The Eurasia Proceedings of Science, Technology, Engineering & Mathematics (EPSTEM)
ISSN: 2602-3199

The Eurasia Proceedings of Science, Technology, Engineering & Mathematics (EPSTEM), 2022

Volume 21, Pages 328-334

IConTES 2022: International Conference on Technology, Engineering and Science

Vehicle Plate Recognition System Using Image Processing

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Abstract: In this study, the license plate reading system, which is needed in security applications, automatic door systems, or parking lot entrance and exit processes, is designed. The main reasons for choosing this system are that it greatly reduces the workload and contributes to the acceleration of operation in areas with heavy traffic. This work has been programmed with image processing methods on MATLAB and will take an image input with an internal or external camera system and give an output to the user. When we look at all the countries of the world, it is observed that there are different shapes and sizes on the license plates. In this study, simple but effective morphological operations and Sobel edge detection method were used so that these differences do not cause the system to make any mistakes. With this approach, the letters and numbers on the plate were divided by using the bounding box method, and an effective study was carried out. After this study, the template matching approach is used to identify the characters.

Keywords: Image processing, Sobel filtering, License plate recognition system

Introduction

Nowadays, the increase in the population has led to an increase in the number of vehicles, and the increase in the number of vehicles has brought with it an increase in the problems in traffic, making it difficult to follow and control the vehicles (Yigit & Celik, 2014). For this reason, the need for traffic control has increased and the License Plate Recognition System is needed. Plates are like unique identification numbers of vehicles (Ozalp & Dugenci, 2011). All information about the vehicle to be detected can be accessed when the license plates of the relevant vehicles are found. This makes the License Plate Recognition System useful and practical.

The main usage areas of the License Plate Recognition System are applications such as places where entrances and exits must be controlled, toll collection systems and toll highways, tracking and identification of vehicles in traffic, and automatic passage systems (Bingol & Kuscu, 2008). The fact that each of these processes is done by humans increases the processing time. Today, the number of vehicles used in traffic is increasing due to the increase in vehicle brands and models, the rapid production of vehicle manufacturing factories with the industry 4.0 revolution, and the increase in the world population. This increase causes the problems of difficulty in vehicle tracking due to the density in places such as parking lots and shopping centers that can be entered by vehicle, as well as traffic density.

License Plate Recognition System is used in many areas such as automatic passage and parking systems, vehicle tracking and detection, traffic control (Yalim & Dogan, 2008). For this reason, there are many studies in the literature on license plate location and license plate recognition. Plate recognition is commonly performed by detecting the license plate region. In the old methods, image processing was frequently used to make license plate recognition. However, features such as the image being dirty and having low contrast have made this method very difficult to use and therefore a lot of preprocessing is required.

In addition to being technological devices that have entered our lives with the advancement of technology, this technology is also used in vehicles. Previously manual vehicles are now automatic, and almost every new model

vehicle is now equipped with rear view cameras (Cavuslu et al., 2008). Thanks to these cameras in the equipment of the vehicles, vehicle and license plate recognition can be done easily through the cameras in the vehicles without the need for any additional equipment. In addition to the problems mentioned, vehicle and license plate recognition is becoming increasingly important in order to understand whether the people in the vehicles are followed in any way (Eldem et al., 2017). In the study, there is primarily the license plate area in the instant vehicle images taken from the camera. The license plate characters in the resulting image are separated from the image. Finally, the characters extracted from the license plate region are given to the optimization algorithms determined for the recognition process and the license plate recognition process is completed.

Determining the Plate Area on the Vehicle

The first step we will take in this study is to find the location of the license plate region (Er, 2004), (Martinsky, 2007). It is important that the license plate area in the vehicle photo is determined correctly and without errors. If a mistake is made at this stage of the process, the data entered and received in the rest of the system will have no meaning, and the plate will not be readable. The original photo of the license plate is shown in Figure 1.

Figure 1. Original photo of the license plate

First, the original photo of the license plate is uploaded to the system. Three color values define pixels on the photograph. These colors are red, green and blue (RGB-Red, Green, Blue). These pixel components take values in the range of 0-255 (Vishali et al., 2007). After the arithmetic average of the R, G and B values of the color photograph taken as input to the system is found, the arithmetic average of the average values of these three colors is found. This value will help us determine our threshold value. After these calculations are made, some pre-processes will be applied to the photo in order to remove unnecessary areas from the photo.

