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A Vehicle License Plate Recognition with Improved Character Segmentation & Recognition Techniques

Nupur[1], Alisha[2]
[1,2] Department of Computer Science Gateway Institute of Engineering & Technology (GIET), Deenbandhu Chhotu Ram University of Science & Technology (DCRUST), Sonepat

Abstract: ***A License Plate Recognition (LPR) System is one kind of an Intelligent Transport System and is of considerable interest because of its potential applications in highway electronic toll collection, security systems and traffic monitoring systems. All the above applications required reliable License Plate Recognition software system. In this paper, we provide an efficient technique for solving number plate recognition on different vehicles. We use three basic concepts of license plate recognition such as – plate localization, character segmentation and character recognition. For plate localization, we use hybrid approach of histogram equalization, edge detection, filtering and component analysis. All these techniques play an important role in the extraction process. For character segmentation, an interpolation algorithm based on information obtained by filtering and adaptive thresholding is used to separate each character. For character extraction we use artificial neural network along with optical character reader concepts.***

Keywords— ***Character segmentation, Character, Artificial Neural Network, Plate Localization***

I. INTRODUCTION

License plate recognition (LPR) is an image-processing technology used to identify vehicles by their license plates [1]. This technology is gaining popularity in security and traffic installations. In recent years, with the increase of terrorist activities around the world, security has become a major concern. The demand for security related services has been higher than there ever was, and there is a great need to find new way to protect ourselves or improve the existing methods by using information technology. One area of interest has been automated surveillance systems controlled by computers that could work independently with minimal human intervention. An automated system that could identity suspect vehicles passing though can issue alerts or report such incidence to corresponding authorities immediately. This will speed up response time and can save lives.

The purpose of this paper was to develop a real time application which recognizes license plates from cars at a gate, for example at the entrance of a parking area or a border crossing [2]. The system, based on regular PC with video camera, catches video frames which include a visible car license plate and processes them. Once a license plate is detected, its digits are recognized, displayed on the User Interface or checked against a database. The focus is on the design of algorithms used for extracting the license plate from a single image, isolating the characters of the plate and identifying the individual characters.

In this paper, innovative methods are proposed for license plate recognition that is targeted to solve the inherited issues. For plate localization, a heuristic combining several traditional image processing technique is used. Techniques such as histogram equalization, edge detection, filtering and component analysis each plays a role in the extraction process. For character segmentation, an interpolation algorithm based on information obtained by filtering and adaptive thresholding is used to separate each character. Artificial neural networks (ANN) [3] are in charge of the Optical Character Recognition. Traditional training method for ANN are extremely time consuming and often result in sub-optimal configurations. A hybrid training method is introduced by combining traditional gradient descent based Back-propagation and random selection based Simulated Annealing process to overcome such shortcomings.

II. POTENTIAL APPLICATIONS

Vehicle license plate recognition is one form of automatic vehicle identification system. LPR systems are of considerable interest, because of their potential applications to areas such as highway electronic toll collection, automatic parking attendant, petrol station forecourt surveillance, speed limit enforcement, security, customer identification enabling personalized services, etc. Real time LPR plays a major role in automatic monitoring of traffic rules and maintaining law enforcement on public roads. This area is challenging because it requires an integration of many computer vision problem solvers, which include Object Detection and

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Character Recognition. The automatic identification of vehicles by the contents of their license plates is important in private transport applications. There are many applications of such recognition systems, some of them are discussed below [4].

Law Enforcement: The plate number is used to produce a violation fine on speeding vehicles, illegal use of bus lanes, and detection of stolen or wanted vehicles. License plate recognition technology has gained popularity in security and traffic applications as it is based on the fact that all vehicles have a license plate and there is no need to install any additional tracking apparatus. The main advantage is that the system can store the image record for future references. The rear part of the vehicle is extracted off the filmed image and is given to the system for processing. The processed result is fed into the database as input. The violators can pay the fine online and can be presented with the image of the car as a proof along with the speeding information.

Parking: The LPR system is used to automatically enter pre-paid members and calculate parking fee for non-members (by comparing the exit and entry times). The car plate is recognized and stored and upon its exit the car plate is read again and the driver is charged for the duration of parking.

Automatic Toll Gates: Manual toll gates require the vehicle to stop and the driver to pay an appropriate tariff. In an automatic system the vehicle would no longer need to stop. As it passes the toll gate, it would be automatically classified in order to calculate the correct tariff.

