License Plate Recognition System Using Haar Wavelet

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Abstract- In present world, crimes are increasing day by day with a rapid speed and criminals use vehicles in crimes. When we go at a crowded place, we see that people does not follow traffic rules during driving. So license plate recognition system is designed to control crimes and to make traffic system neat and clean for public safety. License plate recognition system (LPRS) is composed of three parts, which are license plate detection, character segmentation and the character recognition. In recent years template matching was used for license plate recognition but it is sensitive to noise. In this paper, Haar wavelet is used for license plate detection, and feature extraction of license plate characters. Haar wavelet requires least time for license plate detection, character segmentation, feature extraction, and for training. As number of license plate images in training database is increased, recognition rate increases but at the same time training time also increases. The proposed system has been implemented in MATLAB.

Keywords- License Plate Recognition System, Image Processing, Character Recognition, Haar Wavelet.

1. Introduction

License plate recognition systems have received a lot of attention from the research community. With the rapid growth in the number of vehicles, there is a need to improve the existing systems for identification of vehicles. A fully automated system is in demand in order to reduce the dependency on labor. The Automatic Number Plate Recognition (ANPR) was invented in 1976 at the Police Scientific Development Branch in the UK. However, it gained much interest during the last decade along with the improvement of digital camera and the increase in computational capacity. It is simply the ability to automatically extract and recognition a vehicle number plate's characters from an image. In essence it consists of a camera or frame grabber that has the capability to grab an image, find the location of the number in the image and then extract the characters for character recognition tool to translate the pixels into numerically readable character.

1.1 Phases in License Plate Recognition System

LPR system mainly contains four phases to recognize a vehicle license plate of any country. Step in phases are shown in Fig. 1.

These are explained as follows:

1.1.1 Image Acquisition

This is the first phase in an LPR system. This phase deals with acquiring an image by an acquisition method. In our proposed system, we used a high resolution digital camera to acquire the input image. The input image is 1200 x 1600 pixels.

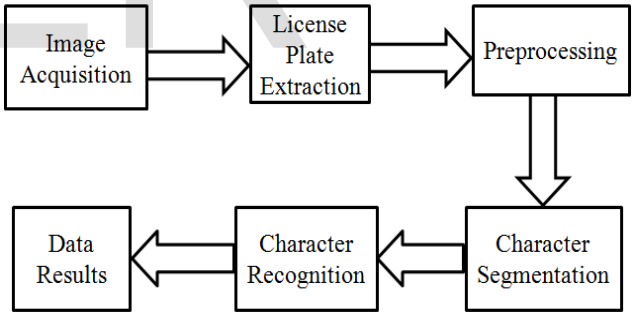

Fig. 1 License Plate Recognition System Phases

1.1.2 License Plate Extraction

License Plate Extraction is a key step in an LPR system, which influences the accuracy of the system significantly. This phase extracts the region of interest, i.e., the license plate, from the acquired image. The proposed approach involves "Masking of a region with high probability of license plate and then scanning the whole masked region for license plate".

1.1.3 Character Segmentation

License Plate Segmentation, which is sometimes referred to as Character Isolation takes the region of interest and attempts to divide it into individual characters. In the proposed system segmentation is done by the OCR method.

1.1.4 Optical Character Recognition

The last phase in LPR system is to recognize the isolated characters. After splitting the extracted license plate into individual character images, the character in each image can be identified. There are many methods used to recognize isolated characters. In the proposed system we are using Optical Character Recognition which is an inbuilt feature in MATLAB.

