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Novel Algorithm for Iraqi Car License Plate Detection and Recognition

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Abstract: In this study, we present an algorithm to detect Iraqi car license plate and extract its number. Our method has two main stages. The first main stage is to detect the license plate which includes applying Sobel edge detector and morphological operators to the input image. After that the proposed license plates areas are compared to training images already recorded in the system using similarity index. The second main stage is the recognition process which is applied on the detected license plate; the number is extracted based on comparing each character with training numbers and letters already recorded in the system through image subtraction. The system performance is evaluated using significant number of images. The images were taken from different distances from to attain an accurate assessment. The proposed method showed superior performance at distances (1-3 m), however, as the distance increases the system accuracy decreases gradually.

Key words: Licenses plate recognition, similarity index, car plate recognition, morphology, edge detection, superior performance

INTRODUCTION

Globally, the number of vehicles rises rapidly; as a result, the number of violations such as speeding, stealing cars and entering unauthorized cars to the parking area is rising (Kasaei *et al*., 2009; Villegas *et al*., 2009). A key aspect to resolve all problems previously listed is using automatic car license plate recognition system (Beibut *et al*., 2014). Current systems for traffic measurements such as inductive loops, sensors or EM microwave detectors are expensive, bulky and unable to detect slow or stop vehicles. On the other hand, systems based on computer vision are flexible, since, they utilize the current resources of traffic surveillance, upgrade easily and flexible to redesign (Panchal *et al*., 2016). These systems research through applying computer vision techniques for car license plate detection and recognition, since, it provides full information about the car owner. Indeed, this is one of the most promising side to use computer vision in intelligent transportation system (Patel, 2013). However, there is no general algorithm which is able to detect license plates in different countries because of the differences in license plate styles or designs. In this study, a method is proposed for Iraqi's car license plate detection and recognition.

Literature review: Car License Plate Recognition (LPR) system was firstly presented in the 80 sec. Currently, there are many LPR systems and the research continues by developing many complicated algorithm for plates detection and characters recognition (Patel, 2013). In the following paragraphs we will explore different methodologies introduced for LPR systems.

Sobel edge detection algorithm has been widely used in many studies for license plate detection through combining it with other techniques (Patel, 2013; Ashoori-Lalimi and Ghofrani, 2011; Prabhakar *et al*., 2014; Barnouti *et al*., 2017). For instance, by Patel (2013) to extract the License Plate (LP), Sobel edge detector was used then the edges were smoothed using morphological operators. The LP has been segmented and forwarded to the final stage which does number recognition based on neural network. Another convolutional methodology was used by Rafique *et al*. (2018).

In fact, different successors of Region-based Convolution Network (RCNN) have been used for license plate recognition such as (RCNN) fast, (RCNN) faster and the exemplar-SVM (Rafique *et al*., 2018). Signal processing techniques are utilized to obtain a High-Resolution (HR) image from many observed low-resolution images; this is called super resolution technique and it is beneficial to overcome the limitations of optical sensors (Park *et al*., 2003). After detecting the LP, this technique was applied to extract the text in low resolution LP images (Balamurugan *et al*., 2015). The greyscale image is converted to binary image through thresholding. By John *et al*. (2017) dynamic thresholding technique which computes the threshold value for each pixel based on the neighbor pixels was used to automatically locate the

