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Increase of efficiency of railway junction with application of intelligent model module of railway station

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Abstract
The given work is directed on formation of intellectual technology of determination of a rational way of receiving of freight trains on the basis of techno-technological parameters. The technical and technological parameters of the railway station when performing train and shunting operation are taken as the main elements of the study. The basis for the generated model for the implementation of train work is the methods of neural networks that allow the formation of a self-learning automated system. The presented model of railway train operation is implemented on the basis of artificial neural networks using the learning algorithm "with the teacher" in the Matlab environment. This proposal is advisable when there is a dispatching centralization on a certain section of the railway line. As a result of the research, a model of the technology of operation of the railway station in the performance of train work with elements of artificial intelligence is formed. The model allows providing informed decisions to the station duty officer regarding the choice of a rational and safe variant of reception and non-stop train handling with the possibility of self-learning and adaptation to changing conditions. This condition is achieved due to the principles of the neural network functioning. The model of an intelligent control system for the process of determining the rational way for the receiving of trains of various categories in the operational mode in the case of a situation that has not arisen before will calculate the most rational variant of the performance of train work.
Key words: RAILWAY JUNCTION; RAILROAD YARD; ARTIFICIAL NEURAL NETWORK; JUNCTION, INTELLECTUAL SYSTEM

Problem statement

Under market conditions, one of the main tasks of the railway junctions is to use more profitable logistic schemes for the transportation of goods and reduce the costs associated with operating work.

The selection of cars along the entry lines and cargo handling stations can be performed at the freight or railway yard of the junction. In the first case, local cars arrive at the railway yard on a specialized shunting yard track, from where they are directed to the parcel station in the transmitting trains, where the cars are assembled at the points of loading and unloading. In the case of a selection of cars at a railway yard, several rail tracks are allocated in the shunting yard and during main and second re-sorting the local cars arrive here, and then transfer trains are formed in these ways in accordance with the procedure for the delivery of cars groups to the points of freight operation.

At the same time, the arrival of cars at the parcel station can occur in two ways: 1) at random intervals; 2) with uniform intervals. The choice of this or that variant of the organization of work with local cars depends on local conditions, but in any cases, it should be such that the cost of processing local cars is minimal.

The main material. In organizing the operation of railway junctions [1], there are reserves that can improve the quality of the transportation process. One of such reserve is the provision of a uniform supply of transfer trains to the railroad yard. An integrated approach to the task of improving the work of railway junctions should include the improvement of the technology of the railroad yards and parcel stations, planning the dispatch of goods at them in order to organize the uniform receiving of cars.

The railway junction K considered in the course of the research (Figure 1) includes the following stations in its composition: 1) a two-sided railroad yard D; 2) section station V; 3) parcel stations KP and KV; 4) intermediate stations L, S and Zh.

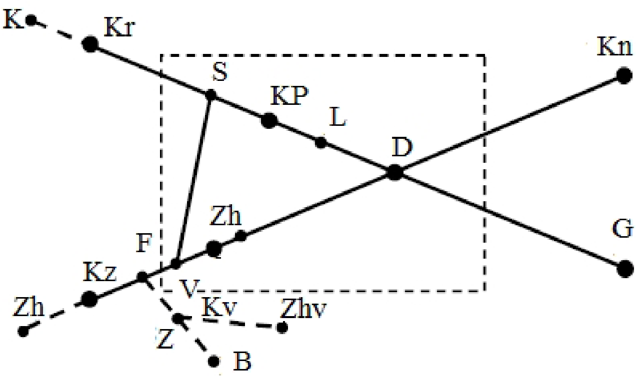

Figure 1. Schematic diagram of the K junction

During the research, the interaction of the odd system of the railroad yard D with the parcel stations KP and KV is considered.

Station D has two sorting systems and operates in four directions – D-KN, D-G, D-Kr, D Kz lines, which are double-track equipped with automatic interlocking.

During the studies, a simple statistical aggregate of the random values of the daily number of cars arriving at each entry line was obtained and their mean statistical value M, which was used during further modeling was determined [2].

The artificial neural network with two hidden layers and a sigmoidal activation function will be a base of the solution of the task of constructing a model of an intelligent automated control system for the process of determining the rational way of receiving trains of various categories. This kind of networks, as a rule, is used in control systems of mobile objects since their main feature is the memorization of sequences. As an example of this pair, in order to solve the problem, it is possible to give an unambiguous pair, i.e. a pair that with a given input vector can have only one defined output value or the output values can be strictly limited:

$$X \rightarrow Y = \{x_1, x_2, ..., x_n\} \rightarrow \{Y_1, Y_2\} = (\{x_1, x_2, ..., x_n\}, \{Y_1, Y_2\}), \quad (1)$$

According to the above expression, we can obtain a typical unambiguous value at the output of the network:

$$\left\langle \begin{matrix} x_1 - \text{Characteristics of the rail track No1;} \\ x_2 \quad \text{Characteristics of the rail track No2;} \\ x_{n-1} - \text{Characteristics of the rail track No } x_{n-1} \\ x_n - \text{Train Characteristic} \end{matrix} \right\rangle \rightarrow \left\langle \begin{matrix} Y_1 - \text{Receiving yard} \\ Y_2 - \text{Rail track No5} \end{matrix} \right\rangle \quad (2)$$

In this case, it should be noted that one of the advantages of using neural networks for simulating operational processes is that the number of pairs of type (input, known output) (the so-called training examples) is significantly less than the total number of possible combinations of input and output signals when receiving trains of various categories to the railway station.