2. Related Work

In license plate recognition system, a lot of work has been done by many researchers. We will explain related work in every phase of LPRS one by one. Some of which are explained as follows:

2.1 Image Acquisition

Image Acquisition is the first step in an LPR system and there are a number of ways to acquire images, the current literature discusses different image acquisition methods used by various authors. Comelli et. al. [1] used a CCD TV camera for image acquisition mounted on the framework of a tollgate. In such a way it is possible to frame a rear view of a passing vehicle, whose presence is reported by an ending- race sensor. Salgado et. al. [2] proposed a advanced Sensor subsystem, having a high resolution CCD camera supplemented with a number of new digital operation capabilities. Naito et. al. [3] developed a novel sensing system, which utilizes two CCDs and the prism to split an incident ray into two lights with different intensities, has been presented. One of the main features of this sensing system is that it covers wide illumination conditions from twilight to noon under sunshine. Kim et. al. [4] proposed a learning-based approach for the construction of license plate recognition system.

2.2 License Plate Extraction

License plate extraction is the most important phase in an LPR system. Here, we will discuss some of the previous work done during the extraction phase.

Lee et. al. [5] proposed a method to extract Korean license plate depending on the color of the plate. In this method a neural network is used for extracting color of a pixel by HLS (Hue, Lightness and Saturation) values of eight neighboring pixels and a node of maximum value is chosen as a representative color. Park et. al. [6] proposed a method which first applies two neural network-based filters to a color image and then it uses a post-processor to combine the two filtered images in order to locate license plates. Kim et. al. [4] presented a vehicle license plate recognition system. It consists of three modules, each of which was an integration of various vision technologies. One of them is the car extraction module which detects car in given image sequence. Tianding Chen [7] proposed a character localization method for color images. The method operates directly on the compressed image using discrete wavelet transform and neural network.

2.3 Character Segmentation

Many different approaches for segmentation phase have been proposed in the literature and some of them are as follows:

Seetharaman et. al. [8] used conventional technique for segmentation of characters. Once the license plate is localized and the bounding rectangle is obtained, the license plate area is hunted for a character. Salgado et. al. [2] proposed algorithms based on lateral histogram horizontal and vertical accumulations. Horizontal accumulations where used to distinguish between single and two line car-plates. Vertical accumulations where applied to separate the characters according to the so-called slopes of the vertical dynamic range. Kim et. al. [4] used neural network as filter for segmentation. To find the license plate from the candidate area, this module first applies two neural network-based filters to an input and then it uses a post-processor to combine the two filtered images in order to locate license plates. Abdullah [9] proposed a image segmentation technique using clustering approach.

2.4 Optical Character Recognition

This section presents the methods that were used to classify and then recognize the individual characters. One of the recognition module is shown in Fig. 2. The classification is based on the extracted features. These features are then classified using either the statistical, syntactic or neural approaches. Some of the previous work in the classification and recognition of characters is as follows:

Khotanzand and Hong [10] used Zernike Moments by several authors for recognition of characters. Caner et. al. [11] used template matching and neural networks are the two methods frequently used in character recognition. Salgado et. al. [2] A particular character recognition strategy was developed specially suited to overcome the following problems not considered in the standard OCR approaches: small character resolution, low image contrast, motion blur, geometrical distortion and corrupted image information. Boaming Shan [12] Based on the study of plate location, the method of vertical projection information with prior knowledge is proposed to segment character and extract the statistic feature, then use the RBF neural network to recognize with feature vectors as input.

