

Automated formation of discipline sequences for higher ecological and agricultural education using mivar expert systems

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Abstract. Training qualified specialists for agriculture, ecology and industry is becoming increasingly important in today's rapidly changing world. The constant development of science and technology leads to an expansion of the required knowledge, which creates difficulties for students in assimilating huge amounts of information in a limited time. This discrepancy requires constant updating and improvement of educational programs, ensuring the inclusion of relevant courses and workshops, and maintaining a logical sequence to prevent knowledge gaps. At Bauman Moscow State Technical University (BMSTU), about 25,000 students study in more than 600 programs, including ecology and forestry, using the Electronic University system for automated management of educational processes. Logical AI helps in planning individual educational trajectories, improving decision-making and quality control, especially in the field of agriculture and ecology. The development of mivar networks for educational programs further optimizes management, an example of which is the construction of mivar networks for specific courses. This approach solves the problem of managing large unstructured volumes of data, providing a model for transforming input knowledge into competencies. The integration of mivar expert systems offers a structured method for sequencing courses, ultimately improving the educational structure at Bauman Moscow State Technical University.

1 Introduction

In the modern world, the preparation of qualified specialists is becoming an increasingly important task. With the rapid development of science and technology, the volume of necessary knowledge is constantly growing. Employers regularly change and raise requirements for graduates of educational institutions. Students have to master a huge amount of information in a limited time. This contradiction between the growing demands for education and limited opportunities requires constant updating and development of educational programs.

Programs should include relevant academic disciplines and practical courses that need to

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be constantly adjusted. It is also important to maintain consistency in students' study of various disciplines to prevent situations where a lack of basic knowledge at the initial stages of education hinders the assimilation of more complex material at later stages. Academic disciplines should be organized in a certain order, forming a coherent course of study for students in various fields.

Bauman Moscow State Technical University educates about 25,000 students in more than 600 educational programs, the formation and development of which use its own automated educational process management system "Electronic University". Logical artificial intelligence helps in planning individual educational trajectories for students. The goals of the EU include the automation of business processes and the formation of an information system to support decision-making in university management. The use of the EU improves the educational process and allows for quality control.

The development of mivar technologies in logical artificial intelligence has been going on for quite some time. These technologies have proven effective in solving tasks within the framework of production networks, as they enable finding solutions with linear computational complexity [1]. Mivar technologies are widely used for creating expert systems in various fields, such as the management of educational programs at universities [2], the detailed description of knowledge in a scientific discipline [3], the detection of bank check fraud [4], intelligent plant care systems [5], decision-making on the safety of thermolabile blood components [6], optimization of the process of preparing fresh frozen plasma for transfusion [7], diabetes diagnosis [8], automated assembly [9], mechanical engineering [10], and many other areas. Additionally, mivar technologies have found their place in the creation of hybrid artificial intelligence (AI) systems. They can be implemented in a wide range of activities, such as creating a brief overview of judicial practice [11], detecting energy theft in smart grids using explainable attention maps [12], using metagraphs to represent data sets [13] to overcome limitations [14] and improve existing knowledge bases [15], for tasks of analysis and classification [16] of equivalent logical operations [17], and solving first-order logical equations with exhaustive search for solutions [18].

The hybrid AI approach with the application of mivar technologies includes neural network methods. Neural networks can be used for sentiment analysis based on text and audio data [19], for processing media information [20] and its optimal encoding [21], for working with satellite images [22] and text queries [23]. Hybrid AI can also be applied in the development of polymer microstructures [24] and composites [25], in modeling heat exchangers [26], as well as in the formation of intelligent technological units [27]. The use of mivar technologies in conjunction with a neural network approach simplifies the process of analyzing LiDAR data for the task of finding trees and estimating their diameter [28], and for measuring active gases affecting the climate at carbon landfills [29]. Mivar technologies are capable not only of decision-making but also of performing intelligent analysis of pulsed EPR for recognizing 3D objects by an optical location system [30]. One of the most promising areas of application of the mivar approach and hybrid AI is the development of robotics [31], as well as the navigation systems of robotic complexes [32], and the creation of intelligent vehicle control systems [33]. One of the complex tasks in this area is pathfinding [34] with planning the shortest route for a robotic complex [35], which is especially important when moving autonomous transport on public roads, where many conditions need to be taken into account [36].

2 The problem of creating mivar networks of educational programs

At Bauman Moscow State Technical University, the project on formalizing educational programs in the format of mivar networks "Objects, Rules" continues to develop for

improving university management. Based on previously obtained results, it was justified that mivar technologies of logical artificial intelligence will help automate the educational management process at the university even in such large volumes (millions of rules) and changing conditions. Thus, during the project, a mivar network of 75 parameters and 57 rules was created for the educational program in the field of “Rocket Complexes and Cosmonautics.” Additionally, a mivar network of 90 parameters and 14 rules was built to describe the knowledge chain of the discipline “Rocket and Space Production Technologies,” combining 8 academic disciplines.

