Application of systems of telematics on commercial vehicles

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Abstract
The analysis of systems of telematics of commercial transport is provided in article, the factors influencing its application ways of development of the systems “Fleet management” in Russia are offered and also the pilot model of telematic system, more available from the economic point of view, with function of forecasting of technical condition of the rolling stock on the basis of expert system is presented.

Keywords: Telematic system, commercial transport, expert system, system of onboard preliminary treatment of the vehicle, architecture of intellectual system.

The cargo transportation which is carried out by motor commercial transport constantly develops owing to what volumes of this type of transportations increase what statistics of the Ministry of Transport of the Russian Federation of [2] confirms. Owing to the development this field of activity has the expanded regulatory base, wide coverage zone and huge number of units of the rolling stock both private cargo carriers, and huge transport companies.

At implementation of cargo transportation the owner and/or the driver of single commercial car in view of requirements of the legislation existing in the Russian Federation faces need of implementation of the list of control operations:
• control of mode of behavior of drivers (onboard tachograph);
• control of observance of route (Platon system);
• control of weight condition of the vehicle (points of weight control);
• control of safety of freight (onboard preliminary treatment, in some configurations of vehicles);
• control of technical condition (onboard preliminary treatment, periodic technical inspection);
• documentary maintenance.

All above-mentioned operations can be realized or separately, using the specialized equipment, or with application of the complex “Fleet management” system including as telematics (remote control of the car in flight), and documentary maintenance.

The Fleet management systems are in our country at stage of development and have not received full application yet. At the moment in commercial motor transport the systems of telematics allowing depending on complete set are widely used, far off to obtain information on vehicle geolocation, fuel level in tank, technical condition by results of onboard preliminary treatment, etc. For descriptive reasons we will consider the analysis of the above-stated systems of various type (Tab. 1).

In fact, application of systems of telematics allows to resolve issue of improvement of control cargo system, but in our country it is necessary for further development of the sphere of ”Fleet management”:
• import substitution of systems of telematics of foreign production;
• improvement of consumer properties of system of remote preliminary treatment of commercial cars;
• expansion of universality, informational content and applicability of telematics.
The system which structure is presented in Fig. 2 can be one of versions of the solution of the sounded problems. The structure of system means following processes.

The Fleet management systems have similar structure (Fig.1).

1. Reading of parameters of technical condition of the vehicle braking system has to happen by means of connection to the regular socket (for example, like “OBD II”) the reading-out adapter equipped with the Bluetooth radio-module, or “WiFi”.

Table 1. Analysis of systems of telematics of commercial transport

| Qualities and functions of system | Name of telematic system |
|----------------------------------|--------------------------|
|                                   | «Transics» (WABCO) [5]   | «J-TDO» (Cojali Group) [4] | «Truck-control» [3] |
| Modularity                        | +                        | -                        | +                        |
| Geolocation                       | +                        | -                        | +                        |
| Control of technical condition of the tractor | -                        | -                        | -                        |
| Control of technical condition of the trailer | +                        | +                        | -                        |
| Control of weight state           | +                        | +                        | +                        |
| Control of mode of behavior of the driver | +                        | -                        | +                        |
| Use of the server of data storage | +                        | -                        | +                        |
| Documentary maintenance           | +                        | -                        | -                        |
| Cost of components                | Does not function in Russia | ≈30000 RUB               | from 20000 RUB            |

Figure 1. The developed architecture of system of Fleet management
2. Data storage of work of system of telematics has to be carried out on the special server.
3. Collecting, drive and display of data on technical condition of the braking system of the commercial car and its geolocation (above) and the installed developed application has to be realized by means of the smartphone (tablet) with the Android 4.0 operating system. Data transmission to phone from the reading-out adapter it has to be carried out under the Bluetooth protocol, or "WiFi". Data transmission on the server for storage of information and also on additional devices for remote control of technical condition, it has to be realized through Internet network. Phone has to obtain data on geolocation of the commercial car from the existing GPS and GLONASS networks by means of the built-in sensors.
4. Steering, the analysis and display of data on technical condition of the braking system of the vehicle and its geolocation is required to be carried out the developed software.
5. The developed system has to be autonomous, during its work the dispatching center will not be required. Application of this system has to allow to keep track of technical condition of the braking system of all road train.
6. Documentary maintenance of operations of transportation of freight has to be provided by integration into the software of system of the special module of document flow.

