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An Approach to Efficiently Recognize Number Plates from Car Images

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***Abstract*- The current scenario is envisaging a tremendous growth in the usage of cars. This increase is demanding automated process for many situations like highway electronic toll collection, automatic parking attendance, petrol station forecourt surveillance, speed limit enforcement, security and customer identification enabling personalized services. An Automatic Number Plate Recognition (ANPR) is a system that can be used in these situations. Motion video or camera still images are used to recognize the car's number plate characters. This paper presents an efficient approach for Automatic Number Plate Recognition which consists of four phases i.e. Number Plate Localization, Preprocessing, Character Segmentation and Optical Character Recognition. The results have been compared with standard methods at each phase and this proposed method presents better results than the existing ones.**

Keywords- Automatic Number Plate Recognition, Optical Character Recognition, Number Plate Localization, Character Segmentation.

I. INTRODUCTION

The rapid technological development in the area of computer image processing and constantly increasing need for efficient and cheap security and steering systems resulted in the development of different kinds of solutions based on computer picture analysis. One type of these solutions is automatic car identification systems based on localization and recognition of the number plates shown in photos or camera picture. An (ANPR) Automatic Number Plate Recognition is a system that can be used in these situations. Motion video or camera still images are used to recognize the car's number plate and characters. This paper presents an efficient approach for Automatic Number Plate Recognition which consists of four phases i.e. Number plate Localization, Preprocessing, Character Segmentation and Optical Character Recognition. In the present work, a template based matching is performed to identify each character and then convert them into ASCII format. The results have been compared with standard methods at each phase and this proposed method presents better results than the existing ones.

II. LITERATURE SURVEY

The ANPR was invented in 1976 at the Police Scientific Development Branch in the UK. Prototype systems were working by 1979, and contracts were let to produce industrial systems, first at EMI Electronics, and then at Computer Recognition Systems (CRS) in Wokingham, UK. Early trial systems were deployed on the A1 road and at the Dartford Tunnel. The first arrest through detection of a stolen car was made in 1981.

As early as 2000, immigration officials in the United States and Canada began promoting LPR technology and cargo X-ray scanners. [1] In 2005, patrol stations along the U.S.Mexico border also incorporated the technology to record the entry and exit of vehicles. [2] However, little academic research on LPR technology has occurred in the United States. One of the most complete studies, conducted during a 4-month evaluation period in 2004, examined the effectiveness of the technology in identifying stolen vehicles and license plates, as well as vehicles driven by wanted felons [3]. While the review of the technology was generally favorable, the report indicated that the software produced over 1.8 million scans during the research period but caused 3,286 alarms, of which, 108 were positive (meaning the license plate characters and state matched a valid entry in the computer system). Of particular interest, the study found that the reader could not match stacked or small characters on a license plate.

Moreover, until this period the plate number has to manually typed by a personnel which then would be searched in a database for a match, in 2005, the first automatic LPR was installed which could 'read' the number automatically as they enter a road, using a road side camera.

The year 2006, introduced mobile ALPR where the deployment of patrol car-mounted ALPR was used. From this period, the efficiency of the ALPR was continuously improved and during 2007-2008, a number of wireless technologies, like two-way radios, smartphones, mobile broadband cards, and scanners were analyzed to integrate ALPR [4].

Garcia-Osorio et al. (2008) used artificial vision system to recognize the Spanish car license plate numbers in raster images. The algorithm is designed to be independent of the distance from the car to the camera, the size of the plate number, the inclination and the light conditions. In the preprocessing steps, the algorithm takes a raster image as input, uses a filter to remove noise and produces an ordered list of license plate areas candidates. According to their result, the first candidate itself proves to be efficient, but in case when requirement is for more accuracy, the second and third varieties were considered. The filter used was applied only to low contrast areas. Khalifa et al. (2007) proposed an approach to perform recognition of license plates under any environmental conditions with no assumptions about the orientation of the plate or its distance from the camera [5]. The localization problem is solved by using a simple texture-based approach based on edge information Segmentation is performed using connected component analysis and a multi-layer perception neural network is used during character recognition [6]. An exhaustive study of license plate recognition is provided by Shridhar et al. (1999), concluding that fusion of gray scale morphology and homomorphic processing are yielding to high rates of string extraction and recognition. Naito et al. (1999) provided a solution to the problem of fast passing vehicles and image blurring is given [7]. Variable image acquisition angles give rotated characters in license identification strings. Such alterations are handled using the Hotelling transform (Hegt et al., 1998) or by the invariant properties of the normalized moment of inertia (Torres-Mendez et al., 2000). Recognition is generally achieved by template matching, neural networks (Sirithinaphong and Chamnongthai, 1998; Parisi et al., 1998; Park et al., 1999.

