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# Using Mean Shift for Iranian license plate detection

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**Abstract**
In this paper, Mean Shift (MS) as a clustering algorithm is used to localize the Iranian license plate. In this procedure after clustering, based on the optimized MS method, we applied the geometrical features and edge density in order to remove those parts in every cluster, which cannot be the license plate. The main advantages of MS are no need to know the number of clusters and it is completely independent of the Iranian license plate characters colors or background colors. However, for MS implementation, we should only predetermine a parameter named bandwidth. The experimental results show that our proposed method achieves appropriate performance. We should mention that our system accuracy for optical (OP) with 300 images is 94.6% and for infrared (IR) with 80 images is 98.3%.

**Keywords:** Mean Shift, Iranian license plate detection, Cluster analysis, Kernel density estimator.

## 1. INTRODUCTION

Automatic vehicle license plate identification has an important role in many applications, such as recognizing and tracking vehicles on roads and highways. In general, Automatic license plate recognition (ALPR) system consists of four main parts: 1) image capturing by a camera, 2) license plate detection, 3) characters segmentation, 4) characters recognition. ALPR system should be able to detect the plate under different imaging like darkness and low quality, different lighting such as sunshine, cloud, and further more damaged plate. Among the four main parts mentioned above, the license plate detection has a key role for any ALPR system. Connection components that group the same discovered regions were proposed in [1]. Notifying the intensity variation of the plate background is greater than the plate characters was used in [2], [3]. Sobel mask as standard operator for edge detection was used in [4], [5] and random or noisy edges were removed as well. In [6], [7] the unwanted edges were removed and then by using the morphology filter the license plate region became candidate. In [8], a method based on the edge density for the plate segmentation was proposed. Through this procedure, the elements excluding the license plate candidate were removed by using the morphological operator, the plate aspect ratio and the plate shape of the characters.

In general, color-based methods are less used in comparison with other methods as it was applied in [9], [10]. However, color-based methods are applicable for plates with fixed color markings, where the lighting conditions are stable and

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unchanged. In [11], the license plate was detected by using the morphologic operator, Adaboost and machine-based techniques. In most applications, a combination of the above methods such as edge, color, and morphology was used in order to improve the detection accuracy [24].

In this paper, the MS [12] algorithm is used to localize the Iranian license plate. The MS method is a clustering algorithm that is widely used in applications like segmentation [13] and object tracking [14]. The main advantages of MS are no needs to predefine the form of data distribution, and no needs to know the number of clusters, and local maxima. In addition, MS is robust to rotation or distortion of the interested region. Furthermore, the performance of proposed method based on MS is completely independent of the Iranian license plate characters colors and background colors. However, for MS Implementation we should only predetermine a parameter named bandwidth.

The paper is organized as follows. Section 2 explains the original MS algorithm and the optimized MS algorithm in detail. In Section 3 the license plate detection algorithm procedures is expressed based on the MS. Section 4 presents the simulation results for OP images and IR images as well. Finally in Section 5 the paper conclusion is given.

## 2. ORIGINAL MEAN SHIFT (MS) AND OPTIMIZED MS ALGORITHM

MS is a clustering algorithm that estimates the probability density gradient for detecting states in an interactive mode, so in [15] the image segmentation based on the intensity similarity in spatial range was implemented. In [16], [17] the nonparametric clustering method which means that the feature space can be considered as the probability density function (pdf), was proposed.

In general, the MS algorithm [12] is a nonparametric statistical clustering method for seeking the main mode of a point sample. The MS vector *mean(x)* [18], [19], which leads points toward dense region, is:

$$mean(x) = \frac{\sum_{i=1}^{n} x_i g(||\frac{x - x_i}{h}||^2)}{\sum_{i=1}^{n} g(||\frac{x - x_i}{h}||^2)} - x \quad (1)$$

where $x$ is the data whose MS vector is obtained, $h$ is the bandwidth parameter, $x_i$ are those points that are at bandwidth distance to the $x$ data, $n$ is the number of $x_i$ and $g$ refers to the kernel function gradient (i.e. $g(x) = -\frac{d(k(x))}{d(x)}$ where $k$ refers to different kernel functions written in Table 1) [20]. As input image consists of three matrixes in RGB domain, for every pixel a new vector *mean(x)* has been formed. When *mean(x)* is less than a threshold value, the MS operation stops for that pixel. In this way, for every three RGB matrix, the MS algorithm runs as long as all pixels get the final values. It should be noted that the original MS algorithm for license plate segmentation was time consuming, so in this paper, we have proposed an optimization MS that explained in following.

For an input image with $m$ pixels, a matrix with size $5 \times m$ pixels is formed as

$$\begin{bmatrix} R_1 & \dots & R_j & \dots & R_m \\ G_1 & \dots & G_j & \dots & G_m \\ B_1 & \dots & B_j & \dots & B_m \\ X_1 & \dots & X_j & \dots & X_m \\ Y_1 & \dots & Y_j & \dots & Y_m \end{bmatrix}$$

where every columns consist of the color components $R_j$, $G_j$, $B_j$, and the pixel spatial $X_j$, $Y_j$ (for $j=1:m$). Obviously, the 1-st column belongs to the first pixel and the $m$-th column belongs to the last pixel of input image with size $m$. Although two threshold values as bandwidth of the domain (for color components) and bandwidth of the spatial (for pixels coordinate) are needed, in order of simplicity, we consider only one threshold value as bandwidth which is called $h$ in general. Now, the procedures of optimized MS algorithm for 1-st column are listed in the following and the steps for other pixels are completely similar to these phases.

1) Distinguish those pixels (i.e. obtain the column index) where $|[R_1, G_1, B_1, X_1, Y_1]^T$-

$[R_j, G_j, B_j, X_j, Y_j]^T| < h$. The first pixel is named $x$ and any other selected pixels are named $x_i$.

2) Compute the mean value according to Eq. (1) for those pixels which are considered as one cluster according to step 1.
3) If $|x\text{-}mean(x)|>Th$ then consider $mean(x)$ as the first pixel value, i.e. $x=mean(x)$ and go to step 1, otherwise the first cluster is dedicated, and we have to repeat steps 1-3 for remained pixels in order to find other clusters.

