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## DECISION-MAKING INFORMATION TECHNOLOGY FOR FLEXIBLE INTEGRATED MANUFACTURING

The **subject** of the study in the article is flexible integrated robotic systems. The **aim** of the work is to integrate models and decision-making methods in order to create information technology for flexible production. The following **tasks** are solved in the article: analysis of current trends in the development of production systems, consideration of intellectual decision-making systems as one of the key elements of automated control systems, consideration of the creation of information technology, based on a set of methods and decision models, including adaptive decision making for non-deterministic tasks. Research **methods** are the theory of sets and the theory of predicates. The following **results** were obtained: the main problems of the development of flexible integrated systems of modern production were analyzed and formulated. As a new element in the technological systems, it is proposed to introduce the intelligent production agents implemented as mobile robotic platforms capable of performing transport and assembling functions, executing the monitoring tasks, and establishing the basic requirements for them. From the formal point of view, the decision-making process in flexible robotic systems is considered, based on the interaction of the properties of the robotic system, the properties of the working space and the set of possible solutions. The fulfillment of each individual technological task involves the development and implementation of a plan of work of robotic equipment, the set of variants of which is a strategy of functioning of the intellectual robotic system, described in the form of predicate logic. To solve the required technological tasks, the use of the automatic procedures of the generator of solutions, which operates based on the frame-like structures is proposed. The decision-making process consistently supports the consistent decision-making information technology in a robotized production system based on the models of different types. **Conclusions:** application of the concept of the intellectual agent in the production environment requires the integrated application of models and methods of decision making, which can be a separate information technology of robotic production.

**Keywords:** economic security; construction; risks; financial risks; construction companies; fraud.

### Introduction

The research, development and application of flexible integrated systems (FIS) are the features of human entrance to the post-industrial stage of development. Application of FIS must provide the quick and low-cost transition to the new production types output, especially for conditions of low-series production. The efficiency of FIS is determined by optimal organization of technological equipment usage, supplied by robotized and transport systems, delivering bars, details and instruments, making the required service and check of technological processes [1].

The automation of modern manufacturing is based on widespread application of Flexible integrated systems (FIS) of different types. Their features are: the ability for quick adaptation to production technology changes at levels of technical refitting of particular units, parts and accessories, ability to reconstruct software according to new technological tasks. In addition, the key feature of FIS is its close connection and structural integration to existing production systems, which gives possibility to systematic modernization of them by modular method, simplifies the exploitation of technological systems and their technical supplement. This way of design, development and implementation of technical systems describes the modern automobile-, airplane- and shipbuilding, mechanical engineering, electronic (and other) devices production, that can be observed at assembling of European Airbus project A-380 [2] or of British aircraft carrier Queen Elizabeth [3].

The creation of automatic plants is currently impossible with traditional methods of manufacturing development. There are need the shifts in instrumental technology and in manufacturing organization, based of computer-integrated system base.

To create the machine-building plants of future there are need the following transformations:

- refusal of the differential details processing and assembling in several operations, transition to centralized processing and assembling in one operation, at one machine, one processing and assembling system;
- transition to application of machine's systems, executing the whole range of works and supplying the continuity of manufacturing processes;
- integration of different processes for manufacturing and control to the single computerized production system;
- transition to imitation simulation during sample's and manufacturing processes examination;
- intensification of technological detail-node specialization for production, shortage of seriality, the individual customer requirements execution;
- profession combining, workers qualification increase under whole shortage of them;
- electronization of manufacturing, development of communication and in-formatization tools;
- improvement of production organization under rule "everything only if need".

Therefore, the development of automated control systems for FMS has the certain level of structural organization and automation. The next steps for Flexible Automated Sectors (FAS) development can be in the introduction of intellectual technologies, which supplies more manufacturing flexibility, especially for low-serial production, with next phased transition to automated factory concept [4].

The perspective direction of FIS development is automatic solving of all the tasks by application of intellectual control system as a part of future automatic plants. Among their characteristics are [2, 5, 6–7]:

- high labor productivity level, high flexibility degree

to new production transmission;

- the shortest manufacturing loop for details production;
- the supplement for high quality production output, low energy consumption, high coefficient of machines and raw exploitation;
- non-waste technology, complete utilization of waste by transformation to raw materials, fabrication of secondary rows for collateral production;
- the high equipment reliability and of the whole plant by self-diagnosis methods, that controls the equipment malfunctions or supplies the short-term restoration;
- labor humanization, the creation of conditions for human health safety, for physical labor decrease, for full computerization of intellectual activity;
- ecological safety, save of environment;
- mobility for new science and technics achievements, for new technologies and equipment.

