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Implementation of License Plate Recognition System in ARM Cortex A8 Board

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Abstract

Automatic License Plate Recognition (ALPR) is a computer system which automatically recognizes the license plate from the digital image ie. from captured image of vehicle. This system involves various processes such as Image Capturing, Localization of Number Plate, Segmentation of characters and Optical Character Recognition (OCR) of the alphanumeric characters. The main aim of this system is to design and develop an efficient image processing techniques and algorithms for localization of license plate in captured image, segmentation of characters from that license plate and recognition of each characters from the segmented part using Open Computer Vision Library. This system has been implemented in single board computer called Beagle Bone Black with the support of OpenCV and python programming language. Many applications can be developed using this system such as security, highway speed detection, light violation, handwritten text identification, detecting stolen cars, and automated toll collection systems.

Keywords: Beagle Bone Black, Localization, OCR, OpenCV, python, Segmentation

1. Introduction

Nowadays the usage of cars and other vehicles are keeping on increasing across the country. All those vehicles have their unique vehicle identification number as their primary identifier. This identification number is actually a license number which indicates a legal license to participate in the public traffic. Each and every vehicles in world should have its own number plate that should be mounted onto its body (at least at the back side). The need of vehicle identification has been increasing in parallel to the number of the vehicles. This recognition system helps in the cases of security, automatic switching systems, highway speed detection, light violation, detecting stolen cars, man-free and automotive toll collection systems. Automatic License Plate Recognition system replaces the task of manually typing the license plate number of the passing vehicle into the computer system.

To have a proper recognition of a character, License plate recognition system consists of three main topics. They are, finding plate location from digital images, character segmentation from the plate images and Optical character recognition. The most primary and important step is identifying the exact location of license plate in captured image. Localization of license plate can be identified by either shape analysis or color analysis method. In license plate area the unwanted blobs are removed by connected component analysis.

Most of plate recognition systems are developed using Matlab and implemented in either computers or laptops. But in this paper an ALPR(Automatic License Plate Recognition) system has been developed using the Open Computer Vision Library and python programming. Instead of computer and laptop, the Beagle Bone Black which is a single-board computer is used for implementation. This single board computer with opencv package has the ability of image processing in an efficient manner.

2. Related Works

Research on License Plate Recognition is still challenging one. It involves three main steps. They are number plate area identification, character segmentation and character recognition. For each step various methods have been proposed to improve the efficiency. One such a method [1] used adaptive thresholding for highlighting characters and suppressing background. In order to eliminate undesired image areas, a connected component algorithm is first applied to the binary image converted from original plate. A special algorithm called Image Scissoring is used for segmentation Finally Optical Character Recognition engine called tesseract, which returns the ASCII of the license number. The whole system has implemented using opencv.

Another approach [2] is based on the use of feed forward back propagation method to classify the characters. The Artificial Neural Network is trained using the Back Propagation algorithm. The steps in pre-processing involves Size normalization, Binarization and Edge Detection. The horizontal and vertical histogram and connected component analysis are able to handle the character segmentation problem.

[3]Another method in which Character regions are selected through Binarization, connected component analysis. A blob analysis method removes unwanted blobs, combine the fragmented blobs, and splits clumped blobs. This module achieved an accuracy rate of 97.2% in character segmentation. The recognition accuracy rate was 90.9%.

[4]presents an approach based on efficient morphological operation and Sobel Edge Detection method. This approach is simplified to segmented all the letters and numbers used in the number plate by using bounding box method. After segmentation template matching approach is used to recognition of numbers and character. This whole system was implemented by using MATLAB

[5] explains the overview of the connected component analysis and different processes such as Aspect Ratio analysis and pixel count analysis are discussed.

In [6] author studies the comparison of four algorithms are cascade classifier using statistical features, Hough Transform and Contour algorithm , mean shift approach and morphological operations and showed their results.

Handwritten text segmentation [7] has been done by Morphological Watershed Algorithm. The noise removal, Slant Correction, Binarization and normalization has been done in preprocessing stage. After segmentation process extraction of segmented image has done by reversible integer to integer wavelet transform. Then classification is done by neural classifier.

