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## ALGORITHM OF MACHINE CREATION USING THE MECHANISM OF ARTICULATED DISJUNCTION

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**Abstract.** *Problem statement.* Any methodology is based on knowledge about the problem. The fullness and orderliness of the base determine further volumes and possible options for implementing the methodology. *Purpose.* To analyze the existing ways of machine creations and propose the new effective algorithm of machine creation using the mechanism of articulated disjunction. Considering the research structure and improvement of the informational and program technologies, changes to the traditional methodology of machine creation are made. The existing paradigm: parametric and functional performance of the machine, the design of which is improved based on existing machines, is a modification of predecessors' parametric and functional performance. Proposed paradigm: parametric and functional performance of the new machine, improved based on the subject area of technical solutions, methods of design and operational conditions more precisely coincide with the technological process to realize what they are called. Proposed hypothesis: there are such methodologies of design that provide an opportunity to provide rational productivity within existing operational conditions. *Methodology.* Morphological space is used to form qualitative features of the created machine. The peculiarity of the proposed methodology is that the set of features of the created machine also contains subsets of processes and phenomena in which the machine is involved. This allows assessing the compliance of the process in which the machine is involved and the machine operation processes. *Findings (results).* The algorithm of machine creation using the mechanism of articulated disjunction is proposed. It allows the creation of the new construction at a given sequence of stages to improve at every step in a given direction based on the determined criteria. *Originality (novelty).* Method of articulated disjunction, which is based on the principle of formation of the set of necessary properties of the structural elements of the machine based on a given primary criterion of machine efficiency. The essence of the method of articulated disjunction is that the sample of elements that have common features and properties is reformulated based on a given criterion. The proposed method provides an opportunity to determine the advantages of one structure described by various factors, in comparison with others, based on the criterion set. *Practical value.* The algorithm of synthesis and improvement of existing machines allows for determining their main quality features in the initial stages of the design of machines.

**Keywords:** knowledge base, the algorithm of machine creation, mechanism of articular disjunction, morphological space, quality features of the machine, graphs of constructive schemes of machines.

## **Introduction**

The creation of new equipment allows for improving material production, designed to meet human needs for food products, household products, housing, etc. Products manufactured in production are subject to the requirements of quality, efficiency and cheapness, so the machines that produce them must also be efficient and cheap.

The new program software is created and developed at the stages of design, construction and sales of new machines and equipment. This software simplifies the work of researchers, designers and operators. These are software environments MathCad, MatLab, Matematica, Maple, Dymola, computer-aided design systems AutoCad, CATIA, T-FLEX CAD, Compass, ANSYS, Unigraphics, Pro/ENGINEER, SolidEdge, SolidWorks, database management systems Microsoft Access, Paradox, dBase, Visual FoxPro, Oracle, MS SQL Server. In the conceptualization phase (formation of the idea and the synthesis of structure of the new machine), phenomenological description of design methods is used (heuristic methods, iteration methods, morphological analysis, decomposition, theory of solving inventive problems). Attempts to create environments for processing large arrays of knowledge, rather than just information, have not yet achieved excellent results, as there are no methods of synthesizing the necessary properties of machines according to the criteria of their effective functioning.

Therefore, there is an urgent need to create a methodology for the synthesis of machine designs according to specified criteria at the stage of formation of the idea and structure of the machine.

## **Problem Statement**

In the study of literature sources on methodologies for the creation of new technology, it was found that any methodology is based on knowledge about the problem.

The fullness and orderliness of the database determine the further scope and possible variants of implementation of the methodology. Based on the existing knowledge base, there is a generation of the idea of improving the design of the machine, and structural synthesis of one or more options for its implementation is carried out [1-3]. The next component may be the task of choosing the optimal design based on specific criteria. Another component is the parametric synthesis of structures, which makes it possible to determine the quantitative characteristics of the created machine [4]. For the created machine, it is essential to determine its functional properties, which on the one hand, make it possible to check the quality or accuracy of the machine, and on the other hand, to determine the features of the machine functioning in the specified operating conditions.

