



Automatic License Plate Recognition in Kurdistan Region of Iraq (KRI)

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Abstract

The development of countries increases the number of vehicles on the roads now than there used to be. Consequently, controlling and managing the congestion of traffic is virtually difficult without the use of computer technology. This paper aims to identify automatic license plate recognition (ALPR) of vehicles in Kurdistan Region of Iraq (KRI). It uses computer vision techniques where a cluster of Gabor feature vectors using K-means is used, furthermore, the resulted cluster feature is optimized with Wrapper Sub Eval technique to reduce the dimensionality of features vectors, then, the optimized features are fed into classification techniques such as Support Vector Machines (SVMs), K-Nearest neighbors (K-NN) and Radial Basis Function (RBF) Neural Network in order to examine the recognition rate of the license plate of the vehicle automatically. The experimental work shows that the proposed technique produced promising classification results in recognizing license plate of vehicles. The best optimal accuracy result under various illumination conditions was 96.72

Introduction

Electronic government (E-government) is the application of Information Communication Technology (ICT) to improve the performance of government functions and services. It has the ability to provide higher quality and more cost effective government services, and better relationships between citizens and government. The main benefits of e-government do not come merely from digitizing information and placing it online. Instead, they come from influencing the new ICT tools to offer better services to citizens and make government more effective and efficient [1]. The ability of identifying the vehicle manufacture (car make) by the standard Automatic License Plate Recognition (ALPR) systems in the context of e-government systems applications, is getting more and more important.

Therefore, the paper aims to tackle one of the applications of the e-government system to identify the numbers and alphabets of the plate in order to improve and increase the use, efficiency and effectiveness of the traffic police system in information gathering and dissemination. In addition, to identify any suspicious vehicle or terrorist threats entering the state. This will be done by implementing the automatic license plate recognition systems.

Automatic License Plate Recognition (ALPR) is a vital function of intelligent traffic control systems. These systems include various applications such as parking management systems, access control, tracking vehicles during traffic signal violations, border control and monitoring, and automatic ticketing. The idea is to localize the license plate region(s) from the rear or front of the vehicle images, captured through a camera, and interpret them using an Optical Character Recognition (OCR) system [2]. This system can be implemented in two types; an online ALPR system and an offline ALPR system. In an online ALPR system, the localization and interpretation of license plate identified in real time. However, an offline ALPR system, gets the vehicle pictures and stores them in a central server for additional processing, for instance for recognizing of vehicle license plate. This paper tackles the latter type of application.

The rest of the paper is as follows: Section 2 presents the other related work on automatic license plate recognition, Section 3, introduces the principles of the Gabor Feature Vectors, and SVM algorithm is presented in Section 4, whereas, in Section 5, the proposed system for the recognition of license plate is explained, then, Data Set is explained in Section 6, followed by details of the experimental result and discussion in section 7, and finally the conclusions of the paper are outlined in section 8.

Related Work

In this section the authors provide a brief reference source for some of the researchers who previously proposed approaches for Automatic License Plate Recognition systems. Many of the ALPR systems are based on image processing techniques and character recognition systems. Each ALPR system is based on three basic parts such as; image capturing, License Plate Detection (LPD), and Optical Character Reader (OCR), [3].

There are various algorithms of LPR; some of them have a better accuracy with more complexity than others. Selecting those algorithms is based on some factors such as memory usage, time, and the algorithm complexity when used in different situation [4]. Some LPR is used in real-time system, in which offers both accuracy and acceptable response time [5]. Most of the LPR systems are based on image processing techniques and character recognition systems [6].

[7] In their work analyzed six LRP techniques such as; dynamic programming, Hough transforms, Gabor transform, Morphology-based, Ada Boost, and edge-based model based on different factors. The study findings revealed that the dynamic programming algorithm is the fastest and the Gabor transform is the most accurate algorithm. Some cases of failure or bad recognition are improved with various kinds of image pre-processing. However, some types of failures of vehicle plate detection are vital and require more examination and extra techniques. Hence, using a method based on distribution of vertical edges to detect the vehicle plate location. Although, some of the approaches available in the literature used SIFT descriptor. For instance, a set of 1200 logo images corresponding to 10 distinctive vehicles manufactures are used to assess a Scale Invariant Feature Transform (SIFT) based approach which describes local features [8]. This method is robust and reliable for several patterns recognition; it can also be used to recognize characters of license vehicle plate.

