An Intelligent License Plate Recognition System

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Summary
Automatic license plate recognition plays an essential role in many applications and a number of methods have been proposed. These applications range from complex security systems to common areas and from parking admission to urban traffic control. License plate recognition has hard properties due to varied effects as fog, rain, shadows, irregular illumination conditions, variable distances, cars' velocity, scene's angle on frame, plate rotation and conservation, number of vehicles in the scene and other. These effects make plate recognition much more complex and difficult than the traditional pattern recognition systems. The proposed system is composed of the following three stages: 1) detection and extraction of a license plate area by video camera 2) segmentation of the plate characters and digits; and 3) character and digit recognition. The plate image area extracted using the proposed system is segmented into disjoint characters for the character recognition phase, where the neural network classifier is used to recognize the characters based on edge moment invariants and principal component analysis features of wavelet coefficient matrix. The main goal of this research is to develop a new plate recognition system with intelligent issues surpass the systems introduced in literature and to reduce many of the restrictions in the working environment. here the part of summary.
Key words:
License plate detection; character recognition; moment invariants; principal component analysis; neural networks

1. Introduction

All Computer vision and character recognition algorithms for license plate recognition are used as core modules for intelligent infrastructure systems like electronic payment systems (toll payment and parking fee payment) and freeway and arterial management systems for traffic surveillance [1,8-12]. A system for automatic car license plate recognition consists of a camera, a frame grabber, a computer, and custom designed software for image processing, analysis and recognition [2].

In [1], a comprehensive and critical survey of up-to-date License plate recognition (LPR) methods is presented. This survey focused on LP detection, character segmentation and character recognition. The extraction of the plate region methods are categorized into the following described processing: binary image processing, gray-scale processing, color processing, and classifiers. Several methods are reported in this paper to tackle the problems for detection of LP. These methods are edge statistics, mathematical morphology, Connected component analysis, spatial measurements, global and partial image analysis, statistical measurements, hierarchical representations, region segmentation, probabilistic object tracking in videos, image transformations. Character segmentation is needed to perform character recognition, which fully relies on isolated characters. Many methods are used in character segmentation and recognition to segment and recognize each character after plate localization has been developed. For more details, refer to [1].
The UK police have been using automatic number plate recognition for over a decade, originally to enforce traffic offences [3,5].

Many methods have been proposed for license-plate recognition, which can be classified into two types: the Template Matching and the NN(Neural Networks). After choosing a standard template, a comparison between the standard template and image recognition is made in Template Matching. It is found that the Template Matching's biggest advantage is its quick recognition, while the weakness is its lack of adaptability, it can be affected easily by taking position, scale and rotation. The Back-Propagation Neural Network (BPNN) is the most popular method in all kinds of NN. Because the BPNN has anti-noise and anti-distortion characteristics, it has been often applied to license-plate recognition [4,6].

In this research paper, the concentration will be on detection and extraction the image of car plate and recognition of the characters segmented from the car plate image using artificial neural networks. The main goal is to develop a new plate recognition system with intelligent issues surpass the systems introduced in literature and to reduce many of the restrictions in the working environment.

The rest of the paper is organized as follows: image acquisition and preprocessing is discussed in Section 2 of this paper; Section 3 describes feature extraction and neural network is discussed in Section 4. Section 5 describes the proposed system. Section 6 presents the

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results and observations of this study and finally, the conclusion is presented in Section 7.

2. Preprocessing

2.1 Image Acquisition and Filtering

The video is captured using a digital camera by the program Auto Movie Creator 3.26 [14] . The video file is saved in wmv format. Then the file is divided into sequence of frames(isolated images) by mmread matlab program [15]. The input isolated image is filtered to improve the quality of the image by median and Wiener filters [22].

2.2 Edge Detection

Edge detection is a fundamental step in several fields such as pattern recognition, image processing and computer vision and the first step of image analysis and understanding. Edges define the boundaries between regions in an image, which helps with segmentation and image recognition [18]. The classification of edge detection introduced in [19] is based on the behavioral study of these edges with respect to the following differentiation operators: Gradient edge Detectors (first derivative or classical), Zero crossing (second derivative), Laplacian of Gaussian (LoG), Gaussian edge detectors, colored edge detectors. In this paper, Prewitt detector operator is used to obtain the edge detection image.

2.3 Plate Extraction

Run-lengths are suggested for writer identification and documents segmentation. Run lengths are determined on the black and white image taking into consideration either the black pixels corresponding to the foreground or the white pixels corresponding to the background [20]. The plate is extracted using vertical and horizontal run-length encoding and vertical and horizontal histogram. The detailed process for the rectangle of plate extraction has the following steps:

Step1: Determine the vertical borders of the rectangle plate by applying the horizontal run length on edged binary image. Then the vertical run length encoding is applied.

