Iraqi License Plate Localization by Morphology operation and Connected Component Labeling

Dr. Bashar M. Nema
Mustansaryiah University
bashar_sh77@yahoo.com

Emad A. Mohammed
Mustansaryiah University
emadcio@yahoo.com

Shymaa Mohammed Jameel
Mustansaryiah University
shymaa792003@yahoo.com

Abstract

Morphological image processing is a collection of non-linear operations related to the shape or morphology of features in an image. Morphological techniques probe an image with a small shape or template called a **structuring element**. The structuring element is positioned at all possible locations in the image and it is compared with the corresponding neighborhood of pixels. Some operations test whether the element "fits" within the neighborhood, while others test whether it "hits" or intersects the neighborhood. A set of pixels in which each pixel is connected to all other pixels is called a connected component. A component labeling algorithm finds all connected components in an image and assigns a unique label to all points in the same component. In this paper, the Morphology and CCL are used to find the Iraqi license plate location which represents the main operation in any LPR system. Most of the conclusions reached by the researcher showed that the process of identifying the car plate location is a complex process and requires a set of steps that are applied to the original image and through which to improve that image. The input images are colored images with the size of 800X600. The number of samples used in this paper are 31 vehicle with complex background , different weather and under various illumination conditions and distance .The number of samples that have been successfully detect its plate are 28 sample and the number of samples that did not detect its plate are 3.

KEYWORDS: Color image, LPR system, Morphology, Connected Component, Localization.

المستخلص

تعتبر عملية معالجة الصور الصرفية عبارة عن مجموعة من العمليات غير الخطية المتعلقة بالشكل او التشكل لتلك الصورة للحصول على قالب يتم تحريكه على جميع الصورة للحصول على الشكل الأقرب والأكثر تشابها مع ذلك القالب. في هذا البحث تم استخدام عمليات التشكل وكذلك ترميز المناطق المترابطة لغرض تحديد موقع لوحة السيارة في المركبات العراقية. وتعتبر هذه العملية هي الأكثر تعقيدا من بين عمليات انظمة (LPR). أظهرت معظم الاستنتاجات التي توصل إليها الباحث أن عملية تحديد الموقع لوحة السيارة هي عملية معقدة وتتطلب مجموعة من الخطوات التي يتم تطبيقها على الصورة الأصلية والتي يمكن من خلالها تحسين تلك الصورة. الصور المدخلة عبارة عن صور ملونة مع حجم 600*800 . عدد العينات المستخدمة في هذه الورقة هي 31 صورة مركبة مع الخلفية المعقدة، والطقس المختلف وتحت ظروف إضاءة مختلفة والمسافة غير ثابتة. عدد العينات التي تم الكشف عن موقع اللوحة فيها بنجاح هي 28 عينة وعدد العينات التي لم يكشف عن اللوحة فيها هي 3.

1. Introduction

License Plate Recognition or LPR is a technology solution that takes photographs of license plates and converts these images to text. LPR is an image-processing technology used to identify vehicles by their license plates. This technology is gaining popularity in security and traffic installations. Much research has already been done for the recognition of Korean, Chinese, European, America and other license plates; this paper presents a license plate recognition system as an application of computer vision for Iraqi license plate. A license plate (LP) is the unique identification of a vehicle. License plate has the rectangle shape, it contains alphabets and numbers; it should be fixed onto the car body (at least at its backside) and it means a legal license to participate in the public traffic **[1]**. Localizing is an algorithmic function that determines what aspect of the vehicle's image is the license plate. This operation is the main goal of this paper. The theoretical background and proposed solution will be discussed in the following sections.

2. Theoretical background

2.1 Histogram:

The histogram of a digital image with gray levels in the range [0, L-1] is a discrete function $\mathrm{h(rk)} = \mathrm{nk}$ where rk is the *kth* gray level and *nk* is the number of pixels in the image having gray level *rk*. It is common practice to normalize a histogram by dividing each of its values by the total number of pixels in the image, denoted by n. Thus, a normalized histogram is given by $\mathrm{p(rk)} = {}^{\mathrm{nk}}/_{\mathrm{n}}$, for k=0, 1,p ,L-1. Loosely speaking, $\mathrm{p(rk)}$ gives an estimate of the probability of occurrence of gray level *rk*. Note that the sum of all components of a normalized histogram is equal to (1) **[2]**.