For any university, an important problem is the automation of educational activity management with quality control of the educational process organization at all stages. When forming an optimal curriculum, the main difficulty is the large volume of unstructured data describing the outcome of the educational program. To solve this problem, a mivar approach to forming a model of the learning process based on the analysis of competency acquisition within the educational program is proposed. This approach requires describing each academic discipline as a rule for transforming input knowledge into output knowledge. The main difficulty is the clear definition of input and output parameters for each academic discipline.

As noted, Bauman Moscow State Technical University has an actively developing automated university management support system, Electronic University (EU). One of the subsystems of the EU is the “Library of Educational Programs,” which contains information about academic disciplines. By extracting information from the sections of the academic disciplines interface from the “Library of Educational Programs” of the EU, output data can be obtained, which then become input parameters for subsequent disciplines.

In previous stages of the project, the problem of constructing a graph of academic disciplines within the educational program was solved using the environment “Constructor of Expert Systems Mivar KESMI Wi!Mi RAZUMATOR 2.1.” For the selected educational program, a learning process chain was built, starting from school knowledge and ending with the final qualification work (FQW). Also, for knowledge detailing, the discipline “Rocket and Space Production Technologies” was chosen, and a mivar network was built, combining 8 academic disciplines.

Continuing the work, we will consider the construction of a mivar network for a number of disciplines of the SM10 department. For example, to study the discipline “Mivar Technologies of Logical AI,” it is necessary to have knowledge obtained from the study of preceding disciplines. Further in the example, the relationship is shown, where four input parameters are analyzed at the input, and the output parameter “Mivar Technologies of Logical AI” is obtained at the output.

Example: “Relation o6”.

Rule: Possibility of studying mivar technologies.

Input parameters: Object-relational data model=1; Graph data models=1; Technologies for interacting with post-relational databases=1; Working with graph databases using Neo4j DBMS as an example=1;

Relation formula: var a, b, c, d, e; if (a==1 && b==1 && c==1 && d==1) {e=1} else {e=0} Result (output parameters): Mivar technologies of logical AI=1.

During the research and analytical work with the descriptions of disciplines as operators of transforming input competencies into output ones, the following problems were identified:

1. Broad formulations of skills, knowledge, and proficiency that do not reflect specific key terms of the discipline’s subject area.
2. Insufficient correspondence between the output competencies of the first discipline and the actually necessary input knowledge for studying the second discipline, as the output competencies are formulated as the final set of specialist skills.

3 Description of the methodology for forming a sequence of academic disciplines in a university using mivar expert systems

The learning process at a university can be represented as a “process” model, where the inputs are “school knowledge” objects, and the outputs can be considered the competencies and knowledge acquired during the study, which are tested in exams and the defense of the student’s final qualification work (FQW). For the example of formalization in this work, we take the FQW as the output object and the sign of graduation from the university. In turn, the student’s ability to prepare and defend the FQW reflects their successful mastery of a set of specific knowledge required for the chosen field of study or specialty.

A more detailed structure of the learning process model can be represented as a directed bipartite graph, where each node is a discipline studied within the educational program. It is assumed that each discipline must cover a certain part of the complete set of knowledge established by the educational program. Each node has an input and an output. The input is the competencies covered by the preceding discipline. The output is the competencies covered by the current discipline.

To solve the problems formulated above, a method for forming a sequence of academic disciplines in the formalism of mivar networks is proposed. According to this method, the following actions need to be performed:

1. Identify a set of disciplines for which the educational route will be built. At this stage, it is necessary to select the academic disciplines that will be included in the educational program. Disciplines should be chosen from the automated university management support system “Electronic University” (EU). This system has a section “Library of Educational Programs,” which contains all the necessary information about educational programs and academic disciplines, particularly in the field of “Information Processing and Management Systems.”

2. Identify input knowledge. At this stage, for each of the selected disciplines, it is necessary to determine the input data, i.e., the already studied topics required for successful mastery of the material. Input parameters can be obtained from the academic discipline files located in the “Library of Educational Programs” of the EU.

3. Identify output knowledge. At this stage, it is necessary to determine the set of main topics that the student will master as a result of studying each discipline. Similar to the input data, output parameters can be obtained from the academic discipline files located in the “Library of Educational Programs” of the EU.

4. Formulate rules describing the sequence of studying disciplines. To formulate the rules describing the sequence of studying disciplines, it is necessary to take the section of the document “Working Program of the Discipline” - “Place of the Discipline in the Structure of the Educational Program,” where for each discipline, a list of disciplines that need to be previously mastered and a list of disciplines for which this discipline is necessary as a prerequisite are indicated.

