Application of Freeman Chain Codes: An Alternative Recognition Technique for Malaysian Car Plates

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Summary
Various applications of car plate recognition systems have been developed using various kinds of methods and techniques by researchers all over the world. The applications developed were only suitable for specific country due to its standard specification endorsed by the transport department of particular countries. The Road Transport Department of Malaysia also has endorsed a specification for car plates that includes the font and size of characters that must be followed by car owners. However, there are cases where this specification is not followed. Several applications have been developed in Malaysia to overcome this problem. However, there is still problem in achieving 100% recognition accuracy. This paper is mainly focused on conducting an experiment using chain codes technique to perform recognition for different types of fonts used in Malaysian car plates.

Keywords
Image processing, recognition, chain codes, segmentation

1. Introduction

Car plate recognition system is a complex image processing application which recognizes the characters on a car plate based on the given conditions and instructions. The car plate recognition system is installed in many places such as toll gates, parking lots and also entrance of highly secured buildings. Even polices are using this application because they can detect speeding vehicles from distance away. These systems are beneficial because it can automate car park management, improve the security of car park operator and the users as well, eliminate the usage of swipe cards and parking tickets, improve traffic flow during peak hours, detect speeding cars on highways, and detect cars which run over red traffic lights.

Among the car plate recognition systems available worldwide are LPR [1, 4], SIREVIA [2], ALPR [3], VLP [5] and etc. However, these systems are not suitable to be applied in Malaysia due to different styles of car plates endorsed. In Malaysia, the developments of image processing applications for the above said purpose are still inadequate where it is unable to reach the 100% accuracy in recognition eventhough various techniques have been applied. Due to that, it is recommended that research is still conducted for this application because of the importance of car plate recognition.

(a) (b)

Fig. 1 (a) Samples of common Malaysian car plates. (b) Samples of special Malaysian car plates with various styles of fonts and sizes

The Road Transport Department of Malaysia has endorsed a specification for car plates that includes the font and size of characters that must be followed by car owners. However, there are cases where this standard is not being followed. Private car owners tend to use various kinds of fonts and sizes for their car plates. Fig. 1 below shows samples of common and special Malaysian car plates. This various fonts and sizes of characters will lead to problems during recognition phase.

One of the factors that contribute to the failure in achieving 100% accuracy in recognition was unable to recognize similar pattern characters such as in the case of recognizing ‘B’ and ‘8’, ‘O’ and ‘0’, ‘G’ and ‘6’ [13], character B or 3 as 8, character 5 as 6, character 6 as G , character A as 4 and character I as 1 [14], character 3 with 8, 4 with A, 8 with B and D with 0 [15] and “8” and “B” or “0” and “D” [16].

Therefore, this paper will focus on conducting an experiment by applying chain codes technique for recognition to be considered as an alternative solution for recognizing characters in Malaysian car plates. Single line Malaysian car plates will be used as testing images.

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2. Related Works

There are many techniques applied by different researchers in the recognition phase. The techniques are such as multi-methods [6, 8], hybrid methods [7], Hausdorff Distance [9] and minimum distance classifier and neural network method [10]. Due to the different types of characters used in car plates such as the combination of Chinese and Roman characters [6, 7] makes the use of multi-methods or hybrid methods become popular in recognizing car plates. Other reasons why the combination of several techniques becomes a preference are the ability to improve the computation time which is very essential in any real-time car plate recognition system and the ability to shows a high percentage of recognition accuracy.

As proposed by [6], applying multi-methods in performing recognition can increase the correction rate and reduce the computation time and has been approved by a result of 98% accuracy. The multi-methods are the combination of projection sequence feature matching and template matching to recognize Chinese characters and Roman characters in car plate.

Another popular combination of technique is hybrid method which was proposed by [7]. In this research, statistical and structural recognition methods have been applied and the result shows that the method applied is more effective and robust. However, to recognize Chinese character is still a challenge for the researcher.

Performing multi-methods in recognition does not always gives a satisfying result in terms of processing time [8]. The combination of proposed three steps in the recognition approach: the character categorization, topological sorting and self-organizing (SO) recognition only improved the recognition rate but not the time complexity. This was due to the neural-based OCR process running on a sequential computer.

Many researchers applied single technique to perform recognition of characters in car plates. Hausdorff Distance has been chosen as a technique to recognize Thai car plates [9] and proven to achieve high percentage of recognition accuracy. The proposed system was able to perform 92% for valid recognition but needed more research to get high performance in recognizing poor quality images and among groups of similar-pattern characters.

