Simulation of the Vehicle Test Based on the Design of Elements of Artificial Intelligence

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Abstract: The paper examines the structure of the expert system for analysis and optimization design of the vehicle. The structure of the expert system consist a user interface, mathematical model, the inference module and a knowledge base. The user interface is designed for both input conditions and output characteristics and to evaluate the performance of the system, which allows further optimize the system. Inference module is built on the principle of multi-agent systems (MAS). It includes, the coordinator agent and agents specializing in vehicle systems. The source of algorithms for agents inference module is rule base, the base use case, the database and the neural networks that are part of the knowledge base. A mathematical model, which is part of the expert system is used for self-performance system.

Key words: Expert system · Multi-agent system · Knowledge base · Simulation model of vehicle

INTRODUCTION

The current stage of the development of mechanical engineering, both abroad and in our country is characterized by a high level of competition between manufacturers. The main focus of the competition is to raise the quality of products, while maintaining an acceptable level of prices for it. Modern machinery production in order to be competitive and to ensure the required quality of the products must be flexible and quickly respond to any changes in the production and external environment. As a result, the company must apply the advanced automation techniques in all phases of the product lifecycle. With the reduction of the lot size and increasing the number of modifications in the cost of each product, we can observe the increasing share of costs attributable to the preparation stages of its production: design, testing, development increases and the manufacture of products is accounted as a smaller portion of the total time of the order. Consequently, the main reserves of the reduction of production cycle time and cost of its production are integrated in the sphere of complex production preparation. To enhance its competitiveness the enterprise continually expands the range of products and therefore increases the amount of pre-production.

Structure of the System for Automatic Analysis and Optimization Vehicle Characteristics: Pre-production stage involves several cycles of design documentation development, prototyping, testing, changes in the design documentation, completion of a prototype, re-testing (Fig. 1).

Nowadays to reduce the costs of research in preparation of production are used software tools with the use of computational techniques and statistical analysis of empirical data. There are many systems allow to do analysis and optimization of the various characteristics of the vehicle [1]. But these systems are just add-ons for other software systems used for basic calculations. Therefore, the acquisition of the system for the calculation itself and the optimization system is necessary, which leads to increasing of the costs. In addition to design, for example, an expert system, which structure may include several independent modules, often requires adaptation, data conversion, because the same MatLab operates matrix computations [2]. Also versatile products are characterized by complex means of support, high cost and the best solution is implemented for each individual technology not always.

For taking effective and timely solutions to the pre-production stage is necessary to consider a lot of factors, have reliable data on analogues, the decisions

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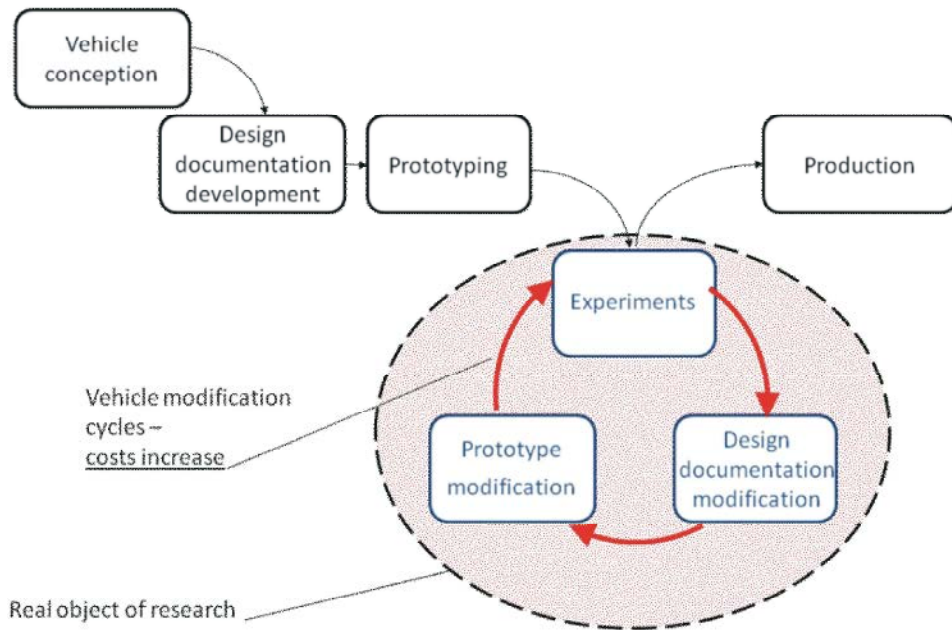
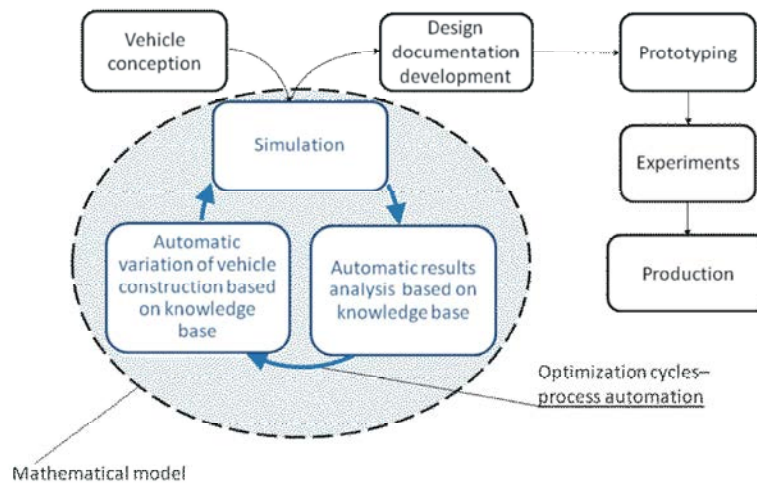Fig. 1: Existing vehicle development procedure