### 1. Decision-making systems background

The consideration of robotized technology design process shows the importance of every planning strategies act at every stage of technological operation execution. The similar case is for movement planning of mobile platforms: the transition result is the sequence of operations to move to some direction, to stop, to change direction, to move manipulator's joints (if platform has it). But, if movement needs additional actions like to prevent collisions with random obstacle, the planning task is accented not on whole multi-stage structure, but on planning of every partial decision for action of robot.

The most of particular tasks of strategies planning have to be of adaptive manner because of execution for conditions of predictable or unpredictable workspace. While the adaptive systems still have no first positions in technical planning systems, they have publications on psychology and human decision-making [3, 8, 9].

The human (or other organism, or technical system) ability to adapt to slow, moderate or quick change of external impacts and the ability to execute the given tasks, really, is adaptation. Certainly, adaptation is possible only for conditions is organism (technical system) is able to respond to external world effects, having the sensors to observe the effects of workspace of object's states, according to which the selected task is decided (or selected solution is executed). Other required thing is mechanism of organism to respond to external effects, including the changes of internal states and external response by particular action of human or robot to avoid the external impacts (f.e. to avoid stones on robot's way or to clean them) or to adapt to them (to select the reliable and correspondent to conditions chassis of robot).

Such intensions, however give no answer how the robotic system (also mobile system), equipped by tools of external workspace monitoring (sensor system); the intellectual component to generate the plans of movement; the execution mechanisms (manipulators), can respond to external world changes and to re-build its activity, taking in account the complexity of tasks and need to support the functional ability.

The adaptive control methods still take insufficient place in researches on automatic control theory. Among the sources adaptive control system is formulated as system, which automatically selects the required control law on base of object's behavior analyzes. From this position adaptive systems are divided into two classes: systems able for self-organization and systems able for self-settings.

For systems, able for self-organization, functioning process includes the formation of control algorithm, which allows to optimize system from control's goal view point. Such tasks arise for conditions of structure and parameters changes of controlled object and are dependent of functioning mode, especially if there is no priory information for current control mode setting. There is said about free regulator structure [8] and connected complex tasks.

The synthesis problem for continuous dynamic objects is described in [8]. Let the object of control is affected by the measured perturbations (initial impacts), non-measured impacts and the impacts of control. The output variables of object are observed. The behavior of object depends on number of unknown parameters –  $\xi$  set. There is given the set  $\Xi$  of possible values  $\xi$ , which defines the class of possible objects and impacts. This is set the target of control, which defines the behavior of controlled object. The result must be the synthesized control algorithm, which uses the measured or calculated values, that not dependent of and supplies the given control target achievement for every.

For case of FIMS adaptivity is a possibility to keep manufacturing system workability for case of functioning condition changes, caused by external (other FIMS, transport system, energy supplement, ventilation system etc.) and internal (work of processing units, NPC-units, transport system, personal activity etc.) sources [9–10].

For such conditions FIMS must adapt to the current conditions and change the schedule (plan) for whole system functioning or fro some parts, providing the adaptation of functioning strategy.

The technological process of mechanical processing and assembling must be provided in one or several workshops with processing centers, NPC-machines, industrial and transport robots, storages and the transport system, connecting the technological equipment and the automated storehouse.