Main advantages of similar technical solution:
• complete solution for control of the vehicle in flight;
• exception of "human factor" in control operations by introduction independently trained expert system;
• possibility of improvement of the software and expansion of its functions;
• low cost of accessories of system;
• application of similar system does not demand modification of design of the car and installation of specialized telematic modules.

Besides, in this system use of expert system of onboard preliminary treatment with possibility of forecasting of technical condition of the car is offered.

The architecture of system of preliminary treatment of [1] failures of the vehicle represents two subsystems: subsystem of reception and information processing and subsystem of interpretation of the obtained information on condition of subject to diagnosing. The first carries out reception of data on condition of object and their further processing (distribution of data, assessment of variables and their display). The second subsystem makes recognition by means of artificial neural network of failures of systems of the vehicle, and the indistinct controller makes recommendations about realization of further actions (forms conclusions and the option proposes solutions).

Now IS are used at the solution of problems of various types: decision-making in the conditions of uncertainty (incompleteness), interpretation of symbols and signals, prediction, preliminary treatment, designing, planning, steering, control, etc.

The main design stages of model of neural network for assessment of technical condition of vehicle:
1) definition of the logical conditions allocating the analyzed selection in the registered transition processes;
2) task of symbolical indistinct variables for vectors of entrance and exit of the modelled object;
3) formation of the base of "indistinct" rules describing all possible operational modes of behavior of systems of the car;
4) creation on the basis of the registered selections of real transition processes of correct work of the training, testing and test data for training;
5) training of adaptive neuro and indistinct network.
Such representation allows to create the system of preliminary treatment on the basis of neural network, having defined all design stages. That is to create base of logical conditions and rules for system, to design it and to train.

Any system of preliminary treatment relies on probe of object of preliminary treatment, receiving and transformation of the signals arriving from object (interface), stay and malfunction repair and execution of the assumptions of further work of object.

On entrance of object of preliminary treatment the signal by means of which at the exit reliable information about work of all system in general is issued is given. The received signal via the interface will be transformed and arrives on entrance of neural network where according to operation algorithm of neural network it is investigated, and conclusions about condition of system are displayed on the screen. Thus, the problem of preliminary treatment of the electromechanical device on the basis of neuronets comes down to probe of changes of any parameter of the device, entering in the knowledge base of information on serviceability and failure of the device in the studied parameter, comparison of the put and obtained information and formation of offers on further operation of the device.

As it has been told above, one of properties of neural network is the ability to training, that is the expert-teacher, forming neural network, puts the knowledge, conclusions of serviceability or failure of this or that system in its knowledge base, and the neural network itself submits the conclusions about condition of system. It preliminary treatment considerably becomes simpler.

Neural networks also have the high computing power and high fail-safety.

At probe of influence of properties of neural network on quality of preliminary treatment on entrance of neural network the vector (matrix from two lines) with serviceable and faulty signals with vehicle moves. Reference of faulty points (aberration) to the second class (failure is result of training at change of parameters). Process of training is carried out and the network is tested for viewing of results of training. With increase in number of neurons the quality of recognition increases.

Let's consider in more detail the intellectual system of diagnosing of the braking system of the car. Its main objective is determination of technical condition of the braking system of the diagnosed car and issue of recommendations at misfit of operation parameters of this system to standard values. In this case the expert system "tree of decisions" is applied. Subtasks of system are:
1) Machine learning for improvement of operation algorithm.
2) Possibility of forecasting by results of collected data on work of system.
3) Determination of style of driving.

The solution of task is based on application of expert "tree" system. The settlement scheme of process of braking of the car is submitted in Fig. 3(a).

The accepted symbols:
- $\Theta_S$ – the deflection of elastic element of mechanical suspender;
- $p_{S1}$ - pressure in in air suspension of front axle;
- $p_{S2}$ - pressure in air suspension of rear axle;
- $S_{Bi}$ – the current value of braking distance;
- $S_B$ – the current value of pressing brake pedal;
- $G_1$ - the weight of front axle;
- $G_2$ - the weight of rear axle;
- $V_W$ – vehicle weight;
- $V_{Wi}$ – speed has begun braking of wheel
- $s_i$ – wheel slip;
- $\varepsilon_V$ – the complex parameter of the braking system;
- $j_B$ – the current value of the established slowdown when braking;
- $j_E$ – reference value of the established slowdown when braking.

