TRANSPORT ROBOT WITH NETWORK CONTROL SYSTEM

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Abstract

A network control system of Transport Automatic Integral Robot (TAIP) motion in the real environment is suggested. Input data and general structure of the network are described. A program is reported of further efforts to investigate and refine the network control systems.

Introduction

The problem of artificial intelligence creation for robots is characterized by several specific features. A robot has to exist in the natural environment. It receives information from its own sensing elements mostly during an active work. There is no one here to take care for information to be complete (sufficient to solve a problem accurately), consistent, and convenient in its form of representation • The framework of build-up of current efforts on the robot artificial intelligence (See, e.g.,[1]) seems to us, therefore, too narrow. The most of suggested procedures does not admit of inconsistent data employment and creates great difficulties in real-time work. It entails necessity of limiting the input data volume by all means.

Repeated attempts were undertaken to overcome arising difficulties by network devices. Obtained results are unsatisfactory as a whole. No sound methods of synthesis of the network devices for solving specific problems were obtained hitherto. Nevertheless we are endeavouring once more to rehabilitate the network methods of artificial intelligence construction. There are several reasons:

1. Network devices possess a large number of advantages in bulk information processing.
2. Approach that is being elaboratea oy us differs from those verified earlier and will, possibly, yield other results.
3. Achievements of the modern engineering allow to estimate anew various methods for device synthesis.

Theoretic efforts to study prospects and capabilities of the approach developed have already been carried out at our Department for a long time. Computer models were created simultaneously to verify theoretic notions. A large number of effective digital models developed by A.M. Kasatkin, L.M. Kasatkina, S.A. Talaev, V.D. Fomenko, and D.N. Galenko testify to the rightfulness of the chosen approach.

Development is currently under way of a simulator of the network system for transport robot control in the natural environment- An outline of this system and discussion of further efforts direction will be given in what follows.

Problem of Transport Robot

The Department of Biocybemetics engaged in 1972 in designing a simulator of a moving independent system - a transport robot - capable of purposeful movement and performance of some actions with objects in a natural environment of the yard type. The problem of robot is close to that described in L. Sutro's, W. Kilmer's work [2], however, our principal goal is to test a vehicle onboard control system having the form of a neuron-like network with SRI [3].

The preliminary check of capabilities of a network of physical elements (consisting of 26 nodes and approximately 300 connections) was executed on the simulator modeling a movement system in a hypothetical environment shown on a map. Capability is realized in this system to travel from one point of an area to another with due account of all positive and negative attributes characterizing the given hypothetical environment as well as of constraints on time and energy consumption. Hesults of the system experimental investigations [4] have shown the feasibility and expediency of robot control system construction on the base of networks with SRI.

Creation of transport robot presupposes solution of a number of problems on which the system capability hinges largely. We restrict ourselves to a brief enumeration of these problems.

1. Moving part must provide for movements of the robot where roads are impassable.
2. System must "know" objectives it is aimed at. Such objectives may consist in:
   a) determining points on an area where the robot must arrive in;
   b) certain actions that the robot must execute (manipulation with objects, data collection, campling, etc);
   c) operating in modes with a given energy and time consumption.
3. System must be able to orient on an area (to locate itself with respect to one or another coordinate system).

4. Robot must be equipped with a set of sensory organs (sensing elements) supplying it with information on the environment as well as on its own "inner" states. The "eye"-type system, rangefinder, various distant and contact sensing elements, energy consumption sensors, etc., should be included among them first of all.

5. Robot needs efficient devices enabling it to perform one or other actions with objects in the environment. These are various manipulators and primarily - the "hand"-type system.

6. Robot must be able to communicate with a human being therefore a system of natural speech discrimination is expedient.