Furthermore, some algorithms used in LPR are complex and have the largest amount of calculation which cannot satisfy the real time automatic plate recognition. The method which is proposed by the authors in [9], is a simplified SIFT descriptor generating algorithm, which is based on the specifics of the plate characters. The feature points can be taken from the geometric center of the license plate characters. Then the main direction can be found using principal component analysis (PCA) algorithm to simplify the process of directing feature points. Then the characters are classified and identified using SVM. In [10], there are three stages such as detection, character segmentation and character recognition of license plate, they used SVM

algorithm to detect the character, and the study showed that the proposed system is better compared to the neural network. However, statistical methods and the edge detection of the shapes have been used to identify plate location [11]. The drawback of this system is merely due to a single plate is extracted from an image, and difficulty of the extraction of plate from images. In addition, Authors in [12] introduced a novel approach for recognition and localization license plate which is not based on color features, their work was based on a simple tool such Sobel Edge Detection.

Furthermore, a novel approach proposed to solve the automatic license plate number recognition, by using intelligent template matching (ITM) technique. This approach does not require prior training, also is simple and flexible compared to ANN [13].

However, in this paper Gabor feature is clustered via K-means technique to build feature vectors for the plate numbers then will be used in classification for identification the plate number. The main issue here is how provide a good clustering for Gabor features to build visual words. This will be done by probabilistic experimental testing for the number of clusters.

Gabor Feature Vectors

This is considered as one of the most important topics in the area of image processing, computer vision and pattern recognition and it has been used by many researchers to solve various applications such as face recognition, object recognition and etc. Gabor Features Vectors (GFC) concept derived and obtained through modulating a sinusoid by means of a Gaussian. Basically, with a Gaussian a one dimension signals can be modulated. This type of filter can react to some frequency of a localized part of the signal. However, this situation with two dimension signals is different in which a Gabor feature is obtained by combining the sinusoid with a Gaussian. Apparently, a two dimension filter in the spatial domain, such as images can be modulated through a sinusoidal plane wave [14] and [15].

It has to be notified that in computer science in general and in image processing fields in particular, a Gabor filter is actually a linear filter that is commonly used for detecting edges. Gabor features have been widely used in pattern analysis applications [14] and [15]. Fundamentally, Gabor features have two properties; these are namely; frequency and orientation representations. Research works in [16] and [17], it is stated that Gabor filters act for the local special frequency distribution as a band pass. The two dimensions Gabor filter $\varphi_{f,\theta}(x,y)$ is expressed as a complex sinusoidal signal which can be modulated via a Gaussian kernel function as shown in equation (1).

$$\varphi_{f,\theta}(x,y) = \exp \left[-\frac{1}{2} \left\{ \frac{x_{\theta_n}^2}{\sigma_x^2} + \frac{y_{\theta_n}^2}{\sigma_y^2} \right\} \right] \exp \left(2\pi f x_{\theta_n} \right) \quad (1)$$

Where, x_{θ_n} is the orientation, f is the central frequency of a sinusoidal wave, the standard deviations σ_x^2 and σ_y^2 of Gaussian along with x and y dimensions.

Where, x_{θ_n} is expressed in equation (2).

$$x_{\theta_n} = \frac{\pi(n-1)}{p} \quad n = 1, 2, \dots, p \quad p \in N \quad (2)$$

Where p represents the number of orientations, and the orientations for along x and y dimensions can be expressed in equation (3).

$$\begin{bmatrix} x_{\theta_n} \\ y_{\theta_n} \end{bmatrix} = \begin{bmatrix} x \\ y \end{bmatrix} \times \begin{bmatrix} \sin \theta_n & \cos \theta_n \\ -\cos \theta_n & \sin \theta_n \end{bmatrix} \quad (3)$$

It is worth marking that tweaking the filter with a specific band of spatial frequency and orientation is of more significance in scheming Gabor filters. This is evidently done by picking suitable parameters of the filter, and these parameters, namely are; radial frequency, x_{θ_n} , the other Gaussian on, the standard deviations σ_x , σ_y of Gaussian along with x and y dimensions. Having said this, it is perfectly clear to state that a bunch of Gabor filters with various frequencies and orientations might be supportive of mining good features from an image.

