GENETIC FUZZY ALGORITHM USED FOR ROBOT NAVIGATION

Tihomir LATINOVIC[1], Milan LATINOVIC[1], Sorin DEACONU[2]

[1] st. Save Ljuboje 2, 78000 Banja Luka, University in Banja Luka, Faculty of Mechanical Engineering, Bosnia and Herzegovina, tiho@inecco.net
[2] st. Revolutiei nr. 5 , Politechnica Faculty, Hunedoara, Romania, sorin.deaconu@fih.upt.ro

ABSTRACT

A mobile Robot is a machine able to extract information from its environment and use knowledge about its world to move safely from point to point. Robot navigation and obstacle avoidance are some of the most important problems in mobile robots, especially in unknown environments. Techniques such as Fuzzy logic, Neural Networks and Genetic Algorithms, have been applied to mobile robots in order to improve their performance. During the past few years the Genetic-fuzzy method has appeared as one of the most active areas for research in the application of intelligent system design. The objective of this work is to provide a Genetic Fuzzy algorithm for robot navigation which will provide an improved set of rules governing the actions and behaviour of a simple navigating and obstacle avoiding mobile robot.

Keywords: Mobile Robot, Fuzzy Logic, Genetic algorithms, Hybrid, Soft Computing.

INTRODUCTION

In this paper we will demonstrate the use of fuzzy behaviour in the field of autonomous mobile robots. We address here how we use learning techniques to efficiently coordinate the conflicts between the different behaviours that compete with each other to take control of the robot. We use fuzzy rules to perform such fusion. These rules can be set using expert knowledge, but as this can be a complex task, we show how to automatically define them using genetic algorithms.

The use of fuzzy logic is rapidly spreading in the area of consumer product design in order to satisfy the following requirements:

- To develop control systems with nonlinear characteristics and decision making systems for controllers,
- To cope with an increasing number of sensors and exploit the larger quantity of information,
- To reduce development time,
- To reduce costs associated with incorporating the technology into the product.

Fuzzy technology can satisfy these requirements for the following reasons.
Usually, fuzzy rule base is designed to fulfill a single control policy or goal. On such a robot we need autonomy. Mobile robots must be capable of achieving multiple goals whose priority may change with time [4]. Therefore algorithms should be designed to realize a number of task-achieving behaviours that can be integrated in order to perform different control objectives. This requires formulation of a large and complex set of fuzzy rules. In this situation a potential limitation of monolithic fuzzy controllers becomes apparent.

Since the size of a complete monolithic rule base increases with the number of input variables [6], multi-input, one layer systems are potentially inappropriate for real time response systems. Hierarchical rule structure can be employed to overcome this limitation by reducing the rate of rule increase to linear.

HYBRID GENETIC-FUZZY APPROACH IN RESEARCH

The integration of different methods, adequate for their specific domain of problems, results in more powerful hybrid systems with higher machine intelligence, than using a single method exclusively. In particular, a great number of publications explore the use of GAs for designing fuzzy.

Fuzzy behaviours are synthesized as fuzzy rule/base, i.e. a collection of a finite set of fuzzy if/then rules. Every behavior is implemented into one Fuzzy Logic Control Block (FLCB) (Fig. 1) that has an independent rule base, designed for a particular input and output.

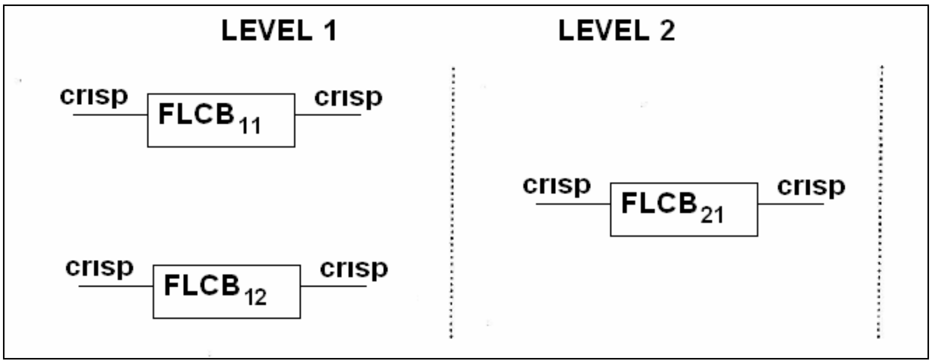

Fig. 1 Fuzzy Logic Block.

The proposal is a bottom/up hierarchy of increasing behavioral complexity. Activity at a given level is dependent upon behaviors at the preceding levels.
The first level processes sensor information. This is the most “primitive” level, which aims at detecting input and making reactive (non/intelligent) decisions. However it determines the perceptive base of the robot - more different types of sensors means better evaluation of the surrounding world.
The second level unites the results from the previous level in order to achieve more intelligent tasks. At every level we have crisp input and output from FLCB so we don`t have real propagation of fuzzy truth values.
Separate results from separate inference processes are united by a new inference process.
The advantages of this architecture are:

- The hierarchy facilitates decomposition of complex problems.
- Increased run-time efficiency by avoiding the need to evaluate rules from behaviours that are not active
- Flexibility: Every FLCB can be regarded as an independent and replaceable unit

SYNTHESIS OF THE ALGORITHM

- The easiest way to describe the synthesis of the algorithm is to use an object like Rug Warrior [4] and to build the model of the robot. We need a small robot with IR sensors, Microphone, Bumpers and Photo cell. The choice of sensors depends on the concrete tasks we want to be achieved by the robot.
- The next step is the description of primitive behaviours. This includes the whole procedure from the FLCB description. We need two level behaviours to control for executing parts (motors, actuators, and so on). An example of hierarchy is presented in Fig. 2.

