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SMART AUTOGATE USING OPTICAL CHARACTER RECOGNITION (OCR) AND COLOR DETECTION

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ABSTRACT

This paper proposed a project entitled Smart Auto gate using Optical Character Recognition (OCR) and color detection. It consists of two sections that used an image processing technique which are License Plate Recognition (LPR) and Color Detection. Image processing has been widely used in various types of field. LPR is one of the systems which used an image processing technique to extract the vehicle's number plate from an image or from a video in an editable text. Most LPR are being used in monitoring activities and for security aspects. The purpose of this paper is to implement the combination of LPR with color detection in home automatic gate. MATLAB were interfaced with Arduino Mega 2560 to represent the system. For color detection, the output was triggered once the desired color programmed in MATLAB was recognized through the camera. Basically, LPR involves a process starting from image acquisition, preprocessing, segmentation and finally recognition. OCR was used in the recognition process to recognize each character on the license plate. There are 10 cars in total that had been experimented with LPR and the character confidences obtained for alphabetic character is 87.28% success rate and 77.83% for number character.

INTRODUCTION

Smart Auto gate using Automatic License Plate recognition (ALPR) is a proposed project using computer image. There are over 1 billion cars on the street of the world today. Despite the rapid growth of the vehicle on the streets, it also led to a bad behavior of certain people. Crime rate keeps increasing day after day and there are so many reported and recorded case regarding car theft and burglary. In 1899, Mr. C. Barthes had been provided with the first license plate by a German police [1]. This is the first ever plate number ever invented. ALPR was developed in early 1979 for UK police to implement in any monitoring field [1]. Nowadays, ALPR has become an important section of the intelligent systems for vehicle monitoring system. ALPR can also be applied in various types of field. It can be used with either on current television network or speed trap camera at highway. This high-end technology is widely used by police enforcement as a method of electronic toll system collection, border control, detect and monitoring traffic activity [2] [3]. With this ALPR system, the crime rate such as car theft and speeding car are believed to be reduced. For this project, ALPR will be applied to our current home automatic gate. It has the ability to access the control system automatically. On par with the name SMART home, it makes our home more sophisticated. In fact, ALPR act as a top-notch security as it is an alternative way to prevent car theft or burglary. Basically, this system operates by a process monitoring followed by acquiring the image, localization, segmentation and recognition. The system is design to automatically trace the license plate of the car and at that moment recognize the character from the license plate using various types of algorithm [4][5]. In year 2004, Color Edge Detection and fuzzy maps were used for number plate recognition. There are 2 steps involved which are Pre-processing and OCR (Optical Character Recognition). After binarization process using a variable thresholding technique is completed, at that point Connected Component algorithm was adopted to the binarized region to remove unwanted zone. OCR can be used as the character recognition for license plate numbers [6][18]. In (2015) Sai Krishna had proposed an Automatic License Plate Classification using computer software. In his project work, color adjustment, edge finding and elimination of noise with the adoption of some filter is examined. His thesis work proposed a method using simple morphological operations and filtering.

Finally, the work concluded that the proposed method was succeeding and suited for recognition of Indian number plates [19]. Recently there are more deeply investigated in the area of recognition and classifications such as by Darmawan *et al*. (2020) and Zakaria *et al*. (2020) [20][21]. The objective of this research is to design and develop a smart auto gate that able to detect the vehicle's plate number and detect the vehicle's color using image processing technique with the help of OCR algorithm. The process of image processing will be analyses using MATLAB which act as a medium to program the system and it will be interfacing with Arduino Mega 2560. In this paper, it covered the process of ALPR with a combination of an additional color detection.

PROPOSED ALGORITHM

This section elaborated in detail the method and the proposed algorithm used.

Digital image processing

Computer algorithms are used to process images. Digital image has more advantages over analog image during their development process. It permits a substantially wider scope of the algorithm to be applied to the input data. Digital image processing also can be applied to overcome problem such as noise and signal alteration [7][17].