![Figure 3. Model of braking of the vehicle: a – the scheme of forces operating on car wheels; b – the settlement scheme of definition of diagnostic indicators.](image-url)
The diagnosed system is considered as "black box" (see Fig. 3(b)) and its characteristics are described by the complex parameter of the \( \varepsilon_T \) braking system. At braking implementation the system defines the current \( \varepsilon_v \) value and compares to reference and accounting of borders of admission:

\[
\begin{align*}
\varepsilon_v & \geq [\varepsilon_v] - \Delta([\varepsilon_v]); \\
\varepsilon_v & \leq [\varepsilon_v] + \Delta([\varepsilon_v]).
\end{align*}
\]

During the work of expert system there is automatic correction of values \([\varepsilon_v]\) and \(\Delta([\varepsilon_v])\) depending on wheel slip of \(s_i\) depending on weather conditions. In this case \(\Delta([\varepsilon_v])\) is criterion for evaluation of style of driving, the size \([\varepsilon_v]\) characterizes the current technical condition of the braking system. Proceeding from the level \([\varepsilon_v]\) the forecast of operability of the braking system is formed. Besides, during the work of expert system control of failures of the braking system is made ("X" parameter) at which repetition the system informs on need of urgent repair.

In Fig. 4 the architecture of intellectual system of diagnosing of the braking system of the car is presented, the algorithm of realization of expert system is given in Fig. 5.

At the initial stage of work collecting the database \([\varepsilon_v]\) and \(\Delta([\varepsilon_v])\) depending on \(s_i\) for implementation of machine learning of expert system will be carried out.

Figure 4. Architecture of intellectual system of diagnosing of the braking system of the vehicle
Figure 5. Algorithm of realization of expert system
The adjusting parameter - the level of loading of the vehicle (depending on suspender type - pressure in air suspension of front axle $p_{S1}$ and pressure in air suspension of rear axle $p_{S2}$, or deflection of elastic element of mechanical suspender $\Theta_{Si}$) and wheel slip of $s_i$.

The steering parameter - the current value of pressing $S_{Pi}$ brake pedal.

Output parameters - the speed of some wheel of $V_{Wi}$ and the current value of braking distance of $SB_{i}$.

Diagnostic parameters – value of complex parameter of the $\varepsilon_{Bi}$ braking system.

Application of the presented system will allow:
- to increase availability of system of telematics of commercial transport;
- to exclude "human factor" at operation and forecasting of technical structure of commercial transport;
- to increase safety of transportations and traffic owing to timely prevention intellectual system about possible refusal;
- at introduction and development of the offered system there will be possibility of its integration with the systems of supervisory authorities that will lead to simplification of implementation of control operations by them.

References

[1] Veselov O. V. Metody iskusstvennogo intellekta v diagnostike : manual / Vladimir: Vladimir state university named after Alexander and Nikolay Stoletovs 2015

[2] TRANSPORT ROSII. Informacionno-statisticheskij byulleten’ 2018 URL: https://www.mintrans.ru/documents/7/9738

[3] Sputnikovyj GPS/GLONASS monitoring Truck-control 2019 URL: http://rus.truck-control.ru/

[4] Jaltest J-TDO Campo de Criptana, Ciudad Real, España 2019 URL: https://www.cojali.com/ru/%D0%9D%D0%BE%D0%B2%D0%BE%D1%81%D1%82%D0%B8-%D0%A1%D0%BE%D0%B1%D1%8B%D1%82%D0%8F31%D0%B1%D1%80%D0%BE%D1%88%D1%8E
 %D1%80%D0%B0-jaltest-j-tdo/

[5] Transics a WABCO compoany TRANSICS INTERNATIONAL BVBA Ieper Business Park - Zone K - Ter Waarde 91 - 8900 Ieper – Belgium 2019 URL: https://www.transics.com/