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An Efficient Method for License Plate Recognition System Based on Neural Networks

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Abstract: In recent years, as a result of many applications in daily lives such as the management of stolen cars, management of parking lots and traffic flow control, the necessity of intelligent and automatic recognition of cars' License Plates (LP) is swiftly increasing. Taking into account the specific application to define the algorithms, hardware and the network structure, the process of recognizing involves localization of the license plate region, exploiting of the plate characters and identification of the characters. This work is based on a designed algorithm to recognize the plates by means of the pictures taken under wide-ranging environmental conditions from bright direct sunlight to poorly illuminated conditions at night as well as diverse angles and distances. The threshold for license plate region is determined by using Otsu's thresholding method and the plate features. Vertical and horizontal histograms are used for character segmentation. At last, recognition of Iranian plate characters is achieved by a new algorithm based on neural network. Simulations are performed using MATLAB Software.

INTRODUCTION

Nowadays it can be observed the rapid development of freeways and the wide use of vehicle. In parallel to this, an automation of many ordinary processes such as efficient and accurate intelligent transportation systems is noticeable everywhere (Deb *et al*., 2012). Automatic Number Plate Recognition (ANPR) is being developed as a powerful automated system which possesses broad range of applications in our life where the vehicles on the road are escalating exponentially day by day. As a corollary, this system is proposed to help improve the control of such high concentration traffic congestion (Ozturk and Ozen, 2012). License Plate Recognition (LPR) is usually employed in parking control systems, payment of tolls systems and real-time highway camera monitoring. The determination of in-contract vehicles in parking garage by recognizing the car's license plates, monitoring of speed control, management and checking cars by installing some stations around the cities, implementation of highly reliable security by detecting unauthorized cars, ring the arrival of specific vehicles and tracking or identifying various vehicles are some of the applications of an accurate recognition and reading system of vehicle's license plates (Lazrus and Choubey, 2011).

Several approaches to license plate extraction have been proposed. On one hand, however, an exclusively single method that could fulfill an efficient performance in every use having numerous complex issues including

uncertainty of edges, varying plate in size and type, different forms of illumination and daylights, the blurry images, different colors, fonts, syntaxes, spacing and angles as well as multi-rows. On the other hand, previous works in the literature utilized variety of parameters such as image source, outdoor environment and image condition. Consequently, license plate detection is considered as the most crucial component of the LPR system. Previously, several techniques have been presented to locate the license plate area by means of visual image processing (Patel, 2013). Currently, in the literature, some algorithms exist in order to apply for license plate locating such as the color feature-based methods, edge extracting (Gonzales *et al*., 2009; Kanayama *et al*., 1991), feature description by using histogram (Cho and Cho, 1998), symmetry (Kim and Chien, 2001) and morphological steps.

License plate localization is of great important in detecting of car license plate for intelligent transportation systems. Taking into account the specific application, the algorithms, hardware and the network structure for recognition are defined accordingly. Lately, with the development in the science and technology, the algorithms and hardware present efficient and robust framework and now license plate recognition systems are used in a wide variety of applications. Accordingly, various methods such as wavelets transform, template matching, SVM based method; neural network and genetic algorithm were proposed for this work. Character recognition of the number-plate is a properly well-developed module for computer vision associated with the applicability of building template and neural networks which is capable of presenting satisfactory outcomes (Shah *et al*., 2009).

An automatic license plate recognition system based on Neural Networks trained by back propagation algorithm has been suggested by El-Adawi etc. Their system yielded 89% success detection rate for license plate extraction and 93% success detection rate for character recognition. Park *et al*. (1999)employed Neural Networks in order to localize the license plate. Accordingly, networks were examined from two sets of data and the success rates for localization were 97.5 and 99% (Park *et al*., 1999). Kim *et al*. (2000) segmented the plates by Neural Networks and captured the characters by using Support Vector Machines. The obtained segmentation rate and character recognition was 97.5% and 97.2%, respectively (Kim *et al*., 2000). Another research by Jianfeng *et al*. (2003). applied on Chinese car license plate system. They took advantage of a Neural Network in order to analyze the color owing to achieve aprecise plate extraction. The attained success detection rate appeared to be 95.7% (Jianfeng *et al*., 2003). The proposed algorithm robustly works with a variety of conditions such as illumination, shadow, scale, rotation and weather condition. In this connection, the algorithm possessing the ability of extracting license plate candidates by means of edge statistics and morphological operations followed by eliminating the errors attributed to the detected features of the considered license plates. In order to examine the proposed technique, numerous License Plate (LP) images have been utilized associated with diverse conditions and its effectiveness and applicability are established by the attained results.

