AUTOMATIC RECOGNITION OF THE LICENSE-PLATE LOCATION BASED ON OPTICAL FLOW AND NEURAL NETWORKS FOR ARABIC AND FARSI CHARACTERS

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ABSTRACT

Automatic license plate recognition (LPR) plays an important role in numerous applications and a number of techniques have been proposed. However, most of them worked under restricted conditions, such as fixed illumination, limited vehicle movement and stationary backgrounds.in this paper we present a new method to recognize the position and the characters of license-plate for moving cars having Farsi characters. In this method, car motion is not considered as a restriction for the LPR system. car motion will be recognized using the optical flow of the image. The camera takes the image in an appropriate time according to the information acquired from optical flow measurement. Then the license-plate is located and its characters are distinguished using image processing techniques. Finally, characters are recognized using a Hopfield neural network.
The performance of the proposed method is evaluated under different weather conditions and varying distances for 400 grey level images. The location of the license plate is identified successfully 95% of the times while the successful character recognition probability using Hopfield neural network is 99%. Hopfield network can store several patterns of characters and also it can convert those patterns to the stored prototype patterns with minimum error. Therefore Hopfield network can be used as an efficient pattern classifier for character recognition.

KEYWORDS: *Image Processing, Neural Networks, Optical Flow, Plate Detection, Farsi and Arabic Characters.*

I. INTRODUCTION

Nowadays, license-plate recognition (LPR) plays an important role in numerous applications such as traffic management, toll payment, stealth car identification, and security systems.
A typical LPR process consists of three main stages: i) taking a suitable image ii) identifying the plate location, and iii) recognition of the characters on the license-plate. Several methods based on edge detection have been proposed to locate the license-plate of a car from the image of the car [1]. These methods cannot produce suitable results in all kinds of images because available edges in other parts of the image may cause incorrect results. Color features of the plate have been also used [2] to identify the plate location. However this method cannot produce suitable results in different ambient conditions. Huff transform [3], [4], fuzzy logic [5] and morphology operators [6] are among other methods that have been used for LPR. These methods usually require extensive computational resources making them unsuitable for real time license-plate recognition applications.
A video is a combination of sequential frames. Each image is a frame of a video in a specific time. If car image was taken at a suitable time or the suitable frame was selected among sequential frames, plate location can be identified more precisely that can help the whole LPR system. In this paper, optical flow is used to determine the appropriate time to take the car image that alter can be used to recognize the plate license of moving cars. For fixed cars, only one image can be taken because there is no motion in the scene and the distance between the camera and car is constant.

The distance between the camera and car is an important factor at the time image is taken. Car license can be located from the image only if the image is taken at a proper time. In most methods that have been proposed so far, the suitable time for taking the appropriate image of a moving car is overlooked and only the methods for identifying plate location and recognizing its characters are discussed [7], [8]. However, in real-life conditions, a LPR system must be able to take the suitable image automatically.

Optical flow is used to determine the suitable time to take the grey level images image of the car automatically. We use both edge detection and morphology operators to locate the plate to increase the system performance. Hopfield artificial neural network is used to recognize the characters.

The rest of this paper is organized as follows. In Section II, optical flow concept is discussed. Horn – Shunk optical flow and the method of taking a suitable image using optical flow information are described in this section, too. Plate location, character detection and character recognition using neural networks are presented in Sections III, IV and V, respectively. Experimental results are presented in Section VI. Concluding remarks and future works are given in sections VII and VIII.

II. OPTICAL FLOW

Optical flow is the velocity of the movement of individual pixels within a sequence of images. It gives information about the relative displacement of the camera and the objects it is viewing. In this paper we use Horn – Schunk method as a simple and fast method to calculate the optical flow.

