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Program Hierarchical Realization of Adaptation Behavior of the Cognitive Mobile Robot with Imitative Thinking

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Abstract: Now rapid development of research and development in the area the androidnykh (anthropomorphous) robots is abroad observed. In the modern options such robots are equipped with the control system including: system of technical vision, system of voice-activated control and system of voice messages, tactile system, system of dimensional orientation, control system of a gait and stability, control system of behavior. The most practical designs of such robots are developed in Japan. They are called humanoid robots as are similar to the person not only in a form, but also, to some extent, on behavior. A number of such robots is developed for commercial application: Asimo (Honda), SDR-4X (Sony), Hoap-2 (Fujitsy). PETMAN – robot - android, (Boston Dynamics) Possibilities of anthropomorphous robots are defined by their design and a control system. When developing prototypes of humanoid robots special attention should be paid to development of the system of management which defines an athletic and behavioural ability of robots. The complexity of behavior of mobile robots results in need of searching of nonconventional paths of creation of their control systems. One of such paths consists in use of the principles of the organization of nervous system of the person disclosed by the modern psychology and a neurophysiology. The behavior of the robot described in article is realized by the functional hierarchical system of controllers, similar to a control system of behavior of a human body. The behavior arises under the influence of informational requirement on which imitative thinking determines orientation in a situation by models of the external environment and behavior. Orientation comes to the end with the choice of the corresponding line-up of subprograms of hierarchical system of controllers which realization leads to realization of behavior. Subprogrammes of actions of behavior of robots are set in programming languages.

Keywords: Cognitive Adaptive Robot with Thinking, Robotic Programming Languages of Behavior, Hierarchical Algorithms of Robotic Actions

1. Introduction

The behavior of the mobile robot is formed by set of the actions made by it. Programming of hierarchy of actions happens on their dominance in behavior. Criterion of hierarchy of operations of the robot is its specialization and a task to it. For this purpose the system of adaptations of prototypes of actions allowing to program the virtual hierarchical structure of behavior of the robot is under construction. Using the mechanism of the central motor programs which is well studied by neurophysiologists, also the control system of behavior of the robot is under construction. The actual behavior is implemented on model of a surrounding medium and behavior model. Technical capabilities and computing power limit abilities of behavior of robots so far.

2. Structural Aspects of the Robot

The cognitive robot has the system of a discernment of the interlocutor, the system of speech input of informational requirements, the system of realization of informational requirements (the system of imitation of imitative thinking), the neural network system of synthesis of the speech in the text of realization of informational requirement.

The system of realization of informational requirement contains the system of assimilation of knowledge, the system of symbolical and language communication, the system of tutoring, a knowledge base, base of abilities, the neural network system of reading printing system and the system of graphic display. The system of tutoring contains subsystems of machine translation. The system of a discernment of interlocutors is neural network system.

Informational unit of communication of the person with the robot is informational requirement. The interlocutor uses informational requirements which contain in a robot knowledge base and also a combination of informational requirements. The robot receives new informational requirements and their realization during its tutoring. Polysemantic words of informational requirement have a semantic marking. Cognitive navigation of the robot on its realization is carried out through the intrinsic dictionary. For example, the semantic marking of the word "put" indicates or a lexical meaning, or arithmetic action, or behavioural action.

Acquaintance of the robot to the person is carried out through the neural network system of face recognition. If the person is unknown to the robot, then the receptive system remembers its speech dictionary and the person. If it is known to the robot, then the system will customize the system of speech input of informational requirement on the speech dictionary by the interlocutor. After that the informational contact between the robot and the person begins. The system of speech input will transform speech informational requirement to the text in the functional natural language. The robot on the basis of symbolical language communicative logic with associative and communicative symbolical language elements of knowledge models imitative thinking [1-4].

3. Specialization of Cognitive Adaptive Robots

Specialization of cognitive adaptive robots is carried out on the basis of knowledge bases, bases of abilities and implementers of behavior. For example, implementers of behavior allows the robot to the lecturer on a healthy lifestyle to train in physical exercises. To physical culture for a normalization of a tone of an organism. To gymnastics for a normalization of rhythms of functioning of an organism. To charging on a normalization of a power system. The adaptive behavior goes imitative thinking on the instructions of the person and is carried out on models of a surrounding medium and behavior. Cognitive management of behavior is more reliable, than telecommunication. Programming of adaptive behavior of robots is carried out via the program interface.