Aiming to present a technology-based system for license plate recognition of vehicles, this paper involves detecting Iranian car license platefrom digital pictures. Morphology-based approach is employed to image to localizing the license plate. Afterwards, a histogram equalization method is used to preprocess thelicense plate region. The mathematical computation of Neural Network is carried out through MATLAB Software used as the platform.

MATERIALS AND METHODS

The neural network approach for license plate recognition: Considering the fact that a license plate area of an input image contains numerous vertical edges, a bright background is employed to localize the dark characters in which the license plates approximately possesses the identical mean pixel intensity taking into account all three features (RGB Model). Accordingly, we investigate an input color image taken from a vehicle from which a License plate could be discerned. In this regard, the optimum technique in order to transform RGB to gray scale is illustrated by the following equation (Duan and Guping, 2004):

$$Lu = 0.299*R+0.587*G+0.114*B \quad (1)$$

Some preprocessing modules could serve based on the gray level image. The filtering, image binarization with a given threshold, contrast escalating as a result of histogram equalization, detecting edges, removing of redundant pixels, rectifying the skew, eliminating the shadow associated with the exploiting of the rectangular areas in which the license plate could be denoted. Figure 1 indicates the flowchart of the aforementioned algorithm. Furthermore, regarding the gray scale image, some instances relating the recognition of diverse license plate in the distinctive conditions are shown in Fig. 2.

Noise present in the original image is removed by using well-known median filtering. We use median filtering to eliminate the noises as well as amplify the concentration of high frequencies, thereby, making it useful to denote the edges in the input images. Performing this trend aims to remove impulse noise, refining other

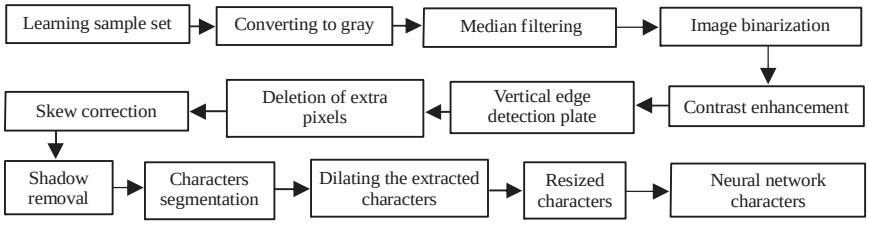

Fig. 1: Flowchart of proposed Iranian method

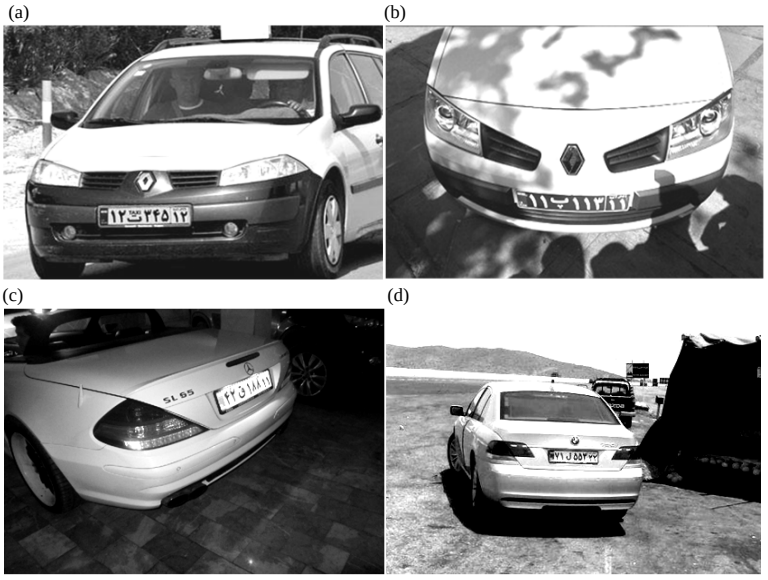

Fig. 2(a-d): Examples of license plate recognition in the gray-scale image

types of noises, reducing the distortions and etc.The input images containing salt and pepper noise is also removed by means of Median filter as a prominent choice.

