Intelligent information systems

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AUTOMATION OF VEHICLE PLATE NUMBERS IDENTIFICATION ON ONE-ASPECT IMAGES

The **subject matter** of the article is the method of automating the identification of vehicle plate numbers based on the processing of one-aspect images obtained using video recording means. The **goal** is to provide automation of the process of identifying vehicle plate numbers within a wide range of changing the viewing angles and the levels of illumination. The **task** is formulation of the method of automated identification of vehicle plate numbers on one-aspect images, which are obtained by means of video fixation within wide limits of changing both the viewing angles and the levels of illumination. **Analysis** of the problems of methods and algorithms of automated detection and recognition of vehicle plate numbers has shown that it is most promising to use flexible algorithms that adapt to the changing conditions of observation of traffic control devices. One of the promising technologies for implementing such algorithms is the application of artificial neural networks. The solution of the problem of recognition of vehicle plate numbers can be represented as a complex of image processing and analysis of algorithms, which includes the initial preparation of the image, the discovery of the area of the vehicle plate on the image, the segmentation of symbols and the recognition of symbols. **Conclusions:** an algorithmically implemented method of identifying vehicle plate numbers, which makes possible searching the text areas under an arbitrary angle in different lighting conditions, is proposed. This method allows automating the process of identification of vehicle plate numbers within a wide range of distances to the car, as well as viewing the angles and levels of illumination. The **purpose** of further research is to improve the proposed method for its implementation, using modern software and hardware.

Keywords: vehicle plate number identification; image processing; character recognition; neural network; convolutional neural network.

Introduction

On the present stage of society development, the problem of providing road safety has become a major one [1]. In particular, the road safety is paid much to in our country. The problem of improving the level of road safety is to be solved, including through the introduction of automated means of traffic control, as well as the improvement of carrying out the analysis of causes of road traffic accidents [2]. Automation of vehicle plate numbers identification with the integration of video-fixing systems of traffic rules violations will provide reliable control over the transport routes.

Problem analysis and task setting

Currently, there are quite a few systems for automatic vehicle plate numbers recognition. A comparative analysis of the literature dealing with the methods for recognizing symbols on the images [3, 4] showed that a large number of methods can be used to identify vehicle plate numbers. The definitions of the most effective of them [5, 6] occur depending on the conditions of general illumination, the shooting angle and the presence of partial shading of license plate images.

The solution of the problem of recognizing vehicle plate numbers can be represented as a complex of algorithms of processing and analysis of images, which includes the initial preparation of the image, the discovery area of the vehicle plate number on the image, the segmentation of characters and the recognition of symbols.

The **purpose** of this article is to develop methods and algorithms for automated identification of vehicle plate numbers based on the processing of one-aspect images.

The necessity of developing such methods and algorithms is related to the possibility of geometric distortions of the vehicle plate number image, which is due to various conditions for its obtaining.

One can use the images of identified vehicle plate numbers in accordance with the known types as the input data entering the vehicle plate number automated identification algorithms being developed, [7]. Such images may have certain deviations from the reference vehicle plate number image having a zero rotation angle in the image plane and uniform illumination: the angle of the vehicle plate number in the image plane and the reference ratio of the horizontal image size of the vehicle plate number to the vertical one, due to changes in the angle of the survey; different general background on various images, as well as partial shading of license plate images resulting from different lighting conditions during shooting.

The main part

The main problem while identifying vehicle plate numbers is its arbitrary orientation relative to the horizon, which makes it difficult to use the existing algorithms for segmentation of text information on digital images [3, 5].

Given this circumstance, an algorithmically implemented method for identifying vehicle plate numbers, which allows searching for text areas at an arbitrary angle and consisting of the following 8 steps, is proposed.

Stage 1. Correction of the histogram of the original image. The original image contains low informative zones, so that one needs to perform the "trim" of the histogram to the left and to the right of the measured levels of brightness, depending on the maximum filling of the histogram. The specified levels of the image brightness reduction are due to the type of photodetector used and the general level of illumination [3].

Stage 2. Localization of the plate number area on the obtained image of the car is carried out with the help of the algorithm presented in the specified literature (Fig. 1) [6, 8].

Fig. 1. Localization of the plate number area

Stage 3. Binarization of image. It consists in viewing the entire image by rows and columns. For each pixel of the input image, when the binary condition is fulfilled, the unit is written into the output image and zero if this condition is not met.

Stage 4. Morphological operations of compression and expansion. It is proposed to use morphological operations to isolate the connected regions of pixels, corresponding texts to the alphanumeric areas of plate numbers in the image of the car. Morphological compression is used to eliminate small objects and lines of 1 pixel width. Then, the separation of connected regions is performed by means of a morphological expansion [3, 9].