Step2: Determine the vertical borders of the rectangle plate by applying the vertical run length on edged binary image. Then the horizontal run length encoding is applied.

Step 3: Apply the vertical and horizontal histograms on the images obtained from step 1 and 2.

2.4 Normalization

There are several methods to compute the skew angle for the vehicle license plate: horizontal skew, vertical skew and combination of both horizontal and vertical skew [17]. PCA is used to analyze data in several application fields such as pattern recognition and image processing. This method is a statistical technique that is used to find the Eigen vectors. These vectors represent the relation of these data sets along that line [16]. In this paper, the image of the car plate is normalized based on PCA technique to determine the skew angle[16-17]. The extracted plate image is rotated using negative of the calculated skew angle.

2.5 Segmentation

The plate image determined using the above steps is converted into binary image. The binary image is segmented into two parts: Arabic part and English part by horizontal projection profile histogram. Then each part is segmented into isolated characters by vertical projection profile histogram [21].

3. Feature Extraction

In the following subsections, different feature extraction approaches will be used to extract some useful features to use them in the recognition stage.

3.1 Principal component analysis (PCA)

Principal component analysis is a very important statistical method that explains the covariance structure of data by means of a small number of components. These components are linear combinations of the original variables, and often allow for an interpretation and a better understanding of the different sources of variation. PCA is widely used because it is concerned with data reduction and PCA is used for the analysis of high-dimensional data which are frequently encountered in chemo metrics, computer vision, engineering, genetics, and other domains. PCA is then often the first step of the data analysis, followed by discriminant analysis, cluster analysis, or other multivariate techniques. It is thus important to find those principal components that contain most of the information [23].

In [23], a new robust principal component analysis approach is proposed which combines projection pursuit ideas with robust scatter matrix estimation. It yields more accurate estimates at non contaminated data sets and more robust estimates at contaminated data.

3.2 Wavelet Transformation

Wavelet transformation is widely used in many application and fields such as such as numerical analysis, signal and information processing, image processing, seismic exploration, speech recognition, CT image formation, quantum theory, computer optical illusion, and machine fault Diagnosis [24].

In [25], the wavelet packets are computed based on an orthogonal wavelet. Two filters of length 2*N are used*, denoted *h*(*n*) and *g*(*n*), corresponding to the wavelet.

The following sequence of functions are defined ($W_n(x)$, n = 0,1,2,...) by

$$W_{2n}(x) = \sqrt{2} \sum_{k=0,\ldots,2N-1} h(k) W_n(2x-k)$$
$$W_{2n+1}(x) = \sqrt{2} \sum_{k=0,\ldots,2N-1} g(k) W_n(2x-k)$$

where $W_0(x) = \phi(x)$ is the scaling function and $W_1(x) = \psi(x)$ is the wavelet function.

For example for the Haar wavelet, the following values are defined

$$N = 1, h(0) = h(1) = \frac{1}{\sqrt{2}}$$

and

$$g(0) = -g(1) = \frac{1}{\sqrt{2}}$$

The equations become

$$W_{2n}(x) = W_n(2x) + W_n(2x-1)$$

and

$$(W_{2n+1}(x) = W_n(2x) - W_n(2x-1))$$

$W_0(x) = \phi(x)$ is the haar scaling function and $W_1(x) = \psi(x)$ is the haar wavelet, both supported in [0,1].

The followings can be obtained W_{2n} by adding two 1/2-scaled versions of W_n with distinct supports [0,1/2] and [1/2,1], and the following can be obtained W_{2n+1} by subtracting the same versions of W_n.

Starting from more regular original wavelets, using a similar construction, smoothed versions of this system of *W*-functions can be obtained, all with support in the interval [0, 2*N*-1].

In this paper, Daubechies wavelet is used to extract the wavelet coefficient matrix.

3.3 Moment Invariants (MI)

The moment invariants of an image are statistical descriptors of the image that are invariant to translation, rotation and scale changes [26]. These moments will be used in the recognition stage based on image edges.

4. Neural Networks

In this paper, back propagation neural network (BPNN) is used. BPNN uses a supervised learning technique, and is built from simple computational units referred to as neurons. Neurons are connected by weighted links [26]. The architecture for a BPNN is given in Fig. 1. For more details, refer to [26].

