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License Plates Recognition System for Light Limited Conditions

Ali Ganoun, Faraj Farhat and Omar El Baruni

University of Tripoli, Faculty of Engineering, Electrical and Electronic Engineering Department
Tripoli, Libya
a.ganoun@uot.edu.ly, f.farhat@uot.edu.ly, O.Elbaruni@uot.edu.ly

Abstract—**A growing demand for traffic data concerning traffic flow and automatic car identification, motivates researchers around the world to adopt advanced computer vision techniques to monitor and control traffic flow.**

This paper presents the application of License Plate Recognition (LPR) system for Libyan vehicles in light limited conditions. The proposed system based on captured image sequences with infrared camera.

Generally, LPR system consists of four main stages, in the first stage video frames was processed and analysed with some image processing techniques such as equalization and filtering. The second stage is the localization of license plates in the image. The next stage is the segmentation of plate characters. The last stage is the recognition stage where the plate characters recognized and identified.

The proposed system was implemented and tested using three videos sequences with different sizes. The overall system accuracy level was about 51% in its best cases, while for the localization and the segmentation stages the system provided an 80% percent accuracy. It is observed that results influenced by the quality of input images and distance between the camera and the vehicle.

Keywords— **LPR, localization, segmentation, recognition light limited conditions.**

I. INTRODUCTION

LPR system is the ability to automatically extract and recognize of vehicle number plates from an image. In essence, it consists of a camera that capture images and algorithm ms that can detect and recognize license plates.

LPR systems has been used in many applications such as security control, traffic management systems, border crossings, car parking and many other applications.

In general, vehicles in each country have a unique license number written on its license plate used to distinguish one vehicle from the other. An automated LPR system can be implemented to identify the license plate of a vehicle and extract the characters from the region containing a license plate. The license plate number can be used to retrieve more information about the vehicle and its owner, which can be used for further processing [1,2].

The main objective of this project was to develop an efficient LPR system that recognize the license plates in limited luminance conditions. and to Implement and test the proposed system. Other objective is implement, test and evaluate the performance of the proposed system.

II. PRINCIPLES OF LICENSE PLATE RECOGNITION

As shown in Fig 1, a typical LPR system consist of the following stages:

- License plate Localization.
- License Plate Segmentation.
- License Plate Numbers Recognition.

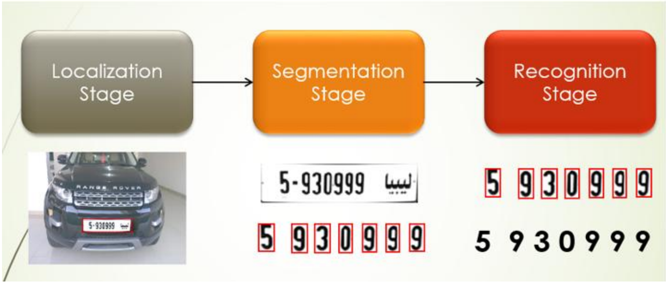

Fig. 1 The main stages of a typical LPR system

A. License plate Localization

License plate Localizations the most important and the most difficult stage in the recognition process. Generally, it is based on license plate regional characteristics to determine the location of the license plate in the image. The accuracy of this stage directly influence the accuracy of the whole LPR system. There are many techniques can be used for localization stage such as Neural networks, Ad boost Algorithm.

Other methods use the structure of plate texture, edge, gray histogram, angular point, horizontal or vertical projection geometry characteristics combined with the image processing methods to determine the location of the license plate. There are also many techniques are based on the license plate's

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background color, color-space distance, and similarity calculation [3,4].

B. License Plate Segmentation

After license plate localization, segmentation involves splitting characters and segment each character. Many techniques can be applied for character segmentation such as Thresholding which provides an easy and convenient way to perform image segmentation based on different intensities or colours in the foreground and background regions using a threshold value. The main challenge in this approach is selecting the optimum threshold value. Other techniques based on edge detection. Edges occur on the boundary between two different regions in an image. Based on this, edge detection is segmenting the image using the difference in pixel values. There are many techniques based Connected Component Analysis (CCA), which analyse and segment connected components in a binary image. The goal of the connected component analysis is to detect connected region or object. The set of connected components are used to partition an image into segments. [6,7]

C. License Plate Recognition

Plate recognition refers to the process of assigning a given input data into one of a given number of categories. It is the process of identifying each character and assigning it to the correct character class. There are several recognition techniques can be used such template matching, neural networks, statistical approach, structural approach [7,8].