Step 5. Search for connected areas in the image corresponding to the vehicle plate number. To find common areas, it is suggested to use a wave algorithm in the given work . The essence of using the wave algorithm is as follows: for each single pixel of the image the wave propagates in 4 directions per unit pixels. At each step of the wave algorithm, the pixels belonging to the same group are introduced into a corresponding list, and in the input image, the pixels are assigned a zero value to exclude the looping of the algorithm. Then, the revealed areas are ranked according to the dimensions, and the areas with the largest dimensions are transmitted for further processing [3].

Stage 6. Design of a bounding quadrangular area. To do this, the image is scanned by columns and they search for pixels corresponding to the middle of the columns forming the bound area. Further, pixels corresponding to the middle line of the bound area are searched for. After performing this, the parameters of a straight line approximating the center line points are searched for. On the basis of obtained parameters of the straight line slope, the maximum width of the bound region and the coordinate of the abscissa axis of the left and right extremities of the bound region, they construct the lines forming the bounding quadrangular region (Fig. 2) [5, 6].

Fig. 2. Separated quadrilateral area of the vehicle plate number

Stage 7. Transformation of the deformed by projection distortions quadrangular region into a rectangular one. The text of the vehicle plate number is located at a certain angle relative to the base of the image, in this connection it is proposed to use affine transformations of the quadrangular region into a rectangular one. The latter can be accomplished by using the conversion formulas of a point from one two-dimensional plane *xy* into another one *x'y* ':

$$x' = \frac{a \cdot x + b \cdot y + c}{g \cdot x + h \cdot y + 1}, \quad y' = \frac{d \cdot x + e \cdot y + f}{g \cdot x + h \cdot y + 1}, \tag{1}$$

where *a, b, c, d, e, f, g, h* are transformation coefficients.

Knowing the coordinates of the 4 points of the transformable region, as well as the coordinates of the 4 points of the rectangular region, presented in Fig. 3, one can substitute them in the transformation formula (1), and obtain two equations from each pair of points, thus, from 4 pairs of points 8 equations with 8 unknowns are obtained. Solving this system, they obtain the required coefficients a, b, c, d, e, f, g, h. Substituting them in (1), one obtains the formulas for the transformation of a quadrangular domain into a rectangular one.

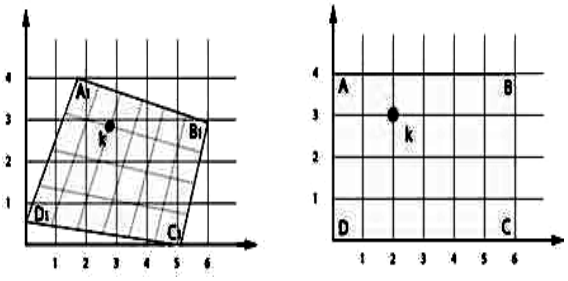

Fig. 3. Quadrangular and rectangular areas of vehicle plate numbers

In Fig. 4 there is represented the conversion result of the specified quadrangular area of the vehicle plate number (Fig. 2) with certain vertices of the quadrilateral region, limiting the area corresponding to the vehicle plate number, into a rectangular area suitable for further segmentation and recognition of single symbols.

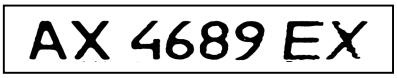

Fig. 4. Converted rectangular area of the vehicle plate number

Step 8. To recognize individual vehicle plate number characters, it is suggested to use a convolutional neural network trained by the method of error reversing. The choice of technology for artificial neural networks, in general, and neural networks of the above structure, in particular, is due to the specific nature of the task of identifying the vehicle plate number symbols [6, 10].

The structure of convolution neural network for plate number symbols detecting on the image consists of several convolution layers, before which are downsampling layers, and output layer before which will be applied several layers to combat re-training problem by means of dropdowm method [11].

Also, before each collapsing layer will be added preparatory layers, those add zero elements along the contour of input matrix for processing on the next layer.

The image sizing 32x32 pixels with image area of each sign of the vehicle plate number are at the matrix input.

Output result of neural network is probability vector of each of the possible characters of the number. The algorithm of neural network creation and training was represented [12, 13].

Obtained neural network scheme represented at the Fig. 5.

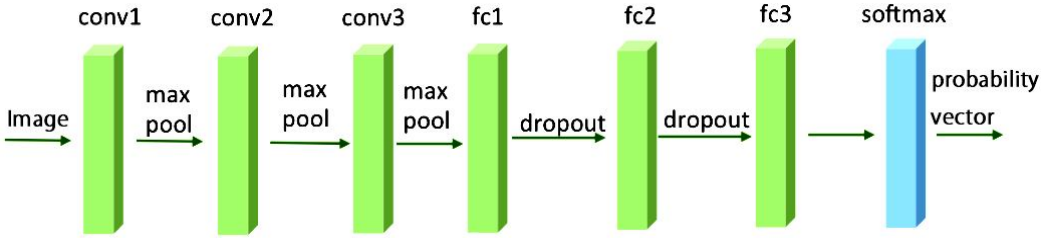

Fig. 5. Generalized structure of obtained convolution neural network (every convolution layer consists of three sub-layers)

For creation programming product which will demonstrate developed method the Python programming language was chosen.