7. Robot must know how to construct its "inner" model of the outer world and plan its behaviour.

8. Robot must be a system that is able to adopt and learn.

Mechanics and System of Sensing Elements

The robot simulator developed by us is constructively a three-wheel undercarriage where sensory organs, the control unit, and other devices are installed

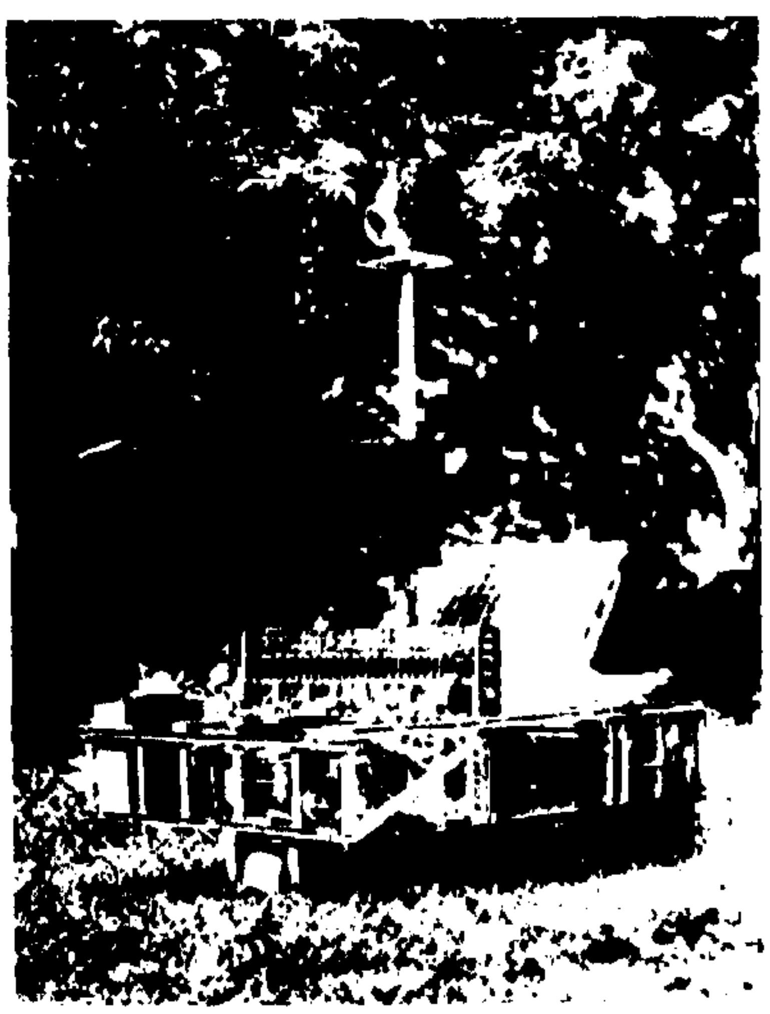

Fig.1 Transport Autonomic Integral Robot (TAIR).

(see Fig.1). The under carriage dimensions: 1600x1100x600 mm. All three are driving wheels and each has an independent drive from 60 W d.c. motors. The front wheel is the turning one. Power is supplied by two accumulator batteries each of 12V voltage and 40Ahr capacity.

The system of sensing elements may be divided into several groups:

1. Sensing elements determining the robot position in space:
   a) radio-navigation system with two radio beacons and the compass;
   b) sensors of angles of the vehicle inclination in two planes.
2. Sensing elements supplying information on the environment:
   a) distant ones. An active optic rangefinder, whose high speed is up to several hundreds of measurements per second, permitting to "probe" the surrounding relief at a distance up to 10m. A system of optic "probes" - rangefinders designed for detecting an object within the specified range of distances (about 30 cm);
   b) contact ones - a system of microswitches set on an elastic cover of the vehicle.
3. Sensors of robot states:
   a) temperature sensors on the electric motors;
   b) torque sensors on the wheel drive;
   c) voltage pickups on the accumulator batteries;
   d) vibration pickup.
4. Timer.