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Border Crossing: This application assists the registry of entry or exits to a country, and can be used to monitor the border crossings. Each vehicle's information is registered into a central database and can be linked to additional information.

Homeland Security: The LPR system's ability to read strings of alpha-numeric characters and compare them instantaneously to Hot Lists allows a Command Center to organize and strategize efforts in reaction to the information captured. Fixed LPR systems, which can be mounted to bridges, gates and other high traffic areas, can help keep a tight watch on entire cities, ports, borders and other vulnerable areas. Every LPR camera is capturing critical data such as color photos, date and time stamps, as well as GPS coordinates on every vehicle that passes or is passed. This incredible database provides a wealth of clues and proof, which can greatly aid Law Enforcement with

- Pattern recognition
- Placing a suspect at a scene
- Watch list development

III. PROBLEM FORMULATION

The license plate recognition process can be roughly divided into three steps (as shown in Figure 1) Plate Localization, Character Segmentation and Character Recognition. Each step will be carried out by an independent module. An input image submitted to the system is first examined and processed to obtain the vehicle license plate region, then the plate region is process to locate each individual digit and character, these are then submitted to the final Optical Character Recognition (OCR) process to determine the identification.

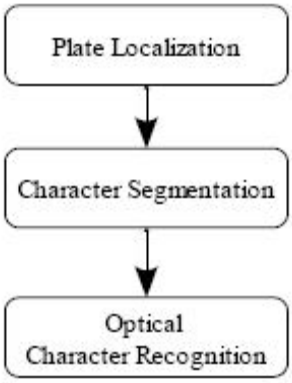

Figure 1: Recognition Steps

A. Plate Localization

This is the process of extracting the license plate region out of an image. It involves basic image processing techniques combined with some decision making based on deterministic threshold. Without any prior knowledge on how large the plate is, or where it is located, the entire image must be inspected and analyzed in order to extract candidate regions [5][6].

There are many different approaches on how to accomplish this, some algorithm assume that the plate region location of the image should not varies by much, and it should be adjusted by using sensors, thus limiting the search range for fast results. Some technique makes use of only edge information for plate location, and there are also very complex algorithms such as vector quantization, fuzzy clustering and fuzzy logic.

B. Character Segmentation

Once the candidate region is detected from the input image, the next stage is to segment the plate to extract individual digit/character for recognition. This process is highly dependent on the format of the plate being processed. Because different country and regions have different plate shapes and sizes, the color used as plate background and foreground are totally different and their content varies both in length and combination of digit and characters. For example, the Chinese license plates analyzed in

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have dark background with character in lighter color; the algorithm used cannot be directed applied to the plates in Alberta, Canada, since those are completely opposite [7].

C. Character Recognition

Once each individual digit and/or character is extracted, it must be identified in some way. This process is called Optical Character Recognition, and there are several different solutions to this problem. Two approaches are particularly popular among many different researches on license plate recognition.

One of the methods is template matching. In this method, a series of slightly different templates of all glyphs are kept in a database. Once a image is submitted for recognition, existing templates are compared to the new image, and the best fit will determine its identity. This method requires that the template database be large enough to cover most glyph variations, and it must also have an efficient algorithm to process large set of templates [10].

The other way is by using Artificial Neural Networks as classifier. The ANN classifier must be trained before use to recognize all the different digits, characters and symbols that require identification.

IV. PROPOSED ALGORITHM

The algorithm proposed does not make any assumption regarding possible location and/or size of the plate region. It only relies on both edge and color information for extracting the license plate region out of random images.

A. Plate Localization

It makes use of some constants that provide helpful information on the plate location in any image.

No matter the lighting condition, plate background color are all lighter and plate foregrounds are darker.

Plate region are all rectangular shape with same specific proportion between width and height.

Plate region will be high in edge concentration.

The following a flow diagram of the algorithm used (Figure 2).

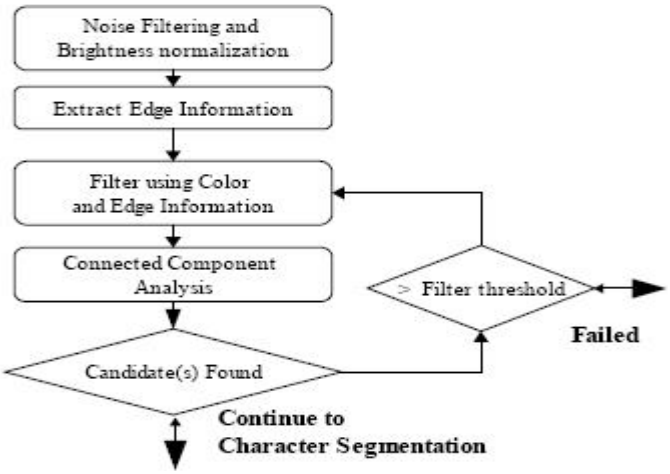

Figure 2: Plate Location

B. Character Segmentation

The high-level flowchart of the algorithm is shown in Figure 3.

