

Real Time Vehicle License Plate Recognition Based on 2D Haar Discrete Wavelet Transform

R. T. Lee, K. C. Hung, and H. S. Wang

Abstract— This thesis is to present a new approach for license-plate recognition using 2D Haar Discrete Wavelet Transform (HDWT) and Artificial neural Network. This thesis consists of three main parts. The first part is to locate and extract the license-plate in an image. The second part is to train of the license-plate. The third part is to real time scan recognize of the license-plate. Traditional license plate recognition system design complexity. The paper present is a vehicle license plate after 2D Haar Discrete Wavelet Transform three transforms, select only after the third conversion coefficients of low-frequency part of the image pixels, image pixels into one-sixty fourth, thus reducing the number of scanning image pixels, increasing rapid implementation of recognition work and the memory usage. This article is to directly scan for license plate recognition, without recognition of the individual characters. This new approach is a real time recognition, experimental results of license plate recognition rates can be as high as 95.33%.

Index Terms— Haar Discrete Wavelet Transform, real time, Artificial neural Network

1 INTRODUCTION

1.1 The Motive of the Research

TO suggest the that is because of the promotion of life quality, vehicles have become an essential vehicle. The increase of vehicle number produces some management problems, such as the building vehicles, company vehicles management, and so on.

Therefore, we propose a applications in a limited district of automatic license plate recognition system to control the restricted districts of the vehicle, it can to save on labor costs and improve efficiency.

1.2 Research of Related Literature

In [1, 3, 4] license plate recognition system are real-time recognition, and in [1, 2, 3, 5, 6, 7] are make a lot of ways the license plate location. In [1] use HSI color space method, the recognition easy light affect. In [2] only make the location of the vehicle's license plate. In [3, 4] are the license-plate characters recognition, but it is not easy to cut character complete and the similar characters confusion problem, such as 1 and I, 0 and O, and so on. In [5] need to find the thresholds of row and column, but affected by light or night and other factors, it can not find the ideal thresholds. In [6] because the image does not at the same position to photography and road has slope. Hence, they will not be effective for the license plate matching. In [7] need to create a reference model, and the standard li-

cense plate for recognition, but the position photography is different, so its easily lead to recognition errors.

1.3 This Thesis Proposed of Method

Raised in this paper is a license plate recognition and at present Taiwan uses license plate size is 150 mm x 320 mm, license plate have two letters and four-digits consist of each word, words and the interval is 10 mm, lack of space between words and the correct cutting, application of this article to improve the short comings arising out window scanning combination 2D Haar Discrete Wavelet Transformation [2] and Artificial neural Network [11, 12] license plate recognition. To propose the method as following describes.

This articles main license plate recognition system have training and recognition of two parts, training is used vehicle license plate edge functions and Sobel shield edge detection for license plates, and automatically look for vehicle license plate location and extract license plates. License plate recognition have three parts: The first part is a 32×64 resolution window scan, the second part is the use of 2D Haar Discrete Wavelet Transformations, and extract images of low-frequency (LL), the third is to use Artificial neural Network on the limited district of vehicle license plate recognition. Therefore, there character segmentation problems can be avoided.

The advantages of Haar Discrete Wavelet Transform are that it each time transform only needs 1/4 of the original image. Hence, this method can fast execution speed. This paper simulation results by MATLAB software that recognition up to 95.33%.

2 STUDY METHODS

After studying the way is to scan the image in this article, use 2D Haar Discrete Wavelet Transform and Artificial neural Network for recognition. 2.1 chapter is 2D Haar Discrete

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Wavelet Transform of introduction, 2.2 chapter is the introduction of Artificial neural Network, described later.

2.1 2D Haar Discrete Wavelet Transform

The Discrete Wavelet Transform is a very popular method in digital image processing in recent years, especially in multi-resolution representation. The Discrete Wavelet Transform can decompose an image into some sub-bands and encodes the signal of sub-bands according to the importance of signal.

Discrete Wavelet Transform turns an image into high frequency and low frequency data. According to these different data, we can do the processing respectively. Due to the sensitivity of human's eyes, the low frequency data forms the important part of the original image. If the values of low frequency coefficients change, one can recognize the change easily. On the other hand, human's eyes are much less sensitive to the high frequency part, because it is hard for a human to discover it.

