License plate localization and recognition in camera pictures

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Abstract

This paper presents an approach to license plate localization and recognition. A proposed method is designed to perform recognition of any kind of license plates under any environmental conditions. The main assumption of this method is the ability of recognition of all license plates which can be found in an individual picture.

To solve the problem of localization of a license plate two independent methods are used. The first one was based on the connected components analysis and the second one searches for the "signature" of the license plate at the image. Segmentation of characters is performed by using vertical projection of license plate's image. However, a simple neural network is used to recognize them. Finally, to separate correct license plates from other captions in the picture, during the license plate recognition process, a syntax analysis is used.

The proposed approach is discussed together with results obtained on a benchmark data set of license plate pictures. In this paper examples of correct and incorrect results are also presented, as well as possible practical applications of proposed method.

Keywords: license plate recognition, object character recognition, neural nets, image processing

1. Introduction

A quick technological development in the area of computer image processing and constantly increasing need for efficient and cheap security and steering systems resulted in the development of different kinds of solutions based on computer picture analysis. One type of these solutions is automatic car identification systems basing on localization and recognition of the license plates shown in photos or camera picture.

License plate recognition systems can be applied in different situations. They can form the bases for automatic systems steering the access to protected areas i.e. a car park, route traffic monitoring systems, offences and crimes on public routes. According to practical use these systems must fulfill specific demands [3]. Firstly the working time of the system should be as short as possible, and the system itself the most universal. So it should recognize license plates from various countries, differing in color, shape and size. The system should also be resistant to any kinds of disturbances which may occur in photos and mechanical plate damages which may appear in reality.

Factors which may have a negative influence on the results of license plate identification method from photos can be divided into a few groups:

- weather conditions,
- lighting conditions,
- license plate placement in the picture,
- vehicle movement,
- mechanical plate damages,
- and other captions in the picture.

Most of the above mentioned factors can be eliminated by the use of proper lighting, specialistic equipment recording the image, designing a workplace and by the use of proper computer image processing techniques. All these elements show a highly complicated problem of the license plate recognition from the picture and how difficult it is to solve.

Presented assumptions concerning the license plate recognition system strongly limit the space of methods which can be used to fulfill the task. The generality of the system depends mainly on the generality of license plate localization method. Comparing the image to the license plate pattern [8], or looking for its features such as the shape and the color [5] [12] seems to be aimless and ineffective, especially when the system has plates of different colors and sign patterns. Thus the license plate localization method should be based only on common features characteristic for different kinds of license plates. One of such features is among others contrast, which means a relatively big difference in brightness or color between the signs and the background of the license plate. This fact is often used in many different license plate localization methods [1] [2] [4] [7] and in the problem text localization in the image [9] [10] [11].

2. Description of the method

The above presented introduction shows that the universal license plate localization method should be resolve itself into the localization of any kinds of captions appearing in the picture and then into the elimination of these which do not fulfill specific conditions.

