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A Multiple Level MIMO FL Based Intelligence For Multi Agent Robot System

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ABSTRACT

Fuzzy Logic is a many valued logic. It is quite similar to human reasoning, using approximate measures rather than exact. This makes it suitable for linguistic variable analysis. It can be applied to many applications in AI, control and robotics. In this application we discuss the development of an AI system using FL for a dynamic multiple agent robot system. The system has two gaming teams with four robots each with multiple identity assignment. Each robot will have its distinct behavior. To design pure FL based AI, we use fuzzy logic blocks in parallel and series combinations. Further, there is multiple input - multiple output (MIMO) implementation in fuzzy logic blocks. This is necessary to utilize pure fuzzy logic control in AI. The concept was taken from FIRA Micro-Robot World Soccer Tournament (MiroSot). In our setup, there are four robots in each team to be assigned with three different identities; the Forward, two Back and the Goalie. Identity assignment depends on the position of each robot in the play area. Isolation is done to tune each fuzzy logic block individually. Some tuning is performed in a simulator while most in the actual platform. The linguistic approach of FL along with human reasoning nature made it possible to achieve the purpose. Overall, the proposed AI produced expected response experimentally.

Keywords: Fuzzy Logic, Artificial Agents, Robots, Game

1. INTRODUCTION

Fuzzy Logic is a continuous valued logic very similar to human reasoning. Human reasoning is continuous, not true and false kind. It uses approximate measures not exact. This makes FL suitable for linguistic variable based analysis. It has been applied to numerous applications in AI, control and robotics.

Here, I talk about the extension of an AI problem in the domain of a dynamic robot platform having multiple robots and identity assignments. This means that each robot has a distinct behavior. FL was applied multiple times calling each stage as a FL block. These blocks are organized in different parallel and series configuration thus making it multilevel in structure. Further, there is MIMO FL implementation in several blocks, to utilize pure FL control in the whole AI.

A multi agent cooperative robot platform was designed for testing AI in a multi robot system for MiroSot. The system involved complex intelligence as individual agents perform specific tasks dynamically, unlike systems duplicating a single task for all agents. Three robots were used in each team and three different identities were assigned to them; the Forward, Back and Goalie. In this extension work the team has been created with four robots. The identity assignment of each robot is dynamic and depends on the position in the play area. Each FL block is tuned individually. Some tuning is done in a simulator while most in real time in the actual platform.

1.1 Motivation

Several studies and researches are being done to provide efficient and effective algorithms for various applications. A soccer robot competition is one application. Robot path planning based on Petri-Net providing descriptions of actions and relationships of action has been introduced in [5]; but it did not include a formal description of robot states and environment. Shifting of roles can be also based on Petri-Net mathematical model suitable for simulating distributed systems. Again, methods have several shortcomings. It is difficult to obtain an exact mathematical model for a real time and unpredictable environment a game. Thus, a fuzzy logic-based system for robot navigation and task performance can be applied in soccer robot competitions.

1.2 Objective

The main task is to apply FL based AI in a gaming problem i.e. in the domain of a dynamic robot platform using multiple robots as players. Multiple identity assignment is required as each robot should have its distinct behavior. FL is applied multiple times, calling each of stage as them as a block. These blocks are in different parallel and series configuration making a multilevel structure. Furthermore, MIMO fuzzy logic implementation is applied in one of the several fuzzy logic blocks.

2. LITERATURE SURVEY

MIMO Fuzzy Logic Based AI was applied for Cooperative Robot System [1] creating a virtual game having three robot players on each side. Each robot determines its behavior using FL based reasoning. The concept of Fuzzy Logic (FL) was proposed by Lotfi Zadeh in 1965 [2] for processing data allowing partial set membership rather than crisp membership and non-membership. FL assumes that people do not use precise, numerical information input and are capable of adaptive control. Controllers which could accept noisy, imprecise input would be more effective and cheaper implementation-wise.
Robot soccer game [3] has very dynamic and uncertain characteristics. There exist competitions between robots. The soccer-player robot has to take an action according to its role of striker or sweeper. The self-control mechanism uses action selection schemes according to the field situation. A multilayer perceptron (MLP) is used to implement human like behavior given a situation. The first Micro Robot World Cup Soccer Tournament (MIROSOT) [4] was held in Korea. Three robots per team play soccer. The field was 130 cm x 150 cm.
A novel representation frame-work called PetriNet Plans (PNP) was described for high level robot and multi-robot programming [5]. PNPs have been used for effective plans for robotic agents in dynamic environments. A design of the computer vision system and robot/ball detection is described for MiroSot [6]
The designing and implementing behavior based FL controller is done in [7] for a one-on-one robot soccer system. It can be dealt as a visual serving system. Robot soccer requires fast, accurate and reliable vision for a team performance. Field conditions for robot soccer may vary from field to field, and day to day. A system that can adapt to varying conditions while maintaining speed and accuracy is described in [8].

