Control of vehicles and robots: creating of knowledge bases for mivar decision making systems robots and vehicles

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Abstract. An important element in the control of machines and robots is the Mivar decision-making system based on production rules and cause-effect relationships. For example, unmanned vehicles must know the traffic laws rules in a real environment. It is shown how young scientists and students of the department "Information Processing and Control Systems" of the Bauman Moscow State Technical University successfully create production knowledge bases for mivar decision-making systems for unmanned vehicles and robotic systems. It is proposed to use actively our experience in all educational and scientific institutions where they solve the problems of controlling machines and robots.

1. Introduction

It is well known that in Russia in the field of artificial intelligence (AI), new mivar information processing technologies were created: evolutionary accumulation and fast logical inference (and automatic construction of algorithms), which made it possible to remove the restriction of NP-completeness of logical inference by dramatically reducing its computational complexity to linear [1, 2]. Mivar technologies removed the most important limitation that led to the second "winter of AI" in the second half of the 1980s – this is the limitation of a complete exhaustive solution to the problems of logical inference and planning the actions of robots in various state spaces. Mivar networks, due to a new approach to representation of product information in the form of bipartite directed graphs, allowed us to reduce the problem of logical inference and / or automatic construction of algorithms to finding a quasi-shortest route on bipartite oriented graphs, and, due to the use of multidimensional database technologies, linear computational complexity.

As you know, earlier the logical inference problem belonged to the class of NP-complete problems, but now this very task (and all the tasks that can be reduced to it) has been "withdrawn" from the NP class and an algorithm with linear computational complexity, patented in Russia, has been proposed for it. The millennium problem with the formulation $NP = P$ has not yet been solved, but one practically important class of problems has been deduced from this "curse of dimension". In our studies, to solve practical problems, mivar networks of 1200 rules and more than 3000 rules were created, which are solved on a regular laptop in a split second. If we apply "pre-mivar approaches", then the complexity of these tasks will be 1200! (factorial) and more than 3000!. Experiments with 5 million rules were conducted. They involved two-dimensional matrices that were automatically generated, and the time to search for solutions to them and / or inference on an ordinary laptop did not exceed hundredths of a
second. It was this fact of the linear complexity of the logical inference that allowed us to move to a new level of research in the field of AI and brought scientists closer to creating a full-fledged "strong" "general" artificial intelligence (AGI), which all of humanity dreams of.

Currently, our research continues at the Scientific Research Institute MIVAR and at the Department of IU-5 "Information Processing and Control Systems" of the Bauman Moscow State Technical University (BMSTU). For several years now, we have been teaching students how to work with the CESMI WiMi "Razumator" software package (included in the Register of Russian Software of the Ministry of Communications of Russia), which can process more than 5 million production rules / sec on a regular laptop. Note that mivar technologies are developed at the department as a part of a more general scientific approach in the direction of hybrid intelligent information systems [3, 4], for example, scientific works on Metagraphs [5-7], cognitive computer graphics [8], neural network algorithms [9] and methods of intellectual analysis [10]. It is currently important to note that it is the hybrid use of the logical and reflex levels in the field of artificial intelligence that can lead to the achievement of the goal of creating a "common" and / or strong AI (AGI).

It is important to emphasize that mivar technologies are successfully applied at the logical level of research in AI in all main directions [1] for the development of intelligent systems, management information systems [11], decision support systems for a doctor [12], and control of unmanned vehicles [13-15], as well as for the analysis of traffic accidents [16]. In 2018, a new metric of autonomy and intelligence of robotic systems (RCs) and cyber-physical systems (CPS) was proposed [17], based on measuring the number of production rules and actions of the RCs and CPSs in possible situations: the more possibilities of the elementary actions of the RC are, the more complicated its behavior can be. But in general, the number of combinations of various situations is determined by the factorial of the number of elementary rules-actions. To control mobile robots and cars developed: mivar systems for monitoring compliance with traffic rules on the basis of "Razumator" and expert systems [18].

Since 2018, mivar technologies began to be used for intelligent planning of the behavior of robots in the state space [19] and a new MIPRA algorithm (MIPRA – Mivar-based intelligent planner of robot actions) was proposed that replaces STRIPS planning [18]. It is important to note that for communicating robots and machines in natural language with people and among themselves, a mivar virtual Russian-language text consultant can be used [20].

2. Decision systems for controlling machines and robots

Currently, research is actively developing in the field of control of machines and robots, for example, for unmanned vehicles. Vision systems are successfully created based on the reflex level of AI research through the active use of neural network technologies. However, for decision-making in complex and non-standard situations, it is necessary to apply a logical level, where recently mivar technologies for creating expert systems have been successfully used. It is important to note that cause-effect relationships in the form of production rules in the If-Then formalism make it possible to formalize, for example, traffic rules.

