Journal of Engineering and Development
www.jead.org
Vol. 19, No.05, September 2015
ISSN 1813-7822

IRAQI VEHICLE NEW LICENSE PLATE STYLE RECOGNITION

Gregor Alexander Aremice*

Asst. Lect., Electrical Engineering Department, Al-Mustansiriyah University, Baghdad, Iraq

(Received:3/12/2014 ; Accepted:1/4/2015)

Abstract:
The recognition of vehicle license plate system is considered to be one of the important computer intelligent systems. In this research a simple algorithm is proposed to analyze and recognize the new style of Iraqi vehicle license plates. The proposed algorithm based on some steps performed respectively, first step is the color recognition of the right hand rectangle bar of the license plate to decide the class of the vehicle using the properties of HSV color model, second step is to analyze the Arabic alphanumeric region of the license plate in order to recognize the Arabic (Hindi Numeral System) numbers by testing geometric areas, and recognizing the Arabic Letter by indicating and measuring the extrema points of the letter image under process, the third step is to analyze the state name to decide which state the vehicle registered in.The proposed system is tested on samples of license plate captured images using digital camera with fixed distance from the vehicle (5 meters), the results of the analyzing were accepted of about 75% and failed by 25%.

Keywords: *Image Processing, Vehicle License Plate Recognition, Number Recognition, Color Recognition*

تمييز النموذج الجديد من لوحات تسجيل المركبات العراقية

الخلاصة:
نظام تمييز لوحة تسجيل المركبة هي واحدة من اهم الانظمة الذكية في مجال علم الحاسوب. في هذا البحث تم اقتراح خوارزمية جديدة وبسيطة لتحليل وتمييز النموذج الجديد من لوحات تسجيل المركبات العراقية. الخوارزمية المقترحة تستند على بضعة خطوات تنفذ بالتتابع، الخطوة الاولى هي لتمييز اللون للمستطيل الموجود على يمين لوحة التسجيل لتحديد فئة المركبة بأستخدام خواص نموذج الالوان HSV، الخطوة الثانية هي تحليل منطقة الحروف والارقام العربية للوحة التسجيل وذلك لتمييز الارقام العربية (نظام الارقام الهندية) وذلك بأختبار مساحات هندسية، وتمييز الحرف العربي بتحديد وحساب النقاط القصوى لصورة الحرف تحت الاختبار، الخطوة الثالثة هي لتحليل اسم المدينة لتحديد المدينة التي تم تسجيل المركبة فيها.النظام المقترح تم اختباره على نماذج صور لوحات تسجيل ملتقطة بأستخدام آلة تصوير رقمية بمسافة ثابتة عن المركبة (٥ أمتار)، نتائج التحليل كانت مقبولة بنسبة (٧٥%) وفاشلة بنسبة (٢٥%).

* gregoralexander1977@gmail.com

1. Introduction

Image processing techniques, security purposes, intelligent systems are mixed together for science development. The need of image processing in traffic systems and/or security systems are widely used specially these systems that deal with the license plate of vehicles.Detection and recognition systems of vehicles license plate that based on image processing are used in many fields i.e. vehicle garage parking, electronic toll collection on roads, road traffic systems, border Control, Law Enforcement.The main aim of this research is to recognize the new Iraqi license plate style with color bar on side, and declare the (color, class and the state of the vehicle registration). Mainly license plate (LP) analyzing steps are LP localization, color verification, number segmentation and recognition. Many related works for vehicle license plate analyzing provide methods of color detection and verification depending on the color models (RGB, HSI) taking under consideration the Hue and Intensity in HSI model to recognize colors [1].Different segmentation methods were used to segment candidate regions from LP and segment the LP numbers and characters such as using Hough transformation to detect lines in an image [2], and Horizontal and vertical projections were used for character segmentation[3].For character recognition a template-matching with an artificial neural network method were used [4]. Some related works used words recognition depending on character segmentation methods [5].

2. Color Spaces (Models)

In general, color space or model is an mathematical representation describing the way in which colors can be represented as sequence of numbers, typically as three component model (RGB color space) or four component model (CMYK color space). To make a color that is the same as the origin color different color spaces can be used, for example, when colors are displayed on computer monitor, they are usually defined in the RGB (Red, Green and Blue) color space. Another way to make same color is to use their Hue, Saturation and Brightness, which is called the HSV, HSB or HIS color space, many color spaces can be represented as three dimensional (X, Y, Z) values [6].

2.1 RGB Color Space

RGB color space is any additive color space based on three color lights (Red, Green and Blue), when they added together in various ways a different color array (color map) is produced [7]. The main purpose of RGB color model is for sensing, representing and display of images in electronic systems. RGB model is represented by the three dimensional cube with Red, Green and Blue orthogonal components at the corners of each axis, as shown in "Fig. 1".