3. License Plate Recognition System

The series of steps in ALPR system are implemented in Beagle Bone Black as shown in block diagram

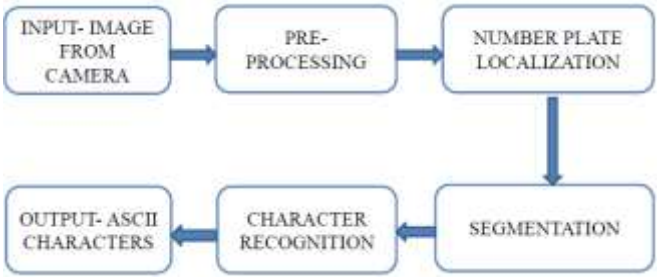

Fig. 1. Block Diagram

3.1 Input Image From Camera

The number plate of the vehicle is captured from high resolution camera. The accuracy of number plate recognition system depends on captured image. The captured image is in RGB format and this should be converted to gray image

3.2 Preprocessing

Preprocessing is the set algorithms applied on the image to enhance the quality through which gray image has been converted into binary image. Before converting into binary image the smoothing of image is done in order to reduce the noises. Preprocessing can be done by thresholding algorithm. There is various type of thresholding such as

- Global Thresholding
- Adaptive Mean Thresholding
- Adaptive Gaussian Thresholding

Global Thresholding: Thresholding is a non-linear operation where the two levels are assigned to pixels that are below or above the specified threshold value. Threshold value is fixed. The grayscale image to a binary image conversion is done according to the formula

$$\mathtt{dst}(x,y) = \begin{cases} \mathtt{maxValue} & \text{if } \mathtt{src}(x,y) > T(x,y) \\ 0 & \text{otherwise} \end{cases} \quad (1)$$

where T(x,y) is a threshold calculated individually for each pixel.

Adaptive Mean Thresholding: Threshold value is the mean of neighbourhood area.

Adaptive Gaussian Thresholding: threshold value is the weighted sum of neighbourhood values where weights are a Gaussian window.

3.3 Number Plate Localization

The license plate is extracted using either shape analysis or color analysis method. In general license plate is in rectangular shape. Hence algorithms look for geometric shapes of rectangular proportion. In India, most of the license plate is in white color or yellow color, hence color analysis can also be used. Before finding the rectangular region in an image, image should be in binary image or edges in an image should be detected. Then relevant rectangular corners have to be found and connected. Finally connected regions are bounded with box and all the rectangular regions of interest are extracted.

3.4 Segmentation

Once the license plate is extracted each character should be segmented. For segmentation connected component labeling is used in computer vision in order to detect the connected regions in binary digital images. Connected component labeling works by scanning an image, pixel by pixel from top to bottom to find the connectivity of the pixels and the connected pixels are labeled. In 2D images

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the pixel connectivity can be varied into 4-connectivity or 8-connectivity[8].

3.5 Character Recognition

For character recognition, segmented characters in license plate should be matched with templates which has already been created. The recognition process returns the license number in ASCII format and saved in text document. In [9] the recognition as a two-pass process. In the first pass, an attempt is made to recognize each word in turn. Each word that is satisfactory is passed to an adaptive classifier as training data. The adaptive classifier then gets a chance to more accurately recognize the text.

4. Experimental Setup and Results

The proposed ALPR system has been implemented in Beagle Bone Black board. The board must be either connected to monitor via micro HDMI to VGA cable or connected to laptop via VNC(Virtual Network Connection) connection. This board includes a 2GB on-board eMMC flash memory chip. In addition to the eMMC, the board can also boot directly from a microSD card. In this system Debian operating system has been booted in Beagle Bone Black board through microSD card. Then Opencv3.1 and python package has also been installed in Debian operating system and hence the image processing techniques can be implemented. The advantage of using OpenCV over MATLAB are effectively reduce the image processing time, free of cost and portability. The license plate recognition system implementation in Beagle Bone Black are explained below.

