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Study of Character Recognition Methods in Automatic License Plate Recognition (ALPR) System

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Abstract - *Automatic License Plate Recognition (ALPR) is a kind of image processing and pattern recognition technology for recognizing the vehicle number plate from an image or video of a vehicle. ALPR has become a very important tool in our daily lives because of the unlimited increase of vehicles, which makes it difficult to be monitored by humans. Some of the examples are traffic monitoring, tracking stolen cars, managing parking toll, parking space management and border checkpoints. It's a challenging problem, due to the diversity of plate formats, different scales, rotations and non-uniform illumination conditions during capturing the image. In this paper, we discuss various methods used for character recognition and compare the accuracy of the methods. Character recognition is the final stage of ALPR system and choosing a correct recognition algorithm is important for recognizing the characters on license plate.*

Key Words: **Automatic License Plate Recognition (ALPR), Character Recognition, Template Matching, Artificial Neural Network (ANN), Support Vector Machine (SVM), Optical Character Recognition (OCR).**

1. INTRODUCTION

Automatic Number Plate recognition plays a significant role in different applications such as traffic monitoring on highway, automatic toll collection, parking lot access control, identification of plundered vehicles etc. It was first employed in 1976 in United Kingdom at a police station. This type of secured technology is now used in various restricted areas, such as parliament house, military area, Supreme Court etc.

Automatic license plate recognition of the standard number plate is very easy to recognize. But it is very tough to identify if it the number plate has no standard size and pattern. Therefore it requires a competent algorithm for better recognition of number plates. Several techniques were proposed to improve the system by many research groups. ALPR process is divided into six stages. Firstly, Video or image of vehicle is captured using a camera. The captured image may contain noise such as holes and dirt particles. The noise is removed from the image of the vehicle in pre-processing step. In Plate Detection stage, vehicle number plate is extracted from the pre-processed image of the vehicle using various algorithms. The features of vehicle plate which include presence of characters, aspect ratio, color, size and rectangular shape are used to localize the plate. The characters on the vehicle plate are isolated in the plate segmentation stage. The final stage is to recognize the alphanumeric characters present on the vehicle plate. The features of the characters like shape, size and contours of characters can be used for character recognition. This paper will present the various methods of character recognition.

1.1 Working

Vehicles play an important role in transportation in our daily lives. Due to the growth in population vehicles are increasing day by day. Therefore, controlling of vehicles has become a big problem. So, there is a need to recognize the vehicles in order to control them. As Vehicle number plate is unique for every vehicle, we can use vehicle registration plate for the purpose. Manual recording of vehicles is time consuming, costly and not efficient. Therefore there is a need for automation of process of vehicle plate recognition. Automatic License Vehicle Plate Recognition (ALPR) is an image processing and pattern recognition problem which plays an important role in traffic surveillance systems. Such systems are applied in parking areas, highways, bridges and tunnels, which can help a human operator and improve overall quality of a service. Automatic number plate recognition is a mass surveillance method that uses various character recognition methods on images to read vehicle registration plates. It is a technique which is used to identify vehicles using their license plate numbers. It is the process of extraction of license plate number from an image of a vehicle or video of a moving vehicle. The main use of ALPR is security. This technique is very helpful in toll collection, parking management, access control, radar based speed control, border control and road patrolling. The way the ALPR work is as shown in Fig 1:

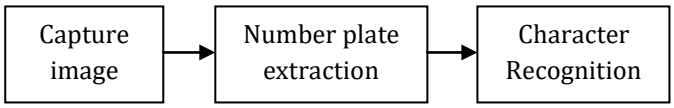


Fig-1: Working of ALPR

First of all the video of a moving car is taken. Then video is converted into frames. Then the key frame is to be selected.

