HYBRID NEURAL-BASED CONTROL SYSTEM FOR MOBILE ROBOT

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Abstract

The architecture of control system for mobile robots is proposed in this paper. This architecture is based on hybrid approach using neural networks for classification of images and organization of associative memory as well as semantic networks for natural language processing and organization of memory and achievment of goals.

Keywords: hybrid intelligent systems, mobile robots, neural networks, semantic networks, natural language, recognition of images.

In last decade investigators and developers of applied artificial intelligent systems are trying to develope hybrid approach to implementation of AI systems [1-6]. This approach includes as logical processing of data by classical kinds of inference such associative processing by neural networks. From one hand its application allows to use many results, achived in knowledge engineering, with its comfortable for visualization, verbalization and formalization of knowledges. From other hand it allows to use possibilities of lerning and really work with fuzzyness of neural networks.

Hybrid approach is most interesting in development of intelligent robots because ones accumulate all achievments of AI, and task of impementation of strong AI is connected with creating of robots. In this paper one kind of robot - mobile intelligent robot, is consided.

In wide world hybrid approach to control of mobile robots is developed in last some years [7-13].

Architecture, described in this paper of control system of mobile robot, is based on two-level structure of data processing in mind and model of associatve memory of intelligent system, proposed by one from authors in [14,15].

Intelligent system may be subscribed as two levels: logical (verbal) and associative thinking or processing of knowledge. Logical level deals with concepts, which may be described in any sign system (in particular in natural language). On this level processes well known in knowledge engineering are used, for example, inference, different kinds of search. Associative level deals with images (patterns) and in this level solving of task is described as associative processes – storing and recall of associations, as well as classification, clusterization and generalization.

Set of images can be divided on static and dynamic and into homogeneous and heterogeneous images. Strictly speaking, the static images do not exist at all in the real world. However, for simplification of representation and handling of knowledge it is useful to consider separately images, which do not depend essentially on time and to consider as their static.

In corresponding to model in [14] and described above, proposed control system of robot includes symbolic and image levels.

Symbolic level is based on semantic network and executes functions of recognition of sense of sentences in natural language and planning of achivement of goals. Image level consists of part for processing of sensor data and part for control of engines. For one's part processing of sensor data consists of functions of classification (clusterization) (neural network 1) and associative memory (fig.1).

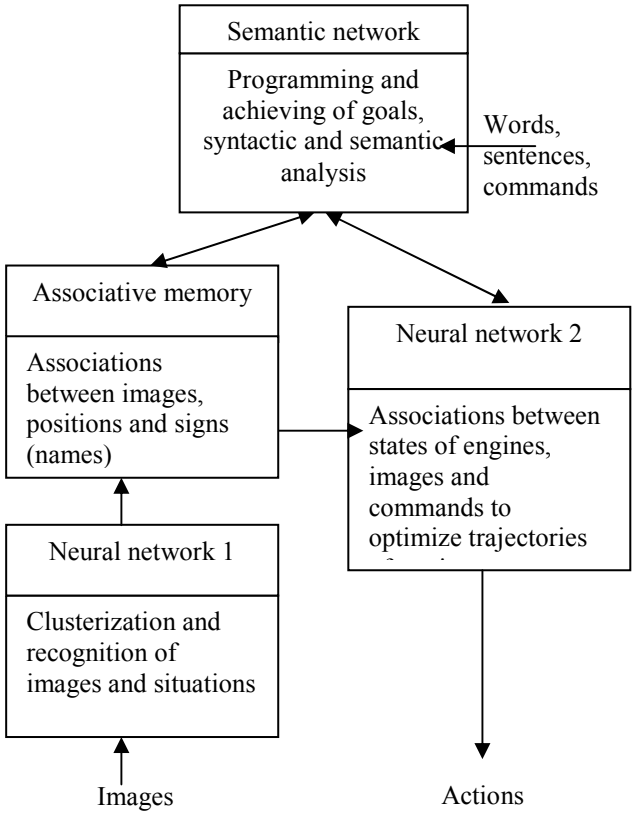

Fig1. Hybrid architecture of Control System

This control system may be used for solving of following tasks:

1. Control by sentences in natural language after learning to associations between words (concepts), coordinates and images.
2. Description of place, where robot is situated.

Human may be name any object being in front of robot (in field of vision). For example, it may be table, cupboard, chair, man and so on. At that associative links are created between image of object, its localization (coordinates) in environment and its name. Then human

may be order to robot “move to table” and robot is making this motion.

Neural network 2 is used for storing and execute path to place with found coordinates

Other possibility of this architecture is to explain where robot is situated. In this case query for associative memory may be recognized image.