## **Review of Modern Information Sources on the Subject of the Paper**

In general, the methodology of creating machines is represented by several areas in which there are existing or absent identical components. Thus, one direction contains the components of the structural synthesis of the optimal design, the parametric synthesis of characteristics based on which the task of choosing an effective option is carried out. The methodology proposed by B. I. Kindratsky can be an example. The second direction, proposed by Yu. N. Kuznietsov, K. V. Frolov, provides a structural synthesis of structures options based on which the task of choosing an effective option and subsequent parametric synthesis of an effective option is carried out [5]. P. M. Hashchuk and A. F. Krainiev propose the third direction when from the base of ready-made structures options, an effective option is chosen [6]. For this option, parametric synthesis and the research of their operational properties are carried out. Directions 1 and 2 are most suitable for creating new models of machines when the knowledge base regarding the design of the machine, the principles of its use is not complete enough. Then there is a need to create a number of structures and choose the optimal one based on specified criteria. Direction 3 is used to improve samples of machines with already formed content bases when there is a need to investigate their properties under the influence of new external factors. In this case, the improvement with the help of insignificant changes is carried out when it is too labor-intensive to use optimization synthesis. In all three cases, authors do not stop at such components as idea generation or the way of machine structure creation, although it is crucial for further research.

Three types of methods are used in the formation of the idea and synthesis of the structure of the new machine: random search (brainstorming, focal objects), a functional-structural study of objects

(morphological analysis, Roth's catalogs, theory of solving inventive problems), problem-oriented methods (system heuristics, Kudryavtsev's method) [7–11]. These methods are written in the form of algorithms and are formed from specific conditions and types of problems. In this case, the problem of choosing a rational structure is usually postponed until the following stages of creating a machine. Criteria for the machine's efficiency, which are crucial in its creation and subsequent operation, are not always formed. The analysis of criterion assessments of the quality of design of machines and mechanisms showed that there is no general approach to the selection of evaluations by the degree of their importance; the methods of their selection are not always justified.

### **Objectives and Problems of Research**

To analyze existing ways of creating machines and propose a new efficient algorithm for creating machines using the mechanism of articulated disjunction.

### **Main Material Presentation**

Considering the research structure and the improvement of information and software technologies, changes have been made to the traditional methodology of creating machines. Existing paradigm: parametric-functional indicators of the machine's performance, the design of which is improved based on existing machines, is a modification of the parametric-functional indicators of the performance of predecessors. Proposed paradigm: parametric and functional indicators of the performance of a new machine, improved based on the subject area of technical solutions, design methods, and operating conditions more closely coincide with the technological process in which they are designed to implement.

Proposed hypothesis: There exist such design methodologies, which provide an opportunity to ensure rational performance under existing operating conditions.

Due to the proposed paradigm, stages of machine creation are specified: forming a research base; analysis of the database; creating a process model; comparison with the actual process; choice of improvement method; development of the principle of improvement; technical implementation of the principle of improvement.

The proposed methodology describes the concept, developed methods and algorithms for the synthesis of machines using the method of articulated disjunction, which is based on the principle of forming the set of necessary properties of machine design elements based on the essential criterion of machine efficiency [12].

The method of articulated disjunction is used to form the characteristics and properties of machines [13]. This is done based on initial information about the machines and their applications. It would be worthwhile to try to use the method of an articulated disjunction to form the structure of machines based on typical blocks of which usually machines consist.

The disjunction of two statements is a new statement that is true if and only if at least one of these statements is true.

From a sample of items that may have common features and properties and generally combine with each other on a set of features, one can choose those items that have a common property or criterion. The transformation using articulated disjunction is shown in Fig. 1.

Based on the energy assessment of process elements, a number of requirements (criteria) are formed for machines that implement each process element. For the most energy-intensive operations, machines are being improved. The starting point for machine improvement is the criteria of machine efficiency and the knowledge base of the process and the machine involved in this process. Modification of the machine must begin with forming the structure of knowledge about the process and the machine. Visually selected from the general and disordered knowledge, the knowledge needed for the improvement of the machine can be represented by a graph of knowledge about the design of the machine (Fig. 2). This graph organizes the local areas of research of the designer and indicates the dominant subject variables  $r, u, l$  of subject areas of knowledge about the machine, in which it is advisable to conduct primary research.

Based on knowledge selected with the help of the graph (Fig. 2) and morphological synthesis (Fig. 3), it is possible to form a structure of the machine with the necessary characteristics and its graph

(Table 1). Graphs of structures of various machines by their purpose can be very similar. For example, the graphs of the structural scheme of the shredder and wind turbine are similar (Table 1). Similarity with other graphs of other machines in the process of production of the final product will allow the use of the same mathematical models in the study of operational and technical characteristics of machines.