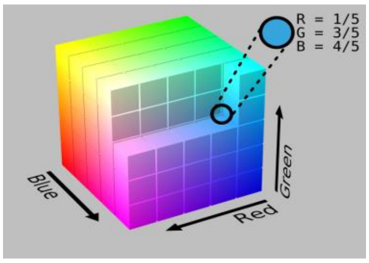


Figure 1. RGB Color Space Representation

2.2 HSV Color Space

HSV color space is known also as HSB (Hue, Saturation and Brightness) or HIS (Hue, Saturation and Intensity) color space, it is considered to be more natural to think about a color in terms of hue and saturation rather than in terms of additive or subtractive color components [8]. HSV is a transformation of an RGB color space, and its components and color measurement are related to RGB color space from which it was derived. HSV is used in many fields such as (color picking or image editing software and image analysis field). The HSV, HSB and HIS are not described by the color percentages, but rather by their “Hue”, “Saturation” and “Intensity”. The “Hue” represents the color itself; the “Saturation” represents the “pureness” of the color, and “Intensity” describes the color brightness. The three components are unlike R,G,B components they are not orthogonal and can be represented by many shapes, one of which is shown in "Fig. 2" [9].

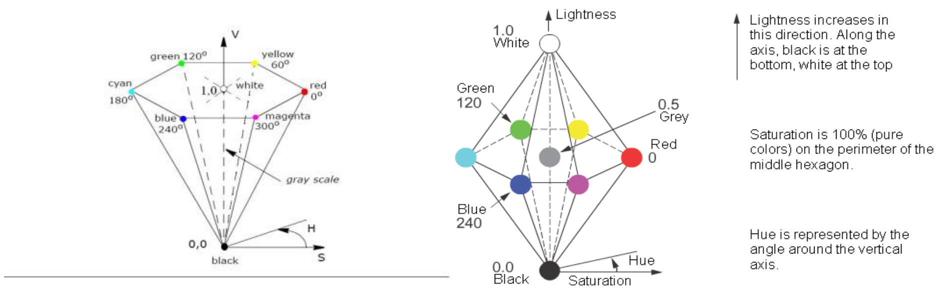


Figure 2. HSV Color Space Representation

The Hue (H) component vary from (0°) to (360°), representing at (0°) the red color, the yellow color at (60°), the green color at (120°), the blue color at (240°) and then going back to the red color at (360°). The Saturation (S) component which is the radius of the hexagon diamond in "Fig. 3", ranges from (0) to (1), when (S=0) the gray value of intensity of the color is reached, when (S=1) the saturated level is reached of a specific color. The Intensity (I) component, which is the color brightness component, vary vertically along with the Z-axis, when (I=0) the dark level of the color is reached and when (I=1) the light level of the color is reached.

3. Iraqi Vehicle License Plate New Style

The new style of Iraqi vehicle license plate, shown in "Fig. 3", is featured as follows:

1. The plate has rectangular shape.
2. It is divided into three main regions; Color Bar Region (R1), Alphanumeric Region (R2) and Class-State Region (R3).

Figure 3. Iraqi Vehicle License Plate New Style

3.1 Color Bar Arrangements

On the left hand side of the viewer to the license plate, one can observe a color bar associating the specific license plate to a particular class of vehicles. “Table 1” shows all classes available according to the traffic office arrangements:

Table 1. Vehicle Classes According to Bar Color

Bar Color	Vehicle Class	Vehicle Class as printed on the license plate
White	Private Vehicle	خصوصي
Blue	Government or Companies Vehicle	حكومية أو شركات
Red	Public Transport Vehicle	أجرة
Yellow	Cargo Vehicle	حمل
Light Green	Agronomic Vehicle	زراعي

White colored bar stands for private vehicles, blue colored bar stands for government or companies vehicles, red colored bar stands for public transport vehicles (Taxi, Mini-Bus and Bus), yellow colored bar stands for cargo (light and heavy) vehicles and light green colored bar stands for agronomic vehicles.

3.2 License Plate Regions

The new license plate style divided into three main regions, (R1) region which is for color bar that defines the class of the vehicle as described in the previous section, (R2) region consists of two rows the upper row is for alphanumeric letters which has one Arabic character and not more than five numeral digits printed in (Hindi Numeral System), the lower row is the translation of the first row into English character and numeral digits printed in (Arabic Numeral System) with smaller size than that in the upper row, “Table 2” shows the available Arabic characters for license plate classification:

Table 2. English Letters to Arabic Letter as Printed on License Plates

English character	Arabic characters
A	ا
B	ب
J	ج
D	د
R	ر
S	س
T	ط
F	ف
K	ك
M	م
N	ن
H	هـ
W	و
E	ى

(R3) region consist of two columns for all license plate classes accept the Blue colored class (Government or Companies) vehicles which has one column, the column on the left of the viewer is for vehicle class specified by an Arabic word that stands for that class of the related bar color in (R1) region, according to “Table 1”, the word "خصوصي" comes with private class vehicles (white colored bar), "اجرة" comes with public transport vehicles (red colored bar), "حمل" comes with cargo vehicles (yellow colored bar), "زراعي" comes with agronomic vehicles (light green colored bar) and for government or companies class vehicles the contents of the single column is printed with the word "حكومية" or "شركات" respectively (blue colored bar).