2.1. Optical flow calculation

The methods to estimate the optical flow of sequential images are classified into three groups: differential methods or gradient based, the segmentation methods and frequency domain methods. We used Horn – Schunk method a gradient based algorithm because of its low computational requirements. In Horn – Schunk method, the brightness of an image is represented by *E(x,y,t)*, where *x* and *y* describe the position of image pixels and *t* represents the time. The following equation describes a relationship between image velocity field and partial image derivatives in Horn – Schunk method [9].

$$E_x u + E_y v + E_t = 0 \tag{1}$$

Where *Ex*, *Ey*, and *Et* are the partial derivative-intensity with respect to the horizontal, vertical, and temporal directions, and, u and v are the velocities of pixels in each direction (optical flow). This equation is solved for the two unknown variables *(u,v)*, considering the constraint that changes in the optical flow must be smooth. This means that there is no large elham in image sequences. Therefore if we use Laplacians to apply smoothness conditions to the optical flow, the following typical equations are obtained:

$$u = \bar{u} - E_x \left[E_x \bar{u} + E_y \bar{v} + E_t \right] / \left(\alpha^2 + E_y{}^2 + E_x{}^2 \right) \tag{2}$$

$$v = \bar{v} - E_y \left[E_x \bar{u} + E_y \bar{v} + E_t \right] / \left(\alpha^2 + E_y{}^2 + E_x{}^2 \right) \tag{3}$$

Where $\bar{u}$ and $\bar{v}$ are the Laplacians of velocities u and v,and α is an adjust factor. $\bar{u}$, $\bar{v}$, Ex, Ey, and Et can be calculated independently. Based on these equations the procedure to calculate optical flow using Horn - Schunk method is illustrated in Fig. 1.

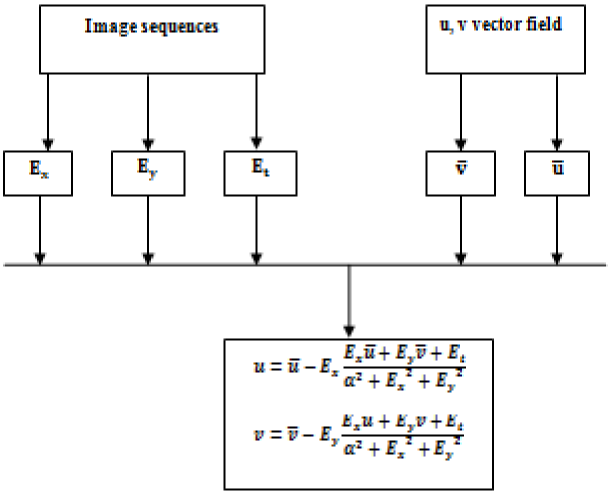


Fig. 1. Flow chart diagram of Horn -Schunck procedure to calculate optical flow

Motion is typically represented as a vector field (u,v), with each vector approximating the apparent motion of a pixel or group of pixels within an image. Fig. 2 shows three frames of an image sequence with a square moving to the right.

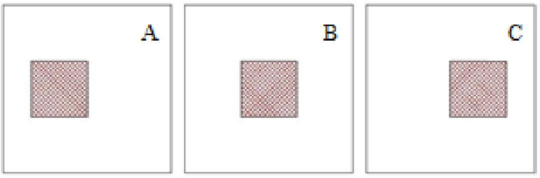


Fig. 2. Three frames of an image sequence

Optical flow is extracted from a sequence of images to produce a vector field of the velocity flows. Fig.3 shows the estimated optical flow at the time of the second frame.

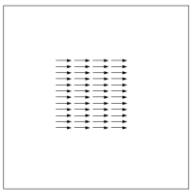


Fig. 3. Estimated optical flow at the time of the second frame

As illustrated in Fig. 3, fixed pixels are equal to zero and moving pixels have nonzero optical flow. The magnitude of optical flow of each pixel can be calculated using the following equation.

$$magnitude_{flow} = \sqrt{u^2 + v^2} \quad (4)$$

2.2. Taking a suitable image using optical flow information

The video of a moving car comprises several image of the car at different position. The key that has not been addressed adequately in the literature is the importance of identifying the ideal position to take the picture of the car. Here we adapt the
optical flow, used for motion recognition in systems based on image processing, for the license-plate recognition application. Motions in the image are transformed into optical flow vectors. Therefore, the procedure to select the suitable frame is simplified to finding the frame with ideal optical flow vectors that is schematically illustrated in Fig.4.