2.2 Histogram equalization (HE)

Histogram equalization is best technique for contrast enhancement because histograms are simple to calculate in software and also lend themselves to economic hardware implementations, thus making them a popular tool for real-time image processing **[2]**. Histogram equalization is a technique which rescales the range of an image’s pixel values to produce an enhanced image whose pixel values are more uniformly distributed The enhanced image tends to have higher contrast. The mathematical formulation is as follows. Let $a \in Z_l^X$ denote the source image,$n = card(X)$ and nj be the number of times the gray level j occurs in the image a. recall that $Zl = \{0,1, \dots, l-1\}$,the enhanced image b given**[3]**.

$$\boldsymbol{b}(\boldsymbol{x}) = l \sum_{j=0}^{a(x)} \frac{nj}{n} \dots\dots\dots\dots\dots\dots\dots\dots\dots (1)$$

2.3 Conservative smoothing.

The conservative smoothing is the noise reduction technique that employs a simple fast filtering algorithm which sacrifices noise suppression power in order to preserve high spatial frequency details in an image. The algorithm finds the minimum and maximum intensity values within a window around the pixel under consideration excluding the intensity value of central pixel. If the intensity of the central pixel lies within the intensity range spread of its neighbors, it is passed to the output image unchanged. However, if the central pixel intensity is greater than the maximum value or less than the minimum value then it is equal to the maximum or minimum value respectively. The idea is illustrated in **Figure (1)**. The central pixel of this figure contains an intensity spike (intensity value 19). In this case, the conservative smoothing **[4].**

13	15	16	10	10	**Neighborhood Values :** 10,10,13,14,15,15, 16,17,19 **Max Value** : 17 **Min Value :** 10
12	**14**	**16**	**17**	15	
18	**10**	**19**	**15**	14	
19	**15**	**10**	**13**	13	
11	16	10	12	10	

Figure (1): Example of Conservative smoothing

2.4 Edge detection by sobel

A vertical and horizontal Sobel operator is applied on the image to amplify the corresponding edges. The sobel operator is implemented using two convolution masks/kernels, each designed to respond maximally to edges running at$\mp 45^{\circ}$ to the pixel grid, **Figure (2)** represent the mask in x-derivative and y-derivative, The magnitude |G| and orientation of the image gradient are thus given by **Figure (3).[4]**