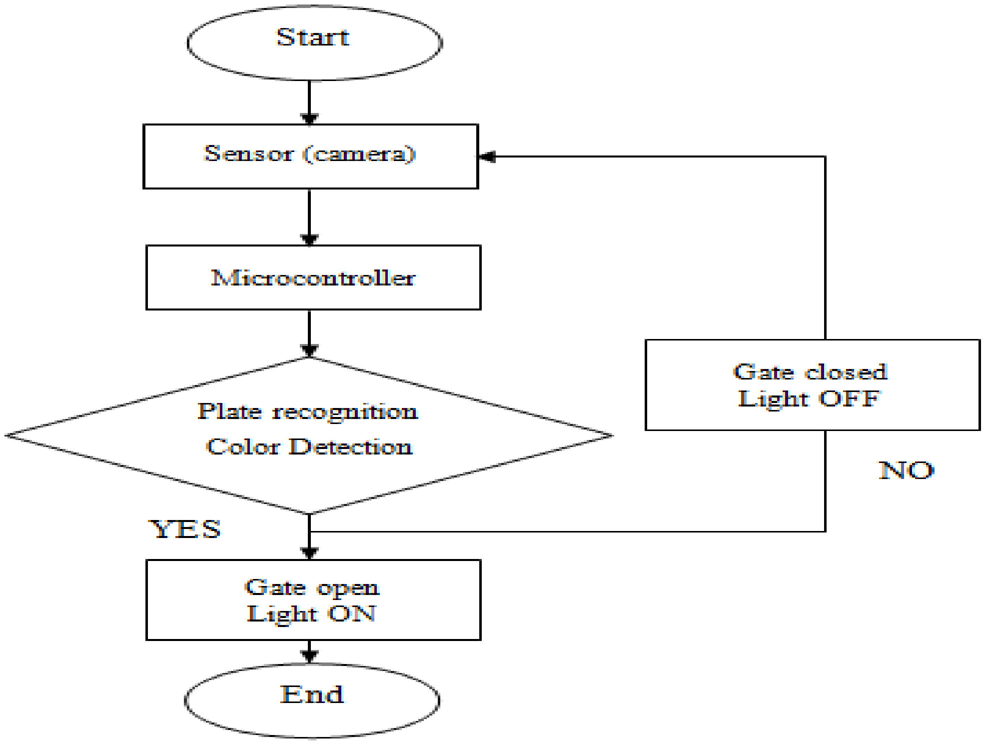

Figure 1 Smart Auto gate using OCR and Color detection.

Figure 1 shows the sequence of processes for this whole Smart Auto gate using OCR and Color detection. First of all, the camera which acts as a sensor will start to operate and detect whether there is an existing car within the range. Once the camera detected a car approaching the gate, the image processing system will start to run. Arduino Mega 2560 act as a microcontroller to control the overall process. There are two requirements for the car to access the gate which is authorized plate number and color of the registered car. ALPR processes are discussed in subsection 3.2 while color detection process is discussed in subsection 3.3. If the car recognized as an authorized vehicle, it will trigger the gate motor to start operate and open the gate. If unauthorized license plate detected, the gate will remain closed. There are two types of image processing system involved in this project, which are a) License Plate Recognition and b) Color Detection.

License plate recognition

An image with a number plate act as an input to the program and the number plate must be located as an output image for the next stage.

