Indian Institute of Technology
Kanpur

CS771 Machine Learning: Tools,
techniques, applications
Project

Identifying and Recognizing Number Plates

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1 Introduction

The world, today, has unimaginably increasing number of automobiles. Increase in globalisation, increased standards of living, and high availability of luxurious low rate cars has led to this rapid growth. But with such increased numbers, the concerned risks and crimes also increase. The security administrations, and the owners wish that they are able to track their vehicles in case of any untoward incident. This can be handled by installing cameras at various checkpoints or traffic signals. However, this amounts to huge data and thus memory, to store all such videos where most data is not even valuable. Also searching for a particular car, in a long video, say even a day long, would take a considerable time. Keeping track of the cars can be done more efficiently by identifying and storing the respective number plates. Since a number plate uniquely identifies a car, this can prove to be highly beneficial for recording and searching purposes. Our project aims to accomplish this task of number plate extraction and recognition in a given frame or video.

2 Literature Review

Typically, an ANPR system consists of four stages from number plate extraction to finally pinning down to the characters present on the plate. A lot many different approaches have been opted to increase accuracy of each step, still a lot of work needs to be done in order to create a robust system that works under all kinds of environment and number plates.

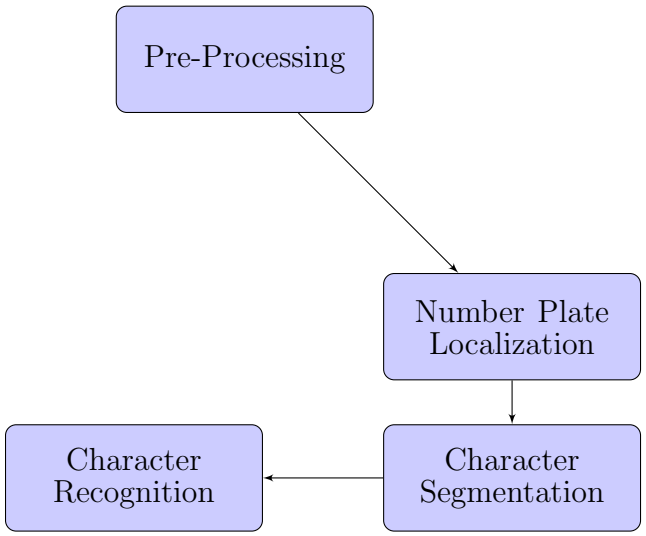
- License Plate Extraction: Instead of the pixel by pixel analysis, most of the techniques use feature extraction to localize license plate. These features can be derived from the characters, color of plate, rectangular shape (aspect ratio) combined with area [1], the rapid black to white color change because of characters. People have started using the combination of two or more features to extract correct number plate candidates. Connected Component Analysis (CCA) has been successful in extracting plates even from low resolution images [2]. Haar features, a techniques popular for face detection has gained popularity because of its invariance to brightness, color, size and position of the searched feature. [3]
- License Plate Segmentation: Methods like bilinear transformation [4], least-squares method [5], Karhunen-Loeve transformation [6] etc. have been used to correct the horizontal and vertical tilt. Most of the used methods make the image noise-free and enhance its quality before segmenting to characters as incorrect connectivity leads to wrong segmentation. Segmentation methods using pixel connectivity [7],

projection profiles (horizontal to determine starting and ending points with vertical projection to find individual characters) [8], contours of characters [9] and their combinations have been successful.

- Character recognition: The non-triviality involved is the condition in which each character is obtained. Characters are first resized and then various techniques are used. The grey-level image of the characters can be used to match against the template for numbers and alphabets [7]. This techniques takes time as it analysis each pixel. Recent works extract features of the characters for classification using a pre-trained multiclass-classifier [10].

