NEXUS 2007 – 3D SOCCER SIMULATION TEAM DESCRIPTION

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Abstract— Soccer simulation as an effort for motivating researchers in field of artificial intelligence and robotic research has always been a progressive approach. Robotic soccer is a particularly good domain for studying multi-agent systems and behaviors. In this paper, we describe researches done by Nexus team from the prior 3D simulation environment till current humanoid simulation version. Some very basic humanoid actions are also explained.

Keywords— Soccer simulation, multi-agent systems, fuzzy logic, action selection, humanoid robot, ZMP

1 Introduction

Robotic soccer is a particularly good domain for studying multi-agent systems. It has been gaining popularity in recent years with international competitions like RoboCup which is planned for the near future [1]. Soccer simulation environment is a client-server platform which provides an excellent testbed to develop multi-agent systems. With this testbed, researchers need not get involved with the complexities of physical robot developmets. In RoboCup simulation league, many teams of 11 autonomous software agents compete against each other by using RoboCup soccer server simulator software which is available from the official simulator website [2].

Nexus[1] is the RoboCup Soccer Simulation of Ferdowsi University of Mashhad, Iran. Established in 2002, the team firstly participated in RoboCup contest in 2003 Padova, Italy in Soccer-2D league. Afterwards, NEXUS could go as high as the third round in RoboCup 2005 Osaka, Japan, and ranked 9th-12 th place among 33 teams. In this paper, we briefly proposed our research works done in the RoboCup simulation filed. Actually since humanoid simulation league is very new members just confined themeselves with simple exprimentral approaches in contrast with prior scientific approaches.

2 Applied Techniques to 3D Soccer Agents

Because of the simplified model of 2D simulation league, a three-dimensional physical simulation was created. The three-dimensional physical simulator used in Soccer Simulation League addresses additional classes of problems as well as global team behavior, decision making procedures and etc.

Based on the 2005 3D version work [3], Nexus team proposed a new scoring module [4] to select the best point on the goal line to shoot, considering player's position, catching and shooting time difference, and distance to target. To find the best point on the goal line to shoot, it is necessary to evaluate all points and obtain the one with the maximum calculated priority. Consequently, we designed an algorithm which firstly eliminates the points at which ball can not reach its target due to opponent interception.

As a rule of thumb, the shoot evaluation module deals with physical aspects of the ball controller agent, opponents, goalie, and the ball. Our aim is to find the best point on the goal line based on whose information if the ball is kicked, it will pass the goalkeeper ending inside the goal.

One of the parameters we need for the evaluation module is the temporal difference between ball and the goalie movement to reach the target. In other words, we calculate if the goalie reaches the target point sooner than the ball. This parameter would be then fed into the next fuzzy phase to estimate the catch probability. To do so, we subtract the time the agent takes to shoot considering rotation, from the time the goalie takes to reach the point and catch the ball. This subtraction trivially shows whether the ball will pass the goalie or will be intercepted. Let T_b be the time the ball takes to meet the target with the maximum speed, and T_r be the rotation time for the ball controller to adjust it's position beside the ball. T_g represents the time the goalie takes to catch the ball (Figure 1). Having calculated the above three parameters we define Δt as: $\Delta t = T_g - (T_b + T_r)$

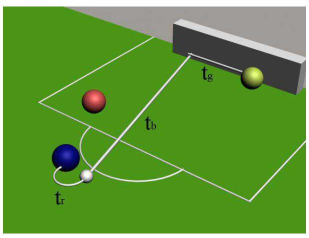

Figure 1. Temporal measurements

If $\Delta t > 0$, the ball would definitely pass the goalie and if $\Delta t < 0$, the ball would be intercepted. The greater the Δt, the higher probability of scoring

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[1] http://nexus.um.ac.ir/

goals. All these calculations were done assuming that there are no other agents except the goalkeeper in front of the ball controller to deviate the ball's direction.

In order to approximate the physical features of the environment, 100 of offline training test cases in which an agent shoots the ball from certain point toward the goal were done and results were saved on a log file. Having saved the above data, we try to formulate T_b, T_g, and T_r by means of interpolation. The Gaussian function $T_b(d)$ calculates the time takes the ball to pass distance d. Candidate shooting targets is a set of 25 points distributed along the goal line with 30cm interval. Figure 2 shows temporal difference measurement (Δt) through the goal line.

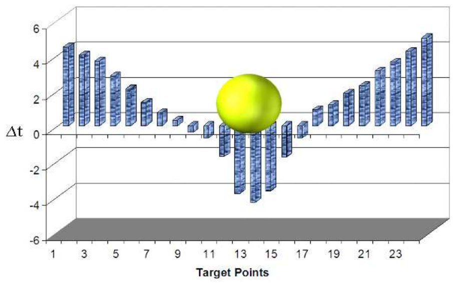

Figure 2. Temporal Difference Measurement (Δt) Through the Goal Line

In [4], we proposed a fuzzy approach to select the best shoot decision. It has shown that fuzzy systems provide a simple, efficient, and fast way of decision-making in comparison with the cumbersome and tedious process of applying many different rules for achieving the same results. We expected the fuzzy system to be appropriate for shoot evaluation process in the soccer simulation environment, considering the noise produced by the soccer server and uncertainties which affect all the perceptions and actions of the agents. Our fuzzy rule base includes 15 rules.