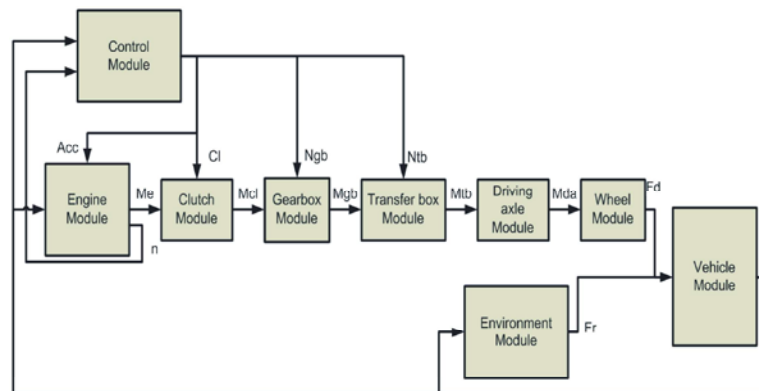Fig. 2: Proposed procedure for vehicle development

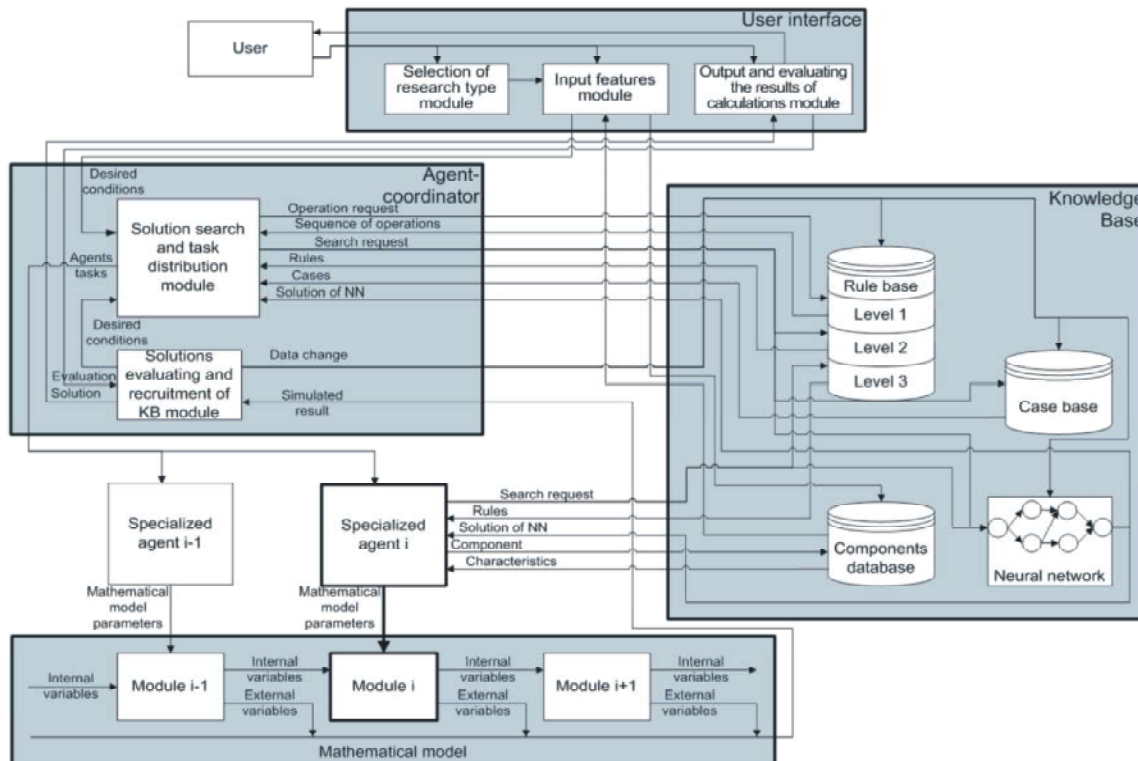

Fig. 3: Structural model of vehicle

Fig. 4: Structure of agent-module interaction

taken and the impact of these decisions in the design, the features of a car, for the optimization of which a lot of experience in this area is demanded (i.e., these techniques are directly related to expertise knowledge) [3, 4]. To solve these problems a decision support system (DSS) that will significantly reduce the time cost and improve the quality of decisions is widespread [5]. The test procedure and the creation of a prototype, in this case, is replaced by a computer simulation of the test vehicle or its components (Fig. 2).

