The Template Matching Method for The OCR system of Thai Car License Plate

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***Abstract*— This paper presents the similarity method to enhance the performance of the template matching method for Thai optical character recognition for car license plate. The proposed similarity method is the average percentage of similarity between template image and input image. From the experimental result, the proposed similarity method for template matching gain better result than the traditional method which concern only the percentage of the similarity to template image. The result of the experiment from 202 samples which comprise of 44 Thai characters and 10 digits show that the accuracy rate of the system is 98.51%.**

Keywords*— *Digital image processing; License plate; Optical character recognition; Similarity method; Template matching

I. INTRODUCTION

The identification of a car plays an important role on Intelligent Transportation system (ITS) such as: unattended parking lots, automatic toll collection, traffic data collection, crime prevention and investigation and so on. Therefore, the automatic license plate recognition (LPR) is required. It is an image processing application area which can locate license plate, segment alphanumeric characters on the plate, and recognize these characters. Many researches have been proposed methods to recognize alphanumeric characters such as decision tree [1], Hausdorff distance technique [2], Neural Networks [3-5], template matching [6,7].

This paper proposes the similarity method used in template based pattern matching for Thai alphabet and Arabic numerals recognition of license plate. The proposed similarity method is the average percentage of similarity between template image and input image.

II. THAI CAR LICENSE PLATE RECOGNITION

A. Structure of Thai Car License Plate

This research focused on 4-wheel Thai car license place image, an example of 4-wheel Thai car license place image is shown in Fig. 1. The license place image is composed of two lines. The upper line consists of 2-3 alphanumeric characters category, following by 1-4 digits running number. The lower line represents province name. This research is working on the upper line of Thai car license place image.

Fig. 1. Structure of Thai Car License Plate.

B. OCR of Thai Car License Plate Recognition

In 2001, Laokulruch and Areekul [1] presented Thai vehicle license plate automatic recognition using Characters Cut and Classification method. The method cuts characters in horizontal and vertical directions and classifies cutting points with tree structure resulting in fast computation time. The experimental result showed that 70.59% of vehicle license plates were correctly recognized. Fig. 2 shows the example of tree structure proposed by Laokulruch and Areekul.

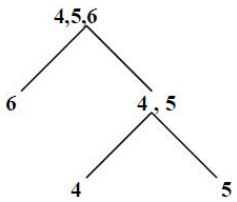


Fig. 2. Tree structure of number 4, 5 and 6.

In 2005, Juntanasub and Sureerattanan [2] divided each character pattern into 5 x 5 blocks as shown in Fig. 3. Therefore, each character will have 25 values in which each value will have its own accumulated pixel intensity. After that, they recognize character by using Hausdorff Distance technique (HD) for similarity measurement. The recognition accuracy rate was 92%.

In 2010, Leelasantitham and Kiattisin [3] transformed the image size of each character into 40x80 pixels (3200 pixels) to be an input for the neural network. The neural network used to recognize Thai character is three-layer back-propagation neural network (BPNN). The BPNN structure has 3 layers; 3201 nodes of input layer including bias 1 node, 100 nodes of hidden layer and 54 nodes of output layer, as shown in Fig. 4. The results reveal that an accuracy rate of this method is 97.00%.

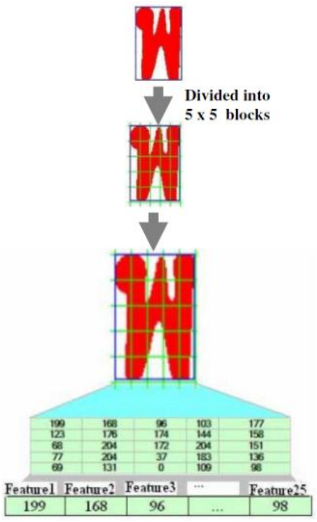


Fig. 3. Features extraction process.