The 2D Haar Discrete Wavelet Transform [2] can decompose an image into four sub-bands. Have high frequency (HH) and the high and low frequency (HL) and low and high frequency (LH) and low frequency (LL) the four sub-bands. Low frequency (LL) between the pixels of change is relatively small, image clearer, so after each conversion only to extract low frequency (LL) part. Haar Transform characteristics of: (a) Multiplication is not required. (b) Input and output points the same. (c) Frequency two parts, low frequency all is 1 and high frequency (half are 1, half are -1). (d) You can analyze a signal localized features. (e) Instruction cycle very fast. But it does not suitable for signal analysis.

2.2 Artificial neural Network

Artificial neural Network the network level can be divided into input layer, hidden layer and the output layer and other three. Output transfer function between the layers is to use the hyperbolic tangent function (Tan-sigmoid Transfer function).

Artificial neural Network in this article is the special value output layer neurons converting binary decimal output, and output layer neurons of the components of the target value converted to a decimal value for comparison. Such as output values and target values are the same for training completed, or the express train failed, return train.

3 TRAINING AND RECOGNITION LICENSE PLATE STEPS

In front of the license plate recognition, first through extract license plates of sample use Artificial neural Network training. This license plate recognition system are divided into three parts, the first window scan some, and the second is the 2D Haar Discrete Wavelet Transform extract images of low-frequency (LL) part is a class of Artificial neural Network recognition. The license plate recognition system is used 32 x 64 resolution windows scans the image, combined with 2D HAAR Discrete Wavelet Transform filter out high frequency part of the image, leaving low-frequency part of the coefficients with using Artificial neural Network to recognition, while the third part of class among the various layers of the Artificial neural Network weights or basis weights are deter-

mined by the license plate feature values obtained through the Artificial neural Network training institute.

Following a part of the 3.1 chapter is simulation software and hardware environment, the 3.2 chapter is vehicle license plate photograph, the 3.3 chapter is license plate training step process instructions, and the 3.4 chapter is license plate recognition step process instructions.

3.1 Simulation Software and Hardware Environment

Using personal computer simulation, the software is Microsoft Windows XP, home edition, version 2002, service pack 2, hardware is Compaq Presario CQ2020TW computer, Intel@ATOM™ 230 processor, 1024MB DDR2, 160GB hard disk space.

3.2 Vehicle License Plate Photograph

Using the CASIO EXILIM, 10.1 MEGA PIXELS DIGITAL CAMERA EX-S10, adjusting the resolution 480 x 640 for photography vehicle license plates, photograph location diagram as fig. 1 of the 12 pieces O sign locations, in the figure indicating the position camera photography, simulation of right side of the forward direction of the cameras installed in vehicles in lanes 25 cm, and camera distance of 300 cm started as photo taken after the first time, each 20 cm according to photo taken at a time until the distance between vehicles 200 cm total photos taken 6; another simulation of vehicle direction if left 50 cm, camera distance 300 cm started as photo taken after the first time, each 20 cm according to photo taken at a time until the distance between vehicles 200 cm total according to photo 6, all according to each vehicle taken 12 when extract license plates as training samples in this article. Forward direction at a distance of vehicles from 200 cm to 300 cm of right 25 cm and 75 cm (fig. 1 have O signs of 12 pieces is photo position) regional routes within each vehicle in any different position in the interregional, according to vehicle license plate location photography like 6, when the license plate recognition sample.

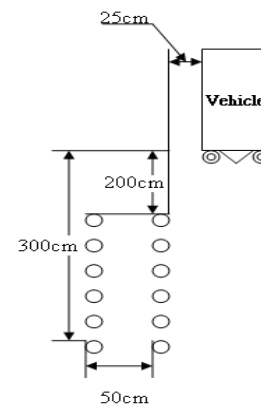


Fig. 1. Vehicle image photo location map

3.3 License Plate Training Step Process

License plate training processes in fig. 2 as shown in the license plate train seven steps in this article, described it as follows.

Step1. Enter license plate images, as in fig. 5(a).

Step2. Vehicles with license plates Image pre-processing (as fig. 5 and fig. 7).

2.1). Color photo use (1) equation transform HSI gray-level image, Y are the gray-level image after the conversion and R, G and B are the three elements of the original color image. And because vehicles stepped on induction coil and regional position is fixed, so the image pretreatment, such as crop top 150 pixels, down, left and right around the crop 100 pixel, the crop will not affect the license plate shown, and reduces background noise and run time.

$$Y(i, j) = (R(i, j) + G(i, j) + B(i, j)) / 3 \quad (1)$$

$Y(i, j)$ are gray-scale space red, green and blue color components.

