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Development of Vehicle License Plate Number Recognition Algorithm in Afghanistan

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The increasing number of vehicles in all cities, not only makes it easy, on the contrary, it causes many problems to identify cars in various fields such as traffic control, management of parking lots, management of security areas, identification of unlicensed cars, etc There are cars whose licenses have expired, stolen cars, and cars with fake license plates in Afghanistan. Overcoming these problems requires the use of various financial and human resources, and human resources will not be able to manage and control the cars efficiently. By using an automatic system to recognize the car's license plate number, the problems can be overcome to a great extent. Although plate recognition algorithms and systems have been built in almost all advanced and developed countries, no system or any type of algorithm that is useful for Afghan vehicle plates has been developed yet. Vehicle plate number identification includes three basic steps, which include identifying the location of the plate; the extraction of plate characters; and the recognition of plate characters using the method of observation and library of all three mentioned steps. The activities performed in those areas have been investigated using the Matlab R2019B programming tool. Among the techniques used in the proposed algorithm are image monochromatic techniques, morphological methods to remove noise and edge detection, the use of histograms to increase the accuracy of plate location detection, the use of perceptual artificial intelligence with predetermined criteria for more accurate detection of the plate location, labeling to isolate the plate characters, and comparison with the original samples to identify the pointed plate characters. The results obtained from the research and implementation of our proposed algorithm are very promising and efficient, so the accuracy of detecting the location of the plate is 98% and the character recognition is 90%. Our method is better than any other proposed method or algorithm that was conducted during research.

Keywords: Image processing, car number plate recognition, Afghan vehicle number plate recognition, Matlab.

1. Introduction

Due to the existence of this huge flood of cars and other vehicles, it is obvious that human power alone and without the use of a computer system is not able to control and manage such traffic, even in small dimensions like a public parking lot. Also, the cost of using human power is very high, and it has very low efficiency. Therefore, the need for mechanization in this field is very strong and workable. In the automatic vehicle plate number recognition system, the main goal is to identify the location of the plate in an image to read the number plate. This

system helps us to extract the plate number that is in an image automatically by the computer from moving images or photos, and we can use them numerically when this system is in operation. By controlling the speed of cars by using the time the cars travel between two bases, the average speed of the car along the route can be obtained. Also, the management and control of cars through the installation of bases in the city, the place of tax collection, and the exit of the cities to prevent the exit or movement of prohibited and stolen cars in the city or outside the city, tracking and identifying the offending cars by installing The above systems are used in places with traffic lights, intersections, and one-way streets, as well as in general areas that need constant police control. It is very useful to create an electronic fine sheet for the police and remove additional operators, etc. Since the beating heart of any system is its algorithm, in this article, we have targeted the development and implementation of the vehicle license plate number recognition algorithm in Afghanistan.

Vehicle control

One of the very useful applications of the motor license plate recognition system is to control how to follow the rules. Having a license plate number is used to detect traffic violations. For example, in the city of Kabul, in some areas covered by the project, only vehicles with special conditions have the right of passage. If the license plates of these vehicles are given to the database, other offending vehicles will be identified and prosecuted. It is also possible to allow certain people to enter or leave only at certain times. One of the important applications of the automatic car plate identification system is to identify stolen cars and thieves. This is done by registering the stolen vehicle's license plate. It is also possible to identify the offender by taking a photo of the driver of the vehicle in question, and by installing a camera and license plate recognition software, the license plates of the cars can be examined. Also, public parking lots can use the automatic plate number recognition system to detect the duration of parking and the parking of cars in the parking lot by recording the time of entry and exit of the car, calculate and collect fees through the credit cards of the subscribers, and eliminate the need for manpower. Reducing costs increases accuracy and efficiency, and by speeding up operations, they attract customer satisfaction.

Problems and obstacles in the development of the plate number recognition system

The influence of climatic and geographical conditions

There is no doubt that the factors influencing the quality of recorded images are atmospheric and environmental factors such as the amount of ambient light and the angle of light. Also, factors such as fog, humidity, rain, dust, etc. have a direct and undeniable effect on the quality of images. In a country like Afghanistan with all kinds of weather and climatic conditions, such as wet weather, cold and dry weather, mountainous weather, desert weather, etc., creating an efficient system for all work areas is very difficult. and requires the use of very efficient algorithms.