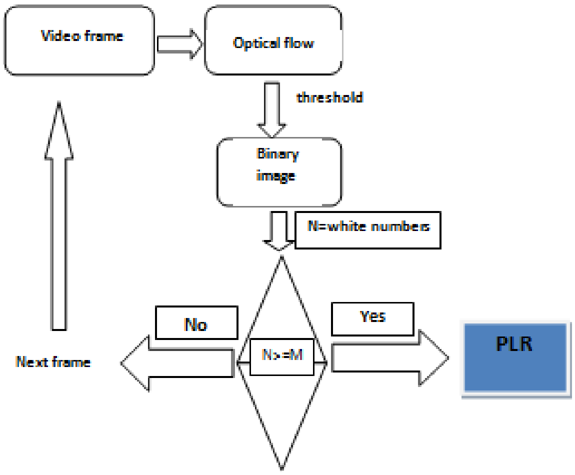
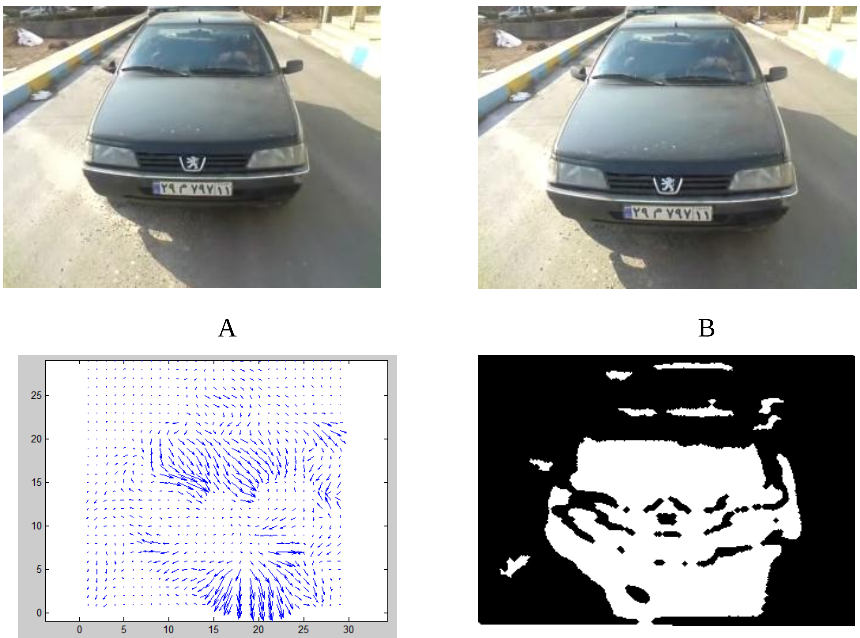


Fig. 4. Procedure to select the suitable frame

The illustrated flow chart in fig.4 is explained as follows in more detail:

1- The camera takes the frames of the video of the moving car one by one.
2- The optical flow is calculated for each frame.
3- A suitable threshold is applied to the magnitude of obtained optical flow.
4- Each pixel that its flow magnitude is greater than threshold gets 1 as its new value and other pixels becomes 0. So a binary image is produced from original image.
5- If the number of pixels with value of one (M) is greater than a specific value (N) in the binary image, then the car is in the suitable position and it is adequately near to the camera and the frame can be selected for LPR system.