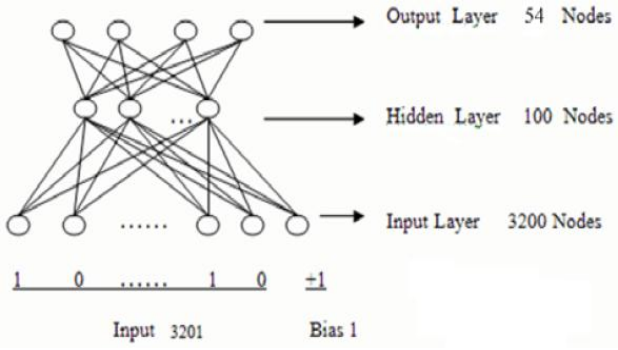


Fig. 4. Three-layer back-propagation neural network.

In 1998, Sirithinaphong and Chamnongthai [4] using four-layer back-propagation neural network to recognized characters and numbers as shown in Fig. 5. The accuracy rate of this experiment was 80.81%.

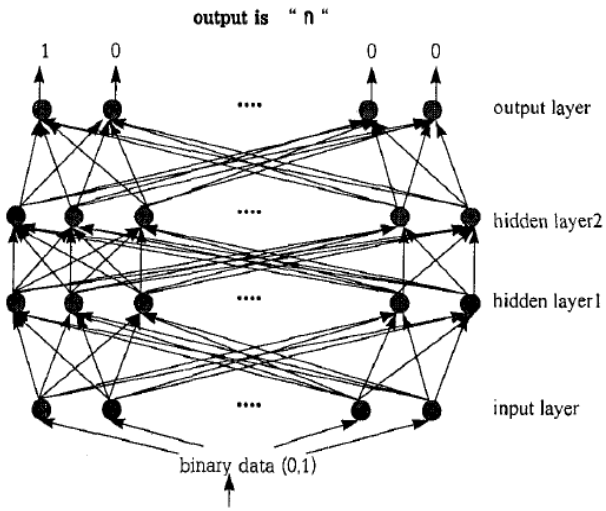


Fig. 5. Four-layer back-propagation neural network.

In 2012, Sutheebanjard [5] presented the method for Thai optical character recognition for Thai car license plate. The method composes of two important steps to input data for the recognition and prediction system. Firstly, the group of characters will be divided into subgroups depending on its own dominant features [8]. The features of the character can be divided into 2 categories, a number of character's legs and character's borders (lower border and upper border). There are three types of character's legs as 1 leg, 2 legs, and 3 legs as shown in Fig. 6 and there are two types of border as open and close. The example of lower border (open and close) was shown in Fig. 7. The process is determined by using histogram.

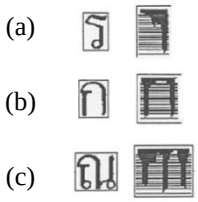


Fig. 6. Three types of character's legs.

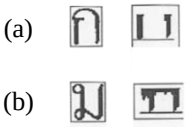


Fig. 7. Lower border (open and close).

Secondly, after categorizing the group of characters, the image of characters will be transformed into 40x56 pixels and then divided into 5x7 blocks (block size is 8x8 pixels) as shown in Fig. 8. Later, the number of cumulative frequency of pixels in each block will be counted to be an input for the four-layer back-propagation neural network (BPNN) to recognize and predict the characters. The results of the experiment from 202 samples show that the accuracy rate of the system is 96.04%.

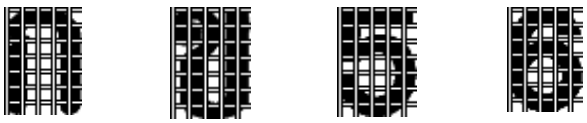


Fig. 8. The character divided into 5x7 blocks.

In 2011, Martínez-Carballido *et al.* [6] proposed the method to recognize digit by using digit template. It is the 5x7 pixels template which comprise of only 0 or 1 in each pixel. This method will reduce the size of the digit into 5x7 pixels (as in Fig. 9) and compare with the template to select one with the smallest difference. The result showed 97.3% of correct recognition rate.

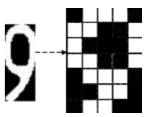


Fig. 9. Reduced digit (5x7 pixels).