In addition, a feature based on the color of the plate was utilized, a color filter applied to the image and the output was examinedto find that whether the given area possesses the plate's shape or not. In this connection, Wang et al. employed atechnique using special filter rather than a clear filter.

As the output of this stage could be the character-shaped objects, the gray image associated the convolved filter,and thus the regions of interest were scanned in order to ascertain the candidate region (Stamatopoulos *et al*., 2007). All the color-based algorithms are vulnerable to the illumination condition as well as various colors and sizes because the colors are dependent on the degree of illumination.

Afterwards, the system will recognize the license plate and convert the images into grayscale images. Subsequently,the grayscale images convertinto binary images, only possessing '0' and '1'. '0' denotes black and '1' denotes white.To remove the tonal variation between Red, Green and Blue channels of input images and converting it into gray scale flatness to a single hue.

Four examples of binarized image of LP are depicted in Fig. 3. The gray-scale could capture pixels of the input imageas a number from 0-255 which is the intention of the binarization. This stage proceeds to image segmentation in which each individual character and number will be segmented. Additionally, an Otso technique is used to determine the threshold for the vehicle license plate recognition. This technique opt an optimum threshold so as to minimize the intra class variance of the black and white pixels. The functionality of this method is directly on the gray level histogram regarding 256 number.

Adaptive histogram equalization is adopted to improve the differences in the binary image. That is the difference between highest and lowest intensity amount of the input image. As a matter of fact it is in contrast to the conventional equalizing the histogram because it computes numerous histograms each correlated to a specific component of the picture and reorganizes the