Control Device

A neuron-like network with semantics and SKI realized physically is a basis of the control system. A detailed characteristic of such networks, which got the name M-networks, is given in [3].

The M-network is formally a set of nodes and unidirectional connections linking the nodes. Each node is made to correspond with some meaningful notion. Each connection is put in correspondence with some relation between notions. The nodes can be in the state of excitement. The excitement is an analog quantity. The excitement can pass along the connections from one node to another. The connections are functionally divided into reinforcing and inhibitory ones. The existence in the M-network of a specific system for reinforcement and inhibition (SRI), which sets the positive node excitement feedback and thereby provides for the domination of one or sevexal nodes over all others at each time instant is of essence. In the M-network data input/output corresponds to the excitement of its nodes (input and output, respectively).

The robot control system is now calculated to effect a purposeful movement with provision for its own security (travel around obstacles, avoidance of dangerous places, keening internal parameters in assigned limits) and minimization of the energy and time consumption- The whole network (whose node number equals 100) is divided into 6 spheres. Semanticsand purpose of the discriminated spheres are as follows (see Fig. 2).

ftstimation sphere and situation recognition isphere. These spheres are input ones. Similar to sensory systems of the human brain, the analysis of information received by sensing elements is performed here on the basis of which the environment, problem conditions and own states are estimatedintegrally.

The character of behaviour in the current situation is chosen in the decision sphere. Here the decision can be made determining a general direction of movement or a choice of come complex movement maneuver or even execution of some elementary action. Organization of the movement behaviour proper is carried out by three spheres being output ones for the network, i.e. by the sphere of maneuvers of the upper level, the sphere of maneuvers of the lower level, and by the sphere of elementary actions. The sequence of commands delivered to the effector system - the control system of turning and traction electric motors - is formed here. However, the emergency cutoff is envisaged in the system that is shown in the diagram by the direct connections from sensing element system to effector system.

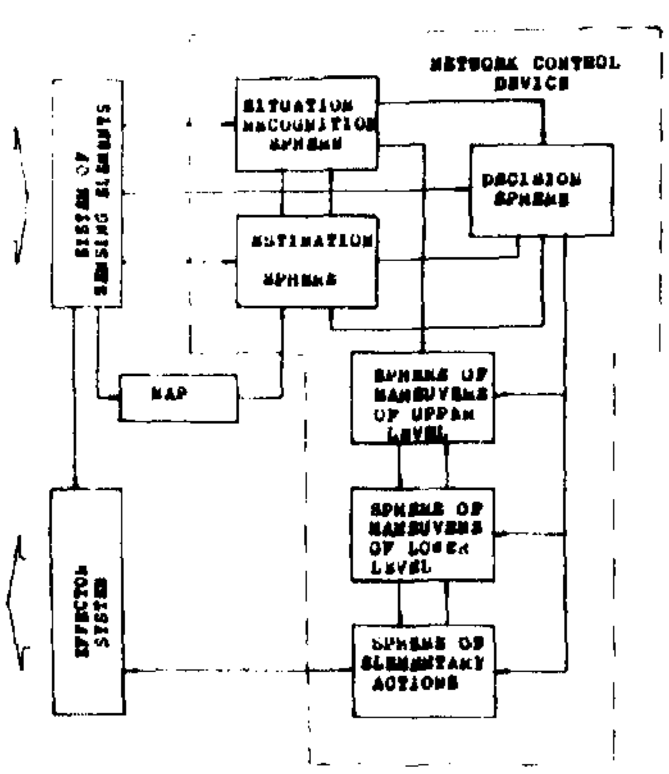

Fig.2 Block Diagram of the TAIR's Control Device.

All network nodes are d.c. amplifiers having special characteristics. Similarly in every sphere its own SRI acts. Connections between nodes are composed of resistive elements in a matrix-like device. 60 channels are used for data input from sensing elements into the network control system.