The robot component realizing adaptive behavior in the external environment includes touch, operating, executive motor systems and the system of diagnostics [5].

The touch system is intended for perception and transformation of information on a condition of the external environment. It turns on television and optiko-laser devices, ultrasonic range finders, tactile and contact sensors, situation sensors, neural network devices of a pattern recognition of the external environment, etc. Robotic perception is a process during which robots display results of touch measurements on internal structures of representation of the environment.

On the robot it is possible to assign a problem of maintaining in tolerance limits of the parameters of heat and cold, vital for the person. Ability of the robot, the equivalent to perception of a tone of the person, can warn about an overload. Perception of pressure is function without which the manipulator of the robot cannot do. This function can be entered in the robot by various methods depending on purpose of the robot. It is especially important when fingers of the robot have to take various, sometimes friable, objects. Taction sensors at the person are very sensitive and numerous that allows to use them for distinguishing of a form. Now this task is already not really difficult.

Various elements, including chloride and lithium (Danmor sensor), carbon, elements on the basis of polyelectrolytic resistance, ceramic elements, capacitor devices and elements on the basis of alumina are applied to perception of humidity. These developments can be used in robotics.

In certain cases the robot it is necessary to allocate with ability to measurement of level of temperature either in itself, or in a surrounding medium. For this purpose use any of well-known methods of electric determination of temperature.

The method of precise indication of position of the robot is implemented by navigation technique, based on comparison of provisional regulations of impulses with provisional regulations of reference impulses. Indication of position of the robot is important for its orientation in space. Mapping and localization of an image of an object is carried out with use of the scanning laser ranging sensors. For measurement of distance use ultrasonic sonars, infrared sensors, laser sensors. Achievement of an object is carried out on the received coordinates. Procedures of realization of behavior are performed by the movements of parts of motor mechanisms of the robot according to a route of movement and the sequence of motive acts of parts of motor mechanisms of the robot. The route of driving of the robot is under construction in classes of patch and polyrated functions.

The system of diagnostics exercises control of execution of simple movements of parts of motor system of the robot on each step of realization of behavior, transfer of necessary information of the managing director to system on a condition of motor system for its correlation with information from touch system in real time and also reports about the end of the simple movements.

The executive motor system realizes procedures of behavior of the robot in the external environment carrying out the various movements. The motor system has mechanical hands (manipulators), mechanical legs (pedipulyator). The manipulator can take, turn, transfer, collect, bend around obstacles etc. The walking robot can move on the unfamiliar area with the composite relief, overcoming obstacles.

The procedure of realization of behavior is under construction on type a situation action. In the mode of realization of behavior the operating system constantly processes information on a situation from touch system and from the system of diagnostics and starts the executive system.

The robot determines model of the external environment by informational need of the person and touch information. It determines behavior model by model of the external environment and informational need of the person. Then it determines the sequence of the behavioural acts of motor system in the external environment on type a situation action realized from the point of view of the functional and touch opportunities by models of the external environment and behavior.

For the particular external environment at the robot the model of the external environment, behavior model and procedures of realization of behavior are set. In the particular external environment the robot on the informational need of the person (INP), models of the external environment, behavior model realizes informational need of the person procedures of realization of behavior. On IPCh the robot forms network of bit-by-bit realization of informational requirement for subject domain. If the network is built, then imitative thinking starts procedures of realization of IPCh. In the course of realization of IPCh the robot via touch devices controls a condition of the external environment. If the condition of the external environment on any circumstances does not correspond to a condition of model of the external environment, then the robot gives the message that it cannot realize IPCh in connection with change of the external environment and waits for the following informational requirement from the person. After realization of IPCh the robot reports to the person about the termination and results of the activity.

In the acritical external environment the robot according to touch information forms model of the external environment (EE), selects standard behavior model for IPCh and sequentially realizes IPCh procedures of realization of behavior: lays a safe route of movement of the robot on the VS model, on behavior model the standard procedure builds the serial-parallel movements of manipulators, pedipulyator and other motor mechanisms of the robot.