Another research that applied single technique was done by [10]. Malaysian car plates are used as the test subject of car plate recognition. However, two methods of recognition were used to perform the recognition in order to find the best result. The methods are the minimum distance classifier (Method A) and three-layer neural network (Method B). This research however does not shows a very impressive result due to having some kind of 'mustache' portions generated in the thin line formation and less training samples were used.

3. Chain Codes

Chain codes are one of the shape representations which are used to represent a boundary by a connected sequence of straight line segments of specified length and direction. This representation is based on 4-connectivity or 8-connectivity of the segments [17]. The direction of each segment is coded by using a numbering scheme as shown in Figure 2 below. Chain codes based from this scheme are known as Freeman chain codes.

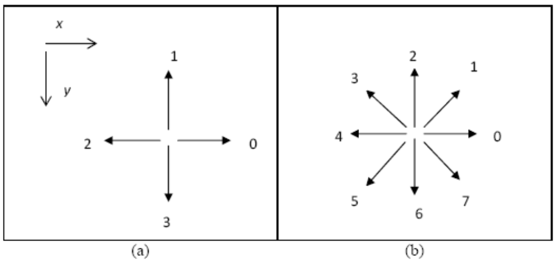


Fig. 2 Direction numbers for (a) 4-directional chain codes, (b) 8-directional chain code

A coding scheme for line structure must satisfy three objectives [18]:

a. It must faithfully preserve the information of interest;
b. It must permit compact storage and convenient for display; and
c. It must facilitate any required processing.

According to [19], chain codes are a linear structure that results from quantization of the trajectory traced by the centers of adjacent boundary elements in an image array. A chain code can be generated by following a boundary of an object in a clockwise direction and assigning a direction to the segments connecting every pair of pixels.

First, we pick a starting pixel location anywhere on the object boundary. Our aim is to find the next pixel in the boundary. There must be an adjoining boundary pixel at one of the eight locations surrounding the current boundary pixel. By looking at each of the eight adjoining pixels, we will find at least one that is also a boundary pixel. Depending on which one it is, we assign a numeric code of between 0 and 7 as already shown in Figure 2. For example, if the pixel found is located at the right of the current location or pixel, a code "0" is assigned. If the pixel found is directly to the upper right, a code "1" is assigned. The process of locating the next boundary pixel and assigning a code is repeated until we came back to our first location or boundary pixel. The result is a list of chain codes showing the direction taken in moving from each boundary pixel to the next. The process of finding the boundary pixel and assigning a code is shown in Figure 3. This method is unacceptable for two main reasons:

a. The resulting chain of codes tends to be quite long
b. Any small disturbances along the boundary due to noise or imperfect segmentation cause changes in the code that may not be related to the shape of the boundary.

Chain codes have been claimed as one of the techniques that are able to recognize characters and digits successfully [20]. This is because of several advantages possessed by this technique as listed by [21]. The first advantage over the representation of a binary object is that the chain codes are a compact representation of a binary object. Second, the chain codes are a translation invariant representation of a binary object. Due to that, it is easier to compare objects using this technique. The third advantage is that the chain code is a complete representation of an object or curve. This means that we can compute any shape feature from the chain codes. According to [22], chain codes provide a lossless compressing and preserving all topological and morphological information which bring out another benefit in terms of speed and effectiveness for the analysis of line patterns.

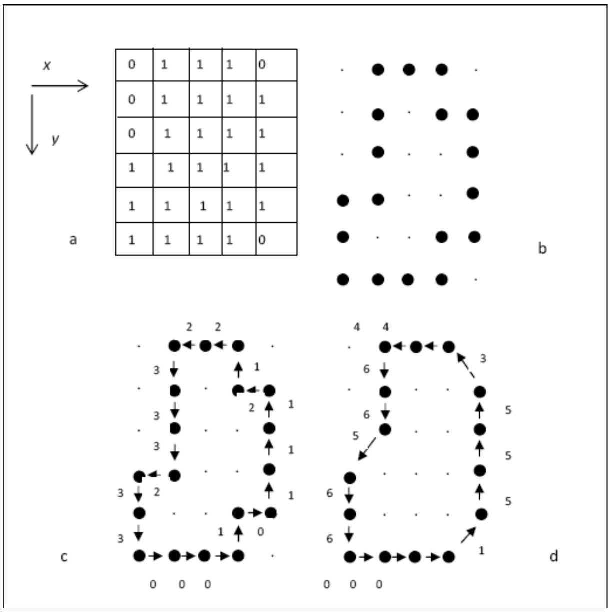


Fig. 3 a & b) A 4-connected object and its boundary; c & d) Obtaining the chain code from the object in (a & b) with (c) for 4-connected and (d) for 8-connected

4. Methodology

The Fig. 4 below shows the methodology for this research. There are six phases involved; image acquisition, data definition, image pre-processing, image segmentation, chain code derivation and character recognition. The images of car plates are varied in terms of its sizes and fonts for the testing process (during recognition).