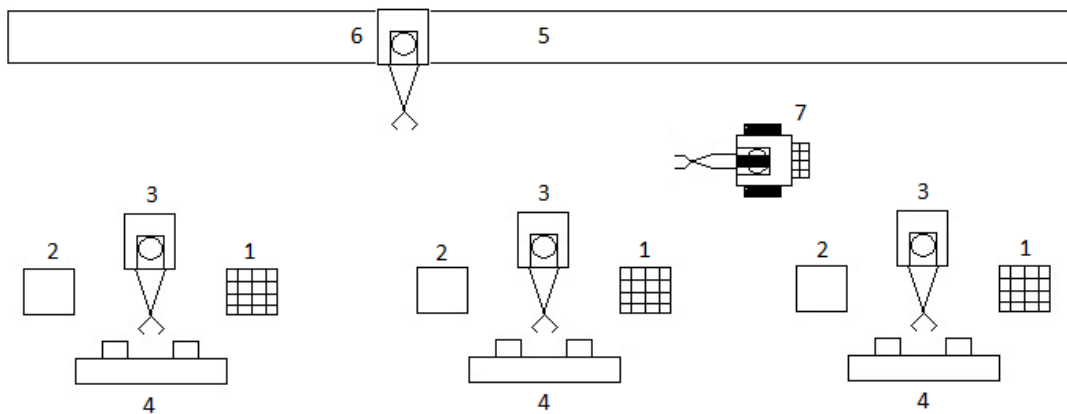
The lacks of production process organization for the mentioned mechanical and assembling workshops are [11, 12]:

- the fixed mode of transport system work and insufficient level of automation with limited application of industrial robots;
- the manual loading for NPC-machines;
- the absence of automatized tools to avoid the emergency or non-standard production situations.

To overcome the mentioned lacks there are proposed:

- to introduce the mobile assembling-transport robot to the equipment of flexible integrated systems and workshops (fig. 1);

- to develop the mathematical and algorithmic supplement, the software for the mentioned robot.



**Fig. 1.** Structure of Flexible Automated Line (1, 2 – input and output storages, 3 – industrial robot, 4 – NPC tool, 5 – transport system, 6 – transport robot, 7 – intellectual transport-assembling robot)

The mobile assembling-transport robot must correspond to the following requirements:

- free movement in range of workshops out of technological equipment units workspace;
- robot supplies the delivery of billets and other materials to the workspace of processing centers and NPC-machines;
- robot supplies the delivery of needed instruments or equipment on regular or irregular calls;
- robot supplies the execution of selected assembling operations;
- robot supplies the monitoring for technological and other equipment of workshop;
- robot checks the functionality of technological equipment.

To supply its functionality the assembling-transport robot must correspond to the following construction demands:

- the presence of mobile platform chassis;
- the presence of manipulator (or of several manipulators);
- the presence of cargo block to transport billets, details, instruments and equipment;
- the presence of communication system;
- the presence of control system with computer on-board;
- the presence of sensor system for chassis and manipulator.

The assembling-transport robot must be selected on base of existing models of transport robots and manipulators.

The particular element of control system for mobile assembling-transport robot is decision-making support system (DMSS). As to dynamics of robot's workspace DMSS must supply the problem-solving for transition tasks of assembling-transport robot to particular workspaces, to schedule the loading-uploading operation for technological equipment, instruments and supplement, to plan some assembling operations. The dynamic nature of assembling-transport robot workspace, determined by particular production system, defined the demands of functioning strategies adaptivity, which must supply the

increase stability and productivity of flexible manufacturing systems.

In particular, RTS (set X) from ACS problem-solving point of view is proposed to describe consisting with the next elements:

- manipulator (with description of movements for particular joints of manipulator, movements execution);
- control system (with signal set, sent/received by manipulator or chassis);
- sensor system (with sensors to supply the transmission of signals on WS states to the control system of robot);
- technical (computer) vision system (with monitoring of WS and transmission of signals to robot's ACS);
- communication system (to transmit/send the signals from robot's control system, from other robots);
- robot's chassis (to transmit/send information to/from, movements execution).

The description of decision set D is proposed as containing:

- decision on manipulator (manipulators) movement for particular operations level (take object, move, put, replace objects), including the achievement of goal point;
- decision to direct the mobile robot's chassis movement (rightward, leftward, direct, back etc.), to change speed and acceleration;
- requests to sensors and technical vision system;
- expected result (accepted decision);
- pre-conditions of decision-making.

The description of external workspace objects set S:

- objects of WS (object's coordinated, direction and velocity, class of object, technical state, ability to use for decision execution);

- state of WS (topographics, available paths and their conditions, obstacles and their changes, fallouts, lighting etc.).

The description of goals set Y of robot's ACS:

- to position robot to WS point (or near the needed object of WS);
- to make operation (manipulation) at WS point (or near the needed object of WS);
- to get date on WS (with sensor system or CVS).