4. Proposed Algorithm

In this paper an algorithm is proposed for analyzing new Iraqi License Plate (LP) forms with color bar on side, as shown in the "Fig. 4":

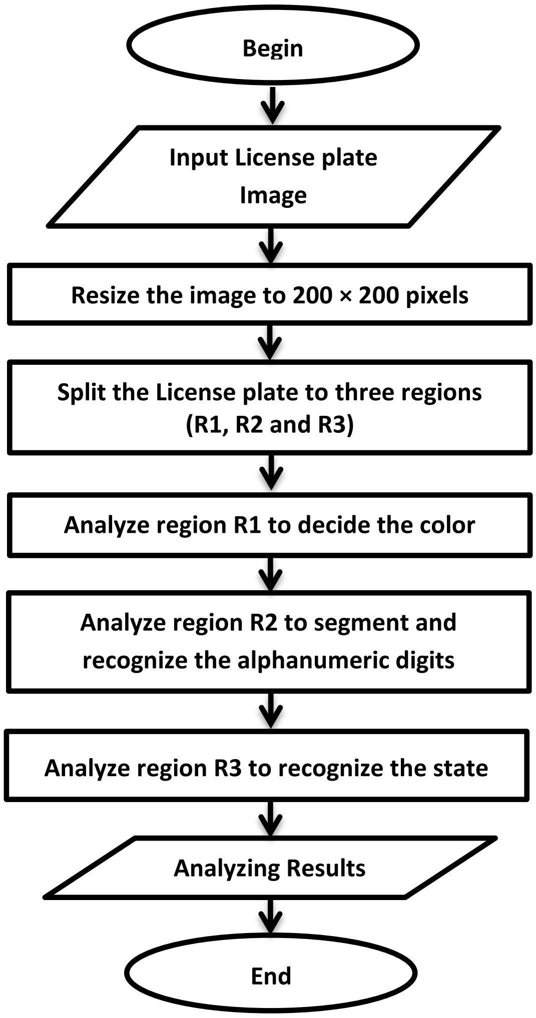


Figure 4. License Plate Analyzing Algorithm Flowchart

4.1 Pre-Analyzing Stage

An outdoor digital camera is used to capture vehicle image, then License Plate (LP) localization is performed to get the LP area only, "Fig. 5".

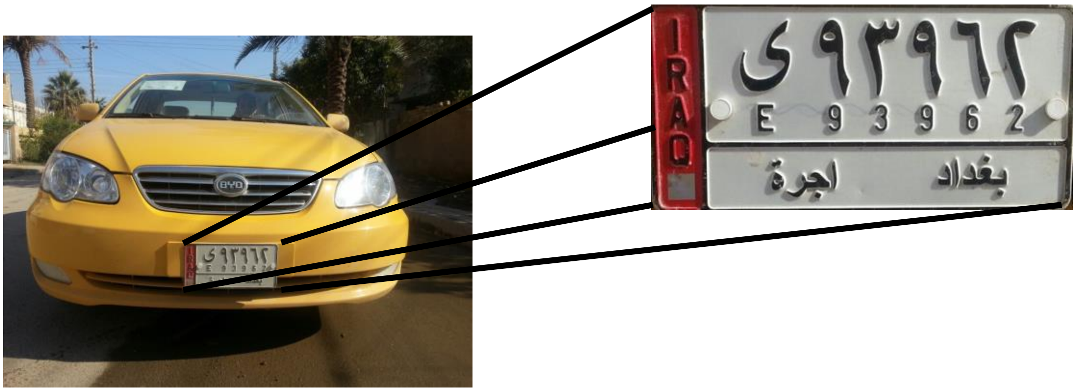


Figure 5. License Plate extraction

4.2 License Plate Region Reading and Resizing Stage

The extracted image is an RGB image, for easy calculations the RGB image with correct pixel value numbers is converted to RGB image with floating-point pixel value numbers as explained in "Fig. 6".

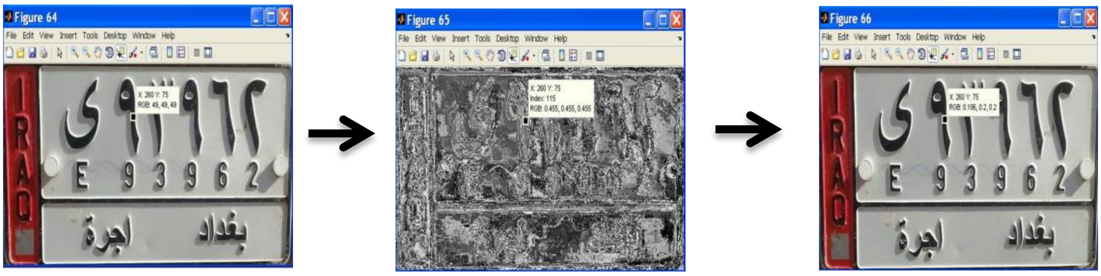


Figure 6. RGB (fixed-points) to RGB (floating-points) Conversion

Since the LP area is divided into three main regions as mentioned in previous section, first, the LP area image is resized into a specified dimension (200 × 200) pixels for easy dimension calculations, each region of the three regions (R1, R2 and R3) are cropped separately as shown in "Fig. 7".