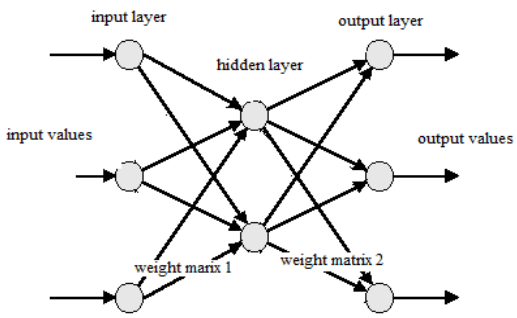


Figure 1. The architecture for a BPNN

5. The Proposed System

The proposed system has the following stages:

Stage 1: The video file is converted into isolated frames as described in section 2.

Stage 2: The plate is detected, normalized and extracted using the process described in section 2 and shown in figure 2 .

Stage 3: The plate is segmented into isolated characters by the techniques presented in section 2 and shown in figure 2.

Stage 4: The segmented character is represented by a feature vector based on PCA Eigen values features of the wavelet coefficient matrix and edge moment invariants features as shown in figure 3.

Stage 5: The recognition stage has two steps as shown in figure 3. The first step is to train the neural network based on the training feature vector samples of the characters to get the optimal weights. The second step is test the system using a new input character.

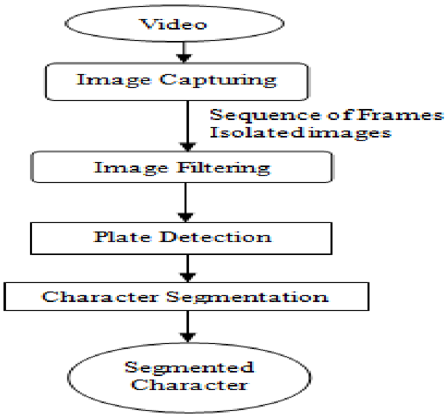


Figure 2. Block Diagram of the Preprocessing Stages

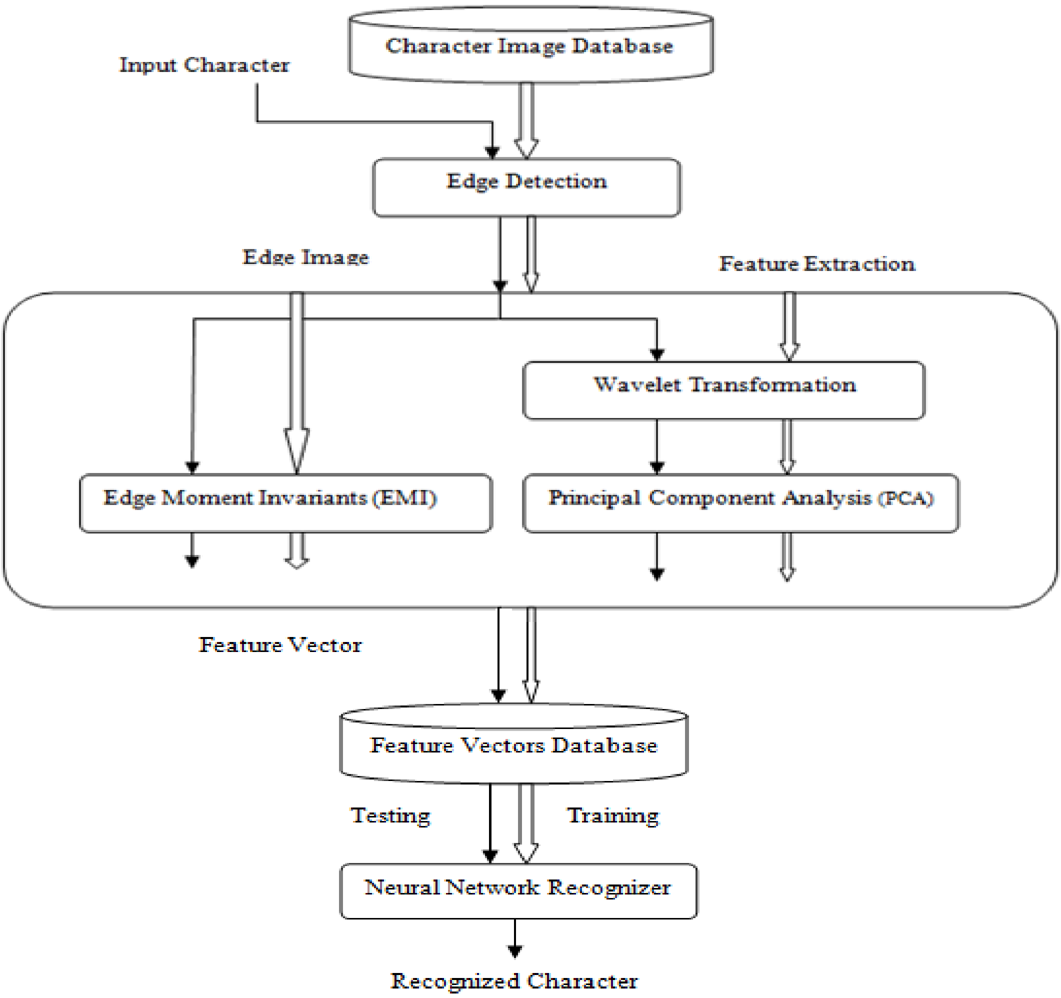


Figure 3. Block Diagram of the Proposed Plate Recognition System

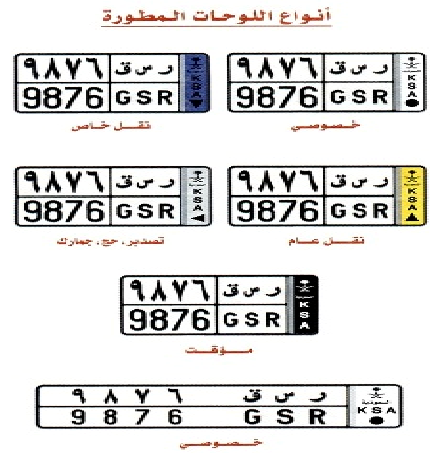
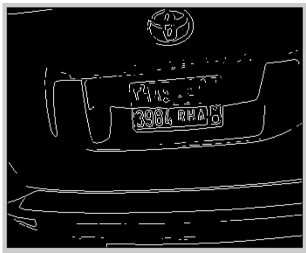
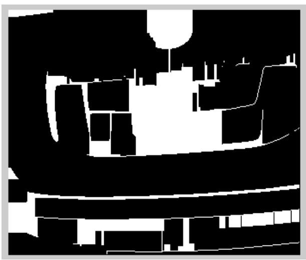


Figure 4. The images of developed Saudi Arabian license plates

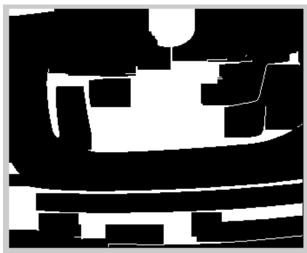
(a) the original image



(b) the edge image



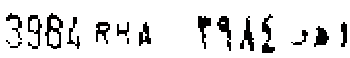
(c) vertical runlength encoding image



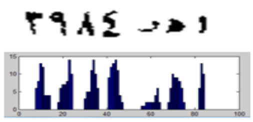
d) horizontal runlength encoding image

(e) the detected plate

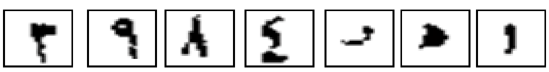
(f) the normalized plate



(g) the segmented two parts



(h) the segmented characters using histogram



(i) the segmented characters

Figure 5. The plate detection and segmentation(a-i)

6. Results and Discussion

