Self-training Neural System for Autonomous Control of a Mobile Robot

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Key Words: Neural networks, self-organizing, mobile robot.

Abstract

Unsupervised training is of great importance for adaptation to the environment. This adaptation is performed by means of continuos training as a result of interaction between robot and environment. In this case the teacher is the environment. This paper presents the way for the implementation of unsupervised learning and self-organizing. Such approach is offered to be use for a mobile robot.

1. Introduction

One of the most important goals in the design and development of intelligent mobile robots is the ability of a vehicle to adapt to the environment. Life is full of situations, which are impossible to predict. In these cases the ability of a robot to self-training and self-organizing is of great importance. It permits the artificial system to progress without a person (self-progress). It is especially important, whether the robot operates in the aggressive environment or on other planet.

This paper describes a self-organizing system for reactive control of a mobile robot. Such a system must collect a training data into groups itself and learn during the interaction of a robot with the environment. The main principles of self-organizing system are discussed.

2. The general architecture and approach

The general approach to building of the self-training systems consists in the fact, that the initial knowledge of the robot can be filled up and corrected in the process of functioning. It is supposed that the fundamental knowledge of the robot are contained in blocks 1-3 and 6, which are determined by logical way, as it was shown in the previous paper. Then the task is to train multilayer perceptron (block 4) for providing the robust control on the narrow intervals of motion in the process of robot functioning. The scheme of interaction of the robot with environment in the process of self-training is presented on Figure 1. In this case the control is performed from analytical block and binary neural network.

The process of self-training takes place by means of a tries and mistakes on the narrow intervals of motion. If the manoeuvre is carried out successfully the training data for the learning of the multilayer perceptron are formed. If the try is not a success there is a return of the robot to the initial point for several steps back and the repetition of the manoeuvre (Figure 2).

The block of the situation analysis is meant for the reconstruction of the situation on the previous step of the robot (t-1) and the formation of the correcting direction of the movement $\gamma(k_1)$:

$$\gamma(k_1)=\gamma(k)\pm\delta,$$

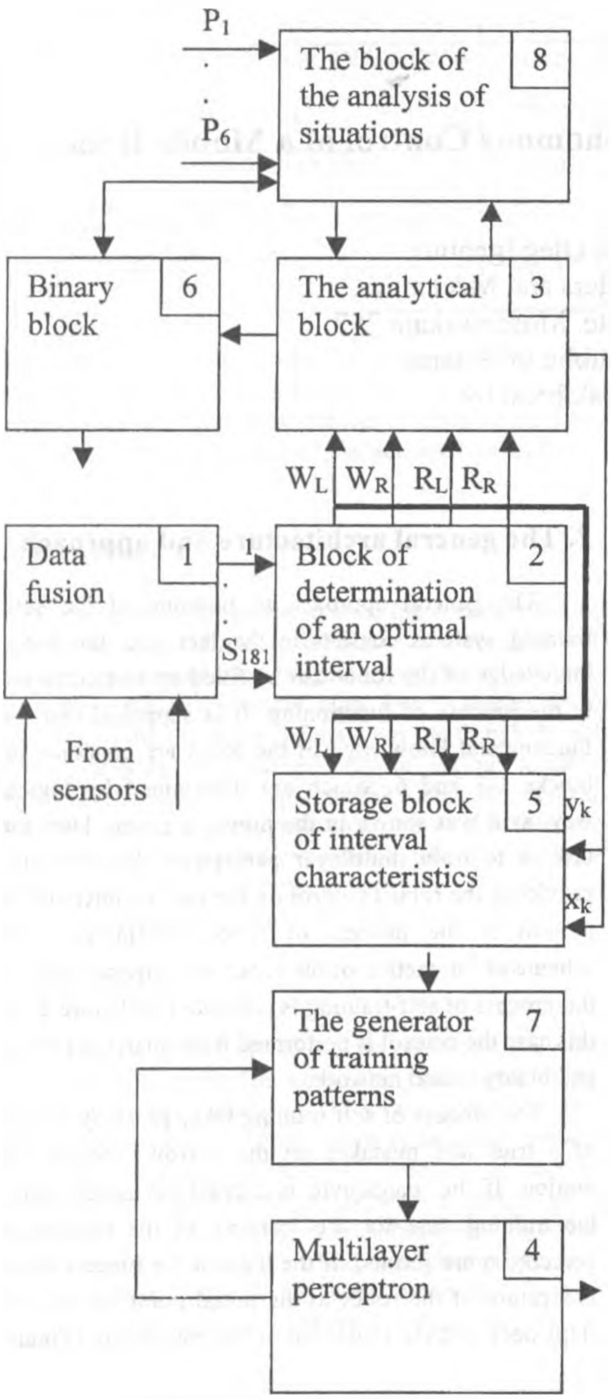

Figure 1. The scheme of the neural system in a self-training mode

where $\gamma(k)$ is the direction of the motion, formed by the analytical block in the given point during the previous try of the manoeuvre; δ is the angel of the correction of the motion direction.

The data from the tactile sensors are used as the input information of the block of situation analysis (Figure 3). By this the input signal of the sensor i equals one (P_i=1), if there has been the contact of the corresponding sensor with the obstacle.

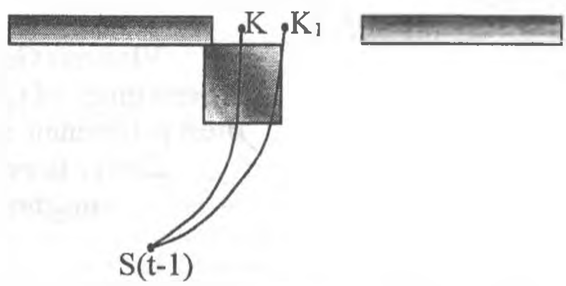

Figure 2. An example of an incorrect trajectory of the robot (point K): K_1 – corrected direction of driving

In the opposite case P_i=0. The correction of the direction of the robot motion is performed by means of logical analysis of the information of the tactile sensors and the previous direction of the movement:

$$(P_1 = 1 \vee P_6 = 1) \rightarrow \delta$$

$$(P_2 = 1 \vee P_3 = 1) \rightarrow -\delta$$

$$((P_4 = 1) \vee (P_5 = 1)) \wedge (y = 1) \rightarrow -\delta$$

$$((P_4 = 1) \vee (P_5 = 1)) \wedge (y = 0) \rightarrow \delta$$

In the expressions given above the signal y is formed as follows:

$$y = \begin{cases} 1, & \text{если } \gamma(k) > 0 \\ 0, & \text{иначе} \end{cases}$$

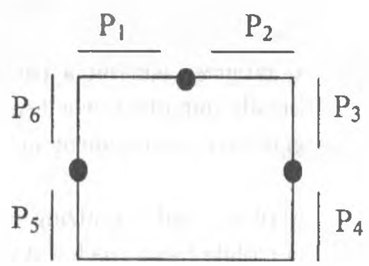

Figure 3. Tactile sensors disposition

Thus the block of the situation analysis forms the positive or negative meaning of the angle of the correction of the motion direction if there has been a collision with the obstacle. It means that the point K in the selected interval of movement has not been correctly chosen and it is necessary to define the coordinates of the point K_1 according to the new direction $\gamma(k_1)$.

As the binary block operates under the control of the analytical block as a result there is also the correction of output data of the binary neural network. In some situations it is necessary to correct the output meanings of the binary neural network by means of changing of the variant of its functioning. It is carried out by means of the analysis of the information of the tactile sensors and previous output meanings of the binary block. For example, if

$$(P_1 = 1) \wedge K(t-1) = 0110 \rightarrow K(t) = 0100,$$

$$(P_2 = 1) \wedge K(t-1) = 1010 \rightarrow K(t) = 1000,$$

where K(t-1) and K(t) – are accordingly the output meanings of the binary block of the previous and the present stage of functioning. The block of analysis of situations keeps the coordinates of the previous point of movement S(t-1), so as to reconstruct the situation of the previous step. The robot returns in the previous point in case of the collision with the obstacle.