2.2). Vehicle images edge function and Sobel mask operator, and the edge function will automatically detect the critical threshold, the following (2) formula is MATLAB software program. Effects of vehicle images and 0 and 1 binary, making vehicles licensing and background are distinct.

$$\text{Image1} = \text{edge}(\text{Image}, 'sobel') \quad (2)$$

Image for the input image, edge is a instruction, Sobel was operator, Image1 for the output image.

2.3). Using license plate district, height, width, width to height ratio and distance up and down the second one taking a line to extract license plates.

Step3. License plate 2D Haar wavelet Transformation three times, each conversion or last when the license plate features only selected LL low-frequency parts.

Step4. 2D Haar after the discrete wavelet Transform, take the low-frequency part of the data line up. Columns when license plate the feature-values, and the feature coefficients regularization of regularization (3) formula when the artificial neural network input data.

$$\frac{X_i}{\sqrt{\sum_{i=1}^{i=32} X_i}} \quad (3)$$

X_i a line up of train cards coefficients of feature.

Step5. Using Artificial neural Network to train. Set type of Artificial neural Network parameter, enter the number, the number of hidden layer neurons, such as output layer learning rate, number and frequency of training, initial random weight values between layers and partial weight parameter value, and so on. Artificial neural network set the parameters as follows in this article, enter the number of neurons is license plate features factor into a column of values, number of neurons in the hidden layer is 20, number of output layer neurons is 8, and train number 1000, learning rate 0.5, and input layer and hide the layer weight values, hidden and output layers between weight values, input layer with hidden layer basis values, hidden and output layer basis values, the four initial values are randomly generated by a computer program.

Step6. Determine. Up reach to cycle times and convergence. Finally storage weight values and basis values.

Step7. End. After training is complete, get fig. 3 training of vehicle license plate convergence graphs.

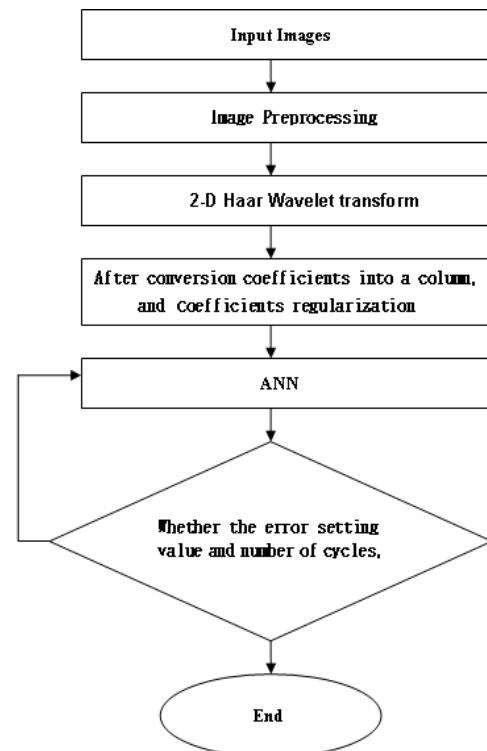


Fig. 2. License plate training flow chart

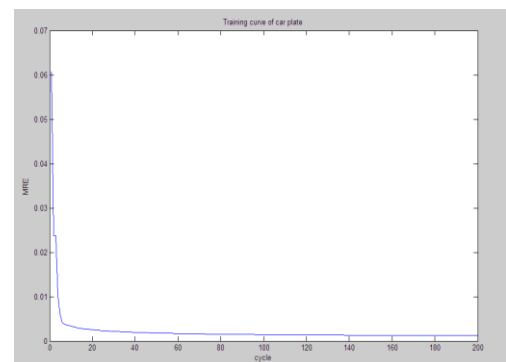


Fig. 3. License plate convergence graph of training

3.4 License Plate Recognition Step Process

License plate recognition system recognition processes such as fig. 4. These eight license plate recognition steps are described below:

Step1. Enter recognition plate, such as fig. 5(a) first location map, its recognition plate samples such as fig. 1, according to 12 photo positions at inter regional, any of 6 different locations, experimental-production 100 vehicles total photos taken 600 sheets when the recognition of samples.