X derivati

1	0	–1
2	0	–2
1	0	–1

Y derivati

1	2	1
0	0	0
–1	–2	–1

Figure (2): Sobel Kernel

$$|G| = \sqrt{G_x^2 + G_y^2} \dots\dots\dots\dots\dots\dots(2)$$

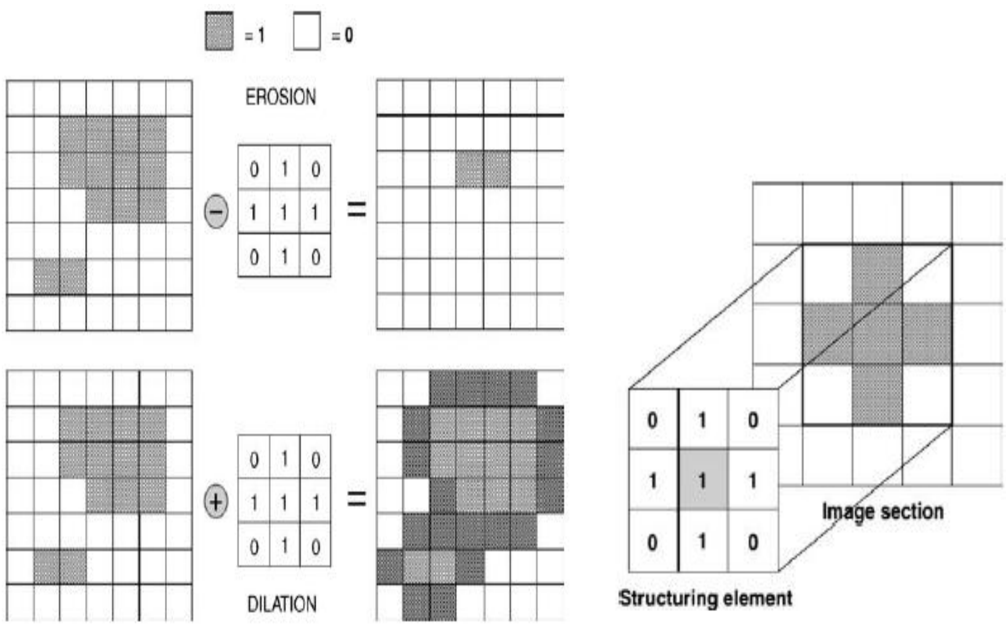
$$\theta = tan^{-1}\left(\frac{G_y}{G_x}\right) + \frac{1}{4}\pi \dots\dots\dots\dots(3)$$

Figure (3): Equation of magnitude and orientation

2.5 Morphological operator dilation and erosion

The most widely used processing procedures for binary images are often collectively described as morphological operations.

- ***Dilation***: To perform dilation of an image, we successively place the center pixel of the structuring element on each background pixel. If any of the neighborhood pixels are foreground pixels, then the background pixel is switched to foreground. Formally, the dilation of image A by structuring element B is denoted $A \oplus B$ **[5].**
- ***Structuring elements (SE):*** A structuring element is a rectangular array of pixels containing the values either 1 or 0 (akin to a small binary image), **Figure (5)** shown SE that used in all morphology operation for proposed algorithm.
- ***Erosion***: To perform erosion of a binary image, we successively place the center pixel of the structuring element on each foreground pixel (value 1). If any of the neighborhood pixels are background pixels (value 0), then the foreground pixel is switched to background. Formally, the erosion of image A by structuring element B is denoted $(A \ominus B)$**[5].**
- ***The mechanics of dilation and erosion:*** operate in a very similar way to the convolution kernels employed in spatial filtering. The structuring element slides over the image so that its center pixel successively lies on top of each foreground or background pixel as appropriate. The new value of each image pixel then depends on the values of the pixels in the neighborhood defined by the structuring element. **Figure (4)** shows the results of dilation and erosion on a simple binary image **[5].**



Figure(4) :Dilation and erosion operation

2.6 Region filling

Binary images usually arise in image processing applications as the result of thresholding or some other segmentation procedure on an input grey-scale or color image. These procedures are rarely perfect (often due to uncontrollable variations in illumination intensity) and may leave 'holes', i.e. 'background' pixels within the binary objects that emerge from the segmentation. Filling the holes within these objects is often desirable in order that subsequent morphological processing can be carried out effectively. Morphology operation that fill enclose Region filling based on set dilations, complementation, and intersections. Beginning with a point P inside the boundary, the objective is to fill the entire region with 1's .If we adopt the convention that all non-boundary (background) points are labeled 0, then we assign a value of 1 top to begin. The following procedure then fills the region with 1's:

$$X_k = (X_{k-1} \oplus B) \cap A^c \quad k = 1,2,3, \dots . n \dots \dots \dots \dots . (4)$$

where $X0$ =P , and B is the symmetric structuring element , The algorithm terminates at iteration step k if Xk = X k- 1· The set union of Xk and A contains the filled set and its boundary. The dilation process of Eq. (1) would fill the entire area if left unchecked. However, the intersection at each step with Ac limits the result to inside the region of interest **[2,5].**