There are many models of neural networks used for classification and clusterization. Most known from ones are: perceptrons with forward and errors back propagation, self-organizing maps of Kohonen, RBF-nets, model of Hemming, the models ART-1 and ART-2 of Grossberg-Carpenter.

First three from ones has determined disadvantages. Main of its is necessary of previous knowledge about number of classes and also its approximate characteristics (in RBF-nets and Kohonen’s maps). Model of Hemming can work with binary input vectors.

From our view to provide solving of tasks describes above neural network for classification and recognition (neural network 1 in fig.2) must have following features:

1) learning algorithm must be constructive and must provide solving of clustering,

2) model of neural network must support work with analog signals as well as binary.

Such demands are supported in model ART-2 of Grossberg and Carpenter. For proposed control system, modified model ART-2 may be used. Modification is following. In unlike to classical model in this kind two regimes are proposed – learning and using. In regime “learning” it is possible to create new clusters (new output neurons) and in regime “using” this possibility is locked. First regime is set when it is needed to store association between image (its class) and any words (or sentence). The second regime is set when robot is monitoring for environment during motion.

For implementation of static associative memory for store of association between recognized images, words (concepts) and position (coordinates) may be used model of Hopfield and its modifications but model of Hopfield has one disadvantage – low information capacity. Therefore, errors during processing of query to memory are very possible. Yet task demands exact corresponding between recognized word (concept) and coordinates of object (position), named by this word. In addition, for implementation of this associative memory on Hopfield’s model is necessary determined number of inputs and outputs (number of neurons) that is impossible after using of ART-2. So simple table is proposed for organization of associative memory. For every new cluster (from ART-2) new record of table is created including index recognized concept or word and coordinates.

Known some examples of application of neural networks for control of mobile robots, which may be used for implementation of dynamic associative memory for store of associations between coordinates, states of robot and actions. Most known and interesting of ones are robot GMD [10,11] and DRAMA [8].

Similar neural network allow to solve following task for robot. Robot can to learn with teacher by show him how it is needed to act in determined situation (for example, in front any obstacle) or sequence of actions for achievement of goal (in particular to turn of obstacles).

In last decade one of actual areas of an artificial intelligence and robots is development of devices for care for elders and people with disabilities. In particular, in many laboratories of the world works on creation of robots wheelchairs [25], which, due to use of AI, allow to facilitate control of them are conducted. One of such projects is the project which is carried out in laboratory «Intellectual systems» of Research center NARC University of Ulsan (Republic Korea) [26].

Till now this wheelchair could work in one of three modes: manual with control by joystick, automatized with control by head (turn of a head operates turn of an wheelchair, a nod of a head is corresponding to set/off of movement), automatized with control by ball (the wheelchair goes on the certain distance behind a ball, which is carried ahead by the person).

Last two modes are based on use of technical vision (video camera).

The architecture of a control system of the mobile robot suggested in the present article is used for implementation of the fourth mode. In it the wheelchair can be trained in a verbal designation of a place, where it is or object which it sees, and then to execute a verbal order to move to this place (object).

To test and debugging of connections between modules of proposed architecture, for check features and possibilities of model ART-2 for recognition of images program model of control system was developed.

In program model following functions were implemented:

- Clusterization and classification of images (pictures from graphic files in format .bmp);
- Simulation of placement of robot in 2D-environment;
- Simulation of moving of robot from current position to position-goal;
- Storing associations between coordinates, images and names of situations (“viewed” images) in associative memory, implemented as table;
- Fuzzy recognition of words – name of images (part of technology of natural language processing, described above);
- Simulation of recall of association between input word and coordinates and moving of robot to position-goal with its coordinates.

In fig. 2 structures of processes and data in this program model are shown.

To test features of application of model ART-2 as neural network 1, possibilities of fuzzy recognition of words and abilities of connections between ART-2, words recognition and associative memory, some experiments are provided with this model.

From results following conclusions are done:

1) the model ART-2 is able to solve task of recognition of images in proposed control system if threshold is choose enough correctly;

2) the shifts of image don’t serious influence on carefully of recognition;

3) the light does more influence on carefully of recognition;

4) even in case with errors this errors don’t exerts influence on solving of first task (order to robot to move by name of place, where he must go);