We should notice that recognizing distinguish colors for clusters are dependent on the used kernel in MS algorithm, different kernel functions [19] which are written in Table 1. The MS algorithm can use different kernels such as Gaussian, and Uniform. As shown in Fig. 1, using Gaussian kernel due to high color resolution is recommended in comparison with Uniform kernel. There is no distinction between green and yellow when the MS algorithm used the Uniform kernel function. In addition, the MS processing time with Gaussian kernel function is faster than the processing time with Uniform kernel function.

Table 1. Types of kernel functions.

| Kernel | K(x) |
|---|---|
| Uniform | $\frac{1}{2}1, (\|x\| \le 1)$ |
| Triangle | $(1-\|x\|)1, (\|x\| \le 1)$ |
| Epanechnikov | $\frac{3}{4}(1-x^2), (\|x\| \le 1)$ |
| Quatric | $\frac{15}{16}(1-x^2)^2 1, (\|x\| \le 1)$ |
| Triweight | $\frac{35}{32}(1-x^2)^3 1, (\|x\| \le 1)$ |
| Gaussian | $\frac{1}{\sqrt{2\pi}} e^{-\frac{1}{2}x^2} (\|x\| \le 1)$ |
| Cosinus | $\frac{\pi}{4}\cos(\frac{\pi}{2}x)1, (\|x\| \le 1)$ |


Fig. 1. (a) The original image, (b), (c) the outputs MS clustering algorithm where Uniform and Gaussian kernel functions are used in order.

## 3. DETECTION IRANIAN LICENSE PLATE BASED ON OPTIMIZED MS ALGORITHM

MS is known as a color image clustering. In this section, the license plate detection based on MS is proposed where only 'h' as bandwidth should be set. The procedures of proposed algorithm are shown in Fig. 2 and are explained in the following.

### 3.1. Color Clustering

The colored input image is clustered by optimized MS algorithm based on the different region colors [21]. Fig. 3 shows six sample images and Fig. 4 shows the clustered images by using the MS based on Gaussian kernel function. As seen, the final image consists of different clusters with different colors. Each pixel is corresponding to a cluster according to the mean value irrespective of pixel location. So, all pixels which belong to a cluster, have the same color but they may not have connection in spatial domain. The numbers of clusters by the optimized MS algorithm for images shown in Fig. 1(a-f) are in order (54, 37, 39, 50, 35, 30).

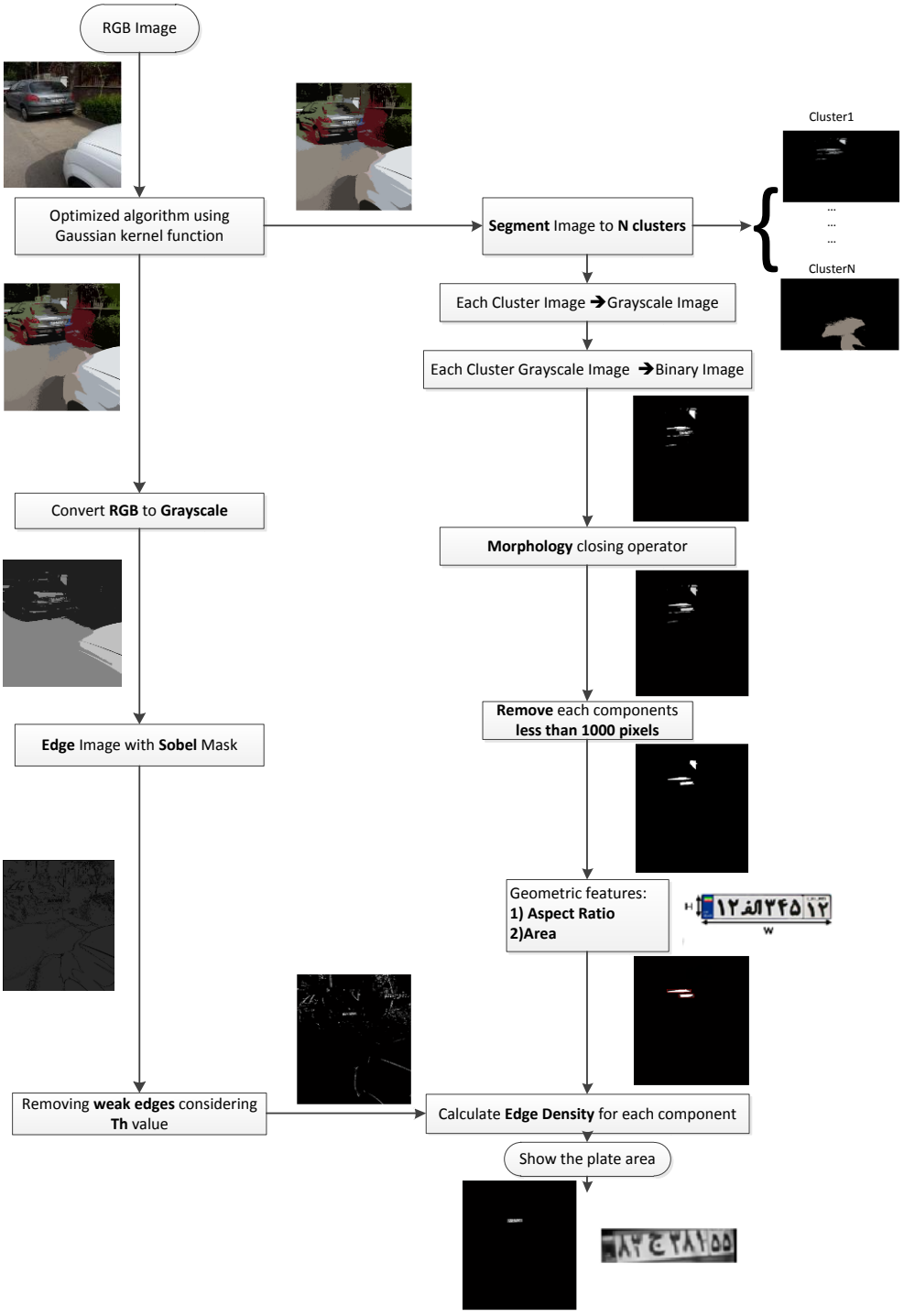


Fig. 2. Block Diagram of the optimized MS algorithm for Iranian license plate detection.