Support Vector Machines

Support Vector Machines are commonly used for a classification task. The inputs to these machines are in the shape of feature vectors. The dimension of the feature vector can be determined by the number of extracted features. It is considered that support Vector machines are quadratic optimization problems. The main role of support vector machines is to shrink the average error between inputs and targets in classifying data. This can be done via support vector sets through minimizing the structural risk [18].

Certainty, it appears that different classes are separated by support vector machine in the feature space via defining the maximum hyper plane. This process is done either via a straight line in two dimensions or a plane in three dimensions or hyper plane. It has to be said that these hyper planes are normally tipping to produce better generalization, in other words, these hyper planes can lead to increase the generalization ability of classifiers. A finest hyper plane can be produced by a classifier; this means that the maximum margin can be found between two or more classes [19].

Kernel functions of support vector machines are able to bring a non-linear classification. Thus, the inputs are not unambiguously mapped into high-dimensional feature spaces. Linear, Polynomial, Radial Basis Function, and Sigmoid are commonly the utmost functions used [20], [21], [22], [23] and [24].

Proposed System

The proposed system consists of four phases namely; image capturing, image processing, plate and feature extraction and recognition of the alphanumeric license plate. To achieve these phases, the authors employ Gabor technique and SVM algorithm. Figure 1, illustrates the block diagram of the proposed system. It shows the visual representation of internal processes of the system in which the recognition task is carried out in any plate number. The figure consists of two parts; part (a) involves training and testing of the images which are depending on part (b) in which processing is conducted.

In this paper, we did not shed light on some minor processes to the plate image such as Noise filtering, Gamma function and removing illumination. The image plate was considered as a matrix form; this matrix processed and reduced its elements in accordance to Gabor function. The result of this function which represents Gabor features will be quantized to (N) features according to the same number of clusters which has been computed with all images in the dataset. A set of clusters has been used probabilistically to examine the suitable cluster which gives more classification results were 650, 750,900,1000,1200,1300 clusters have been used for the above purpose. The technique modifies the range of the image pixels into its customary range, in other words, the range gets changed to another domain. Subsequently, this modification will help classifiers perform better classification task. In fact, inputs of classifiers (e.g. SVM, K-NN, and RBF) will be Gabor features vectors of the plate image. These processes guided us to build our own data set which will be explained in the next section.