Table 1. The result of 100 shoots

Number of Shoots	Simple Shoot Evaluation	Fuzzy Shoot Evaluation
10	6	7
20	11	13
30	13	18
40	19	23
50	22	28
Average Precision	42%	51%

To measure the shoot performance, *precision* measure was used as the ratio of the number of goal retrieved to the number of shoots through the goal expressed as a percentage. As Tab.4 shows, the results of 50 shoots comparing fuzzy approach and the non-fuzzy one, confirm the proposed method's superiority.

3 Applied Techniques to 3D Humanoid Agents

The current development of 3D Soccer Simulation League leads towards humanoid robots known as *soccerbot* agent, which already can be controlled by a lower level interface. However, controllers for these robots have to be developed in order to provide an easy-to-use interface. The rules has been maturated in many points and gained focus on the issues that are essential from a technical point of view. Thus, the center of mass of all robots has to be on a certain height in relation to the size of the feet. Fundamental for playing soccer are the abilities to walk and to kick. As body contact between the physical agents is unavoidable, the capability of getting up after a fall is also essential. For keeping a goal, the robot must be able to perform special motions.

3.1 Walking skill

Transferring the weight from one leg to the other, shortening the leg not needed for support, and leg motion along the walking direction are the key ingredients of this gait. Walking forward, to the side, and rotating on the spot are generated in a similar way. As the first step toward a skillful humanoid agent, walking is performed with a traditional control method that follows a set of generated ZMPs[2] along the path. This working dynamic model for biped robot walking is shown in Figure 3.

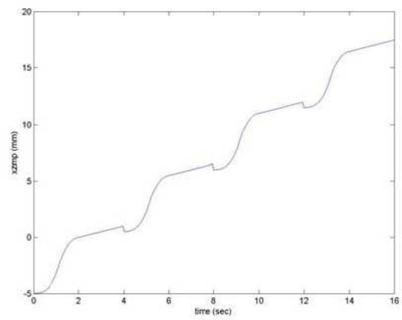

Figure 3. ZMP trajectory

The trajectory tracking methods (specially generated by a series of ZMPs) to control the agent balance while moving has been investigated in [5]. Generated trajectory is followed by a precise controller. The controller, knowing the exact path of the agent's joints, determines the velocity of the joint motors to direct different parts of the robot along the computed path. The walking skill of our agent is depicted in Figure 4.

[2] Zero Moment Point

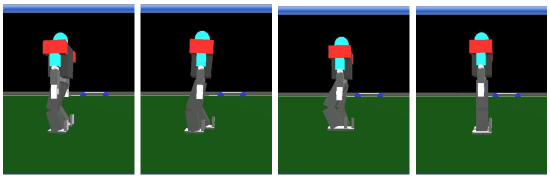

Figure 4. Soccerbot walking skill

3.2 Kicking skill

After inhibiting the walking behavior and stopping, the robot moves its weight to the non-kicking leg and then shortens the kicking leg, swings it back and accelerates forward. The kicking leg reaches its maximal speed when it comes to the front of the robot. Same principles for keeping robot's balance while walking or running are applied in performing actions like kick or dribble. The effectiveness of using dynamic methods like following the path generated by ZMPs with the help of new control methods like fuzzy PID control is already proved in such fields [6, 7].

3.3 Goalie dive skill

The goalie is capable of diving into both directions. First, it moves its center of mass and turns its upper body towards the left while shortening the legs. As soon as it tips over its left foot, it starts straightening its body again. While doing so it is sliding on its hands and elbows. These steps are depicted in Figure 5.

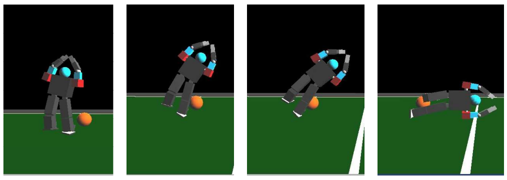

Figure 5. Soccerbot diving skill

8 Future Work

Further improving the controller will be the next stage. Number of learning and optimizing methods such as artificial neural networks, genetic algorithms and other evolutionary approaches will be considered to give the controller an adaptive smooth behavior. For example genetic algorithm could be used to search the trajectory path, computed by the traditional dynamic model, with a small margin to achieve a better walking performance. Fuzzy logic, as a powerful tool in dealing with imprecise environments, can also improve the performance of the designed controller.

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