Step2. Vehicles with license plates Image pre-processing (as fig. 5 and fig. 7).

Step3. 32 x 64 scans the image pixel scan window, and at

the same time using 2D Haar discrete wavelet Transform three make the image smaller and only select LL low-frequency parts, in order to reduce the image pixels three times the result like fig. 11. Three pressures after the low frequency parts of vehicle license plate imaging become 60×80 images.

Step4. License plate after 2D Haar Discrete Wavelet Transform, select only the third transformation of LL low-frequency parts.

Step5. The LL low-frequency coefficients into a column, as each scan the regional characteristic of values. After special feature values of regularization, as such Artificial neural Network input data.

Step6. Using Artificial neural Network recognition. Set number input neuron for the license plate number of feature values, and the number of hidden neurons was 20, and the number of output layer neurons was 8, and the load after training is complete Input layer and hide the layer weight values and the hidden and output layer weight values and input layer with hidden layer basis values and the hidden and output layer weights equivalent. Such Artificial neural Network operation output binary strings, and convert the binary string to decimal values.

Step7. Determine. The scanning district feature values, as the Artificial neural Network training algorithm input values, and Artificial neural Network output the correct license plate number, otherwise continue to scan the next district.

Step8. Output the results of recognition.

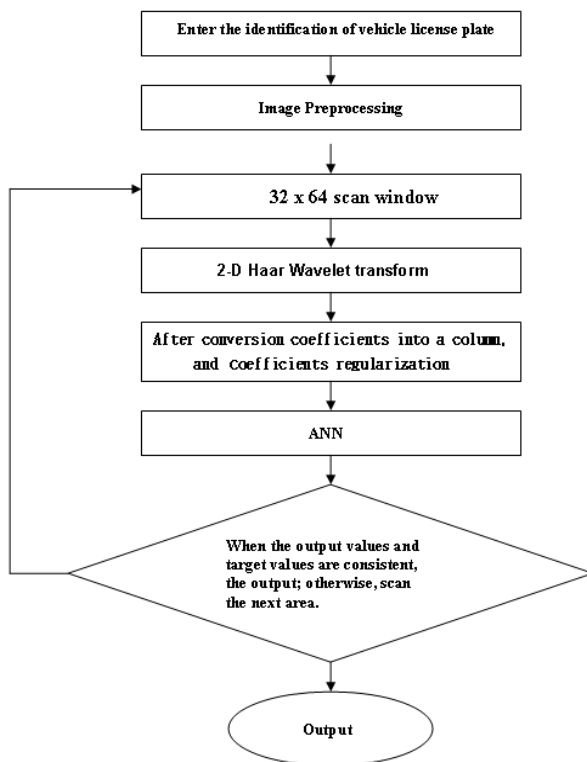


Fig. 4. License plate recognition process.

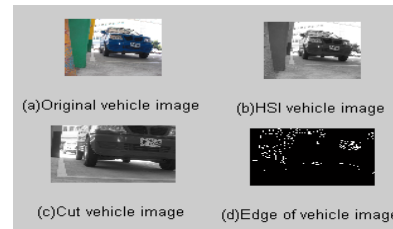


Fig. 5. During the day image preprocessing.



Fig. 6. During the day edge of vehicle image.



Fig. 7. At night image preprocessing.



Fig. 8. At night edge of vehicle image.



Fig. 9. (a) During the day license-plate location. (b) License plate



Fig. 10. (a) At night license-plate location. (b) License plate



Fig. 11. (a) 9M-7249 and (b) 7M-7982 are license plate HDWT three times Transform.

4 EXPERIMENTAL RESULT AND ANALYSIS

Experimental 1800 cars in the picture, one can see from figure 1 locations per license photo taken 12, a total of 1200 sheets license plate train, while figure 1 locations within each license photo taken 6 pictures, a total of 600 sheets were being used as a test data set, and each image is 24-bit color images. Is in the different location photography, collected the image displays the following properties: (1)The left side photography lead to more complex backgrounds. (2)Some pictures as the evening sunlight and low quality. (3)According to the distance was taken different plate sizes vary.

