License Plate Recognition:

A Comparative Study on Thresholding, OCR and Machine Learning Approaches

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***Abstract*- License Plate Recognition (LPR) aims to locate and extract vehicle plate information captures from images or videos. In this paper our objective is to bring forth a comparison based upon the considerations like average accuracy, precision and recall between algorithms according to threshold values, character recognition. The system thus formulated captures real-time input image. It identifies the license plate from extracted image. The work presented in this paper mainly focuses on classification and recognition of characters using Viola Jones Machine learning algorithm. LPR is the most interesting and challenging area of research due to its importance to a wide range of commercial applications, ranging from automated payment services (e.g. Parking and toll roads payment collection), traffic related applications such as road traffic monitoring, searching of stolen vehicles, airport gate monitoring, speed monitoring for more critical applications, to border crossing security and traffic surveillance systems.**

Keywords- License Plate Detection and Recognition, Image Segmentation, Threshold, Optical Character Recognition, Computer Vision System, Machine Learning algorithm.

I. INTRODUCTION

LPR is used to store text from a license plate. It was invented in 1976 at the Police Scientific Development Branch in the UK [1].It is used in identification of the stolen cars, invalid license plate checking, finding smuggling of cars, checking usage of cars in a terrorist attack, etc. Applications in traffic system, electronic toll collection and many others. LPR units are based on images of the front and/or rear plates. In this an image of the car is captured from real time with the help of magnetic loop detector sensor (most popular vehicle sensor). Then it is processed by a series of algorithms including License Plate Localization and Orientation, Normalization, Character Segmentation etc. to obtain the extracted number plate. After extracting a number plate, we convert the captured license plate image into a text entry. We used three different approaches for this process. There are more false negative images in threshold process. OCR (Optical character recognition) does not give correct output for all images. The machine learning algorithm is best among these. Previous work in this area and some algorithms are presented in Table 1. We intend to develop a system in MATLAB which can perform detection as well as recognition of car number plate. We can get our License Plate Recognition done in three sequential steps that involve detection as well as capturing a vehicle image followed by detection and extraction of the number plate and then finally using image segmentation technique to get the individual characters [2]. These are the fundamental steps used in order to carry out the LPR process and can be described as follows:

- *DETECTION OF IMAGE*: Object detection is the process of finding out objects (in this case license plate). Object detection algorithms recognize instances of an object category using features.
- *EXTRACTION OF NUMBER PLATE*: The objective of Feature extraction is achieved in multiple steps. It starts from an initial set of measured data. Next, intended values are build for the feature to be illustrative and non-redundant. This expedites the successive learning and generalization steps, and in some cases leads to better human interpretation.

Table 1 Pervious work

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Study	Target application	Method	Result	Limitation/ comment
Sarfraz et al. [8]	License Plate Extraction & Character Recognition.	Sobel algorithm, filling algorithm and Segmentation.	License Plate Extraction: 587/610, overall system efficiency: 95%	Detection only for some specific colors.
Ozbay et al. [9]	Extraction of plate region & recognition of characters	Edge detection algorithms, segmentation, smearing algorithms, filtering and template matching.	Extraction of plate region:97.6% Overall system efficiency: 92.57%	This system is drafted for Specific license plates of Turkish.
Sulehria et al. [10]	Image Enhancement & Recognition	Histogram equalization method, thickening, Morphological Operations, Implementation of neuron model.	Overall system efficiency 95%.	Technicalities should be improved
Chen et al. [11]	Recognition	Hough Transform (HT), recognizing license, Optical Character Recognition.	Extraction of plate region: 95.7%. Overall system efficiency: 93.1%.	Deliberated for the recognition of Chinese license plates.
Suri et al. [12]	Edge Detection	Sobel Edge Detection filtering of noise by Median Filter, Smoothing, Edge detection algorithm	All over system result is not mentioned in this paper.	Due to improper light segment or varying illumination effects detection is not clear.
Kumar et al. [13]	Extracting the Plate region and recognition	chain code concept is used with different parameters.	Overall system Efficiency: 98%.	Drafted for Malaysian license plate.
Muhammad et al. [14]	Localization & recognition	In this paper noise alleviation, changing color Space is used along with Feed forward neural	Overall system Efficiency 91%	Detection only for English and Parisian number plate.
Asthana et al. [15]	Number plate recognition & Detection	Techniques used in this are Image conversion, neural network, mpl algorithm and matrix mapping.	Overall system Efficiency: 96.5%	The image is captured from the distance of 2-3 Meters.
Sharma et al. [16]	Extraction	Histogram equalization, edge detection algorithm (canny operator) is used along with various morphological operations.	Overall system accuracy: 89.74%.	Sensitive to physical appearance, angle of view and surrounding conditions.
Lee et al. [17]	Extraction and Training	Process by 2D Haar, locate and extract the license-plate along with training and real time recognition	Overall system accuracy:93.0%.	Fast execution speed but in this paper only specified cameras used
	License Plate recognition & character recognition	a) Number plate recognition using threshold b) optical character recognition c) Viola jones: a machine learning approach	an average accuracy of 80%	

The key step in this is Feature extraction that directly affects the rate of recognition [3].