2.7 A connected components Labeling Algorithm:

Connected component labeling is defined on a set of objects. In an image, connected component is said to be a separate and independent object. Independency comes with the connectivity. A connected component may be 4-connected or 8-connected. In 4-connected case, any element having coordinate (x, y) in that connected component has at least one element having coordinate in the following set:

$$\{(x, y-1), (x, y+1), (x-1, y), (x+1, y)\}$$

and all the elements having coordinate in that set should belong to the same connected component. For 8-connected the neighboring set of coordinate will be

$$\{(x-1, y-1), (x-1, y), (x-1, y+1), (x, y-1), (x, y+1), (x+1, y-1), (x+1, y), (x+1, y+1)\}$$

In a binary image scanned from left to right, an unlabeled object pixel is assigned a label, say X and each of its neighboring object pixels is assigned the same label till there is no more unlabeled object pixel in the image.

An alternate strategy of connected component labelling can be defined in two passes as illustrated in **Algorithm (1)**

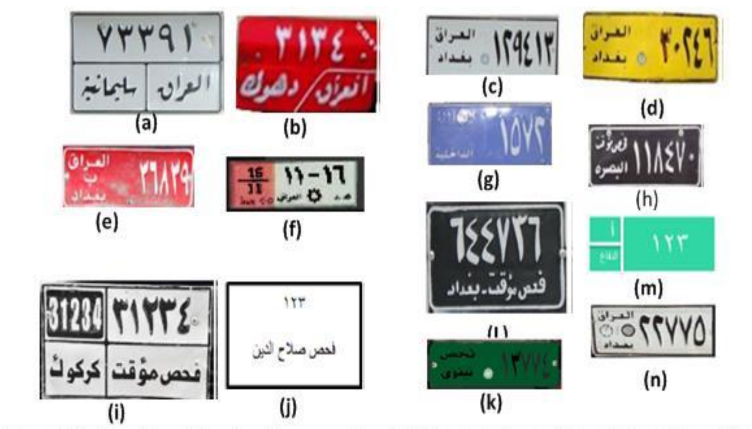
The objective of connected component labeling is to determine all the connected set of components in an image an assign a distinct label to each pixel in the same connected component**[9].**

Algorithm(1): Connected Components Labeling
Input Image **Output** ObjectLabels , ObjectCount
Begin **Step1:** ***First pass***: Search the entire image ***R*** row by row and assign a non-zero value (***v)*** to each non zero pixel ***R(i,j).*** The value (***v)*** is chosen according to the labels of the pixel's neighbors,(neighbors' outside the image Rare not considered). • If all the neighbors are background pixels (with pixel value zero), ***R(i,j)*** is assigned a new (and as yet) unused label. • If there is just one neighboring pixel with a non-zero label, assign this label to the pixel ***R(i,j)***. • If there is more than one non-zero pixel among the neighbors, assign the label of any one to the labeled pixel. If the labels of any of the neighbors differ ***(label collision)***, store the label pair as being equivalent. Equivalence pairs are stored in a separate data structure-an equivalence table. **Step2:** ***Second pass***: All of the region pixels were labeled during the first pass, but some regions have pixels with different labels (**due to label collisions**). The whole image is scanned again, and pixels are re-labeled using the equivalence table information (for example, with the lowest value in an equivalence class). **End**

3. Iraqi license plates features

License plates of Iraq have many different styles **Figure (6) and Figure (7).** In this paper the newest style is be used, it consists of a vertical strip on the left side of the plate with a color refers to the vehicle type, and the word "IRAQ" written in English. There are two rectangles beside this strip one for left top anther to left bottom .The first (top) rectangle part has one letter followed by more than six numbers. The letters varies from(أ,A) to(ي,Z) and the numbers from (0,0) to (9,9) all contain this part written in Arabic and English ,these seven characters uniquely identify the vehicles for each government , the Arabic font size bigger than English font size. The bottom rectangle contains a word referring to the type of the vehicle, and/or the province name, all words are written in Arabic **[7]. Table (1)** shows the type of the new license plates that are used in Iraq.