The robot for work with the acritical external environment has many various touch devices. The behavior model of the robot forms the procedure of realization of IPCh of a set of standard procedures. The behavior of the robot is implemented along a route of driving and the sequence of the intermediate configurations of the motive acts leading to realization of IPCh. The sequence of configurations of motive acts is built according to a route and IPCh.

The behavior model builds the movements of motor mechanisms of the robot on the law of change of their generalized coordinates guaranteeing realization of IPCh. Driving is defined by the vector of the generalized coordinates defining the current provision of degrees of mobility of its mechanical part. Working parts of motor mechanisms make rotations on the trajectory determined by a vector of phase coordinates.

Interaction with the external environment and its perception carries out the robot by means of different sensors and touch systems. Actual situations are described in memory of the robot by means of a set of indications of touch sensors. Touch information can be photographic, scanned, dalnometrichesky from optical and ultrasonic systems of technical vision.

In terms of indications of touch sensors primary description of model of the external environment is formed. The analysis and processing of this information lead to the generalized description of a situation with the help of concepts. According to the generalized description of a situation and IPCh the behavior model of the robot and a set of standard procedures of realization of IPCh are selected.

In behavior model the functional properties of the robot, mobile opportunities of the robot are reflected in the external environment. Thanks to it the robot can render services in IPCh, according to mobile opportunities, the VS model and behavior model in the unfamiliar external environment.

The task of the analysis of touch information, discernment and the description of a situation is relevant for interaction of the robot with the acritical environment. This problem by tutoring of the robot to distinguish objects of the external environment through the systems of a discernment of three-dimensional objects, to describe in a natural language elements of three-dimensional scenes on the basis of touch information by means of a totality of the partial situational signs is solved. For example: further, more to the left, below, are disconnected, areas of different color, etc. The description of the external environment is set in a natural language by means of a totality of the partial situational signs.

The robot, analyzing a situation of the external environment on standard model of the external environment, touch information, to the description of a scene of the external environment selects for IPCh behavior model, procedures of realization of behavior, builds a route of movement and sequentially forms motive acts of parts of motor mechanisms of the robot for requirement realization. Distinguish the cyclic and positional systems of coordination of motive acts. In the cyclic systems of a trajectory of motive acts are limited to 2-4 points of positioning on each of mobility degrees, and in positional systems the number of these points can make several tens that allows to realize are difficult" e motive operations.

Cyclic and positional management provides movement of an action on a broken trajectory from a point to a point. The concept of the relative relative frame of reference of coordinates is central. The relative relative frames of reference of coordinates are bound to each positional point of a part of the motor mechanism.

For each positional point on each step is defined sequentially at what size and in what direction to move it from the current situation to the given. For each part of motor mechanisms, the bound to a positional point, is defined in what direction and on what corner it is necessary to turn.

Simultaneous turn and transfer of a part of motor system concerning the generalized frame are calculated on formulas [5].

For pneumatic parts of motor mechanisms the scale specifying in how many times to increase or reduce the part size is set. The behavior model and procedures of realization of behavior are defined by the field of professional activity in which the robot has to realize IPCh.

Direction cosines of part P1P2 of motor system of the robot in characteristic relative frame it is calculated on formulas [5].

The behavior model contains algorithms of adaptive integrated management of the movements, a route of movement of the robot and the sequence of motive acts of parts of motor mechanisms of the robot.

Procedures of realization of behavior are performed by the movements of parts of motor mechanisms of the robot according to a route of movement and the sequence of motive acts of parts of motor mechanisms of the robot. The route of driving of the robot is under construction in classes of patch and polyrated functions.

Let the area represent the plane, obstacles by polygonal lines and coordinates of an initial point of the robot and target where the robot has to move are set.

It is necessary to construct an optimum route as a polygonal line from an initial point in target which does not cross obstacles and has the least length.

This problem is solved by a classical method of a dynamic programming of successive approximations in the function space, using the recurrence relation of function f, defining length of a route from an initial point in target. The strategy of finding of a minimum route is defined by a successive approximation of the constructed arbitrariest route to minimum.