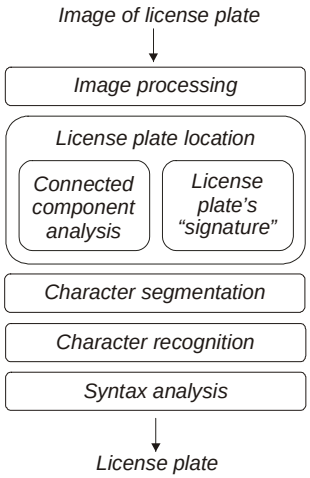

Fig. 1. Diagram of the proposed license plate recognition method

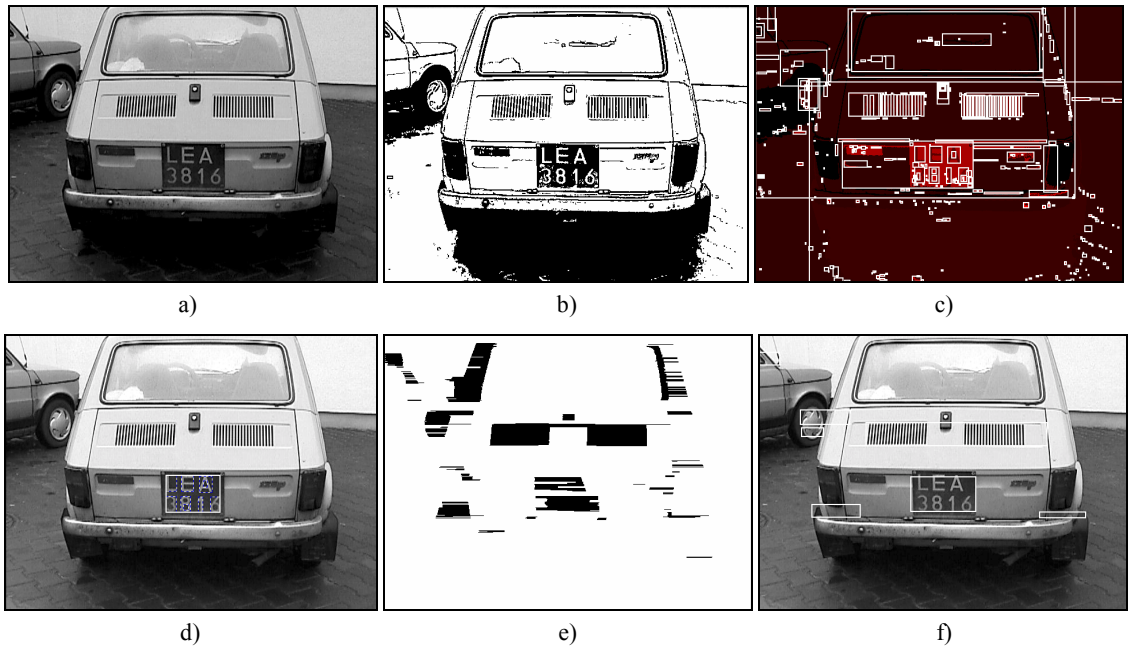

Fig. 2. Localization of license plate in camera pictures: a) input image, b) image thresholded with proposed filter, c) thresholded image after labeling, d) license plate candidate after grouping and eliminating of objects in connected component analysis method, e) "signatures" of license plates, f) license plate candidates after "signature" localization method

Such approach is proposed in this paper. To localize the license plate shown in the picture two complementary methods are used. The first one is based on the connected components analysis [4], the other one localizes the license plate "signature" as it was presented in [1]. These methods work simultaneously and each of them results in a set of license plate candidates which are then passed to the character segmentation module. Segmented characters are passed to a recognition module which is based on neural network. Finally, the result of recognition in the form of chain of characters is compared with the patterns of correct vehicle identification numbers by the use of syntax analysis. This scheme is presented in Fig. 1.

2.1. Image processing

The input image is initially processed to improve its quality and prepare it to next stages of described method. Color space of the image is changed to the YUV model but only the luminance is recorded. Later the picture is normalized with some threshold which helps to minimize the differences resulting form changing environmental conditions and increases the contrast between the characters and the background of the license plate shown in the picture.

2.2. Localization of license plate using connected component analysis

The first method of license plate localization is based on the connected components analysis. A set of elements (objects) which can be a set of license plate characters prepared in the binary image is localized. So initially the picture is thresholded so that the license plate characters were represented in the picture in a color different from the background. The elements present in this picture are identified in the labeling process to take part in a set of eliminating and grouping operations, which are to locate the license plate through a set of characters presented on it.

A special filter, whose aim is to select such areas of the picture in which the contrast between neighboring points exceeds certain threshold, was designed to binarize the picture, as it was proposed in [7]. The neighborhood of every point of the image is analyzed in the form of a square (5x5) to specify the biggest difference in brightness. If the specified contrast exceeds the threshold for a given point, it means that a sort of edge was found in the image which may mean some kind of border between the character and the background. This point is specially marked then. If the contrast in the given point is too small then only the threshold operation takes place. An example of effects of such a filter is shown in Fig. 2 b.

The above presentation shows the importance of initial image processing, as it forms the basis for the contrast between the characters and the license plate background. The contrast enables correct license plate localization thus if the contrast is too small slight differences between the background and the characters on the license plate won't be identified.

White and black areas which are the results of the thresholding are then labeled, which means that every spot is identified and its size and area are described so that different operations can be done on each spot separately (Fig. 2 c).

After labeling the black and white spots the process of elimination takes place. The aim of this stage is to leave in the picture only these spots which are most likely to be license plate characters, assuming that each spot represents a single character and isn't connected with any other object in the image. Values of properly chosen parameters, which are evaluated and compared with certain expected empirically calculated values, are calculated. The spot is eliminated if one of the below given conditions is fulfilled:

- the width of the spot is smaller than 3 points,
- the width of the spot is bigger than 1/4 of the input image width,
- the height of the spot is smaller than 8 points,
- the height of the spot is bigger than 1/3 of the input image height,

- the ratio of the spot's width to its height is smaller than 0,1,
- the ratio of the spot's width to its height is bigger than 4 (because of two or three joined characters),
- the ratio of the spots area to the spot's bounding box area is smaller than 0,15.

Further processing stages are directly connected with identifying fragments of the image which probably contain license plates. It is done by special grouping of spots in sets resembling sets of characters on license plate. The neighborhood of each spot in the image is analyzed and if there is another spot of the same size in this neighborhood the spots are grouped. The grouped spots are called a segment and other spots which fulfill the same conditions and don't differ much may be added.

Then the elimination process is applied to the aroused segments and it has similar course as in elimination of spots. Segments which will remain in the picture after this process represent different kinds of captions but in many cases it's not enough to correctly represent a license plate. It occur that in a single row license plate the row is represented by the two neighboring segments or in a double row license plates each row is represented by a single segment. Thus it is necessary to perform a grouping process for the neighbored segments.

After grouping of segments each of them contains a license plate, caption or some fragment of input image which is similar to a license plate. Then another elimination process is performed to eliminate those segments which contain incorrect number of spots.

Finally all segments remained in the image are treated as license plate candidates, that is areas of the input image which most probably contains a license plate (Fig 2 d).