The recognition result is shown in Fig. 6.

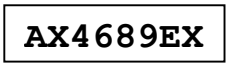

Fig. 6. Recognized vehicle plate number

Thus, after the recognition operation is performed, on the basis of the proposed method the vehicle plate number is presented either to the operator, or enters the corresponding database for registration.

To implement a software product that demonstrates the developed method, Python programming language was selected.

Conclusions

Thus, an algorithmically implemented method for identifying a vehicle plate number, which allows searching for text areas at an arbitrary angle in different illumination conditions, is proposed. This method makes it possible to automate the process of identifying vehicle plate numbers in a wide range of changes in viewing angles and levels of illumination. The purpose of further research is to improve the proposed method for its implementation in modern software and hardware means.

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Автоматизація ідентифікації автомобільних номерів на одноракурсних зображеннях

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Предметом вивчення в статті є спосіб автоматизації ідентифікації автомобільних номерів на основі обробки одноракурсних зображень, отриманих за допомогою відеорегіструючих засобів. **Мета** – забезпечення автоматизації процесу ідентифікації автомобільних номерів в широких межах зміни кутів спостереження і рівнів освітленості. **Завдання** – формулювання методу автоматизованої ідентифікації автомобільних номерів на одноракурсних зображеннях, отриманих за допомогою засобів відеофіксації в широких межах зміни кутів спостереження і рівнів освітленості. Аналіз проблем методів та алгоритмів автоматизованого виявлення і розпізнавання номерів автомобілів показав, що найбільш перспективно використовувати гнучкі алгоритми, які підлаштовуються до зміни умов спостереження засобів контролю дорожнього руху. Однією з перспективних технологій реалізації таких алгоритмів є застосування штучних нейронних мереж. Рішення завдання розпізнавання автомобільних номерів можна представити у вигляді комплексу алгоритмів обробки і аналізу зображень, що включає в себе первинну підготовку зображення, виявлення області номера на зображенні, сегментацію символів і розпізнавання символів. **Висновки:** запропонований алгоритмічно реалізований метод ідентифікації номера автомобіля, що дозволяє здійснювати пошук текстових областей під довільним кутом в різних умовах освітленості. Даний метод дозволяє автоматизувати процес ідентифікації автомобільних номерів в широких межах зміни відстані до автомобіля, кутів спостереження і рівнів освітленості. Метою подальших досліджень є вдосконалення запропонованого методу для його реалізації на сучасних програмно-технічних засобах.

Ключові слова: ідентифікація автомобільного номера; обробка зображень; розпізнавання символів; нейромережа; згорткова нейронна мережа.

Автоматизация идентификации автомобильных номеров на одноракурсных изображениях

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Предметом изучения в статье является способ автоматизации идентификации автомобильных номеров на основе обработки одноракурсных изображений, полученных с помощью видеорегистрирующих средств. **Цель** – обеспечение автоматизации процесса идентификации автомобильных номеров в широких пределах изменения углов наблюдения и уровней освещенности. **Задача** – формулирование метода автоматизированной идентификации автомобильных номеров на одноракурсных изображениях, получаемых с помощью средств видеофиксации в широких пределах изменения углов наблюдения и уровней освещенности. Анализ проблем методов та алгоритмов автоматизированного обнаружения и распознавания номеров автомобилей показал, что наиболее перспективно использовать гибкие алгоритмы, которые подстраиваются к смене условий наблюдения средств контроля дорожного движения. Одной из перспективных технологий реализации таких алгоритмов является применение искусственных нейронных сетей. Решение задачи распознавания автомобильных номеров можно представить в виде комплекса алгоритмов обработки и анализа изображений, включающего в себя первоначальную подготовку изображения, обнаружение области номера на изображении, сегментацию символов и распознавание символов. **Выводы**: предложен алгоритмически реализуемый метод идентификации номера автомобиля, позволяющий производить поиск текстовых областей под произвольным углом в различных условиях освещенности. Данный метод позволяет автоматизировать процесс идентификации автомобильных номеров в широких пределах изменения расстояния до автомобиля, углов наблюдения и уровней освещенности. Целью дальнейших исследований является совершенствование предложенного метода для его реализации на современных программно-технических средствах.

Ключевые слова: идентификация автомобильного номера; обработка изображений; распознавание символов; нейросеть; сверточная нейронная сеть.