Development of an automated system for recognizing the parameters of a railway carriage (railway tanks)

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Abstract

The solution to the problem of automated recognition of the parameters of rolling stock units in real time is considered. A method for solving the problem of recognizing the main identification marks of a railway carriage in real time is selected. A specific example of the implementation of the method proposed in the article is given. The results of the developed program are presented. The application of the developed system will allow to completely solve the problem of automated recognition of the parameters of rolling stock units, and save money by avoiding downtime, delays in return of wagons and conducting reasoned work with contractors.

Keywords [1]

identification of standard signs of freight railway wagons, effective recognition methods, neural networks

1. Introduction

Today, an important aspect of the efficiency of using railway transport and monitoring its condition is the identification of rolling stock (RS) cars by their inventory number. This is due to the fact that a unique inventory number assigned to a railway car can determine its main characteristics and provides code protection for reliable reading of the railway car number [6]. Car number recognition systems find various applications, for example, in commodity production and metrology services, security services, logistics departments and railway shops.

The main problem of optimizing production processes at the station is that the process of monitoring the movement of objects of the rolling stock of railway transport, including their identification, is not automated at the processing station. Today, hundreds of employees are involved in the control of rolling stock, who ensure the appropriate production and technological processes. Considering the fact that the survey of the cars is carried out manually, the final operations with the car take a lot of time and this process is economically expensive.

The search and identification of numbers of railway rolling stock units is relevant, since every day the need to automate control of entry into the territory of objects and reduce the influence of the human factor increases. In this regard, the problem arises of automated recognition of the parameters of railway RS cars in real time, the solution of which can be carried out using neural networks. The purpose of developing the software package is to recognize not only the car number, but also such parameters of railway rolling stock units as: boiler calibration sign, administration code, etc. The article presents a solution to the problem of automated recognition of the main identification marks of railway RS units in real time based on the use of neural networks.

2. Formulation of the problem

An automated system for recognizing the parameters of rolling stock units must create 3 images in three projections of each passing car (on both sides and on top of the car); and 2 photos of the beginning and end of the car.

The problem statement can be presents as follows: an automated system for recognizing the

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parameters of rolling stock units, consisting of the next components: a frame with cameras, a server with a recognition program, and an automated workstation (AWS) of the user. The work is carried out as follows: when the train passes through the installation with cameras, each car is photographed from several angles, then all images are transmitted in real time to the server, where the images are stored and processed (search and identification of identification marks applied to the railway carriage). After the train passes through the installation with cameras and the processing of all received images is completed, the information about the train is transmitted to the user AWS. A general view of the system operation process is shown in Figure 1. The model "Automated system for recognition of rolling stock units" is built on the basis of the objects of the use case diagram.

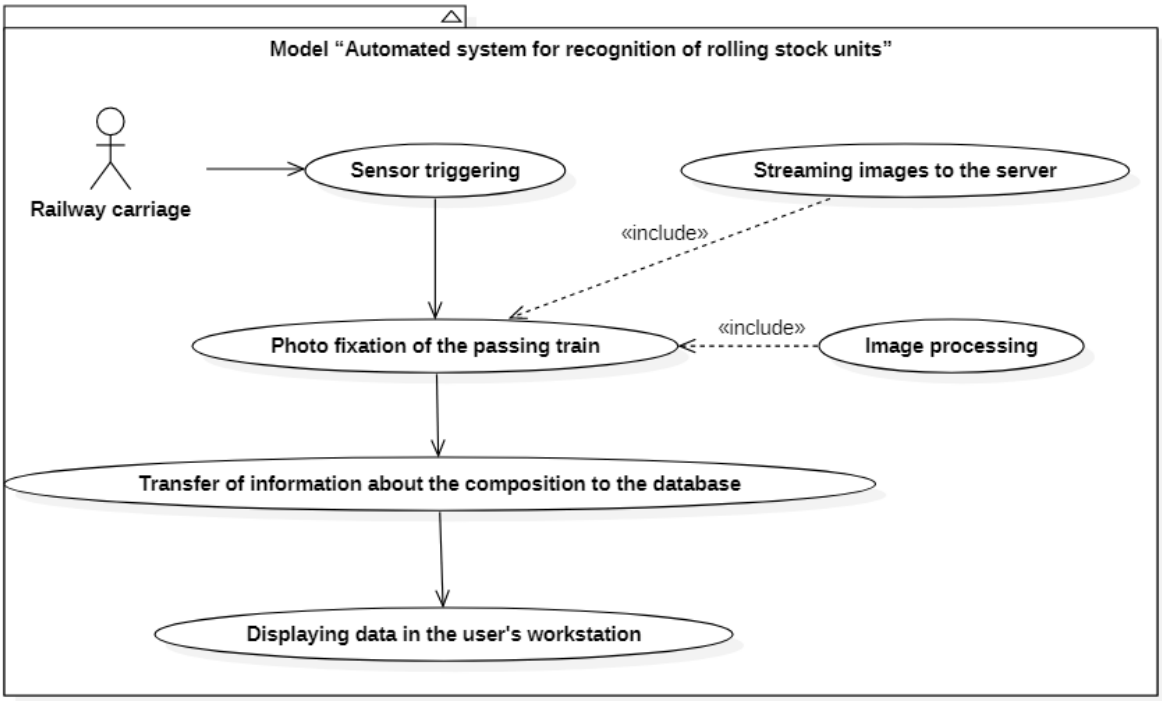

Figure 1: The model "Automated system for recognition of rolling stock units"

Color images from cameras installed on the frame are fed into the recognition program, at the output the data is transferred to the user AWS, basic information is available to the user: date and time of recognition, identification number, boiler calibration sign, administration code and load capacity.