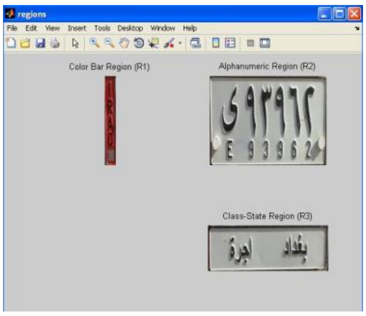


Figure 7. Separated License Plate Regions

R1, R2 and R3 regions dimensions from main extracted (200 × 200) pixels LP image are (25 × 200) pixels, (176 × 135) pixels, (176 × 66) pixels separately. This is done by specifying cropping ranges constantly for each separation process, and for R1, R2 and R3 regions the constant cropping dimensions from the (200 × 200) pixels LP image are, ([0 0 25 200], [25 0 200 135] and [25 135 200 200]) separately. And this is stands for [Xmin Ymin Width height].

4.3 License Plate Color Recognition Stage

(R1) region is analyzed first to decide the color. According to the color of (R1) the Class of the vehicle is decided, and this is performed by calculating the components (Hue, Saturation and Intensity) of the color bar region image after converting it from RGB color space to HSV (HSI) color space as shown in "Fig. 8", and calculating the number of pixels to the corresponding color.

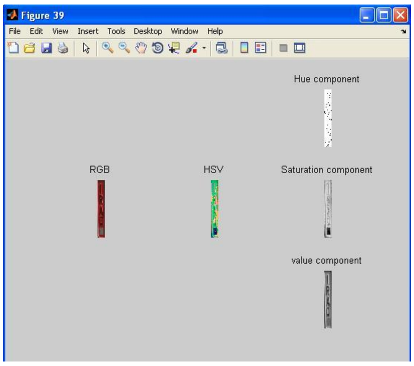


Figure 8. RGB to HSV Color Space Transformation

According to the ranges of (S and I) a threshold is calculated for the color saturation (S) and brightness (I) and a comparison is performed between the values of the Hue and the threshold to compute the number of pixels for each color, as follows (recalling "Fig. 2"):

if a pixel in hue layer with value $\leq 30^\circ$ ***or*** $\geq 330^\circ$***, then it belongs to red color level***

if a pixel in hue layer with value $> 30^\circ$ ***and*** $\leq 90^\circ$***, then it belongs to yellow color level***

if a pixel in hue layer with value $> 90^\circ$ ***and*** $\leq 150^\circ$***, then it belongs to green color level***

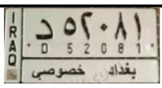
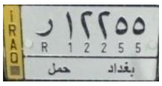
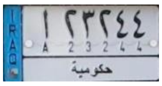
if a pixel in hue layer with value $> 120^\circ$ ***and*** $\leq 270^\circ$***, then it belongs to blue color level***

and for white color region it can be observed from "Fig. 8" that, the computation is depending on the values of pixels in (S and I) layers, when pixel value in (S) layer is close to (0) the gray level is reached and at the same time when for the same pixel value in (I) layer is close to (1) then the light level is reached.

Then counting the total true pixels (pixels which belong to the corresponding color level) to decide the color according to the greatest amount of true pixels.

“Table 3” shows samples of license plates and the number of pixels to each color level after color recognition stage:

Table 3. Samples of License Plates with Number of Pixels to each Color Level

License Plate Samples	Region R1 (Color Bar)	Number of pixels in Red Level	Number of pixels in Green Level	Number of pixels in Blue Level	Number of pixels in Yellow Level	Number of pixels in White Level
		**33**	**0**	**0**	**1586**	**3132**
		**4804**	**0**	**0**	**83**	**113**
		**216**	**23**	**13**	**4321**	**414**
		**0**	**0**	**531**	**0**	**29**

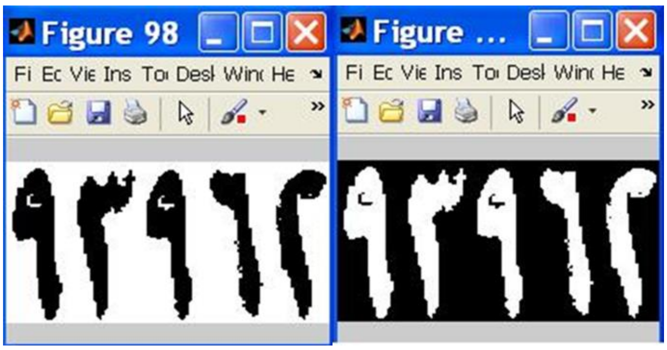
4.4 Alphanumeric Segmentation and Recognition Stages

The next step is to analyze (R2) region, and this is done by segmentation process of (R2) region of each digit then character recognition operation is performed for the five numeric digits and the Arabic letter.

4.4.1 Segmentation Stage

The proposed algorithm for segmentation stands on two steps, numeric segmentation step and letter segmentation step.