Table(1) Characteristics of Plate			
Vehicle type	Plate Background Color	Foreground Color (color font)	Size of plate (width X height)
Private Vehicle	White	Black	30 X 15
Public (ex: taxi, bus)	Red and white	Black	30 X 15
Carrying (ex: Truck)	Yellow and white	Black	30 X 15
Governmental (ex: Ministries)	Blue and white	Black	30 X 15
Diplomatic	Red and white	Black	30 X 15



Figure(6) Old style of the Iraqi license plate: (**a**) The province of Kurdistan of Iraq for private vehicle(**b**) The province of Kurdistan of Iraq for taxi vehicle(**c**) Baghdad private (**d**) Baghdad carrying (**e**) Baghdad taxi (**f**) diplomatic(**g**) MOI (**h**)temporary license plate used in basra Province (**i**)temporary license plate used in Kirkuk Province (**j**)temporary license plate that is used in Salah Al-Deen province(**k**)temporary license plate that is used in Neynewa province (**L**)temporary license plate that is used in eleven

Figure(7) New style of the Iraqi license plate:
(**a**) private vehicle (**b**) Taxi vehicle
(**c**) government (**d**) Taxi vehic

4. The Proposed System for Iraqi License Plate Localization(ILPL)

License plate extraction is the most important phase in an LPR system, which influences the accuracy of the system significantly **[8],** the proposed approach shown in **Figure (8):**

4.1 **Preprocessing**

The first step in an ILPL system the images taken from camera with resolution (800X600), the images captured by camera usually have complex background. There exits uncertain factors in license plate image due to weather condition, illumination, fouling and occlusion of license plate. For this reason there is a need to enhance the image to make it suitable for the stage of localization. Contrast enhancement by using histogram Equalization and noise eliminated by using conservative smoothing are implemented before that convert color image to grayscale image. **Figure (9)** shown the result after apply this stage:

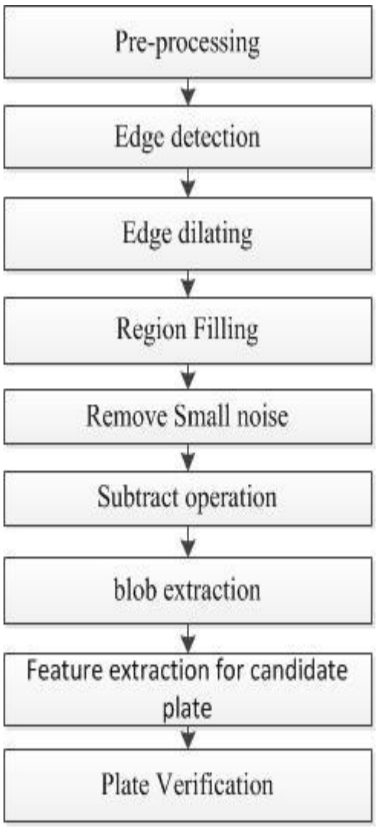


Figure (8) license plate localization stages

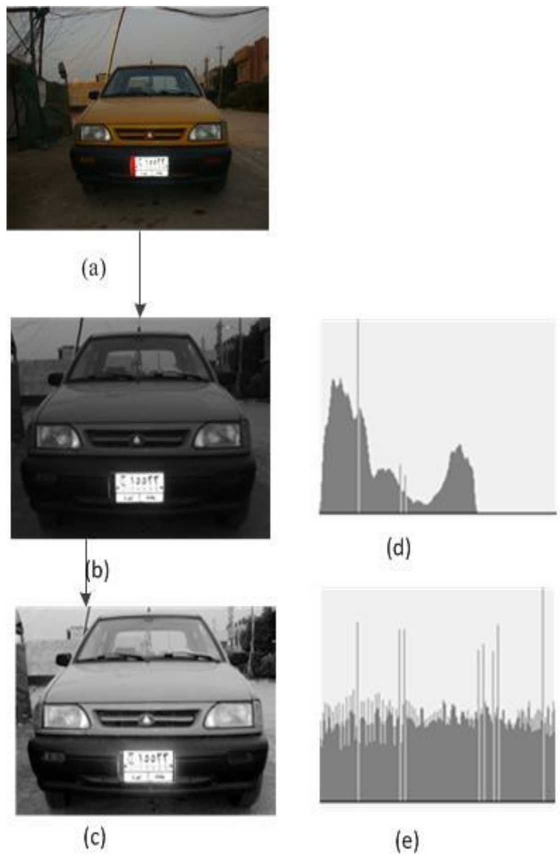


Figure (9) Output after applied preprocessing stage
(a) Color Image (b) Grayscale Images (c) Results of histogram equalization and noise elimination for image in (b). (d) Corresponding Histograms for image (b). (e) Corresponding Histograms for image (c)

4.2**Edge detection**

Detecting the edges of image helps to filtering out useless data, while preserving the important structural properties of a vehicle image. The second benefit to detect boundary of regions in vehicle image and may give closed regions. The vehicle LP is rectangular closed shape. In this paper, horizontal and vertical sobel operator is used.

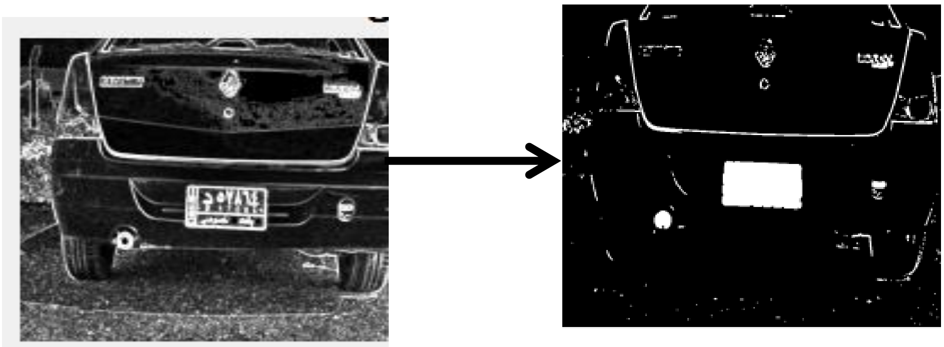
4.3 Edge dilating

Design for the new Iraqi license plates covered by a transparent plastic contains the word "العراق" in white color , which leads to separation of the frame into more than one parts are not connected F**igure (10)** .Used dilation morphology operation to solve this problem. Dilation increases the size of a binary object, broadening and thickening narrow regions and growing the feature around its edges **[5].**

Figure(10): Plate with separate frame signed by blue arrow

4.4 Region Filling

After image enhancement, edge detection, dilate operations done. Region filling used to fill all hole inside boundary. Region filling based on set dilations, complementation, and intersections by using **Eq.(4)**. **Figure (11)** shows the results of applying this stage.



(a) (b)

Figure (11) : Region fill operation (a) edge image (b)fill image

4.5 Remove small noise

The resulting image in **Figure (11)** of the previous stages contains a collection of small noises. Morphological opening carried out to reduce this noise **Figure (12).**Opening is the name given to the morphological operation of erosion followed by dilation with the same structuring element. We denote the opening of A by structuring element B as

$$A \circ B = (A \ominus B)$$

The general effect of opening is to remove small, isolated objects from the foreground of an image, placing them in the background. It tends to smooth the contour of a binary object and breaks narrow joining regions in an object **[5,2].**

