International Journal of Electrical and Computer Engineering (IJECE)
Vol. 4, No. 2, April 2014, pp. 278~284
ISSN: 2088-8708

Implementation of Dynamic Time Warping Method for the Vehicle Number License Recognition

Made Sudarma, Sri Ariyani
Department of Electrical Engineering,
Faculty of Engineering Udayana University, Bali, Indonesia

Article Info

Article history:

Received Nov 19, 2013
Revised Jan 4, 2014
Accepted Jan 28, 2014

Keyword:

Dynamic time warping
Image matching
Image segmentation
Template matching
Vehicle license

ABSTRACT

In the era of information technology vehicle numbers identification needs to be done by system automatically. Therefore, the accuracy of the data is well documented and work porses identification can be done quickly. Motor vehicle license recognition is a recognition system by comparing character feature in license plate with reference feature which exists in database. This system uses chain code method and template matching to extract character feature in license plate's image. Feature extraction with chain code method will result in an array of direction codes which stored in dynamic array, which stored in dynamic array. In this application test feature will be matched with feature stored in database using dynamic time warping method (DTW) to obtain a distance value between test feature and reference feature, the smaller the distance obtained shows that both the features are more similar. The result of this system is the recognition of each character in license plate's image. In this study, samples of license plate's images are tested with the number of research objects. From the study feature extraction is obtained with template matching method provides better success rate compared to feature extraction with chain code method, where the success rate of feature extraction with template matching method is at 78% whereas feature extraction with chain code method is at 68%.

Corresponding Author:

Made Sudarma
Jl. Tukad Yeh Aya No. 46, Denpasar 80225, Bali - Indonesia
Telp./Fax.: +623617956800 / +62361257055
Email: sudarma@ee.unud.ac.id

1. INTRODUCTION

Digital image processing currently not only ranges between digital image editing by using existing filter effects, but also covering pattern recognition technique automatically such as the pattern recognition of face, fingerprint, hand writing and character pattern of printing result [1]. Generally pattern recognition is a science to classify or drawing something based on quantitative measurement of feature or main property of an object. The pattern itself is an entity which is defined and can be defined and named. The pattern can be a collection of measurement results or observation and can be stated in vector notation or matrix [5]. In this research will be discussed regarding motor vehicle license plate recognition on digital image, where the system is expected to be able to recognize letter and number character contained in motor vehicle license plate's image. Recognizing motor vehicle license plate is indispensable in the security system of parking area, tracking a motor vehicle and identifying a motor vehicle [3]. Each vehicle has an identity in the form of motor vehicle license plate which is legally issued by the state. License plate is also called vehicle registration plate, or in United States is known as a license plate [4]. The shape constitutes a piece of metal or plastic mounted on motor vehicle as a formal identification put in the front or rear of a vehicle. The uniqueness of this license plate that making this plate widely used as an identity in various systems such as parking system, building security system, toll system and so on, but often there is a mistake in recognition

since the current existing systems still mostly using manual system namely the recording of motor vehicle license plate conducted by the officer in order to identify the vehicle [2]. This method has a weakness that put in human. Human has a nature of quickly bored and tired so that easy to make mistakes, moreover typing process also requires a longer time.

License plate has serial number that is the arrangement of letters and numbers devoted to that vehicle. This number in Indonesia is called police number, and can be integrated with other information regarding that vehicle, such as color, brand, model, year of manufacture, vehicle identification number or VIN and of course the name and address of the owner [9]. All these data also listed in motor vehicle registration letter which is evidence letter that police number is specified for that vehicle.

