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Application of Artificial Neural Networks in Vehicles' Design Self-Diagnostic Systems for Safety Reasons

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Abstract

The article examines an approach to increasing the safety of a vehicle's design with the help of artificial neural networks (ANNs) integrated in the vehicle's self-diagnostic system. Solving this problem will require the vehicle's self-diagnostic system to be provided with a database with numerous states so that each information parameter can be assessed in terms of its impact on the probability of transition of the vehicle into some state. ANNs will help to correct the values of self-diagnostic output signals for prompt maintenance and current repairs as well as safe operation of the vehicle.

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Keywords: Vehicle, structural design safety, operation, self-diagnostic system, artificial neural networks.

1. Introduction

A modern vehicle is a complicated system with components which have to meet many controversial requirements. Safe design projects of both new and existing vehicles as well as justification of operating parameters of motion require mathematical models which will cover main features of the vehicle as a controlled object and allow predicting the behavior of a vehicle due to environmental impacts and driver's actions.

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Theoretical researches are carried out using computer modeling to correct the parameters of structural design safety throughout design and development stages and modifications made in the approved technical solutions.

A modern vehicle has a specific design feature of having a lot of different electronic control units which affect its operating safety.

Electronic control units (ECU) of a vehicle provide control and diagnostics for engine control system and automatic transmission, towing and braking control systems, air bags, other systems of active and passive safety. The ECU has an adjustment function which can adjust the database of states of a controlled system and control program according to their actual condition.

The vehicle's self-diagnostic system provides cross checks of signal’s level of the ECU with their reference values stored in the memory. If the signal level exceeds the allowable limits, the ECU processes it as a fault and sends an alarm message to the memory. These alarms can be retrieved from the memory as a "fault code". After being retrieved these codes provide important information for diagnostics of the vehicle.

The vehicle's self-diagnostic system has not achieved such a level which will guarantee 100% fault detection rate. For example, a fault code will not show up in those cases when the software does not process relevant information from some sensors or states.

Neural network technologies are intended for solving complicated issues among like condition diagnostic features of a vehicle. This results from the fact that very often a researcher has to deal with a mass of different facts which are not covered by some mathematical model yet.

One of the most convenient tools for addressing this sort of issues is artificial neural networks, a powerful and flexible method to simulate processes and phenomena.

2. Study of the application of artificial neural networks in the vehicle's self-diagnostic system for increasing their structural design safety.

Today artificial neural networks are implemented using hardware and software tools to create specific models and devices. Artificial neural networks address wide-ranging problems related to vehicle's self-diagnostic capacity based on the algorithms of image discrimination theory.

Neural networks have a distinguishing ability to learn using experimental data of some study area. Regarding the vehicle's self-diagnostic system, the experimental data is represented as a set of numerous source features or parameters of an object and a diagnosis based on them which are 100% credible [Anil et al. (1996)].

The learning for a neural network is an interactive process during which the neural network identifies hidden nonlinear dependencies between source parameters and final diagnosis as well as the most satisfactory combination of weight coefficients of neurons connecting adjacent layers and which has the minimum final diagnostic error. Neural networks have an advantage of their relative simplicity, nonlinearity, operation with fuzzy information, minimum requirements for source data, capability to learn on specific examples. During the learning process the neural network input receives a sequence of source parameters together with diagnoses which are derived from these parameters [Belyakov et al. (2001), Viktorova (2012)].

For the neural network to learn it shall be provided with a sufficient number of examples to adjust the adaptive system with the required degree of credibility. If the examples belong to different diagnostic groups and the number of such groups covers as many components of a vehicle as possible, then the artificial neural network will allow identifying and comparing the diagnoses for virtually any new case provided that the given set of indicators is similar to those used for training the neural network. In so doing, the neural model will have the advantage of requiring no complicated mechanisms to describe the diagnostic event.

At the same time, the application of neural networks causes a number of difficulties. One of the major problems of application of neural network technologies is an unknown level of complexity of a designed neural network which will suffice to produce the right diagnosis [Semykina (2012), Khakhanov and Shcherba (2010)].

There are different approaches and concepts about formation and training of artificial neural networks. The actual selection depends on the characteristics of a task which is planned to be resolved by the ANNs. ANNs help to solve different problems like image discrimination, forecasting, approximation of functions, etc.

Within the framework of the artificial neural networks, vehicle's design safety issue can be addressed through image discrimination. Data about the forecast variable within a certain time interval which form an image the class