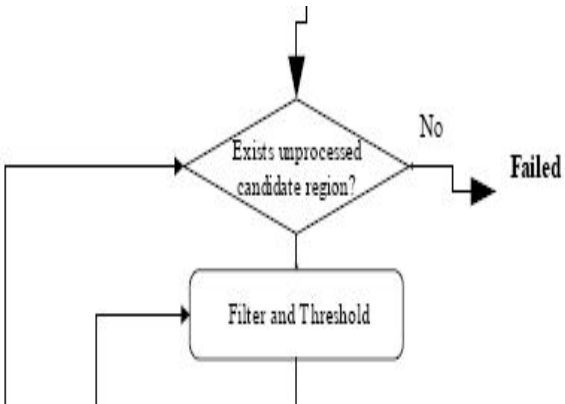

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Figure 3: Character Segmentation

The segmentation algorithm is a combination of several techniques that are applied as necessary. First, a simple method like adaptive binary thresholding is used along with some clustering. If results are negative, then some other methods are added progressively increasing its complexity.
The following steps are repeated for each possible candidate region until valid set of character/digit regions are found in one of them.

1) *Apply Color Filter:* The candidate region is filtered by eliminating the /colors that do not correspond to neither the background nor foreground. This filter is applied again to eliminate the colored text at the top of the plate. It also eliminates other foreign objects on the plate, such as stickers.
2) *Thresholding:* Use an adaptive algorithm to find a threshold for this image and use a inverse thresholding function to create a binary image.

$$img_{ij} = \begin{matrix} 255, if\ img_{ij} < threshold \\ 0, otherwise \end{matrix}$$

In the best case scenario, the only pixels left after the binarization would be the pixels forming the license number.

C. Characters Extraction

Create connected component out of the filtered image and use boxes to fit the components. Try to extract the glyphs by finding a series of boxes with very similar size and shape. For a successful image, different boxes should be found, each one will contain a group of pixels forming a digit or a character.
After individual characters are extracted, each character is converted into a 20x10 matrices of ones and zeros. This matrix will be submitted to the final stage of recognition by neural network.

D. Character Recognition

The Optical Character Recognition method chosen as part of the LPRS system is an Artificial Neural Network.

1) *Artificial Neural Networks:* Artificial neural network (ANN) is an area of research in Artificial intelligence (AI) that attempts to model the human brain. An ANN is composed of a large network of interconnected processing components (Neurons). Just as our brain process information by having neuron cells interact with each other, an ANN try to solve problems in the same way.

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ANN differs from conventional AI problem solving, as it does not depend on particular algorithms, but it relies on all its neurons working as independent agents.

Neurons interact with each other by receiving and firing signals according to its internal structure. The firing of the neurons is determined by all the input signal it receives, adjustment weights and a firing rule. Weights are used to alter the signals traveling from neuron to neuron. By adjusting these weights in the learning process, a network can be taught to produce the desired outcome given an input. The Firing rule used by neuron can be a threshold-based step function

$$f = \begin{matrix} 1, if \sum w_{ij} > threshold \\ 0, otherwise \end{matrix}$$

or a sigmoid function

$$f = \frac{1}{1+e^{-t}}$$

ANN can solve classification problems. Input data act as external stimulus to the network, and all neurons interact with each other in parallel as the it receives signal from some neurons and fire signals to others. The final output of the ANN will be a pattern that identifies the class/group in which input data belongs to [9].

V. IMPLEMENTATION & RESULTS

This proposed number plate extraction method work well for all types of vehicle images (png, jpeg, jpg, tif, tiff, bmp etc). Total 150 vehicle's images are used for testing. Images are taken in different illumination as well as background conditions. They are of different colors and different sizes. The images are taken from different distances relative to camera.

Figure 8 a) Original Image b) Edge detected Image

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c) Binarized Image, d) Candidate Region image
e) Plate Localization f) Low frequency filter
g) Binarization h) Final character segmentation

The result of proposed method for number plate extraction is shown in table 1.This method is implemented in MATLAB 2010b.