4.1 Captured Image

First step in this system is capturing of vehicle image from the digital camera. Here an image is captured from 2 mega pixel camera. This image will be stored as JPG format on the camera. Then captured image is stored in Beagle Bone Black board.

4.2 Preprocessing Output

This step converts captured RGB image into a gray scale image. Then the gray image is converted into a binary image by means of adaptive thresholding method. Thresholding is simplest way to segment objects from a background. If background is relatively uniform then global thresholding can be used. For large variation in background intensity adaptive thresholding is used.

Fig. 2. Captured Imag3

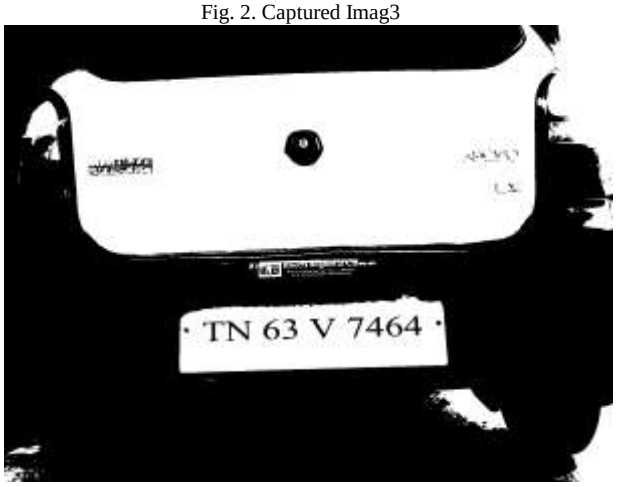

Fig. 3. Global Thresholding

In Global thresholding, the threshold value is taken as 127. If the pixel value is below 127, it will be taken to pixel value 0 which is considered to be black. For the pixel value above 127, it will be taken as pixel value 255, which is considered to be white color.

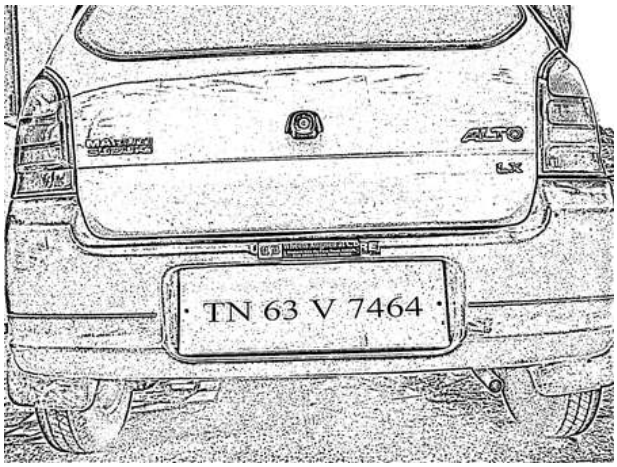

Fig. 4. Adaptive Mean Thresholding

In Adaptive Mean Thresholding, threshold value is taken as the mean of neighbourhood area.

Fig. 5. Adaptive Gaussian Thresholding

For Adaptive Gaussian Thresholding, threshold value is the weighted sum of neighbourhood values where weights are a Gaussian window.

4.3 Localization of Number Plate

From the global thresholding image, the rectangular region is identified by contour shape analysis method and the identified region of the license plate is bounded. This method can be explained simply as a curve joining all the continuous points (along the boundary), having same color or intensity. For better accuracy the binary image is given as input. Contour finds the many regions in the binary image, to find the exact license plate region contour area for all the regions are found. After that contour area is matched with range of license plate area, so that exact license plate region can be found.

Fig. 6. License plate region identification

The license plate region is also identified at different distances.