For step one, cropping the five numeric digits region from (R2) region then converting the cropped RGB image to binary image and taking the complement for the image as shown in "Fig. 9":



(a) (b)

Figure 9. Five Numeric Digits Region Cropped from R2 Region

(a) Cropped Binary Image. (b) Cropped Binary Complement Image

A labeling process to the connected objects in the image is performed, as shown in "Fig. 10", the index part start from (1) to (5) indicating five connected objects in the image. Also image properties calculation is performed to get some information (Area, Centroid and BoundingBox) for each connected object in the image under process.

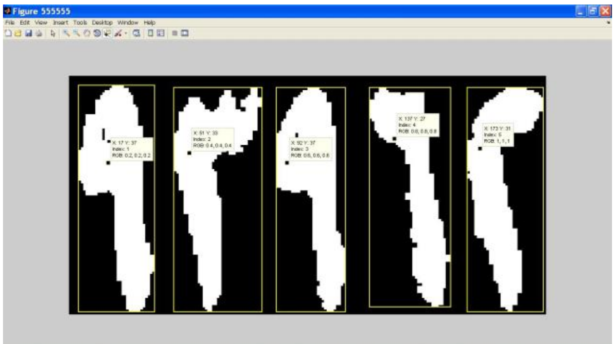


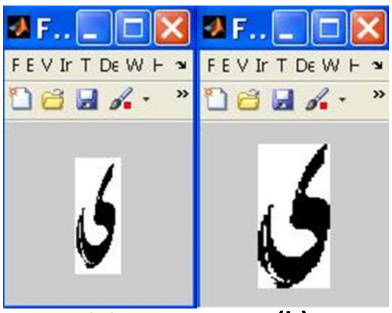
Figure 10. Labeled and Box Bounded Objects

Now the segmentation is done depending on pointing to the start and the end of the rectangle around the object, in other words cropping objects from "Fig. 10" depending on top and bottom coordinates of the rectangle around each object. The cropped objects are shown in "Fig. 11".

(a) (b) (c) (d) (e)

Figure 11. Segmented Objects (a, b, c, d, e)

In step two, cropping the Arabic letter area from (R2) region then trimming unwanted columns and rows around the letter and resizing the trimmed image to (50 × 100) pixels we get "Fig. 12".



(a) (b)

Figure 12. Arabic Letter Area Cropped from R2 Region
(a) Cropped Binary Image. (b) Cropped Binary Resized Image

4.4.2 Recognition Stage

The proposed algorithm for recognition stands on two steps, numeric recognition step and letter recognition step.

For step one, number recognition is done depending on the value of a geometric rectangular areas from the binary image of the numeric digit under process, each image of these is divided into (40) areas with a specific dimensions as shown in "Fig. 13".

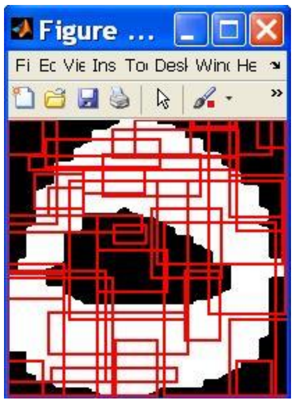
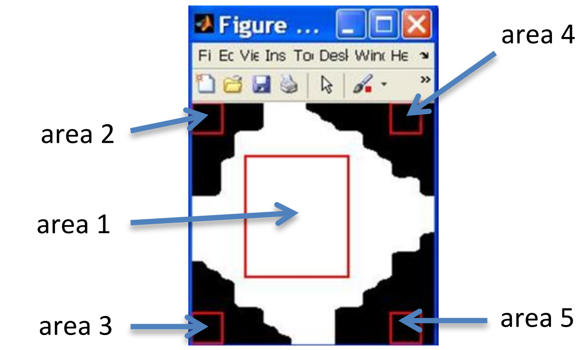
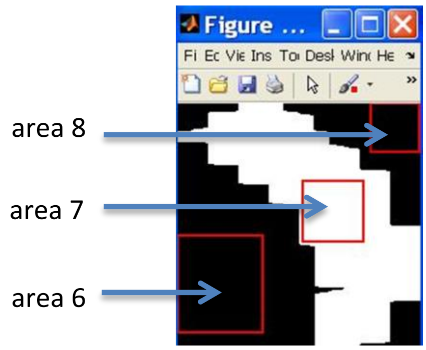
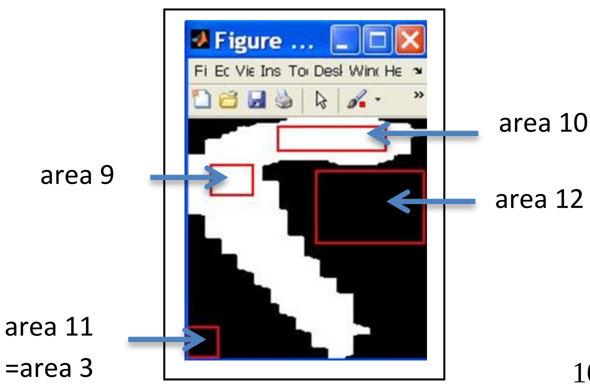