Table 1: Result of Number Plate Extraction

Total Vehicles images	Extracted license plates	Unsuccessful extraction
150	147	3
Percentage	98%	2%

VI. CONCLUSION

The process of vehicle number plate recognition requires a very high degree of accuracy when we are working on a very busy road or parking which may not be possible manually as a human being tends to get fatigued due to monotonous nature of the job and they cannot keep track of the vehicles when there are multiple vehicles are passing in a very short time .To overcome this problem, many efforts have been made by the researchers across the globe for last many years. In this paper, we provided an efficient technique for solving number plate recognition on different vehicles.

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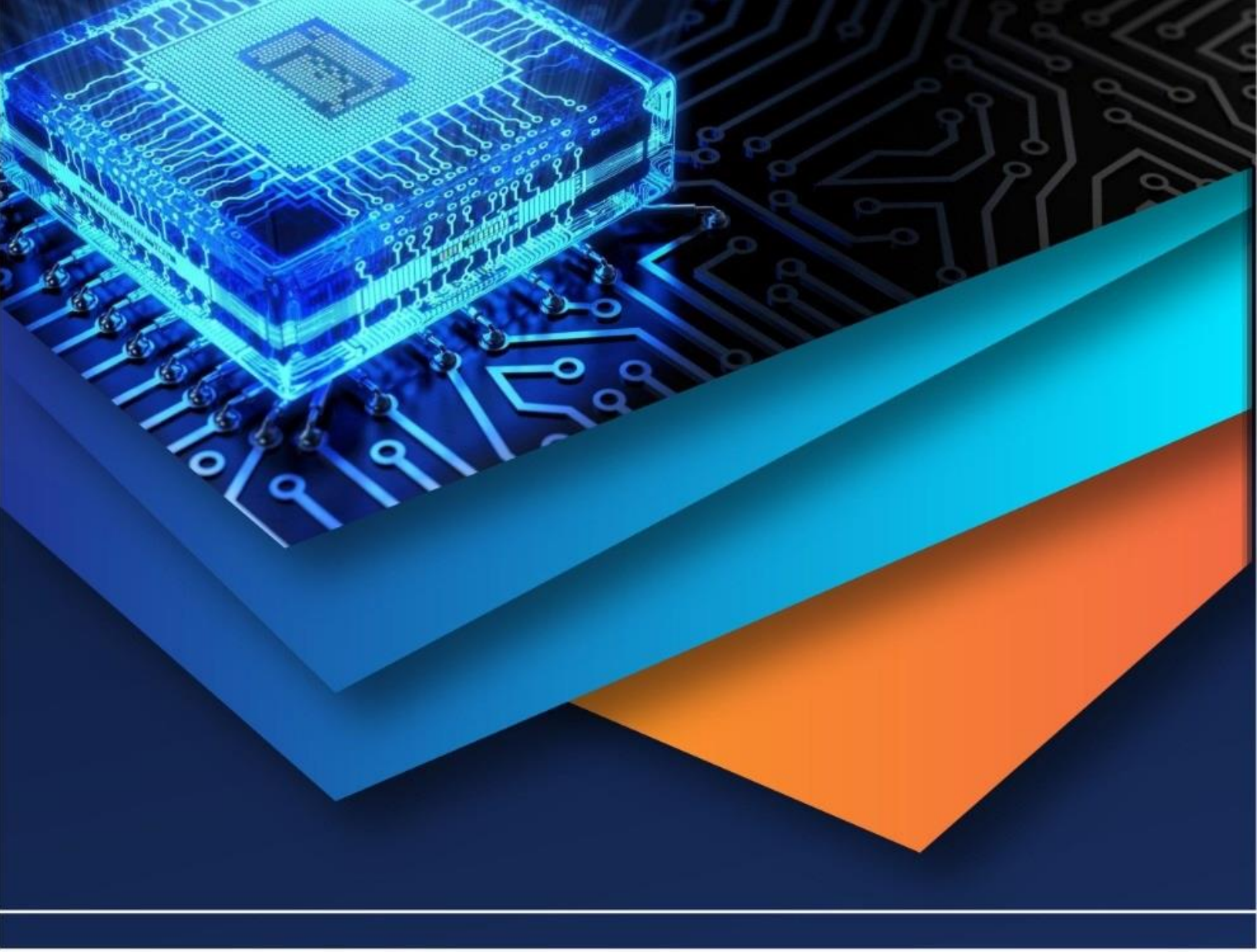

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