In 2012, Sutheebanjard [7] proposed the OCR system of Thai alphabet and Arabic Numerals for Car License Plate Recognition by using Template Matching. This system composed of two steps. Firstly, the image size of each Thai alphabet and Arabic Numerals was reduced to 40x56 pixels. Secondly, the transformed image will be compared with template images to recognize and find out the result.

There are 54 templates composed of 44 Thai character templates and 10 numeric templates. All the 54 templates were used to recognize 3-position alphanumeric character category and the 10 numeric templates were used to recognize 1-4 digits running number.

The process of comparing Thai alphabet and Arabic numerals image with the template image is to count the number of object pixels of the input image at the same position as the template image (n_m). Then, this number will be calculated as the percentage of the similarity to template image (sim_t) as shown in (1).

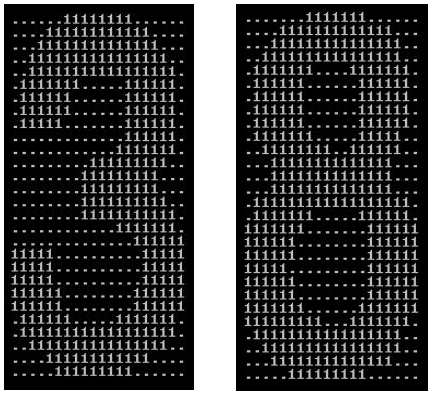
$$sim_t = \frac{n_m}{total_t} x100 \quad (1)$$

Whereas:

n_m is the number of matching object pixel between input image and template image at the same position.

$total_t$ is the total number of object pixel in template image.

The template which has the highest value of sim_t from (1) will be selected. The examples of the number "3" and "8" template images were shown in Fig. 10 (a) and (b) respectively. These examples image were reduced its size to 20x28 pixels while the actual size of the real process will be 40x56 pixels. The *point* in Fig. 10 refers to background pixel and the *number 1* refers to foreground pixel (object pixel). There are 269 object pixels in Fig. 10 (a) and 331 object pixels in Fig. 10 (b).

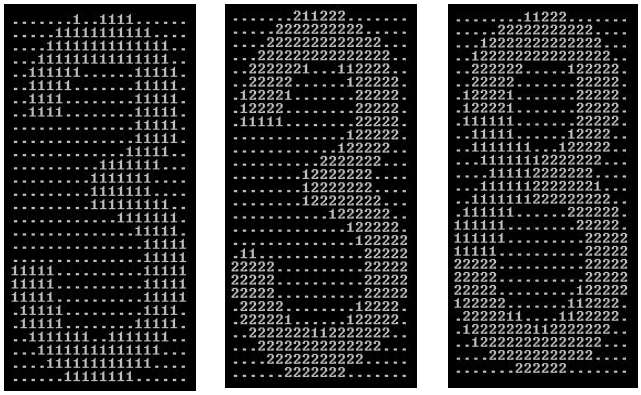


(a) (b)

Fig. 10. The number "3" and "8" templates images.

The example of input image was shown in Fig. 11 (a), it has 248 object pixels, The result of similarity between the input image (Fig. 11 (a)) and the number "3" and "8' templates were shown in Fig. 11 (b) and (c) respectively. The *number 2* in Fig.11 (b) and (c), refer to the matching object pixel between input image and template image.

It can be seen that the number of matching object pixel (n_m) between the input image and the number "3" template is 240 pixels while the number of matching object pixel (n_m) between the input image and the number "8" template is 241 pixels.



(a) (b) (c)

Fig. 11. The number "3" input image and the result of compared to template images.