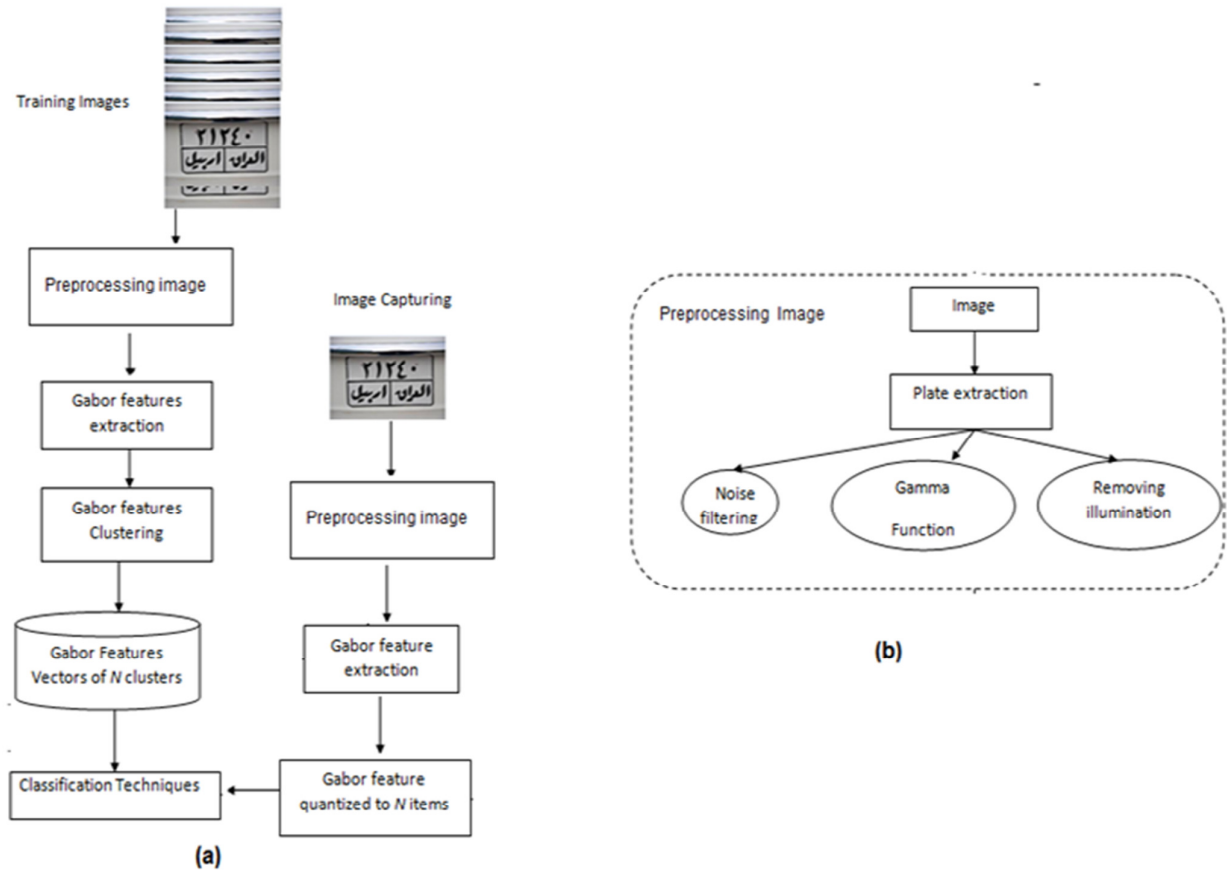


Figure-1: The phases of the plate recognition system

Dataset of Plate Number

A set of 1000 images (JPG image format) was taken from the Directorate of General Traffic Police in Kurdistan for experiments. Each image was taken in 1-5 meter distance from the designated car. The size of the image is 309X240 Pixel. The image was converted from color to grey scale so that to be processed more efficiently. Also the images captured in different weather conditions like cloudy, sunny day and sometimes at night as illustrated in Figure 2).



Figure-2: Samples of plate images (these were taken at different distances and times)

Experimental Results and Discussion

Various types of experiments have been conducted to check the accuracy performance of Gabor Feature Vectors (GFV). Moreover, the distance factor is taken into consideration, the best results were demonstrated by the system were in the range of 1-5 Meters. The first experiment is to test the accuracy of the proposed approach, through working on the proposed data set on the plate image. The Gabor features were extracted from each image. The size of each frame image was 309 X 240. The GFVs are extracted to express different image plates of cars in different environmental streets namely; main, sub road, car parks, etc. The decision making of recognition is taken in accordance to the correlation values between the current image scenes and all of the stored plate images. The maximum values of k nearest neighbors are used to select current plate recognition for the car. The algorithm implemented on various illumination and weather conditions (sunny, cloudy, night), and a number of different running tests were used to demonstrate the accuracy performance of GFVs, and finally, the performances were reported using the average of the obtained classification results. Several testing performances are carried out on plate images, these are namely: performance accuracy, correctly classified instances, incorrectly classified instances and mean absolute error as shown in Equation (4).

$$M = \frac{1}{n} \sum_{i=1}^n \left| \frac{T_i - P_i}{T_i} \right| \quad (4)$$

The true false rate equation based on is shown in Equation (5).

$$\text{False Positive Rate} = \frac{FP}{FP + TN} \quad (5)$$

Where *FP* is number of false positives and *TN* is number of true negatives.