2. RESEARCH METHOD AND DISCUSSION

The objectives expected from this research preparation to find out the stages in designing a motor vehicle license plate recognition system in a digital image, to find out the performance of motor vehicle license plate recognition system in a digital image. Furtheremore, the research preparation is using several assumptions with an objective that the discussion can be more directed and to simplify and limiting the problems. The research is conducted by using motor vehicle license plate's image which experiencing preprocessing so that appropriate motor vehicle license plate area's image is obtained to be segmented. Segmentation process is conducted by way of tracking each pixel on the image to find out the width and height of the character so that producing good output to be further character recognition process is performed [6]. In this motor vehicle license plate recognition, the research material conducted is including three (3) things such as the stages in performing character segmentation, feature extraction process is using chain code method and template matching to obtain characteristic differentiator from each segmented character, and character recognition by matching each extraction result of character feature from previous stage by using reference database.

In the program algorithm section, will be discussed regarding the processes occurring in the system, where the processes having important relation with each other. As for the process used in this research, namely character segmentation process aims to perform separation between objects in order to get the desired object, feature extraction process from each character that being segmented by using chain code method and template matching which further used for character matching stage, and character matching process.

Image Preprocessing is raw data input transformation to assist computational ability and feature seeker and to reduce noise. In preprocessing, image (signal) that being captured by a censor will be normalized so that the image will be more prepared to be processed in the stage of feature separation [8]. The quality of feature that being produced in the feature separation process is so much dependent on preprocessing result.

To obtain a grayscale image the formula used is:

$$I(x,y) = \propto R + \beta G + \gamma B \quad (1)$$

with *I (x, y)* is the grayscale level in a coordinate obtained by setting color composition of *R (red), G (green),* and *B (blue)* presented by parameter values of α, β, and γ. Generally the value of α, β, and γ is 0.33. Other value also can be given for the three parameters provided that the total of overall values is 1.

Thresholding process will result in a binary image, the image having two values of grayscale level, black and white. Generally the threshold process of grayscale image to produce binary image is as follows:

$$g(x,y) = \begin{cases} 1 \; if \; f(x,y) \geq T \\ 0 \; if \; f(x,y) < T \end{cases} \quad (2)$$

with *g (x, y)* as binary image of grayscale image *f (x, y)*, and *T* to state threshold value. *T* value has a very important role in threshold process. Result quality of binary image is so much dependent on *T* value used.

There are two types of thresholding, global thresholding and locally adaptive thresholding. In global thresholding, all the pixels on the image are converted to become black or white with one threshold value of *T*. Probably in global thresholding there will be a lot of information lost due to using only one value of *T* for overall pixels. To handle this problem it can use locally adaptive thresholding. In local thresholding, an image is divided into small blocks and then local thresholding is performed on each block with different *T* value.

Dot detection isolated from an image in principle occurred straightforwardly. We can say that a dot to be said isolated if:

$$|R| \geq T \quad (3)$$

where T is positive threshold and R is the value of equation:

$$R = \sum_{i=1}^{9} WiZi \quad (4)$$

Thus, the isolated dot is a different dot (significantly) with the dots around it. Line detection of an image is performed by matching it with mask and shows a certain part which is differed in a straight line whether vertically, horizontally, or leaning 450 (either right or left). Mathematically can be formulated as follows:

$$|Ri| > |Rj| dimana\ i \neq j \quad (5)$$

The direction of image's edge is varied. There is a straight and there is like a curve. There are various methods of edge detection that can be used to detect various types of edge. Each technique has its own advantage. One edge detection technique may be work well in one certain application but on the contrary it may not work optimally in other application. Edge detection is a process to find out obvious different intensity changes in an image's section. An edge detection operator is a contiguous/neighborhood operation, namely an operation that modifies gray value of a dot based on gray values of dots around it (its neighborhood) each having its own weight. The weights' values are depended on operation that will be performed, whereas the amount of neighborhood's dots involved usually is *2x2, 3x3, 3x4, 7x7*, and so on. Usually the operator used to detect the first edge is operator based on gradient (first derivation), namely robert operator, sobel operator, and prewitt operator. The second is operator based on second derivation, namely Laplacian operator and Laplacian Gaussian operator. Chain code is often used to describe or encode the contour of an object. The establishment of the chain code is starting with specifying the first pixel from an object. Based on the pixel object chain code is established by following the direction rule of chain code. Based on the chain code, the analysis to an object can be done by calculating the perimeter, area, and the form/shape factor.
The perimeter states the length of the frame produced. Perimeter is calculated with the formula as follows:

$$P = jumlah\ kode\ genap + \sqrt{2}.jumlah\ kode\ ganjil \quad (6)$$

For chain code of 077 076 455 453 012 334 201 stated above, the frame length is:

$$P = 10 + 11\sqrt{2} = 25.56\ unit$$

The including of $\sqrt{2}$ factor in determining of P in odd code, because odd code has diagonal direction. The calculation of area based on chain code can be stated as follows:

Code 0: Area = Area + Y	;	Code 1: Area = Area + (Y + 0.5)
Code 2: Area = Area	;	Code 3: Area = Area – (Y + 0.5)
Code 4: Area = Area Y	;	Code 5: Area = Area – (Y – 0.5)
Code 6: Area = Area	;	Code 7: Area = Area + (Y – 0.5)

Shape factor is defined as follows:

$$S = \frac{Parameter^2}{Area} \quad (7)$$

Since S is a ratio between perimeter and area then S does not present a dimension quantity, so that S has invariant properties to the scale, rotation, and translation, which constitutes a very useful feature characteristic.
Template matching is a process to find an object in the whole objects inside an image. Template is compared with the whole objects and if the template is fit with an unknown object in the image then the object is marked as a template. The comparison between template and the whole objects in the image can be done by calculating the difference of the distance, as follows:

$$D_{(m,n)} = \sum\sum \left[f_{(j,k)} - T_{(j-m.k-n)} \right]^2 \quad (8)$$

With $f_{(j,k)}$ stating the image where the object located which will be compared with template $T_{(j,k)}$ whereas $D_{(m,n)}$ stating the distance between template and object on the image. In general the size of template is far smaller from image's size. Ideally, template is to be said matching with object on the image if $D_{(m,n)} = 0$, however condition like this is difficult to be fulfilled let alone if template is a grayscale image. Therefore, the rule being used to state that a template is matching with object is:

$$D_{(m,n)} = L_{D(m,n)} \tag{9}$$

with $L_{D(m,n)}$ is a threshold value.
Dynamic Time Warping (DTW) is a method to calculate the distance between two time series data. The advantage of *DTW* from other distance methods is its ability to calculate the distance between two data vectors with different length. The distance of *DTW* between two vectors is calculated from optimal warping path of both vectors. Of several techniques used to calculate *DTW*, the most reliable one is dynamic programming method. The distance of *DTW* can be calculated with formula as follows:

$$D_{(U,V)} = \gamma_{(m,n)} \tag{10}$$

$$D(u,v) = d_{base}(u_i, v_j) + min\begin{cases} \gamma(i-1,j) \\ \gamma(i-1,j-1) \\ \gamma(i,j-1) \end{cases} \tag{11}$$

$$\gamma(0,0) = 0, \gamma(0,\infty) = \infty, \gamma(0,0) = 0, \gamma(\infty,0) = \infty \tag{12}$$

$$(i = 1,2,3 \ldots m; j = 1,2,3 \ldots n)$$

The value in the column of *(i, j)* is seen as addition value of warping path from the column of *(1,1)* until *(i, j)*. Column with the value of $\gamma^{(i,j)}$ *(1 < i < m, 1 < j < n)* is called summed distance matrix. The following is the example of summed distance matrix.

3. RESULTS AND ANALYSIS

3.1. System Testing

The testing of success rate from motor vehicle license plate recognition system is conducted by way of comparing the result obtained by the system (objective) with the result of our reasoning itself (subjective). Recognition system which is being made is tested with 50 images and 381 character objects. Where the outcome of recognition system is producing two outputs namely recognition outcome with chain code method and template matching method. System testing includes three things, namely segmentation, chain code feature recognition, and template matching feature recognition.