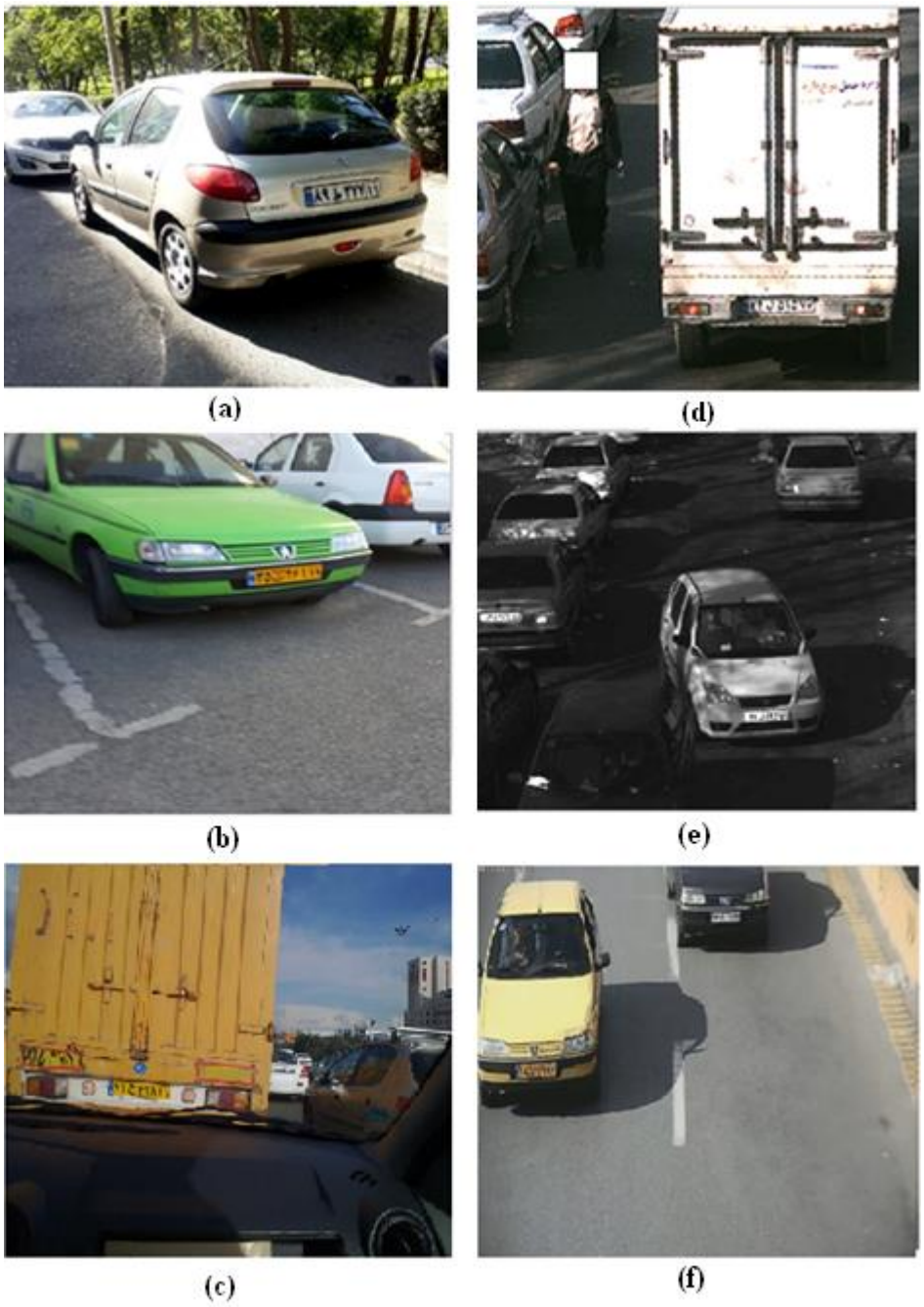


Fig. 3. Six sample images are shown (a-c) OP image, (d-f) IR image.