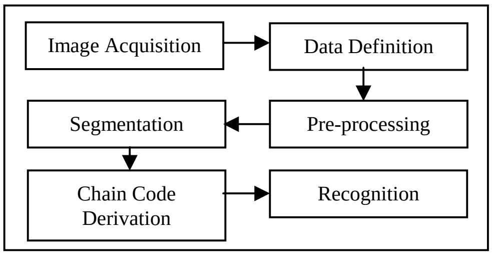
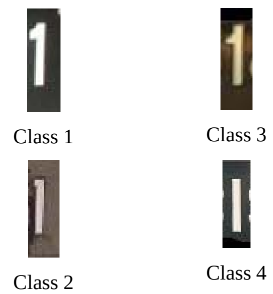


Fig. 4 The proposed methodology

4.1 Data Definition

Data that comes from the form of images of car plates need to be identified and analyzed first before tested. The information about types of fonts used need to be gathered since our problem is that the different types of fonts have been used in car plates which lead to problem in recognizing characters by using computer. Therefore, by having this information, all data to be tested will get good results. Based on the observation on collected images of car plates, there are about one to four types of fonts that have been used in car plates (referring to standard car plates). Table 1 below shows types of fonts observed from the collection of images obtained that has been used as raw data.

Table 1 Classification of similar patterns of character '1' taken from four different car plates



4.2 Preprocessing

Two processes are involved in pre-processing which are threshold and filtering. Images used are gray-scaled images and are converted into binary images which means that every pixel in the image is convert to the binary values (“0” and “1”). Fig. 5 shows image of car plate in the form of gray-scale and after threshold.

(a) (b)

Fig. 5. (a) Gray-scaled image of car plate. (b) Image after threshold process.

4.3 Segmentation

Two processes have been done in this phase; the boundary extraction and segmentation. The boundary image of car plate extraction is done in order to ease the process of deriving the chain codes and illustrated in Fig. 6. The segmentation phase or character isolation takes the region of interest (from the boundary image) and attempts to divide the region into individual characters. To help in detecting the characters, the plate image is divided into seven images where each will contain one isolated character. For the purpose of research, only car plate images which contain 7 characters, with 3 letters at the position of C1, C1 and C3 and 4 numbers at the position N1, N2, N3 and N4 will be used. The segmentation has been done using the pixel count technique first. The connected component labeling technique has been performed for other images which were failed to be segmented using previous technique.

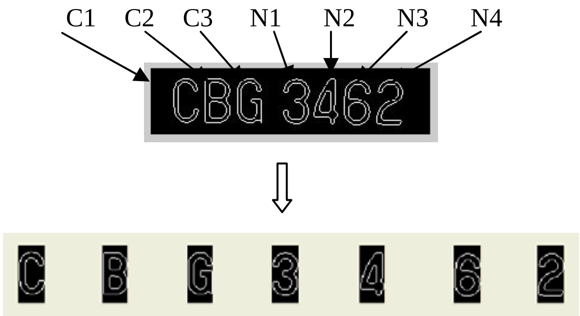


Fig. 6 The boundary image and 7 segmented regions

4.4 Chain Code Derivation

This phase is to derive the chain codes for each character or number in the specific region which is the result from image segmentation phase. The algorithm for extracting chain codes for 8-connected boundaries is as follows [23]:

1. Find the pixel in the object that has the leftmost value in the topmost row; call this pixel P_0.

2. Define a variable *dir* (for direction), and set it to equal to 7(since P_0 is the top-left pixel in the object, the direction to the next pixel must be 7).
3. Traverse the 3x3 neighborhood of the current pixel in a counter-clockwise direction, beginning the search at the pixel in direction dir + 7 (mod 8) *if dir is even* or dir + 6 (mod 8) *if dir is odd.* This will sets the current direction to the first direction counter-clockwise from *dir*:

dir	0	1	2	3	4	5	6	7
dir + 7 (mod 8)	7	0	1	2	3	4	5	6
dir + 6 (mod 8)	6	7	0	1	2	3	4	5

4. The first foreground pixel will be the new boundary element. Update *dir*.
5. Stop when the current boundary element P_n is equal to the second element P_1 and the previous boundary pixel P_{n-1} is equal to the first boundary element P_0.