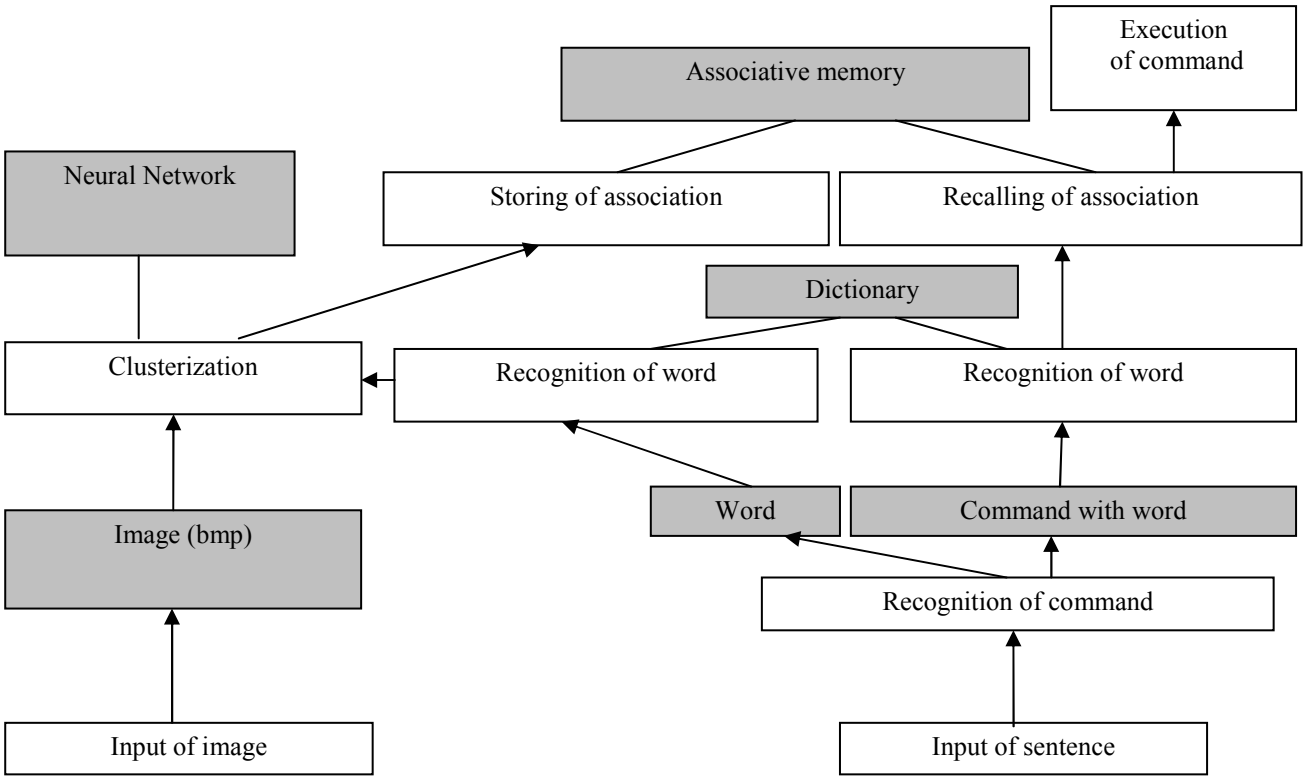

Fig 2. Structure of program model of hybrid control system of robot

5) there is task to select right value of threshold for on one hand to recognize similar images if it is needed, and from other hand do not create many clusters for analog images, which must recognized as similar;

6) there is task to select time of calculate of new coefficient of normalization for new several images.

Also this program model was used for test of fuzzy recognition of words.

For example, for threshold equal 0,8 word "kitchen" was recognized right for following input words with errors: kitchens, kichen, kitchan, ketchen, kithen. For threshold equal 0,7 words "kechen" and "kichene" were recognized as "kitchen" too.

In this paper the hybrid architecture of control system for mobile robots is developed, based on neural and semantic networks. The application of this architecture for implementation in robot wheelchair is proposed. This architecture is oriented on supply of control by voice in natural language.

As shown in experiments with program model of this architecture, one can to solve tasks to order for robot go by call of position-goal in natural language. Moreover was shown that proposed for this architecture model ART-2 and technology of fuzzy recognition of words are suitable. At the same time the simulation of this architecture and analyzing of features of this architecture show any problems for solve in continue of this investigations:

1. The continues development of technology of natural language processing to adapt ones for description of situations (positions) and its using for forming and achievement of goals and explain where robot is situated (now this technology is oriented for search texts by query in Natural Language.
2. Development and investigation of application of speech for control of robot.
3. Development of methods and devices of adapt of parameters "threshold for creating of new cluster" and "threshold for words recognition" during action of robot, as well as development of adaptation by recalculation of coefficient of normalization of images.
4. Development of subsystem for control of moving of robot to goal based on neural network.

Moreover, of cause at first the physical experiments with robot wheelchair are planned in short future.

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