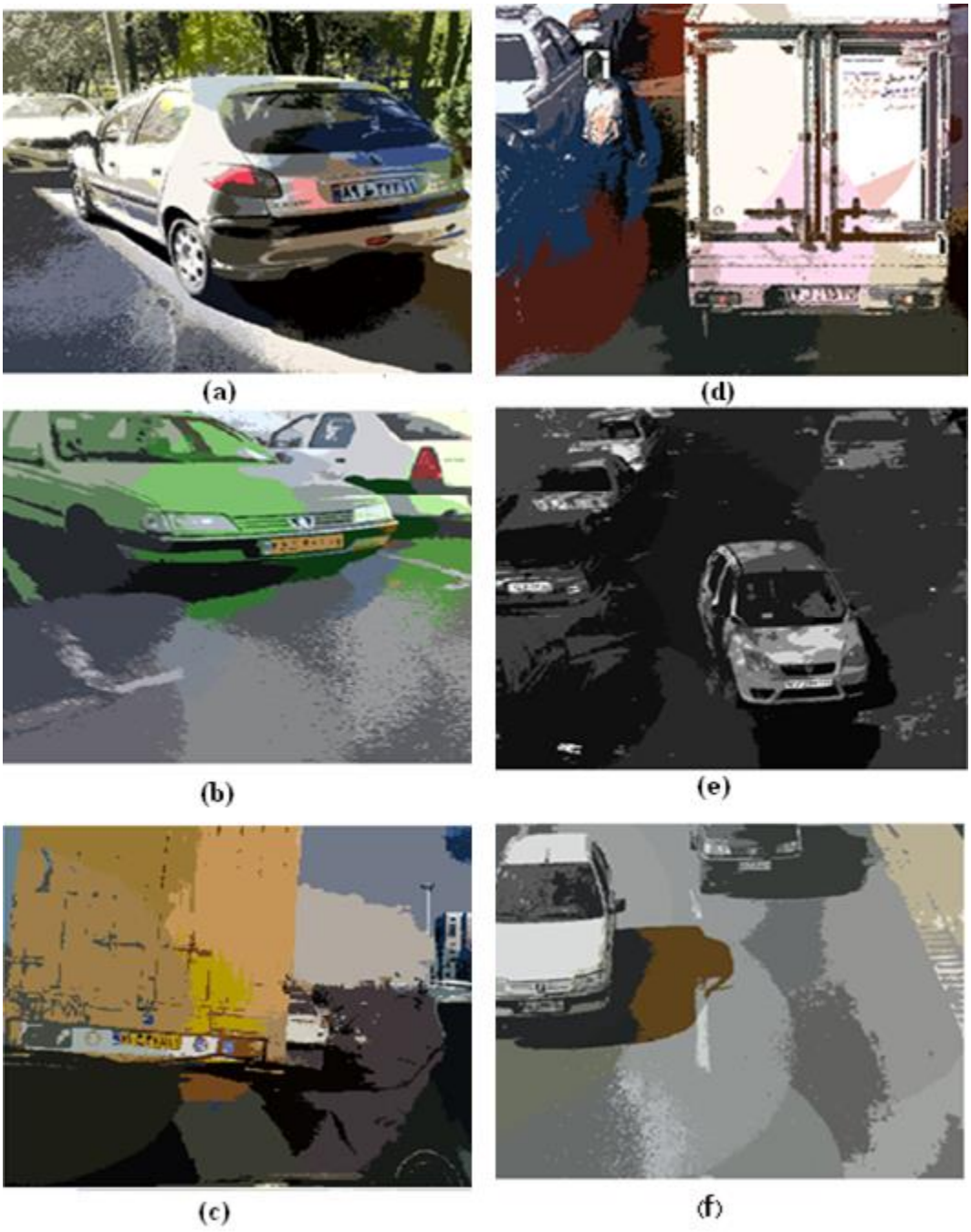


Fig. 4. The output of optimized MS algorithm by using Gaussian kernel function.

### 3.2. Morphological Closing Operator in the Binary Image of Clusters

As explained, the image which processed by MS algorithm, consist of clusters with different colors, So every cluster is converted to gray scale image, then pixels with the value greater than zero are converted into one and others are set with zero. Through this, the binary image is made, see Fig. 5. Then the morphology closing operator in order to fill small holes is used where the structural element is supposed to be $B=[1111111111]$, see Fig. 6.

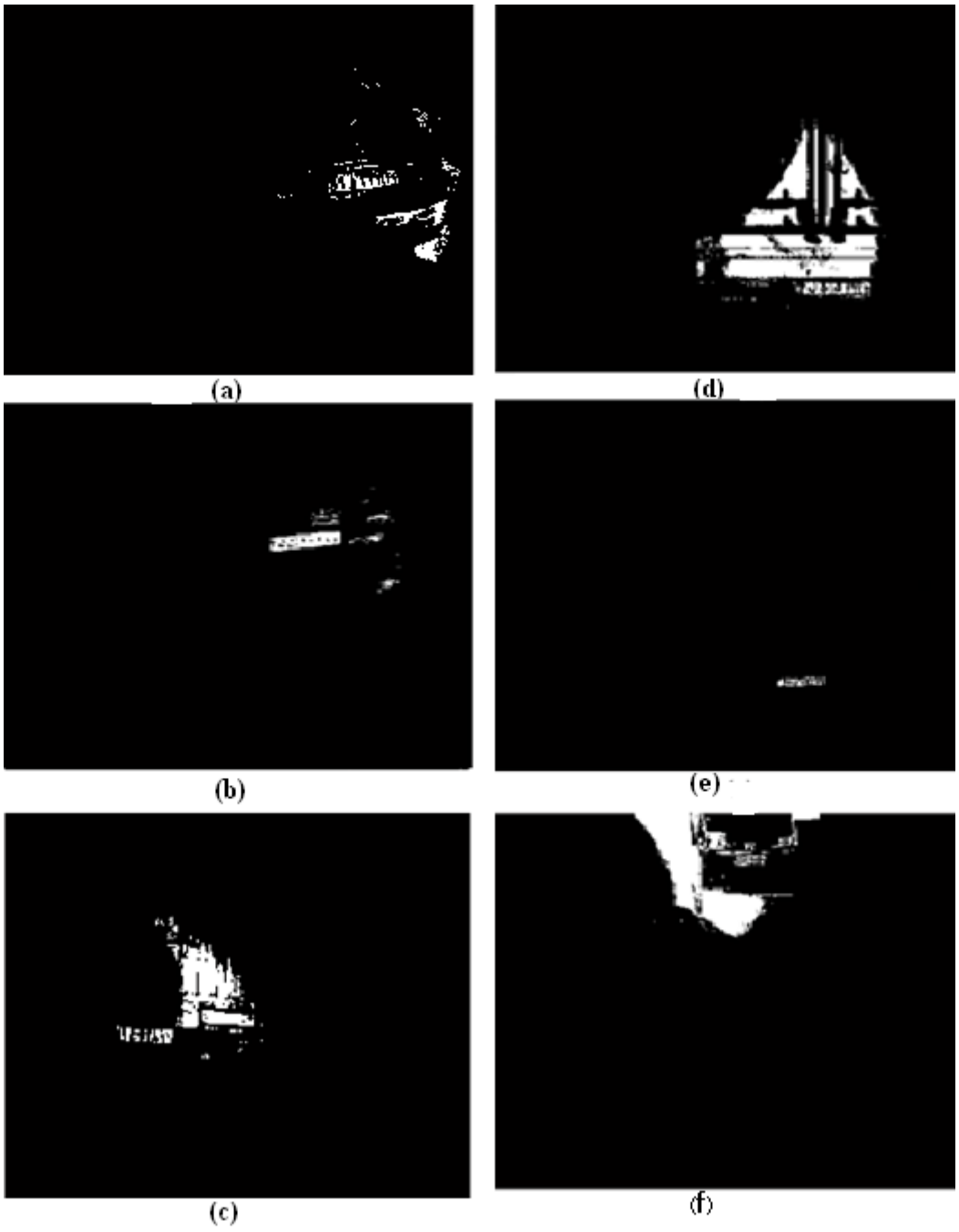


Fig. 5. The binarized images are shown.