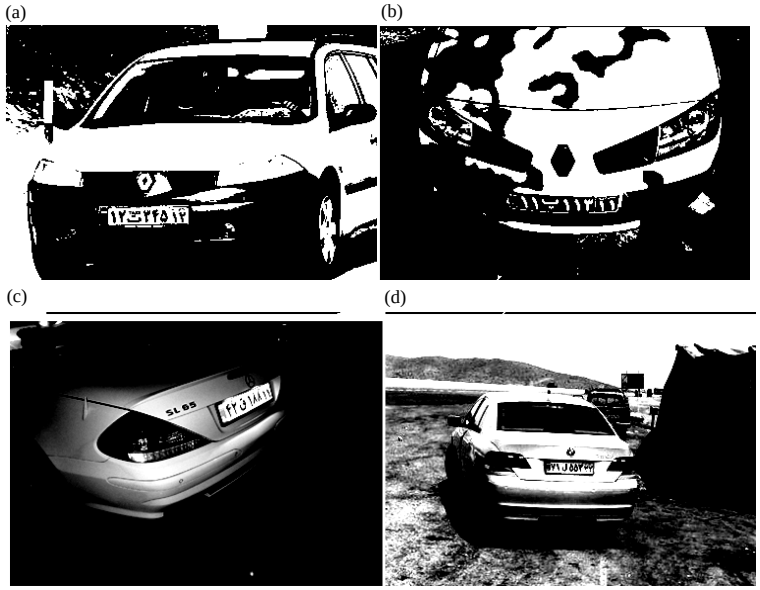

Fig. 3(a-d): Binary image of vehicle license plate recognition

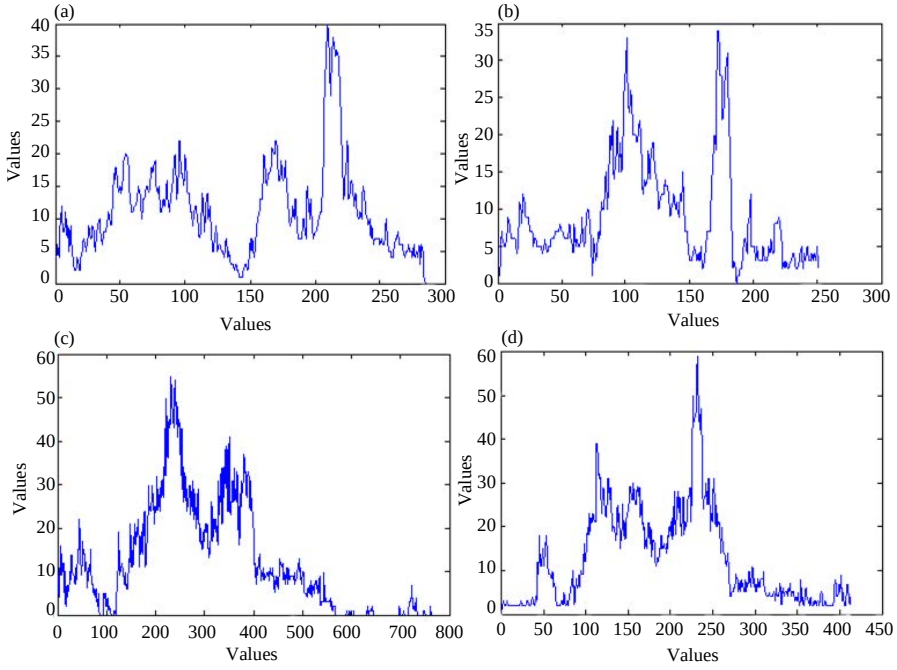

Fig. 4(a-d): Examples of histogram equalization of license plate detection

brightness amount of the input image. Moreover, it presents better contrast than conventional histogram equalization. Figure 4 illustrates some examples of histogram equalization of LP.

Detection of vertical edge technique is employed to implement the localizing the License Plate (LP). As it is obvious in Eq. 2, Sobel's edge detector is utilized to accentuate the vertical lines. Numerous sudden changes in the intensity can be denoted; nevertheless a group of 10-15 acute intensity changes is taken as the license plate zone. The input image is convolved in conjunction with horizontally oriented rank-filter of M×N pixels, resulting in a bright-extended spot of ellipsoidal shape in the plate's area (Shapiro *et al*., 2006).

Following the performing of the Sobel edge recognition technique, localization of the LP region is

Fig. 5(a-d): Edge detection of input images

achieved by certain rules. The first one is used to recognize the column by column range of the vehicle license plate. In the Second step, rows extents are identified. Afterwards, license plate is attainable. In order to eliminate some candidate, therefore, the pseudo license plate aspect ratio of each region of interest is computed. Accordingly, a technique based on the combination of Hough transform and counter algorithm is employed to identify the LP area. In the aforementioned technique, firstly, the counter algorithm is designated to discern the closed boundaries of the objects (Jin *et al*., 2012). Interacted parallel lines appears to be determined by converting these counter lines into Hough coordinate which are taken into account as vehicle license plate nominee. Filtering the candidate license plates is performed by means of the aspect ratio of the vehicle license plate and the horizontal cross sections. In this case, the number of horizontal cross sections related to 1 row plate ranges between 4 and 8. Two row plates include the range of 7-16. Edge detection of the input images is depicted in Fig. 5. The vertical sobel operator:

$$\begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix} \quad (2)$$

The rotation angle a between the principal axis X and the horizontal axis X of the tilt VLP region is shown in

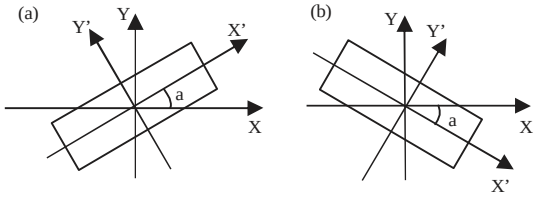

Fig. 6(a, b): VLP tilt input image, (a) Tilt angle a>0 and (b) tilt angle a<0

Fig. 6a, b. Subsequently, by means of this angle, the entire image is rotated in order to tilt correction along horizontal direction. After the filtering stage associated with positive outcome in relation to the input image, to solve the rotation adjustment issue, some assessments such as center of area and the axis of least second moment are introduced. Figure 7 indicates the input image frame before and after adjusting the rotation.