The data set used in the experiments is collected from the captured images of original real plates. In this research, the experiments will be performed on the developed Saudi Arabian license plates shown in figure 4. The results of detected plates and segmented characters are shown in figure 5(a-i). The case in figure 5 is so complicated because of the shadow on the upper side of a plate. This means that when the image is converted into black and white, the threshold value will not be the same.

Four recognition subsystems are built for classifying the characters and digits: two subsystems for Arabic characters and digits and two subsystems for English characters and digits. Four neural networks are created to train the data to get the optimal weights. The number of inputs in the proposed approach is 11. 7 features are extracted based on EMI and 3 features are extracted from the PCA of wavelet matrix. 300 characters are used in testing. In PCA, MI and Wavelet approaches, the experiments are performed on original images. In the proposed approach, the experiments are performed on edge image of isolated characters. The results are shown in table 1.

TABLE I. THE RECOGNITION RATE OF PCA, MI, WAVELET AND THE PROPOSED APPROACH

The Approach	***PCA***	***MI***	***Wavelet***	***The Proposed Approach***
The Recognition Rate	95%	96.3%	93.3%	97.6%

7. Conclusion

In this paper, an experimental comparison has been performed between PCA, MI, Wavelet approaches which are based on the original binary images of the characters and the proposed system which is based on EMI and PCA of wavelet matrix of the edge image. The proposed system achieved high recognition rate. The proposed system will be developed in the future to tackle the problem of recognizing the color of plates and the old types of plates.

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