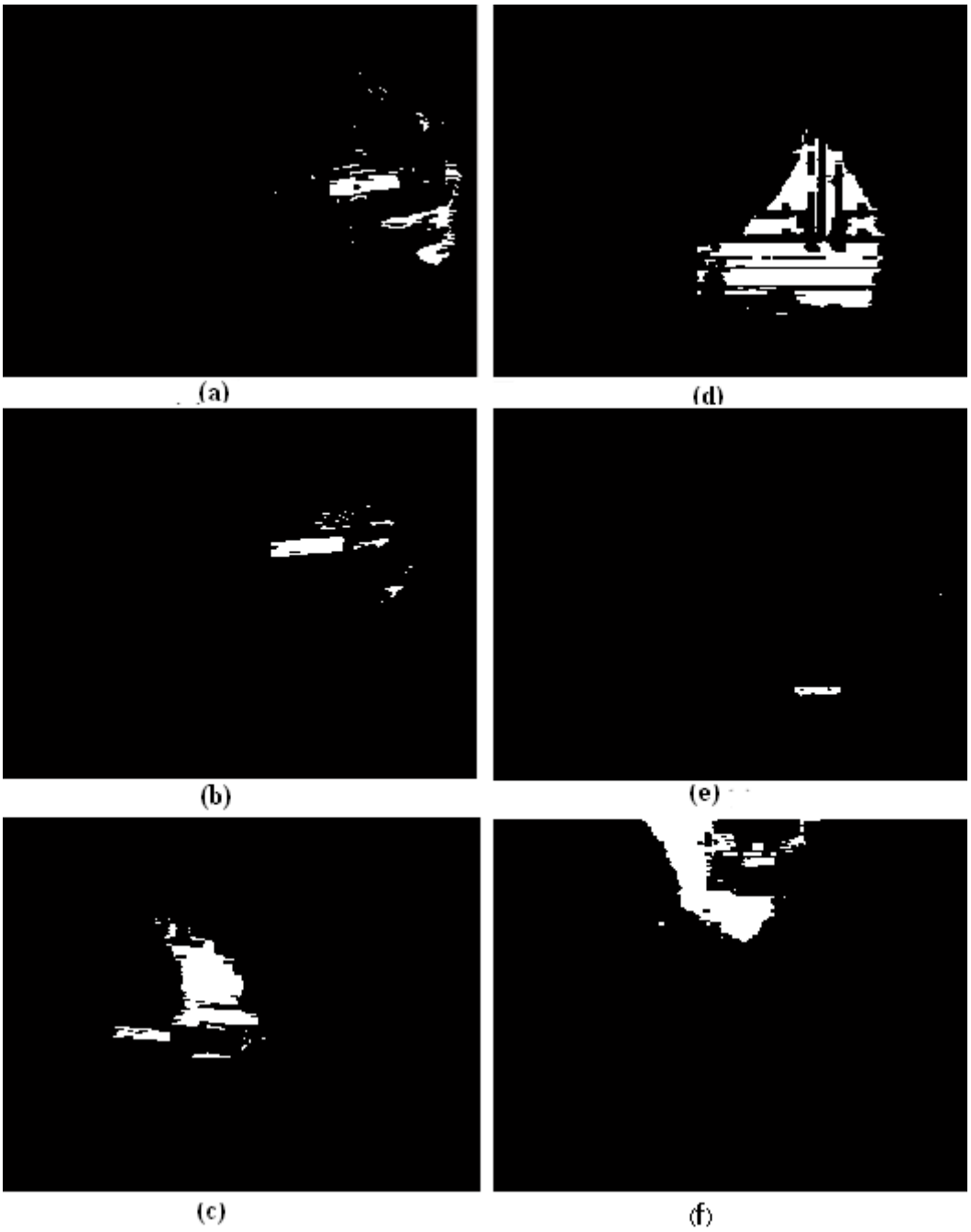


Fig. 6. The output images of using morphological closing operator are shown.

### 3.3. Component Segmentation

As said before, the spatial bandwidth and range bandwidth parameters are to be set for the original MS implementation algorithm. In this paper, for simplicity, the values of these two parameters are considered equally and as result of that equality, there are spatially discontinuous components in clusters. Using Iranian license plate data bank, which includes 300 OP images and 80 IR images, and according to width and height of the license plate, we investigated that the plate region includes at least 1000 pixels. So all areas, which include less than 1000 pixels are eliminated, see Fig. 7.

