AUTOMATIC VEHICLE IDENTIFICATION SYSTEM USING LICENSE PLATE

S. ADEBAYO DARAMOLA[1], E. ADETIBA[1], A. U. ADOGHE[1], J. A. BADEJO[1], I. A SAMUEL[1] AND T. FAGORUSI[1]
[1]DEPARTMENT OF ELECTRICAL AND INFORMATION ENGINEERING, COVENANT UNIVERSITY OTA, OGUN STATE, NIGERIA.

Abstract:

This paper presents a new approach for development of an Automatic Vehicle Identification System (AVIS). The proposed system can be divided into three major modules; they are vehicle image preprocessing, license plate feature extraction and classification algorithm based on Hidden Markov Model (HMM). Experiment has been conducted to demonstrate the effectiveness of the proposed system. The proposed system is tested using Nigeria vehicle license plates. Recognition rate of 98% is obtained; the result is superior in comparison with the results obtained from previous systems.

Keywords: ***License plate, Vehicle image, Feature Extraction, Hidden Markov Model.***

1. Introduction

License plates are used for identification of vehicles all over the nations so it is illegal for two vehicles to have the same license number. Vehicles are identify either manual or automatically. Automatic vehicle identification is an image processing technique of identify vehicles by their license plates. Automatic vehicle identification systems are used for the purpose of effective traffic control and security applications such as access control to restricted areas and tracking of wanted vehicles. Real –time automatic vehicle identification based on Digital Video Recorder (DVR) play a major role in maintaining law enforcement on roads [1][2].

Extraction of license plate from vehicle image and classification of extracted features into different classes are difficult problem in Automatic Vehicle Identification System. The accuracy of the system depends mainly on the effectiveness of the extracted features and the pattern classifier. Many researchers have used different technique to extract or segment license plate character for different classifiers.

Othman Khalifa el al[3] proposed Malaysian vehicle license plate recognition system, texture based edge information is used to locate license plate and segmentation of characters is performed by using connected component analysis. Multi-layer perceptron neural network is used to classify the characters. Also S. Hamidreza Kasaei el al [4] proposed Iranian car plate detection and recognition system. Car license plate is localized using morphology operation and template matching scheme is used to recognize the digit and character within the plate. Serkan Ozbay et al [5] proposed Automatic Vehicle Identification by plate recognition. Edge detection algorithms and smearing algorithm are used for extraction of plate region, filtering and morphological algorithm are used for character segmentation and recognition of plate characters is based on template matching. And Xinfan et al [6] proposed vehicle licenses plate character recognition based on Chinese license characters. Neutral network is used to segment and recognize characters simultaneously.

Most of the previous vehicle license plate recognition systems perform classification of license plates based on segmented characters [3],[6],[7],[8]. The new approach presents in this work is different from the method presented in previous systems. In the proposed system, a new license plate feature extraction technique, training and classification algorithm based on HMM is presented. Features are extracted from license plate without segmentation of plate to individual characters notwithstanding the position, font of the numbers and characters. The extracted feature is the input observation of the HMM for effective modeling and recognition of license plate. HMMs have proven very effective in modeling both dynamic and static signals [9]. The application of HMMs in this work is motivated by its successes in speech, signature and character recognition [9][11].

Section 2 provides the description of the proposed system, the vehicle image preprocessing, and license plate feature extraction technique. Section 3 presents license plate classification using HMM. Recognition and result are given in section 4. Finally conclusions are presented in section 5.

2. The Proposed System

The vehicle recognition system proposed in this study is basically divided into five stages namely data acquisition, vehicle image preprocessing, license plate extraction and training and recognition stages as shown in Fig. 1.