Fig. 5 represents the results of selecting the appropriate frame among the frames of a moving car video. In Fig. 5.a and 5.b two consecutive frames are shown. Fig. 5.c illustrates the resulted optical flow of these frames. Fig. 5.d illustrates the first frame after applying the suitable threshold on the optical flow.



A B

C D

Fig.5. Taking suitable image using optical flow information, (a) first frame, (b) second frame, (c) optical flow, (d) after applying the suitable threshold on the optical flow

Pixels having optical flow magnitude larger than the threshold values are shown as white pixels and other are shown as black pixels. When the numbers of white pixels are equal or larger than a specific

value then that image is selected for LPR. In the next stage, image processing techniques and neural networks are used to recognize the plate license.
The results of the simulation of the frame selection procedure show that for the cases which the camera is properly fixed and the car speed is not too much, the frame is selected appropriately.

III. PLATE LOCATION

In this paper, gray level images are used therefore the plates of different colors can be recognized. The stages of the plate position recognition are illustrated in Fig. 6 and are explained in more detail in the following.

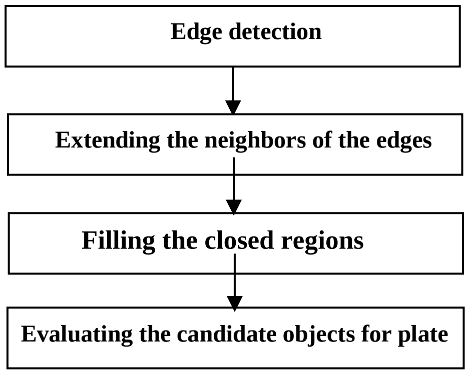


Fig.6. Stages of plate position recognition

Fig. 7.a shows an image which its plate number to be recognized in the following sections.

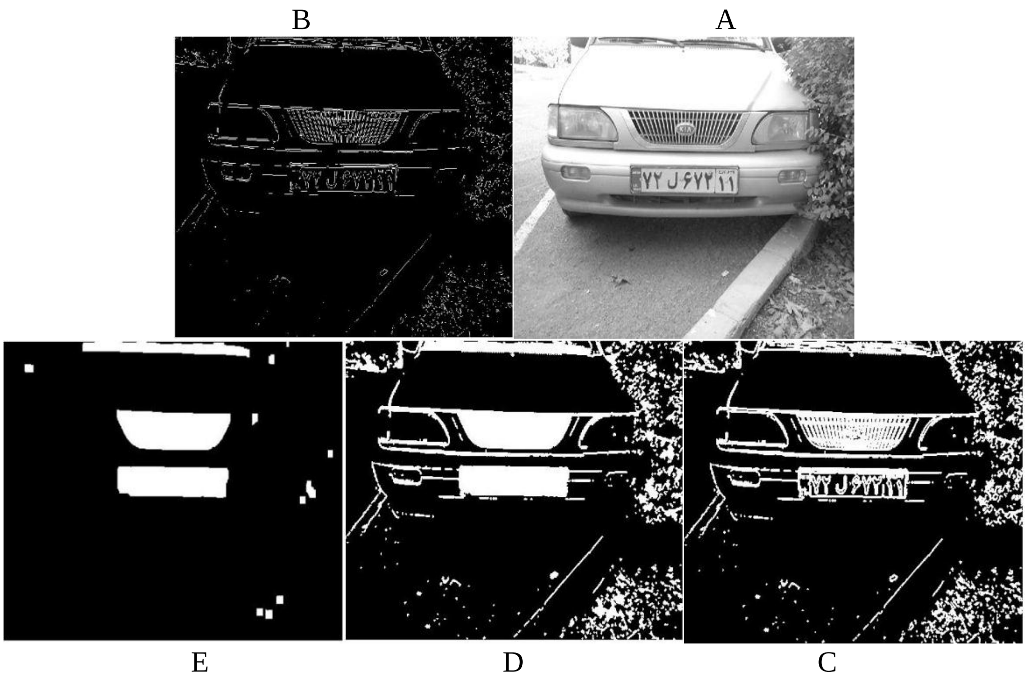


Fig.7.(a) Input gray scale image, (b) input picture after horizontally and vertically Sobel mask, (c) extending the neighbor of the edges, (d) filling the closed regions,(e) removing extra lines