Then the plate is to be extracted or detected from the image of the car. Then software for character recognition is to be run. Character Recognition is the last and final stage of ALPR system. The output of ALPR system is the Vehicle License Plate Number. Recognition of number plate is done by using one of the Recognition algorithms which are discussed in further sections. Various recognition algorithms discussed here are

- Template Matching
- Support Vector Machine (SVM)
- Optical Character Recognition (OCR)
- Artificial Neural Network (ANN)

1.2 ALPR PHASES

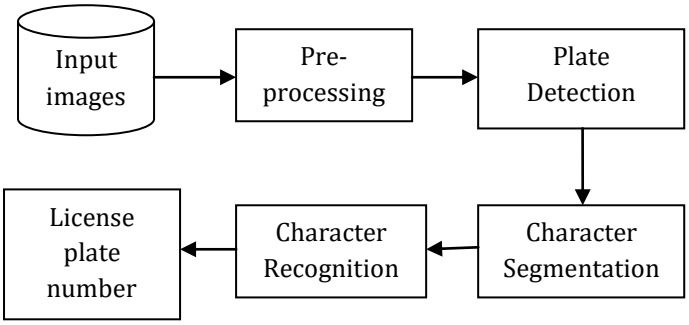


Fig-2: ALPR system components

Figure 2 shows the ALPR system components. Firstly, image is captured using a camera. Both Video and images can be taken. Features of camera such as resolution, shutter speed and orientation have to be considered into account while taking the video of a moving vehicle. Next video is converted into the frames and the key frame is to be selected. The frames may have noise. They may contain impurities such as holes and dirt particles. Therefore, after selecting the key frame, in second stage pre-processing steps which include dilation of image and the noise removal is done. The contrast is also adjusted. The image is enhanced and pre-processed so that it is easy to recognize the vehicle car plate number. In third stage, the vehicle plate is to be extracted from that image. The input of this stage is a vehicle image and output is the portion of the image carrying the recognized characters of the vehicle plate. In the next stage of character segmentation we will isolate the characters from the plate so that the characters can be separated from background. The vehicle plate is segmented to extract the characters for recognition in the next stage. The final stage is to recognize the alphanumeric numbers present on the vehicle number plate using various recognition algorithms.

1.3 CHARACTER RECOGNITION

Character Recognition is the final stage of Automatic License Vehicle Plate Recognition System. Segmented Characters of the license plate is input to this stage, characters are recognized and output is the license plate number of the vehicle. The features of the characters like shape, size and contours of characters can be used for character recognition. As License Plate may be bended or tilted with respect to camera, extracted characters may be malformed. Characters may be noisy, broken or incomplete. Extracted characters do not have uniform size and thickness. This may affect the Character Segmentation stage. The characters like (o, 0), (I, 1), (B, 8), (C, G) are similar and may confuse character recognizer. Methods of Character Recognition should be able to deal with all these defects. Working of Character Recognition is as shown in Fig.3.

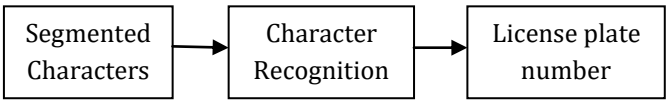


Fig-3: Working of Character recognition

2. METHODS

The main aim of recognition is to employ conversion of image text to characters .The extracted characters are recognized and the output is the license plate number. Character recognition in ALPR systems may have some difficulties. Due to the camera zoom factor, the extracted characters do not have the same size and the same thickness. Resizing the characters into one size before recognition helps overcome this problem. Once the image is captured using the camera the image is subjected to pre-processing. Then the pre-processed image is segmented and characters are recognized in the next stage.
Here we discuss the character recognition algorithms used in Automatic License Plate Recognition (ALPR) system. The character recognition techniques include Template Matching, Artificial Neural Networks (ANNs), Support Vector Machines (SVM) and Optical Character Recognition (OCR).

