Saudi License Plate Recognition

Saleh Basalamah

Abstract—Automatic license plate recognition systems (LPR) can help reduce the number of traffic violations and make our streets safer. In this project we developed an automatic system that locates Saudi license plates in a captured image regardless of the time of day or license plate scale. The proposed system can tolerate slight tilting of the license plate. The localization process is fairly complex due to the highly varying nature of the background. Good results were obtained using the localization stage. A second part of the system was developed to segment and recognize the characters in the located license plate.

Index Terms—Intelligent transportation systems, license plate recognition, saudi license plates.

I. INTRODUCTION

License plate recognition plays an important role in intelligent transportation systems. It serves applications in vehicle tracking, traffic violation, parking automation, etc...

The first to work on Saudi license plate recognition was Sarfraz [1]-[3] from KFUPM in 2003. These early works such as Sarfraz [1]-[3], Zidouri [4] and Khalil [5] were all on the previous Saudi license plates series.

Maglad [6], [7] proposed a system that uses radial basis function neural networks for the detection and recognition of plates. Khalid Almustafa [8]-[10] proposed an algorithm that uses pixel density to recognize characters in license plates. Shaaban [11] proposed a system where a neural network classifier is used to recognize the characters based on edge moment invariants and principal component analysis features of wavelet coefficient matrix.

Alginahi [12] proposed a system that recognized both old and new Saudi license plates. The license plates are detected by searching the vertical lines then the width to length ratio is used to locate the plate. Character segmentation is then performed before both a distance classifier and a Neural Network classifier are used to recognize characters.

Deriche [13] proposed a hybrid system of RFID and license plate recognition. The license plate detection is based on morphological filtering and the character recognition is based on neural networks. Mansour [14] proposed a system based on chain code and tested it on both Egyptian and Saudi license plates.

II. SAUDI LICENSE PLATES

The first Saudi license plates were introduced in the 1950s; a new plate series was introduced approximately every

decade. Figure (1) shows the five different Saudi plate series [15].

The current license plates have the following characteristics [16]:

- The plate size is 32cm × 16cm.
- The ratio of width to length is 2:1.
- The plate is divided into 5 sections; Arabic letters, Hindi numbers, Latin letters, Arabic numbers and vehicle type section which is color coded and includes the name and logo of Saudi Arabia.
- There are 4 color codes; white is for private cars, yellow is for transport cars, blue is for commercial cars and green is for diplomatic cars.
- Size of letters is 36 × 21mm and size of numbers is 55 × 26mm.

Fig. 1. History of Saudi license plates [15] introduced in (from top to bottom): 1950, 1962, 1972, 1978, 1996 and 2007.

III. PROPOSED SYSTEM

A. Localization

Locating the license plate in an image is the first step in any license plate recognition system. Variation in license plate location in different cars, variation in location of cars in images and variation in lighting during day/night makes this step challenging.

We started looking into locating the plates by searching for black lines that borders the license plates thus we have to look for a horizontal line and a vertical line, however we

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found that in many cars that border is hidden under a frame that is commonly used to hold the plate.

We have noticed that particular to Saudi license plates, there is a black cross that centers all license plates, this cross is visible in all plates and is not hidden by frames since it is in the center of the license plates.

We apply an edge detector to find the horizontal and vertical maps; we then use the average value of pixels in each map as a threshold to convert it into a binary image and use a median filter to remove noise and find the binary addition of the maps. To help remove incorrect candidates, we zero all ones that originate from a color region in the original image since the cross we are looking for is in a black and white plate.

Fig. 2. Binary image after pre-processing to locate cross in the license plate.

Fig. 3. Cross located in license plate.

This last binary image is finally searched for the cross and the center pixel is considered the center of the plate where the lowest difference is found.

The search for the cross could lead to false locations especially when there is slight rotation in the image. The search had to be modified to look for a black line within the neighborhood of 6 lines. This gives some tolerance to possible image rotation and overcomes the slight rotation problem. This also affects finding the exact license plate border and the image needs to be rotated slightly accordingly.