The shadow of input images is treated as regular and irregular. In the case of irregular, various illustrations can be applied to vehicle license plate. Accordingly, cyclic components play an important role for the shadow identification. Furthermore, the input image possesses greater cyclic components of the characters than shadow components. In this regard, bo that morphology conversion are utilized to even the image. Its Structure Element (SE) appears to be a square element having length of K = 0.25 H where H is the height of the vehicle license plate.

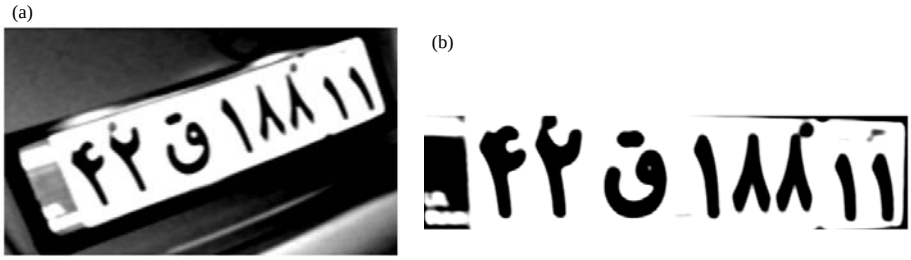

Fig. 7(a, b): (a) The input image before and (b) After adjusting the rotation

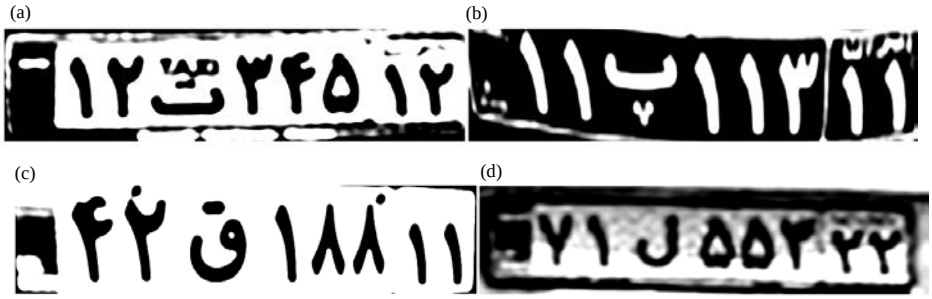

Fig. 8(a-d): Cut exactly LP Area

Process of segmenting the character is introduced to isolate the characters within the number plate detected picture on the basis of some aspects and traits of the characters and digits. Recognition of the characters and digits of the license plate appears to be carried out by passing the divided characters and digits to the character detection stage. Moreover, the located image correction is performed to promote the character segmentation and recognition for Vehicle License Plate Recognition (VLPR) system. A dilation technique is applied afterward to the segmented characters of the previous stage in order to escalate the input image.

Altering the size of the license plate characters to '20×30' is performed prior to apply the neural networks. Accordingly, the attained characters are introduced directly to the Probabilistic Neural Network. Consequently, the outputs of this stage appear to be the detected characters. Afterwards, the value of the correlation in relation to each obtained character and each template in the database is computed. The license plate character segmentation includes the smoothing process followed by calculating the critical points of the boundaries. Figure 8 illustrates cut exactly LP area.