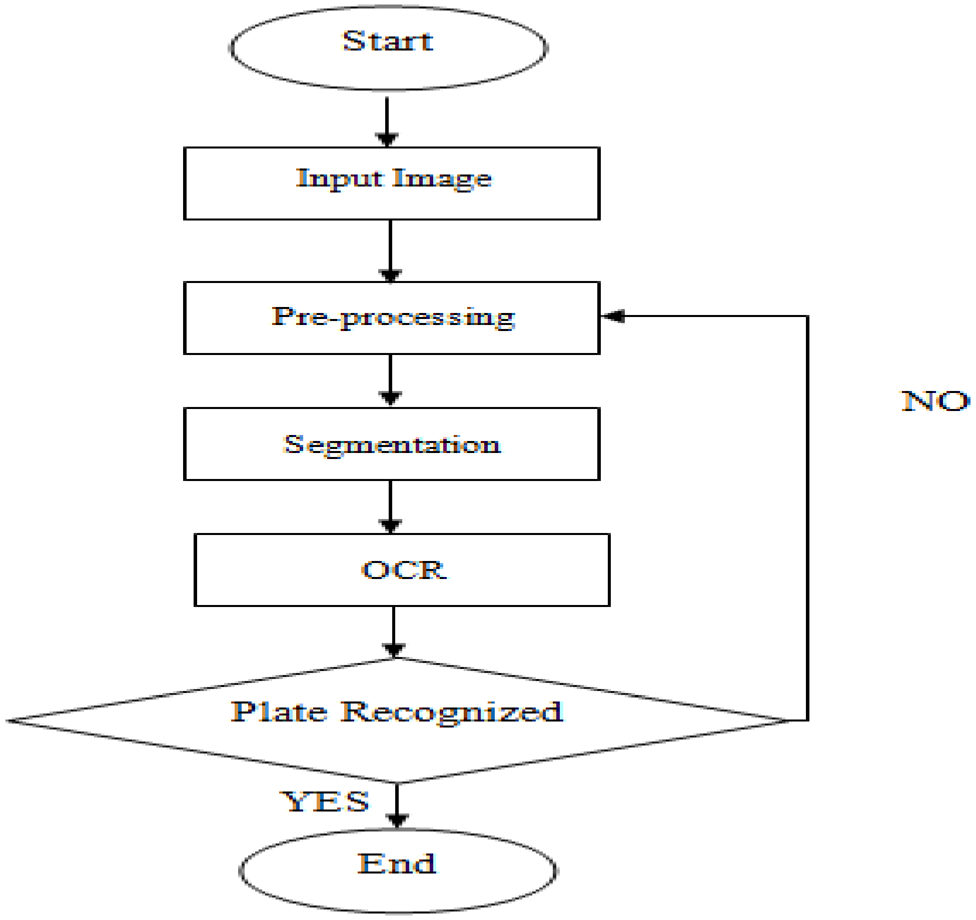

Figure 2: Procedure of number plate's recognition.

In order to recognize the number plate's character from the input image, several processes (such as presented in Figure 2) need to go through before it can be recognized. These processes can be described as follows:

Image acquisition

Image acquisition is an essential stage for ALPR. It can be acquired using existing image or from the live screen image. Once the image is acquired, the next stage can be preceded.

Image preprocessing

The obtained image is pre-processed. The main objective of this stage is to improve the low-quality image and reduce the unwanted noise. This pre-process stage is where the resizing and conversion to grayscale image completed. The image size from the camera might be large and need to be resized for the program to run smoothly. The image obtained comes in standard format or transformed into multimedia type of image. It comes in RGB mode and by using MATLAB function, it will eliminate the class and fullness while remaining the luminance to produce grayscale image.

MSER region detection

Region detection was executed to localize the plate number. Maximally Stable Extremal Region (MSER) as a feature detector are required for the next stage to proceed. MSER is one of the best region detectors, but it is sensitive to a blur image [8][9]. It is a blob detection method that was implemented in an image. MSERS have two desirable properties which are perspective transformations of monotonic transformation of image intensities and transformation image coordinates [10]. All pixel on outer boundary processing in the MSER region have either lower intensity or higher intensity [8]. It works well if the region in an image is clear and not out of focus.

$$(i)=|Qi+\Delta \setminus Qi-\Delta |/|Qi| \qquad (1)$$

The regions must endure stable after a confident number of thresholds was checked using equation (1). Maximally stable region was taken if and only if $Qi+\Delta$ is not larger than $Qi-\Delta$ [11].

Geometric properties region

Even MSER appeared to detect the plate's character; there is certain region other than the text that also included together during the execution process. The entire unnecessary region can be filtered out by using geometric properties. For these properties, it required a value of threshold to filter out non-text region. Several geometric properties were used in the programs which are solidity, extent, euler and eccentricity. These geometric properties are a shape measurement used to filter out unnecessary region. The entire connected component was measured using region props tools [12].

Color detection

After ALPR process is completed, the color detection process is needed to detect the color of vehicle approach the gate. Webcam or external camera was used to detect the vehicle with desired color as a program in MATLAB. Video acquisition properties for this color detection were set up first before the process is executed. Figure 3 shows the process used for color detection in this project.