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number plate in the input image to the system; morphological operators was used after that to remove the small objects and joins the disconnected edges (John *et al*., 2017). Another proposed algorithm locates the LP based on parking lights of the cars; this technique can remove lots of environmental interface and locates the LP effectively under different environmental conditions (Hsieh *et al*., 2009; Hung and Hsieh, 2010). However, it works only for LP detection mounted on the back of the vehicle. Two sequential stages method has been developed for vehicle plate detection based on searching in the image to locate characters. The first stage consists of locating proposed car plate regions in the input images based on the characters searching but the scene usually has other characters such as road signs. Accordingly in the second stage, the proposed plate regions are passed to a classifier which researches based on the machine learning to determine which region is the actual car plate (Park and Jun, 2017). Harris detector is a combined corner and edge detector is advanced by Harris and Stephens (1988). This methodology has been used to detect the LP followed by a segmentation process to extract the plate characters (Panchal *et al*., 2016). Scale Invariant Feature Transform (SIFT) is an efficient method for pattern recognition and it is applied to many problems in which local features are critical and helpful (Zahedi and Salehi, 2011). Accordingly, SIFT has been used to locate the LP features in the input image prior the segmentation process (Yousef *et al*., 2015; Zahedi and Salehi, 2011).

MATERIALS AND METHODS

There is a shortage in research done for Iraqi license plate detection. A simple and computational efficient algorithm has been developed for Iraqi LP detection and recognition. This part explains this methodology starting from detection then recognition to the final part which discusses the evaluation procedure used for system assessment.

License plate detection: The input image was converted to a gray scale image. Then, Sobel operator was used to emphasizing edges. The result image was in binary form. After that dilation operator was applied to connect the separating edges and this was followed by filling the gaps in the image. At this stage, many blobs appeared in the images and to get rid of small anomalies, erosion operator was used with relatively large structuring element. Blob detector was used on the binary image; consequently, the bounding boxes coordinates pointed to the possible LP areas in the input image. Accordingly, each area had been cropped and passed to similarity test step.

Structure similarity index introduced by Wang *et al*. (2004) was utilized to compare the proposed license plate region (after resizing) with a reference image of an Iraqi car LP. Each possible LP area has similarity value with the training image; as a result, the image which has maximum similarity was considered the true license plate area. The overall LP detection process is illustrated in Fig. 1.

License plate recognition: The detected license plate in the previous step was segmented for the number recognition process. The Iraqi LP contains Arabic and English characters in a manner that the same number is written in English and Arabic while an equivalent English letter which has the same Arabic letter sound is used. However, the English characters are written in much smaller font size than the Arabic characters. Accordingly, a methodology was developed to locate the area which contains the Arabic characters before the recognition step. Firstly, rectangle detection algorithm was applied. The identified rectangles in the image classified based on their areas in descending order. The second large rectangle which contains the numbers was selected because the largest one represents the overall plate. Secondly, characters which lies on the same row were gathered in one group. As a result, more than one group of characters were obtained. Consequently, to crop the Arabic number the algorithm selected the group of Arabic

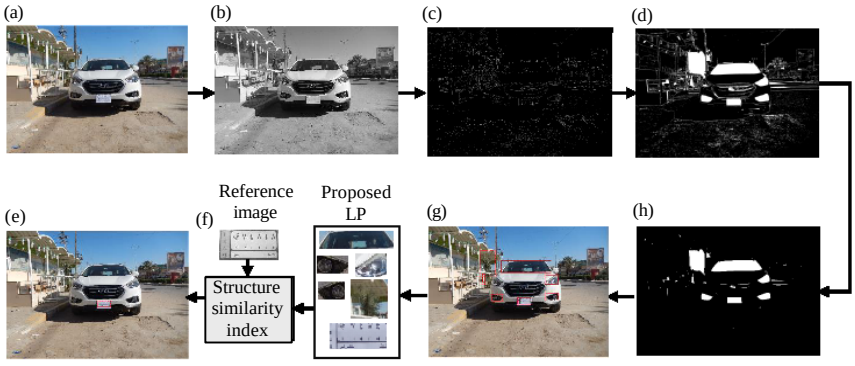

Fig. 1: The detection process of licence plate: a) Input image (RGB); b) Convert to greyscale; c) Sobel operator; d) Filling the gaps; e) The detected LP; f) Matching process; g) Possible LP regions and h) Morphologica; operation