The percentage of similarity between Fig. 11 (a) and the number "3" and "8' template images can be seen in (2) and (3) respectively. Therefore number "3" which has the highest value of sim_t will be selected, which is the correct answer.

$$sim_t = \frac{240}{269} x100 = 89.22 \quad (2)$$

$$sim_t = \frac{241}{331} x100 = 72.81 \quad (3)$$

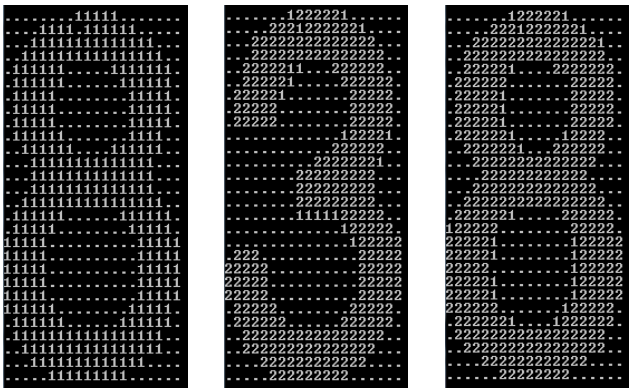
The results of the experiment from 202 samples show that the accuracy rate of the system is 96.53%.

Even though the template matching method would be a simple and efficient method for the OCR system of Thai car license plate recognition, there is a weakness in the percentage of similarity to template image (sim_t) as shown in the following example. The example of input image was shown in Fig. 12 (a), which has 323 object pixels. The result of similarity between the input image (Fig. 12 (a)) and the number "3" and "8' templates were shown in Fig. 12 (b) and (c) respectively. It can be seen that the number of matching object pixel (n_m) between the input image and the number "3" template is 216 pixels while the number of matching object pixel (n_m) between the input image and the number "8" template is 261 pixels.

The percentage of similarity to template image (sim_t) between Fig. 12 (a) and the number "3" and "8' templates can be seen in (4) and (5) respectively. Therefore number "3" which has the highest value of sim_t will be selected, which is not the right answer.

$$sim_t = \frac{216}{284} x100 = 76.06 \quad (4)$$

$$sim_t = \frac{261}{349} x100 = 74.79 \quad (5)$$



(a) (b) (c)

Fig. 12. The number "8" input image and the result of compared to template images.

III. PROPOSED TEMPLATE MATCHING

This paper proposed the similarity method to enhance the performance of the template matching method for the OCR system for Thai car license plate [7]. The template matching method composes of two important steps. Firstly, the image size of each character will be transformed into 20x28 pixels. Secondly, the proposed of similarity to input image (sim_i) is shown in (6) while the average percentage of similarity (sim) between template image and input image is shown in (7).

$$sim_i = \frac{n_m}{total_i} x100 \quad (6)$$

$$sim = \frac{sim_t + sim_i}{2} \quad (7)$$

Whereas:

$total_i$ is the total number of object pixel in input image.

From the previous example, the percentage of the similarity to input image (sim_i), between Fig. 12 (a) and the number "3" and "8' templates, can be seen in (8) and (9) respectively while the average percentage between the similarity to template image and percentage of the similarity to input image, between Fig. 12 (a) and the number "3" and "8' templates, can be seen in (10) and (11) respectively. Therefore number "8" which has the highest value of sim will be selected, which is the correct answer.

$$sim_i = \frac{216}{323} x100 = 66.87 \quad (8)$$

$$sim_i = \frac{261}{323} x100 = 80.80 \quad (9)$$

$$sim = \frac{76.06+66.87}{2} = 71.46 \quad (10)$$

$$sim = \frac{74.79+80.80}{2} = 77.80 \quad (11)$$

IV. EXPERIMENTAL RESULTS

The algorithm implemented in C++ using OpenCV library, the compiler is g++. The results of the experiment from 202 samples show that the accuracy rate of the system is 98.51% as shows in table I. The examples of Thai car license plate used in the experiment show in Fig. 13.

TABLE I. THE EXPERIMENTAL RESULTS

No.	Type	Characters	Correct	Correct %
1	Alphanumeric	70	67	95.71
2	Numeric	132	132	100.00
Total		**202**	**199**	**98.51**

Fig. 13. Thai Car License Plate.

V. CONCLUSION

This paper proposed the similarity method to enhance the performance of the template matching method for Thai optical character recognition for car license plate. The proposed similarity method is the average percentage of similarity between template image and input image. The result shows that the proposed similarity method can increase the accuracy rate of template matching method, with 100% for numeric characters and 98.51% for overall characters.

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