Fig. 7 below shows the initial location (P_0) and the direction derived using the above algorithm while Fig. 8 illustrates the list of chain codes of character ‘C’.

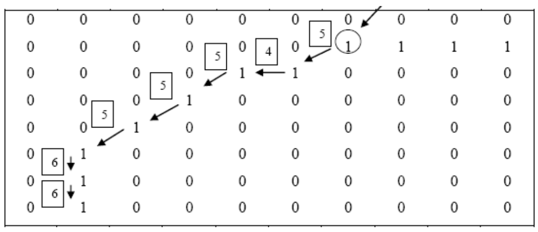


Fig. 7 The initial location, P_0 and the direction to derive chain codes.

```
Columns 1 through 19
 5 4 4 5 4 5 4 5 5 6 6 5 6 5 6 6 6 6 6
Columns 20 through 38
 6 6 6 6 6 6 6 6 6 6 6 6 6 6 7 6 6 6 6
Columns 39 through 57
 6 7 6 7 7 7 7 7 0 0 7 0 0 0 0 0 0 1 0
Columns 58 through 76
 1 0 1 1 1 2 1 2 2 1 2 2 2 3 4 4 4 4 5
Columns 77 through 95
 6 6 6 5 5 5 5 4 4 4 4 4 3 3 3 2 3 2 2
Columns 96 through 114
 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
Columns 115 through 133
 2 1 1 1 1 0 0 0 7 0 7 7 7 6 7 6 7 0 0
Columns 134 through 152
 0 1 2 2 2 2 3 2 2 3 3 3 3 4 3 4 4 4 3
Columns 153 through 154
4 4
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Fig. 8. The chain code extracted from the boundary image of character ‘C’

4.5 Recognition

The character recognition has been done by using the list of chain codes derived for each character from the previous phase. It works by calculating the total of each code contained in the list of chain codes. The total of each code is then used as a guide to recognize the characters by matching the chain codes extracted from the previous phase.

5. Result and Discussion

An experiment using 110 images of car plates have been done with different types of fonts have been classified into several classes of similar pattern of characters depending on samples of images collected. The results have been observed in two different ways; the recognition accuracy and the computational time. Table 1 shows the result of segmentation and recognition accuracy.

Table 2: Results of segmentation and recognition

Phase	Technique	Successfu l	Percentage
Segmentation	Pixel count	94/110	85.45%
	Connected component labeling	105/110	95.45%
Recognition	FCC	80/105	76.19%

From the table, we can see that different techniques give different result in terms of the segmentation accuracy. Pixel count technique can only achieved up to 85.45% while connected component labeling is up to 95.45%. Eventhough the rate is quite high, however the best technique should be able to reach almost 100% accuracy. In terms of recognition accuracy rate, using FCC only achieved up to 76.19%. This is considered as low rate since our aim is to achieve almost 100% accuracy.

Recognition time for each character is about 0.01s to 0.07s. and varied with the differentiation in types of fonts but most characters have same recognition time regardless its font types. For example, character '1' has recognition time of only 0.01s for all types of fonts.

From the analysis, the high recognition time for certain font types of characters are due to variation of sizes of fonts used for car plates. Fonts with thin and small size have less recognition time compares to fonts with thick and big size. This factor gives impact for the recognition time because it is related to the number of pixels for all seven characters in a car plate which are used during the processing to calculate the recognition time. As one of the features that are used to recognize objects (for this case, the characters of car plates), the number of pixels do play an important part where logically, an increasing of the number of pixels will increase the recognition time.

As a conclusion, based on the experiment, not all types of fonts used in Malaysian car plates can be recognized by using the Freeman chain codes technique due to its disability to give a high recognition accuracy rate. Eventhough it has an advantage of less recognition time which is very promising however, we do look at the recognition accuracy rate as important as recognition time. To achieve high recognition rate it is suggested that this technique should be applied with other technique which is able to derive the specific or unique features of each character to avoid the error in recognition or to improve the recognition rate.

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