The examples of robot's goals (task) setting are:

*being\_at\_point(x, y, z);*

*make\_operation(take\_object(class(nut))).*

The goal of decision-making system (DMS) is to transfer to goal state  $y$ , reaches by application of Cartesian products  $X * D * S$  of FIS's states, its decisions and of WS by order at every step of system functioning.

To reach the goal, initially at moment  $t_0$  DMS generates the initial plan:

$$\vec{D}^0 = \{d_0^0, d_1^0, \dots, d_{n-1}^0\},$$

which proposes the sequential transitions for states:

$$X_0^0 \rightarrow X_1^0 \rightarrow \dots \rightarrow X_{n-1}^0 \equiv Y,$$

and can be implemented by Cartesian products:

$$X_0 \times D_0^0 \times S_0 \rightarrow X_1 \times D_1^0 \times S_1 \rightarrow \dots \rightarrow X_{n-1} \times D_{n-1}^0 \times S_{n-1},$$

and may lead system to the goal state  $Y$ .

Transitions must follow the restrictions:

$$\|X_1 - D_0 \times X_0 \times S_0\| \leq \varepsilon_1, \|X_2 - D_1 \times X_1 \times S_1\| \leq \varepsilon_2, \\ \|Y - D_{n-1} \times X_{n-1} \times S_{n-1}\| \leq \varepsilon_n.$$

It means, that every new achieved by Decision-making acts step, which is a result of decision  $D_i$  to the current state  $X_i$  and for conditions of workspace  $S_i$  mustn't be different from planned  $X_{i+1}$  for more then  $\varepsilon_{i+1}$ .

The selection of decision for every stage and its dependence will be defined by goal (or subgoal) of robot's automatic control system (ACS).

For example:

$D\{move, take, look\} \times$   
 $X\{manipulator, controller, sensor, CVS, CS, chassis\}$   
 $= Y\{robot\_at\_point(x_i, y_i, z_i)\} = D\{move, manipulator\}, \{move, controller\},$   
 $\{move, sensor\}, \{move, CVS\}, \{move, CS\}, \{move, chassis\}, \{take, manipulator\},$   
 $\{take, controller\}, \{take, sensor\}, \{take, CVS\}, \{take, CS\}, \{take, chassis\},$   
 $\{take, manipulator\}, \{look, controller\}, \{look, sensor\},$   
 $\{look, CVS\}, \{look, CS\}, \{look, chassis\}\} =$   
 $D\{move, chassis\}, \{take, manipulator\}, \{look, CVS\}\}.$

The last line takes in account the compatibility of Cartesian product pairs, with compatible chassis and move operation, operation take for manipulator, computer vision system (CVS) and looking operation, while incompatible are taking operation for controller or movement for sensor.

Action «move» has the expected result – *robot\_at\_point(x, y, z)*, so form set  $D$  operation  $\{transfer, chassis\}$  is selected:

$$D\{transfer, chassis\} = Y\{robot\_at\_point(x_i, y_i, z_i)\}.$$

Also the decision has pre-conditions

$$D\{transfer(expected\_result(robot\_at\_point(x_i, y_i, z_i)), \\ pre\_condition(robot\_at\_point(x_{i-1}, y_{i-1}, z_{i-1})))\}.$$

The presence of pre-condition needs the recursive solving of new subgoal:

$$D\{...\} \times X\{...\} = Y\{robot\_at\_point(x_{i-1}, y_{i-1}, z_{i-1})\}.$$

For case of static workspace (WS) the planning process looks rather simple. But interesting moment appears when the found decision meets the impossibility of implementation and need to adapt already formalized (at previous state) decision for current conditions of robot's WS.

We can notice, that adaptive strategies planning has next natural properties:

- 1) generation of initial plan before decision execution;
- 2) execution of accepted plan;
- 3) looking for situations for which the accepted plan becomes impossible to execute;
- 4) for case of previous plan failure – new plan generation with decision adaptation to the changed circumstances.

## 2. Description of Decision-making IT

In practical terms, the implementation of intelligent robot control systems in many aspects comes from the project STRIPS (Stanford Research Institute Problem Solver [8–9]) – strategies planning system for the closed world of a robot that interacts with the executive system PlanEx (plan execution).