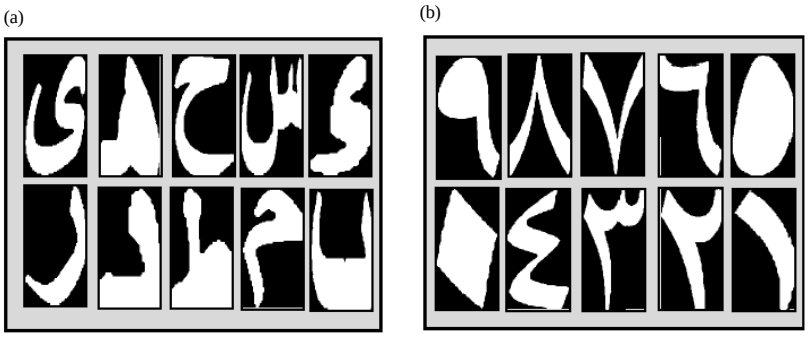

Fig. 2: Samples of the training images: a) Letters and b) Numbers

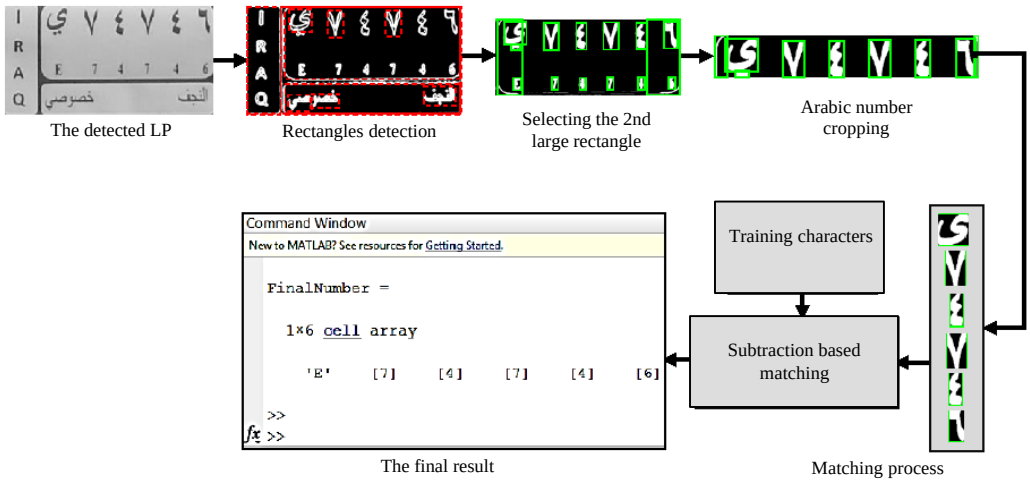

Fig. 3: License plate recognition process

characters which has lowest row number. After the Arabic number had been cropped, each character was segmented and passed to the matching stage. In this stage, the first character was compared with all the Arabic letters while the rest of them were matched with the numbers. The sample of training letters and numbers are shown in Fig. 2.

Image subtraction was used for matching process; after the subtracting the segmented character from all the trained images, the number of ones in the output binary image were calculated. The result which has lowest number of ones was denoted the correct character. The final number was stored as cell array. The overall recognition process is shown in Fig. 3.

System evaluation: To evaluate the system performance, it is desired to follow the same evaluation methods introduced in Iraqi car plate license research papers (Barnouti *et al*., 2017; Omran and Jarallah, 2017). However, their assessment techniques have some drawbacks such as insignificant number of images were used to test the system and the images were taken either close or too close to the car license plate; consequently, this leads to inaccurate results of the system performance. Accordingly, we proposed a strong evaluation method to know the limitation of the system that we developed because we had taken into account using significant number of images and considering distance between the license plate and the camera. Totally, 280 images were used to assess the system.