3.1. Edge detection

Edge is a sudden change in the intensity of the image. Intensity of the plate boundaries is usually different from the plate itself. Therefore using the edges of the plate can be useful to detect the plate position .there are many methods to detect the plate position .there are some techniques to detect image edges. In this research, we use Sobel method to extract the image edges. Soble method uses specific masks which are applied to the image horizontally and vertically. Fig. 7.b illustrates the detected edges in the image.

3.2. Extending the neighbour of the edges

To make the extracted edges continuous, their neighbors must be extended to detect the edges obviously. The extended edges are illustrated in Fig. 7.c. As shown in Fig.7.c the region plate is a closed Region in the image.

3.3. Filling the closed regions

Because of the availability of edges around the plate, filling the closed regions in the image causes the plate to be filled. Fig. 7.d illustrates the filling operation results.

According to previous sections, the processed frame was selected when the car was enough close to the camera. Therefore the size of the car plate is guaranteed to be larger than a specific size. The results of deleting the image objects which are smaller than this specific size are represented in Fig. 7.e.

3.4. Evaluating the candidate objects for the car plate

There are some major features for every plate which can be used to locate it. Shape and dimensions of the plate are two important features of plate. In addition to these features the number of object pixels can be considered as another feature. This feature is the result of applying optical flow to select the suitable frame because optical flow causes a rather constant distance between the camera and car. Therefore the plate size is usually a specific fraction of the size of the whole image.

The relationship between height and width of the plate, and the number of available black pixels in the plate, as an separate object, are another features that we have used to locate the plate precisely. Applying above features for Fig. 7.e results in the located plate that shown in Fig. 8.a.

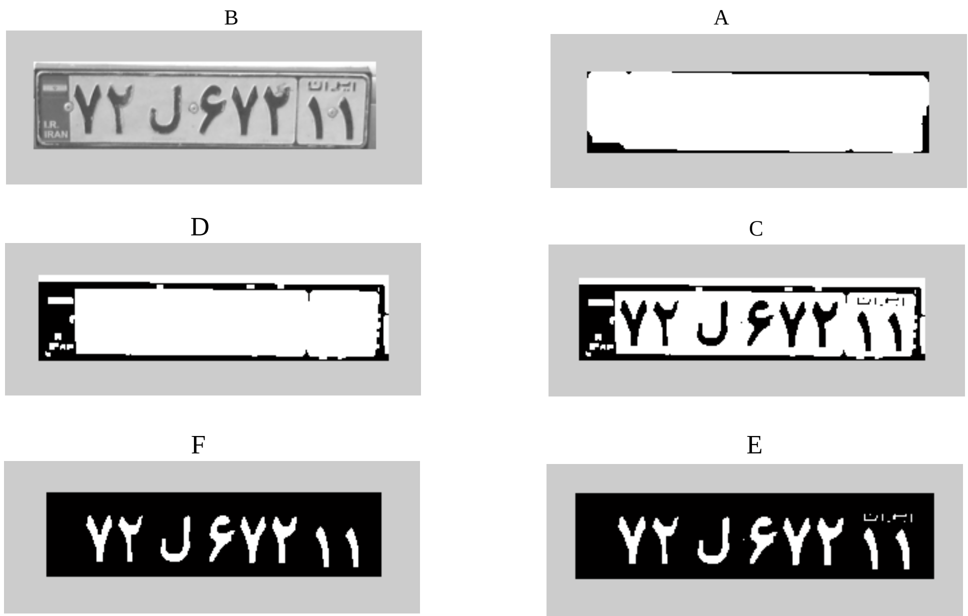


Fig.8. Character detection, (a) selected object with plate binding box,(b) extracted plate from fig.7.a, (c) Thresholded plate, (d) filled plate, (e) result of XOR between c and d, (f) after removing the available noise

According to the position of the selected object as plate, the plate can be extracted from original image depicted in Fig. 8.b.

