Polish Academy of Sciences
University of Engineering and Economics in Rzeszów

TEKA

COMMISSION OF MOTORIZATION AND ENERGETICS IN AGRICULTURE

AN INTERNATIONAL QUARTERLY JOURNAL ON MOTORIZATION, VEHICLE OPERATION, ENERGY EFFICIENCY AND MECHANICAL ENGINEERING

Vol. 13, No 4

LUBLIN – RZESZÓW 2013

All the scientific articles received positive evaluations by independent reviewers
Linguistic consultant: *Paweł Nosko*
Technical editor: Nikołaj Klipakov
Typeset: *Hanna Krasowska-Kołodziej, Olena Mogilna, Tetiana Pogoreleva*
Cover design: *Hanna Krasowska-Kołodziej*

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ISSN 1641-7739

Edition 200+16 vol.

The basic principles in development of the program module for calculating time of movement of enterprise's rolling stock

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Received September 13.2013: accepted October 04.2013

Summary. The basic principles are presented in this article for development of the program module for calculating of adequate time of enterprise's rolling stock movement. As an alternative tool to traction calculations, a neural network is offered to be used.

Keywords. Shunting work, trip, traction calculations, neuronet.

INTRODUCTION

One of the characteristics for the large and medium-sized industrial enterprises is absence of accurate daily plan of conducting, cargo and shunting works. It is caused by that many processes are subordinated to stochastic probabilistic character and are not reliable subject to forecasting process. With development of computer and management information systems more attention began to be paid to this problem. In this regard there was a question raised on adequacy of planning and rationing of shunting work.

The purpose of this work is allocation of the main aspects for calculating of time of shunting work, and also development of a program module for calculating of the time of movement of enterprise's rolling stock.

To find adequate time of shunting work, it is necessary to know specific conditions of its performance, such as data on enterprise infrastructure, cross-sections of ways, quantity of locomotives, cars, loading/unloading areas and so forth. Besides that, reaching this objective is not possible without initial dividing of this process into the "pure" time of movement that consists of trips, and additional operations.

MATERIALS AND METHODS

The most justified method of realization of calculating of time of movement is modeling of this process [15, 16, 25, 26, 29]. Many scientists dealt with this problem, but it still remains unsolved as it was generally mend for train work only. Conditions of shunting work significantly differ from the train work: while maneuvering accelerating and slowing down is the main repeating elements, shunting locomotives diesel engines do not operate at a normal state, and mainly in the conditions of repeated mode transitions, braking is carried out by a direct-action of locomotive's wheel brakes, braking and change of positions of the hand lever of the brakes crane operated by the driver happens more often, the condition and cross-section of railways at the industrial enterprises considerably differ from the railways on which the organized trains operate [1, 2, 9, 11, 12]. Taking into account the specified factors for receiving results of calculations with demanded degree of accuracy, the only applicable calculations would be the automated traction calculations adapted for shunting work.

Nowadays traction calculations are carried out mainly by computers according to available software. DIIT crew is engaged in software implementation (for example, the MoveRW program), DVGUPS crew (the SPARK program, ERA), etc. Each of the listed programs carries out separate tasks, but none of them is capable to completely cover requirements and conditions of industrial railway transport.

By means of traction calculations under the set conditions, it is possible to calculate the time of performance of the trips, its maximum speed, fuel consumption and other parameters [33]. It is more difficult to find these parameters in the presence of restrictions on length of a way, speed, time and fuel. In Klyuyev's article [15, 18] there is developed program complex described, which allows to find values of these parameters upon transition from one system state to another during each of the steps. Each step includes time interval equal to three seconds as a minimal interval given for transition by the driver from one working state of the controller to another.

Advantage of such program complex can become its downside if to try to introduce it at the large enterprise. All initial parameters are very detailed, giving the exact time of movement, but calculation takes a lot of time if to consider complexity of an enterprise scales. The device of the same accuracy, which would spend less system resources is required.

Given the knowlage on modern scientific researches in the field of information systems and technologies [8], the following is offered: to use neuronets as the device which would predict the time of a trip, trained on data received from the automated system of traction calculations at the concrete enterprise [6, 17, 20].

RESULTS, DISCUSSION

This background for this idea serves such property as uniformity and the limitation of shunting work caused by its binding to a track diagram of the enterprise.