After the optimum, safe route is constructed, by methods of the generalized, relative and phase coordinates motive acts of motor parts of the robot are under construction. Coordination of motive acts is serial – information coordinator of behavior model which is in the field of an attention of memory of the robot in parallel carries out.

4. Management of Behavior of the Robot

Behavior of the created robot the multifunctional hierarchical system of controllers, similar to a control system of behavior of a human body operates. The behavior arises under the influence of informational requirement which causes orientation in a situation on models of the external environment and behavior. Orientation comes to the end with the choice of the corresponding line-up of programs of hierarchical system of controllers as instructions to actions which realization leads to realization of behavior. Advantage of the organization such consists in development of behavior of the robot on the basis of expansion of hierarchy of the subprogrammes setting acts of behavior.

The controller is a computer on a chip. It is intended for control of various electronic devices. The controller of the robot is the diminutivest computer. It contains the processor and peripheral devices: FLASH memory, timers, interfaces for communication with peripheral equipments and a set of other useful schemes. The controller operates according to the given program which is loaded into it from the potent computer. It is loaded by means of a programmator (in the simplest look is an express cable) into the microcontroller.

The robot has bodies for interaction with a surrounding medium. Bodies which obtain information from a surrounding medium are called receptors (or sensors). And bodies which influence a surrounding medium – effectors: engines, loudspeakers, light-emitting diodes and so forth. The controller has a quantity of entrances and exits. To entrances receptors, and join exits effectors. Microcontrollers can process information from entrances and create electric signals at the exits how we will program behavior of the robot [6].

5. Programming of Behavior of the Robot

The behavior of the robot is set in programming languages. Many programs for the generalizing architecture were realized in behavior language which was defined by Brooks. This language represents language of management in real time on the basis of rules which result of compilation are AFSM controllers. The separate rules of this language set by means of syntax, similar to Lisp are compiled in the AFSM submachine guns, and groups of the AFSM submachine guns unite with the help of set of mechanisms of transfer of local and global messages.

As well as the generalizing architecture, language of behavior is restricted as it is aimed at creation of the simple AFSM submachine guns with rather narrow definition of a stream of communication between modules. But recently on the basis of this idea new researches which led to creation of a number of the programming languages similar on the spirit to behavior language, but more potent and providing faster realization are conducted.

One of such languages is the universal robotic language, or in abbreviated form GRL (Generic Robot Language). GRL is a functional programming language for creation of larger modular control systems. As well as in behavior language, in GRL as the main design units finite-state automations are used. But as control over these automatic machines the GRL language offers much wider list of designs for definition of a communication stream and synchronization of restrictions between various modules, than behavior language. Programs in the GRL language are compiled in efficient programs in such languages of teams as Page.

One more important programming language (and the related architecture) for the parallel robotic software is the system of scheduling of jet actions, or in abbreviated form RAPS (Reactive Action Plan System). The RAPS system allows programmers to set the purposes, plans, the bound to these purposes (or partially to define policy) and also to set conditions under which these plans most probably will be implemented successfully.

Extremely important the fact that also the tools allowing to cope with inevitable refusals which arise in actual robotic systems are provided in the RAPS system. The programmer can set procedures of detection of refusals of various types and provide the procedure of elimination of an exclusive situation for each type of refusal. In three-level architecture the RAPS system is often used at the executive level that allows to cope with the unexpected situations which are not demanding rescheduling successfully.

There are also several other languages which provide use in robots of means of formation of reasonings and tutorials. For example, Golog represents the programming language allowing to provide perfect interaction of means of algorithmic problem solving (scheduling) and the means of jet management set immediately by means of the specification.

Programs in the Golog language are formulated in terms of situational calculation taking into account a padding possibility of application of operators of nondeterministic actions. Except the specification of a time schedule control with opportunities of nondeterministic actions, the programmer has to provide also the complete model of the robot and its environment.

As soon as the time schedule control reaches a point of the nondeterministic choice, the scheduler (the given in a form of the program of the theorem proving) for definition of what to do next is called. Thus, the programmer can partially define the given controllers and rely on use of the firmware schedulers for acceptance of the final choice of the management plan.