The results of accuracy performance under various illumination conditions (are about 96.72% and 96.18; 95.27 and 93.46; 88.23 and 84.468 respectively, where these results are obtained on two different training sets 70% and 60% of the total data set) are shown in Figure 3.

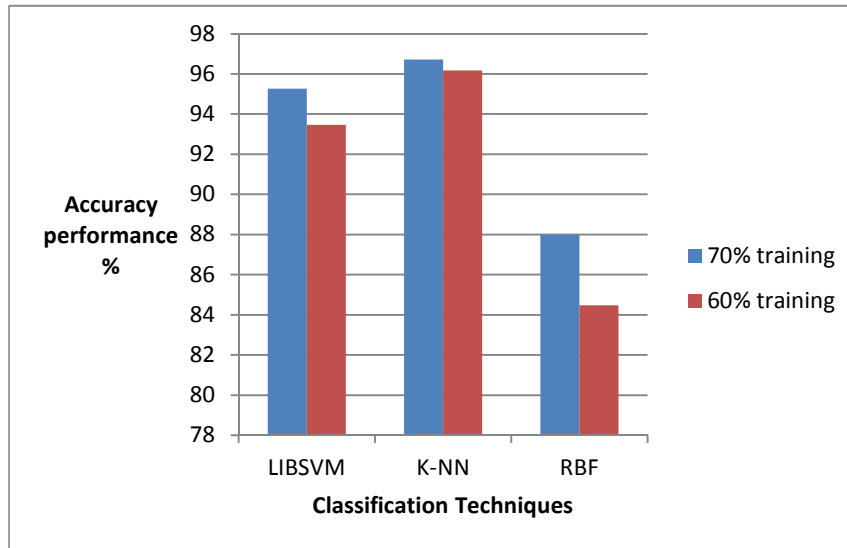


Figure-3: Accuracy performances for different classifiers under two different training sets

It is clear that the performance of the proposed approach using k-NN is more accurate than SVMs and RBFs. This does not mean that k-NN is better than SVM and RBFs, since the theoretical background of the two methods are known.

Figures 4, 5 and 6 show additional testing performances, namely; correctly classified instances, incorrectly classified instances, and mean absolute error.

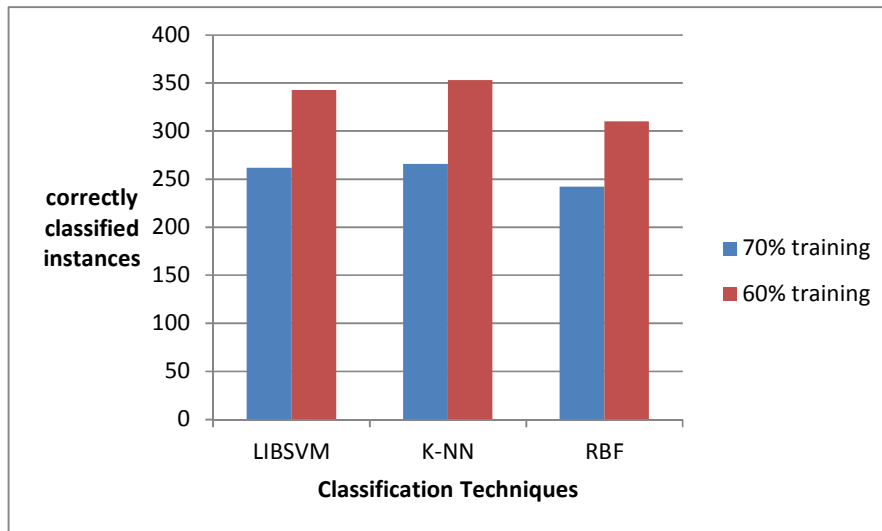


Figure-4: Accuracy performances for different classifiers under two different training sets