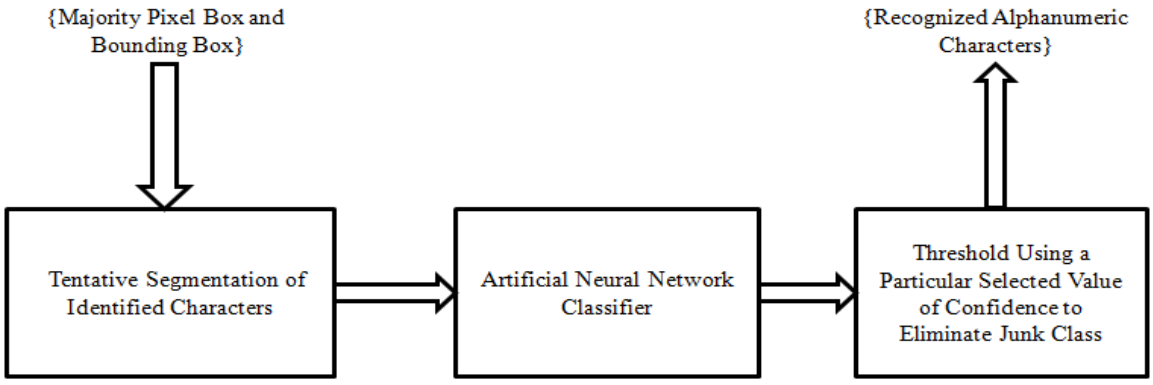

Fig. 2 Recognition Module

3. Haar Wavelet

Haar wavelet is used for license plate recognition system. A wavelet is a mathematical function used to divide a function or signal into different scale components. A wavelet transform is the representation of a function by wavelets. The wavelets are scaled and translated copies of a finite length or a fast oscillating waveform. Wavelets cut up data into different frequency components, and then study each component with a resolution matched to its scale. They have advantages over traditional Fourier methods in analyzing physical situations where the signal contains discontinuities and sharp spikes. If objects are small in size or low in contrast, they are examined at high resolutions. The signal to be analyzed is decomposed into an approximation and a detail. The approximation is further decomposed into an approximation and detail and the process is repeated. Wavelet transform is very similar to conventional Fourier transform, but it is based on small waves called wavelets, which is composed of time varying and limited duration waves. The wavelet transform is computed separately for different segments of the time-domain signal at different frequencies. Wavelet transform decompose the signal into four details i.e. approximation details, horizontal details, vertical details and diagonal details as shown in Fig. 3. By using wavelet transform we get the complete information of image at all frequencies by using these details.

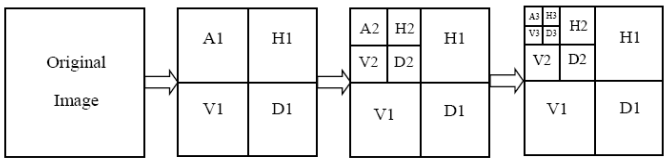

Fig. 3 Wavelet Decomposition Levels

Haar wavelet is the simplest wavelet and is the only orthogonal wavelet that has symmetric analysis and synthesis filters. Haar wavelet is a certain sequence of rescaled "square-shaped" functions which together form a wavelet family or basis. Wavelet analysis is similar to Fourier analysis in that it allows a target function over an interval to be represented in terms of an orthonormal functions basis. The Haar sequence is now recognized as the first known wavelet basis. Haar used these functions to give an example of a countable orthonormal system for the space of square-integrable functions on the real line. Haar wavelet is also the simplest possible Wavelet.

Wavelets are used in license plate recognition system because these have advantages over traditional Fourier methods. Wavelets are localized in both time and frequency domain. If both small and large objects, low and high contrast objects are present simultaneously then it is advantageous to study them at several resolutions. So wavelets are used, it decomposes the images into four details i.e. approximation, vertical, horizontal and diagonal details. Using wavelets we get whole of the information contained in license plate images. In license plate recognition system, different wavelets are used for license plate detection and after that features of license plates are extracted using them. In this way, we get complete information of license plate images.

4. The Proposed Haar Wavelet Based License Plate Recognition System

For real time application, the system requires a video camera (frame grabber) which acquires the images of vehicles from rear or front view. But for the present work, due to unavailability of the required hardware, we have used 3.5 Megapixels camera inbuilt in mobile.

The images of various parked vehicles have been acquired manually, thereafter fed to the software where they are first converted in to gray scale images. Brightness, contrast and gamma adjustments are made to optimum values to enhance the number plate and its digits. Then the region with highest probability of number plate is masked and extracted. Then the resulting region of interest is scanned for characters and numerals by continuously changing the

coordinates of bounding box in an OCR session. The output of OCR is saved in a spreadsheet and then for each iteration the result is checked if it qualifies to contain all the digits in number plate. Whenever the results meet the conditions specified, the software displays the number and terminates the execution of program so that next image can be processed.

