Multi-agent system based on Artificial Neural Network for terrain exploration

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***Abstract*—In the presented paper Multi Agent System (MAS) with automatic formation selection based on the Artificial Neural Networks (ANN) is described. Presented system aims at testing the collective behavior of robots in unknown territory, their ability to cooperate in case where information and communication are extremely limited. As an example of MAS usage, the task of searching the experimental area to find a specific point is presented.**

I. Introduction

Multi Agent-Systems composed of agents are under investigation by scientists around the world. It has been confirmed that such systems enable features as: parallelization of tasks, reducing of the failure rate of the system and the costs of the individual agents (in the case of complex of robots used in those systems). Therefore, research and development of MAS are an important part of modern science. Multi Agent-Systems are used for tasks such as searching the area, the optimization of routes from starting point to destination [5], cooperation with tasks performance [1][4][6].

In the presented article a system composed of several agents is described. Main task of presented MAS is to search of an unknown land with the purpose of localization of the target location on the simulation board. Previous systems have used algorithms involving incremental searching [2][3] of the area or simplification in determining the probability of target localization in a given area on the board [7]. In the present approach, it is assumed that the whole area has the same probability of finding a target. The search is performed with the help of agents who can work both in groups or individually.

Paper is combined as follows: in Section II, the MAS used in simulations has been described, Section III contains the results of experimental studies, short summary is presented in Section IV.

II. System description

MAS is composed of several identical agents described in the first subsection. The second subsection, describes the flow of information from the sensors through the decision-making process, which is based on Artificial Neural Network (ANN), to the agents movements. The third subsection shortly describes assumed behavior of agents.

A. Agent description

Single agent (Fig.1) consists of a carrier (black circle) and four sensors located on the carrier in a way that the sensors could cover the surrounding area. It was assumed that these sensors have a limited range, everything beyond the reach of the sensors is invisible for the agent. Each of the agents have individual map of the terrain. Agents can communicate to improve each other terrain map based on the knowledge of each individual agent in communication range.

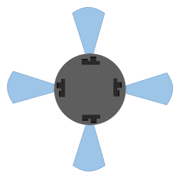

Fig. 1. Single agent with visible sensor range.

B. Information flow and decision making.

Control flow diagram (Fig.2) presents overall data processing in decision-making for single agent, where each element is described bellow:

Sensors Data Gathering - this module is responsible for collecting data from sensors on the robot, as well as knowledge sharing between agents.

Data Estimation - a module for processing received data. In the case of sensors, it is a simple averaging obtained data and detecting obstructions on the map. When communicating with other agents it also provide correction in record map overwriting of unknown areas without overwriting already discovered board.

Group Behavior - a task module determines in which direction agent should move to both keep in touch with the group and to provide collision-free and the most optimal collection of information about the area.

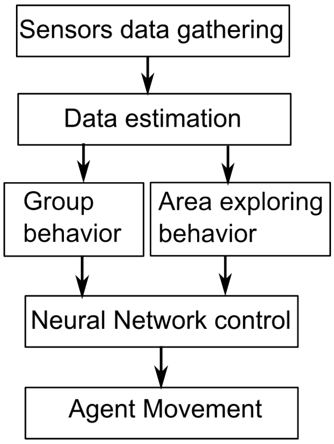

Fig. 2. Structure of agent control with data flow diagram

Exploration Area Behavior - module operates on the principle of distributing the agent map on smaller square areas, it means that unexplored parts of the map are ”attractive” to the agent. If this attraction is sufficiently large it could lead to separating an agent from the group.

Neural Network Control - thanks to information received from the other modules, the final direction of agent movement is determined. NNC is based on feed-forward network which though its simplicity provide results up to the task.

Agent Movement - moving an agent depending on the information obtained from the Neural Network Control module.

C. Assumed possible agents behaviour.

The other tasks of the agents in the system can be described in addition to those already mentioned, which include:

The spreading of the formation - it is the traffic agent optimization based on other agents in the group. Depending on the available space of the formation is reduced or extended.

The escape from the formation of individual agents or groups of agents - depending on the attractiveness and distance unexplored areas may be exposed to escape agents to quickly explore those areas. Re-adjustment back to the group is possible at the next meeting with a group of agents.

III. Simulation results

The simulation was carried out for different numbers of agents and different number of obstructions on the board. Example simulation window with obstacles, agents and target is shown in Fig.3.

Simulation was carried out in Matlab. As examples of the executed simulations results are given sample map built by the agents (Fig.4). Additional results will be presented in full paper.

IV. Conclusion

Presented results of the system allow to assume that the proposed approach has potential in applications in the implementation on real robots. The advantages of the present

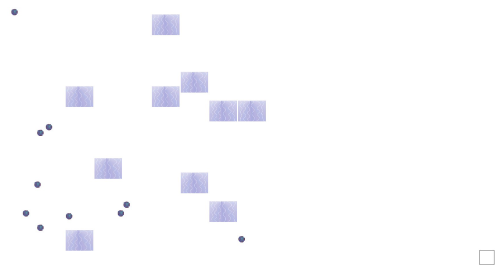

Fig. 3. Simulation window for tests of proposed system, where: dots are agents, blue squares are obstacles and white square is the target.

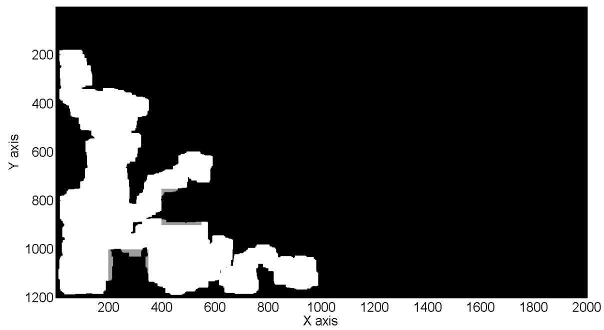

Fig. 4. Example of partially constructed terrain map, where the black area is the area not yet discovered, white area is an discovered area free of terrain obstacles while the gray areas are detected obstacles.

system is undoubtedly the high flexibility of the behavior of agents, a wide range of behavior of individual agents and the whole group which may allow for a better view on biological MAS (for example ants). The disadvantages include some chaos in behavior of the agents and the need for more elaborate communication system. In summary the system is able to complete all the tasks, although there is still room for improvement.

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