3.2. Object Separation

This result test presented in Table 1 and Figure 1, is conducted to find out system success rate in analyzing object integrity in the image by dividing each object in the image into its own space. Object separation process will simplify recognition process, since this process is one of determinant factors in the success of this recognition system [10].

Table 1. The variation of thresholding values and width references.

No	Thresholding	Width Reference	Segmentation (%)
1	95	5	57
2	95	10	80
3	95	15	79
4	127	5	66
5	127	10	93
6	127	15	94
7	159	5	66
8	159	10	85
9	159	15	86

The test is conducted with several test images and with image thresholding parameter values and different width references. The segmentation result of the system will be compared with objective reasoning. The success rate of the system in segmentation stage with the variation of thresholding values and different width references is shown in the following graphic from the data of test result.

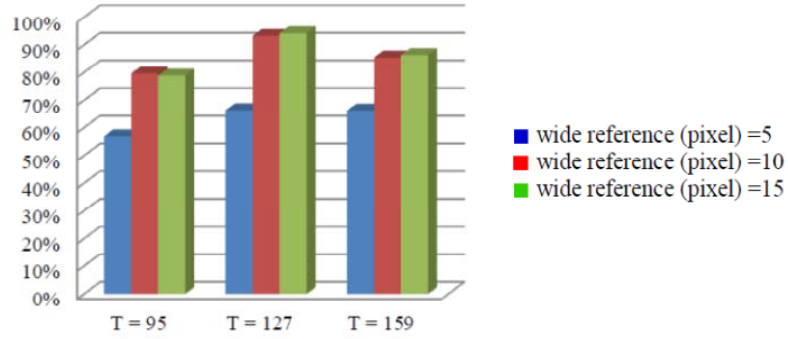

Figure 1. The graphics of segmentation test

3.3. Chain Code Feature Recognition

Test result of this recognition system will be compared with the result of objective reasoning. Test result of chain code feature recognition system with *DTW* can be seen in the table below. The following is the graphics that present the success rate of the system in recognizing character with chain code feature, where matching process is using *DTW*. From the data in the graphic of test result shows in Figure 2, can be concluded that the recognition with chain code feature, where matching process is using *DTW* having success rate of 67% and recognition error 33%. The error in character recognition is due to several reference features having similarities with test features, so that several errors occurred in character recognition process. The failures also occurred in the stage of chain code feature extraction, system failure in feature extraction stage is at 1% and success rate at 99%.

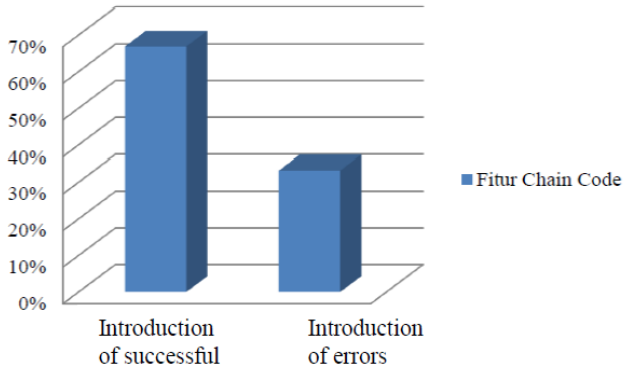

Figure 2. The graphics of recognizing chain code feature with *DTW*.

3.4. Template Matching Feature Recognition

Test result of this recognition system will be compared with the result of objective reasoning. Test result of template matching feature recognition system with *DTW* can be seen in the table below. The following is the graphics of test result data that present the success rate of the system in recognizing character with template matching feature, where matching process is using dynamic time warping.