2.1 Template Matching

In ALPR system, the most significant and critical stage is to generate proper output. The previous stages are responsible for detecting the pattern of characters from captured image. The segmented number plate characters are rescaled to resemble the characters within a window. Each vehicle number plate character is converted to binary image with proper size and standard dimension before additional processing steps are applied. Recognizing the characters is the final stage in ANPR system. In addition, determining the accuracy level of recognition for the system is very

important to implement the most applicable approach for recognition processes. In order to do so, a template matching technique is applied to the segments (objects) that are attained from the previous step. In this technique characters are identified by comparing the similarity of object or character element. Template matching is the process of finding the exact location of segmented characters inside the template images. The inputs to this phase are segmented characters and output of this phase is license plate number. The character recognition is done using correlation. Correlation checks the degree of similarity between the segmented characters and the template characters. In the character recognition step firstly, a database that consists of 42X24 pixels A to Z alphabet and 0 to 9 number images is generated. Read all image and store them in database and this result into 36 character templates. After the loading of templates, character normalization is done. In character normalization, all the segmented characters are resized to template size 42X24. Sometimes the segmented characters do not have the same size so the better way to overcome this problem is to resize the characters into one size (equal to template size) before actual recognition starts.

In the last stage the segmented characters are matched with template characters using correlation. The similarity between the template characters and segmented characters is measured and the template that is most similar to the character is recognized as target. In fact, the character is recognized based on the highest correlation coefficient value between the input image and one of the template images. The value of correlation is calculated by comparing the normalized segmented character image with each template character image and selecting the most relevant image and writes that character into text file as shown in figure.

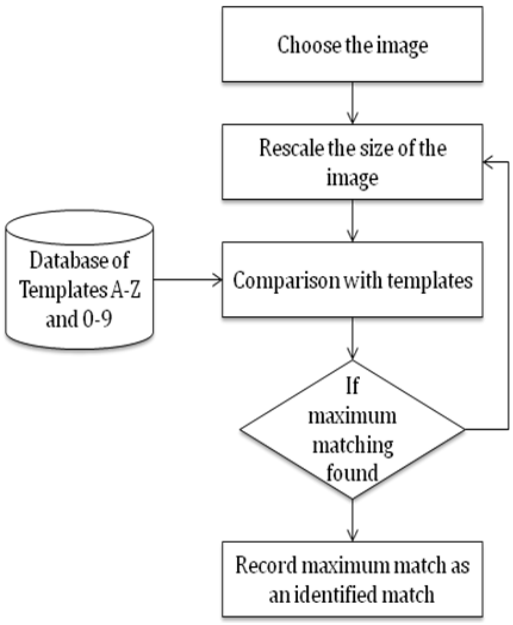


Fig- 4: Flow chart of template matching

2.2 Support Vector Machine

The basic issue in number recognition is shape analysis. Here we use Support Vector Machine (SVM) algorithm to train character samples and obtain the rules that are used to recognize the numbers on number plates and classifies them. A Support Vector Machine (SVM) recognizes the pattern and classifies data without making any assumptions about the underlying process by which the observations were granted. The SVMs use hyper planes to separate the different classes. Many hyper planes are fitted to separate the classes, but there is only one optimal separating hyper plane. The optimal hyper plane generalizes with comparison to the others. The hyper plane is constructed so as to maximize a measure of the margin or the boundary between classes. A new data sample is classified by the SVM according to the decision boundary defined by the hyper plane.

In order to recognize a number plate, SVM includes the following steps.

- Pre-process the image of license plate.
- Segment the image into several parts of which each contains only a single character of license plate.
- Normalize each letter or digit on the number plate.
- Extract the feature vector of each normalized candidate
- Recognize the single character (a digit or a letter) by the 36 SVMs trained in advance.
- If there are no more unclassified samples, then STOP. Otherwise, go to the previous step.
- Add these test samples into their corresponding data base for further training.
- Recognize number plate by bringing all characters recognized together.

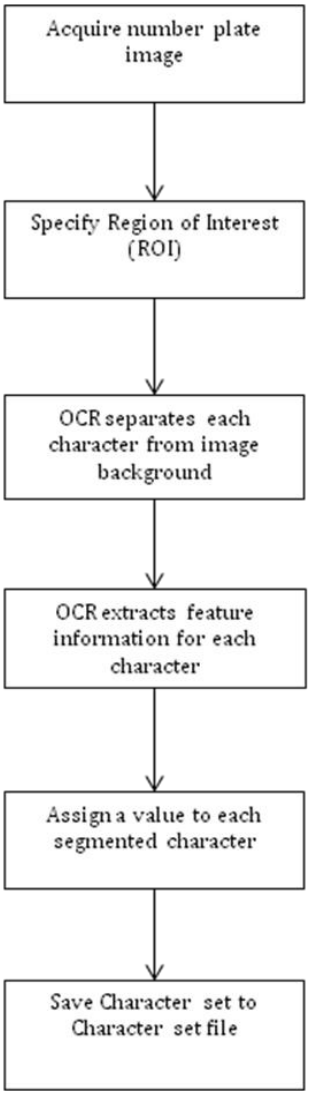
The number plate is segmented and the images containing individual characters (digits and letters) forming the number plate are obtained. Each image of a character is normalized into size of 20x36.