III. METHODOLOGY

The hardware generally includes triggering unit, camera, lighting and image acquisition. Software includes number plate location, preprocessing to enhance the captured car image, number plate character segmentation and character recognition algorithms.

The number plate localization or plate detection is a process that extracts the number plate candidate regions from the car images. Preprocessing is the process of removing noise from the extracted number plate. The result of preprocessing is an enhanced version that can be used to efficiently segment the characters of the number plate.

The third phase, character segmentation is the process which identifies and segments the various characters in the number plate. In general, the segmentation process creates N character segmented sub images for a plate having N characters. These sub images are used as input by the fourth phase, character Recognition. This phase recognizes the number of character in each sub image and converts them into an ASCII format.

In the present research work, enhancement of images are termed as ‘Preprocessing Techniques’ and consist of two stages.

Stage 1: Implement denoising method to remove the noise generated during acquisition of car images.

Stage 2: Analyze the performance of various edge detection algorithms on car images.

IV. IMPLEMENTATION

The experiments were conducted in three stages. The first stage analyzed the performance of the localization. The second stage analyzed the performance of the preprocessing algorithms that are used to enhance the car image. The third stage analyzed the performance of region segmentation and character recognition algorithms. The results are compared with traditional algorithms.

4.1 Denoising algorithm

Two performance metrics were used while studying the performance of the denoising algorithm. They are Peak Signal to Noise Ratio and Denoising Time.

4.1.1 Peak Signal to Noise Ratio (PSNR)

PSNR is often used as a quality measurement between the original and a compressed image. To compute PSNR, the block first calculates the Mean-Squared Error (MSE) and then the PSNR by using (1).

$$\text{PSNR} = 10 \log 10 \left[\frac{R^2}{\text{MSE}} \right] \quad \ldots (1)$$

$$\text{where MSE} = \frac{\sum_{M,N}[I_1(m,n) - I_2(m,n)]^2}{M * N}$$

where M and N, m and n in MSE equation are number of rows and columns in the input and output image respectively.

4.1.2. Denoising Time:

The time taken by the algorithm to perform the denoising operation is termed as denoising time. The time is measured in seconds.

4.2 License Plate Localization

To evaluate the performance of license plate localization algorithm four metrics were considered. They are false negative, false positive, true positive and true negative. In the definitions, 'positive' is 'correctly identified' and 'correctly rejected' and 'negative' is 'wrongly rejected' or 'wrongly accepted'.

4.2.1 False Negative

False negative is the ratio of number of images where the algorithm fails to identify the correct location of the license plate to the total number of images.

4.2.2 False Positive

False positive is the ratio of number of images where the algorithm identifies a wrong location as license plate to the total number of images.

4.2.3 True Positive

True positive is defined as the ratio of number of images the algorithm correctly identifies the license plate location to the total number of images.

4.2.4 True negative

It is defined as the ratio of number of times the algorithm fails to localize the license plate location when an image with no plate is given.

4.3 Character Recognition Time

The character recognition algorithms performance is analyzed using recognition rate and recognition time.

4.4 Recognition Rate and Reliability

The Recognition Rate is defined as the ratio of correctly recognized characters and is calculated using (2).

$$\text{Recognition Rate} = \frac{\text{Number of correctly recognized test patterns}}{\text{Total Number of test patterns}} \quad \ldots\ldots (2)$$

4.5 Edge Detection algorithms

For detecting edges of the number plate, five edge detection algorithms, namely, Sobel, Prewitt, Robert, Canny, LoG are selected for analysis. This section presents the results obtained while testing the selected five edge operators with six car images. Apart from detection of edges, the speed of detecting the edges was also analyzed, as this step is only a part of the ANPR system. The results are presented in the following Table .1.

TABLE 1: EDGE DETECTION TIME (SECS)

Operator	Car1	Car2	Car3	Car4	Car5	Car6	Average
Prewitt	**1.79**	**0.06**	**0.04**	**0.02**	**0.03**	**0.23**	**0.36**
Roberts	**0.04**	**0.02**	**0.02**	**0.02**	**0.02**	**0.01**	**0.02**
LoG	**0.55**	**0.10**	**0.07**	**0.03**	**0.05**	**0.12**	**0.15**
Canny	**7.85**	**0.28**	**0.29**	**0.21**	**0.13**	**0.37**	**1.52**
Sobel	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.01**	**0.02**