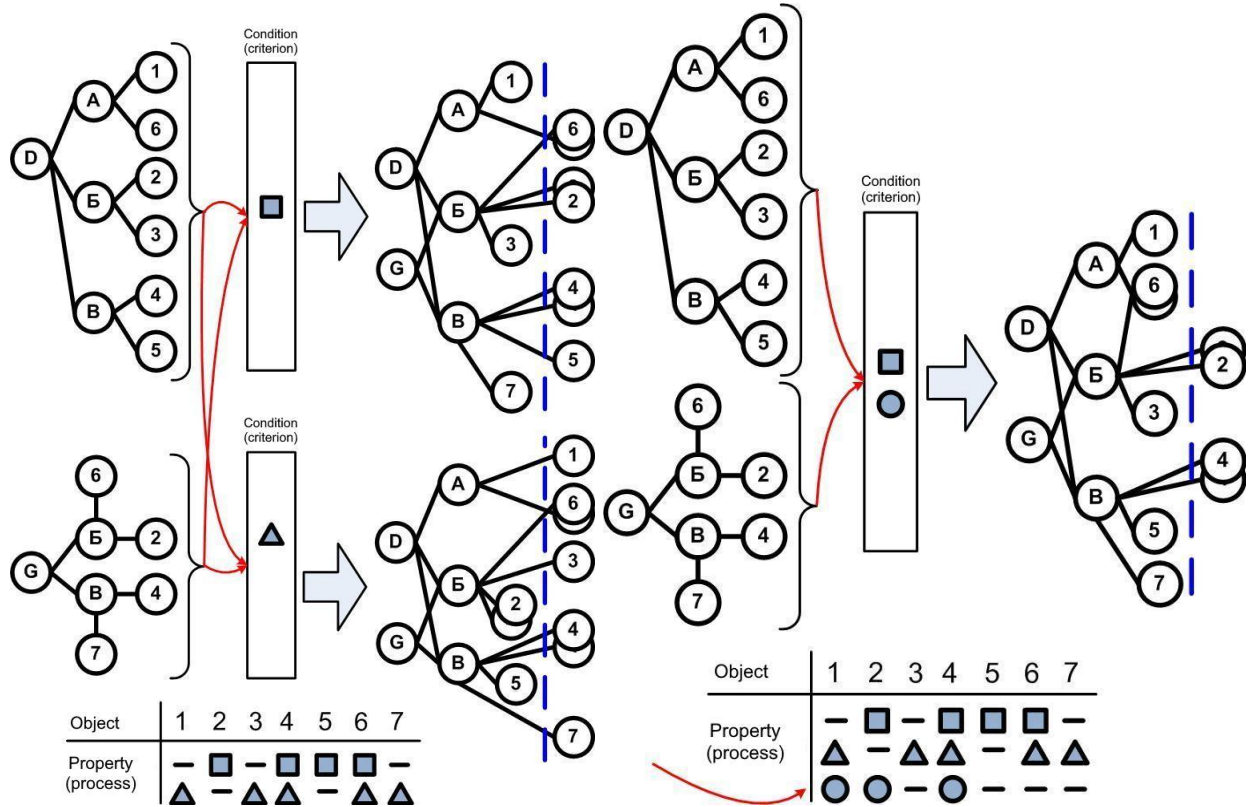


Fig. 1. Formation of a new set of machine properties using the method of articulated disjunction: by varying the criterion, by combining several processes

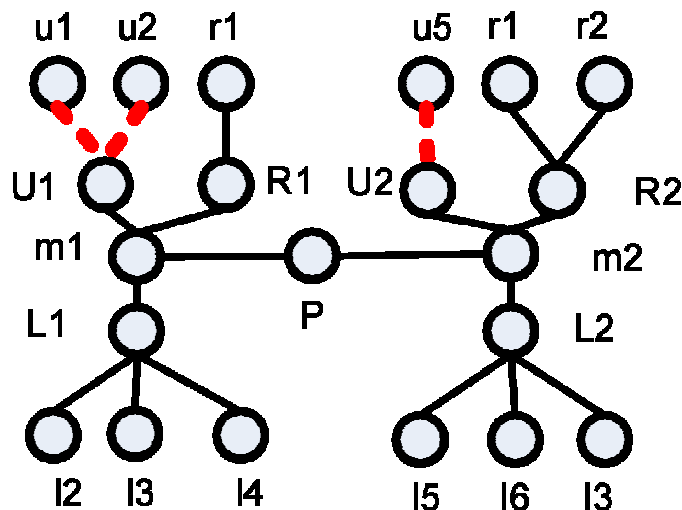


Fig. 2. Predicate  $p$  of the values ratios of the variable  $m$  of the local areas of constructor research  $r, u, l$  in the variable areas of knowledge  $q$  about the machine