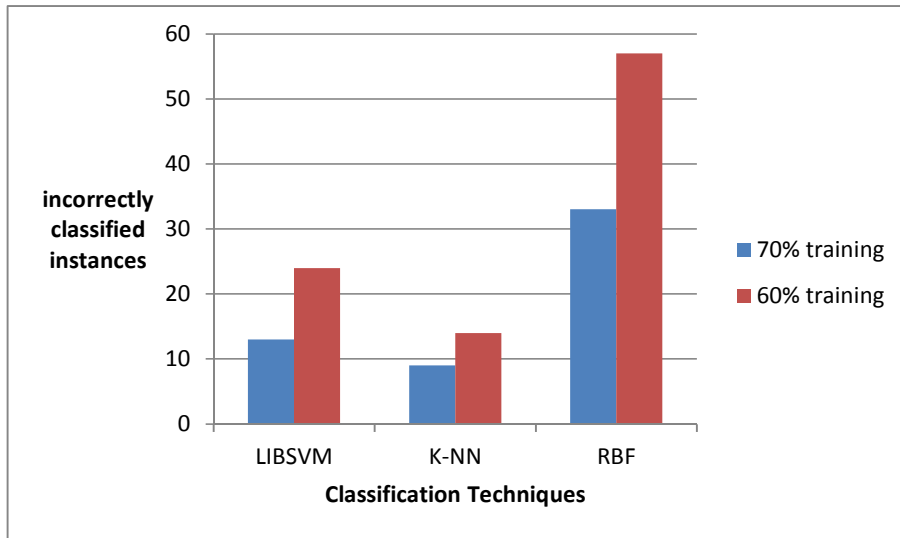


Figure-5: incorrectly classified instances for different classifiers under two different training sets

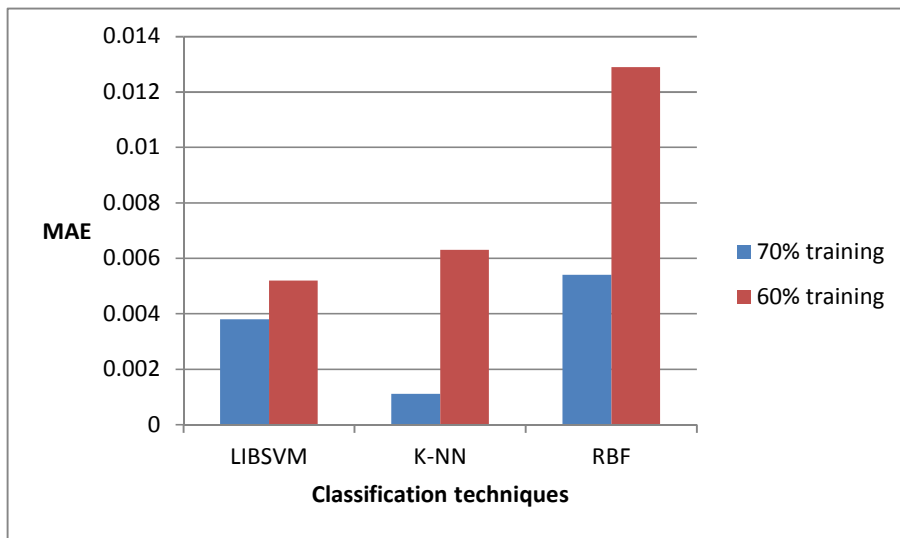


Figure-6: Mean Absolute Error for different classifiers under two different training sets

The results under above figures show that K-NN outperforms the other classifiers on both percentages of training sets. Note that the partition percentage of the training and testing data sets do not significantly affect the overall performance results, whereas it has obvious effects on the results of the mean absolute error.

Conclusion

E-government initiatives enhance in ensuring more democratic, transparency and accountability framework for the public and private sectors to operate. Therefore, one of the main challenges of government is to achieve these potentials. This paper tackled one of the applications of e-government to help government authorities to provide information that could be shared with security forces to protect the general public, and help improve the traffic information system.

However, one of the important issues in this application is a precise process in recognition in the environment to produce accurate results. The problem of confusion for the plate recognition is a challenging issue in computer vision. An accurate spatial representation of Gabor feature vectors provides a promising

solution for this issue. The study proposed a novel approach using correlation of GFVs for plate recognition. GFV was implemented on some approaches, such as K-NN, SVM and RBF using the same datasets to evaluate and measure the accuracy. The GFVs for these visual features represent a spatial relation between them. The correlation between these GFV for two plate images gives an indication that to which extent does these two images are related to each other.

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