5. Create a mivar network. At this stage, using the environment “KESMI Wi!Mi RAZUMATOR 2.1,” a mivar model is created, including a list of rules defining the relationships between the discipline and the knowledge required for its study, as well as rules describing the relationships between the discipline and the knowledge formed during the learning process.

As an example, a part of the curriculum (a chain of disciplines) necessary for studying a number of disciplines of the SM10 department is considered. The knowledge chain consisting of 64 parameters and 14 rules was constructed using KESMI Wi!Mi RAZUMATOR 2.1. An example of a solution graph that can be obtained is shown in Figure 1.

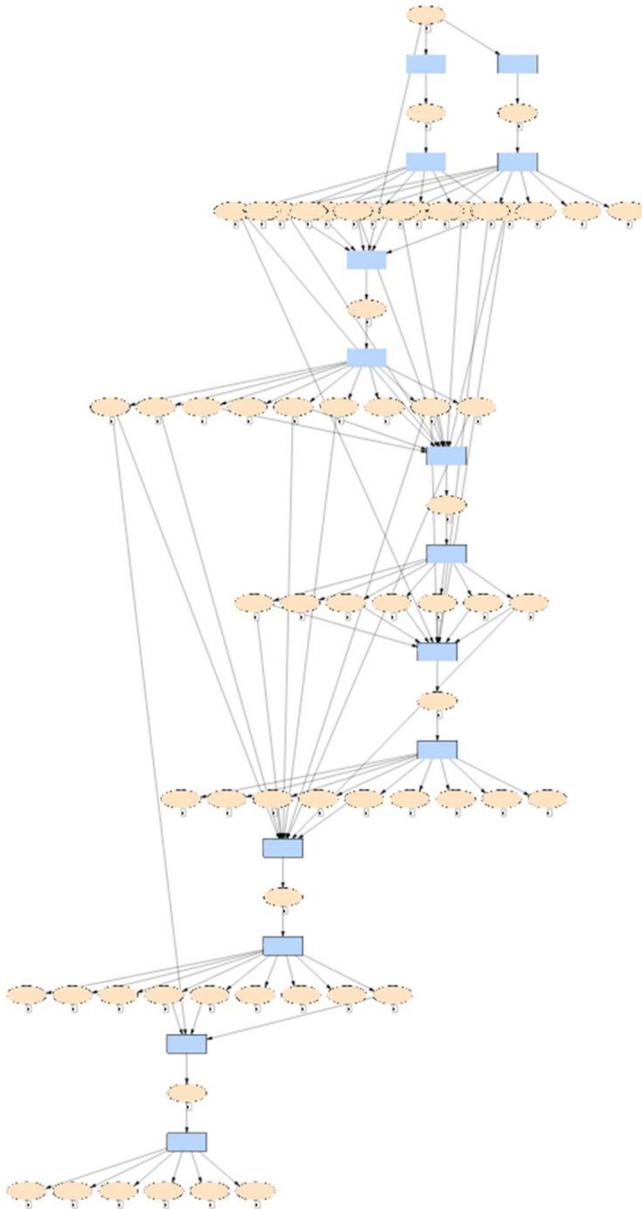


Fig. 1. An example of chain of knowledge in a number of disciplines of the Department of SM10.

Let's provide an example of one rule from the created mivar model of the project: Step № 13

Relation: 08

Rule: Result of studying mivar technologies (Result of studying mivar technologies)

Input parameters: Mivar technologies of logical AI=1;

Formula:

var a, b, c, d, e, f, g;

if (a==1) {b=1; c=1; d=1; e=1; f=1; g=1}

else {b=0; c=0; d=0; e=0; f=0; g=0}

Result: Conceptual design of temporal mivar databases and rules for logical artificial intelligence=1; Mivar networks and domain analysis=1; Mivar technologies for data accumulation and information processing=1; Basics of creating temporal mivar databases and rules for logical artificial intelligence=1; Prospects of mivar technologies=1; Modern capabilities of logical artificial intelligence=1;

The knowledge chain consisting of 64 parameters and 14 rules for a number of disciplines of the SM10 department was constructed using KESMI Wi!Mi RAZUMATOR 2.1.

4 Conclusion

During the development and research of mivar networks for educational programs using the example of Bauman Moscow State Technical University, the effective application of the methodology for describing academic disciplines in the formalism of mivar networks was demonstrated. The creation of mivar models allowed for the structuring of educational programs, highlighting the input and output knowledge for each discipline, as well as establishing the sequence of competency acquisition by students.

The project on formalizing educational programs in the format of mivar networks will significantly simplify the management of educational programs and allow for the optimization of curricula. The use of mivar networks in education improves the quality of student learning by providing them with the necessary knowledge and skills, taking into account the sequence of the educational process.

Further development of the project and the use of artificial intelligence systems in managing educational programs will help effectively adapt to the changing requirements of the labor market and ensure the training of specialists that meet modern demands and societal needs.

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