The objects of the external world (multidimensional information outside) through the reception reflected in the morphological environment (MS) on the set (Fig. 3). The external world is defined as a set

of sets  $\{W, S, U\}$ , where  $W$  – set of objects of the external world;  $S$  – signature – a set (list) of relations and objects location;  $U$  – axiomatics – a set, which is given on the sets  $W, S$ . Under such circumstances the model subsystem of the relationships (MSR) or location (place) of objects in MS  $W$ . MSR contains the set of objects reflection (SOR), its signature  $S$  and axiomatics  $U$ . Signature  $S$  – a group of rules that set the procedure of comparison. Signature contains a set of rules for the reproduction of the basic characteristics and properties, sets of rules for constructing expressions of the elements included in the alphabet. Axiomatics (dictionary)  $U$  are the fundamental concepts that describe properties of objects. Axiomatics contains sets of concepts, definitions, symbols for the reproduction of the basic characteristics and properties, a set of concepts, definitions, symbols and signs by which the language alphabets in morphological environment are formed.

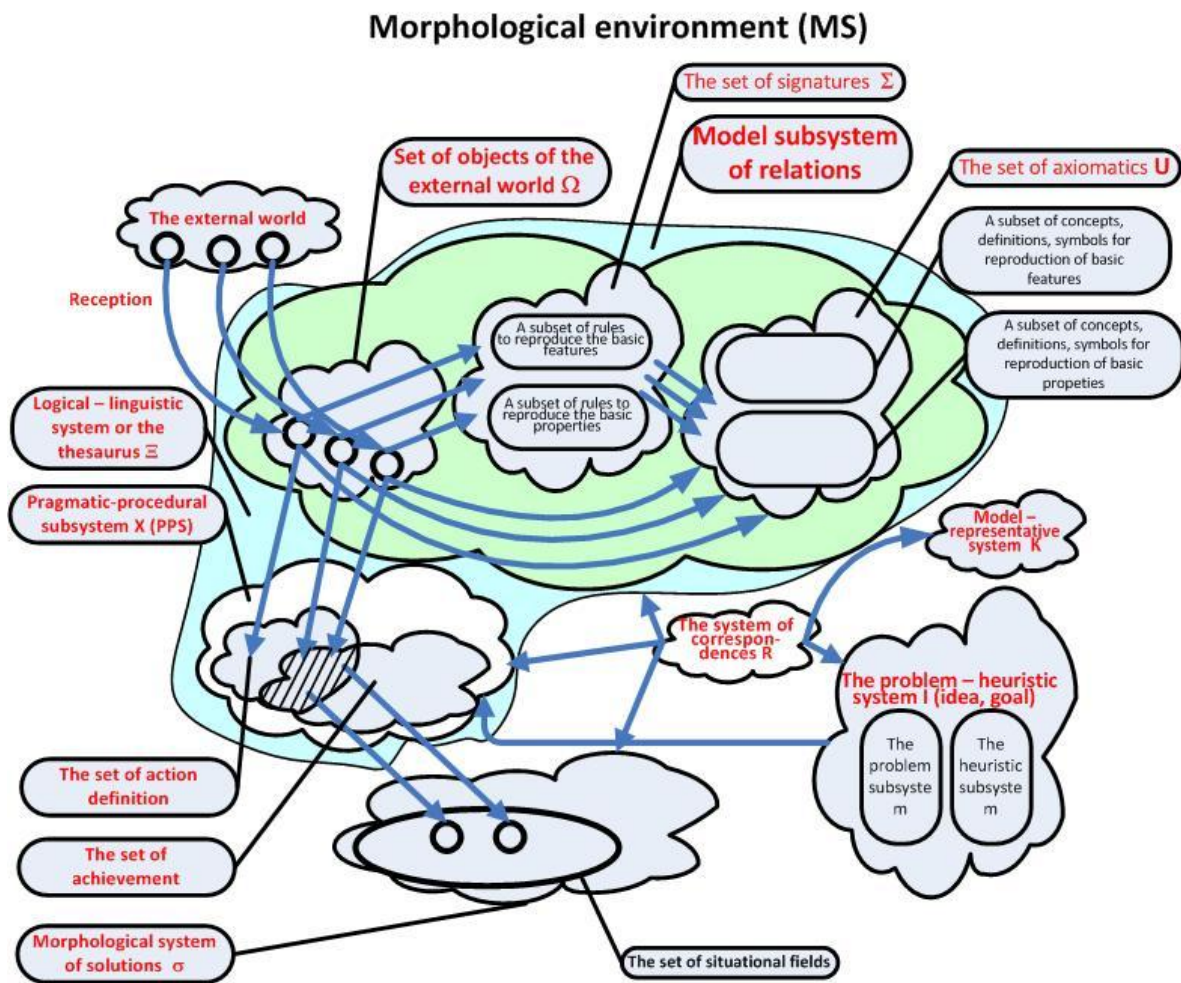


Fig. 3. Relationships of components of morphological space

Pragmatic-procedural subsystem  $X$  (PPS) is the subsystem, which provides various conversion, operations and actions with the components from all major subsystems of the theory, as well as procedures and rules of the performance of these actions. At the same time it includes various axiological evaluations of various components of the space, as well as phenomena and objects in its visual field. Logical – linguistic system or thesaurus contains MSR and PPS  $X$ .