3 Methodology

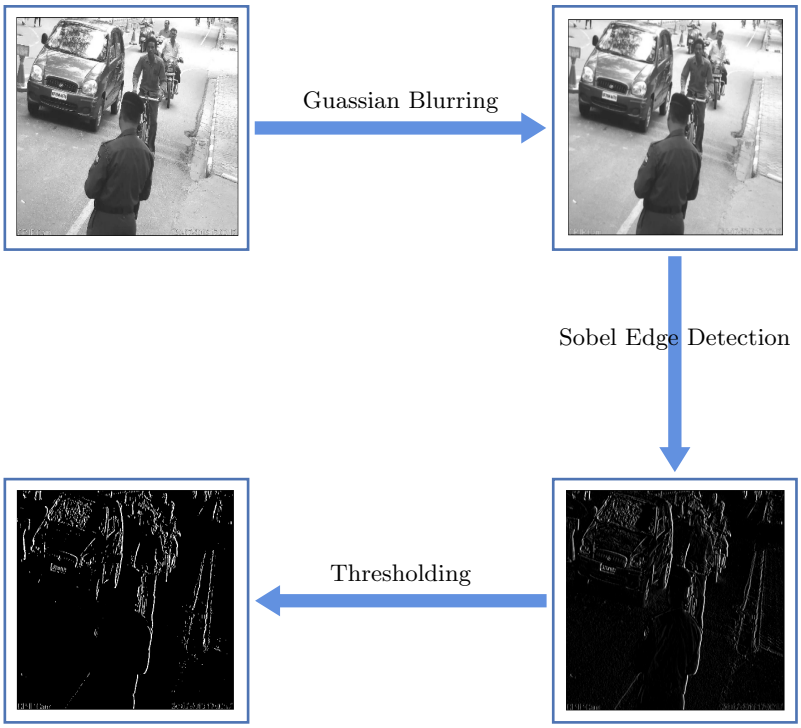
To accomplish our aim, we follow the following procedure :



1. Pre-processing: The first step deals with extracting frames from the video and converting the image to one where number plates can be easily localized
2. Plate Localization: Thereafter follows the process of localization of number plate which provides us with the rectangular image of the number plate.
3. Character Segmentation: On the obtained number plate, we implement the character segmentation algorithm to obtain the individual characters.
4. Character Recognition: Now the task for recognizing the alphanumeric character is employed i.e. the characters obtained as image are read.

3.1 Pre-processing

Pre-processing was basically done to enrich the input image in order to obtain better accuracies in each step. First the image was converted to grey-scale as color won't be useful and it only increases the size of the input. Secondly, the images obtained from videos contain a lot of noise which can be deceiving in gradient calculation steps. So a $5X5$ *Gaussian filter* was convolved over the image. For calculating the horizontal gradients, *Sobel Filter* with kernel size 3 was used. We only need the areas with high horizontal gradients, so thresholding was done with proper limits to work with the most probable regions.



3.2 Plate Localization

License Plate Extraction involves the procedure to work on the processed image in order to identify and extract the number plate.

3.2.1 Morphological Closing

For getting some candidate regions for the number plate, we exploit the fact that the number plate region has a high density of edges. In order to differentiate such regions, we merge the closely occurring edges using the method of morphological closing. This involves sliding a structuring element (a rectangle in our case) across the image, if it touches any of the background pixel (black pixels), without touching any of the white pixels, then that pixel remains black, else it is set to white. Although the image is

distorted, but this actually envelopes the number plate region among others in a white envelope.

3.2.2 Obtaining rectangles

Using getContours function of the cv2 library, we obtain contours in the binary image obtained after morphological closing. These contours are then enclosed in rectangles using the minAreaRect which ensures that excess space is not enclosed. At the same time, this provides a tight bounding rectangle, which would be tilted for a number plate that is tilted, acting like a tight border. This provides numerous rectangles, since most of the regions which qualified and passed the threshold in the pre-processing stage, would have bounding rectangles. This raises the need for a technique to filter out the negative samples. For filtering, we make use of certain geometrical and gradient features of a valid number plate.