III. Infrared light

Infrared (IR) radiation was discovered in 1800 by astronomer William Herschel, who discovered a type of invisible radiation in the light spectrum beyond red light. Slightly more than half of the total energy from the Sun was eventually found to arrive on Earth in the form of infrared. Infrared light is emitted or absorbed by molecules when they change their rotational-vibrational movements. Infrared light is used in industrial, scientific, and many medical applications.

IR light is an electromagnetic radiation with longer wavelengths than those of visible light, extending from 700 nm to 1 mm. Which corresponds to a frequency range of approximately 430 THz down to 300 GHz. IR LPR based systems can capture plates in complete darkness where the plate's reflection will be very bright to the camera because of the illuminator, even though human beings see no light.

In this project IR photography is used, a technique that can capture on film or on a digital sensor where the IR radiation reflected by the scene. Both film and sensor are seriously limited in their capability to record IR radiation. Digital sensors can go as far as 1300nm. Commercial IR films are unable to record radiations below about 900nm.

IV. Proposed LPR system

This section discusses the proposed LPR system used in the identification of the Libyan licence plates in light limited conditions using Infrared illumination. All license plate images and videos are taken with an infrared static camera.

The flow chart in Fig2shows the main stages of the proposed license plate recognition.

A. Pre-processing

Pre-processing for video frames is performed to extract images for the purpose of LP recognition. Pre-processing is done as following:

- Convert the image to gray scale, which can ease further processing.
- Apply an order static filter, to filter the noise on the image.
- Apply histogram equalization to adjust the contrast of the image. Histogram equalization accomplishes this by effectively spreading out the most frequent intensity values. Equalization can help in infrared LP images as the lights of the stop lamps makes the license plate vanish and unreadable, but with the equalization process the light in the image will be redistributed and the license plate can be recognized.
- The last step is to adjust the image to become darker so that the license plate area will become clearer.

Fig 3 shows the pre-processing stages.

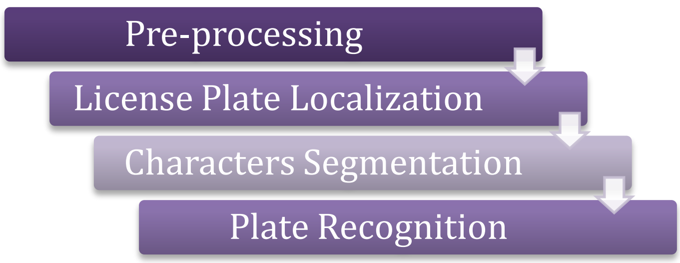

Fig. 2 Block Diagram of the Proposed License plate system.

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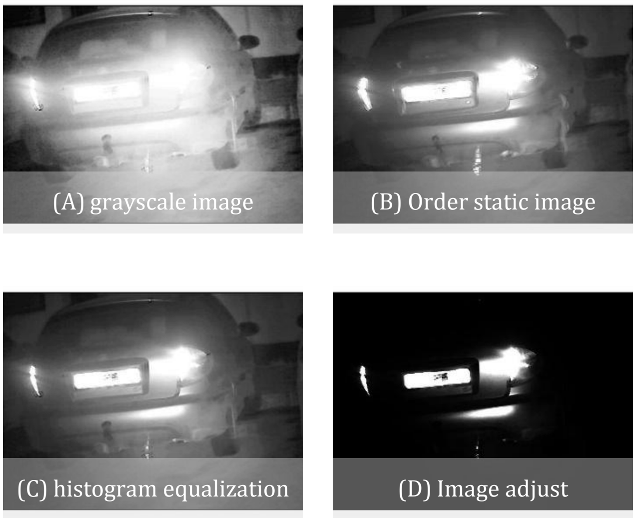

Fig. 3 The Pre-processing Stage

B. *License Plate Localization*

In order to have a reliable localization of license plate in light limited conditions, several steps are required. which includes the following steps:

1)Binary Thresholding

This step used to detect regions and objects in a digital image that similar in properties, Fig. 4 shows demonstrates the binary thresholding for an Infrared image. As can be seen Thresholding can help in removing any non-white object in the image, which can minimize the plate candidates. Usually in infrared car plates images leaves only the plate and the rear lights, this is a good feature of infrared images because this can ease the localization process.