The first step of these processes is to convert the image to gray level. This will prevent unnecessary details in the photo from blocking the system. Photos may have different gray brightness/contrast values as they may have been taken at different times of the day. Photos taken in cloudy or low-light conditions have darker tones, while photos taken under sunlight or bright environments have higher brightness. In order to overcome the problems that may occur due to this imbalance in brightness levels, it is necessary to transform the picture to gray level homogeneously (Arth et al., 2007). The original plate image taken in gray level is shown in Figure 2.

Figure 2. Original plate image taken in gray level

A median filter was applied to the image to remove noise and pollution in this study. The median filter looks at neighboring pixels to calculate the value of each pixel and after sorting the neighboring pixels it takes the value in the middle of the row. If the region has an even number of pixels, the median filter uses the average of these two pixels as the median value (Johan & Prabuwono, 2011). The median filtered plate definition image is shown in Figure 3.

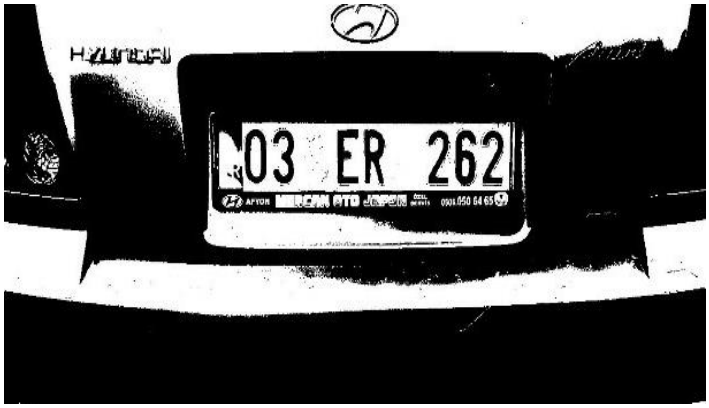

Figure 3. Median filtered plate definition image

The image has an average threshold value. After taking the initial threshold value as any value, the color intensity of the photo is checked. Accordingly, the actual threshold value of the photograph is recalculated. In order to convert the image to binary level, the gray level pixels under the new value are converted to black and the remaining pixels to white. In the binary system created, the numbers with zero represent the black colors and the numbers with one represent the white colors (Beibut et al., 2014). After the binary image created here is transferred to a two-dimensional matrix, all operations are performed on this binary matrix. The binary level image is shown in Figure 4. After the figure 4 is brought to the gray level and binary level, the edges are revealed with the Sobel edge detection algorithm. The Sobel filter reveals a real high-frequency region (sharp edges) that correspond to the edges of an image (Sarfraz et al., 2003). The Sobel filtered image is shown in Figure 5.

Figure 4. Binary level image

Figure 5. Sobel filtered image

The edge information obtained when using the Sobel filter, one of the edge detection algorithms, can be greatly affected by noise (Shapiro et al., 2004). For this reason, it is very important to perform the operations applied in the previous steps correctly. In this regard, MATLAB software has made it easier for us to analyze the image. After applying the Sobel filter, the next step is to highlight the edges. When a Sobel filter is applied to the image, it is observed that there are gaps between the lines representing the edges. This linear space is lost if the Sobel image is expanded using linear structural elements (Martin et al., 2002). Extension; It is performed by stretching the white pixels observed in the image horizontally and vertically after applying the Sobel filter. The image of the plate with its edges highlighted is shown in Figure 6.