2.3. Searching for the "signature" of a license plate

The second method of license plates localization is based on localization of theirs "signatures" as it was proposed in [1]. The "signature" is a characteristic sequence of minimum and maximum in the brightness function calculated on a single row of input image which crosses a license plate. As it can be seen on a Fig. 3 this sequence is characterized by some regular intervals.

To localize the license plate every row of the input image is checked. If there is a part of a row which looks like a "signature" this part is marked (Fig. 2 e). A number of grouping and eliminating operations is applied to the spots created in this way. This process is very similar to the previously described connected component analysis method but operate on a different data set which results in different set of license plate candidates (Fig. 2 f).

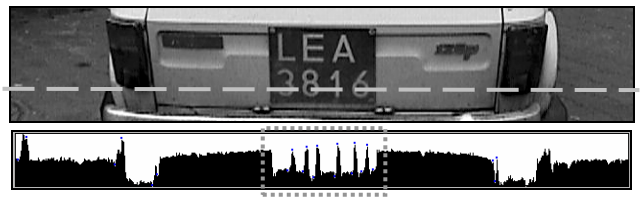

Fig. 3. "Signature" of a license plate

2.4. Character localization and segmentation

As mentioned above the main task of the character localization and segmentation is to identify which parts of the license plate candidate image contain characters and to cut out these parts as individual images for further processing. This operation is applied to all license plate candidates obtained in both license plate localization methods described in previous points.

License plate candidate image is normalized, rotated to get a license plate horizontal and redundant borders are cut off. Then, basing on its horizontal and vertical projection, candidate is spitted into two rows in case of double row license plates and initial character segmentation is performed.

In presented method character segmentation is based on two elements. The first one is "peak-to-valley" function described in [6] which is calculated on vertical projection of the candidate image. Values of this function shows probable segmentation points which correspond to deep "valleys" surrounded with high "peaks" in vertical projection. The second element is a set of spots identified in the candidate image during the labeling operation. Both of these elements are used do make a decision which parts of the candidate image contain license plate characters.

2.5. Character recognition and syntax analysis

To perform character recognition operation a simple, three-layer neural network was designed. An input data set for this network is presented in the form of matrix which contains a projection of single character image obtained in character segmentation process. Number of neurons in the input layer of the neural network is equal to the number of points in the described matrix. However in the output layer each neuron represents a single class (character) which is recognized by this network.

Each of character images identified in the character segmentation process is recognized separately. Characters after recognition are one by one connected in a chain of characters which represents a caption (vehicle identification number) recognized in the license plate candidate image.

To make a decision if the recognized caption is a license plate a simple syntax analysis is performed. Each caption is compared with each predefined syntax pattern which represents a proper vehicle identification number. Those patterns describe length of the proper license plate as well as order of character types (digit, letter or alphanumeric character).

3. Experiments and results

To evaluate effectiveness of the method proposed in this paper a few tests were performed:

T1. Test of effectiveness of the connected component analysis method.
T2. Test of effectiveness of the "signature" searching method.
T3. Test of effectiveness of license plate localization process based on both presented methods.
T4. Test of effectiveness of character segmentation process.
T5. Test of effectiveness of character recognition process.
T6. Test of effectiveness of proposed license plate localization and recognition system.

All test were performed on the same data set which consist of 233 pictures. This data set contains pictures took at the various lighting conditions i.e. in the sunshine or in the night. O these pictures there are many kinds of vehicles like trucks, off-road vehicles, sports cars and buses. The data set also contains pictures of various license plates types i.e. form Poland, Germany, France, England, Russia and Croatia. Pictures were taken from different distances, under different angle and on some pictures there is more than one license plate to recognize. The benchmark data set contains also pictures with a car motion effect. The average quality of all pictures may be described by tree elements: resolution 640x480 points, 24-bit or 8-bit color space, images after JPEG compression.

Results of the performed tests are collected in Table 1. Values in this table represent the percent of proper results obtained in these tests.

Table 1.
Results of the performed tests

T1	T2	T3	T4	T5	T6
89%	81%	99%	68%	65%	47%

4. Conclusions

The method proposed in this paper seems to be very universal in case of localization and recognition of different license plates under various environmental and lighting conditions. It has ability to correctly recognize all license plates located in the picture, in a short time, even if they are dirty or containing small mechanical damages. An example is shown in the Fig. 4 a.

The final result of effectiveness of proposed license plate localization and recognition system isn't very impressive. That is caused by the poor effectiveness of the proposed character segmentation and recognition methods. One wrongly segmented or recognized character is enough to reject whole localized, segmented and recognized caption in the syntax analysis process.

At present we try to take advantage of segmentation techniques based on the recognition of characters. Also it has to improve the recognition method by applying few co-operating methods. These modifications should significantly increase the effectiveness of our method.

a)

b) c) d)

Fig. 4. An example of results obtained on a test image: a) input image with identified license plate candidates, b) license plate correctly recognized, c) digit "8" was recognized as a letter "B", d) character segmentation method identified no characters in this image

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