- *IMAGE SEGMENTATION*- On the basis of characteristics, image can be fragmented into multiple segments through a technique called image segmentation. An immediate goal of this process is to simplify the image and to obtain more meaningful information. In initial process noise is removed, then the result is passed to further to segment the individual characters from the extracted number.

SYSTEM MODEL

There are two categories of LPR system: software model and hardware model. Models are described below in detail.

Image processing technique is used in software model.
ANPR algorithm:
• Capture image
• Extract the plate from the image
• Recognize the numbers from the extracted plate [4].

GENERAL METHODOLOGY

a) NUMBER PLATE RECOGNITION USING THRESHOLD

EXTRACTION: Image conversion is done after apprehending the image into gray scale and then in binary which consists only 1's (white) and 0's (black) on the basis of threshold. Then a threshold of fixed value is applied, such that every edge with magnitude less than that is considered false edge and is set to 0. The sub-image thus obtained determines the exact location of the license plate. [5].

SEGMENTATION: In this technique the vehicle number plate is segmented to obtain each character individually. Applying certain filters such as gaussian filter or sobel operator separates characters from each other. Then normalization is applied. This is done to avoid extra white space surrounding the character.

CHARACTER RECOGNITION: In order to recognize the detected characters, we'll match each segmented image with a standard character template and accordingly the output will be printed on the notepad.

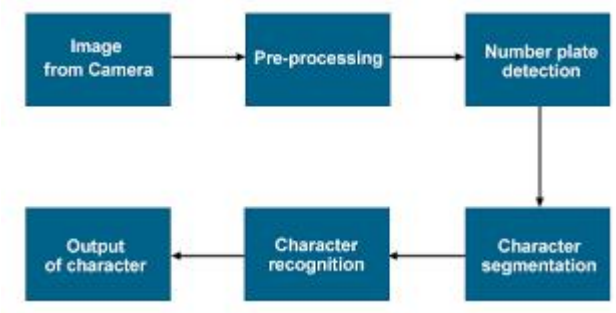

Fig (a) An overview processes taking place

b) OPTICAL CHARACTERRECOGNITION

In the previous approach we observe that we get false positives along with the desired output. Therefore, to overcome the discrepancies faced in the former algorithm we use a direct OCR function which enhances text identification of computer vision applications which includes document analysis, image search and robot navigation. The OCR function finds characters with low confidence followed by obtaining the bounding box locations of these low confidence characters. This information hence enables us to identify the location of the misclassified text within the image.

CHALLENGES OBTAINING ACCURATE RESULTS

A uniform background ensures maximum accuracy. On the other hand, a non-uniform background requires additional pre-processing steps in order to increase its efficiency.
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TECHNIQUES TO IMPROVE RESULTS

Image Pre-processing
ROI-based processing

IMAGE PRE-PROCESSING: The poor text segmentation which is a consequence of non-uniform image background can be dealt with. A pre-processing technique called binarization is used to remove the background variations and improve text segmentation. Along with binarization, morphological reconstruction can also be done to produce a cleaner image for OCR.However, noise issues still persist and some of the discrepancies such as false recognition of letters remain intact. This error in case of two characters having similar shapes and OCR function becomes inefficient and is unable to determine the best classification for a specific character. So, in order to get rid of such a problem the locateTextmethod, that supports regular expressions so that irrelevant text can be ignored, is used.

ROI BASED PROCESSING: This technique is not 100% efficient so other techniques are used along with this to find better results. The region of interest can be selected either manually or automatically. One method for automating text detection is the use of *vision.BlobAnalysis* i.e. The blob analysis System object [6].

VIOLA JONES: A MACHINE LEARNING APPROACH

OVERVIEW: Machine Learning is a subfield of Artificial Intelligence (AI). Conceptually, it deals with "construction and study of systems that can learn from data". It is the fundamental block to make computers learn to behave more intelligently. Theoretically, there are various techniques with various implementations. In other words, "A computer program is said to learn from experience (E) with some class of tasks (T) and a performance measure (P) if its performance at tasks in T as measured by P improves with E".

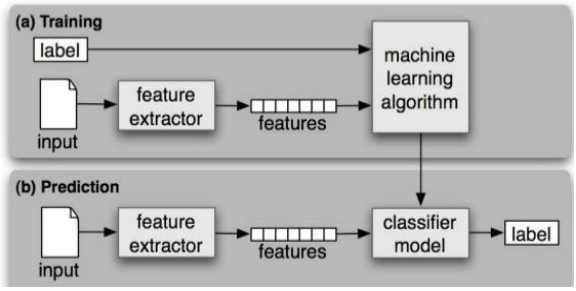

Fig (b) Workflow

Viola Jones object detection algorithm was initially proposed by Paul Viola and Michael Jones in 2001 and improved by Rainer Lienhart in 2002 [7]. Usually called Viola-Jones, its original motivation was face detection, but we have trained it to detect different object classes. It combines four key concepts:

Simple rectangular features, called Haar features
Integral Image concept for rapid feature detection.
AdaBoost machine-learning method.
A cascade classifier to combine all features efficiently

HAAR FEATURE

The presence of a Haar feature (a simple rectangular box) is determined by subtracting the pixel values of the dark region to the pixel values of the light one. Feature is available provided the difference between these pixel values exceeds the threshold limit.