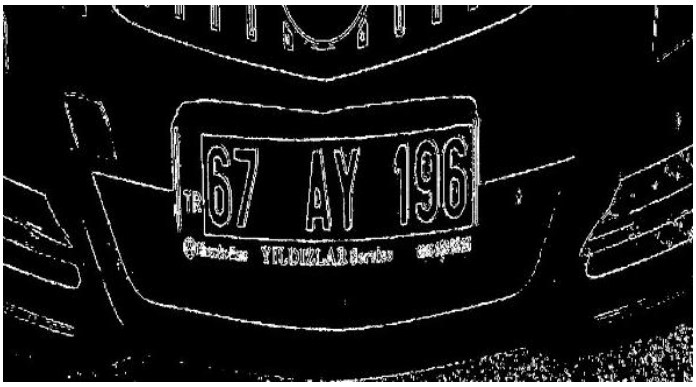

Figure 6. Image of the plate with its edges highlighted

At this stage the outline of the cell looks quite nice, but there are still holes in the cell. These holes are filled with the advantages of MATLAB software. The region of interest has been successfully partitioned, but this is not the only object found. Objects attached to the outer edges of the image can be eliminated using MATLAB functions. This helps to remove the license plate area of the vehicle. The image of filling the blank spaces in the rectangle is shown in Figure 7.

Figure 7. Image of filling the blank spaces in the rectangle

Discharge Character from the Plate Zone

The image with plate location detected is shown in Figure 8. The plate region, which was removed from the image due to the operations performed in the previous stages, was determined. After the plate area is determined in the photograph taken, the next step is to recognize the characters consisting of letters and numbers on the plate. At this stage, what is desired is to purify the characters from foreign objects and reduce the visual pollution as little as possible. Thus, the system can easily detect the characters on the plate and compare with the letters and numbers in the character library. This is the most important part for the results to be error-free. The character purification process consists of three stages: removing foreign objects, calculating the width and height values of the characters, and separating the image into characters (Yousef et al., 2020).

In the purification process, the height values of the characters are calculated by scanning the plate region. In this way, the black areas under the character size limit determined by the system were deleted and foreign objects on the image were cleaned. After the characters on the plate are cleaned of contamination, it is time to recognize these characters and convert them into text information. In this study, template matching method was used. For this method, the characters separated from the plate must be of equal size. Therefore, equalizing the sizes of the characters is essential for the correct operation of the system. After the length of the characters is equalized, their horizontal and vertical projections are extracted.

Figure 8. Image with the plate location detected

This projection is the number of pixels in rows and columns of characters (Srikanth & Kumar, 2022). In this study, the characters are synchronized at 24x42 pixels. Since the matching method is used in this study, the characters on the plate in the image must have the same appearance as the characters in the created library. For this reason, on the final image, blacks are converted to white and whites to black. This converted image is shown in Figure 9.

Figure 9. Converted image

Reading the Characters on the Plate

In the previous stages, the license plate area of the vehicle was determined from the vehicle photo and the characters consisting of numbers and letters on the plate were made clearly visible. Finally, a match for these characters to be made into a text scaling logic has been applied. With this logic, the characters on the plate will match their equivalents in the previously prepared character library and will turn into text with this reference. The identified license plate character library is shown in Figure 10.

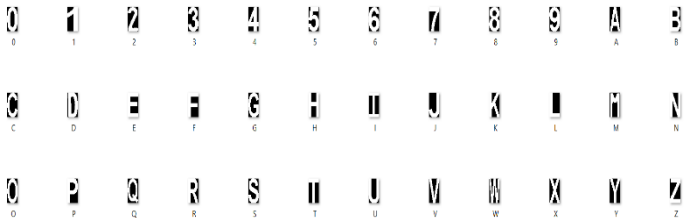

Figure 10. Identified license plate character library

User Interface

An interface has been designed with MATLAB GUIs so that the application can be run easily and this work can be presented to the user in a practical way. The process steps and flow chart of the designed program are shown in Figure 11.