This section describes the 4.1 chapter is a license plate recognition results figure and table, the 4.2 chapter is the recognition and analysis of the results. This article in license plate training step first using edge function and Sobel shield operator for edge detection pre-processing, and automatically looking for license plate location and the extract license plate, in 1200 sheets image have 80 sheets license plate location failed, failed causes have car lamp and too sun strongly reflection or reconnaissance to similar license plate background, and so on problems, extract license plates accuracy rate of only about 93.3%, such as table 1 shows, training and license plate number, such as table 2 shows; extract license plates used for recognition of the correct, by table 3 license plate recognition result that recognition rate of 95.33%, so the license plate recognition system is the most values.

4.1 License Plate Recognition Results Figure And Table

License plate recognition results as fig. 12 and fig. 13 shows.



Fig. 12. During the day license plate recognition result.



Fig. 13. At night license plate recognition result.

TABLE 1. LICENSE PLATE CAPTURE RESULTS TABLE

The number of per vehicle	per vehicle training 12 sheets
License plate number	1200
The correct number of capture	1120
Capture the correct Rate (%)	93.3

TABLE 2. LICENSE PLATE NUMBER TRAINING TABLES

Number of per vehicle training	per vehicle training 1 sheet	per vehicle training 12 sheets
Train number license plate (sheets)	100	1200

TABLE 3. LICENSE PLATE RECOGNITION RESULT TABLE

Per vehicle recognition number	per vehicle recognition 1	per vehicle recognition 6
Vehicle recognition number (sheets)	100	600
Recognition number of successful (sheets)	93	572
Recognition number failed (sheets)	7	28
Recognition rates (%)	93	95.33

4.2 Recognition and Analysis of Results

This image is covered by the limited number of vehicles and vehicle license plates in a certain region of space, and the day at the normal climate as taken in the evening. Recognition of vehicle license plate was shooting at day and night mixing and a weather well, and vehicle license plate location anywhere within the region 6, and 100 vehicles, all total 600 samples as license plate recognition. For each image 32×64 pixels scan window to scan, and three times 2-D Haar Discrete Wavelet transform, filter out high frequency part of the pixel, only extract third Haar Discrete Wavelet Transform of low-frequency parts of coefficients with the image into 4×8 , this method reduces the image factor and fast recognition speed of execution. And load training network weight values and basis weights, after we use Artificial neural Network to recognition of the vehicle of a district, and finally output the vehicle recognition results.

This license plate recognition system first steps is using edge function and Sobel shield operator for license plate edge reconnaissance, and automatically looking for license plate location and the extract license plate, we will extract license plate through class Artificial neural Network training, to

obtained entered layer and hidden layer weight values and the hidden layer and output layer weight values, and the entered layer and hidden layer partial right value and the hidden layer and output layer partial right value, parameter value. Step two is to use 32×64 pixels scan window is different from the training samples of unknown license plate image scanning, and through 2-D Haar Discrete Wavelet Transform three times and take the third transformation of low-frequency coefficient and load weight values of the first steps training and partial weight and other parameters and their values are fixed, unchanging, and in a limited district using Artificial neural Network to recognition of vehicles. Simply speaking, to use the unknown license plate feature values to be kind of Artificial neural Network operations, such as match unknown license plate number is one of the original training sample license plates. Finally, recognition results of output, if the recognition yes, opening the gates for a vehicle to enter. Otherwise recognition fail, prohibition of vehicular enter.

This article by using MATLAB software laboratory test results, the vehicles according to 600 sheets have 28 sheets failed, his resolution of 95.33%.

5 CONCLUSION

This papers by made of license plate recognition system is different from traditional of license plate recognition system, its characteristics is directly scan and the using 2-D Haar Discrete Wavelet three times conversion, and every time conversion image take low frequency part, makes image became original image of $1/4$ coefficients, and by three times conversion image extract low frequency part of vehicles license plate image, make image coefficients became original of one-sixty fourth, thus reducing coefficients of recognition plate imaging, it can fast recognition speed.

This paper Recognition system are combination of 2-D Haar Discrete Wavelet transform and artificial neural networks are license plates through the 2-D Haar Discrete Wavelet transform, get the license plate of the feature values, and characteristic values into a column, then the feature values corresponding to license plate type Artificial neural Network training, when training is complete, it using training received weight values load to Artificial neural Networks. Then, using 32×64 scan window progressive scan unknown effects of vehicle license plate recognition, and outputs the results. MATLAB software test result, license plate recognition rate up to 95.33%.

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