Color extraction

Either live screening or imported video/image, each of the input obtained in a rgb format. This rgb format was then converted to grayscale format. The process of declaring a color value for desired color was performed in MATLAB to extract specific color values from rgb frame.

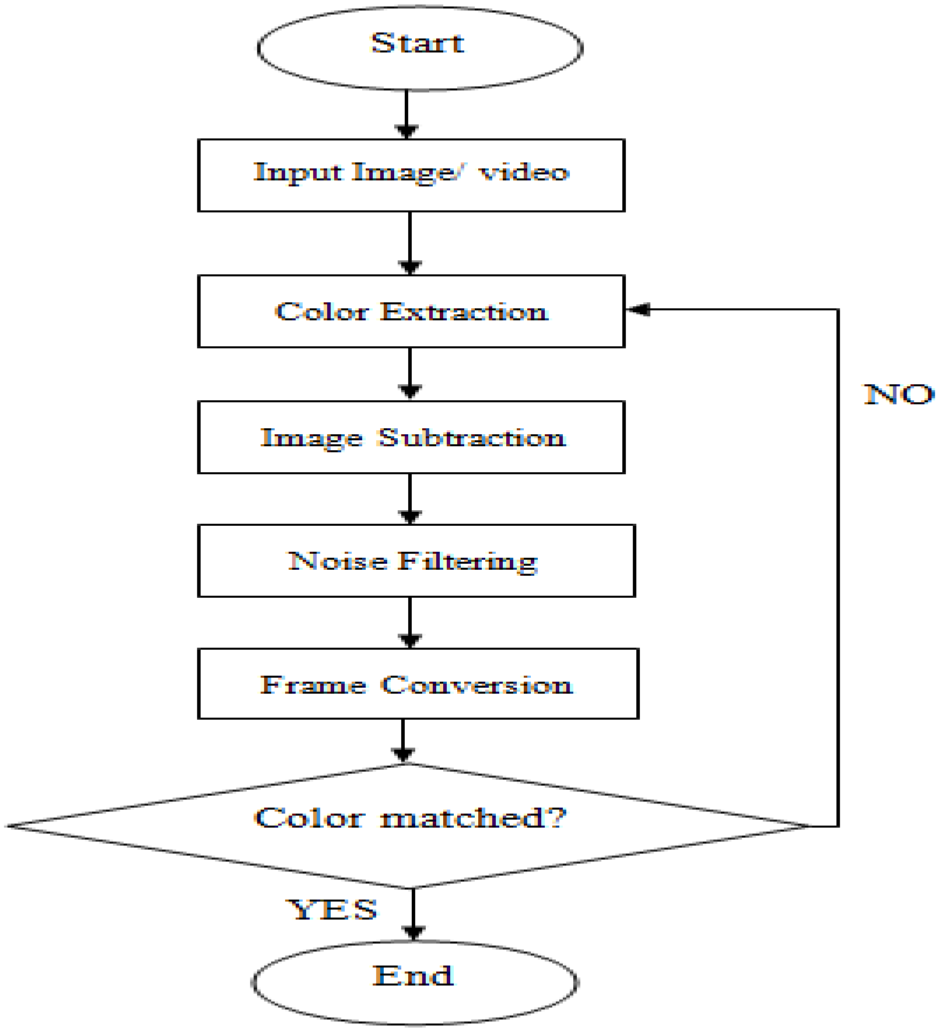

Figure 3: Body Color of Car Detection

Image subtraction

The 2 results obtained until this step which are the grayscale image and extracted desired color are then subtracted by using

$$C = \text{imsubtract}(A, B) \qquad (2)$$

The output of the gray frame represented as B where A represents the desired color frame. Each component in array B is subtracted from the corresponding component in array A and returns the difference in the corresponding component of the output array C.

Noise filtering

Every image, in the image processing contained noise that affects the outcome of the process. In this project, 2D median filter was applied to eliminate unwanted noise from the image. This is the simplest technique to remove all sorts of noise in the image such as pulse noise, spike noise and speckle noise [16]. By using median filter, it preserves edges while removing noise. Median filter can be represented as

Median (D) = Median [D, (m, n)] (3)

The matrix D was filtered in two sizes. Every output pixel contains the median value in m by n neighborhoods. (m, n) is represented (x+i, y+j). This coordinate determines which pixels are to be included in the median calculation.