The main attractive feature of the Golog language is the perfect integration of means of jet management and algorithmic management provided in it. In spite of the fact that when using the Golog language it is necessary to keep rigorous requirements (the complete observability, discrete states, the complete model), by means of this language high-level controlling means for a number of the mobile robots intended for application in rooms were created.

Language JSk CES (reduction from C ++ for embedded systems — C ++ for the firmware systems) is a language expansion C ++ in which probability tools and tutorials unite. Probability distributions are among types of data of CES that allows the programmer to carry out calculations with use of acritical information, without spending those efforts which are usually bound to realization of probability methods.

Even more important the fact that the CES language provides setting up the robotic software by means of training at the basis of examples, in many respects similar to what is carried out in tutoring algorithms. The CES language allows programmers to leave in the intervals code which are filled with the training functions; usually such intervals are differentiable parametrical representations, such as neuronic networks. Further at separate grade levels for which the teacher has to set the required output behavior there is the inductive tutoring by means of these functions. Practice showed that the CES language can successfully be applied in problem areas, the characteristic of partially observed and continuous environment.

The ALisp language represents expansion of the Lisp language. The ALisp language allows programmers to set the nondeterministic points of the choice similar to choice points in the Golog language. But in the ALisp language not the program of the theorem proving, but means of definition of the exact action by means of the inductive tutoring in which tutoring with a reinforcement is used is applied to a decision making. Therefore the ALisp language can be considered as a convenient way of introduction of knowledge of problem area in the procedure of tutoring with a reinforcement, especially knowledge of hierarchical structure of "procedures" of desirable behavior. Still the ALisp language was applied to problem solving of robotics only in imitating researches. It can be finished for programming of robots with imitative thinking and adaptive behavior, capable to tutoring as a result of interaction with the environment.

Cognitive robots with imitative thinking and adaptive behavior have the prospect of broad practical application as digital clever robots of lecturers and consultants in educational activity of the digital universities for tutoring of students on the basis of online courses. Cognitive robots with imitative thinking and the program interface it is possible to use managers and to program on management of robotic clever factories [4, 7-8].

6. Results

Hierarchical approach to realization of actions of behavior of the cognitive mobile robot allows it to perform the useful effect and to provide the movement. Hierarchical algorithms of actions of behavior are divided on agglomerative and divizimny. Agglomerative algorithms begin the realization with the fact that each action is brought in the corresponding cluster and in process of realization unite clusters until at the end does not receive one cluster including all actions of behavior. Divizimny algorithms, on the contrary, at first refer all actions in one cluster and then divide this cluster until each effect is not had in a sootvetstvushchy cluster. Representation of result of a hierarchical algorithm is the dendrogramma - the scheme showing in what sequence there was a merge of actions in a cluster or division of actions into clusters.

Such approach allows to formalize requirements to mobility of behavior of the robot and to develop all possible algorithms of reaction to change of a condition of an environmental situation. For example, when moving on the street applying technology of satellite navigation, and environmental objects, finding by means of cameras or range finders. That is approach allows to project independent robotic systems under realization of a set of the production and social spheres of activity.

7. Conclusion

Russia develops mobile robots with simulated nervous system [9-20]. Use of programmable production will demand the universal mobile robots capable not only to carry out in advance set of operations in a workplace, but also to move freely on production rooms, to transfer between jobs of a component and finished products and to react flexibly to changes in production. Soon such physically simple affairs as work of the druggist or librarian will be sent to a book-depository to robots.

A large number of almost completely robotic factories and plants can will appear by 2020. Robots will begin to use actively in agriculture and also the specialized robots helping the person with hard physical activity. On streets of our clever cities we will see robots cleaners, robots loaders, robots of trishaws, robots of sellers.

Already today technologically developed countries on the basis of upkeep automatic machines piece goods build shopping facilities in which as sellers can use emotional, cognitive, adaptive robots with imitative thinking and speech communication. Cognitive robots with imitative thinking, speech communication and adaptive behavior it is possible to use registrars in policlinics and hotels, at gas stations, at the airports and other services.

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