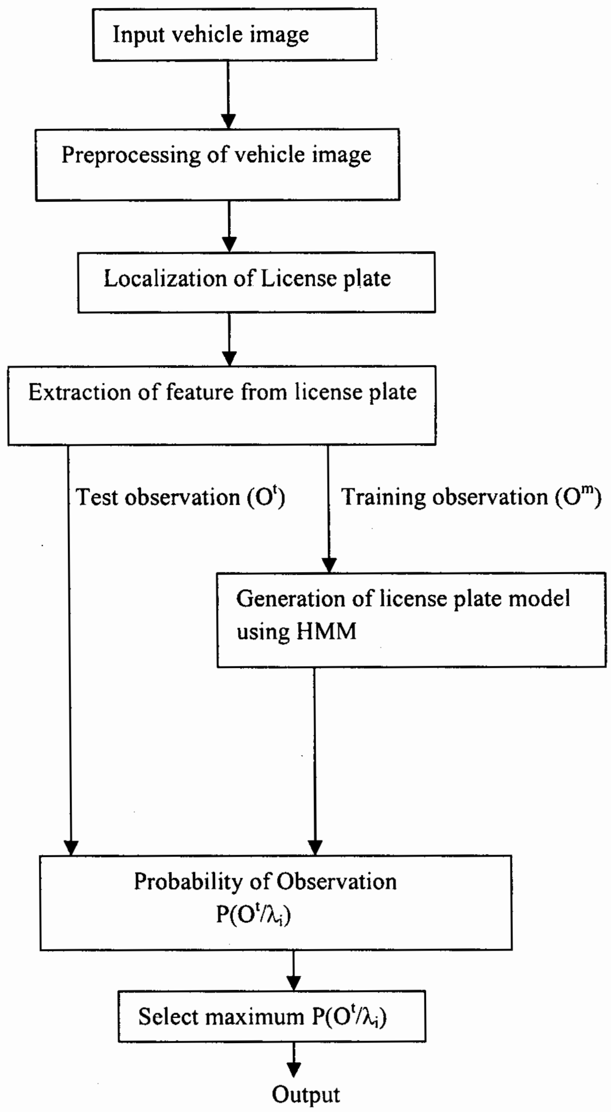

Fig1. Flow diagram of the proposed system

2.1 *Input Vehicle Image*

The input data to the proposed system are moving vehicle images collected at entrance of departmental car park at Covenant University Ota, Nigeria. Surveillance cameras and a DVR are installed at the car park. The surveillance camera is synchronized with a DVR to record videos image of cars entering the car park. The captured still snapshots are then used as input into the proposed system. Example of 24-bit color bitmap input vehicle images to the proposed system is shown in fig 2.

Fig.2. Input vehicle image.

Fig.3. Grayscale vehicle image

Fig. 4. Smoothened grayscale image

2.2 Vehicle Image Preprocessing Stage

The input images are converted from 24-bit color image to 8-bit grayscale image using (1). Fig. 3 shows the grayscale image of the input vehicle image. Median Filter is used to remove noise on the grayscale image. Median filter is used in order to preserve edge features of the image. The output vehicle image from the filter is as shown in fig 4. Also image enhancement and edge detection are carried out on the gray-level image in order to adjust the structural property of the image in preparation for license plate region detection. The output image from image enhancement algorithm and Sobel edge detection algorithm is as shown in fig. 5 and fig. 6 respectively.

$$G(i, j) \,\square\, 0.299 * \mathrm{Red} \quad 0.587 * Green \quad 0.114 * Blue \qquad (1)$$

Fig.5: Contrasted grayscale image

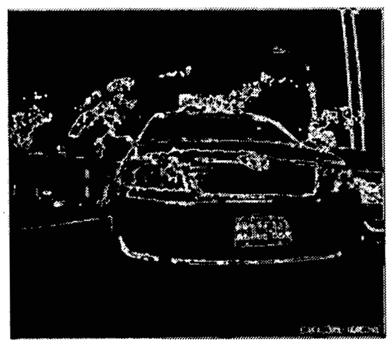

Fig.6: Edge detected image

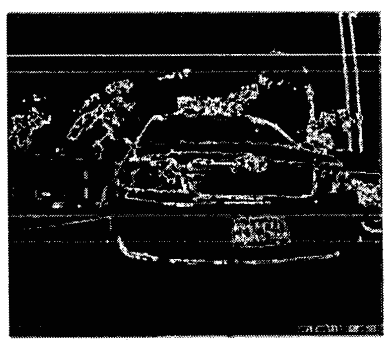

Fig.7: Detected bands on vehicle image.