Frame conversion

The different frame was converted the grayscale image to the corresponding binary image using proper threshold value.

bw = im2bw (I, border) (4)

The output image using Equation 4 will substitutes all pixels by intensity larger than border with the value 1 (white) and switches all other pixels with the value 0 (black). Then image regions properties were measured using regionprops.

EXPERIMENT AND RESULT

The proposed OCR has been realized in computer software. Image for three different angles are taken and execute in the ALPR program. The aim of OCR is to get higher accuracy and the result must match with desired number plate. Table 1 summarizes the accuracy result of the character detected in three angles.

Table 1: Result from 1.8 meter (center angle)

Original Number Plate	Accuracy and Confidences		
	Detected Number Plate	Correlation Test by Character	Average Correlation by Word
VBE	VBE	(0.9304, 0.9551, 0.9681)	0.9512
4698	4698	(0.9489, 0.8813, 0.8901, 0.9028)	0.9058

The confidence level of character was measured from 0 to 1. From the right angle, the detected result was slightly off with the original number plate. Even the confidence level of character result come out quite high, OCR read character [Y] as [ ) and’]. A character that has a similar shape appeared to be hard to read while training. For example [5 and S], [8 and B] and [1 and J]. For the number, it mismatches 8 with 6 and two numbers outside of the bounding box did not include in the result. The result taken from center comes out as the best result for this vehicle with 0.9 above for the average word confidence. Result from left angle come out as 0 array character detected. This problem caused by the position of the expanding region box. The number plate needs to be inside the bounding box area as in Figure 4. to increase the probability of being read by the system. There are certain characteristics that can affect the outcome result which are high contrast, spacing between the characters and line spacing. It is found that the stroke width variation threshold plays a big role in executing the program. Threshold need to be higher in order to detect all the characters more precisely.

There are 14 cars of sample image in total that are tested for plate number recognition and the accuracy were recorded. Table 2 shows the outcome result for 3 cars out of 14 captured from the center of the plate number. For average correlation, OCR will calculate the mean of the correlation result by character. The result of correlation based on alphabet and number is recorded. The sum of choosing character confidences needs to be divided with a total character to get the mean value of a word. From the result obtained, the character confidences obtained for alphabet is 93.3% success rate and 89.8% for number character out of the 14 cars.

Table 2: Correlation Test of Character and the Average Word for 3 cars

Original Number Plate	Accuracy and Confidences		
	Detected Number Plate	Correlation Test by Character	Average Correlation by Word
VBE	VBE	(0.9304, 0.9551, 0.9681)	0.9512
4698	4698	(0.9489, 0.8813, 0.8901, 0.9028)	0.9058
VV	VV	(0.95301771, 0.96674800)	0.9599
5891	5891	(0.9465664, 0.88695335, 0.88128662, 0.61322820)	0.8320
WNY	WN'	(0.91875303, 0.95651478, 0.80239224)	0.8926
1630	1630	(0.90424675, 0.85027248, 0.88373137, 0.89348018)	0.8829

For color detection, Figure 4 shows that detected blue color are in the bounding boxes as programmed in MATLAB. There are 5 bounding box area indicates the location of the detected region. It takes 0.030s for the time used up in a function not including the time used up in its child functions to import the color. On average, the total time for one image to detect the color is 0.5s to 1s. It just needs to change the color value in order for another color to be detected. Once the license plate and color recognition process are completed, it will start to interface with microcontroller and triggered the output.

Figure 4: Blue Color of Car Detection

CONCLUSION

It can be concluded that OCR is one of the simplest techniques and give accurate readings for character recognition. Four process need to be executed as discussed in section II in order to obtain a result. From the results obtained, it sums up 93.3% of recognition rate to recognize a character and 89.8% to recognize a number character. It takes less than 40s for the character to be recognized. The approach of using MSER accelerated the process and gives the most accurate reading. The character might not be able to recognize if the license plate is highly stylized. The use of ALPR in parking area and traffic monitoring system can definitely improve overall quality service in a certain aspect. The combination of ALPR and color detection can help to increase the security level for home automated gate compared to existing ALPR that are being used at the parking entrance gate.

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