3. Choosing a method to solve the problem

To solve the problem, you can use the following methods: accurate algorithms, static models, neural networks.

Exact algorithms are used to solve problems of low / medium complexity with a specific solution algorithm. An example would be: solving a simple arithmetic equation; displaying the program window; printing a document on a printer.

Special statistical methods are used in cases where problems of low / medium complexity arise, the solution to which is not fully defined. An example can be the problem of the simplest forecasting, calculating errors, or approximate solution of equations.

In cases when problems of high complexity arise, the solution of which is not clear in advance, neural networks are used. The class of such tasks includes: image recognition, speech recognition and complex predictions [2].

The range of tasks successfully solved with the help of neural networks has expanded significantly in recent years. First of all, various tasks of image processing and video data analysis began to be solved most actively: the detection of various objects in the image and their classification. This includes the tasks of detecting and recognizing faces and car numbers; searching and locating people and other objects in the frame; detecting fire, smoke, water where they should not be, etc. [7].

Another large class of problems in which neural networks have been successfully used, - word processing in natural language. These are all kinds of texts classifications (for example, classification reviews to positive and negative),

machine translation, chat bots and task bots - programs that can replace, for example, ticket sellers [5].

In addition, neural networks are used in the analysis of scientific data, games, in finance to assess customers and risks of various types, and in many other areas. As a result, neural networks work well with the data, in which there is a correlation of the measurements (images, sound, text, time series) [3].

In view of the above, as a method for solving the problem, a solution using neural networks was chosen.

In the process of modeling and building a neural network, it is important to consider the quality of the source data. Stencils applied to the railway carriage, have a very large variety of colors, fonts, size and location. This is due to the fact that the place where the stencil is applied is not fixed and depends on the model of the tank, and the boilers of the tanks are always painted in a different color. While tanks boilers intended for the second class of goods, colored in light gray (silver) colors, coppers tanks for transportation of methanol - highly toxic flammable liquid of the third class are colored yellow. In addition, you can find railway carriage painted in blue, green, orange and other colors.

In addition, when recognizing the identification marks applied to the railway carriage, the classical analytical algorithms detector finds in the frame any character sets similar to numbers and tries to recognize them.

To improve the accuracy of recognition of identification marks of freight cars, it is necessary to solve such a subproblem as localization of objects.

4. Designing and building a neural network model

The current project is based on the Mask-RCNN-based Nomeroff Net project. Nomeroff Net is system for recognizing the licence plate number of a car, written in Python and open source. The entire project recognition of the parameters of rolling stock units consists of three blocks: two main and one additional.

The main blocks are neural network detectors. The first detector is designed to localize objects (search for their areas in the image), the second for their identification (recognition of numbers). The third, auxiliary unit performs the function of monitoring the correctness of the railway car number recognition.

A variety of labels on railway tanks prevents determine the necessary parameters correctly. In such cases it is necessary to apply the detector is designed to localize objects. The objects localizer successfully works where objects of the required type "overlap" each other in the frame or there is a large amount of visual interference. Finding areas correctly will allow you to exclude other labels. After training, the detector will filter out unnecessary "noise" and due to this, the accuracy of parameter recognition will significantly increase.

To solve the subtask described above, a neural network localizer was designed on the Mask-RCNN architecture. This architecture has several advantages: recognizes objects in the entire image, efficiently consumes computing resources [4], has a high counting rate, allows to recognize objects in the video, easy to learn.

To build a localization model for the railway car number, in the project added to the class AreaSearchNetwork. In the __init__ block, constants and a detector with a default configuration file are initialized, directories are being configured. The "work" method was written to work with the localizer: the input is an image; the output is an array of images, each of which is the parameter of a railway carriage (number, administration code, boiler calibration sign, etc.).

After localization, each parameter is identified using a simple neural network detector, which is trained to search and recognize numbers. It works like this: the input comes from the image area, which has a parameter; at the output - the number of the recognized parameter.

After the railway train passes through the installation with cameras and the processing of all the images obtained, information about the train is transferred to the user AWS. The subsystem "Program for recognizing the parameters of rolling stock units" is shown in Figure 2. Class diagram objects and use case diagram objects are used for display.