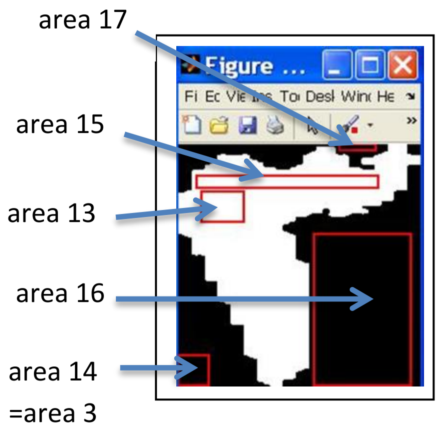
Figure 13. Sample Digit with 40 Explained Areas

Then a test is done on these areas to recognize the number, each number image has a specific number of test areas as shown in "Fig. 14":









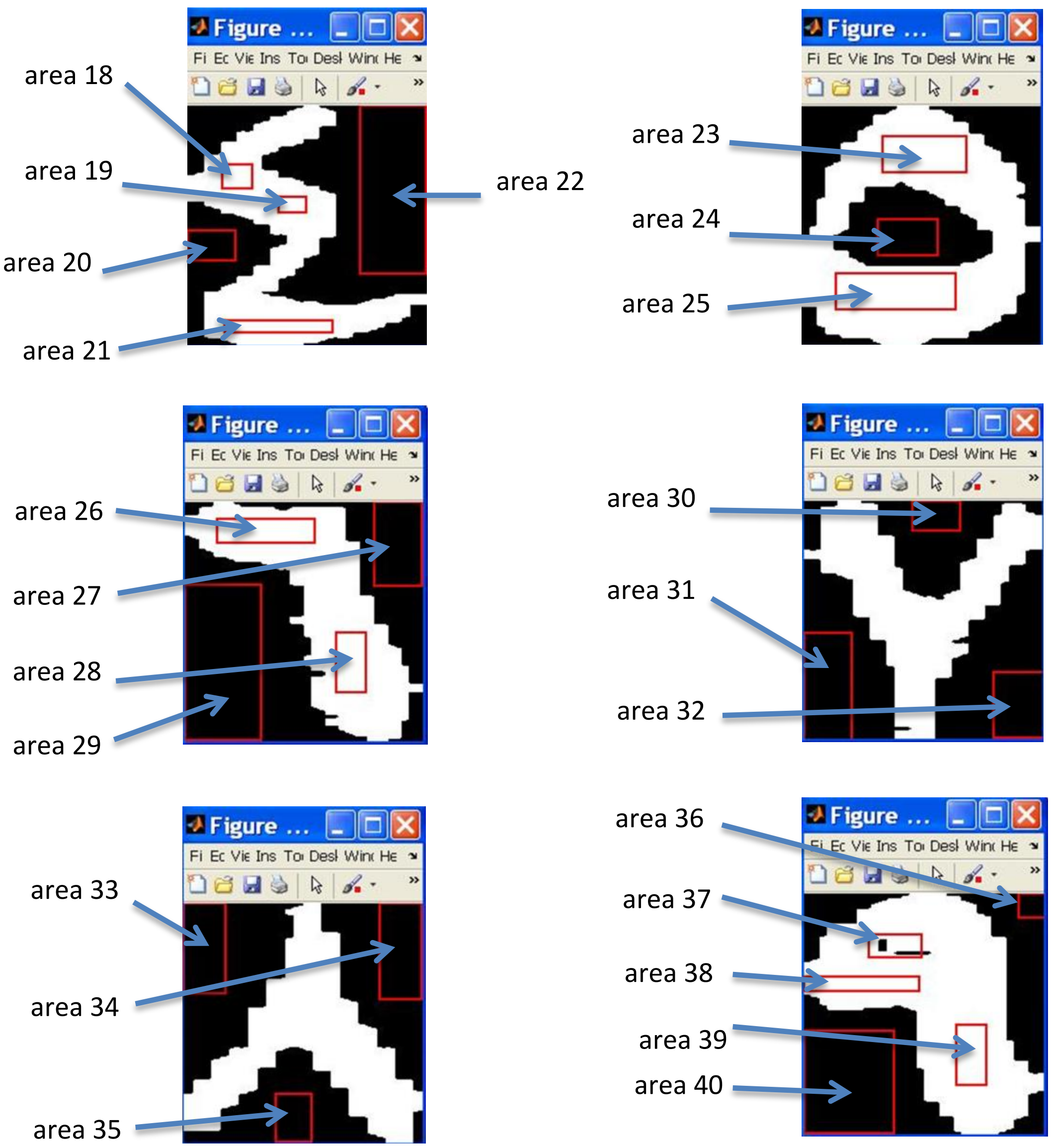


Figure 14. Arabic Number Samples with Explained Areas

The proposed test algorithm is performed as follows depending on the index value of the pixel, pixel value of (0) for black area and pixel value of (1) for white area:

if (area1=1 & area2=0 & area3=0 & area4=0 & area5=0) then number is "zero"
if (area6=0 & area7=1 & area8=0) then number is "one"
if (area9=1 & area10=1 & area11=0 & area12=0) then number is "two"
if (area13=1 & area14=0 & area15=1 & area16=0 & area17=0) then number is "three"
if (area18=1 & area19=1 & area20=0 & area21=1 & area22=0) then number is "four"

if (area23=1 & area24=0 & area25=1) then number is "five"
if (area26=1 & area27=0 & area28=1 & area29=0) then number is "six"
if (area30=0 & area31=0 & area32=0) then number is "seven"
if (area33=0 & area34=0 & area35=0) then number is "eight"
if (area36=0 & any of area37 is white pixel & number of white pixels is greater than number of black pixels in area37 & area39=1 & area40=0) then number is "nine"