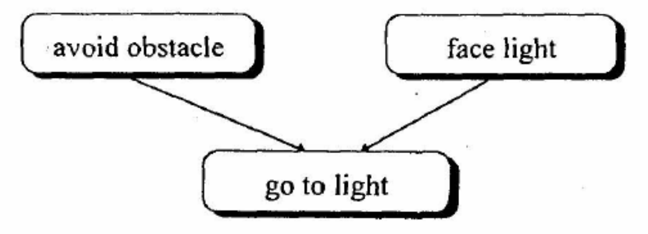

Fig. 2 Example of hierarchy.

The first level includes two behaviours - avoid the obstacle and face the light, consequently two independent FLCBs. The behavior of avoiding the obstacle is based on five IR sensors. For obstacle positioning, the difference between two consecutive sensor readings is used. Results could be converted into linguistic variables on one and the same universe of discourse, since all represent information of one and the same type and range. A full description of the FLCB [5] responsible for that behavior includes:

- Definition of the parameters of the FLCB: type of fuzzy inference process, types of fuzzification and defuzzification procedures;
- Definition of input and output process variables, and conversion into appropriate universe of discourse;
- Membership function (MF) determination. That means choice of shape, number of sets, global range and range of every single MF;
- Rule base definition

In the same way, we describe face light behavior and second level one go to light. We are able to extend the algorithm by including new types of sensors and organizing information into simple and complex behaviors. Communication between behaviors is important as they should be able to suppress, inhibit or modify other behaviors. Communication exits only between one and the same levels (behaviors). Fig. 3
It should be mentioned that decomposition into behaviors for a given mobile robot system is not unique. It is the subject of analysis of the system and task environment.

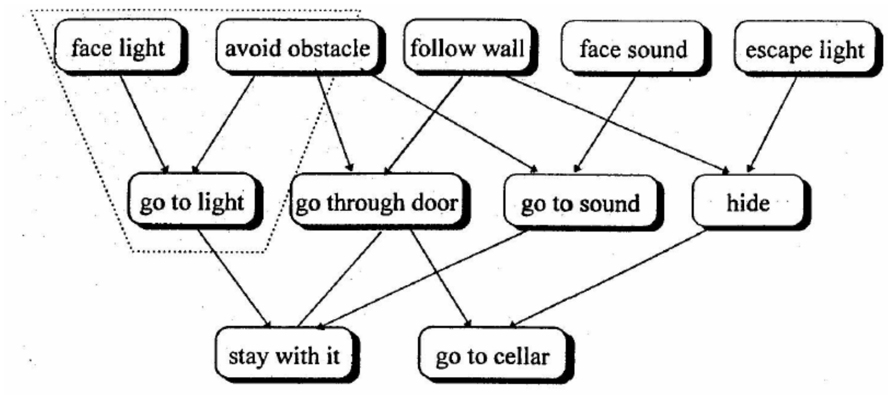

Fig. 3 Example of high hierarchy.