The effect of rules and regulations regarding the appearance of vehicle plates

The most important influencing factor in the discussion of the location of plate detection is undoubtedly the common design and format of the plate in the country or the region of interest of the researcher. The use of default knowledge and information about the plate such as the ratio of characters, distribution of characters, type of font, color of the plate, size of the plate,

number of characters in the plate, size of spaces between characters, and the total number of characters in the plate is very useful. It solves a large amount of the researcher's problems so the lack of use of this knowledge will face increasing problems in the production of the system. There are numbers and letters in Farsi and English, which makes research in this field difficult, as can be seen in the picture, the variety of Afghan plates is large. (Figure-1).

Figure-1: Types of motor license plates in cable

It can be seen that with this wide and heterogeneous range of available plate formats, it is not possible to use the aforementioned default knowledge; Unless we pay attention to a specific type or types of plates.

The effect of conventional calligraphy

The letter recognition stage depends more than any other factor on the type of script used on the plate. Afghan plates use calligraphy, which itself causes many problems. Electronic recognition of continuous printed letters in languages such as Arabic, Farsi, and Urdu is as difficult and complex as recognizing Latin handwritten texts. Recognizing separate letters in the Persian language alone is a very big problem because these letters have different lengths, widths, shapes, and distributions.

Background and history of plate recognition systems

Automatic number plate recognition systems have gone through various ups and downs since their invention.

We try to mention it briefly here. The Automatic License Plate Recognition System (ALPRS) was invented in 1976 by the Police Scientific Development Branch in the United Kingdom, and after many ups and downs and still, after applying a lot of research, finally, in 2021, Abu Jar Md. from Ghazipur Islamic University of Technology, Bangladesh, published an article under the title: Developed an Algorithm for Sequential Sorting of Discrete and Connected Characters. In this algorithm, using image processing of multi-line license plates, it has been tried to read and recognize the plates that have multiple lines and mixed numbers and letters. Also in 2021, Javed Hamdard and Ververt Krato from the King's University of Technology Mangut; Tanbouri, Thailand, presented an article entitled: Recognition and identification of Afghan vehicle license plates using image processing and complex neural networks. This method is designed to be able to correctly locate and read Afghan vehicle license plates that have multiple lines and English letters and numbers mixed using image processing and a complex neural network.

Table (1) research background table

Research approach	Name of author and year of research	Algorithm used	Advantages and Disadvantages	Titles	Results
Persian characters extraction	Javed Hamdard and, Worarat Krathu 2021	Detection and extraction Based on the plate location, Machine learning and neural networks complicated the extraction of sectors has characters, Persian characters, and character recognition.	Advantages: Use of Neural Networks to recognize Plate and characters. High accuracy. Disadvantages: Reading Persian characters That stage Noise removal, leading to remove points It becomes characters.	Afghanistan Vehicle Number Plate Detection and Recognition Using Image Processing and Convolutional Neural Networks	Plate detection accuracy: 99.93% Detection accuracy Plate characters: 98.93%