3. FUZZY LOGIC FOR SOCCER ROBOT SYSTEM PLATFORM

3.1 Basic Component of a Cooperative Robot System Platform

Soccer Robot System (SRS) is a developing multi-agent intelligent control system. It involves multiple robots, computer vision, wireless communications, and control intelligence from a PC [4]. It requires AI method to control independent agents who are cooperating with each other while operating in a dynamic environment. The soccer robot has a size of 7.5 cm x 7.5 cm x 7.5 cm. Their team will be classified by the color patches on top of them.

3.2 Soccer Robot System

A Soccer System has two opposing teams with three robots guided by a machine vision system. The vision system has to identify the position and orientation of the team's robots, ball and goal pit [6]. These are used in the decision making process to determine the robots' behavior for a certain game plan. There is a decision subsystem to analyze field situations and determine the formations, role assignments and motion.

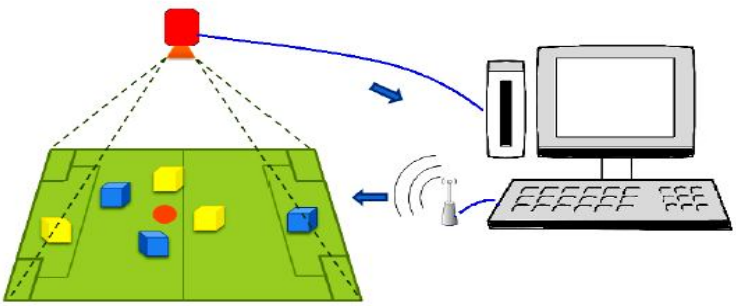

Figure 1 Soccer Robot System Setup

3.3 Fuzzy Logic as Dynamic Robot System Intelligence

Many studies have presented FL based system that can be applied for robot navigation and task performance in soccer robot competitions. The soccer robots can move according to four behaviors, *viz*, tracking, shooting, obstacle avoidance, and defending. The fuzzy logic control provided favorable results.

4. FUZZY LOGIC-BASED INTELLIGENCE

Fuzzy Logic computes results through approximate reasoning rather than exact or fixed. The algorithm thinks like human reasoning to make decisions. It explores the partial truth, where truth values range between completely true and false. The algorithm is applied in control systems and also in many other applications. Its simplicity and flexibility contributes to faster control systems needed in applications such as soccer game play strategies.

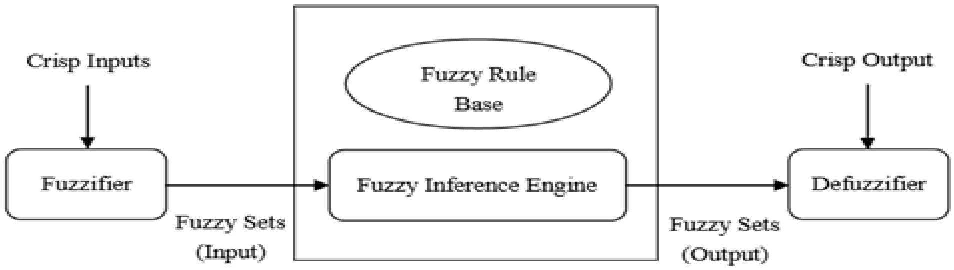

Figure 2 *Block* Diagram of Fuzzy Logic Process

The process can be described more effectively by referring to figure 2. First, the system needs to know what to control, and next how to control those identified parameters. The input has to be related to the output parameter. In this topic, the *output* parameters are the left and right wheel velocities, and they are related to *input* parameters like the coordinates of the robot, the robot position, and the ball position.