The flow chart of License plate recognition system implemented in this thesis work is shown in Fig. 4. There are various steps in this approach and these are implemented in MATLAB.
The first stage of any vision system is the image acquisition stage. The images can be taken by high resolution camera or sometimes database may be taken from internet according to the requirements of the system. After the image has been obtained, various methods of processing can be applied to the image to perform many different vision tasks required today.

After the acquisition of image, preprocessing of image is done. When an image is acquired, there may be noises present in an image. These noises affect the recognition rate greatly. So, these noises should be removed from the images.

License plate detection is the first step of License plate recognition system and directly related to the speed and accuracy of license plate recognition. In this approach, extraction of edge of gray scale image is used to locate the license plate accurately. Normalization of gray scale image is done. Sharpening filter is used for masking. Wavelet transform is done using different wavelet filters. Edge detection is done using sobel operator to extract the edge image of the original gray image. Vertical edge image is achieved by using sobel operators.

Wavelet Transform is done using Wavelet Filter. In this process, image is firstly decomposed using Wavelet toolbox's function wavedec2 and four details of an image are formed. These four details are approximation, vertical, horizontal and diagonal details. These four details give complete information of image because image is decomposed from all sides i.e. horizontally, vertically and diagonally. In this paper work, Haar wavelet filter is used for this work.

4.1 Feature extraction using Haar Wavelet

After segmentation, features are extracted from the characters and these features are used as input to neural networks to find the recognition rate. In some previous methods, statistical features are used. In this dissertation

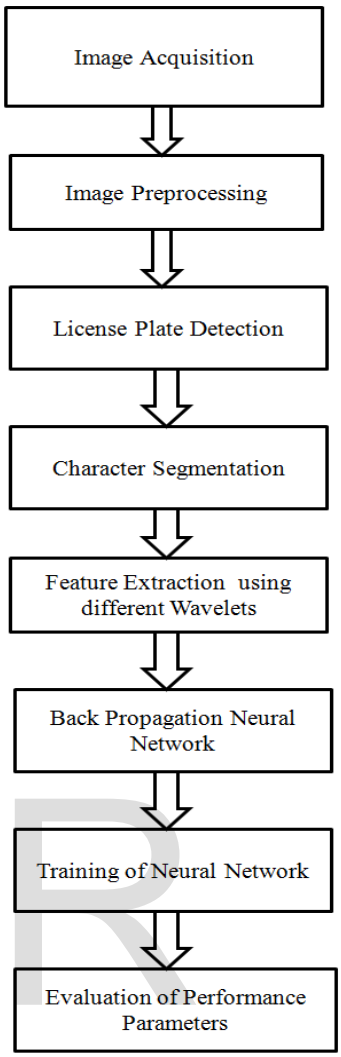

Fig. 4 Flow Chart of License Plate Recognition System

work, statistical features i.e. standard deviation, mean, moments, variance, area, centroid are also computed. License plate detection is done in this process by Haar wavelet only and statistical features are computed and used as input to neural network. It is shown that statistical features have less recognition rate than some shape features extracted by different wavelets and statistical features takes more time. Statistical features are the relevant information extracted from the raw data, which minimize the inner class distance and maximize the between class distance. There are several types of statistic features i.e. mean, variance, standard deviation, meshing features, moments etc.

Mean: In mathematics and statistics, the arithmetic mean referred to as simply the mean or average when the context is clear, is a method to derive the central tendancy of a sample space. For a data set the mean is the sum of the values divided by the number of values. The mean of a set of numbers x1,x2……xn is given by:

$$X = 1/n(\sum xi) \quad (4.1)$$

Standard Deviation: It is widely used measurement of variability or diversity used in statistics. It shows how much variation or "dispersion" from the average mean is present. A low standard deviation indicates that the data points tend to be very close to the mean whereas high standard deviation indicates that the data are spread out over a large range of values. The standard deviation is a measure of how numbers are spread out.