When building a simulation system of the vehicle test is developed a structural model of the vehicle in the form of a set of modules and the interactions between them (Fig. 3) [6]. Such a modular structure allows you to modify, expand and refine the model, depending on the tasks of the expert system. The availability of management and the external environment module allows the use of a model for the calculation of a large variety of indicators under different driving conditions and vehicle control algorithms.

The user interface is the primary means of external control of the expert system. To do this, along with the choice of the type of research modules and input characteristics of the vehicle is provided the output module and the evaluation of the results.

Selection of research type module is necessary to determine the type of work, i.e. simulations to evaluate performance or carrying out the complete cycle of optimization using knowledge base elements. In the optimization of this module the constraints and objective function are set, ie, the target values and characteristics of the studied parameters are determined, the change of which is inadmissible while the optimization.

Input features module allows you to upload, edit and save the characteristics of units and systems based on components, as well as to determine the complete set of the vehicle used for the calculation or optimization.

Output and evaluating the results of calculations module gives the user the parameters of testing vehicle, the parameters of the optimal vehicle, a ranked list of alternatives and the procedures for carrying out the optimization. The user must be able to have the possibility to assess the suitability of the optimization results for their further implementation in practice. After evaluating the results of optimization of the vehicle corresponding entries in knowledge base are to be introduced [7].

The array of data that can be used to create a decision support system have already existed in enterprises. But there are several problems associated
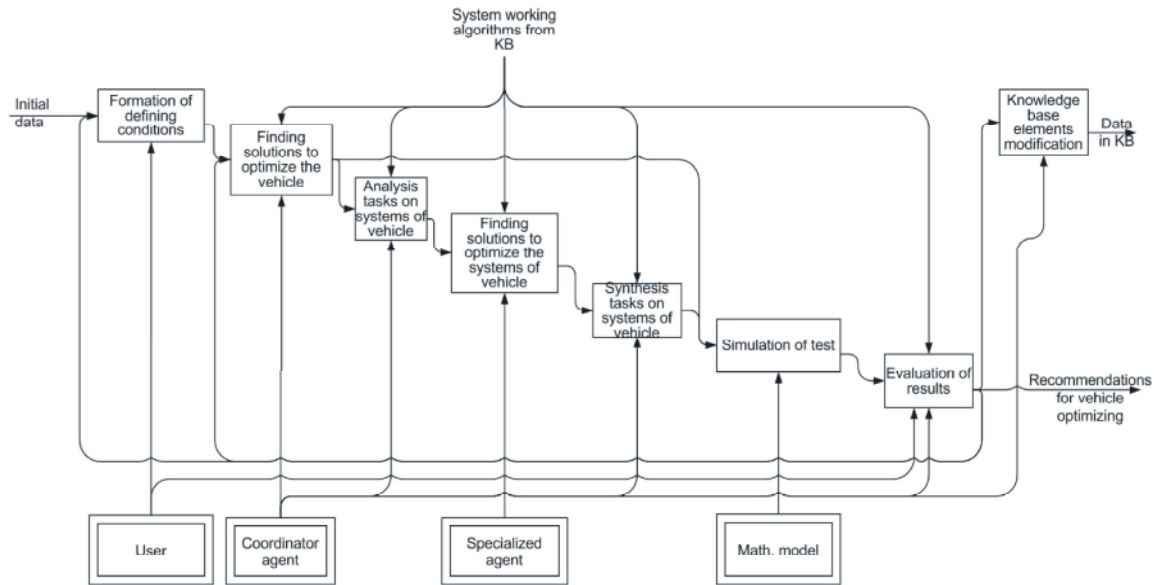
Fig. 5: Functional diagram of finding solutions

with the storage, processing and transfer of expertise data. To resolve these problems, the inference must be separated from the formalized knowledge about the product, which are contained in a special unit - the knowledge base (KB) [8]. There is also a problem of optimality of the proposed solutions, which is necessary to assess the preliminary mathematical modeling of the object.

It is proposed to organize the cooperation of module inference, mathematical models and knowledge - based on the multi-agent approach [9, 10].

Under this approach, the inference module consists of a coordinator agent and agents which specialize in certain vehicle systems. Each agent has the opportunity to access the knowledge base and the assessment of the decisions taken by agents is produced by the mathematical model. The structure of this interaction in relation to one of the agents is listed in Figure 4.

In accordance with the structure of the knowledge base, as described above, the procedure for finding solutions takes the form, represented in Figure 5.

CONCLUSION

Approaches to the construction of expert systems proposed in this paper provide the ability to change the mathematical model based on changes in vehicle design. The database system is divided into the component database and base use case, which reduces its volume by

eliminating duplication in the units and systems of the vehicle. The system has a modular agent-view, which simplifies the development of a knowledge base.

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