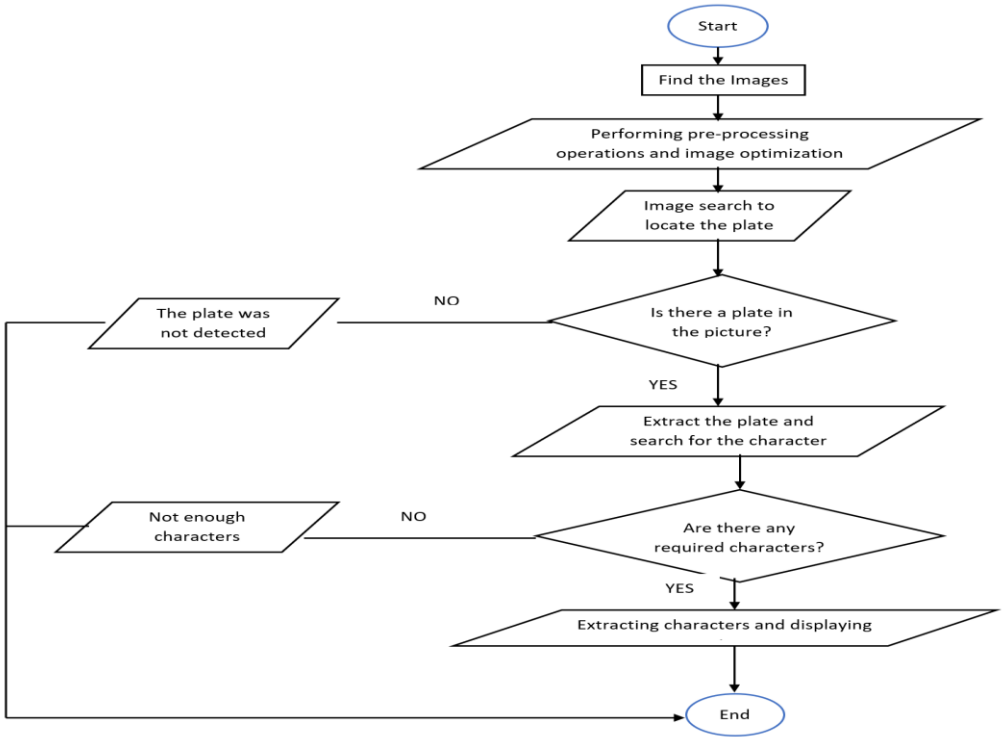
It should be mentioned that no real and efficient research has been done in the field of identifying Afghan plates, and the research done above also used images from the second source, which does not have significant accuracy, and his proposed method extracts Persian characters. It doesn't work because at the stage when we want to remove noise and small objects from the image, the points in the characters are also removed, which practically does not leave the difference between letters like O and 0.

Required research functions:

The words are image reading function in MATLAB, RGB image conversion to Gray and image edge detection function systematically.

Checking the vehicle plate recognition algorithm:

In this section, we try to explain the working of the desired algorithm in a systematic and compact manner.



Flow Chart Algorithm

Receive images from speed control cameras

Due to the progress and reliability of photography equipment and the high shutter speed of photography cameras in general, the desired response can be obtained with new and semi-advanced imaging equipment, and there is no need to provide ultra-professional, advanced, and expensive imaging equipment. Is not. This algorithm operates exclusively on images received from GatSo cameras. The high quality of the images from these types of cameras will help the system work better.

Preprocessing operations

In the first part of the operation of finding the location of the plate on the color image without changing its size, the location of the plate is found using image navigation, so a series of image pre-processing operations are performed, including converting the image to gray and binary, obtaining edges, and de-jamming And the removal of unnecessary points is done at a very small level, not in a wide area or a large area of the image. After finding the location of the plate, it will be necessary to increase the quality of the image, remove the parasitic points, and clarify the points inside the plate by image processing operations, especially morphology operations, which will be mentioned. The second part means separating each element of the plate using various image processing operations such as filtering, noise removal, etc. The image of the plate is brought to a more desirable and visible state, and then each character is separated. After separating the elements of the plate, it is read by an OCR.

Search for the location of the plate

The method used in this algorithm is based on the identification of a pattern in the image, so for the location of the plate in the image, it is necessary to find some fixed features that are common to all the plates, and according to this point, these features can be shaped, as can the proportion of length to width of the plate, the presence of characters, and color distributions.

Extracting plate elements or characters

The elements of the plate are five positive numbers, one negative number, and a maximum of six letters; a total of 12 characters should be extracted separately. The simplest solution is to determine the fixed areas for cutting and extracting the elements due to the relatively fixed location of the elements inside the plate. Another method is to use the edges. By obtaining the location of the edges, you can determine the range of the element for cutting. After transferring the image to the gray level, using image optimization operations, it tries to sharpen the edges and increase the quality of the image. Then, the image of the plate is converted into binary, and by using image processing methods on the edges of the image, noise points are removed from the plate, leaving only the elements of the plate.