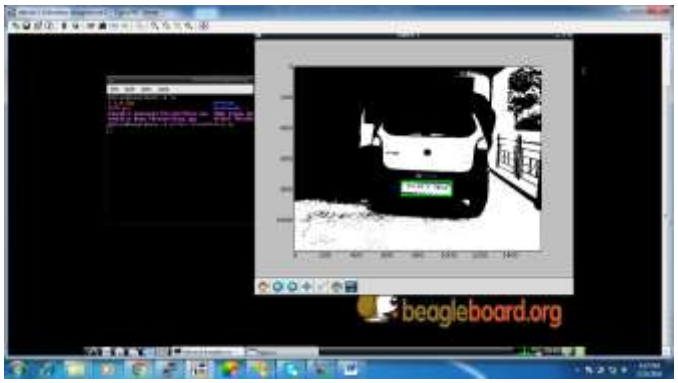

Fig. 7. Identification of license plate region at far distance

Once the license plate is identified, the license plate region is cropped and displayed in gray format. Grayscale number plate is transformed into binary invert image according to the formula

$$\mathtt{dst}(x,y) = \begin{cases} 0 & \text{if } \mathtt{src}(x,y) > T(x,y) \\ \mathtt{maxValue} & \text{otherwise} \end{cases} \quad (2)$$

where T(x,y) is a threshold calculated individually for each pixel

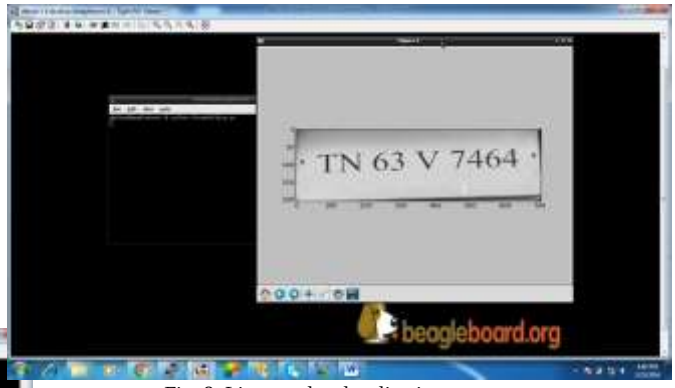

Fig. 8. License plate localization

Fig. 9. Binary image of license plate

4.4 Character Recognition

Tesseract is an Optical Character Recognition engine for various operating system. It is free software developed by HP [1]. The License plate image is given as input to OCR engine and which returns license plate number in ASCII character. Those characters are saved in text file.

Tesseract OCR works in step by step process. The first step in tesseract is thresholding. Next step is connected component analysis, which is used to extract the outline. After that the outlines are converted into blobs. Then Text is divided into words using definite spaces and fuzzy spaces. Recgnition of text is then done in two pass. In first pass an attempt to recognize each word from the text. Then each word is passed to an adaptive classifier as training data. The adaptive classifier tries to recognize text in more accurate manner. Second pass is to extract text from images[10]

Sometimes the unwanted blobs were also recognized as some special characters. Finally the unwanted characters are eliminated and only license plate number is displayed.

Conclusion

In this system, license plate number was successfully recognized by using opencv and python programming. The whole design was implemented in Beagle Bone Black processor board. The working of the system was tested with various images of vehicle. The identification of the number plate using shape analysis method was sometimes failed to detect the exact region of the plate. Future work is to develop the character recognition using template matching algorithm.

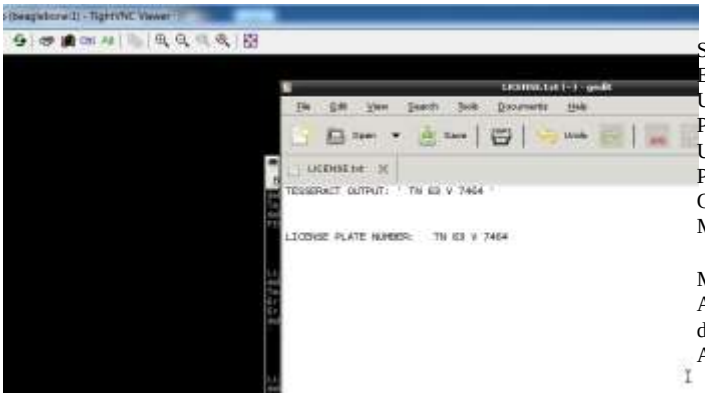

Fig. 10. Characters are recognized and saved in text file

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