To plan its behaviour (the choice of a rout to an aim) the robot is supplied with a special locality map where the optimal route to the aim will be determined. In the given version the map is compiled beforeiuand. It is supposed that in future the robot will compile the map itself and modify it as required.

Experiments Planned.

The robot's moving part, control system of the lower level (effector system; and individual sensing elements were checked and tested in the fall of 1973- Setting up of the rest of devices, of the system as a whole, and experiments with it compose the next stage of developments scheduled to the end of 1975. As stated above, the ability of a purposeful movement on a real ground of the yard type was only required of the system here.

During the planned tests it is supposed to find out what capabilities the developed devices, the network control device mainly, have for solving various navigation problems (azimuth travel, travel to an assigned point in the locality, etc.). They must eventually answer the following principal questions:

1. Is it possible to organize a neuron-like network with SRI to control a transport robot in a respective environment efficiently?
2. What is a rough amount of equipment necessary to solve this problem?
3. What parts of the problem as a whole it is reasonable to solve by network devices and to what extent computer application in control is desirable?
4. What changes must be introduced into the philosophy of construction and technical realization of the network with SHI proper?

Further Research and Development

The program of further research supposes an extension of the transport robot capabilities- The work is now under way and is performed in several directions*

Learning- During the research we intend to develop methods and facilities for the network devices learning. Main attention is directed to creation of sufficiently cheap and simple as to production technology electrochemical elements as learning connections in the networks with SKI. Problems are solved of the elements matrix organization and of their commutation when they are more than 10^6 units in number.

Ensemble Organization of Network. This direction of our research is associated with a more economic use of the network nodes. To this end it is intended to assign semantics not to individual nodes but to their combinations - ensembles. Each node of such network will take part in organization of many ensembles what promises a great saving of nodes in a number of cases. Moreover, the operational reliability should increase in such network. The ensemble organization of the network with SRI designed to solve specific problems gives, however, birth to new problems requiring supplementary investigations.

Setting Up and Optimization of Network Devices. Feasibility is investigated of the setting up of network individual parts (spheres) and auxiliary units by optimization algorithms imitating the evolution processes. These algorithms impose a number of special requirements on hardware necessary for their realization. Creation of such a hardware seems possible. Optoelectronics is promising in this respect.

Visual Perception. At our Department K.G. Agababyan has carried out an investigation earlier that demonstrated the possibility to discriminate a large number of informative features in an image by the network devices [5]. Employment of specialized networks with SHI is intended in further research to solve the problem of discrimination of objects on a common background with their prerecognition. Technical realization of such devices entails necessity of creating large-scale nonlearning networks. Hardware is developed for synthesizing such networks.

Manipulation. Here the research is aimed at solving problems associated with realization of manipulator control programs in the network devices. The basic requirement consists in the network capability to form standard motional acts ("habits") and coordinate them in changing working conditions.

Speech Contact. Investigations are directed here to the search of means for creating network devices capable of speech discrimination and of contact with a human being in a language close to the natural one. Consideration will be mainly given to problems associated with perception and understanding of commands in the context of problems solved by the transport robot.

Construction of Iyer Model and Planning* To act successfully in an environment the robot has to know how to construct a model of the latter and how to plan its own behaviour. Precise discrimination is necessary of the "imaginary" and "real" not to make premature solutions when planning. Plans have to be developed, hierarchic, multivariant. The robot has to evaluate feasibility of the plans concurrently with their elaboration. We intend to study these mechanisms on the learning network having the ensemble organization. Combination of the network with a computer will be probably of use here.

All enumerated directions imply the use of a network device with 1000 nodes and $2x10^6$ learning connections for modeling the bench version under development.

Conclusion

On the basis of our experience of work with network control devices we assume that they are fit for an efficient use in solving a wide range of robot engineering problems. However, one cannot assert preliminary that the network devices will prove competitive. The problem should be obviously solved when the network methods prove actually preferable, when their combination with other methods is advantageous, and where their application is expedient. Our efforts should result in a solution of this range of problems.

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