

License Plate Character Recognition

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Abstract: License plate character recognition is an integral part in Intelligent Transportation Systems. Traditional methods used for number plate recognition were OCR, Optical Character Recognition and Formula Based Recognition. As Neural Network is an intelligence engine, it ensures greater accuracy rate along with better recognition speed. In this system, recognition is done with the help of Neural Network. License plate is automatically located using principal visual word (PVW), discovery and local feature matching. Given a new image, the license plate is extracted by matching local features with PVW. Then image preprocessing operations are performed for improving the quality of plate images. This license plate image is then passed for Character Segmentation and these segmented characters are recognized using Neural Network.

Keywords: SIFT, Difference-of-Gaussians, Affinity propagation, Neural Network.

1. Introduction

License plate recognition [2] plays an important role in transportation systems. It can be applied in vehicle management, such as security control, traffic monitoring, automatic vehicle ticketing, and so on. This has tracked out more attention in privacy protection.

License Plate Recognition consists of three main phases:

- License Plate Extraction,
- Character Segmentation and
- Character Recognition.

1.1 Motivation

The main idea is to recognize the characters in the license plate. The license plate is detected using Scale-invariant feature transform (SIFT) which has the invariance property in rotation, scale and illumination and hence, it is used in object recognition, image search, etc. To detect the license plate in an open environment SIFT is being used.

The detected plate is to be segmented. Certain preprocessing is to be done to clean the noise and then the segmentation takes place. Once the characters are segmented, these segmented characters are then passed for recognition. The recognition is based on Neural network.

1.2 Scope of the project

The aim of the project is to recognize the characters in the license plate. When the test image is given, the license plate is extracted using Principal Visual word discovery and local feature matching. Hence, for each character that is, from A to Z and from 0 to 9, SIFT features [3] falling into the character region are collected and generate PVW by clustering from the training images. The extracted license plate is then taken for

segmentation. This is performed using row-column scan method. The segmented characters are then recognized using Neural Network [2]. The training dataset consists of number of images of each character and this is used for training the Neural Network.

2. Literature Survey

2.1 “Principal Visual Word Discovery for Automatic License Plate Detection.”[1]

Authors : Wengang Zhou, Houqiang Li, Yijuan Lu and Qi Tian.

The goal of this paper is to automatically locate license plates in an open environment.

A novel scheme to automatically locate license plates by principal visual word (PVW), discovery and local feature matching. Observing that characters in different license plates are duplicates of each other, the idea of using the bag of words (BoW) model is applied in partial-duplicate image search. Unlike the classic BoW model, for each plate character, automatically discover the PVW characterized with geometric context. Given a new image, the license plates are extracted by matching local features with PVW.

2.2 “Automatic license plate recognition system based on color image processing.”[8]

Authors : X. Shi, W. Zhao, and Y. Shen.

The goal of this paper is to recognize the characters based on color.

Color-based approaches are based on the observation that some countries have specific colors in their license plates. It is intuitive to extract license plates by locating their colors in the images. a test image is checked with a classifier of color model. Then, candidate regions from the classification results are verified with some post-processing to locate the plates.

2.3 Summary

In certain methods, the license plate detection and recognition may not function properly in an open environment. The main idea is to detect the plate in an open environment. In the proposed method the idea is to recognize the characters in the license plate. The license plate is detected using Scale-invariant feature transform (SIFT) which has the invariance property in rotation, scale and illumination and hence, it is used in object recognition, image search, etc. To detect the license plate in an open environment SIFT is being used. The detected plate is to be segmented. Certain preprocessing is to be done to clean the noise and then the segmentation takes place. Once the characters are segmented, these segmented characters are then passed for recognition. The recognition is based on Neural network.

3. Proposed Method

License Plate Character Recognition [4] is an important part in the Transportation System. Given an input image, the license plate is extracted from the image and this plate is then passed for segmentation. After segmentation, the segmented characters are recognized using Neural Network. When the input image is given, the license plate is extracted with the help of Principal Visual Word Discovery [1] and local feature matching. For this certain number of images of each character is collected and stored in such a way that the features can be extracted from each image for the detection of license plate from the test image. Features are extracted using SIFT. Once the license plate is located, it is then passed for segmentation. The method of Row-Column scan is used for segmentation. After segmentation, the character recognition is performed using Neural Network. The segmented characters are recognized using Neural Network.

3.1 Architecture

As shown in Figure 1, the framework of the approach consists of three main components: License Plate Extraction, Character Segmentation, and Character Recognition. Given an input image, the license plate is automatically located using Principal Visual Word discovery and local feature matching. Once the plate is extracted it is then passed for Character Segmentation. After segmentation, the segmented characters are recognized using Neural Network.