2) Connected component elimination

All objects that have a value which is fewer than P pixels would be eliminated in this step, which can be done by using a connected component filter. In general, connected component labelling is done by forming an algorithm that labelling the vertices based on the connectivity and relative values of their neighbours. Connectivity can be 4-connected or 8-connected. In the proposed system, the connected component elimination effect is performed after the original image is converted to binary, the use of connected component elimination is vital to remove small objects as shown in Fig. 5 [5].

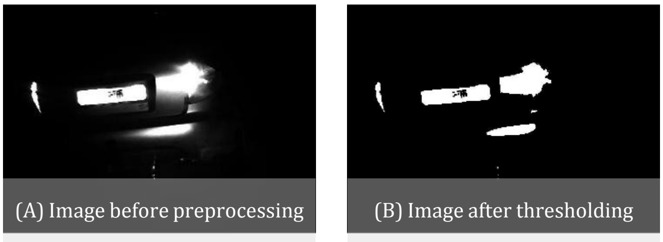

Fig. 4 Binary Thresholdingof IR Image.

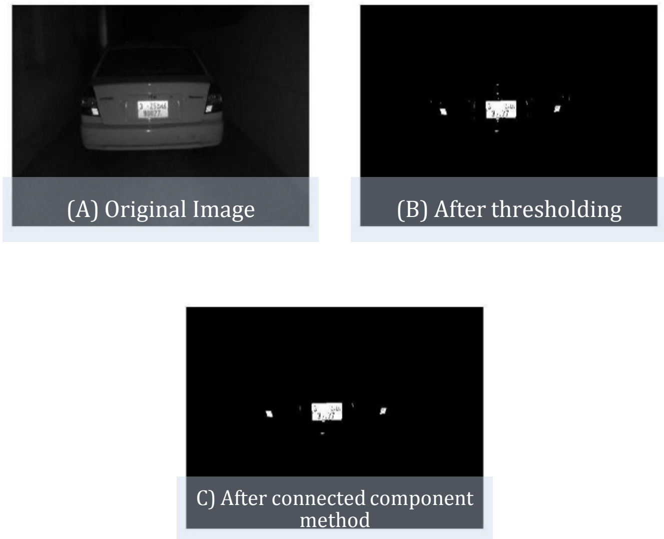

Fig. 5 Effect of Connected Component Elimination.

3) Rectangular ratio

As all license plates have a rectangular shape, therefore in the proposed LPR a filter has been used to filter all non-rectangular shapes, which leaves only the License plate, and some accompanying noise.

4) Euler Number Objects Elimination

Euler number for the binary image is the total number of objects in the image minus the total number of holes in those objects. The proposed system make use of this feature given that objects in the license plate image have at least 7 or 8 holes because it represents the license characters. Generally, other objects in the image have a maximum of 2 or 3 holes so the Euler number can be used to discard these objects. Fig 6 shows the image after applying Euler elimination filter [5].

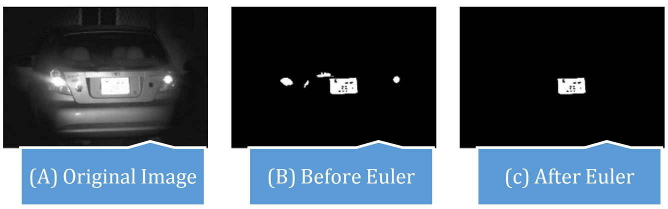

Fig6 Euler Number Effect.

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C. License plate segmentation

After the detection of the license plate position in the image the next stageis the segmentation stage. The segmentation is one of main stages in all LPR systems. If the segmentation fails, a character can be improperly divided into two pieces, or two characters can be improperly merged together. Horizontal and vertical projection of a plate image has been used for the plate segmentation.

The input image to this stage is the localized license plate image. The first step is to convert the image to binary image as required for horizontal and vertical projection.

Next, the system applies horizontal projection where the image is processed row-wise. A histogram is prepared based on this processing. With the horizontal projection the image plate can be divided into two sub images ready for further processing as shown in Fig 7.

The last step in this stage is the vertical projection, which is an essential step in plate segmentation; the image is processed column wise and the operation of scanning the image from left to right column by column. By doing this operation the characters will be separated individually and are ready for recognition as shown in Fig. 8.

