation of future study is to apply normalization technique over Tp3B to gain better result in accuracy. Besides that, to evaluate the accuracy using a different set of data using various classifier may a good future work to explore. Furthermore, the quality of achieved results can be measured using quality tools such as using the technique as proposed in [17].

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