NAVIGATION EXAMPLE

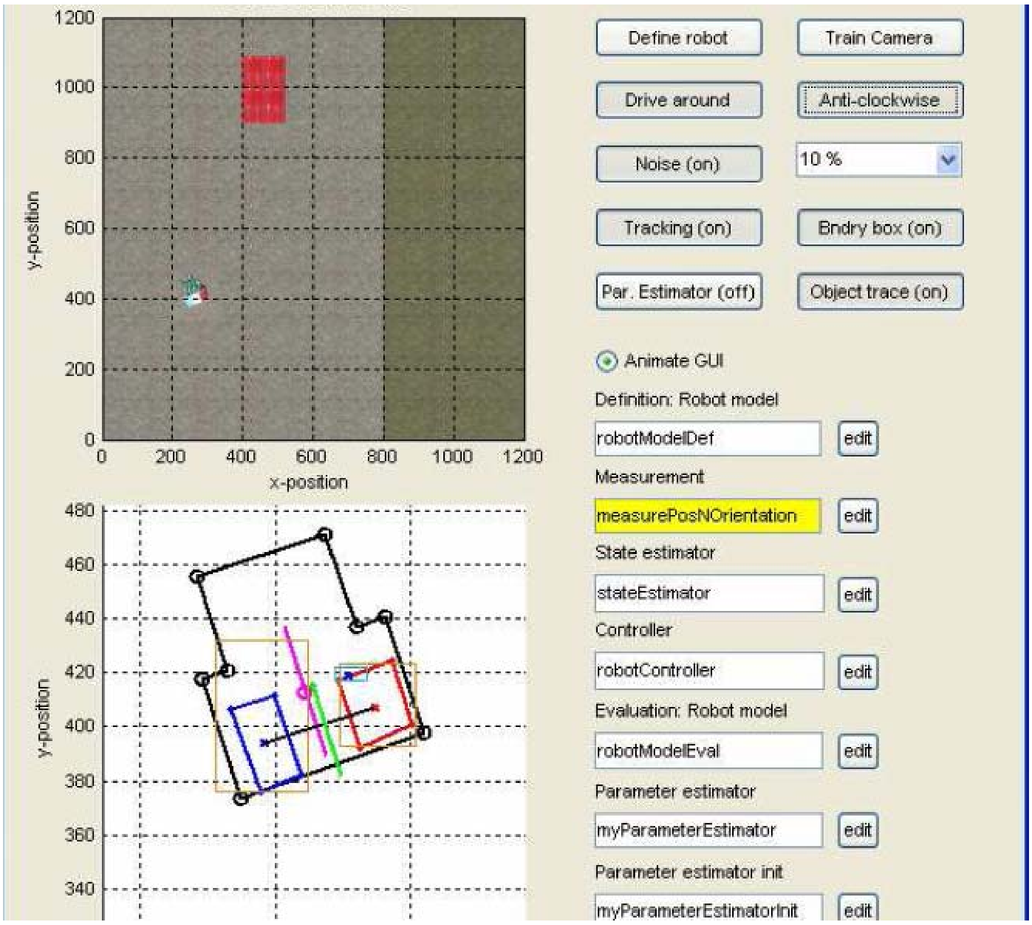

Fig. 4 Simulation of movement of mobile robots in the Matlab environment.

Verification of the described algorithm is done with Robosim – a Matlab program for simulation of the movement of mobile robots in an artificial environment (Fig. 4). It uses the Ray Tracing method for obstacle and target position determination. Fuzzy calculations are done with the MatLAb fuzzy Toolbox.
The simulated world is a hypothetical indoor environment. We can se the initial coordinates of the robot and the target (in this case it is a source of light).
"Avoid obstacle" merely displays cyclic collision-free movement in the immediate vicinity of the robot's initial location. "Face light" on the other hand, forces the robot to rotate in such a fashion that the strongest light source must always be in front.

CONCLUSIONS

The most extended GFS type is the genetic fuzzy rule based system, where a GA is employed to learn or tune different components of an FRBS. Following the guideline of soft computing GAs has been widely used for the automatic design of FLCBs. The basic idea is to learn the rules of a knowledge-based system by artificial evolution. GA has been used diversely for FLCB design either off-line or on-line, although in the latter case computation time is sometimes prohibitive.

The hierarchy of fuzzy behaviours provides an efficient approach to controlling mobile robots: the decomposition of overall behavior into sub-behaviors which are active only if set by a concrete task. To date, simulations are used to predict the performance of real robots and a hardware system is under construction.
The main drawback of Evolutionary techniques is their slow convergence rate and the considerable amount of time that has to be spent to conduct the evolutionary process on a real robot. Therefore, Evolutionary Algorithms have to be fast enough to get the real advantage of evolutionary robotics. Moreover, the issues related to interaction of learning with evolution have to be dealt with more carefully.
The choice of the controller- encoding scheme can have a large impact on the success or failure of the Evolutionary Robotics process. The simulation we used is just a simplified instrument in combination with the application of Genetic Algorithms and Fuzzy logic to achieve the research objective.

REFERENCES

[1] Borenstein J. and Koren Y., Real-time Obstacle Avoidance for Fast Mobile Robots, IEEE Transactions on Systems, Man, and Cybernetics, 19(5): 1179-1187, 1989.

[2] Christopher Lazarus, Huosheng Hu, Using Genetic Programming to Evolve Robot Behaviours, proceedings of the 3rd British Conference on Autonomous Mobile Robotics &Autonomous Systems, Manchester, 2001.

[3] Frank Hoffmann, Soft Computing techniques for the design of Mobile Robot behaviours, Berkeley nstitute in Soft computing (BISC), Information Sciences, Elsevier Science Inc., 1994.

[4] Golberg D.E., Genetic Algorithms in search, optimization, and machine learning, Addison-Wesley. 1989.

[5] Pratihar D. K., Evolutionary robotics – A review, Sadhana, 28(6): 999–1009, 2003.

[6] Roland Siegwart and Illah R. Nourbakhsh, Introduction to Autonomous Mobile Robots, the

MIT Press Edition, 2004.

[7] Saffiotti A., The use of fuzzy logic for autonomous robot Navigation, Soft Computing, 1(4): 180 – 197, 1997.

[8] Sakawa, M., Mori, T., An efficient genetic algorithm for job-shop scheduling problems with fuzzy processing time and fuzzy duedate, Computers & Industrial Engineering, 36(2):.325-41, 1999.

[9] Yun, Y., Genetic algorithm with fuzzy logic controller for preemptive and non-preemptive job-shop scheduling problems, Computers & Industrial Engineering, 43(3): 623-44, 2002.