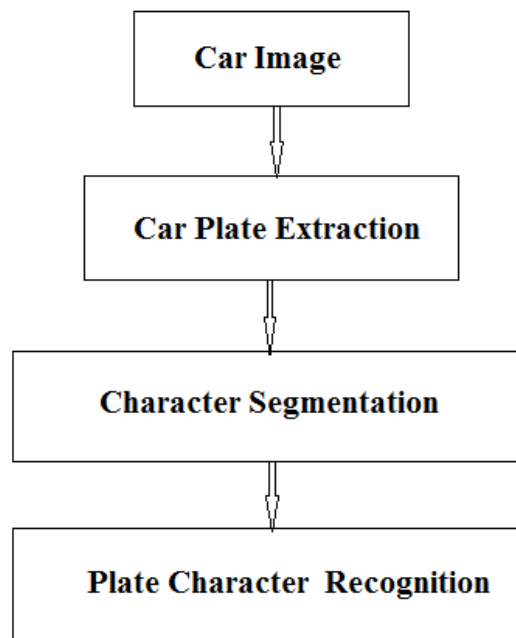


Figure 1: License Plate character Recognition System

3.2 License Plate Extraction

Given an input image, the license plate is extracted with the help of Principal Visual Word Discovery [1] and local feature matching. For this certain number of images of each character is collected and stored in such a way that the features can be extracted from each image for the detection of license plate from the test image. Feature extraction is done using:

Training In order to perform training, images of each character is being stored. For each character certain number of images are collected and stored in such a way that the features can be extracted from each image for the detection of license plate from the test image.

SIFT Generation In the feature extraction, the standard implementation of SIFT is being adopted. The Difference-of-Gaussian [3] detector is used for key point detection and a 128-D orientation histogram along with orientation and scale was extracted to describe the local patch around each key point. SIFT feature is invariant to scale, rotation and orientation.

PVW Generation The characters in the license plate maybe undergoing some changes like illumination or transformation. These characters might be of same format. Since SIFT feature [3] is invariant to changes in scale and rotation, and robust to illumination change and affine distortion, some repeatable and distinctive SIFT features to each character exist, called PVW.

A PVW is denoted as $V(\text{des}, \text{ori}, \text{rat}, \text{pos})$, where des is the 128-D SIFT descriptor, ori is the SIFT orientation, rat = H/s (s is the SIFT scale), and pos = $(f/W, e/H)$ is a 2-D vector denoting the relative position of the key point in the character region. To discover the PVW of each character, we cluster the local features of each character and discover the most representative cluster centers as the PVW. Affinity propagation [5] is used to perform clustering. The advantage of affinity propagation is that, the cluster number need not be specified. It is found automatically in the clustering process. In affinity propagation, a similarity matrix of samples shall be defined. First give the distance metric, which will be used to define the similarity metric.

In affinity propagation [5], the diagonal elements in the similarity matrix are referred to as exemplar preference, which

will influence the number of identified clusters. After clustering [5], the most representative clusters is to be discovered.

For each cluster, count the number of image patches which contain at least one feature falling into the cluster. Then an image-number histogram is built. To select those representative clusters, a threshold thresh shall be specified on the histogram. Any cluster with image number above thresh will be selected. In each selected cluster, the PVW are defined as the average of all samples falling into that cluster. Here the threshold is set as $\text{thresh} = 0.3 * \text{Num}$, where Num is the total sample number of the specific character. Given a test image, discover those characters with features matched to the PVW. First extract SIFT features from the test image. Then each SIFT feature $F(\text{des}, \text{ori}, \text{scl})$ is compared with the PVW of each character. A feature is considered as a candidate match if the minimum descriptor distance to a certain PVW of a certain character is less than a constant threshold T.

Once the character features in the test image are identified, the geometric context of the matched PVW is used to locate the license plate [6]. A bounding box will be estimated to encompass license plate by determining the upper, lower, left, and right bounding lines sequentially. First estimate the upper and lower bounding lines of license plate in images. After that, estimate the left and right bounding lines. In license plate, the ratio of plate width to height is constant. When the plate height h is estimated, the plate width w is obtained. Since license plate must cover all matched key points of SIFT feature [4], the interval between the left bound and the most right key point of matched feature shall be no less than w, so is that of the interval between the right bounding line and the most left key point. Consequently, determine the minimal bounding box containing the license plate.

3.3 Character Segmentation

Once the license plate is extracted then the next part to be done is segmentation. This is performed using row-column scan method. Firstly, the binary image is scanned using line scan method and lower-upper bounds are located. Secondly, the binary image is scanned using the column scan method and the left-right bounds are located.