Reading extracted elements or characters

To read the elements, it is enough to compare the elements of the plate obtained individually from the previous step, i.e., separation, pixel by pixel, with the original samples. Since the font used in the new plates issued during the years 2010–2024 is fixed, this type of reading will be done with high accuracy and will give the desired answer.

Implementation of the algorithm

• Receiving the input image: In the first part of this research, the image is called and read by the imread function.

• Converting the RGB image to gray: using the rgb2gray function, I converted the color image to a gray image.

• Edge detection: using the edge function, it has been tried to identify the edges in the image.

• Increasing or highlighting the edges: the imdilate function and the rhombus structure with the rhombus radius equal to 1 have been used to increase the edges.

• Noise removal: using the imopen function, a linear structure with a length of 3 and an angle of 90 degrees has been applied vertically in the image of the structure.

• Filling the holes: Using the imfill function, the black parts, the zero value areas, and the holes in the image of the possible places of the plate are made white.

• Conversion of the binary image into a label matrix: using the bwlabel function, all the candidate objects for the plate location are labeled.

• Finding the area of the plate and extracting it: using the regionprops function, we find an object whose area and shape are closer to the plate, and then to increase the accuracy of the algorithm, I used two rings and ran it. It should be noted that to avoid errors in the case of not detecting the plate before defining the variable loop, the error is defined with a value of 1, which stops the execution of the remaining codes and warns the user that the plate has not

been received.

Extracting elements or characters

In this step, the extracted image of the plate is completely cleaned of noise and useless parts, and we separate the characters one by one so that they can be read in the next step. If the extracted image has an angle, we use the command (im2=imrotate). We set the angle of the plate to zero concerning the horizon.

• Precise cutting of the plate: Now we open the image with the imopen function with a round structure and a radius of 2, and then we expand the image with the imclose function and with a linear structure with a length of 5 and an angle of zero to the horizon, which in the stage of opening the objects Circles whose radius is less than 2 are removed from the image, and in the closing stage, lines with a length of 5 and a zero angle expand and become thicker.

• Segmentation of the required area: in this step, we have tried to extract all the parts we need from the image piece by piece and then turn it into a single image so that noise and useless objects are removed from the image. In this case, Persian letters are also removed, so instead of extracting the Persian numbers and letters from the image and lowering the accuracy, we extract the English numbers and letters from the plate to make an accurate comparison.

• Recognition and extraction of characters: Now, to recognize the characters of the plate image, we use a method similar to the recognition of the plate frame from the image called in the first step. First, we convert the image to bwlabel and then apply the regionprops function to the image.

Reading the extracted characters:

In this section, with a long but iterative algorithm, each of the letters and numbers separated from the image is compared with the original samples pixel by pixel. Each character should be compared with all the numbers and letters in the original sample. The result of comparing each character is stored as a row matrix or array in variables 1mach to 11mach. Each character in one of these matrices specifies the number of common bits between the numbers and the main letters with the plate character. For example, in the variable 1mach, which specifies the first character of the plate, the numbers are as follows:

mach1= [244 2200 452 214 388 612 293 144 576 …..]

The second number is the degree of similarity of the character with the number one, and in the same way, the degree of similarity is up to 36. So, it is enough to choose the largest number, which in this example is 2200, which indicates the most similarity of the first character of the plate with the number 1.

Graphical environment design: To have a better graphic environment, graphic design has been done using MATLAB software.

General summary and review of influencing factors

The accuracy of the algorithm is divided into two parts, i.e. the accuracy of detecting the plate location and the accuracy of detecting the characters of the plate. Afghanistan's plates are fixed and are as follows:

- Length to width ratio (its width is 2.5 times its length)
- Presence of characters (at least 12 characters)
- Proportion of the color scheme of the foreground to the background (the background is at least 2.5 times the foreground)

The sub-characteristics are as follows:

- The extent of the object (Extent) is above 0.99 in the best case and 0.5 in the worst case
- Solidity is above 0.99 in the best case and 0.90 in the worst case
- Area is completely relative and depends on the size of the image and the size of the subject in the image.