INTEGRAL IMAGES

The Integral Image definition is used to determine the efficiently extracted Haar features used in the Viola-Jones detector. Their computation requires summing the pixel values covered by the rectangles known as an integral image or as Summed Area Table. This table is built by computing, for each pixel, the sum of all pixels above it and the sum of the pixels on its left. Haar features can be efficiently computed with the help of this table, in constant time.

ADABOOST

The selection of which specific Haar features must be used and the threshold levels, AdaBoost machine-learning method combines many "weak" classifiers (they give a little more often the right answer than a random decision) to create the "strong" one. It also assigns weights for each one and this weighted combination creates the strong classifier. AdaBoosting establishes that the filters are placed sequentially in a cascade i.e. the filter with a filter with higher weightage comes first to eliminate non-number plate regions as quickly as possible.

METHODOLOGY FORMULATED

We chose our dataset from this particular site: http://www.zemris.fer.hr/projects/LicensePlates/hrvatski/rezultati.shtml and categorized it into two parts out of which 70% was the training data set and 30% was the testing data set.

SEQUENCE OF STEPS: We passed an image through Haar which will extract probable features (computed by comparing the output difference with some threshold value) and the integral image, also known as Summed Area Table will compute the efficiency of extracted haar features followed by adaboost machine-learning method which will remove the redundant features.

TRAINING: The feature thus extracted by adaboosting is passed through Support Vector Machine (SVM) classifier along with the label (1 for positive image and 0 for negative image) of the image. This results in classification and hence storing of image as either positive image or negative image according to the respective label provided

TESTING: Whereas 30% of the images which lie in the testing dataset when passed as input images are not provided with a label and are directly passed through the sequence of steps mentioned above. The classifier which

now has been trained on 70% of the images classifies the images undergoing testing as either label 1(for positive image) or label 0(for negative image).

OBSERVATIONS AND INFERENCES

Out of 510images in the dataset mentioned above, we tested our algorithm on 70% of the total images and could find an average accuracy of 80% in each of the three implementations.

Consider a common input image shown below:

Fig (c) Rear view of a License Number Plate

ON THE BASIS OF THRESHOLD:

On testing of the threshold regulation algorithm, the following output image was obtained:

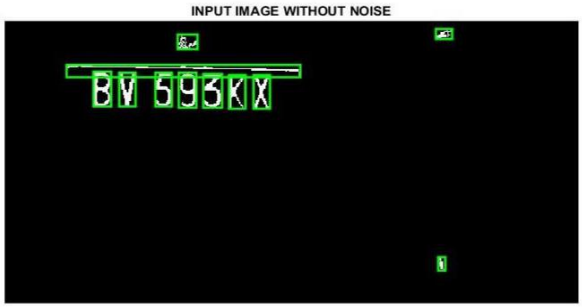

Fig (d) Character Segmentation

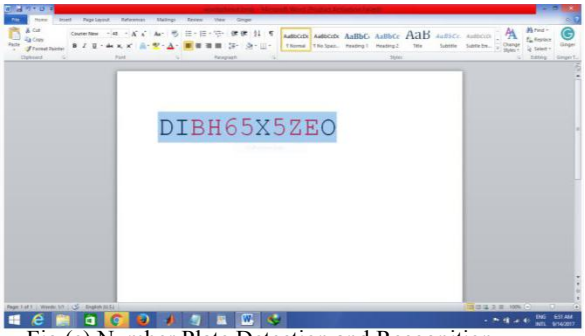

Fig (e) Number Plate Detection and Recognition

We observe that we get false positives alongwith correctly detected characters. This may vary differently with different cars of several contrasting colors, different angles of position of number plate etc. Thus, a better approach of obtaining the same result can be depicted as follows:

USING OCR FUNCTION:

Fig (f) Character Segmentation using OCR function

As we can infer from the above output image that there is a noticeable decrease in the number of false positives, OCR function definitely proves to be a better method.

USING VIOLA JONES ADABOOSTING ALGORITHM

From the above outputs it is observed that the machine learning approach is the best among these.

RESULTS AND DISCUSSION

The proposed work is license plate recognition using Viola Jones algorithm. We compared the output obtained from this with outputs of threshold and OCR technology. Among the three proficiencies tested, we conclude that the machine learning approach that made use of untrained viola Jones algorithm was the most efficient.

FUTURE OBJECTIVES

In the techniques stated above every algorithm has their own disadvantages. All the three methodologies lose out at some point on the account of accuracy of detection and processing speed. Hence fuzzy logic classifiers can prove to have an edge over the methods presented in this paper which will support to identify the plate and characters with better precision. The fuzzy logic classifiers will be able to put on adequately in applications where standard edge detector methods fail due to noisy nature of remotely sensed data.

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