On the basis of the structure's graph of the constructive scheme, the machine design scheme is formed. Taking into account the tasks of the study, on the basis of the structure's graph of the constructive scheme and the calculation scheme, the structure's graph of level connections of generalized coordinates (Fig. 4) of the machine mathematical model is written.

The developed mathematical model allows to study operational properties of the designed machine and to define limits of its effective use. With its help, the properties of such alternatives can be explored.

Depending on the conditions of use of the machine, taking into account the main provisions of the theory of total utility, a structure option that will be effective under specific criteria for use can be chosen.

Table 1

Similar graphs of structural schemes of machines

|  | Rotary shredder | Wind power plant  |
|--|-----------------|---|
| Machine structural scheme                  |                 | <p>WM - windmill<br/>BI - blade<br/>EC - elastic coupling<br/>Re - reducer<br/>EBH - electrohydraulic brake housing<br/>EG - electric generator</p> |
| Structure's graph of the structural scheme |                 |   |

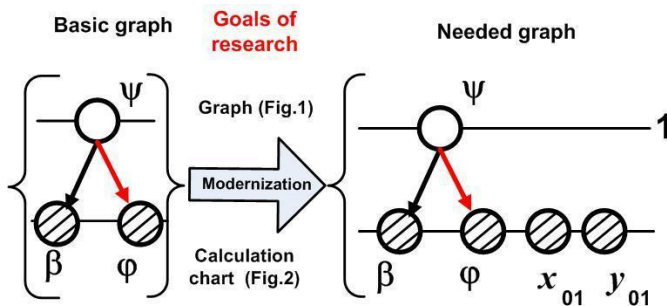


Fig. 4. Graph of the structure of level relations of generalized coordinates of the mathematical model of the machine

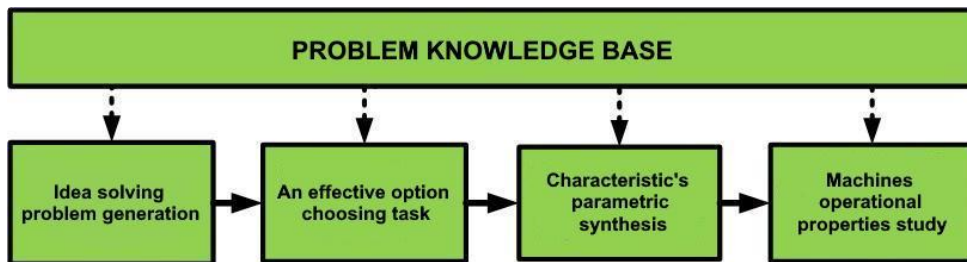
Provision of justified dynamic coefficients obtained with the help of mathematical models of operation will allow to design and justify the elements of structures of created machines at the stage of sketch design more precisely.