During the analysis based on possible options, such as a linear neural network, radial basic function and multilayered perceptron, the last was chosen, as the most corresponding to such type of tasks. The artificial neural network is described as follows:

$$MP \quad 7:7-2-1:1 .$$

Fig. 1. Multilayered perceptron

"MP" means "Multilayered perceptron ", number to the first colon – quantity of the variables given on an entrance, after – quantity of entrance neurons, the following number – quantity of neurons in an intermediate layer, number standing before the second colon – quantity of output neurons, and the last number – quantity of the variables containing the solution of a neural network, in our case – time. The vector of input parameters has the following appearance:

$$t = \{\ Li; Mi; Ni; Ki; Pi; Ri; Ii\ \},$$

where: *Li* – way length, *Mi* – locomotive capacity, *Ni* – number of cars, *Ki* – a limit position of the controler, Pi – the mass of structure, *Ri* – radius, *Ii* – the given bias of a way.

Each of these parameters is significant for a neural network and the task set for it, thus such quantity of variables doesn't influence speed of a neural network.

During this work 200 examples was picked up and analysed, consisting of seven (among the above presented) input parameters, and also the only initial parameter – time which is accepted as a standard when training a neural network. Such format is an optimal one for training of a neural network. Sufficient quantity of needed parameters would allow a neural network to become multiple-purpose and applied both at a given enterprise, and on a great number of others, without considerable deterioration of accuracy, otherwise caused by different features of an enterprise. Thus, the neural network favorably differs from other methods of operational planning when the calculation of features of the enterprise requires a lot of time and resources causing operational planning to be carried out only partially.

Further it is necessary to conduct research which would show adequacy of a model. By comparison of timing results between traction calculations and neuronet calculation, the following results were received.

Figure 2 shows comparison of calculations for two systems: neural network and traction calculations for 46 experiments sorted by increase. On abscissa axis numbers of experiments are designated, on ordinate axis - time movement in seconds. Rather exact predicting of result by a neural network is provided because of giving the right architecture as well as the amount of educational selection. If one of the needed elements would appear absent, the result of these examples would not be a success.

But to judge the accuracy of work of a neuronet according to the schedule insufficiently, it is necessary to check adequacy of the presented artificial neural network, in comparison with the decision the provided method of traction calculations. It is possible to solve this problem by means of Fischer's criterion:

$$F_{p.} = \frac{D_A}{D_E},$$

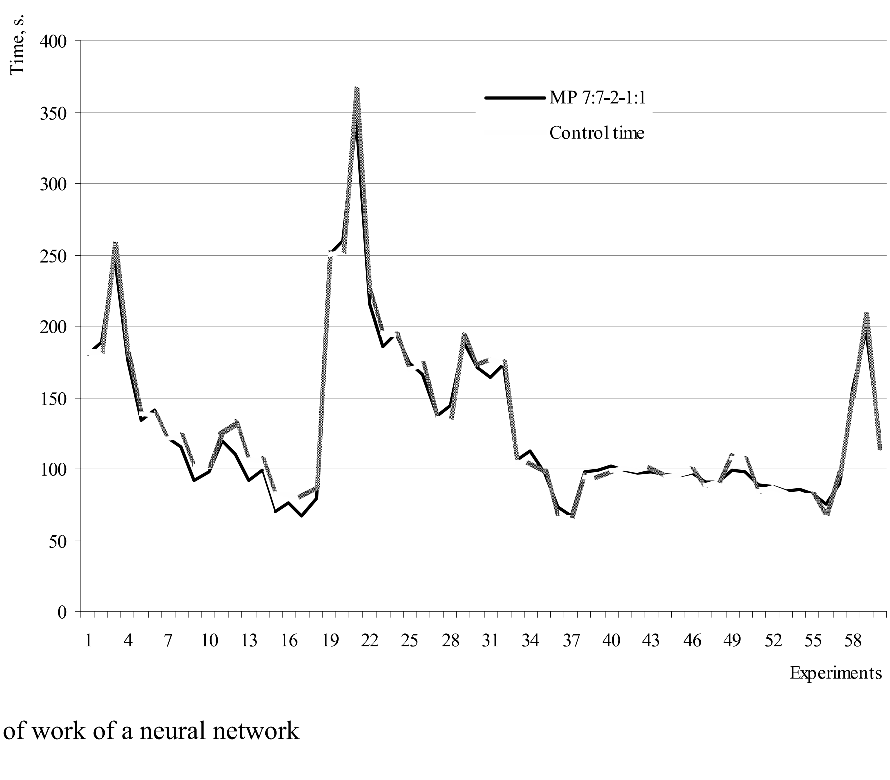

Fig. 2. Example of work of a neural network

where: D_A – adequacy dispersion:

$$D_A = \frac{\sum (y_{im} - \bar{y}_{ie})}{n - d},$$

where: y_{im} -value of function calculated with the equation of regression for factors of *i* experiment, $\bar{y}_{ie}$ - average experimental value of the constructed model in *i* experience, *n* – number of measurements in one series of experiences, *d* – number of coefficients of the equation of theoretical regression, D_E - average dispersion of experiment:

$$D_E = \frac{\sum_{1}^{m}\sum_{1}^{n} (\bar{y}_{ie} - y_{ie})^2}{m \cdot n},$$

where: y_{ie}- the current experimental value of function in *i* experiment, *m* – number of series of experiments.

Therefore, if in these formulas to substitute parameters which answer the data obtained by means of a neural network, Fischer's criterion will be equal 0,033, therefore the received mathematical model of a neural network significant, answers an objective and is adequate. Thus, the task is set above, solved.

Let's consider now realization of mathematical model which was presented above for the solution of a problem of calculating time of movement of rolling stock on industrial railway transport.

The program which realizes mathematical model, is the independent module which can be used in other software products. Let's consider program structure as a whole, and also each of its parts separately.

As shown in Figure 3, the program comprises two classes: class of the most neural network and shell class. The class of a neural network comprises all necessary parameters for work of a neural network, and also the only method starting its work then the result of calculations is given. It allows using this class not only in this program, but also and in others, while applying it practically without adaptation.

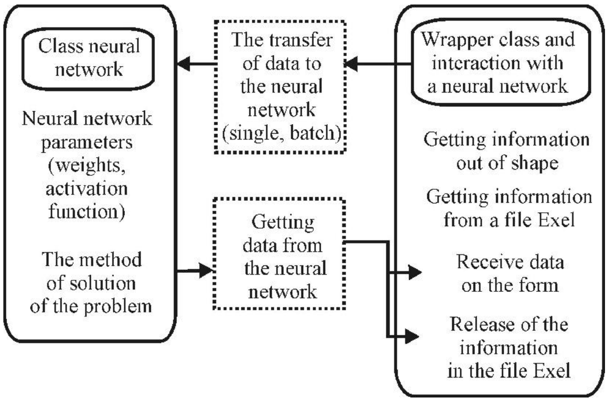

Fig. 3. Program structure

Other class allows using a neural network for examples which were presented earlier. Except the interface, this class also allows to carry out communication with the Excel files. Thus, the user has an opportunity to receive result not only "here and at the moment", directly in a program window, but also to store the received answer for the subsequent use including in other programs.

Let's refer now to the program interface, we will consider its features (Fig. 4).

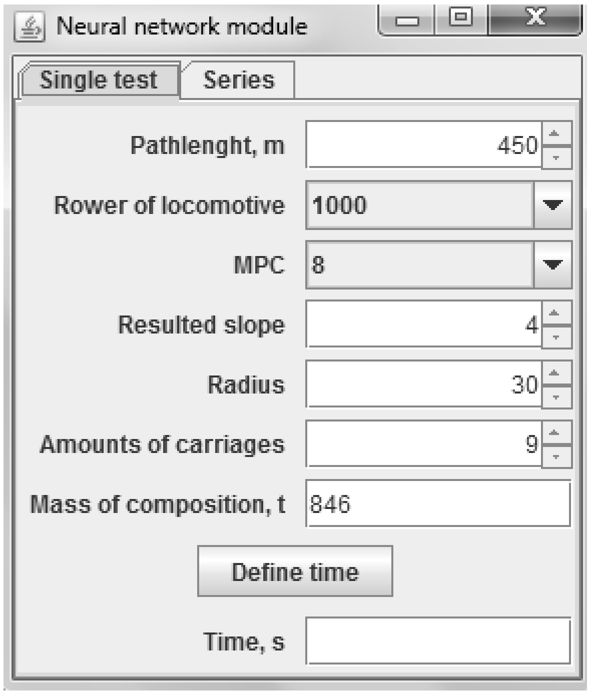

Fig. 4. Appearance of the program (single experiment)

The Single Test tab serves in order that the user could conduct the program's experiment, without using additional data sources. The Series tab is intended for performance of a series of experiments which can be found within the Excel format file. After that the result is registered in the conclusion file. Windows "Way Length", "Locomotive Capacity", "LPC" (Limit position of the controler), "The given bias", "Radius", "Quantity of cars", "Mass of structure" serve for input of initial information. By pressing Define Time button in the Time window the result in seconds is displayed.