For step two, letter recognition is done depending on measuring some region properties of the letter image under process, before that the letter image is converted to binary image, filtering the image from any small unwanted objects, then measuring image region properties.

Many properties can be measured; mainly there are two main property measurements (Shape Measurements and Pixel Value Measurements), our proposed algorithm for letter recognition depends on shape measurements, and specifically dealing with (Extrema) property.

Measuring extrema property for each letter image we get extrema points in the region. We have two shapes of letters; letters with one connected object such as **(ا – د – ر – س – ط – م – هـ – و – ى)** and letters with two connected objects such as **(ب – ج – ف – ك – ن)**, so we have to count number of objects in the letter binary image in order to compute the extrema points for each object, for some samples of one connected object letter the extrema measurements are shown in "Table 4":

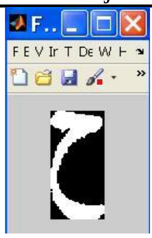
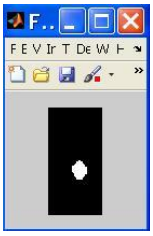
Table 4. Extrema Points Measured for One Connect Object Letters

Letter	Extrema points		Letter	Extrema points	
	46.5000	0.5000		٢٠,٥٠٠٠	٠,٥٠٠٠
	48.5000	0.5000		٢٣,٥٠٠٠	٠,٥٠٠٠
	50.5000	42.5000		٥٠,٥٠٠٠	٧٠,٥٠٠٠
	50.5000	59.5000		٥٠,٥٠٠٠	٨٣,٥٠٠٠
ى	22.5000	100.5000	د	٣٢,٥٠٠٠	١٠٠,٥٠٠٠
	13.5000	100.5000		٥,٥٠٠٠	١٠٠,٥٠٠٠
	0.5000	81.5000		٠,٥٠٠٠	٩١,٥٠٠٠
	0.5000	60.5000		٠,٥٠٠٠	٧٤,٥٠٠٠
	41.5000	0.5000		17.5000	0.5000
	43.5000	0.5000		33.5000	0.5000
	50.5000	27.5000		50.5000	90.5000
	50.5000	51.5000		50.5000	92.5000
ر	27.5000	100.5000	ا	42.5000	100.5000
	18.5000	100.5000		25.5000	100.5000
	0.5000	82.5000		0.5000	21.5000
	0.5000	80.5000		0.5000	10.5000

Each new cropped letter image must pass on extrema measuring step, then comparing these measured extrema points with reference extrema points and getting the smallest difference one to approve matching.

And for a sample of two connected object letter the extrema measurements are shown in "Table 5" for letter (ج):

Table (5): Extrema Points Measured for Two Connect Object Letters

Letter Objects	Extrema points	
	6.5000	0.5000
	14.5000	0.5000
	50.5000	87.5000
	50.5000	95.5000
	44.5000	100.5000
	18.5000	100.5000
	0.5000	75.5000
	0.5000	7.5000
	28.5000	49.5000
	30.5000	49.5000
	36.5000	55.5000
	36.5000	62.5000
	32.5000	67.5000
	26.5000	67.5000
	22.5000	60.5000
	22.5000	54.5000

Samples of one and two connected objects in Arabic letter images with marked extrema points explained in "Fig. 15" and "Fig. 16" respectively.