Nikon camera with a resolution of 18 MP was used to capture the images and they were taken for many vehicles LP at various distances from one up to eight meters. Samples of the images are shown in Fig. 4. Two precision metrics were considered. The first one is the LP detection accuracy and the second one is the LP recognition accuracy. At specific distance, the accuracy of detection or recognition were obtained in percentage based on the following equation:

$$\text{Accuracy percentage} = \frac{\text{Number of detected or recoginized LP}}{\text{Total number of images}} \times 100\%$$

Fig. 4: Samples of test images used to evaluate the system performance: a) Images taken with various distances in meters and b) Different cars types

Accordingly, two curves were obtained representing the accuracy verses distance. One for the LP detection precision and the other one for the LP recognition precision.

RESULTS AND DISCUSSION

The detection and recognition accuracy curves of the system shown in Fig. 5. Form close distances (1 and 2 m), the system showed significant performance by reaching 100% accuracy in detection and 97% recognition. Unlike the systems which are introduced by Omran and Jarallah (2017) and Barnouti *et al*. (2017) for Iraqi LP recognition since, they accomplished lower accuracy from similar distances. Indeed, at 3 m the curves decline slightly to 97% for the detection and 94% for the recognition. Moving a bit further at 4 m, the system detection curve decreases gradually to 90% but the recognition curve falls to 77%. With 5 m distance, the detection performance drops to 73% however, the system reached a low recognition accuracy at the stated distance to be 56%.

At the following distances, the accuracy retains declining. Indeed, the detection precision became 61% at 6 m while the recognition achieved poor precision which was 30%. Finally, the recognition accuracy reached 0% at 7 m but the detection correctness keeps resisting to be 30% before falling to 0% at 8 m. Samples of images tested with our system shown in in Fig. 6. Knowing that the top row shows the images which the system successfully detected the license plates in them but it failed to extract the number, however, the second row shows the images which the system successfully detected and extracted the LP number.

It is obvious that our system reached significant accuracy at close distances in both detection and recognition, however, as the distance from which the

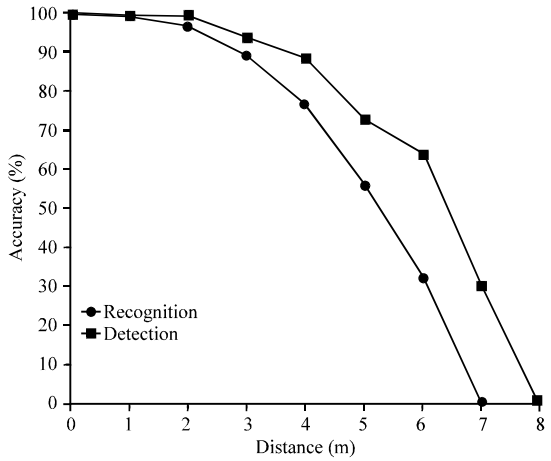

Fig. 5: The accuracy curves for licence plate detection and recognition

image was taken increases, the system performance decreases. In general, the reduction in LP detection accuracy as the distance growth is due to the environmental interface; indeed, many objects start to appear in the image as the distance from the LP increases. Consequently, the probability of false detection will incline in addition, the low resolution of car license plate region plays important rule to case false detection. However, the main reason case the reduction in the recognition accuracy is the low resolution LP which is obtained at large distances. For example, in the second column in Fig. 6 with the same camera type, two images for the same car were captured in different distances; the system successfully detected the license plate in the both images, however, it fails in extracting the LP number of the top image since, it was taken from larger distance than the second one. This is because the detected LP in the top image has lower resolution than the bottom image.