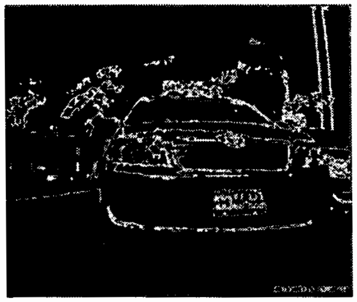

Fig.8: Localization of license plate

2.3 Localization and Extraction of License Plate

The license plate localization is achieved by apply morphological operations on the preprocessed image. The statistical distribution of pixels value at edges of the image in the vertical direction is used to local possible license region as shown in fig.7. Rectangularity of image regions is found in order to detect license plate region as shown in fig.8. After obtaining the license plate region, the unwanted regions are cut off to obtain the license plate image, and then the image is thinned to one pixel wide. The feature extraction algorithm is stated as follows:

(1) Locate license plate image bounding box.

(i) Scan the binary image from top to bottom to obtain the image height.

(ii) Scan the binary image from left to right to obtain the image width.

(2) Centralization of the image.

(i) Calculate centre of gravity of the image using (2).

$$\bar{x} = \frac{1}{N}\sum_{i=1}^{N} x(i),$$
$$\bar{y} = \frac{1}{N}\sum_{j=1}^{N} y(j). \quad (2)$$

(ii) Then move the image centre to coincide with centre of the predefined image space.

(3) The image is partitioned into two sub- image parts

(i) Locate the centre of the image using (2).

(ii) Through point $\bar{x}$ and $\bar{y}$ make a vertical splitting across the image.

(4) Partition each of the two sub-images into four rectangular blocks B1, B2, B3, and B4 as shown in Fig 9a.

(i) Locate the centre of each sub-image parts using (2).

(ii) Through point $\bar{x}$ and $\bar{y}$ make a vertical splitting across each of the sub- images.

(5) Partition each of the block images in Fig 9a into 2 image cells

(i) Locate the centre of each of the image-blocks using (2).

(ii) Through point $\bar{x}$ and $\bar{y}$ make a horizontal splitting across each of image- blocks.

(6) Partition each of the image-cells into 4 smaller image-cells so that each block contains 8 smaller image-cells as shown in Fig 9b.

(i) Locate the centre of each of the image-cell using (2).

(ii) Through point $\bar{x}$ and $\bar{y}$ make horizontal and vertical splitting across the image cell.

Calculate the angle of inclination of each image centre in each cell to lower right corner of the cell.

(i) Locate the centre of each of the 32 image cells using (2).

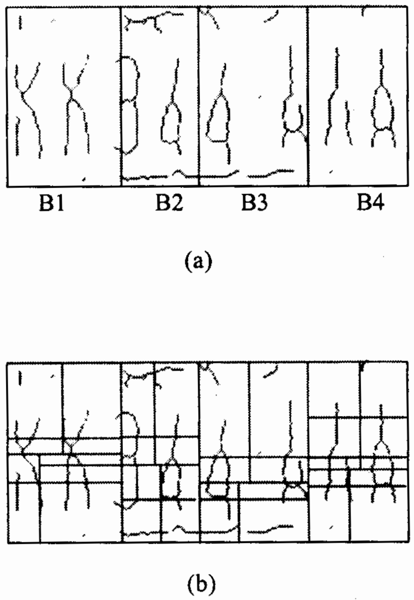

Fig. 9: Feature extraction diagram

(ii) Calculate the angle that each centre point makes with the lower right corner of the cell.
The centre angles of all the image-cells constitute the set of the feature for the license plate image.

3. Hidden Markov Model for License Plate Classification.

Hidden Markov Model (HMM) is a probabilistic pattern matching technique that has ability to absorb both the variability and the similarity between image samples. As shown in Fig 4. Hidden Markov Models (HMM) represent license plate image as a sequence of states. In each state an observation vector can be generated, according to the associated probability distribution. Transitions among the states are governed by a set of probabilities called transition probabilities. The probabilities, or parameters, of an HMM are trained using observation vector extracted from a representative sample of license plate image. Recognition of an unknown license plate image is based on the probability that a license plate image is generated by the HMM [9][10].