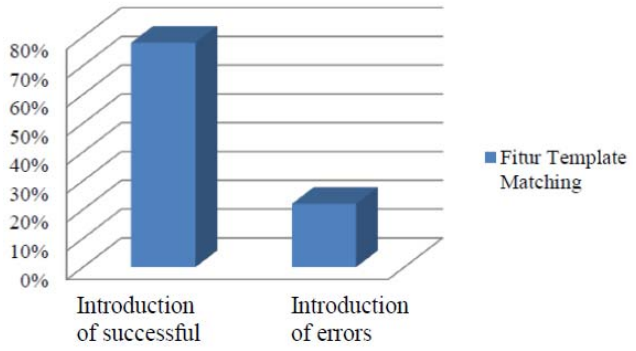

Figure 3. The graphics of system test matching feature with *DTW*.

From the Figure 3, concluded that the recognition with template matching feature of 78% and and 22% recognition error. The error in character recognition is due to several reference features having similarities with test features, so that several errors occurred in character recognition process.

3.5. Result Analysis

The result of this thresholding process will be crucial in success rate of the system in segmentation process, feature extraction and recognition. For character recognition with chain code feature, where matching process is using *DTW* has a success rate of 67% and recognition error of 33%. Character recognition with chain code feature is also experiencing the failure in feature extraction, where system failure for feature extraction process is 1%.

The failure in character recognition with chain code feature is due to 2 factors, first is the failure in feature extraction and second is an error in performing recognition. An error in character recognition is occurred because feature in test image has some similarities with more than one feature in reference database. Whereas the failure in feature extraction is due to the imperfect of object's edge. For character recognition with template matching feature, where matching process is using *DTW*, has a success rate of 78% and error in recognition of 22%. An error in character recognition is occurred because feature in test image has some similarities with more than one feature in reference database [7].

4. CONCLUSION

The recognition system processes performed by binary process, segmentation, feature extraction with chain code method and template matching method, and feature matching process using dynamic time warping method. Accuracy level of chain code feature recognition is at 67% , and accuracy level of template matching feature recognition is at 78%. The result research means successfully conducting to motor vehicle license plate recognition.

REFERENCES

[1] Ardisasmita,M.S., *Pengolahan Citra Digital Dan Analisis Kuanntatif Dalam Karakterisasi Citra Mikroskopik*., Journal Mikroskopi dan Mikroanalisis, Vol3 No.1, 2000, ISSN 1410-5594

[2] Fauziah; Iwan Wahyuddin, M. 2009. *Metode Jaringan Saraf Tiruan Penjejakan Balik untuk Pengenalan Huruf Cetak pada Citra Digital*. Artificial, ICT Research Center UNAS. Volume 3; 1 Jauari 2009. Jakarta : Universitas Nasional

[3] Heerden, R. P. 2002. *Hidden Markov Models for Robust Recognition of Vehicle Licence Plates*. South Africa : University of Pretoria

[4] Liliana; Satia Budhi, G; Hendra. 2010. *Segmentasi Plat Nomor Kendaraan dengan Menggunakan Metode Run-Length Smearing Algorithm (RLSA)*. Jurusan Teknik Informatika, Fakultas Teknologi Industri, Universitas Kristen Petra

[5] Petzold, C. 2010. *Programming Windows Phone 7*. Microsoft Press: United States of America

[6] Purnomo, H.M; Muntansa, A. 2010. *Konsep Pengolahan Citra Digital dan Ekstraksi Fitur*. Graha Ilmu : Yogyakarta

[7] Sutoyo, T; Mulyanto, E; Suhartono, V; Dwi Nurhayati, O; Wijanarto. 2009. *Teori Pengolahan Citra Digital*. Andi Offset: Yogyakarta.

[8] Wahyono,S.E. 2009. *Identifikasi Nomor Polisi Mobil Menggunakan Metode Jaringan Saraf Buatan Learning Vector Quantization*. Jurusan Teknik Informatika, Universitas Gunadarma
[9] http://id.wikipedia.org/wiki/Nomor_polisi
[10] http://pengolahancitra.com/index.php?option=com_content&task=view&id=42&Itemid=26