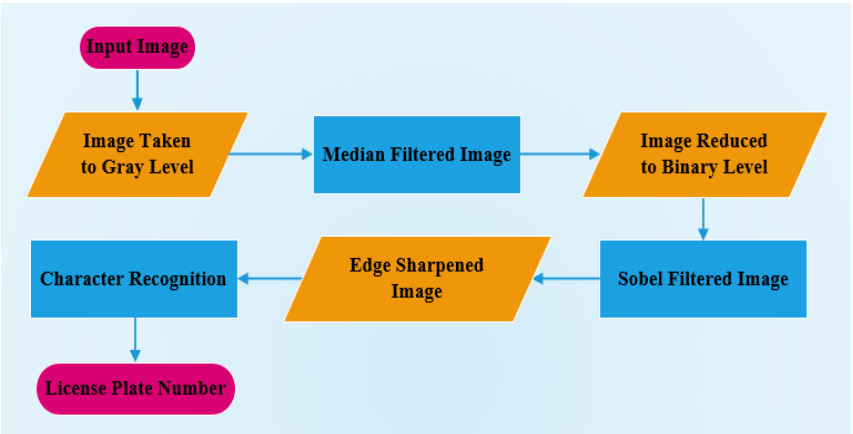

Figure 11. Process steps and flow chart

The designed interface plate recognition program is shown in Figure 12. When the select plate button is clicked on this interface, the system will direct you to the location where the images are located and wait for you to select an image from there. It will appear in the selected visual interface. Then, when the detect license plate button is clicked, the text of the plate will be printed on the output section at the bottom right.

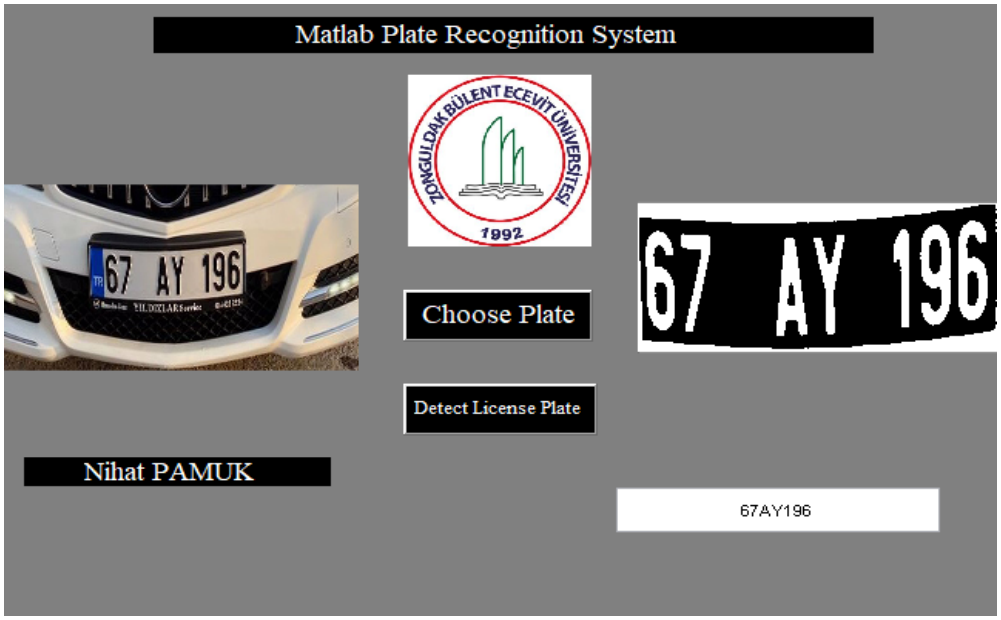

Figure 12. Designed interface program

Conclusions

This study aimed to read the license plate by processing the photograph of the vehicle taken, and high success was achieved in reading the license plate in the tests. While the written program is running, the photograph taken is suitable for the MATLAB software program using a filter. Then comes the process of determining the plate location. The method used for this process determines the rectangular part of the photo. The determined rectangular part is made suitable for reading with the filtering processes used in the MATLAB program. The output is obtained by comparing the characters in the image with the previously created library. Some undesirable situations may occur in the operation of the program. The quality of the photo containing the license plate to be read, the shooting angle, and other objects that may be included in the photo will reduce the program's success rate. For this reason, the license plate photo that is expected to be processed must be taken correctly.

Scientific Ethics Declaration

The author declares that the scientific ethical and legal responsibility of this article published in EPSTEM journal belongs to the authors.

Acknowledgements

* This article was presented as an oral presentation at the International Conference on Technology, Engineering and Science (www.icontes.net) held in Antalya/Turkey on November 16-19, 2022.

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To cite this article:

Pamuk, N. (2022). Vehicle plate recognition system using image processing. *The Eurasia Proceedings of Science, Technology, Engineering & Mathematics (EPSTEM), 21*, 328-334.