A perceptron model defines as a linked network on the basis of a comparison to the human system, which is able to learn using a feedback mechanism, differentiating between correct and wrong answers. Moreover, it contains an input and output layer of nodes, each of which are fully linked to the other. Furthermore, a back propagation

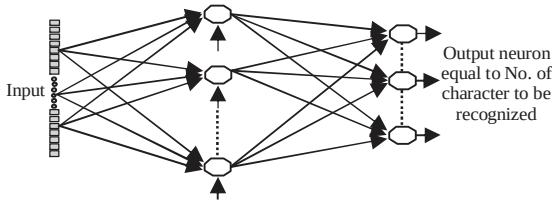

Fig. 9: An example of a simple perceptron diagram

process is made by generalizing the Widrow-Hoff learning law to calculate multiple-layer networks and nonlinear differentiable conversion functions. Therefore, it is permitted the training of the multi-layer perceptrons with non-linear differentiable transfer functions. Figure 9 illustrates an example of a simple perceptron model.

RESULTS AND DISCUSSION

A Pentium-IV 2.4 GHz with 1 GB RAM, Windows Vista Version 6.1 (Build 7600) 32-bit Operating System under MATLAB environment are employed to carry out the experiments.256 samples from Iranian vehicles were taken to test and the size of the pictures was measured to be 800×600 pixels. Furthermore, the condition of images are very different regarding outdoor illumination (night and daylight condition), license number plate angles, size, type, distances from camera to vehicles and colors. Accordingly, Pictures were photographed by means of a digital camera (canon 570 power shot A570 IS) and

Table 1: Experimental results of license plate positioning

Collect environment	Total of positioning	Accurate positioning	Positioning accuracy
Standard images, no special features	86	80	93.02
Rainy day	27	24	88.88
Night images	36	31	86.11
Images with sloping plate	30	27	90.00
Images with dark plate	24	21	87.5
Images with white plate	53	49	92.45
Comprehensive	256	232	90.62

variety of scenes and lighting conditions of the real world, different distances from the vehicle (3-7 meter) as well as various weather are utilized.

The results are tabulated in Table 1. The images areclassified into six groups, regarding their traits. It is obviously seen that all groups possesses over 86% of effectiveness in the recognition, two groups having attained a value of 93%. In association with some images taken at night with flash, accurate outcomes is not achievable by the system owing to the large amount of light reflected by the license plate which in turn spoils the detection of the digits. In spite of this, the mentioned method demonstrates a high degree of accuracy for the remainder the rest of images. The attained outcome appears to be satisfactory. In this connection, the success of detection rate of the vehicle license plate is measured to be 90.62%. Due to various outdoor illuminating conditions as well as presenting multi-objects included in the employed database, those methods have indicated a low degree of performance when coping with more complicated databases.

Subsequently, the license plate candidates are removed from the obtained groups if they do not qualify the following rules:

- License plate region should be large enough
- The shape of the license plate should be identical to a rectangular and plate area should not be more than 1/4th of the pre-specified total area
- The license plate height should be >12 pixels and <1/8th of the input image
- The license plate width should be >16 pixels and <1/3rd of the input image
- The average intensity of the desired license plate region must be light sufficiently
- There should be no contact between the license plate region and the input image margin
- The direction of the license plate regions, by using Principal Component Analysis (PCA) method, should be approximately horizontal (up to 35°)

CONCLUSION

The implementation of automatic identification system concerning the local features of the vehicle license plate is an ideal usage of computer vision and many pattern recognition strategies related to the intelligent transportation. In the current work, a simple but efficient license plate extraction method is presented. We have established an ameliorated Automatic License Plate Recognition strategy for all types of Iranian vehicle license plate which is performed in three unique stages, namely locating the vehicle license plate region in an image, the segmentation of characters and characters identification. The locating of vehicle license plate stage is consisted of a combination of procedures: filtering, image binarization by means of setting a threshold, contrast escalating using histogram equalization, edge recognition, eliminating of extra pixels, amendment of the skew, deleting the shadow and particular features of Iranian vehicle license plate to precisely locate the LP area. This method evaluated 256 vehicle pictures, taken from real system exposing to various outdoor and roadside conditions as follows: light intensity, license plate angle, weather conditions, varying colors and reflected beam. Accordingly, 232 license plates achieved and identified successfully. The proposed method demonstrates its effectiveness compared to some existing methods and the computing time decreased as well as increasing the accuracy. This method meets the requirement for Iranian vehicle license plate and Vietnam environment.