After receiving the input image and applying a series of functions to the image, our algorithm checks all the candidate objects based on these 6 determined characteristics and gives a score between 0-99 for each candidate based on the shape and characteristics of the candidate. Basic characteristics have higher scores than secondary characteristics. In the first round, the minimum score to be recognized as a plate is 70, and if the highest score is below 70, it means that there is no qualified candidate like the plate in the picture. In the second ring, to detect non-standard and angled plates, this number has been reduced to at least 51. Accuracy and scores can change depending on the type of photography, climatic conditions, and angle, which affects the final result. Although the algorithm developed for this research was developed for all internal standard plates that have a border and whose appearance is not covered by fabric or metal frames and meshes, it can detect non-standard plates as well. The color of the plate will not have the slightest effect on the final result because the algorithm is developed in such a way that it can recognize plates with different colors.

Apply the algorithm to 100 photos of plates of the city of Kabul and the province of Afghanistan with characteristics (very low light, very high light, small and large image, image with dark and light frame, image without frame, image with frames and without frames, image with an angle between - 10 and +10 and the image with an angle between -45 and +45, the image with salt and pepper noise, the image with Mission crystal, and the image with Gaussian crystal), and the following results were obtained:In 90 of these photos, the plate was detected with an accuracy between 70% and 99%.

- 3 photos with salt and pepper noise were detected with accuracy between 62% and 87%.
- 3 photos that had an angle (between +45 and -45) were recognized with 51%, 65% and 69% accuracy.
- 2 plates that had motion blur and Gaussian blur in the low and middle levels were successfully detected.
- 2 plates that had motion blur and Gaussian blur at a high level were completely unsuccessful. (accuracy below 50%).

One of the factors of blurred vision is the lack of proper focus, which rarely happens in

photography because today's cameras have the power of automatic focus.