5.METHODOLOGY

5.1 Game Play Strategy Design and Implementation

The implementation is done using multiple levels FL architecture. Two levels are used to calculate the robots' behavior; first the desired target location where the robot should go and the second is to determine the left and right motor speed to reach the target. The three robots will be assigned different roles; the robot nearest to the ball is "Forward", nearest to the home goal is "Goalie" and the third and fourth are "Back". The role is dynamic. Each robot's behavior is calculated by first level of FL, based on role, position and ball position. The three first level strategies are called Forward Strategy, Back Strategy or Goalie Strategy. Forward strategy is decided upon by the relative positions of ball, Forward robot and target goal. Goalie strategy depends on position of ball in reference to the home goal. The Back Strategy is pre-emptive defensive to blocks the direct path of the ball through play area to home goal.

5.1.1 Positions in the Soccer Field

To implement FL to behavior, the important positions must be identified. Positions in the field are categorized into: shoot, deflect and boundary points. Figure 3 shows these points in different colors; red for shoot, yellow for deflect and blue for boundary points, for the team which shoots on right hand goalpost.

Figure 3. Positions the Soccer Field

Red: Shoot Points, Yellow: Deflect Points Blue: Boundary Points

The names of the points in figure explain the behavior of the Forward player, Viz. when the ball is at shoot point, the Forward robot will try to shoot the ball.

5.1.2 Fuzzy Sets and Fuzzy Associative Matrix: Forward Strategy

The input for the Forward strategy contains four variables, assigned as ballX, ballY, robotX and robotY. BallX and ballY, which are the x and y coordinates of the ball and robot positions. The membership functions are as depicted in

Figures 4 and 5. The fuzzy associative matrix consists of 900 elements containing the lookup values for each fuzzy set intersection output.

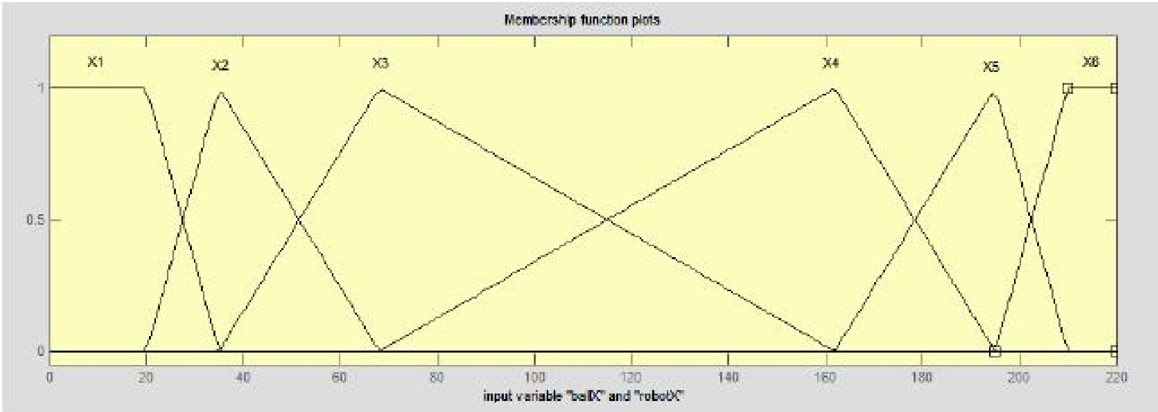

Figure 4. Membership Function for x coordinate.

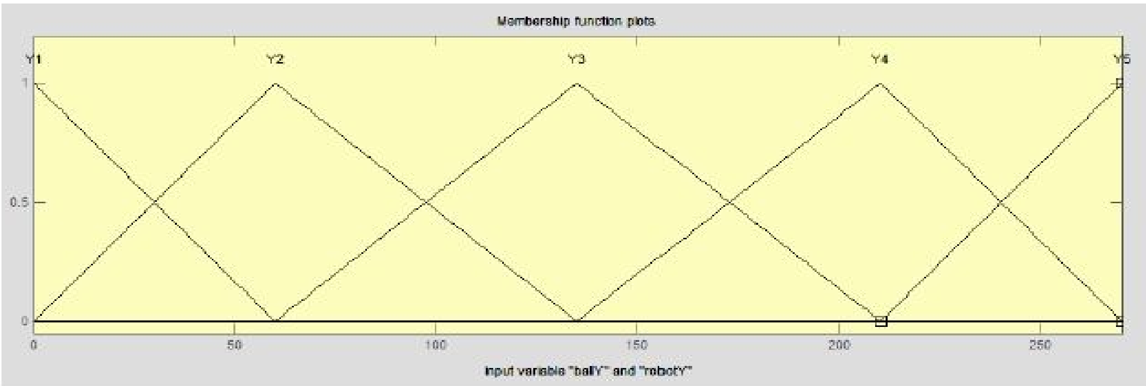

Figure 5. Membership Function for y coordinate.