Variance: The variance is defined as the average of the squared differences from the mean. The second central moment about the mean is the variance. The positive square root of which is standard deviation.

Moments: A moment is quantitative measure of the shape. The second moment is widely used and measures the width of a set of points in one dimension or in higher dimensions measures the shape of a cloud of points as it could be fit by an ellipsoid. Other moments describe other aspects of a distribution such as how the distribution is skewed from its mean, or peaked. The 1st moment is denoted by μ. The first moment of the distribution of the random variable X is the expectation operator mean.

In higher orders, the central moments are more interesting than the moments about zero. The kth central moment of a real-valued random variable probability distribution X, with the expected value μ is:

$$\mu k=\sum((X-\mu)k) \quad (4.2)$$

The first central moment is thus 0. The zeroth central moment μ is one. The normalized third central moment is called skewness. A distribution that is skewed to the left has a negative skewness. A distribution that is skewed to the right will have a positive skewness. It is a measure of the asymmetry of the probability distribution of real valued random variable.

Fig. 5 Input Image

We have conducted a number of experiments for evaluation of our proposed system. One of them is described with details below:

Image shown in Fig. 5 is captured by mobile camera with 3.5 megapixel and given as first input in MATLAB. This is the image for which we have done recognition of character. Image shown in Fig. 6 gives four details of input image using Haar wavelet i.e. approximation, vertical, horizontal and diagonal details. With the help of these details we detect license plate as shown in in Fig. 7.