To solve the practical problems of a robots strategies planning you must automatically create abstract spaces of different levels from the basic objects space and events in which the system operates.

In STRIPS-similar systems [8] abstract space is defined by the level of conditions detail of operators using. This approach allows: to fix the same model of the world – no need to delete the insignificant (for a given level of abstraction) parts from it and no need to take them into account; to make unchanged the operator schemes.

Model of the world must be in a properly constructed set of first-order predicate logic formulas (PCF), which reflect the facts (for example,  $ATR(a)$  – the robot is in point  $a$ ) and laws, such as

$$(\forall y)(\forall z)\{[ATR(y) \wedge (y \neq z)] \supset \overline{ATR}(z)\},$$

that robot can not be simultaneously in points  $y$  and  $z$ .

Operator scheme is determined by name, a list of parameters and records as PCF language logic of predicate of first order conditions of the action and the result of the action. The last one, in its turn contains a remote list and add list. Operators produce different models of the world by generating new facts. The purpose of the system is also supplied as a PCF of the same logic, that it is desirable PPF of a system.

STRIPS begins search with a attempt to get the goal formula  $G_0$  from the original model of the world  $M_0$ . For this the theorems prove program searches a contradiction in the set of disjunction  $\{(M_0 \cup \overline{G}_0)\}$ . If contradiction is found (empty disjunction is displayed), the original problem is solved at this step in a trivial way, that original model  $M_0$  satisfies objectives  $G_0$ . If the specified contradiction is disagreed, the so-called unfinished output

$D_0$  forms. This output is supplied by a set disjunction corresponding to negation of objective formulas (in this case  $\bar{G}_0$ ), plus all their derivatives, if any exists, minus disjunction which are eliminated by the use of the limiting strategies (for example replacement strategies and assessment of predicates).

Unfinished  $D_0$  output is taken as the difference between  $M_0$  and  $G_0$ , that connected to one node  $(M_0, G_0)$ . Next step is to search operators that are appropriate for reducing the resulting difference. These are the operators whose impact on the environment model allows you to continue the proof. If you search operator that is suitable, the values of its parameters are subjected to partial or complete enumeration.

Search of operator consists of two steps. The first step is to make an ordered list of candidate operators. Selection of candidate operators based on a simple comparison predicates from the difference  $D_0$  with the predicates from the operator addition list. The second step is to use the program proofs to determine whether there is disjunction in a specified list of additions that would extend the output after you apply this operator. If this step was a success, the operator candidate with the appropriate values of parameters considered as suitable for reducing the difference  $D_0$ .

When operator candidate is found, the conditions of its application accepted as new subgoals of system. Let robot's task is to move to point  $b$ . Then  $G_0 = \text{ATR}(b)$  attempt to find proof required will be in vain as long as the robot does not find itself in a point  $b$ . Obviously, a particular case  $\text{goto}(m, b)$  of operator  $\text{goto}(m, n)$  – move from point  $m$  to point  $n$  – suitable to reduce difference  $D_0 = \bar{G}_0$ , because the result –  $\text{ATR}(b)$  allows you to continue output of  $G_0$  (in this case - finish it). The role of new subgoal  $G_1$  will be played by correspondent RCF – condition of  $\text{ATR}(m)$  application.

System STRIPS deals with subgoal  $G_1$  in the same way as with the goal. It again uses the theorem proof for derivation of  $G_1$  from  $M_0$ . Here two cases have matter. If system doesn't find proof, it in a similar way forms difference  $D_1$  between  $M_0$  and  $G_1$  also sets subgoals, corresponding to formulas for conditions on application of correspondent operators-candidates. If theorem derives  $G_1$  from  $M_0$ , correspondent particular operator is used to transform model  $M_0$  to new model  $M_1$ . For the mentioned above case subgoal is  $G_1 = \text{ATR}(m)$ . If  $\text{ATR}(a) \in M_0$ , the particular case of  $G_1$ , namely  $\text{ATR}(a)$ , can be derived from  $M_0$ . For this case  $\text{goto}(a, b)$  is applied to model  $M_0$  and forms  $M_1$ , that includes  $\text{ATR}(b)$ . After that STRIPS continues to derive  $G_0$  from  $M_1$ . For our example,  $G_0$  obviously comes from  $M_1$ . However, if derivation of  $G_0$  isn't successful, there must be set the correspondent subgoals and procedure starts [3].