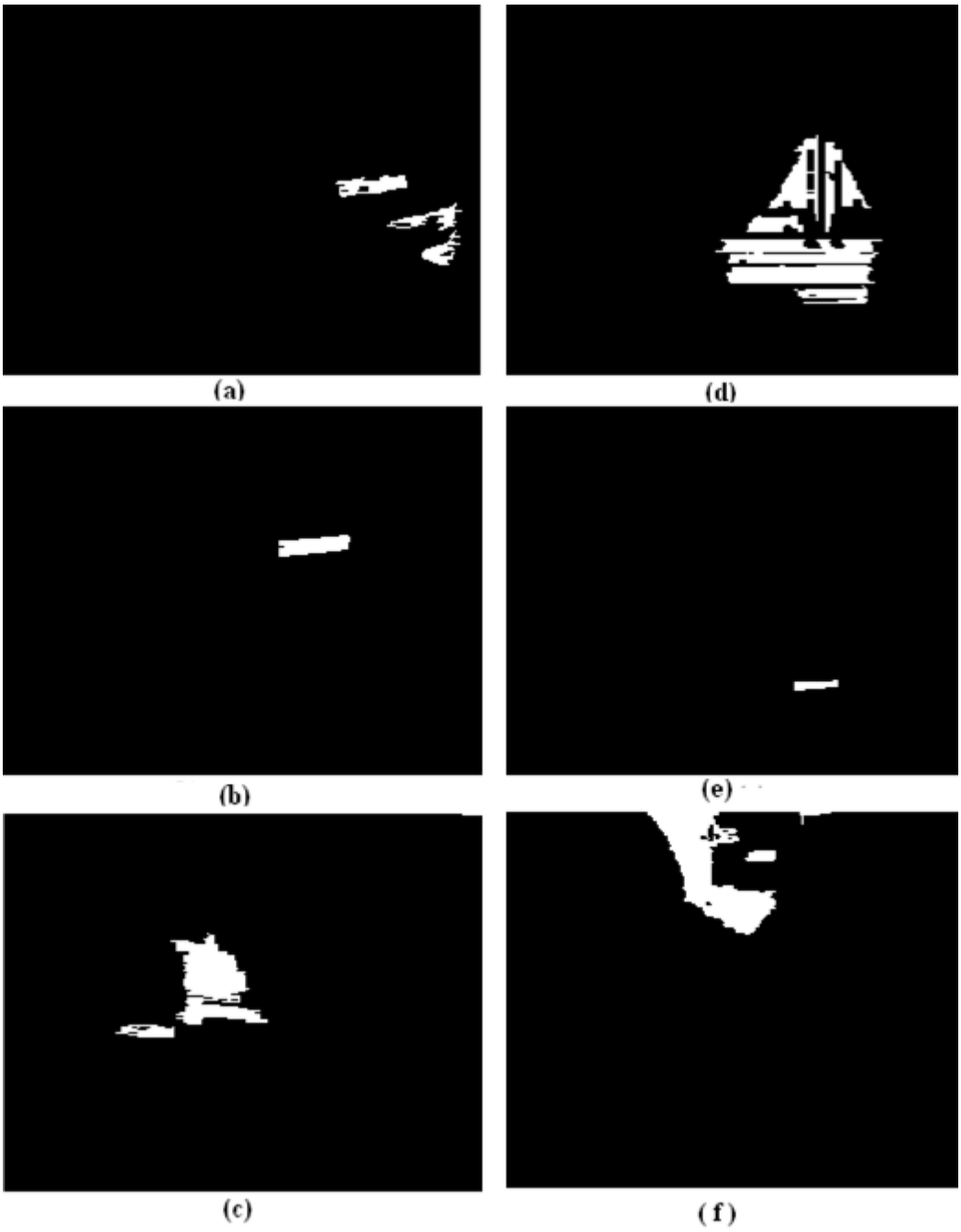


Fig. 7. Removing areas those pixels are less than 1000 pixels.

### 3.4. Geometric Features

Every cluster consists of different components, which should be individually processed in order to remain the candidate as the license plate and remove the others. For this purpose, geometric features analysis includes the rectangular shape, the rectangular area and the aspect ratio (i.e. the ratio of height to width for a rectangular) are used as follows,

$$A = H * W \tag{2}$$

$$AR = H / W \tag{3}$$

where for a rectangular shape candidate as a license plate, *H*, *W* are height and width in order, *AR* is the aspect ratio, and *A* is the plate area. All components in every cluster are analyzed according to Eqs. (2)- (3) and those components that satisfy the above conditions or may be the license plate are investigated where as others are removed, see Fig. 8.

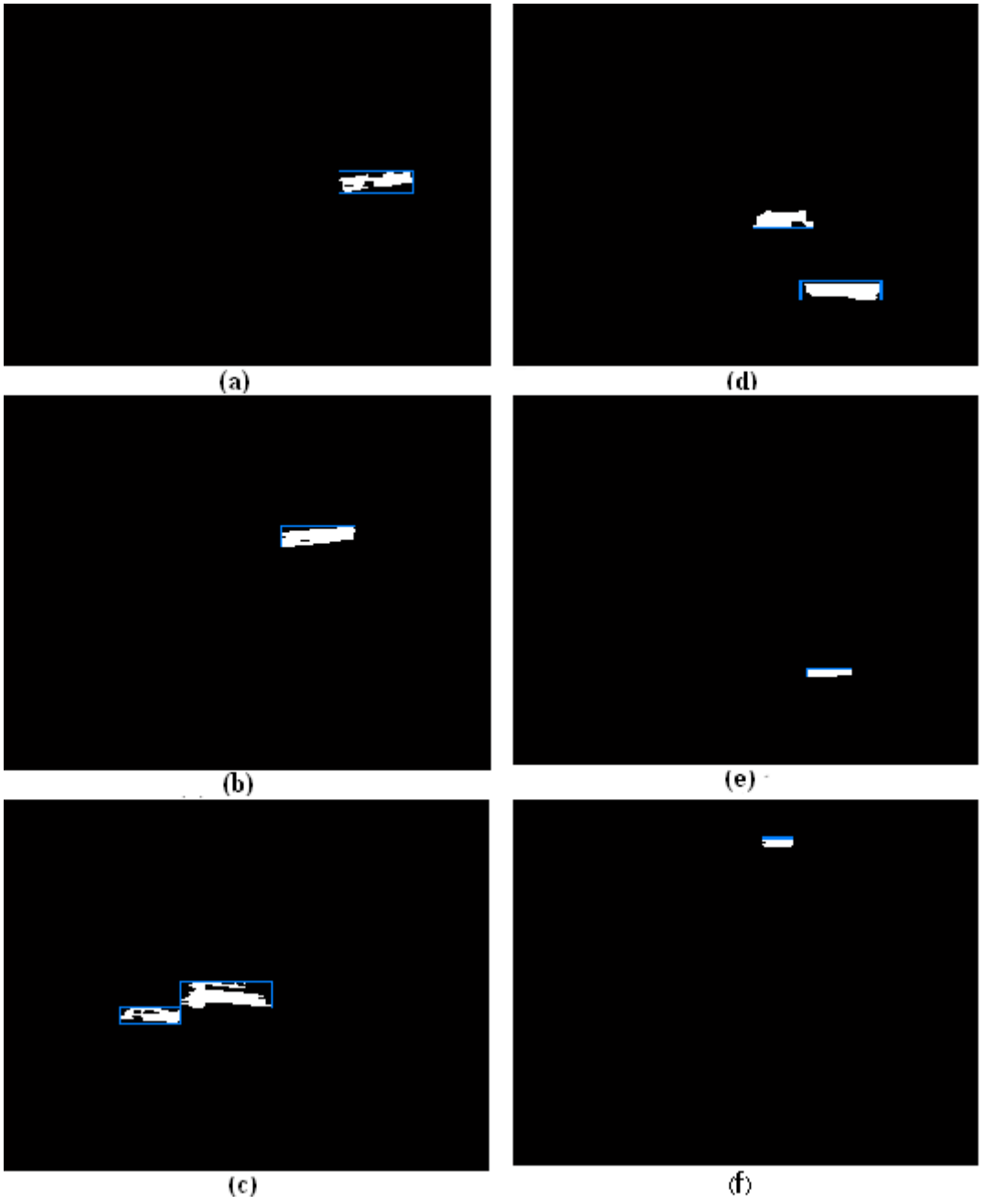


Fig. 8. The output images of using geometric features.