The GoToPoint () fuzzy function utilizes FL for the robot to navigate to a desired point. It uses input parameters as the distance of the robot from the desired point the angle with respect to the robot's x-axis, as in Figure 6.

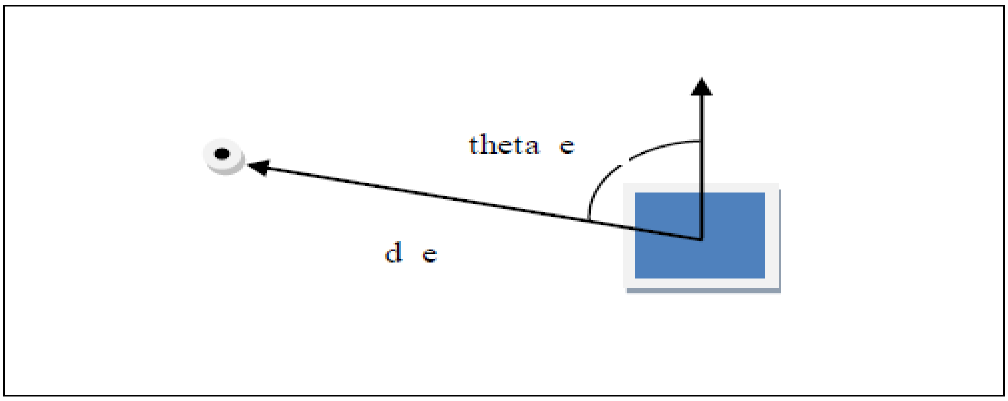

Figure. 6. Error Distance And Error Angle.

In the Fuzzy ruleset, the output parameters are left and right wheel velocities (VL and VR) to navigate the robot.

5.1.3 Fuzzy Sets and Fuzzy Associative Matrix: Back Strategy

The input variables for the Back strategy are the x and y coordinates of the ball's position in the field. The output variables are the x and y coordinate of the desired position for the Back. The Back's intelligence is mostly defensive, so that its target position is always for trying to cover the path of the ball towards the home goal. The Back never tries to pursue the ball and never leaves defensive position. The coordinates of the ball are ball_X and ball_Y. The ranges of ball_X and ball_Y are decided by the play area and the fuzzy sets are shown in figures 7 and 8.