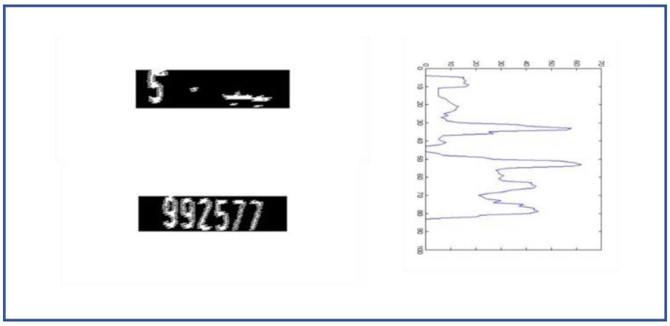

Fig. 7 Horizontal Projection of License Plate.

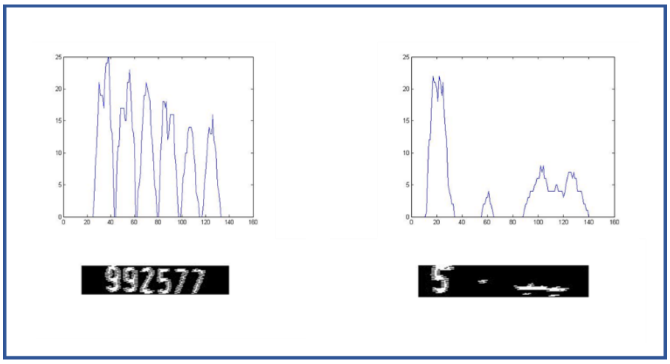

Fig. 8 Vertical projection of License Plate.

D. License Plate Recognition

After the segmentation of plate characters, the next stage is to develop a technique to identify the plate characters. Template matching technique has been used for this stage, this method has fast recognition speed, especially for binary images, and it can meet the real-time requirements, this method can have a higher recognition rates when the license plate image is clear.

The method is quiet simple, it works on the principle of comparing the segments from the previous stage with the templates, a correlation is done with stored templates until the system find its match.

The implemented template matching includes the following steps:

- The system checks if the segment is a number or not, if so the operation proceeds, if the segment is a letter or any kind of noise its immediately discarded.
- Sometimes the segment has a blank space above or below the number, this can affect the matching process, the solution for this problem is removing this blank space using Horizontal projection.
- The system resizes the provided segment to the same size of the saved template so the process of correlation can take place.
- Before the matching operation can start, the system inverts the binary segment. Then it passes through an order static filter to reduce the black area to prepare the segment for matching as shown in Fig. 9.
- The matching is the done by XOR the segment with all stored templates, the highest correlation with the template is saved, this process continues for all sub-images as shown is Fig.10.

Fig. 9 (A) Segment after removing blank space - (B) Resizing segment - (C) negative Segment - (D) applying order static filter.

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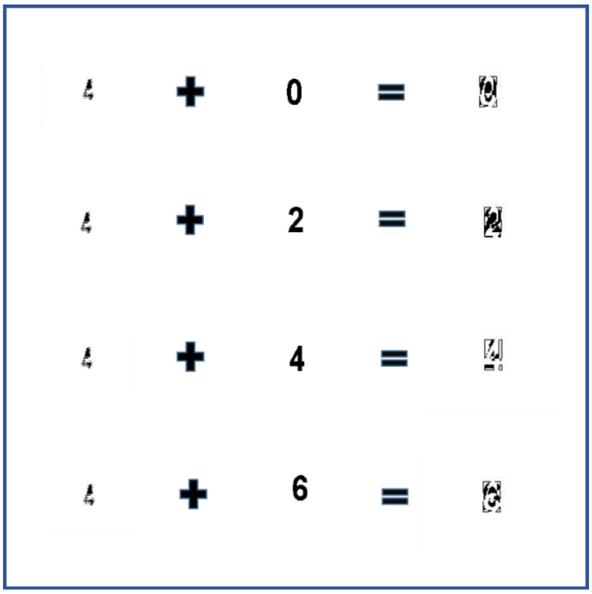

Fig. 10 Example of template matching of sub-image with some samples

V. RESULTS AND PERFORMANCE ANALYSIS

The proposed LPR system deals with video frames as the input signal rather than static images, the performance of the system has been tested using 3 video sequences; these sequences were taken in light limitedconditions with an Infrared camera. Table 1 shows some properties of the test sequences.