The described way implements the logical model of knowledge representation.

The hierarchy of goals, subgoals and models, originated during search process, can be presented as a tree search. Every vertex of such tree has view (workspace\_model, (subgoals\_list)) and corresponds to tasks to reach (according to order) subgoals of goal's list for the given model or workspace.

For the example of tree the top vertex  $(M_0, (G_0))$  is a initial tasks: to reach  $G_0$  from  $M_0$ . For the given case there are set two alternative subgoals  $G_a$  and  $G_b$ . They are added to next son's vertexes at the start of goal's list. Selection of left branch accepts, that at point  $(M_0, (G_a, G_0))$  goal  $G_a$  is reached at  $M_0$  and then the corresponding operator, f.e.  $f_a$  is applied at  $M_0$  to get model  $M_1$  and the next task will be to reach  $G_0$  at model  $M_1$  and such task is presented by vertex  $(M_1, (G_0))$ .

Using other way we can get vertex  $(M_4, (G_0))$ . Let, goal formula  $G_0$  is reached at  $M_4$ , so the vertex  $(M_4, (G_0))$  is end. Then the queue  $f_c, f_b, f_e$  is solution.

The sources of initial information for STRIPS were of robot's workspace, defining the world model, operator's schemes and system's goal (goals). For case of mobile robot's task in determined workspace, the world of robot must correspond to the scheme of objects location in this workspace [12, 13].

Unlike the described scheme of problem-solver for intellectual robot, its adaptive variant must take in account the changes in workspace (WS) and correspond to the next additional requirements:

- 1) ability to change the structure and contents of subgoals, which are set to get the goal of problem-solver;
- 2) ability to change the order problem-solving;
- 3) ability to reject the execution of particular subgoals of generated by problem-solver plan;
- 4) ability to return to previous system's states, taking in account the consequences of already accepted solutions;
- 5) ability to over-formulate the general goal of problem-solver or of particular subgoals.

The adaptivity of problem-solver may describe the ability of strategies planning system to function in conditions, where the robot's WS has changes during the decision execution [14]. Such conditions will require the constant check of WS, that have to provide every time on problem-solver call. Because of recursive functioning of problem-solver, the actual check will be provided at every cycle of strategies planning system. The consideration of robot's activity shows the fuzziness of the next type: fuzziness of execution test (action isn't finished), fuzziness of validation test (object doesn't correspond to given requirements). Depending of case, there can be selected different lists of pre-conditions, removals and add-ons. Therefore, the description of every robot's action is divided into the serie of alternatives, every with own true coefficient, giving the fuzziness for action description predicate. While, the fuzzy coefficient in such case is evaluation tool for alternative action's variant and (if

previous information is absent) may be defined during the execution of decision processes.

For the simplest case the predicate's adaptivity can be implemented by addition of special predicates call to

```

make_plan(Task):- observe_space,
                  // WS information refresh
                  action(N,Objects,Task,achieves),           // search of operator's scheme N
                  action(N,Objects,Task,requires),          // execution of precondition's list
                  action(N,Objects,Task,removes),           // execution of removal list
                  action(N,Objects,Task,adds,1).            // execution of addon list
  
```

While decision-maker works in a recursive way (at condition's list execution), information on objects location will be included. Therefore, the adaptivity of decision-maker will be provided at level of pre-condition list execution [10].

The informational technology of functional strategies planning is process of information transformation during the intellectual robot's functional strategies planning and is based on proposed method and models of strategies planning.

The information sources of developed informational technology are in data on RTS states (set X) and on workspace (WS) states (set S). The goal states of RTS are formulated as certain states of RTS or of WS. They must be produced by application of decisions (set D), forming the strategy, which is a serial transformation of RTS and WS states. Decision-making IT, using sensor system, gets information from WS of FIS and according to production goals makes the analysis of manufacturing situation, then divides global goal into sub-goals. To reach goals and

refresh WS information, where robot makes actions, f.e. [15]:

subgoals, decision-making IT proposes to use a number of models: set-based (for WS detalization), dynamic (to keep limitations), logic-based (to build strategies), fuzzy and probabilistic (to estimate the proposed strategies). The result of models application is in the proposed decision-making strategy, which can be executed by technological equipment.