The interface of the Series tab appears as follows (Fig. 5).

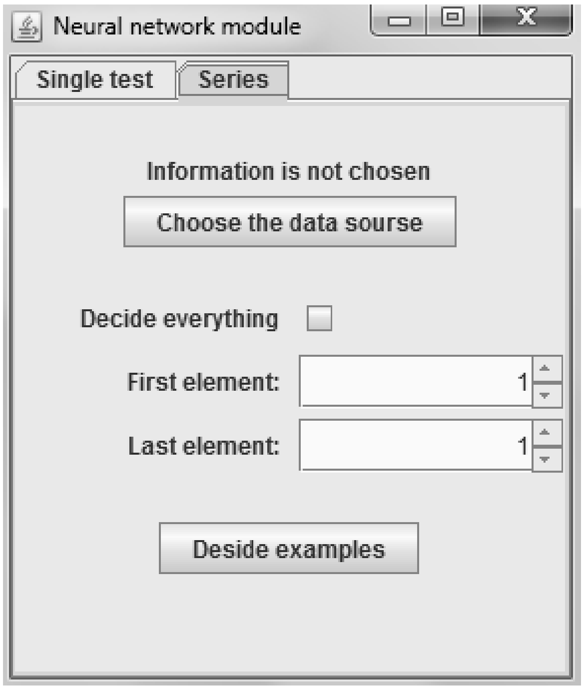

Fig. 5. Appearance of the program (serial experiment)

The file - data source (the Excel format file) allows to select the Choose Data Source item by means of a dialog box. After a file choice its name will be displayed in an inscription over this button. Tag "Solve everything" allows solving all experiments within the chosen file automatically. The window areas "First Element" and "Last Element" allow choosing the first and last experiments which will be solved at start of a neural network if there is no need to solve each example separately. Solve Examples button starts resolving process conducted by a neural network of experiments. After completion of process the program generates new Excel-file (or replaces already existing), which contains answers to the provided tasks.

Thus, the program has the simple, intuitively clear interface. The top part of program's window has two tabs, which are responsible for different types of interaction of neural network with the program and the user. In the "single test" tab allows user to solve different examples, entering their parameters manually (or taken from offered options) into the signed fields, receiving result in corresponding fields.

The 'Series tab', represents different approach. This tab allows user to choose the file from which information would come (the file should have the same or compatible to Excel's format which would correspond to the above-stated table of educational data). After a choice, user can also specify the range of examples which they intend to solve or tick "Solve Everything" trigger. After solving given examples, answers will be put in the output.xls file, from where they can be used further. It should be noted that after each new task the contents of the output.xls file is deleted and updated to more recent one.

The program is based Java, and therefore is cross-platform and can be used in aggregate with other software within different operating systems.

The solution of this task by means of a neuronet, serves as one more step to more global task – calculating of time of shunting work which consists of time of movement of the train (time of trips) and additional operations.

CONCLUSIONS

1.This work consists of the main aspects for the solution of a problem of calculating shunting work time which would allow to put planning and rationing processes to a higher level.

2. Such tasks, as receiving adequate time of the trips based on traction calculations are solved with the ability to take less calculation resources via application of neuronets.

3. Creation of the automated system considering additional operations during the

shunting work is planned as the following stage in this work. The basis of the checklist will be applied that would allow revealing weak spots in shunting work and gradually coming to the era of information systems for planning and rationing.

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ОСНОВНЫЕ ПРИНЦИПЫ В РАЗРАБОТКЕ ПРОГРАММНОГО МОДУЛЯ ДЛЯ НАХОЖДЕНИЯ ВРЕМЕНИ ДВИЖЕНИЯ МАНЕВРОВОГО СОСТАВА НА ПРЕДПРИЯТИИ

Татьяна Нечай, Юрий Шкандыбин, Александр Клюев, Татьяна Балицкая, Никита Соснов

Аннотация. В статье представлены основные принципы для разработки программного модуля для нахождения адекватного времени движения маневрового состава на предприятии. В качестве инструмента, альтернативного тяговым расчетам, предлагается использование нейронной сети.

Ключевые слова. Маневровая работа, полурейс, тяговые расчеты, нейросеть.