The recognition result wasanalysed and the system performance accuracy was determined for each sequence where the percentage of success for every video sequence has been measured.The system compared the outputs of each stage with the actual plates information which had been inserted manually.

From the 258 frames that was tested the license plate was successfully located in 218 frames with a success percentage of 84.91 %, the reason for the 15.09 % error often comes from the source image. For the segmentation process, the characters of 210 frames were successfully separated. The success percentage was 81.39%. The recognition process is analysed by comparing between recognition with thinning or without thinning for each video sequence. Thinning is a step in the recognition stage performed used by using an order static filter.

The overall performance of the proposed system is summarized in Table 2 and Fig.11. The accuracy percentage of the result was calculated using the formula:

$$Accuracy = \frac{Total\ number\ of\ correctly\ detected\ plates}{Total\ number\ of\ plates}$$

TABLE 1
TEST SEQUENCES.

Source	Video Sequence # 1	Video Sequence # 2	Video Sequence # 3
Number of frames analysed	258	362	534
Frames size	720x576	720x576	720x576

TABLE 2
TEST RESULTS FOR VIDEO FRAMES DETECTION AND RECOGNITION

Source	Video Sequence # 1	Video Sequence # 2	Video Sequence # 3
Localization stage success	218	289	292
Localization success percentage	84.91 %	80%	54.8%
Segmentation stage success	210	289	292
Segmentation success percentage	81.39%	80%	54.8%
Recognition stage success% (with thinning)	51%	31.8%	13.7%
Recognition stage success % (without thinning)	39%	25%	10.4%

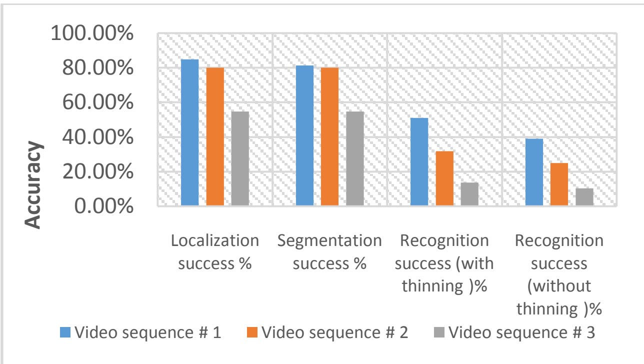

Fig. 11 The Performance of the proposed LPR system.

VI. CONCLUSIONS

This project related to the design and implementation of License Plate Recognition system for Libyan license plates in light limitedconditions (e.g. at night time) using video sequences as input source.

Since the input to the system is a video sequence and not static images, pre-processing was needed before initiating the three major stages in any LPR system. The pre-processingneeded to prepare frame images for the localization

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stage by reducing noise, redistribution of the light in the image and adjusting the intensity values.

In the localization stage many image-processing techniques has been performed such as elimination of small objects using connected component analysis, then using Euler number to minimize the objects in the image .Finally, using structural properties, the correct plate region is identified and localized fromthe candidate regions.

After the selection of plate image, it is passed to the character segmentation stage.For segmenting the individual characters, Horizontal and vertical projection has been considered. In the final stage, a template matching technique has been used to classify and recognize the characters.

It has been noted that the main failure in car licence plate localization and segmentation caused by the low quality source images, also plate angle was a problem in some cases.

The failure in many licence plate segmentation and recognition caused by the variation in image illumination.

This work successfully implemented and tested with Libyan License plate sin light limited conditions; the system achieved an acceptable accuracy level with three sequence images.

The following notes has to considered to improve the performance of the LPR system:

- The used camera has a major effect on the performance to the LPR system, most of video frames that had been captured were in a very weak condition no matter what analysis or filters used to improve its quality, therefore a better quality camera is recommended for development of LPR systems.
- The proposed system did not perform well for high-speed vehicles, in fact any vehicle moving in a speed higher than 20 Km/h would not be analyzed by the system, improvement in this matter is recommended to make the system applicable as a real time system.
- The system efficiency can be improved by considering different techniques and filters.
- Some frames provided a skewed license plates, these frames could not be analyzed properly especially in segmentation stage, therefore a proper skewing technique can enhance the system performance.
- The distance between the camera and the vehicles did not exceed 5 meters because of the limited distance coverage of Infrared camera, so an infrared source with higher distance capability is recommended.

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