Then the support vectors are calculated directly from the normalized sub-images. The feature vectors are stored into two kinds of database, one is for digital numbers, and the other is for letters. 720 dimensional feature vectors are input into SVMs which have been trained successfully. Then, character of a given candidate can be obtained in according to the outputs of SVMs. When all digits and letters on a number plate are recognized (or classified), the recognition of the number plate is complete.

2.3 Optical Character Recognition (OCR)

Optical Character Recognition (OCR) is used for vehicle license plate character recognition. OCR is used to translate human readable characters to machine readable form. OCR

algorithm relies on a set of learned characters. It compares the characters in the provided image to the characters in this learned stage. Optical Character Recognition (OCR) is a type of document image analysis method where a scanned digital image that contains either machine readable or handwritten characters is input into an OCR software engine and translating it into an editable machine readable digital text format.



Character recognition is done by the available Optical Character Recognition (OCR) tool. There are numerous softwares available for OCR method. One of the open sources OCR tools is Tesseract developed by Google. Character extraction is done as the optimization problem based on prior knowledge to maximize a posterior probability. Then a greedy mutation operator is used to reduce computation cost. The adopted method consists of three steps: character categorization, topological sorting and self organizing (SO) recognition. Character categorization is used to classify character as alphabet or number. Second step involves computation of the topological features of the input character and compared with already stored character templates. Compatible templates will form a test set, in which the character template that best matches the input character is determined. The template test is performed by a SO character recognition method. To differentiate the similar characters from character pairs such as (8, B) and (O, D) there is predefined ambiguity set containing the characters 0, 8, B and D. After the unknown character is classified as one of the characters in the ambiguity set, a minor comparison between the unknown character and the classed character is performed. Then in the comparison process only non ambiguous parts of characters are focused. The recognition rate is 95.6% for the upright license plate images. The main challenge in character recognition is to handle unknown text layout, different font sizes, different illumination conditions, reflections, shadowing and aliasing.

2.4 Artificial Neural Network (ANN)

Artificial Neural Network (ANN) also known as neural network is a mathematical term that contains interconnected artificial neurons. The feed forward back propagation artificial neural network is created with the set of inputs, outputs and sizes of hidden layers. It contains input layer for decision making, hidden layer to compute more complicated associations and output layer for decision results. Also transfer function of each layer and training function of ANN is defined. The default weights and biases are initialized. After this, the network is trained with the training data set which includes feature value as input and desired output in the system. Once the system is perfectly trained, it is tested for the test data set and accuracy is calculated. For this, it will first calculate the feature vector. This feature vector value will be given to artificial neural network for testing. The artificial neural network will decide upon the feature vector input and recognize characters from the number plate successfully.

3 APPLICATIONS

3.1 Template Matching

- **License plate detection:** Template matching is widely used in Automatic License Plate Detection (ALPR) system to detect the characters with high accuracy.

- **Face detection in image processing:** Human facial features play a significant role for face recognition and Neurophysiologic research. According to studies it is determined that eyes, mouth, and nose are amongst the most important features for recognition. Template matching methods are also applied in facial feature extraction methods which are sensitive to various non-idealities such as variations illumination, noise, orientation, time-consuming and colour space used.

- **Computer Vision:** Computer deals with the development of the theoretical and algorithmic basis by which useful information about the 3D world can be automatically extracted and analyzed from a single or multiple 2D images of the world. Computer vision is also known as, Image Analysis, Scene Analysis, and Image Understanding in which template matching is highly implemented.