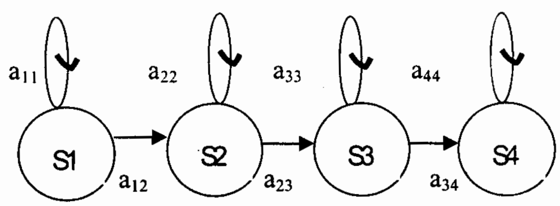

Fig.10: HMM topology for license plate image

In order to define an HMM completely, the following elements are needed.

1. A set of N states $(S_1 \ldots\ldots\ldots S_N)$, where q_t is the state at time t.
2. A set of K observation symbols $(V_1 \ldots\ldots\ldots\ldots\ldots V_K)$, where O_t is the observation at time t.
3. A state transition probability matrix $A = (A_{ij})$ where the probability of transition from state S_i at time t to state S_j at $t+1$ is $a_{ij} = P(q_{t+1} = S_j / q_t = S_i)$.
4. A set of output probability distributions B, where for each state j $b_j(k) = P(O_t = v_k / q_t = S_i)$.
5. An initial state distribution: $\pi = (\pi_i)$, where $\pi_i = P(q_i = S_1)$.

In this paper, a two dimensional license plate image is converted to one dimension feature vector. Each of the segmented blocks of the license plate image represent a state in the HMM. Eight centre angle features are extracted from each of the segmented license plate image-blocks. These feature vector form 1D observation vector for license plate image training and testing. The sequence of the segmented blocks over the image is fashion from left to right as shown in Fig. 10.

3.1 *Training the License Plate Models.*

Each of the subject license plate images is modeled by estimating the parameters for HMM for a given set of observations. A set of five license plate image from each of the 50 subjects are used to train each HMM. A set of eight feature value extracted from each block are used to form the observation vector. Parameters are chosen based on a maximum likelihood criterion that maximize the likelihood of the observation data O. This maximization is performed using the Baum-Welch algorithm known as forward-backward algorithm [9][10]. The follow steps are involved.

1) Firstly, the HMM λ = (A, B, π) is initialized. Each of the training license plate samples is segmented into 4 states (S1, S2, S3 and S4) and observation vectors from the segments of the five training license plate samples are clustered into m dimensional vector using k-mean algorithm [10] and the value obtained are used to obtain the initial estimate of the observation probability matrix B. The initial values for A and π are set given the left to right fashion of the HMM topology.

2) The next step is to re-estimate model parameters using Baum-Welch equation to maximize $P(O/\lambda)$. The iterative procedure stops when the difference between the likelihood scores of the current iteration (k+1) and those of the previous one (k) is smaller than a preset threshold (H) as given in (3).

$$\left| P(O/\lambda^{(k+1)}) - P(O/\lambda^{(k)}) \right| < H \qquad (3)$$

4. Recognition and Result

In the recognition stage, a set of 100 license plate images of 50 vehicles are used to determine the recognition ability of the proposed system. As it is done in the training stage, the extracted feature vectors from each of the states of the test vehicle license plate image are used to form the observation vector. The trained HMMs are used to compute the likelihood function as follows:

(1). Given $O^{(t)}$ as centre angle based observation sequence generated from the license plate image to be recognized.

(2). The probability of the observed vector given each license plate image model $P(O^{(t)}\lambda_i)$ is computed using Viterbi algorithm[9][10].

(3). The observed vector is labeled with class model which maximize the probability $P(O^{(t)}\lambda_i)$.

(4). License plate image (t) is recognized as license plate image (k) in the database if:

$$P(O^{(t)} / \lambda_{(k)}) \geq \max_n P(O^{(t)} / \lambda_i) \quad (4)$$

The recognition rate of 98% is achieved. The proposed system is able to recognize 98, out of 100 license plate images tested. The result is better in comparison with results obtained in [3][4][5].

5. Conclusion

Application of Automatic Vehicle Identification System is needed to monitor movement of vehicles in our environment in order to maintain law and order. Therefore a new approach for effective Automatic Vehicle Identification System has been proposed in this work. Recognition of license plate is done based on Hidden Markov Model using robust feature extracted from the whole license plate image. The proposed system is different from previous systems in term of feature extraction and image modeling method.

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