3.2.3 Filtering Candidate Regions

The various rectangles obtained are filtered using the geometrical constraints of a license plate image. We impose the following restrictions on the rectangles :

- Area of rectangle is given certain upper and lower bounds. We chose 400 and 30000 as our bounds. This wide range is taken in order to incorporate the possibility of the number plate being too close or further away from the camera. We cannot assume a specific distance of the vehicle from the camera since some vehicle on the street may be occluded at that distance by a passerby, while the plate could be visible once it reaches certain other distance.
- Aspect Ratio > 1.3 and < 4.5. This was used to filter out rectangles which are either too wide or too long. The ratio bounds are chosen taking into consideration the various possible designs of number plates in India. We tuned them such that

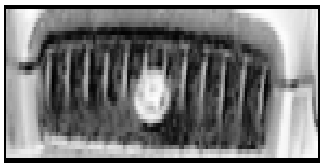
maximum negatives could be discarded without losing out on the real number plates.

- The dimensional projection on the (vertical axis ¡ horizontal axis). This restriction discards the rectangles which are vertical in nature. Since number plates are always horizontally placed on a car, the required rectangles will surely qualify.
- FloodFill technique is implemented which filters large variety of the rectangles, by using random points within the chosen rectangles. It is dependent on the fact that most number plates have a white background and thereby provides a good way of expanding the rectangles which could have missed certain regions or often the number plate region is contained by 2 split rectangles, which are combined through this step. The validation using the above mentioned geometrical features are applied again on the newly formed rectangles.

The above filtered rectangles are then rotatated to the horizontal axis and aptly resized for the classifier in the next step.

3.2.4 Classifying the Candidate Regions

To further fine tune the candidate number plates, we trained a classifier with candidate rectangles obtained from the above process. We have tried various classifiers at this stage, like linear SVM, random forest classifier, Adaboost and extra trees classifier. Also, the parameters for these classifiers have been tuned. Extra trees classifier with 400 estimators is found to be responding the best to the dataset, giving an accuracy of 97.7%. The dataset required for this model has been manually created by labeling 1400 rectangles containing 856 positive samples. The HoG features of the 63 x 260 rectangles are used as input features to the classifier.



3.3 Character Segmentation

The obtained number plate image, is again processed as the initial image, to obtain the relevant contours and minimum bounding rectangles. The verification of these rectangles is carried out with geometrical constraints of area and aspect ratio (1-2). The segmented characters obtained are converted to binary, pasted on a white background (to match

the pattern in the dataset used for training the classification model for recognition) and resized to a 40*40 size (similar to the dataset).

3.4 Character Recognition

We train a model using the dataset English Chars74k [11]. It takes an image of an alphanumeric character as input and outputs the character. We divide our dataset into training and test sets and use the training set to train the model. We then test the accuracy on the test set. We used the HoG features of the input image. We experimented with several models for multi-class classification with parameter tuning and the results are tabulated below for the best parameters in each:

Method	Accuracy (in %)
Multilayer Perceptron(with grid search)	87.2
RBM feature extractor with Log Reg, L.R. = 0.06	93.5
Linear SVM	93.9
Random Forest Classifier(No.of trees=400)	95.8
Extra Trees Classifier(No.of trees=300)	98.6

Since an extratree classifier which gave the maximum accuracy, we used that as the final model for character recognition. Each image of a character given by the character segmentation step is fed into the model to recognize the character it contains.
The images of each character post segmentation.

4 Results

Task	Accuracy (in %)
Plate Localization	80

5 Problems

- White cars pose a problem in number plate localization. This is so because the method for FloodFill actually includes the entire car region too in the white pixels. This eliminates the possibility of localizing rectangles in the number plate region.
- Insufficient dataset for training. Also the dataset provided pleads to blurred images of the localized image due to camera quality. This reduces the accuracy of the segmentation process to a large extent.

6 Future Work

Here, we outline possible tasks that can extend this project and/or improve the accuracy of the overall process.

- We can track the number plate once found in the subsequent frames in the given video so that we do not have to re-process the same plate in the next frame. This will reduce the overall time taken and make the algorithm more robust as well as efficient. [12]
- Number plate detection for motorcycles can be incorporated by allowing aspect ratio variations and some changes in localization techniques
- In India, we have number plates in regional languages too. The dataset can be increased to include such variations
- By enough experimentation for tuning parameters, Optical Character Recognition can be modeled using neural networks for achieving state of the art accuracy [13]

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