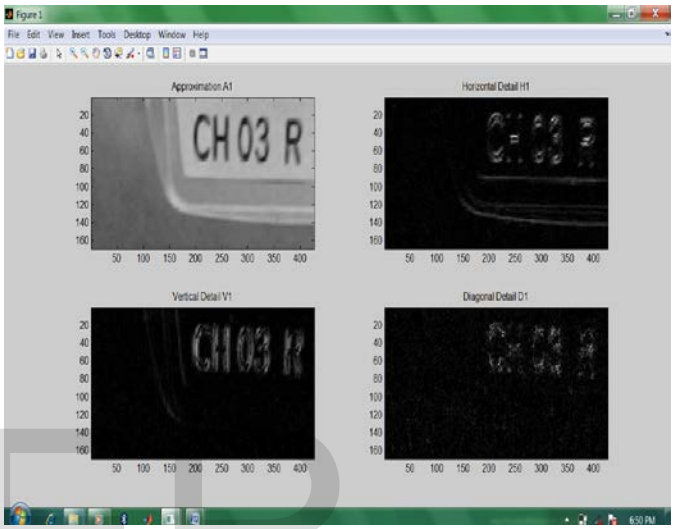

Fig. 6 Details Using Haar Wavelet

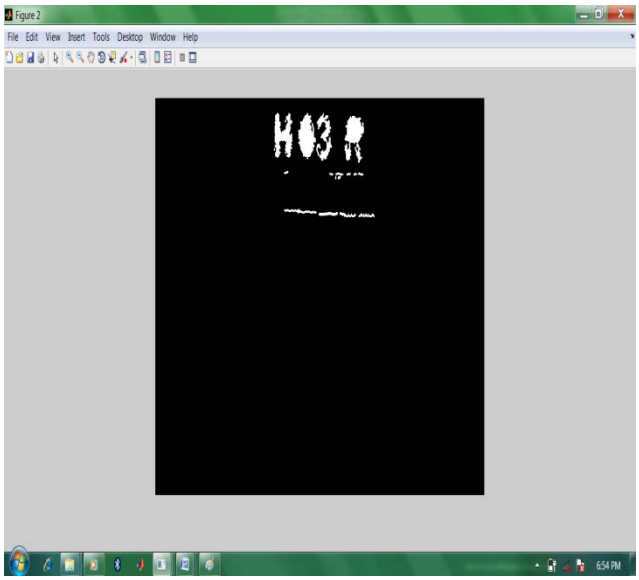

Fig. 7 License Plate Dection

4.2 Experimental Evaluation

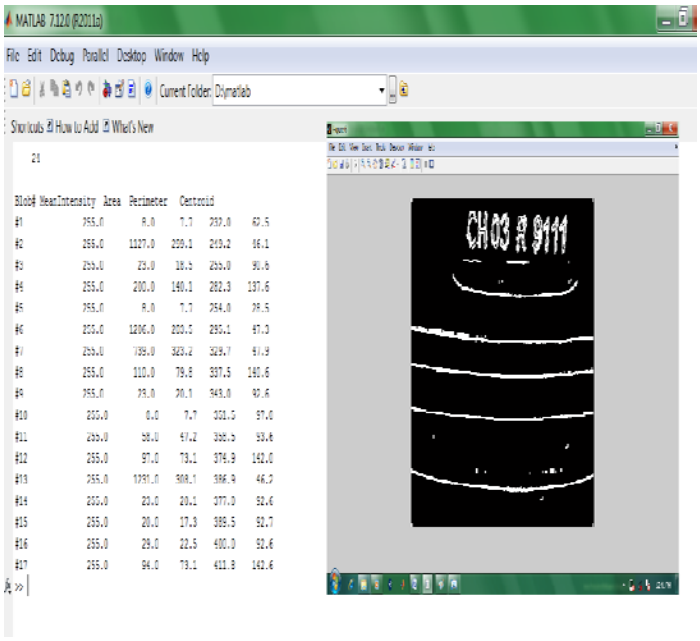

Fig. 8 Character Segmentation with Feature Extraction

We extract statistical features e.g. blobs, mean, intensity, area, perimeter, centroid etc. by using Haar wavelet as shown in Fig. 8. Our final result i.e. character segmentation of license plate with workspace area is shown in Fig. 9. After that features of license plates are extracted and these features are used as input to neural networks.

5. Conclusion

In this paper, Haar wavelet is used for detection and segmentation of characters printed on license plate of vehicles. Image pre-processing is done with the help of medifilt which is median filter function in MATLAB. It removes noise presented in the input image. After that we calculated statistical feature detecting license plate using Haar wavelet. Recognition rate and training time is also computed by taking different number of images in training database. Time taken by Haar wavelet was found lesser as compared to other existing other wavelets e.g.bior3.9 for detection, character segmentation, feature extraction and training of neural network. Total time taken for license plate recognition system is least for Haar wavelet. We trained back propagation neural network for different number of images to calculate training time. As number of images in training database increases training time also increases.

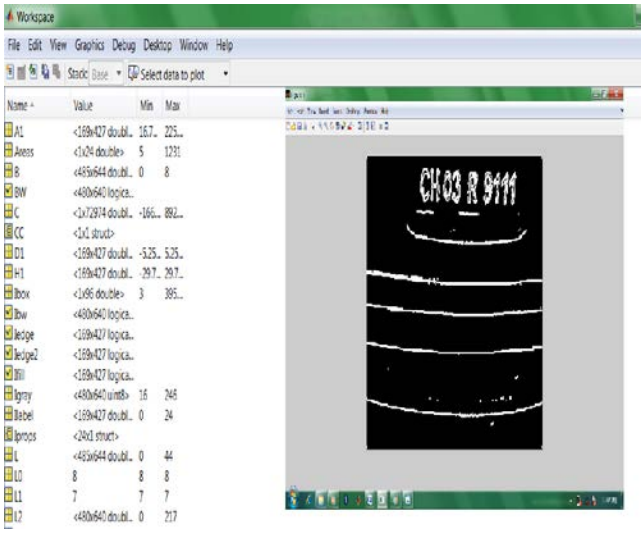

Fig. 9 Character Segmentation of License Plate with Workspace Area

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