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The use of Fuzzy expert system in robots decision-making

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Abstract. The main issue that is investigated in this paper, is a method for decision making of mobile robots in different conditions for this purpose, we have used expert system. In this way, that the conditions of the robot are analyzed by on expert person a special issue (like following a ball) using knowledge base and suitable decisions will be mode. Then, using this information fuzzy rules well be built, and using its rules, robots decisions can be implemented like an expert person. In this study, we have used delta3d base for implementing expert systems and CLIPS and also we have used NAO for simulation rcssserver3d robot and 3d football simulation have been used for implementing operation program.

1. Introduction

Humanoid soccer robot is widely used to extend the robotic science. Because of football's being dynamic, the main attention of the robot could be on football game [1, 2].Because of football's being dynamic the main focus of the robot would be on this game. Humanoid soccer robots have been entered to the robot research to extend the robotic and artificial intelligence research.

3d soccer simulation includes one simulator server , that simulates environmental and physical realities, and two teams that every team represent one executive program that is executed according to the number of the players(robots).this executive program should analyze the received message from the server including environmental information and the information of the robot itself, and regarding these data , it should make the necessary decisions and send them to the server in the command format [3].in this plan ,receiving sending , analyzing , updating the information , mathematic calculation and implementing robot's capabilities are the responsibilities of the program written in C++ language.

CLIPS tool is a tool of expert system that works using inference engine of leading chain. CLIPS is designed for communicating with other languages like C++ and java [4, 5].

In this paper, we want to implement decision-making of robot in special cases using expert systems. A state that is considered for decision making is the case of tracking the ball (intercept).

The robot should decide what to do in every two hundredths of the second.in order to reach the ball in the best condition and the highest speed.

A good state in this case is that the robot locate in the direction of the ball and the goal of opponent.

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2. Procedure

For this purpose, we need fuzzy rules, because we should make the conditions like human football players system, because we need to support inaccurate data [7].

Characteristics considered in this work include four criteria of distance and angle of agent with the ball and also angle and distance of the agent with the rival gate. But we can consider other properties like distance and angle of agent with other agents, that because of high complexity, it hasn't been regarded in this paper.

2.1. priorities of system rules

For priorities of angle kind, nine fuzzy sets and for priorities of distance kind, we have defined four fuzzy sets.

Our priorities include the following:

X1= Distance to ball
X2= Distance to opponent goal
X3= Angle From ball
X4 = Angle from opponent goal

$$\text{gaussian}(x;\text{c},\sigma)=\exp\left(\frac{-1}{2}\left(\frac{x-c}{\sigma}\right)\right) \quad (1)$$

Where c is the center of membership function and σ is the width of membership function.

$$\text{bell}(x;\text{a},\text{b},\text{c})=\frac{1}{1+\left|\frac{x-c}{a}\right|^{2b}} \quad (2)$$

In the second formula, b is considered a positive number. In variables of distance kind, we have considered the following fuzzy sets regarding (1) and (2) formula [6].

1-Very near distance (V Near): V Near = Gaussian (0, 0.4247)
2-Near distance (Near): Near = Gaussian (1, 0.4247)
3-Medium distance (M): M= Gaussian (2, 0.4247)
4-Far distance (Far): Far= Gaussian bell (53.88, 107.8, 57.13)

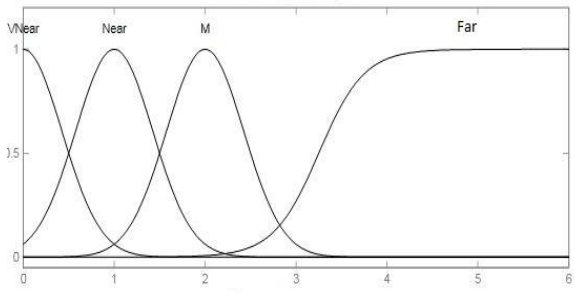

Figure 1. Membership function of define fuzzy sets on the inputs of distance kind

And in variables that are of angle kind (angel can be between -180 to +180) we have considered the following fuzzy sets:

1-Back right direct direction (BR): BR = Gaussian (-180, 9.555)
2-A little leaning to back and right (LBR): LBR = Gaussian (-157.5, 9.555)
3-Right direction (HR): HR = Gaussian (-90, 28.66)
4-Slightly leaning to right and forward direction (LFR): LFR = Gaussian (-22.5, 9.555)
5-Forward direction (DF): DF = Gaussian (0, 9.555)
6-Slightly leaning to left and forward (LFL): LFL = Gaussian (22.5, 9.555)
7-Left direction (HL): HL = Gaussian (90, 28.66)
8-Slightly leaning to the left and back (LBL): LBL = Gaussian (157.5, 9.555)
9- Left back direction (BL): BL = Gaussian (180, 9.555)

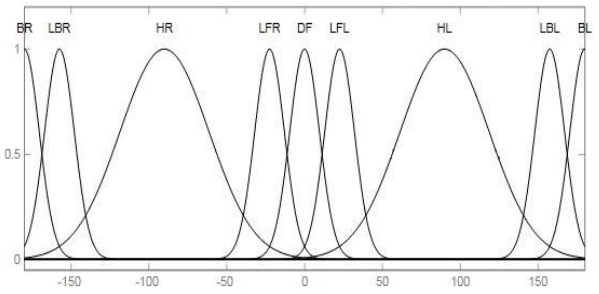

Figure 1. Membership function of defined fuzzy sets on inputs of angle kind.

2.2. Consequents of system rules

In Delta3D base Code, some of the basic operation of robot has been implemented. In this article, we have consequents in rules used for robots' decision-making.