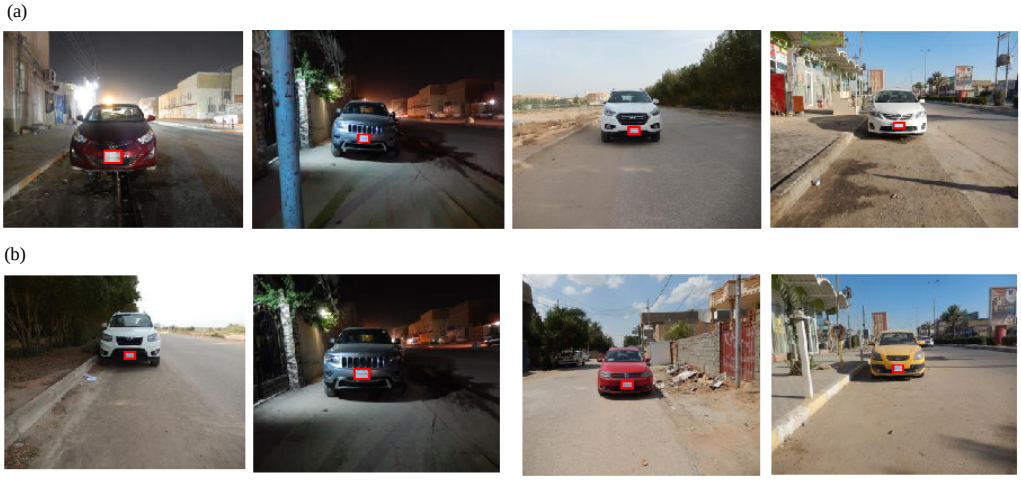

Fig. 6: Samples of resulting images: a) images which the system only detected the LP but failed to extract the licence plate number and b) The images which the system successfully detected and extracted the LP number

Generally, there are many introduced papers which ignored the distance factor in evaluation of their systems for LP recognition such as Prabhakar *et al.* (2014); Omran and Jarallah (2017); Barnouti *et al.* (2017); Yousef *et al.* (2015); Panchal *et al.* (2016) and Rafique *et al.* (2018), in fact, most of the test images are taken from close distances in a range from 1-3 m approximately. In this range, our algorithm showed superior performance and overcomes on many simple and complicated methodologies developed for the same purpose and this is obviously seen in Fig. 5. In average, the system achieved 98% in detection and 96% in recognition in 1-3 m range.

CONCLUSION

This study addressed the problem of Iraqi car license plate detection and recognition. The algorithm we developed is not complicated, easily to implement and computational efficient. Our methodology has two stages; the first one is detecting the licenses plate while the second one is number recognition. In the detection process, Sobel edge detector followed by morphological operators were utilized to detect the licenses plate. The second stage extracts the detected plate through matching each characters with trained ones. The number is extracted as a row vector which could be converted to a text later. The system tested based on many images for different types of cars with various distances. The system accomplishes high accuracy at small distance and it gradually declines as the distance increases.

RECOMMENDATIONS

At future, it is desired to apply our algorithm to different vehicle license plates belongs to different countries and to improve the system accuracy; scale invariant feature detector will be utilized instead of using similarity index in comparing the proposed license plate regions with the training image.

REFERENCES

Ashoori-Lalimi, M. and S. Ghofrani, 2011. An efficient method for vehicle license plate detection in complex scenes. Circuits Syst., 2: 320-325.

Balamurugan, G., S. Punniakodi, K. Rajeswari and V. Arulalan, 2015. Automatic number plate recognition system using super-resolution technique. Proceedings of the 2015 International Conference on Computing and Communications Technologies (ICCCT), February 26-27, 2015, IEEE, Chennai, India, ISBN:978-1-4799-7623-2, pp: 273-277.

Barnouti, N.H., M.A.S. Naser and S.S.M. Al-Dabbagh, 2017. Automatic Iraqi license plate recognition system using Back Propagation Neural Network (BPNN). Proceedings of the 2017 Annual Conference on New Trends in Information & Communications Technology Applications (NTICT), March 7-9, 2017, IEEE, Baghdad, Iraq, ISBN:978-1-5386-2963-5, pp: 105-110.