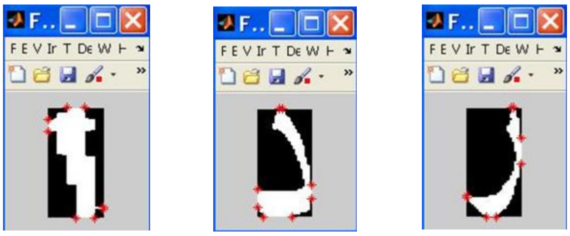


Figure 15. One Connected Object Arabic Letter Samples

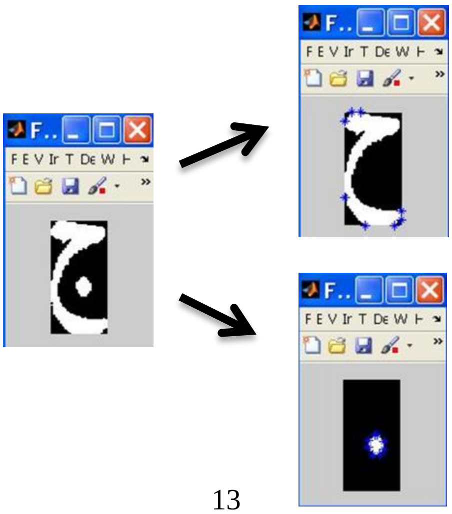


Figure 16. Two Connected Object Arabic Letter Sample

4.5 State Recognition Stage

Analyzing region (R3) to recognize the state in which the vehicle registration plate belongs to. This stage is performed depending on the bar color, where if the bar color is Blue then no need for state recognition step, since region (R3) contains only the vehicle class with the printed word "حكومية" which indicate that the vehicle is governmental vehicle, else then this stage is performed to declare the state name. From the license plate image the state region is cropped to start processing it, in our proposed algorithm another shape property measuring is done which is (Perimeter) property, the – Perimeter – property is a number indicating the distance around the boundary of the connected objects in the image under process, "Fig. 17" explains that for a license plate of a vehicle registered in Baghdad City with the word "بغداد".

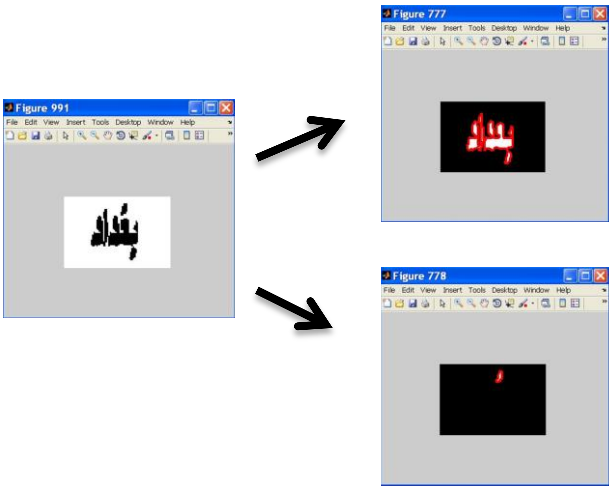


Figure 17. Two Connected Object State Name Sample

For each state name sample there are one, two or many connected objects, the Perimeter property is measured for each object, then, depending on the length of the – Perimeter – of each object and the number of available objects, a comparison is done with the saved reference data and matching is declared.

5. Conclusion

A system for analyzing and recognizing the new style of Iraqi vehicle license plates has been implemented. Dividing the area of the license plate to three regions facilitated the analyzing process. Using HIS color space model for color recognition process has succeeded about 90% for all the captured sample images. The recognition idea that is proposed in this research utilized the black and white areas in the segmented number image and picked (40) rectangular areas to test them and declare the number under process. The recognition of the Arabic Letter for both (one object and two object) letter performed by measuring the extrema points for the white area (Arabic Letter) and preparing a database of the values of these point as a reference and comparing them with the new measured point to declare the letter. The state recognition is performed by measuring the distance around the white area (state name) taking under consideration the number of objects that the state name includes then recording these values in a database to use them as a reference for checking the new captured images. This algorithm is tested on 60 samples of license plate images, 25% of the captured (processed) license plate images failed with this proposed algorithm and the 75% of the images passed this algorithm successfully. The 25% failed samples were failed because of some available noise on the license plate itself, such as mud or dirt on the license plate, but even these 25% were succeeded partially in recognizing numbers but failed with color recognition or vice-versa.

6. References

1. D. Kaushik, C. Hyun-Uk and J. Kang- Hyun, (2009). “Vehicle License Plate Detection Method Based on Sliding Concentric Windows and Histograms”, Journal of Computers, Vol. 4, No. 8.
2. Z. Yungang, Z. Changshui, (2003). “A New Algorithm for Character Segmentation of License Plate”, Intelligent Vehicles Symposium, 2003. Proc. IEEE, pp. 106-109.
3. V. Karthikeyan, R. Sindhu, K. Anusha and D.S.Vijith, (2013). “Vehicle License Plate Character Segmentation – A Study”, International Journal of Computer and Electronics Research, Vol. 2, No. 1.
4. P. G. Sneha, (2013). “Vehicle License Plate Recognition using Morphology and Neural Network”, International Journal on Cybernetics & Informatics (IJCI) Vol.2, No.1.
5. A. Cheung, M. Bennamoun, N.W. Bergmann, (2001). “An Arabic Optical Character Recognition System using Recognition-Based Segmentation”, the Journal of Pattern Recognition, Vol. 34, P.P. 215-233.
6. G. Rafael, W. Richard, (1992). “Digital Image Processing”, 1st ed., Addison-Wesley.
7. Charles A. Poynton, (2003). “Digital Video and HDTV: Algorithms and Interfaces”, Elsevier Science (USA), pp. 234.
8. Agoston, Max K., (2005). “Computer Graphics and Geometric Modeling: Implementation and Algorithms”, London: Springer, pp. 301-302.
9. Kaushik Deb and Kang-Hyun Jo (2009). “Segmenting the License Plate Region Using a Color Model, Pattern Recognition”, Peng-Yeng Yin (Ed.), ISBN: 978-953-307-014-8, InTech, Available from: http://www.intechopen.com/books/pattern-recognition/segmenting-the-license-plate-region-using-a-colormodel