Until now, it was believed that new equipment should be made of the highest quality. New samples were made of the best materials, the highest productivity and efficiency was tried to ensure. The main deterrent was unjustified costs, which led to low payback of such samples.

*Algorithm of Machine Creation Using the Mechanism of Articulated Disjunction...*

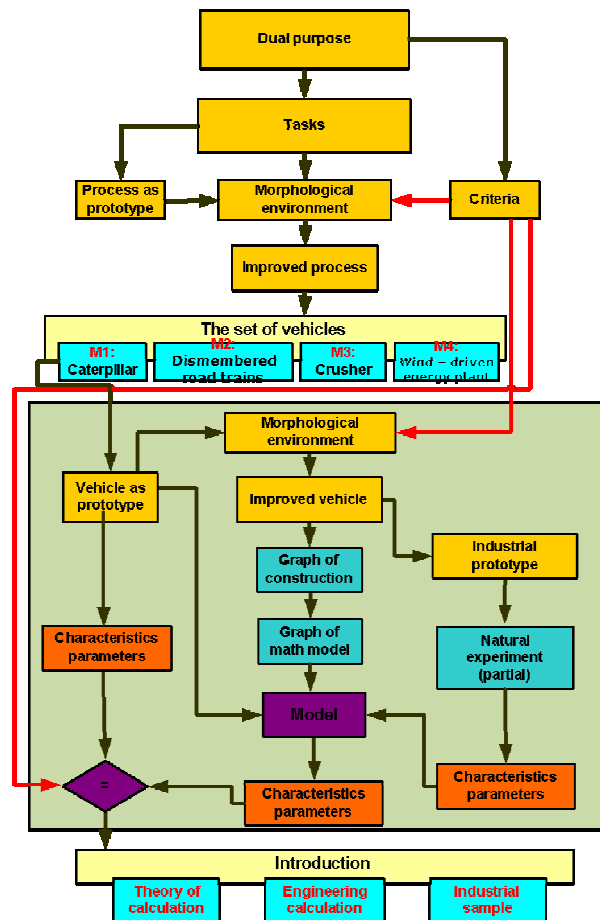
Improving machines (technical systems) is to find their best parameters (requirements) in a specific problem posed by the user (society). For example, the technological speed of agricultural machinery (tractors, combines) is 5–15 km/h. Therefore, there is no need to design such machines with their operating speed of 70 km/h.

Thus, the final methodology of machine design contains the following stages: on the basis of the formed knowledge base about the machine the generation of the idea of creating a machine is carried out (Fig. 5). From the possible options, the most rational is chosen. For this option, different parameters options are considered and the optimal one is selected in the selection field. Next, a study of its performance properties is carried out.



**Fig. 5.** Generalized methodology for creating new and improving existing machines

Accordingly, the methodology of synthesis of new and improvement of existing machines on the basis of a typical algorithm was formed (Fig. 6). The algorithm takes into account the use of morphological spaceto form a knowledge base of structural schemes of designed machines. Carrying out the analysis of features for compatibility, as well as quantitative analysis of their parameters allows setting many important features of the studied machine and determining the limits of change of these features.



**Fig. 6.** Algorithm for synthesis and improvement of existing machines

The peculiarity of the proposed methodology is that the set of features of the created machine also contains subsets of processes and phenomena in which the machine is involved. This allows assessing the compliance of the process in which the machine is involved, and the modes of operation of the machine. For more accurate reproduction of the technological process by the machine, taking into account subsets of processes and phenomena, several phenomena can be combined. An example is the combination of the process of grinding the material with the phenomenon of vibration. And if you set the criterion of energy efficiency, the phenomenon of vibration should be used in resonant modes of operation of the machine.

A manifestation of the flexibility of the methodology is the possibility of varying the criteria for the efficiency of the machine functioning. At the same time, there is a possibility of synthesis of various designs of machines called to solve an existing problem in cardinally different ways.

### Conclusions

Any methodology is based on knowledge of the problem. The fullness and orderliness of the database determines the further scope and possible implementation of the methodology. An algorithm for creating machines using the mechanism of articulated disjunction is proposed, which allows for a given sequence of stages of creating a new structure, at each stage to make improvements in a given direction based on certain criteria. The list of criteria and algorithm of their choice is formed. The structures of inventing methods based on the concept of morphological space are described.

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