The license plate is scanned from top to bottom and area of the first scanned white pixel is marked top and similarly, the plate is scanned from bottom to top and the area of the first scanned white pixel is marked as bottom. The left boundary of the character is marked in the same way. Each time when the white pixel is encountered it is counted. Every character in the plate has a ratio of height to width. The right boundary of the first character is confirmed only if there are no white pixels in the column and the ratio of height to width is maximum. If during scanning there appears a situation where the white pixel count is just one and no white pixels are found and also the ratio of height to width is maximum then the characters must be joined. In such a case the characters must be divided mandatorily. This is repeated until all the characters are segmented.

3.4 Character Recognition

This is the main step in the system and this is performed after character segmentation. After segmentation, the segmented characters are recognized. The recognition [4] is based on Neural network [2]. The neural network is to be trained using the training data for which the true classes are already known. Learning based neural network technique is used for character

recognition and the network used here is BP ANN (Back Propagation Artificial Neural Network).

BP (Back Propagation) Neural Network [2] is a supervised neural network, with three layers input layer, output layer and hidden layer. It utilizes the methods of mean square error and gradient descent. This is a supervised learning method. Backpropagation requires a known, desired output for each input value in order to calculate the loss function gradient. It is therefore usually considered to be a supervised learning method.

3.5 System Conceptual Design

Testing Dataset: To evaluate the approach, the dataset chosen is Caltech Cars 1999 [7]. This dataset contains U.S. license plates.

Training Dataset: The images of each character shall be stored to extract the corresponding features. The images of each character is used for training.

4. Experiments And Results

When the test image is given as input, the license plate is extracted from the input image and the plate image is then passed for segmentation. After segmentation, the segmented characters are recognized using Neural Network.

When the test image is given as input, the features are first extracted from the image. In order to extract the features, the standard implementation of SIFT is being used. The Difference-of-Gaussian detector was used for key point detection. SIFT feature is invariant to scale, rotation and orientation. On an average, 2500 SIFT features per image were extracted from the dataset. SIFT feature [3] is invariant to changes in scale and rotation, and robust to illumination change and affine distortion, some repeatable and distinctive SIFT features to each character exist, called PVW. To discover the PVW of each character, we cluster the local features of each character and discover the most representative cluster centers as the PVW.

Affinity propagation [5] is used to perform clustering. After clustering [5], the most representative clusters is to be discovered. For each cluster, count the number of image patches which contain at least one feature falling into the cluster. Then an image-number histogram is built. To select those representative clusters, a threshold thresh shall be specified on the histogram. Any cluster with image number above thresh will be selected. In each selected cluster, the PVW are defined as the average of all samples falling into that cluster. Here the threshold is set as $\text{thresh} = 0.3 * \text{Num}$, where Num is the total sample number of the specific character. This is shown in Figure 2.

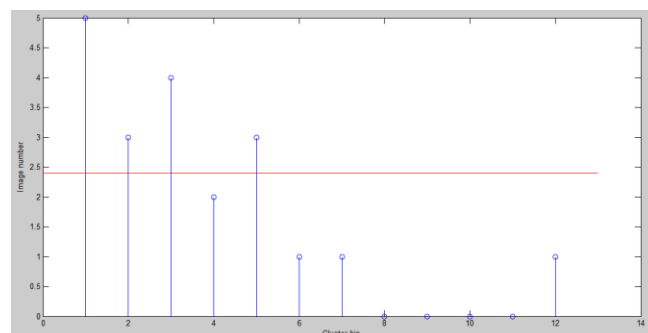


Figure 2: Number of images in each feature cluster of digit "0"

Once the PVW is generated, this is being stored and this is the feature which is being used for the detection of license plate.

After extracting the license plate it is then passed for segmentation. This is performed using row-column scan method. Firstly, the binary image is scanned using line scan method and lower-upper bounds are located. Secondly, the binary image is scanned using the column scan method and the left-right bounds are located. After segmentation, the segmented characters are recognized. The recognition [4] is based on Neural network [2]. The neural network is to be trained using the training data for which the true classes are already known. The performance of the character recognition system is then evaluated in terms of accuracy.

To evaluate the performance in terms of accuracy, the results are of three levels. The table below shows the true, partial and false rate when the experiment is performed on 50 images. The false positive rate is defined as the ratio of false detection results to the total number of detection results. The false positive rate is also shown in the table.

Table1: Recognition Result

<i>Test images [50]</i>	<i>Accuracy</i>			<i>False Positive Rate</i>
	<i>True</i>	<i>Partial</i>	<i>False</i>	
	76%	6.3%	17.7%	23.2%

5. Conclusion And Future Works

License plate recognition [4] is an integral part in Intelligent Transportation Systems. In this system the method of character recognition of license plate image is based on Neural Network technique. In any neural network system, if the network is trained with more number of features the simulation accuracy increases.

Thus the further research can be focused on exploring more number of fonts used for training the network for improving the accuracy of the character recognition.

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