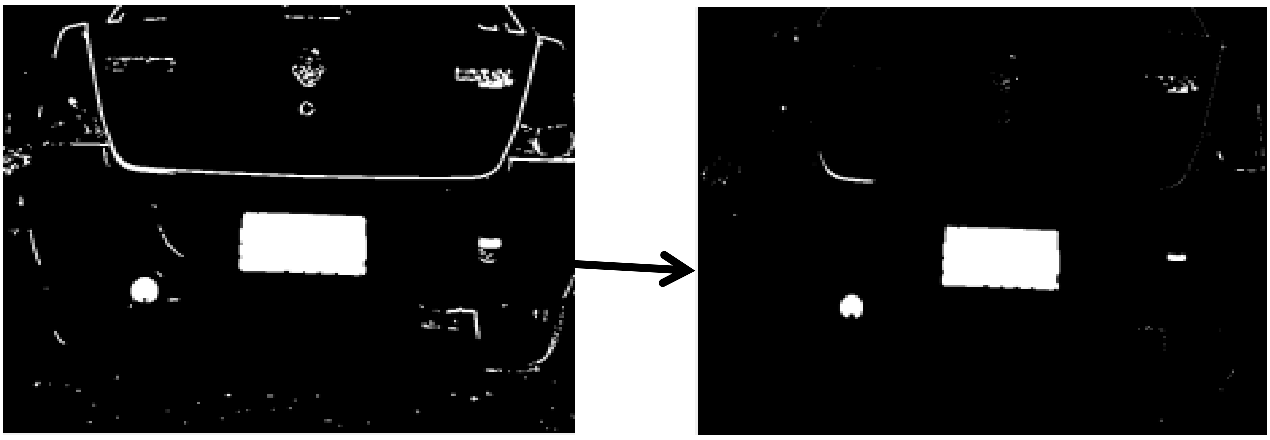


Figure (12) : Remove Small noise
(a) image with small noise (b)image without small noise

4.6 Subtract operat

The subtract ope ne same size and pixel fo ne difference value of corresponding pixels from provided images (if difference is less than minimum allowed value, 0, then it is truncated to that minimum value). The resulting image of the stage remove small noise as source image, the gray scale image is overlay images. **Figure (13)** shows resulted from this operation.

Figure (13) : subtract operation (a) source image (b) overlay images (c) Result image

4.7 blob extraction

After the implementation of a set of previous operations that reduce the number of objects in the image, where the objects of the resulting that the candidate vehicle plate, to extract this objects from image the recursive connect component labeling used.

4.8 features extraction and plate verification

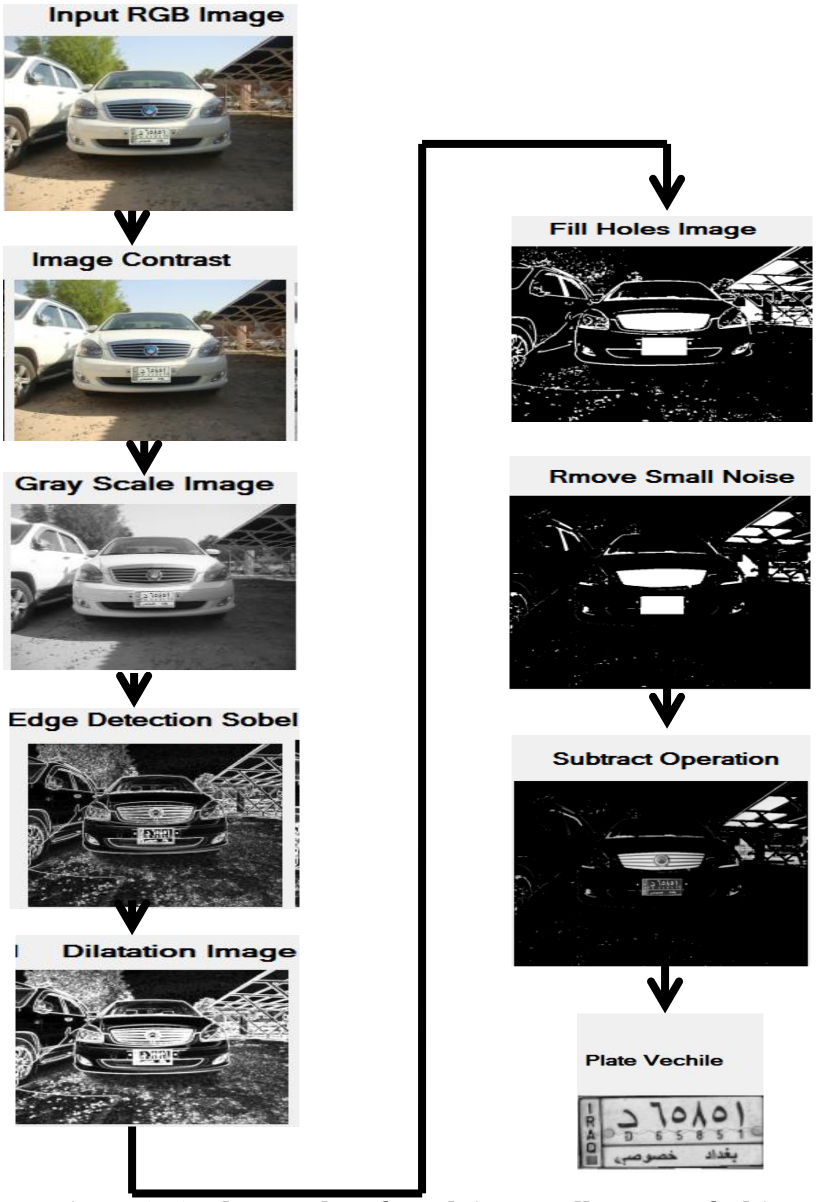
To detect which of the objects are extracted by blob extraction step that contains a positive plate, must extract a set of features, then determined the real plate depend on features extracted. Iraqi plate characterized as a set of features:

- **Width and height:** A iraqi Vehicle license plate to have a rectangle plate or a plate with the height greater than the width.
- **Aspect ratio:** A iraqi vehicle's license plate has a fixed width and height, regardless of how many characters are on the plate,Consequently, the

approximate ratio of the plate width over the heigh is determined as being greater than or equal to 20 percent and not greater than 30.

5. Experimental result

Experiments have been performed to test the proposed system and to measure the accuracy and time of the system. The input images are colored images with the size of 800X600. The number of samples used in this paper are 31 vehicle with complex background , different weather and under various illumination conditions and distance .The number of samples that have been successfully detect its plate are 28 sample and the number of samples that did not detect its plate are 3. The success accuracy rate is 90% and the average time required to detect the plate is 225 milliseconds. **Figure (14)** shows the results of applying to all stages of this proposed algorithm,



Figure(14): the results of applying to all stages of this proposed algorithm

References

[1] Zheng, L., He, X., Wu, Q., and Jia, W., ***"A Hierarchically Combined Classifier for License Plate Recognition"***, 8th IEEE International Conference on Computer and Information Technology, IEEE, PP. 372-377, **2008**.

[2] Rafael C. Gonzalez; Richard E. Woods ***"Digital Image Processing",*** Second Edition, ISBN: 0-201-18075-8, Prentice Hall, **2002.**

[3] Gerhard X. Ritter ; Joseph N. Wilson , ***"HANDBOOK OF Computer Vision Algorithms in Image Algebra",*** CRC Press LLC,

[4] Nafis uddin Khan;K.V. Arya; Manisha Pattanaik , ***"An efficient image noise removal and enhancement method"***, 2010 IEEE International Conference on Systems, Man and Cybernetics , IEEE, **ISSN**: 1062922X , **Pages**: 3735-3740 **, 2010** .

[5] Chris Solomon; Toby Breckon**,** ***"Fundamentals of Digital Image Processing"***, Wiley Blackwell,**2012.**

[6] Linda Shapiro**,*" Computer Vision ",*** Prentice Hall, January **2001.**

[7] Nada Najeel Kamal , ***"Iraqi License Plate Recognition System",*** M.Sc. Thesis, College of science, Baghdad University , Iraq, March **2013**.

[8] Mukesh Kumar**,*" A Real-Time Vehicle License Plate Recognition (LPR) System",*** M.Sc. Thesis, Roll No-80751015, Thapar University, India, JULY **2009.**

[9] Tinku Acharya ; Ajoy **K.** Ray , "**Image Processing Principles and Applications**", Wiley,**2005.**