B. Segmentation

In order to perform the license plate recognition, our method segments the characters in the plates. The plates have to be aligned horizontally by finding the tilt angle that maximizes the sum of horizontal black lines into three areas, at the edges and at the middle. Figure (4) shows the horizontal line profile of a license plate with a tilt and shows

that thresholded profile of an adjust tilt plate.

Fig. 4. Above is the profile of a tilted license plate and below is a thresholded profile of an adjusted license plate.

Once the license plate is horizontally aligned, several steps are then performed to segment the characters:

- 1) Cut the image horizontally in half.
- 2) Cut the lower image vertically in half.
- 3) Remove empty horizontal lines from both ends of lower left and lower right images.
- 4) Remove empty vertical lines from both ends of lower left and lower right images.
- 5) Segment numbers by moving left to right in the lower left image until finding empty vertical lines between numbers.
- 6) Segment letters by moving left to right in the lower right image until finding empty vertical lines between letters.

Fig. 5. Example of a Saudi license plate

Fig. 6. The lower left and lower right images after removal of horizontal and vertical empty lines.

C. Recognition

After segmenting the numbers and letters in the license plate, these numbers and letters are recognized using a template matching technique and by comparing them to reference templates of all possible characters in Saudi license plates. The reference templates have been previously saved and organized. An image size of 50 x 50 pixels was also chosen for our reference templates. Since characters obtained from different license plate images have different sizes; all

segmented characters have to be resized to 50×50 pixels. A simple difference comparison equation is used to compare the segmented characters to the reference templates.

$$d = \sqrt{(x_{Seg} - x_{Ref})^2}$$

Each segmented character is compared with all reference characters and it is recognized when it has the least difference value d .

IV. RESULTS

The threshold value for creating the binary images was changed along with the median filter setting. This was done to find the settings that produce most correct plate centers in all the images. The following table shows a part of the full table that was produced to find the optimum values of the threshold multiplier and the median filter size.

TABLE I: CORRECT LOCALIZATION IN ALL IMAGES AT VARIOUS AVERAGE AND MEDIAN FILTER SETTINGS.

Multiplier	1.25	1.5					1.75					2					2.25		
Filter	6	3	4	5	6	7	3	4	5	6	7	3	4	5	6	7	3	4	
File Name	32	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	
PIC_0574	1	1	1	1	0	1	1	1	0	1	1	1	1	1	1	1	1	0	
PIC_0575	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
PIC_0576	1	0	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	
PIC_0577	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
PIC_0578	0	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	
PIC_0579	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
PIC_0580	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
PIC_0655	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
PIC_0656	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
PIC_0657	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	
PIC_0658	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	0	
Percentage	76.0%	60	59	60	56	56	59	60	56	56	58	61	64	58	59	60	62	55	

The system was tested on 173 images and the localization method shows a success rate of 76% as can be seen in table (1). The segmentation method was successful on all license plates images that were correctly localized. The recognition method was correctly obtained in 140 images with a success rate of 81%.

Results of the segmentation and recognition method are shown in figures (7-10)

Fig. 7. Grayscale and binary images of license plate after tilt correction.

Lower Left Quarter of Plate complement

LLQ of Plate complement (empty lines removed)

Lower Right Quarter of Plate complement

LRQ of Plate complement (empty lines removed)

Fig. 8. Complemented lower left and lower right quarters after removal of empty horizontal lines.

First Letter

Second Letter

Third Letter

XAA

Fig. 9. The three letters segmented and recognized

First Number

Second Number

Third Number

Forth Number

2233

Fig. 10: The four numbers segmented and recognized

V. CONCLUSION

The proposed system locates and recognizes license plates under complex scenarios like variation of illumination, angle, and scale. Good results have been obtained. Further work can be added by using a more robust comparison method in the recognition part of the system to increase the accuracy of the recognition. The accuracy of the system is also expected to increase by mapping the recognition of the Arabic characters and the Latin characters together.

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