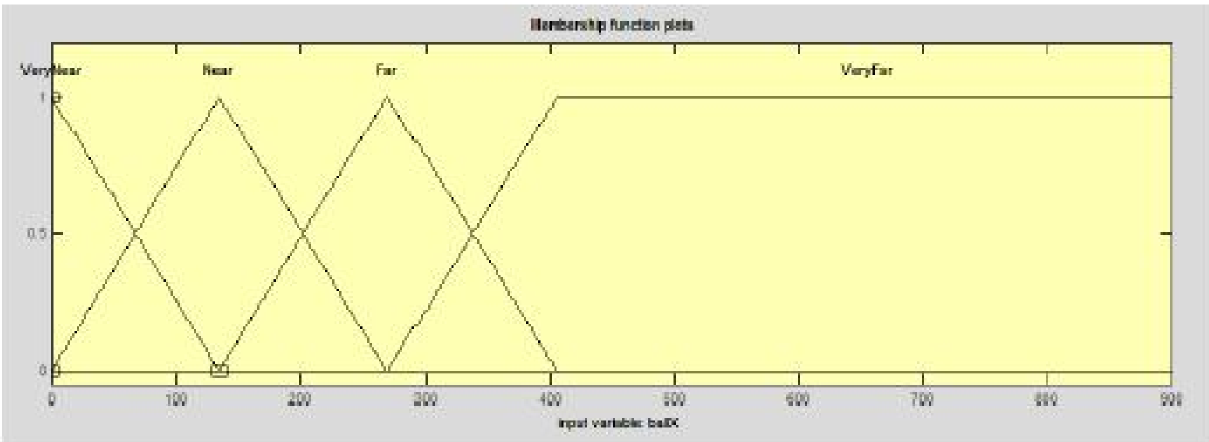

Figure. 7. Membership Function for Ball_X

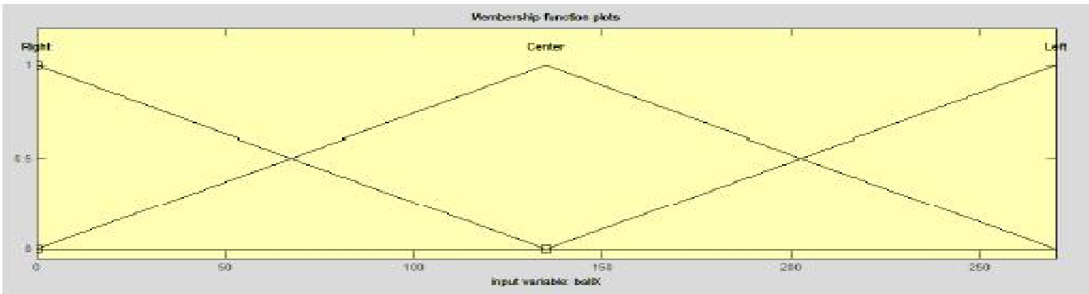

Figure. 8. Membership Function For Ball_Y

5.1.4 Fuzzy Sets and Fuzzy Ruleset: Goalie Strategy

The Goalie is the defender for protecting the goal. Figure 9 describes the goalie's decision process. The soccer robot assigned with a role of a Goalie will always be within the home goal area. The system commands the robot to move toward the home goal area if the robot is far from it.

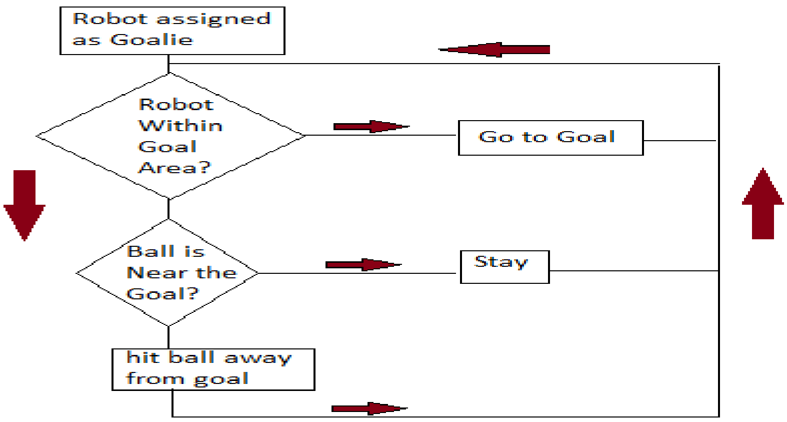

Figure. 9. Flow Diagram for Goalie Decision

Once the goalie robot is within 15 units distance to the goal center, the system will check if the ball is nearing the Goal area. If so, robot is commanded to hit the ball away. If not, then the robot will stay at the goal area center and will prepare for blocking. Commanding it to hit the ball implies assigning wheel velocities to the robot to move to a specified point, which could be the ball's position, implying that the robot will hit the ball. To prevent a goal, the Goalie stay at the standby position and prepare to hit the ball as it approaches the goal. If the ball is far from the goal, the Goalie stays at standby position around the center of the goal area.

6. CONCLUSION

The multi-level FL strategy was tested using the MATLAB fuzzy toolbox using 4x4 Robot System. It was an extension work carried out to extend the MiroSot [6] competition soccer game. Tuning multiple FL subsystems were done offline and again in real time. Rules were not tuned in 100% precision because FL does not aim at uneconomical precision. The system compensates errors through an overall correcting mechanism. The testing was done via predetermined positions. In each test run the simulated robot responded in an expected fashion. Sometimes the forward were able to shoot a goal successfully. The whole strategy implementation was simulated. The developed multi-level system displayed good defense, specifically the Back and Goalie robot strategies. The Forward strategy showed aggressiveness. The multi-level FL based AI cooperative robot system serves as a standalone game strategy. It uses several FL based control codes in parallel and series configuration. The system involves complex intelligence as individual agents perform specific tasks according to roles assigned dynamically, while other systems duplicate a single task for all the agents. The linguistic nature of FL enables developing a rule-set to govern the robots. FL linguistic rules also control the role assignment.

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