Walking straight forward
Walking straight backward
Rotating to the right
Rotating to the Left
Walking in the direction of the ball
Step to the right
Step to the left

2.3. Creating system rules

Regarding that we can merge Br Fuzzy sets that are used in X3 and X4, finally we can implement the system by maximum 1024 rules. On the one hand, all the inputs are not required in many of the rules, We have rules with length of 2, 3 and 4, and by this assumption , the number of our rules are very low[8].for the example when the angle of ball and opponent goal with agent is very low, it's not needed to consider distances. In many cases ,rules can be combined, for example, when the distance with the ball opponent goal is low for small angle and very small angle of the agent with the ball or opponent goal, the same orations a similar be done.

Finally, we have covered all the cases with 58 rules. We can reduce the complexity of rules and system design, using the mentioned mechanisms, so the rules well be more clear and transparent. Finally using such an approach will result in easier development of the system. For establishing the rules, we should also pay attention to the conditions of the agent in the fields. Agent conditions are divided into two parts, general conditions and special conditions. General conditions refer to the conditions that in the most pant of the play happen for one football player agent, like when the ball is in a small angle from the agent and the opponent goal is also in front of the agent. These conditions usually happen in a far distance from the ball.

But special conditions are conditions in which the football player agent less possibly face them during one play, for example conditions in which the ball is beside the agent and the agent is close to the opponent goal.

General conditions constitute a small number of our rules and we have many rules for special conditions.

After building a knowledge base of the rules in WXCLIPS and regarding that WXCLIPS is fully compatible with C++ language, Expert systems can be implemented in operating program, and expert system can be used in robots decision-making

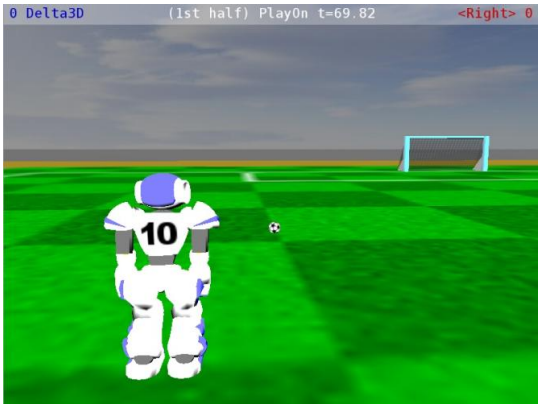

Figure 3. A general Condition

Figure 4. a special Condition

2.4. System evaluation

In order to evaluate the presented method, we will compare the recommendations of the expert system to the robot with the recommendations of expert persons.

Expert persons include two persons that are in expert simulator competition (members of Delta3d team), one person from the base football players of the country and two person from semiprofessional players and a normal person.

For this purpose, we place the football player agent and the ball separately and randomly in a spot of the simulated field, then expert system and the mentioned persons should suggest a combination of suitable actions to reach to the ball by considering the angle of agent with the opponent goal. After suggestion every action, the agent do the defined action, till the agent reach the ball and actions' continuation end.

The mentioned expert persons send the continuation of the action using a controller that is designed to control the robot, that by using it, they guide the football player agent to the desired point. In fact the Expert person can announce every one of the 7 possible actions to the robot. Every repetition is in the way that we announce random coordinate of the agent and the ball to the expert persons in order to give the value of primary coordinate of the agent and the ball and the expert and whenever regarding a good angle with the opponent goal. The ball is in the good situation, the expert person end the controller. It's note Worthy that the interval of the agent arriving to the ball by pressing stop button is very short and doesn't affect the evaluation of suggested continuation by the expert person.

For example you can see the way in which the expert person guide the robot in figures 5, 6 and 7.

Figure 5. Detection of the backward movement by expert person

Figure 6. Detection of right rotation by expert person

Figure 7. Detection of forward movement by expert person

The evaluation criteria that we considered are the average of the time of reaching the ball and the average of final direction of the robot in 100 times. Direction is defined as follows: ((difference of the agent angle with the agent to the opponent goal)). The final evaluation criteria include the time to reach the ball and the required time for reaching to zero direction that is calculated from formula (3):

$$\mathrm{Time}_{\mathrm{total}} = \mathrm{time}_{\mathrm{dis}} + \frac{\mathrm{angle}}{20} \tag{3}$$

In formula 3, time dis is the average of the time of reaching to the ball, angle is the value of direction and time total is the final evaluation value, that lower the final evaluation value is, the robot is quicker in this issue. The results are shown in table 1.

Table 1. The results of comparison between expert persons, previous system and expert system.

Evaluator	Time dis (s)	Angle	Time total
Expert system	85.5 (±19.8)	23(±12)	48.95
Expert person 1	42.1(±24.3)	34(±13)	44.80
Expert person 2	44.0(±25.2)	38(±10)	46.90
Football player 1	51.3(±18.7)	36(±14)	54.10

Football player 2	52.2(±22.5)	39(±13)	55.15
Football player 3	54.5(±23.0)	40(±12)	57.50
Normal person	59.4(±19.8)	31(±18)	61.95
Delta3d 2010	91.4(±31.8)	9(±3)	91.85

Regarding table 1, we conclude that although a small number of expert system in comparison whit the previous system ha was implemented in delta3d 2010.

3. Conclusion

In this article, a method was presented for decision making of the football player robots in a simulated environment.

The proposed system used Fuzzy expert systems for deciding the best action for following the ball and to a large extent act like an expert person. This method has improved the speed of the robot about 87.64% in the case following the ball in comparison whit the previous model that was presented in delta 3d 2010.

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