Beibut, A., K. Magzhan and K. Chingiz, 2014. Effective algorithms and methods for automatic number plate recognition. Proceedings of the 2014 IEEE 8th International Conference on Application of Information and Communication Technologies (AICT), October 15-17, 2014, IEEE, Astana, Kazakhstan, ISBN:978-1-4799-4120-9, pp: 1-4.

Harris, C. and M. Stephens, 1988. A combined corner and edge detector. Proc. Alvey Vision Conf., 15: 147-151.

Hsieh, C.T., L.C. Chang, K.M. Hung and H.C. Huang, 2009. A real-time mobile vehicle license plate detection and recognition for vehicle monitoring and management. Proceedings of the 2009 Joint Conferences on Pervasive Computing (JCPC), December 3-5, 2009, IEEE, Tamsui, Taipei, Taiwan, ISBN:978-1-4244-5227-9, pp: 197-202.

Hung, K.M. and C.T. Hsieh, 2010. A real-time mobile vehicle license plate detection and recognition. Tamkang J. Sci. Eng, 13: 433-442.

John, J.V., P.G. Raji, B. Radhakrishnan and L.P. Suresh, 2017. Automatic number plate localization using dynamic thresholding and morphological operations. Proceedings of the 2017 International Conference on Circuit, Power and Computing Technologies (ICCPCT), April 20-21, 2017, IEEE, Kollam, India, ISBN:978-1-5090-4968-4, pp: 1-5.

Kasaei, S.H.M., S.M.M. Kasaei and S.A. Monadjemi, 2009. A novel morphological method for detection and recognition of vehicle license plates. Am. J. Applied Sci., 6: 2066-2070.

Omran, S.S. and J.A. Jarallah, 2017. Iraqi car license plate recognition using OCR. Proceedings of the 2017 Annual Conference on New Trends in Information & Communications Technology Applications (NTICT), March 7-9, 2017, IEEE, Baghdad, Iraq, ISBN:978-1-5386-2963-5, pp: 298-303.

Panchal, T., H. Patel and A. Panchal, 2016. License plate detection using Harris corner and character segmentation by integrated approach from an image. Procedia Comput. Sci., 79: 419-425.

Park, D. and K. Jun, 2017. Vehicle plate detection in car black box video. Adv. Multimedia, 2017: 1-9.

Park, S.C., M.K. Park and M.G. Kang, 2003. Super-resolution image reconstruction: A technical overview. IEEE Signal Process. Mag., 20: 21-36.

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

Prabhakar, P., P. Anupama and S.R. Resmi, 2014. Automatic vehicle number plate detection and recognition. Proceedings of the 2014 International Conference on Control, Instrumentation, Communication and Computational Technologies (ICCICCT), July 10-11, 2014, IEEE, Kanyakumari, India, ISBN:978-1-4799-4191-9, pp: 185-190.

Rafique, M.A., W. Pedrycz and M. Jeon, 2018. Vehicle license plate detection using region-based convolutional neural networks. Soft Comput., 22: 6429-6440.

Villegas, O.O.V., D.G. Balderrama, H.D.J.O. Dominguez and V.G.C. Sanchez, 2009. License plate recognition using a novel fuzzy multilayer neural network. Intl. J. Comput., 3: 31-40.

Wang, Z., A.C. Bovik, H.R. Sheikh and E.P. Simoncelli, 2004. Image quality assessment: From error visibility to structural similarity. IEEE Trans. Image Process., 13: 600-612.

Yousef, K.M.A., M. Al-Tabanjah, E. Hudaib and M. Ikrai, 2015. SIFT based automatic number plate recognition. Proceedings of the 2015 6th International Conference on Information and Communication Systems (ICICS), April 7-9, 2015, IEEE, Amman, Jordan, ISBN: 978-1-4799-7349-1, pp: 124-129.

Zahedi, M. and S.M. Salehi, 2011. License plate recognition system based on SIFT features. Procedia Comput. Sci., 3: 998-1002.