Logical artificial intelligence Mivar technologies for autonomous road vehicles

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Abstract. The main field of our research is artificial intelligence already implemented in the experimental autonomous road vehicle. Artificial intelligence now is a really huge area of studies. This investigation is focused more on a development of intelligent systems. Such as expert systems, semantic text processing systems, semantic image understanding systems, robotics systems. Wi!Mi is a solution for developing mivar knowledge models. This tool belongs to the class of so-called ES shells – programs that allow significantly simplify and accelerate the ES development process. It uses a novel knowledge representation mechanism based on bipartite graphs and the significantly improved but simple inference engine, which is able to process large systems involving millions of variables in just a few seconds. A special representation model which is called mivar nets with linear computational complexity using if-then rules is used in Wi!Mi. The idea is that the subject domain is divided into objects and connections between them. Scientific investigation allows to implement new decision-making system called “RoboRazum” as a form of an embedded software platform with flexible capabilities to adapt to control by any robotic suites and systems. RoboRazum is a platform for designing autonomous robotic control systems. Provided solutions don’t require powerful computational resources and could be used in small systems-on-chip like microcontrollers. That is why this solution is perfectly fit with conception of Internet of Things (IoT). Reasoned and fast logical decisions based on mivar technologies play important role for autonomous road vehicles.

1. Research areas of artificial intelligence

The main field of our research is artificial intelligence. Artificial intelligence (AI) now is a really huge area of studies and lot of research is going on there [1]. At present time research is being done more at a development of intelligent systems [1]. Such as expert systems [1-2], semantic text processing systems [3], semantic image understanding systems [3], robotics systems [4–10].

So our main task is to develop four basic directions.

- First direction is expert systems, systems intended to help experts to make decisions – how to make the developing process cheaper and faster, in other words ES shell [2].
• The second one is the semantic natural language processing – development of semantic platform for solving tasks of semantic text analysis and natural Russian language understanding [3].
• The third one is an Intelligent image processing (smart image recognition with the text description of the image as a result) [3].
• And the fourth one is robotic control systems. The question is how to force robotic systems to behave intelligently [4–12].

All these directions can be used for autonomous road vehicles.

2. About mivar technology

When you build intelligent systems, one of the main questions is how to represent knowledge about subject domain we are working on in a “good” way. What do it means? The question here is how to represent knowledge in a form, which will be understandable for a computer and for the intelligent system developer as well. Usually in scientific literature they called this feature “expressiveness of the model”. But this is not the only question. We have to work with knowledge. That is why this knowledge representation mechanism should also be effective. It means that we need to be capable to effectively process this knowledge.

Universal modelling system. Knowledge representation (KR) is one of the fundamental problems of AI, which occupies developers to this day. Currently, there are many approaches to knowledge representation including predicate description, semantic networks, production rules, neural networks, evolutionary, agent-oriented, stochastic and many others. In our products we use our own knowledge representation technology.

Principles of mivar-based approach. The idea is that the whole world can be represented in a form of triples (object-property-relation). This concept in different modification served us as a foundation of mivar knowledge representation models in our products. Moreover this idea made it possible to develop Wi!Mi, Tel!Mi and Robo!Razum and to construct out own inference engine.

Wi!Mi is an expert system shell. This shell gave a possibility to develop expert systems in totally different subject domain while significantly reducing time and costs. The Wi!Mi shell uses its own mivar model of knowledge representation developed by the authors. The basis of mivar approach to knowledge representation is adaptive, dynamic description of the modeled domain.

The idea is that the subject domain is divided into objects and connections between them. And all this entities form the bipartite directed graph – mivar net. Mivar logical inference with linear computational complexity using if-then rules. On the base of this representation it became possible to construct the inference engine which works really fast. If we have some task for the system, this engine builds a solution algorithm how to solve this task. After you receive the algorithm you can run it and receive desired results. And this algorithm is constructed in just few seconds in really huge subject domains. On the base of the idea described above, a representation model giving a possibility to create an inference engine has been constructed. This preinstalled inference engine will be used in all systems created with Wi!Mi. The developer only has to fill the knowledge base without paying attention to inference engine.

Mivar knowledge representation model. The Wi!Mi shell uses its own MIVAR model of knowledge representation developed by the authors [12]. The basis of MIVAR approach to knowledge representation is adaptive, dynamic description of the modeled domain. The key concept in MIVAR approach to knowledge representation is the notion of MIVAR net. This net provides formalization and representation of human knowledge when creating expert systems using the Wi!Mi shell.

The mivar net is a way of representing the information part of MIVAR space (objects and rules for processing them) as a bipartite directed graph, consisting of objects P and rules R (Fig. 1). Together, these objects and rules form the domain model.
Figure 1. Bipartite graph of MIVAR net. Here objects are represented by yellow ovals and rules are represented by blue rectangles.

The mivar knowledge representation, described above gave us a possibility to construct an algorithm (method) that allows to build the solution scheme of different problems which occurred in considered subject domains. Using the above representation of domain knowledge, it is possible to construct an algorithm that allows searching for information within the mivar net. The mivar net data model allows determining the open and hidden relationships between objects within the network, and building algorithms for inference path calculation for any given task within relevant subject area.

3. Robot Intellectualization
Integration of service robots is hindered by many factors: poor reliability, high cost of mechanisms, small battery capacity, high cost of sensors and low level of intellectualization. Due to production development, engineers have managed to solve problems associated with components of robotic systems, however the problem of service robot intellectualization is still urgent. Service civil robots should be smoothly integrated into human environment: thus, the robot should interact with infrastructure of the modern world and have capability to communicate with a human being. Therefore, the service robot should be controlled by the on-board autonomous artificial intelligence system. We propose our own approach to robot intellectualization. Implemented decision support system is called “Roborazum”. It’s a form of an embedded software platform with flexible capabilities to adapt to control by any robotic suites and systems. Provided solutions don’t require powerful computational resources and could be used in small systems-on-chip (SoC) like microcontrollers and etc. That is why this solution is perfectly fit with conception of Internet of things (IoT).

4. An example of intellectualization platform integration
We consider autonomous road vehicles and intellectual transport environment elements as a particular case of robots. Robotic suite control system as an example of intellectualization platform integration collects information from sensors and sends it to the decision-making system. System processes the information and finds possible solution transmitted then to the robotic suite control system, and the last one sends control signals to engines. The task could be set in natural language, then using the software product Tel!Mi, system understands, what to do. After that system runs a search of possible solution in knowledge database. Also system gets information from sensors. This knowledge fills the solution models. After all information is processed, system generates control commands and sends them through hardware platform interfaces to the robot. Some projects have already been implemented using our robotics software intellectualization platform.

Expert systems are used in different models taking into account the following: road signs, road users, pedestrians, road surface marking. For example, the first model of autonomous car passing through an
intersection contains 338 parameters and 320 rules. The second model of robot motion in the streets with heavy traffic consists of 240 parameters and 250 rules. As a result of model processing, the car obtains action algorithm for carrying out further actions.

5. Summary
The methodology of creating the control systems of autonomous road vehicles, integrated in intelligent transportation environment has been developed. The experimental autonomous road vehicle representing a platform with open protocol for development and testing of autonomous road vehicles technologies is described in the paper [6–7]. The problem of tactical level is to provide fast and correct decision-making with further logging of each reasoned step. In this case mivar technology implementation allows to find the way of solving the request and then applies logical solution. So all the responses will be logically approved and the response rate will be much higher than in standard systems. Reasoned and fast logical decisions play important role for autonomous road vehicles.

6. References
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