IV. Character Detection

We used the available distance between characters to isolate them. After applying threshold conditions and removing the plate boundary, available noise in the plate is cancelled. Usually there is some noise in the images of car license plates, such as breaks, inner holes, and small spots. In the next step, each character can be detected as a separate object. Thresholded plate, filled plate, the result of XOR logic operation between them and the final characters after removing the available noise are represented in Fig. 8.c to 8.f respectively.
Each character can be isolated as an object itself. The separated characters are illustrated in Fig. 9.

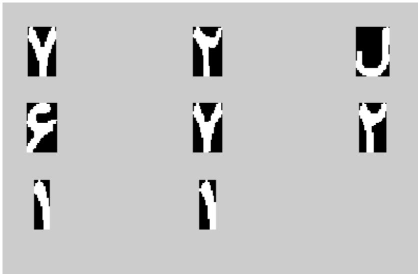


Fig. 9. Separated characters

V. Character Recognition using Neural Networks

We stored all patterns by a Hopfield network. The stored patterns are illustrated in Fig.10.

Fig.10. Trained patterns to the Hopfield neural network

Fig. 11 represents the characters of investigated plate restored by Hopfield network. In despite of differences between available plate characters in Fig.11 and stored characters in Fig. 10, the Hopfield network restores the characters exactly.

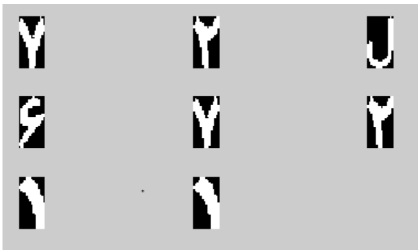


Fig.11. Results of Hopfield character detection

Hopfield network can store several patterns and then converge to the stored prototype pattern. Because the difference between the stored patterns and real patterns is small, the network converges to the expected equilibrium point for many of patterns. Spurious equilibrium points of a Hopfield network can be minimized by several methods [10]. So these networks are a good tool to store our patterns. Applied artificial network is represented in Fig. 12.

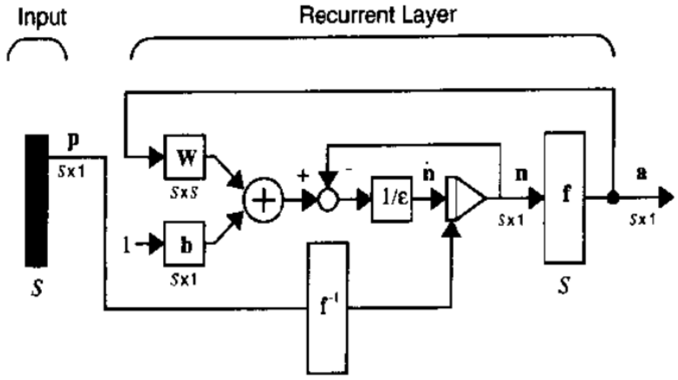


Fig.12. Schematic of the Hopfield neural network [10]

VI. EXPERIMENTAL RESULTS

In our experiment 400 images with 2800*2100 pixels size were tested. The images are down sampled to 800*600 to reduce the time of LPR algorithm. The rate of successful plate location is achieved of 96%. The rate of successful character recognition using Hopfield neural network is 99%.
Currently, our LPR algorithm is running on a (AMD dual core 2.3 GHz CPU with 3 Gbyte RAM) PC using Matlab. Experimental time data are represented in Table 1.