As part of the research work of students at the Department of IU-5, mivar decision-making systems (DMS) are used for unmanned vehicles and autonomous robotic systems (RCs). In 2018-2019, our students explored the field of creating a DMS for training unmanned vehicles in the traffic regulations.

It was decided to divide the traffic laws into several sections and simultaneously create all the necessary knowledge bases. From our students and young scientists, a project manager was selected and appointed, who coordinated the work and determined the formats for representing knowledge. It was revealed that even before the introduction of the rules in the CESMI software package, it is necessary to create mivar tables for quick, "friendly" and convenient creation of mivar knowledge bases for traffic rules. Such tables allow one to check and verify the inconsistency and adequacy of the source data.

Let us give an example of a part of the spread chart for section No. 15 of paragraph No. 1 (edition of January 1, 2019, the traffic rules of the Russian Federation). The rule is formulated as follows: "Drivers of vehicles can cross railway tracks only at level crossings, giving way to the train (locomotive, trolley)".

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This rule passed a preliminary formalization taking into account previously identified parameters of the subject area, the result of which is presented in Table 1.

### Table 1. Example of traffic rules representation in the form of a mivar table.

| Subrule | Formal description | IF | THEN |
|---------|--------------------|-----|------|
| 15.1.1 The presence of a railway crossing | The train (locomotive, trolley, etc.) is approaching | TRUE | Crossing of railway tracks is prohibited |
| | The train (locomotive, trolley, etc.) stands | TRUE | Crossing of railway tracks is prohibited |
| | The train (locomotive, trolley, etc.) is absent | TRUE | Crossing of railway tracks is allowed |
| 15.1.2 The absence of a railway crossing | The train (locomotive, trolley, etc.) is approaching | TRUE | Crossing of railway tracks is prohibited |
| | The train (locomotive, trolley, etc.) stands | TRUE | Crossing of railway tracks is prohibited |
| | The train (locomotive, trolley, etc.) is absent | TRUE | Crossing of railway tracks is prohibited |

Upon completion of the scientific research works, methods were developed for the formation of Mivar knowledge models and material was obtained for creating Mivar knowledge bases. In addition, a technology is being developed to "assemble" various knowledge bases into a common knowledge system for traffic rules.

Created Mivar networks are investigated on models, both virtual and physical. One example of a Mivar network in the subject area of traffic rules is presented in figure 1. In this example, recommendations are made for driving a car at an unregulated intersection. At the crossroads, the "Take the road" sign (parameter X1) is installed and the driver plans to drive the intersection in the direction "Straight" (parameter X2). It is required to determine the need to concede when making a maneuver to cars approaching to the left (parameter Y1) and to the right of the intersection (parameter Y2). To search for vertices Y1 and Y2, the rules R1, R2, and R3 and the intermediate parameters T1, T2, and T3 are used. Set A characterizes the traffic situation, and set B describes the recommended actions of the driver. Depicted in Figure 1, Mivar network is built automatically according to a given traffic situation from the rules of Mivar models [2].
Summarizing all of the above, it should be noted that a major scientific problem has been solved for automatic construction in real time and on the usual single processor of algorithms for making decisions by robots and cars. Techniques have been developed for creating knowledge bases for Mivar networks describing various subject areas, including various subject tasks for controlling machines and robots.

It is necessary to create descriptions of subject areas for various machines and robots in the form of detailed instructions and manuals. Based on such training materials, specially trained cognitive specialists will be able to create automatically mivar bipartite oriented graphs for specific machines and robots used to solve various problems in various environments.

3. Conclusions

Thus, it can be argued that separate systems of Artificial Intelligence have already been created and cognitologists (mivar analysts) are actively teaching it to various subject areas. A new and very promising profession of the future is being created: the "mivar cognitologist", which is engaged in the creation of knowledge bases in the formalism of Mivar networks for controlling machines and robots.

In addition to existing control systems for autonomous unmanned vehicles, Mivar decision systems can be used that can ensure robots know the traffic laws at a logical decision level.

Students of the Department of IU-5 BMSTU, for several years, have been successfully mastering the CESMI Wi!Mi "Razumator" software package and are enthusiastically creating knowledge bases on the
traffic laws and others designed to control cars and robots. We offer to use our experience of training and work on the creation of Mivar knowledge bases for controlling machines and robots in educational and scientific institutions.

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