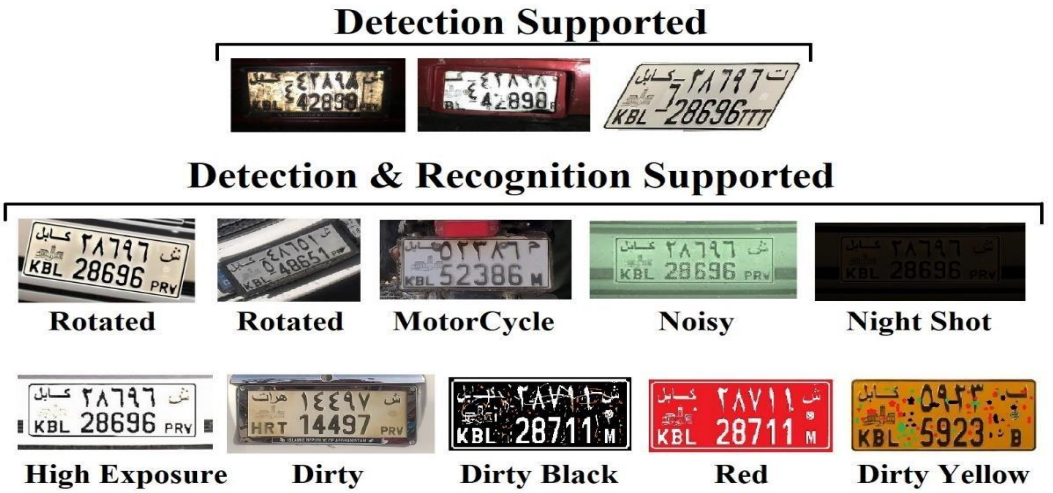


Figure 2: Types of identified plates

2. Conclusion

In recent years, extensive research has been carried out in the area of vehicle license plate number recognition, especially in Southeast Asian countries and Western countries, and numerous license plate number recognition systems have been offered, but no algorithm and no efficient recognition system The vehicle license plate for Afghanistan has not been made yet. We tried to work on an algorithm that can recognize all types of plates distributed since 2010. The way our algorithm works is that it takes an image as input and, after detecting and cutting the exact location of the plate, extracts and recognizes the plate number. Stores the obtained number in a variable and returns it later in the form of text (written) as output. One of the strengths of this algorithm is its ability to recognize the plates of different vehicles. Plates with different color backgrounds and foregrounds and images taken in different weather conditions, including snowy, stormy, and darkness, have a lot of light, and... done. As the algorithm of each system plays the role of its beating heart, therefore, the algorithm of this research can be used in different systems such as parking management systems, highway management, and security areas; it has traffic speed control cameras and... The method used in this algorithm and the results obtained from this research were very promising, so it is far better than any other proposed method or algorithm. Just as every system and every algorithm has its advantages and disadvantages, this algorithm also has some gaps in some areas, such as the lack of ability to detect and remove motion blur and Gaussian blur, which is one of the first gaps in the algorithm. Also, the presence of combined angles above 5 degrees simultaneously in several axes will challenge the algorithm, so the development of the algorithm to overcome this challenge will be significant so that it can be solved in the future. Also, a type of font has been used to read the plate characters, while the vehicle plates in Afghanistan are a combination of different fonts, which reduces the accuracy of our algorithm, which is considered a future work in this research.

References

1. ALPR Sytstems. “Guidance on the Use of Automated Licence Plate Recognition Systems by Police Services” 2017.
2. R. C. Gonzalez and R. E. Woods, "Digital image processing 4th edition, global edition," 2018.
3. McAndrew, "An Introduction to Digital Image Processing with Matlab Notes for SCM2511 Image Processing 1 Semester 1, 2004," 2004.
4. Solomon and T. Breckon, Fundamentals of Digital Image Processing: A practical approach with examples in Matlab. John Wiley & Sons, 2011.
5. R. C. Gonzalez, Digital image processing. Pearson education india, 2009.
6. D. Zheng, Y. Zhao, and J. J. P. r. l. Wang, "An efficient method of license plate location," vol. 26, no. 15, pp. 2431-2438, 2005.
7. Y. Wen, Y. Lu, J. Yan, Z. Zhou, K. M. von Deneen, and P. J. I. T. o. i. t. s. Shi, "An algorithm for license plate recognition applied to intelligent transportation system," vol. 12, no. 3, pp. 830-845, 2011.
8. P. Prabhakar, P. Anupama, and S. Resmi, "Automatic vehicle number plate detection and recognition," in 2014 International Conference on Control, Instrumentation, Communication and Computational Technologies (ICCICCT), 2014, pp. 185-190: IEEE.
9. A. Singh, A. K. Gupta, A. Singh, A. Gupta, S. J. I. R. J. o. E. Johri, and Technology, "Vehicle Number Plate Detection using Image Processing," vol. 5, no. 03, 2018.
10. S. Babbar, S. Kesarwani, N. Dewan, K. Shangle, and S. Patel, "A new approach for vehicle number plate detection," in 2018 Eleventh International Conference on Contemporary Computing (IC3), 2018, pp. 1-6: IEEE.
11. S. Ganta and P. J. P. C. S. Svsrk, "A novel method for Indian vehicle registration number plate detection and recognition using image processing techniques," vol. 167, pp. 2623-2633, .0202
12. M. Ahsan, M. Based, and J. J. T. Haider, "Intelligent system for vehicles number plate detection and recognition using convolutional neural networks," vol. 9, no. 1, p. 9, 2021.
13. A. J. M. M. U. Ahmed, M. A. Uddin, and M. A. J. A. Rahman, "Developing an Algorithm for Sequential Sorting of Discrete and Connected Characters Using Image Processing of Multi-Line License Plates," vol. 10, p. 100063, 2021.
14. J. Hamdard and W. Krathu, "Afghanistan Vehicle Number Plate Detection and Recognition Using Image Processing and Convolutional Neural Networks," in The 12th International Conference on Advances in Information Technology, 2021, pp. 1-8.
15. N. Li, "An implementation of ocr system based on skeleton matching," 1993.