Table 1. Elapsed time for different stages of LPR ALGORITHM (sec)

Stage	Image resize +Optical flow	Plate location	Character isolation	Character recognition
time	0.586295s	0.38263s	0.019889s	0.483586s

VII. CONCLUSION

In this paper, we have presented a new algorithm based on the optical flow theory for successful recognition of license plates of moving cars. Compared to most previous works that in some way restricted their working conditions such as car movement, the optical flow technique presented in this paper makes the LPR system much less restrictive. The proposed LPR algorithm consists of three modules, one for taking a suitable image for the LPR system and others for locating license plates and character recognition.
The algorithm is trained using a set of 400 images, and the following test phase is performed on 400 images. The overall rate of success of the developed method is 95%.
Although this system is intended for the recognition of Arabic and Persian license plates, it can be extended and used as a fundamental approach to the recognition of license plates of other languages or characters.
In the proposed method, the appropriate image is taken automatically using optical flow information of the sequential frames of the moving car. Therefore plate location can be performed more exactly and the performance of the whole system is increased significantly.

VIII. FUTURE WORKS

Image resizing and optical flow calculating are time-consuming procedures which can be implemented on field programmable gate array (FPGA) devices because of its parallel structure in most of proposed optical flow calculation algorithms.
The performance of the whole system can be increased if optical flow is implemented on FPGA devices because it reduces the time of the LPR algorithm significantly.
On the other hand, there are other algorithms to calculate optical flow, such as Lucas-Canade, Fleet-Jepson, Anandan and others that can be used and their results can be obtained and compared. Finally, the best optical flow algorithm can be selected according to the optical flow precision and speed.

REFERENCES

[1]. Wenjing Jia, Huaifeng & Zhang, Xiangjian He & Massimo Piccardi, (2005) "Mean Shift for Accurate licencse Plate loccalization", proceeding IEEE conference on Intelligent Transportation systems, pp 512-521.
[2]. Kanayama, K & Fujikawa, Y & Fujimoto, K & Horino, M, (1991) "Development of Vehicle-License Number Recognition System Using Real-Time Image Processing and Its Application to Tracal-time measurement", In Proceedings of IEEE Vehicular Technology Conference, pp 798-804.
[3]. V. Sunitha & K.Durga, (2012) "Automatic vehicle identification by number plate recognition using Hough transformation", international journal of engineering and science students, Vol. 05, No. 02, pp 87-95.
[4]. Yasuharu, Yanamura & Masahiro, Goto & Daisuke, Nishiyama, (2003) "Extraction and Tracking of the License Plate Using Hough Transform and Voted Block Matching", IEEE IV2003 Intelligent Vehicles Symposium Conference, pp 128-134.
[5]. Nijhuis, J.A.G & Ter Brugge, M.H & Helmholt, K.A & Pluim, J.P.W & Spaanenburg, L & Venema, R.S & Westenberg, M.A, (1995) "Car license plate recognition witch neural networks and fuzzy logic", in Proce. IEEE Int. Conf. Neural Network, vol.5, pp 918-931.
[6]. Hongliang, Bai & Junmin, Zhu & Changping, Liu, (2003) "A fast license plate extraction method on complex background", the IEEE International conference on Intelligent Transportation systems, pp 299-311.
[7]. Zhen-Xue Chen & Cheng-Yun Liu & Fa-Liang Chang & Guo-You Wang, (2009) "Automatic License-Plate Location and Recognition Based on Feature Salience", IEEE transactions on vehicular technology, vol 58, no. 7.
[8]. Shyang-Lih Chang & Li-Shien Chen & Yun-Chung Chung & Sei-Wan Chen & Senior Member, (2004) "Automatic License Plate Recognition", IEEE transactions on intelligent transportation systems, vol. 5, no. 1.
[9]. B. Horn & B. Schunck, (1981) "Determining optical flow", Artif. Intell. vol.17, pp 185-203.
[10]. Martin T.Hagan & Howard B.Demutch & Mark Beale, (1996) "Neural network design", by PWS publishing company.

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