The storage block of interval characteristics contains the coordinates of the present point K and the position of the interval of movement. In case, if the manoeuvre has been a success they enter the generator of the training set.

The manoeuvre is considered to be a success, if the robot reaches the point K in the selected interval of movement without collision with obstacles. The generator by means of rotation defines for blocks MLP_1 and MLP_2 a training patterns, a quantity of which equals approximately to 30, on the basis on coordinates of point K and the characteristics of interval of movement. As a result of modeling of different situations the training set is formed. As the experiments for the stable work of the neural networks have shown necessary volume of the training set equals 120-140. In the process of functioning of the robot it is necessary also the correction of the training set for the binary block. 40 training data are enough for its stable work.

The usage of the binary block for the robot control in the regime of self-training gives an opportunity to decrease the number of mistakes while performing the manoeuvres and consequently to accelerate the process of self-training. By this self-training can take place both for obtaining new knowledge and for correction of the old knowledge. As a result the adaptation of the robot to the environment is provided.

3. Experimental results

For testing of the self-organizing neural system the software has been developed which allows to simulate the robot motion.

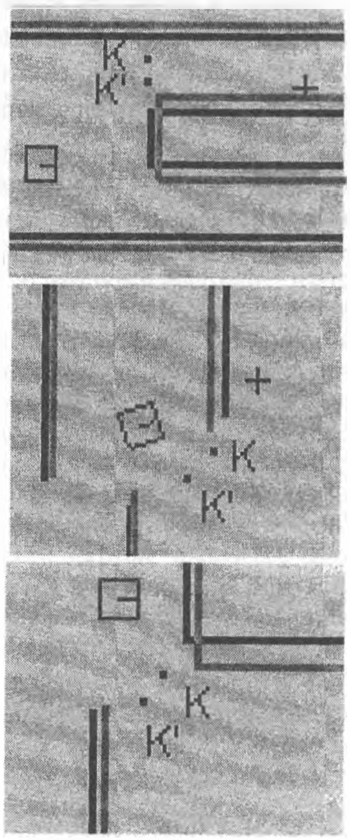

Figure 4. Various kinds of distortions and adjusting direction of the robot; the black color shows real obstacles, and dark-gray - obstacles seen by the robot; a point K is a direction chosen by the robot in the beginning (erroneous), K' – corrected target point of the robot.

The tests were carried out for various situations. By this for the learning and simulation was used inexact data from sensors:

- the linear distances up to an obstacles are differed from real values;
- the angular distances up to an obstacles are differed from real values;
- the sensor errors depend on environment. Therefore the errors of the sensors were changed depending on situation.

The various situation, which were used for simulation are represented on Figure 4. For training multilayer perceptron (block 4) is used the backpropagation algorithm with adaptive step [1]. Such approach permits to reduce a time of training. The experiments have shown, that it takes only several seconds for generating of training set and learning of the multilayer perceptron.

After training the robot motion was a stable for different situations. The self-training permits the robot to reach of a target in case, if the sensor errors are changed during motion. Thus such approach provides the self-organizing of the robot during movement. As a result the robot can adapt to different environment.

4. Conclusion

This paper presents our approaches to autonomous mobile robot navigation. By this during robot motion is performed self-training and self-organization, using the neural networks. The neural networks have been trained in a unsupervised way. During the interaction of the robot with the environment are collected the training data, which are used for training. Such approach permits to adapt the robot to different situations. By this described self-training system works in real time.

5. Acknowledgement

The given work is carried out within the framework of the project INTAS-BELARUS-97-2098 "Intelligent neural system for autonomous control of a mobile robot". The authors thank European Union for the informational and financial support.

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