With the direct formation of the neural network and the construction of the interdependence of the input and output signals for the execution of train operation at the station, that is, the construction of function X → Y, the following requirements must be met [3]:

– ensuring the formation of correct output signals in accordance with all examples of the training sample, which can be formed as a result of the work of an experienced operational officer (the station attendant, the shunting dispatcher);

– ensuring the formation of correct output signals in accordance with all possible input signals that are not included in the training sample. This condition should ensure adequate functioning of the projected neural network when applying to the input of train situations and situations occurring at the station during the performance of operational work. This requirement significantly complicates the formation of the training sample. To estimate the number of neurons in the hidden layers of a homogeneous neural network, we can use the formula for estimating the necessary amount of synaptic weights Lw:

$$\frac{mN}{1+\log_2 N} \le L_w \le m\left(\frac{N}{n}+1\right)(n+m+1)+m \quad (3)$$

Where n – dimension of the input signal; m – dimension of the output signal; N – number of elements of the training sample (it is determined within the permissible limits when testing the developed neural network).

After determining the required number of weights, it is necessary to calculate the number of neurons in the hidden layers [4]

$$L = \left(\frac{L_w}{n+m}\right) \quad (4)$$

The process of functioning of artificial neural networks depends on the size of the synaptic connections. According to this, the adequate functioning of the neural network, which is designed to solve the task, will be based on finding the optimal values of all weight coefficients variables.

In this scientific paper, a binary coding method will be used that will allow us further (in training a neural network) to reduce the load on technical computing devices taking into account a significant number of parameters characterizing the state of the rail tracks and the train arriving at the acquisition station or a continuous pass station.

Thus, it is advisable to define the vector that will characterize the rail track state in the form of the tables 1 and 2. As an example, an input vector element $X = \{x_1, x_2, ..., x_n\}$ was selected, which characterizes the state of an arbitrary rail track, as a result of which x_{n-1} = (1110) was obtained. When decoding, it is determined that on the way with the number $_{n-1}$, there is an outsized train with a dangerous load [4].

Table 1. Rail track Characteristics Code

Characteristic No	Linguistic characteristic of the feature	Code characteristic of the feature	The linguistic value of the code
1	Rail track status	1 0	Busy Free
2	Availability of cars with outsized cargo in the train	1 0	Present Absent
3	Availability of dangerous goods in the train	1 0	Present Absent
4	The presence of a passenger train with which passenger operations are performed (boarding, alighting)	1 0	Present Absent

Also, as an example of an input vector element $X = \{x_1, x_2, ..., x_n\}$ characterizing the train arriving at the station, we obtained x_n = (1 000 100).

When decoding, it is determined that an outsized train of standard length arrives at the station to breaking-up. After determining the method of encoding the input vector, it is necessary to select the appropriate learning algorithm for the neural network.

The algorithm for learning an artificial neural network is a set of formulas that allow you to calculate the necessary corrections for the network weights by the error vector [5].

Table 2. Code characteristics of the arriving train signs

Characteristic No	Linguistic characteristic of the feature	Code characteristic of the feature	The linguistic value of the code
1	Availability of outsize in the arriving train	1 0	Present Absent
2	Availability of dangerous goods in the cars of arriving train	1 0	Present Absent
3	The train with increased length	1 0	Yes No
4	Passenger train	1 0	Present Absent
5	Train with reclassification	1 0	Yes No
6	Train without reclassification	1 0	Yes No
7	Cars for one railroad yard	1 0	Yes No

For the qualitative training of the network, it is necessary to present the same train situation, as well as its possible variations. The peculiarity of training the artificial neural networks is the fact that after repeated presentation of examples, the weight of the network is stabilized, and it subsequently provides the right answers to almost all questions from the database. In this case, it is considered that the network has learned all the examples or the network is trained, or the network is trained. It is believed that for a full training you need to set a few dozen, and better than hundreds of examples [6].

In accordance with certain conditions, the task arises of forming a neural network in analytical and graphic form for a linear railway facility such as a railway station.

As the object for simulation, the railway station of the Kharkov Railway Transportation Directorate

(Basis - receiving yard) was selected, which to some extent corresponds to the rail road development.

After the neuron state has been formally determined in general form, it is necessary to estimate the number of neurons in the hidden layers of a homogeneous neural network.

Proceeding from the task of developing a model for controlling the process of determining the rational way of receiving trains of different categories, it is necessary to construct such a function X → Y so that the correct output signal Y is formed for each possible input signal X [9, 10]. In order to achieve the greatest effect, it is advisable to integrate the developed model into the existing automated work stations of station duty officers. For this purpose, a software module has been developed using MatLab environment that allows the neural network training process to be carried out by the method – "training with the teacher", which should be an experienced station duty officer under the direct supervision of the traffic safety inspector appointed for this site.

Scientific novelty and practical importance

In this scientific work, a model of the railway station operation is formed when performing train operation with elements of artificial intelligence. This model allows providing informed decisions to the station duty officer regarding the optimal and safe option of receiving and passing trains with the possibility of self-learning and adapting to changing operating conditions.

The program module of the intelligent system for controlling the process of determining the way for the receiving the trains of various categories is developed. It allows the duty officer to determine the corresponding yard (receiving, transit, departure) and the expedient way of receiving or passing under the condition when traffic safety is ensured.

Conclusions

In this article, a model for an intelligent automated control system for the process of determining the rational way for the receiving of trains of various categories is created, which in the operational mode allows the duty officer to determine the appropriate yard (receiving, transit, departure) and a rational way of receiving or passing, when the traffic safety is ensured. To achieve the greatest operational effect, the developed model of an intelligent automated control system for the process of determining the rational way of receiving trains of various categories is integrated with existing automated workplaces.

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