### 3.5. Edge Density

As a license plate includes characters with mostly vertical edges. In this paper, we used the vertical Sobel mask in order to obtain the edge density. For the output image of using the Sobel mask, the pixel value of low level brightness toward high level brightness is negative, so the absolute values

are considered, and then the histogram equalization is used to improve the edge image. Plate region because of including the license plate characters is among the strongest edges of the edge image. With using a threshold (*Th*), the weak and unnecessary edges are removed and it leads to restoring the strong edges as well. For this purpose, the *Th* is obtained as [5],

$$Th = Max(E)\text{-}m(E)^{*}\,\delta(E)^{*}0.5 \qquad (4)$$

where $E$ is the edge image, the output of vertical Sobel mask, $m(E)$ and $\sigma(E)$ are in order the mean and the standard deviation values of the edge image. After obtaining *Th* value according to Eq. (4), the new binary edge image named $E_{Th}$ is formed,

$$E_{Th} = \begin{cases} 1, & E \geq Th \\ 0, & E < Th \end{cases} \qquad (5)$$

Fig. 9 shows the image after removing the weak edges and remaining the strong edges. Although those regions, which don't satisfy the plate area and the aspect ratio, are removed, there are still some non-plate regions, so edge density (*ED*) is used in after as,

$$ED = \frac{1}{A_{component}} \sum_{i=1st-col}^{last-col} \sum_{j=1st-row}^{last-row} E_{Th} \qquad (6)$$

where for every component, belongs to a cluster, 1st- and last- refer to the first and the last either row or column. The *ED* is the last feature, which candidate those regions as license plate if $0.2 \leq ED \leq 0.4$ and removes others.

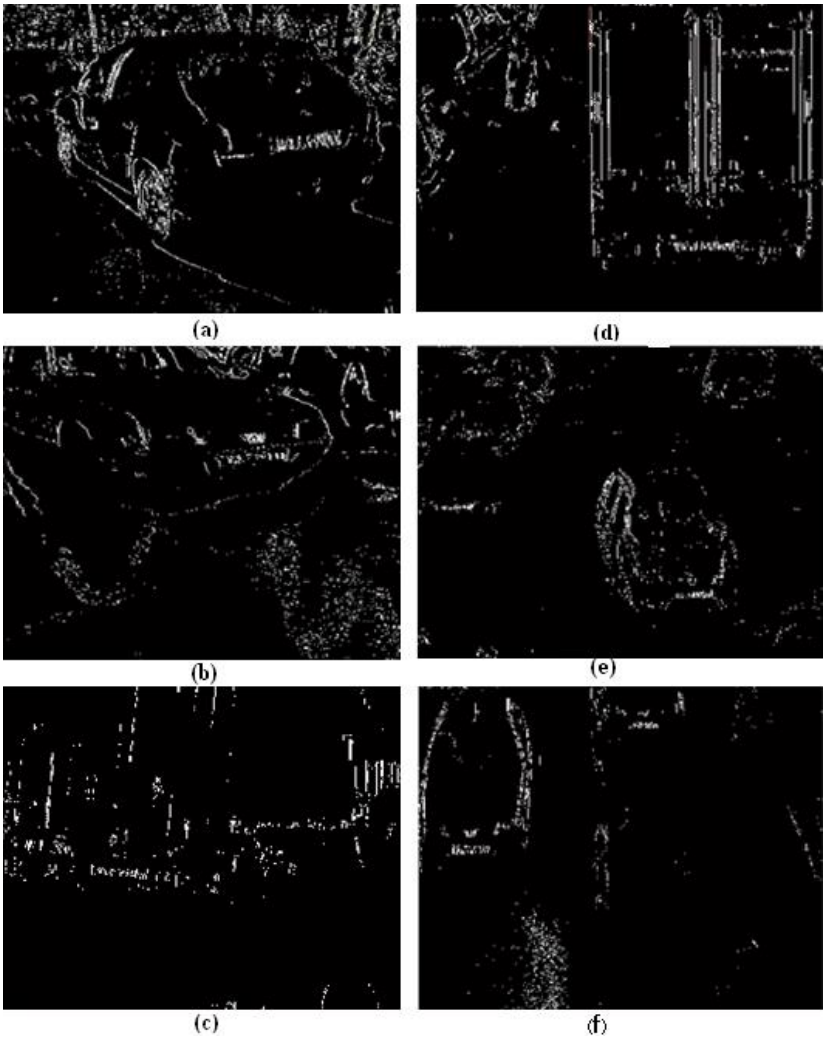


Fig. 9. The output of using vertical Sobel mask is shown where weak edges are removed.

### 3.6. License Plate Region

As explained before, the different parts of every cluster are investigated in terms of aspect ratio, area, and edge density. Those parts that satisfy the three mentioned conditions are candidate as license plate, see Fig. 10.