The essential effect on strategies formation will be provided by changes in states of RTS and of WS, because the reach of goal state will be planned as discrete serial process of RTS and WS state's transformations, correspondent to decision's set D. If the developed initial plan (strategy), because of RTS of WS changes can't be executed, there will arise the request on plan's adaptation – by reformulation of plan under incalculation of dynamics of RTS and WS. The scheme of proposed technology of functional strategies planning is shown in fig. 2. The proposed decision-making IT can be implemented for solving of transport problems of FIS, also for manipulation tasks on assembling operations.

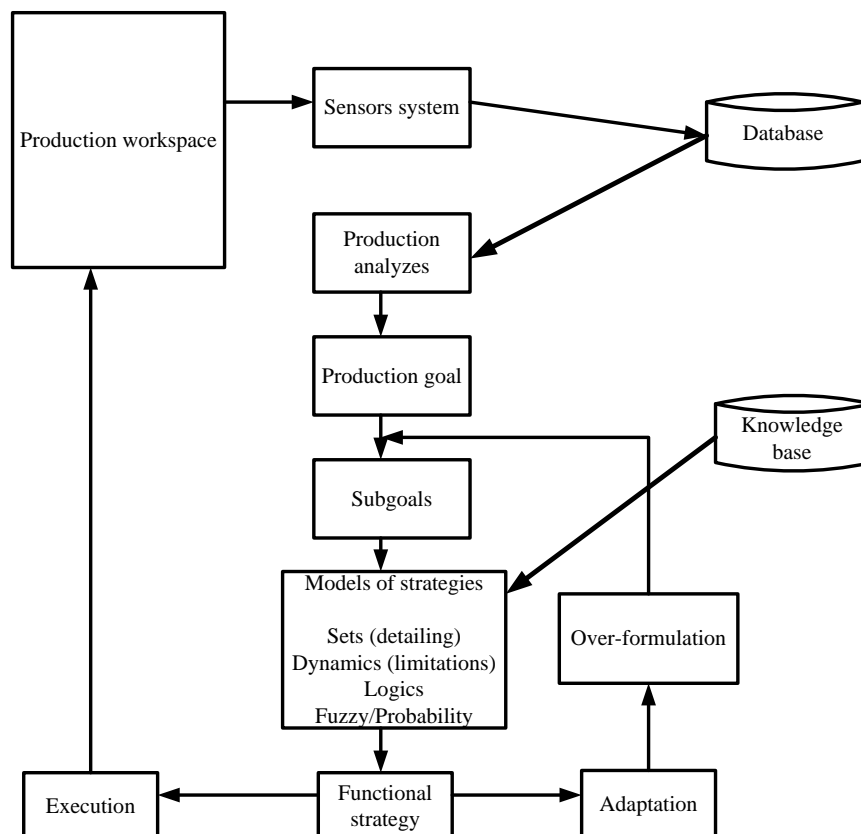


Fig. 2. Decision-making IT for flexible manufacturing

## Conclusion

The current problem of modern flexible integrated production systems is to supply the implementation of production functions aimed at increasing the efficiency of production through the continuity of the operation of the entire system. A control system that takes into account the changes in the working environment and the state of the flexible manufacturing integrated system should oversee the terms of the task and, if necessary, adapt the process of performing the production functions of the robotic system. As such, the intelligent control system based on the IoRT principles can act [14]. The introduction of such a system should significantly improve the characteristics of control systems for robotic systems that are part of the flexible manufacturing systems.