3.2 Support Vector Machine (SVM):

SVM has been used successfully in many real-world problems. Some of them are

- **Text (and hypertext) categorization:** Their application can significantly reduce the need for labelled training instances in both the standard inductive and transductive settings.

- **Image classification:** SVMs achieve significantly higher search accuracy than traditional query refinement schemes.

- **Bioinformatics:** The SVM algorithm has been widely applied in the biological and other sciences. They have been used to classify proteins with up to 90% of the compounds classified correctly.

- **Hand-written character recognition:** Hand written characters can be recognized using SVM algorithm.

3.3 Optical Character Recognition (OCR):

Optical character recognition has been applied to a number of applications. Some of them have been explained below.

- **Invoice Imaging:** Invoice imaging is widely used in many businesses applications to keep track of financial records and prevent a backlog of payments from piling up. In government agencies and independent organizations, OCR simplifies data collection and analysis, among other processes. As the technology continues to develop, more and more applications are found for OCR technology, including increased use of handwriting recognition. Furthermore, other technologies related to OCR, such as barcode recognition, are used daily in retail and other industries.

- **Legal Industry:** Legal industry is also one of the beneficiaries of the OCR technology. OCR is used to digitize documents, and directly entered to computer database. Legal professionals can further search documents required from huge databases by simply typing a few keywords.

- **Banking:** Another important application of OCR is in banking, where it is used to process cheques without human involvement. A cheque can be inserted into a machine where the system scans the amount to be issued and the correct amount of money is transferred. This reduces the waiting time of Banks.

- **Healthcare:** Healthcare has also seen an increase in the use of OCR technology to process paperwork. Healthcare professionals always have to deal with large volumes of forms for each patient, including insurance forms as well as general health forms. To keep up with all of this information, it is useful to input relevant data into an electronic database that can be accessed as necessary. Form processing tools, powered by OCR, are able to extract information from forms and put it into databases, so that every patient's data is promptly recorded.

3.4 Artificial Neural Network (ANN):

- Function approximation, or regression analysis, including time series prediction, fitness approximation and modeling.
- Classification including pattern and sequence recognition and sequential decision making.
- Data processing, including filtering, clustering and compression.
- Robotics, including directing manipulators.
- Used to diagnose several cancers.

4. RESULTS AND DISCUSSIONS

Here we highlight the existing character recognition methods present in literature. Automatic License Vehicle Plate Recognition (ALVPR) is an image processing and pattern recognition problem to identify vehicle license plate Number.. Such system which is applied in parking areas, highways, bridges and tunnels, can help a human operator and improve overall quality of a service. Character Recognition is the final stage of ALVPR system. The features of the characters like shape, size and contours of characters can be used for character recognition. Template Matching, OCR, ANN, SVM are widely used methods to recognize the characters on the vehicle plate. The method which recognizes the character with high percentage accuracy can be used for character recognition. The above algorithms can be implemented in MATLAB tool. The validity, suitability and the effectiveness of the proposed system will be examined through real experiments. Approximate accuracy of the recognition algorithms is shown below:

Table-1: Algorithms accuracy

Algorithm	Approximate accuracy
1. Template Matching	97.5%
2. Support Vector Machine (SVM)	97%
3. Optical Character Recognition (OCR)	95.6%
4. Artificial Neural Network (ANN)	94.12%

5. CONCLUSION

Here we have discussed various character recognition algorithms used in Automatic License Plate Recognition (ALPR). This system can be used in many applications, such as electronic payment systems, and traffic surveillance. Character Recognition is the final stage of ALPR system. Template Matching, OCR, ANN, SVM are widely used methods to recognize the characters on the vehicle plate detection. It is clear that ALPR is difficult system because of much number of phases and presently it is not possible to achieve 100% accuracy of character recognition as each phase is dependent on previous phase. Certain factors like different illumination conditions, shadow and non-uniform size of license plate characters, different font and background color affect the performance of ALPR system. For an effective ALPR system we have to improve the recognition algorithms by increasing the accuracy of the plate recognition.

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