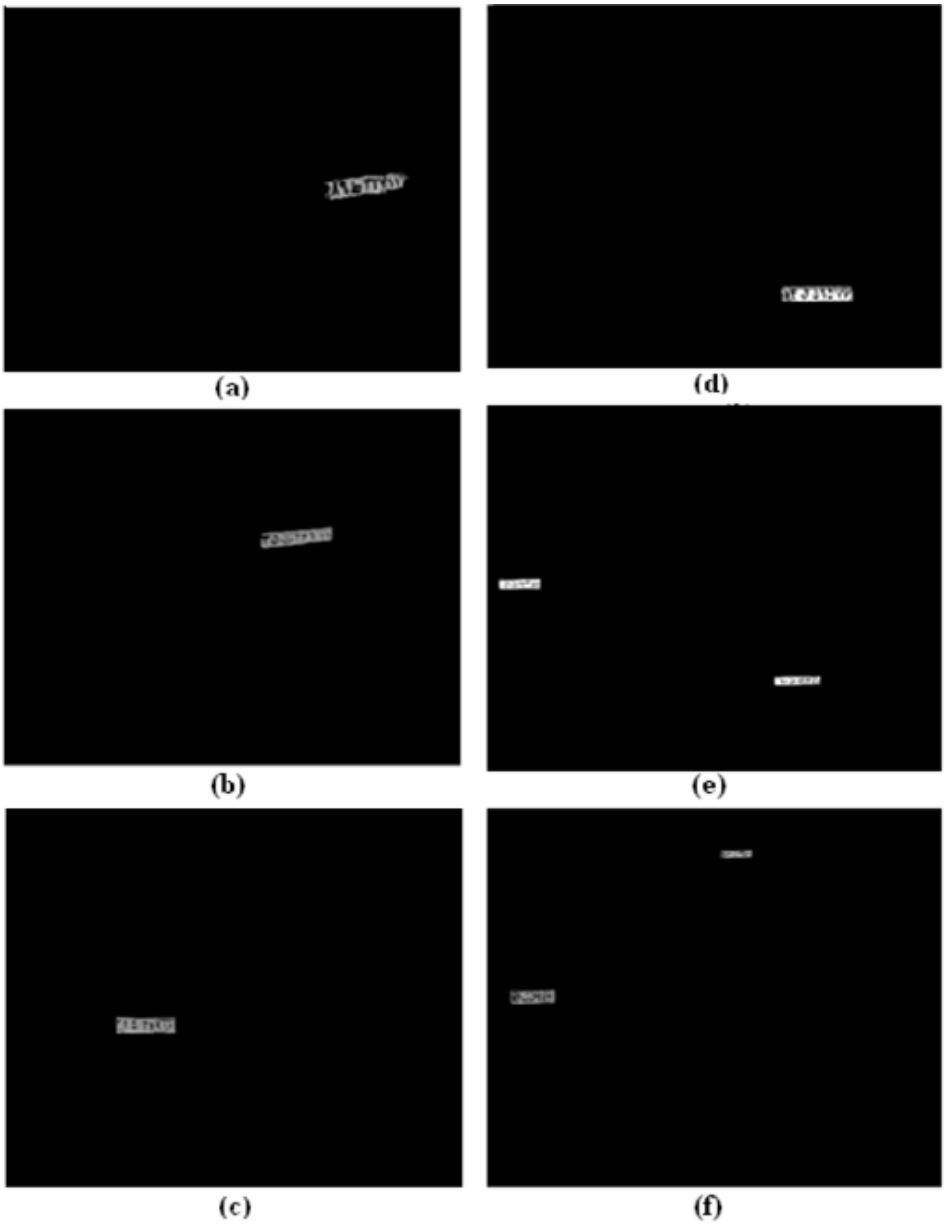


Fig. 10. The detected license plate region based on optimized MS algorithm for six sample images.

## 4. EXPERIMENTAL RESULTS

In this paper, license plate detection for Iranian cars based on optimized MS clustering is proposed. For this purpose, after clustering, we apply the geometrical features and edge density in order to remove those parts in every cluster, which cannot be the license plate. The main advantage of using the proposed method is that the performance of the algorithm is not dependent on the plate background color. This robustness gives possibility of using MS algorithm for the standard Iranian license plate detection, where different

colors for background and characters are used, see Fig. 11. As there is no standard data bank for Iranian license plate, we have used a bank data with 300 OP images including some low-resolution images, multiple license plates, and those with complex background. Furthermore, the algorithm also runs on 80 IR images as well. The distance between camera and car for recorded OP images is at most 4 meters and the distance interval for IR images is at most 3-10 meters.

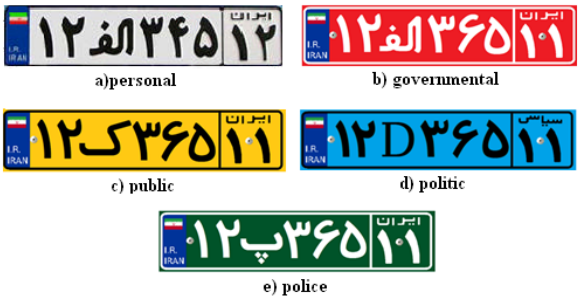


Fig. 11. Five different type of Iranian license plate.

We also used Matlab R2010a software with pc G620 @ 2.60GHZ CPU, 3GB RAM. The prepared data bank are grouped into 1) images captured by an optical camera includes personal, public, and governmental license plate, 2) images recorded by IR camera at night and sunny day. Although, license plate detection by using MS algorithm was proposed in 2007 [18], we used the algorithm for Iranian license plate for the first time.

Table 2 indicated the comparison between our proposed method and [18]. The main advantages of the proposed method based on optimized MS algorithm by using Gaussian kernel functions are:

1) Using the Gaussian kernel not only improves the colors resolvability but also decreases the optimized MS algorithm's run time about five times in comparison with using the Uniform kernel function.
2) Only one bandwidth parameter needs to be set whereas in [18], two spatial and range bandwidths were obtained.
3) As clusters are converted to binary regions and geometric features and edge density are applied in order to able us to detect the license plate with greater rotation angles in comparison with [18].
4) The proposed method as well as [18] is irrelevant to the license plate background color, so it can be applied for different Iranian vehicles.

Table 2. Listed important features of [18] and the proposed algorithm.

| | [18] | Proposed Method |
|---|---|---|
| **Image size** | 243×324 pixels | 600×800 for 300 OP 1028×1028 for 80 IR |
| **kernel function** | Uniform | Gaussian |
| **Plate rotation angle** | [-15˚,15˚] | [-45˚ , +45˚] |
| **The final processing time** | - | 10-20 second. |
| **Accuracy (%)** | - | 96.4 |

In Table 3, we report the achieved accuracy of different methods, those applied for Iranian license plate detection but with using different image data bank. However, the accuracy by our proposed method for either OP or IR images is appropriate.

Table 3. The accuracy achieved by different methods for Iranian license plate detection.

| **Method** | **Number of Images** | **Accuracy (%)** | **Advantage** | **Drawback** |
|---|---|---|---|---|
| **[5]** | 300 | 97 | Irrespective of distance, rotation and contrast. | Dependent on the color of the plate. |
| **[22]** | 390 | 94 | Robust to rotation and low quality of license plate. | Dependent on the color of the plate. |
| **[10]** | 425 | 92 | Low computational cost. | Dependent on the color of the plate. |
| **[23]** | 250 | 94.8 | Useful method when the lightening is not changed. | Dependent on the blue rectangle of Iranian car plate. |
| **[11]** | 1176 | 96.93 | Detect car plates with different sizes. | Require an educational process. |
| **Proposed Method** | 300 OP<br>80 IR | 94.6<br>98.3 | One bandwidth parameter needs to be set, irrelevant to the license plate background color, detect the license plate with greater rotation angles. | The bandwidth parameter must to be reset according to type of camera and the distance between the camera and car. |

## 5. CONCLUSION

A robust method for Iranian license plate recognition was proposed in this paper. This method can be used for images, which include more than one car and the camera has been rotated or there is an angle between license plate and camera. This algorithm is not dependent on the plate background color and characters color. The proposed algorithm for Iranian license plate detection has been run on the provided database that includes 300 OP images, containing different type of Iranian license plate and 80 IR images. Although the proposed method is used for Iranian license plates, the parameters can be set for other license plates as well.

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