The given article proposes the new information technology to organize the process of decision-making for robotized means of flexible integrated manufacturing, which includes the monitoring of states for technological equipment and for workspace; the setting of goals and formation of decision-making strategy with taking in account of limitations and process dynamics, introduced

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## ІНФОРМАЦІЙНА ТЕХНОЛОГІЯ ПРИЙНЯТТЯ РІШЕНЬ ДЛЯ ГНУЧКОГО ІНТЕГРОВАНОГО ВИРОБНИЦТВА

**Предметом** дослідження в статті є гнучкі інтегровані роботизовані системи. **Мета** роботи – інтеграція моделей та методів прийняття рішень з метою створення інформаційної технології для гнучкого виробництва. В статті вирішуються наступні **завдання**: проведення аналізу сучасних тенденцій у розробці виробничих систем, розгляд інтелектуальних систем прийняття рішень як один з ключових елементів автоматизованих систем керування, розгляд створення інформаційної технології, що ґрунтується на наборі методів та моделей прийняття рішень, включаючи адаптивне прийняття рішень для не детермінованих завдань. **Метами** дослідження є теорія множин та теорія предикатів. Отримано наступні **результати**: проаналізовано та сформульовано основні проблеми розробки гнучких інтегрованих систем сучасного виробництва; в якості нового елемента до складу технологічних систем пропонується впровадження інтелектуальних виробничих агентів, реалізованих у вигляді мобільних роботизованих платформ, здатних виконувати транспортні та допоміжні складальні функції, виконувати завдання моніторингу та встановлюються основні вимоги до них; з формальної точки зору розглянуто процес прийняття рішень в гнучких роботизованих системах, який побудовано на взаємодії властивостей роботизованої системи, властивостей робочого простору та множини можливих рішень. Виконання кожного окремого технологічного завдання передбачає розробку та реалізацію плану роботи роботизованого обладнання, сукупність варіантів яких складає стратегію функціонування інтелектуальної роботизованої системи, що описується у вигляді логіки предикатів. Для розв'язання необхідних технологічних завдань пропонується використати автоматичні процедури генератора рішень, що функціонують на базі фреймподібних структур. Послідовна підтримка процесу прийняття рішень у роботизованій системі виробничого призначення на основі моделей різного типу складає запропоновану інформаційну технологію прийняття рішень. **Висновки**: застосування концепції інтелектуального агента у виробничих умовах вимагає комплексного застосування моделей і методів прийняття рішень, які можуть складати окрему інформаційну технологію роботизованого виробництва.

**Ключові слова**: інформаційна технологія; прийняття рішень; мобільний робот; гнучка інтегрована система.

## ИНФОРМАЦИОННАЯ ТЕХНОЛОГИЯ ПРИНЯТИЯ РЕШЕНИЙ ДЛЯ ГИБКОГО ИНТЕГРИРОВАННОГО ПРОИЗВОДСТВА

**Предметом** исследования в статье являются гибкие интегрированные роботизированные системы. **Цель** работы – интеграция моделей и методов принятия решений с целью создания информационной технологии для гибкого производства. В статье решаются следующие задачи: проведение анализа современных тенденций в разработке производственных систем, рассмотрение интеллектуальных систем принятия решений как одного из ключевых элементов автоматизированных систем управления, рассмотрение и создание информационной технологии, основанной на наборе методов и моделей принятия решений, включающих адаптивное принятие решений для недетерминированных задач. **Метами** исследования являются теория множеств и теория предикатов. Получены следующие **результаты**: проанализованы и сформулированы основные проблемы разработки гибких интегрированных систем современного производства; в качестве нового элемента в составе технологических систем предлагается внедрение интеллектуальных производственных агентов, реализованных в виде мобильных роботизированных платформ, способных выполнять транспортные и вспомогательные сборочные функции, выполнять задания мониторинга, устанавливаются основные требования к ним; с формальной точки зрения рассмотрено процесс принятия решений в гибких роботизированных системах, который построено на взаимодействии свойств роботизированной системы, свойств рабочего пространства и множества возможных решений. Выполнение каждого отдельного технологического задания предусматривает разработку и реализацию планов работы роботизированного оборудования, совокупность вариантов которых составляет стратегию функционирования интеллектуальной роботизированной системы, которая описывается в виде логики предикатов. Для решения необходимых технологических заданий предлагается использовать автоматические процедуры генератора решений, функционирующие на базе фреймподобных структур. Последовательная поддержка процесса принятия решений в роботизированной системе производственного назначения на основе моделей разного типа составляет предложенную информационную технологию принятия решений. **Выводы**: применение концепции интеллектуального агента в производственных условиях требует комплексного применения моделей и методов принятия решений, которые могут составлять отдельную информационную технологию роботизованного производства.

**Ключевые слова**: информационная технология; принятие решений; мобильный робот; гибкая интегрированная система.

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