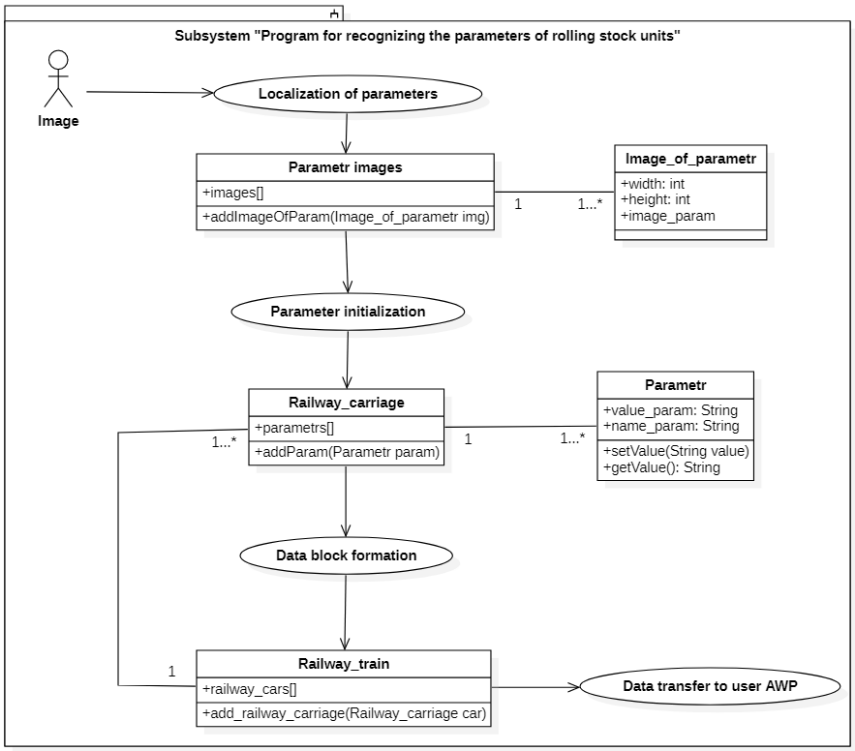

Figure 2: Subsystem "Program for recognizing the parameters of rolling stock units"

5. Neural network training and testing

An important property of neural networks is their ability to learn from environmental data and, as a result of training, increase their performance. Productivity increases over time according to certain rules.

A short neural network training algorithm is as follows:

1. Data preparation - includes splitting all images that will be used for training into test, validation and training sets
2. Annotation of data - determination of the required area in the image and its description, is carried out using the VGG Image Annotator (VIA) [1]
3. Running a script for training a neural network on a GPU in GoogleColab
4. Saving the trained model (file with the .h5 extension)

Examples of the work of the trained localizer and identifier are shown in Figure 3 and Figure 4. During the operation of the localizer, the following were found in the image: tank, number and sign of the boiler calibration. It can also be noted that the number recognized by the program

matches the real number of the car.

Figure 3: The result of the work of the trained localizer

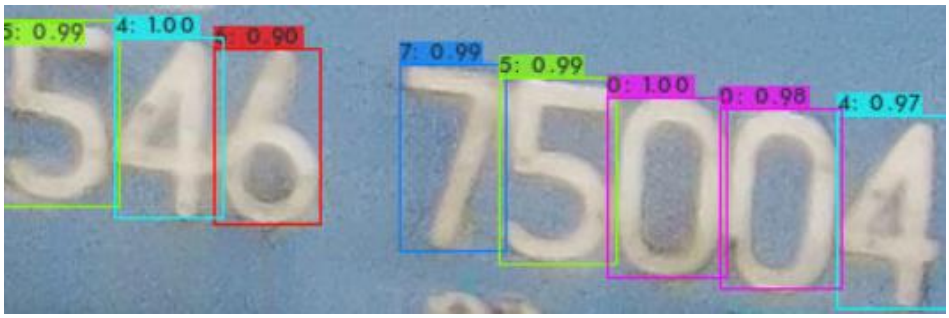

Figure 4: The result of the work of the trained identifier

6. Description of an example of the recognition program

The initial image of the car arrives at the entrance to the program for recognizing the identification parameters of rolling stock units (fig. 5, a). After the work of the localizer, the areas in which the parameters of a railway carriage are located are highlighted (fig. 5, b). Further there is identification of parameters and forming a data block with information about the freight railway wagon (fig. 5, c). The correctness of the recognized railway car number is checked by the checksum. After similar processing of all received images, the collected information about the rolling stock is transferred to the user AWS.

a)

b)

Railway car number: 50142686

Boiler calibration sign: 72

Administration code: 20

Load capacity: 66

c)

Figure 3: An example of the recognition program

7. Conclusion

The article discusses an automated system for recognizing the parameters of a railway carriage (railway tanks). The proposed solution is universal and does not depend on the recognized objects. It has a rational structure that ensures efficient use of computing power.

As part of solving the problem, the possibility of using neural networks for solving problems of finding and recognizing given objects (signatures) with the required accuracy is shown. Application of this solution allows automating the process of monitoring rolling stock at the processing station, which reduces the time of final operations with the freight railway wagons; creates conditions for optimizing the time spent on processing the wagons, as well as the emergence of material savings due to the optimization of production processes at the station.

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