REFERENCES

Chang, S.L., L.S. Chen, Y.C. Chung and S.W. Chen, 2004. Automatic license plate recognition. IEEE Trans. Intell. Transp. Syst., 5: 42-53.

Cho, D.U. and Y.H. Cho, 1998. Implementation of preprocessing independent of environment and recognition of car number plate using histogram and template matching. J. Korean Inst. Commun. Sci., 23: 94-100.

Deb, K., I. Khan, A. Saha and K.H. Jo, 2012. An efficient method of vehicle license plate recognition based on sliding concentric windows and artificial neural network. Procedia Technol., 4: 812-819.

Duan, J. and Q. Guping, 2004. Novel histogram processing for colour image enhancement. Proceedings of the Third International Conference on Image and Graphics, December, 18-20, 2004, Hong Kong, China, Pp: 55-58.

Gonzales, R.C., R.E. Woods and S.L. Eddins, 2009. Digital Image Processing using MATLAB. 2nd Edn., Gatesmark Publishing, Knoxville, TN., USA., ISBN-13: 978-0982085400, pp: 103-112.

Jianfeng, X., L. Shaofa and C. Zhibin, 2003. Color analysis for Chinese car plate recognition. Proceedings of the IEEE International Conference on Robotics, Intelligent Systems and Signal Processing, Vol. 2, October 8-13, 2003, IEEE, Changsha, Hunan, pp: 1312-1316.

Jin, L., H. Xian, J. Bie, Y. Sun, H. Hou and Q. Niu, 2012. License plate recognition algorithm for passenger cars in Chinese residential areas. Sensors, 12: 8355-8370.

Kanayama, K., Y. Fujikawa, K. Fujimoto and M. Horino, 1991. Development of vehicle-license number recognition system using real-time image processing and its application to travel-time measurement. Proceedings of the 41st IEEE Vehicular Technology Conference, May 19-22, 1991, IEEE, St. Louis, Missouri, pp: 798-804.

Kim, D.S. and S.I. Chien, 2001. Automatic car license plate extraction using modified generalized symmetry transform and image warping. Proceedings of the ISIE 2001 IEEE International Symposium on Industrial Electronics Proceedings Vol. 3, (Cat. No.01TH8570), June 12-16, 2001, IEEE, Pusan, South Korea, pp: 2022-2027.

Kim, K.K., K.I. Kim, J.B. Kim and H.J. Kim, 2000. Learning-based approach for license plate recognition. Proceedings of the 2000 IEEE Signal Processing Society Workshop on Neural Networks for Signal Processing X Vol. 2 (Cat. No. 00TH8501), December 11-13, 2000, IEEE, Sydney, Australia, pp: 614-623.

Lazrus, A. and S. Choubey, 2011. A robust method of license plate recognition using ANN. Int. J. Comput. Sci. Inf. Technol., 2: 1494-1497.

Ozturk, F. and F. Ozen, 2012. A new license plate recognition system based on probabilistic neural networks. Procedia Technol., 1: 124-128.

Park, S.H., K.I. Kim, K. Jung and H.J. Kim, 1999. Locating car license plates using neural networks. Electron. Lett., 35: 1475-1477.

Patel, S.G., 2013. Vehicle license plate recognition using morphology and neural network. Intl. J. Cybern. Inf., 2: 1-7.

Shah, P., S. Karamchandani, T. Nadkar, N. Gulechha, K. Koli and K. Lad, 2009. OCR-based chassis-number recognition using artificial neural networks. Proceedings of the 2009 IEEE International Conference on Vehicular Electronics and Safety (ICVES), November 11-12, 2009, IEEE, Pune, India, pp: 31-34.

Shapiro, V., G. Gluhchev and D. Dimov, 2006. Towards a multinational car license plate recognition system. Mach. Vision Appl., 17: 173-183.

Stamatopoulos, N., B. Gatos and A. Kesidis, 2007. Automatic borders detection of camera document images. Proceedings of the 2nd International Workshop on Camera-Based Document Analysis and Recognition, September 14, 2007, Grand Hotel Rayon,.