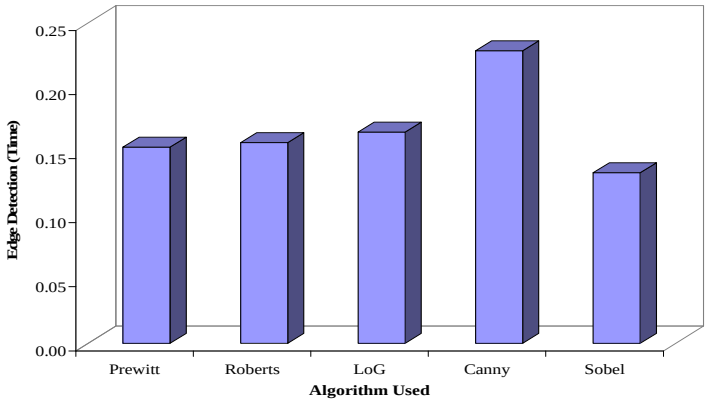

Figure 1: Average Edge Detection Time (Secs)

From the visual inspection of the images obtained it can be seen that the LoG model is efficient in identifying the edges clearly. Further, from table it can be seen that the sobel method is faster than all other edge detectors.

The average value shows that Sobel and Roberts operators are the fastest, followed by LoG and Prewitt. The Canny operator was the slowest among all the five. The average time difference between LoG and Sobel, Roberts is approximately 0.13 seconds. But as the edges detected are more proficient in LoG method, it was decided to use LoG edge operator in further experiments.

V. RESULTS AND DISCUSSION

5.1 Localization Results

The result of the localization algorithm was evaluated using the parameters, false negative, false positive, true positive and true negative. The number plate localization algorithm was tested with 250 images, where 50 images were images that were captured without plates. The results obtained are tabulated in Table .2. The system was compared with that of which is referred to as 'Base System'.

TABLE 2: PERFORMANCE OF NUMBER PLATE LOCALIZER (%)

Algorithm Used	True Positive	True Negative	False Positive	False Negative
Base System	**92.91**	**93.16**	**2.13**	**8.13**
Proposed System	**96.00**	**97.20**	**1.60**	**7.20**

From the results, it could be seen that the proposed system with the usage of LoG edge detector is improved in the process of localizing a number plate from a car image.

5.2 Character Recognition Results

The results obtained while analyzing the character recognition capability of the ANPR system are presented and discussed in this section. The template database had 33 alphanumeric character templates. The main challenge with Indian vehicles is that the number plate use different fonts. In the present research work, three frequently used fonts are considered. They are Arial, Times New Roman and Courier New. Thus the template had 99 alphanumeric characters, which was used during experimentation. A sample is shown in Figure.2.

Figure 1: Sample Template Images

As discussed in the previous section, the accuracy of number of plate position recognition was 95.64%, which means out of 200 car plates, 191 plates images were correctly recognized. The character recognition was performed only on these 191 images.

TABLE 3: PERFORMANCE OF THE CHARACTER RECOGNIZER

Number of Samples	Recognition Accuracy (%)		
	Character	Number	Average
191 Images	97.21	98.16	97.79

The recognition accuracy results show that the recognition of digits (98.79) is more accurate than the recognition of alphabets (97.21 %). Most of these errors were encountered because of the common characteristics that exist between the alphabets and digits. The confused characters mainly include $3 \rightarrow 8$, $4 \rightarrow A$, $8 \rightarrow B$, $D \rightarrow 0$, $S \rightarrow 5$, $Z \rightarrow 2$. From the results, it could be seen that the template matching algorithm is an effective algorithm for recognition of characters. The algorithm reduces the recognition error rate while consuming less time and hence is a promising candidate that can be used efficiently for recognizing the characters in the number plate.

5.3 Speed of ANPR System

To evaluate the effectiveness of the ANPR system, the speed of recognition was taken into consideration and is shown in Table.4.

TABLE 4: SPEED OF ANPR SYSTEM (SECS)

Localization	Preprocessing	Plate Segmentation	Character Extraction	Character Recognition	Total Time
1.83	0.37	0.83	0.44	1.23	**4.70**

On analyzing the speed of the ANPR it can be understood that the proposed algorithm is fast in recognizing the characters in a number plate.

VI. CONCLUSION

The proposed ANPR system consists of various stages like preprocessing, localization and segmentation of number plate, segmentation of alphanumeric characters in the number plate, recognition of the various characters. Several experiments were conducted to test the performance of each stage, since the cumulative efficiency of each stage improves the overall performance of the ANPR system. All the experiments conducted prove that the proposed ANPR system is efficient in terms of accuracy and speed. The research work is summarized and concluded along with some future research directions.

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