FEISIM'06: FEI Reinforcement Learning RoboCup 2D Soccer Simulation Team

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Abstract. *The RoboCup Soccer Domain, which was proposed in order to provide a new long-term challenge for Artificial Intelligence research, constitutes real experimentation and testing activities for the development of intelligent, autonomous robots. At the Centro Universitário da FEI we are developing a project to compete at the Robocup Simulation league, aiming to test Reinforcement Learning algorithms in a Multiagent domain. This text describes the team developed for the 2006 Robot Soccer Simulation competition, to be held in Campo Grande, MS, Brasil. We conclude that Reinforcement Learning algorithms performs well in this domain.*

1. Introduction

The RoboCup – Robotic Soccer Cup – domain was proposed by several researchers [1, [2] in order to provide a new long-term challenge for Artificial Intelligence research. Soccer games between robots constitute real experimentation and testing activities for the development of intelligent, autonomous robots, which cooperate among each one to achieve a goal.

The purpose of this paper is to present a project in this domain that is under development at the Centro Universitário da FEI with the aim of studying Reinforcement Learning algorithms in a Multi-Agent domain integrating undergraduate students with research and providing an active and cooperative learning environment.

This paper, which describes the initial results of this project is organized as follows: section 2 describes the RoboCup Robotic Soccer domain; section 3 presents RoboCup 2D Simulator. Section 4 describes the team developed at the Centro Universitário da FEI and section 5 presents the conclusions of this work.

2. The Robocup Soccer Domain

Soccer games between robots are a way to foster a scientific and technological spirit in the younger generations. The development of soccer teams includes more than the simple integration of AI techniques. According to Kraetzchmar [3], "Mechatronic devices, specialized hardware for controlling sensors and actuators, control theory, sensor interpretation and fusion, neural networks, evolutionary computation, vision,

multiagent cooperation are examples for fields strongly involved with the RoboCup challenge".

The RoboCup have several Soccer competition Leagues that differs among each other due to the size of the robots and the presence or not of a central computer. The categories are:

- Middle Size Soccer Robot (F-2000): a match is played by two teams, each consisting of not more than six players, one of them the goalkeeper. The physical size of the robot cannot exceed 50 x 50 x 80 cm (40 kg of maximum weight) and must be completely autonomous, with cameras and computers on board. The field for the game is plan, with the dimensions of 12 x 8 m. The ball used in matches is a orange FIFA standard size 5 ball.
- Small Size Soccer League (F-180): the physical platform of the is constituted by a field for the game, plan, with the dimensions of 490x390 cm. For each team there is one or more video cameras and respective image acquisition system, one computer, data-communication system and up to 5 robots. The maximum robot dimensions depends on the league and ranges from one that must fit a 180 mm diameter cylinder with a height of 150mm or less (in the Small Size League) to an area of 2025 cm^2 in the X-Y plane, with a maximum height of 80 cm and maximum weight of 80 kg (in the Middle Size League). The robots in the Small Size League are usually composed by 2 electrical motors controlled by a microprocessor, battery and wireless communication system. In the Small Size League, all computer vision and decision processing is carried through in a central computer.
- 4-Legged Robot Soccer: in this league a match is played by two teams consisting of four Sony Aibo robots [4], working completely autonomously. The match is played on a field of 6 x 4 m, and major problems studied in this league is self localization and legged locomotion.
- Humanoid Soccer: in this league, which is the most recent soccer league, autonomous robots with a human-like body plan and human-like senses play soccer against each other. There are two size classes: KidSize (30-60cm height) and TeenSize (65-130cm height). The major problems studied by this league includes control of dynamic walking, running, and kicking, visual perception, self-localization, and team coordination.
- Soccer Simulation: in this league the main research area is multi-agent systems and artificial intelligence. It uses a system that enables for two teams of 11 simulated autonomous robotic players to play a match of soccer against each other. There are two different categories, the 2D simulation and the recently created 3D simulation.

In most of these leagues, the operation of each teams follows one same basic formula: each team or robot carries a image acquisition through its camera and then processes the picture using Computational Vision techniques to discover the position and velocity of the robots and the ball. With this information, a decision system defines the best strategy to apply and the movements of each robot at a defined moment. With the decision of the robot movements, a radio based communication system sends for the robots a message describing the movements that must be done. In the simulation leagues, the sensing and acting is done by using a specific simulator, as presented in the next section.

3. Robocup 2D Soccer Simulation

The RoboCup Soccer Server [5] is a system that enables autonomous agents programs to play a match of soccer against each other (Fig. 1). A match is carried out in a client/server style: A server, SoccerServer, provides a virtual field and calculates movements of players and a ball, according to several rules. Each client is an autonomous agent that controls movements of one player. Communication between the server and each client is done via TCP/IP sockets. Therefore the clients can be written in any kind of programming systems that have TCP/IP facilities, such as UNIX or Microsoft Windows.

The SoccerServer consists of 2 programs: a server program that simulates movements of players and a ball, communicates with clients, and controls a game according to rules and; a monitor program that displays the virtual field from the server on the monitor using the X window system.

Server system work in real-time with discrete time intervals (called cycles), this time intervals is used to client send request to server. The cycles have 100ms and in the end of cycle, server execute the request and update the state of world.

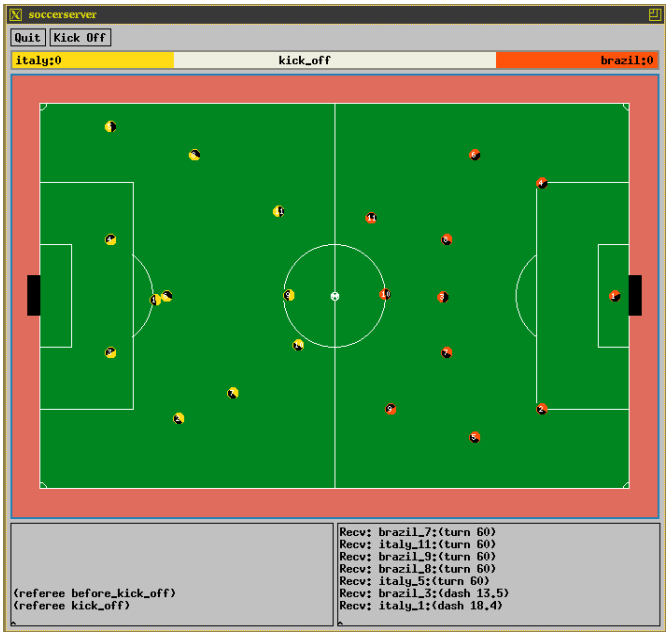

Fig. 1. The RoboCup Soccer Server - Screenshot [5]

4. The FEISIM'06 Team

For being the most popular Reinforcement Learning algorithm and because of the large amount of data available in literature for a comparative evaluation, the Q-Learning algorithm [6] was chosen as the one to be used by the team.

To implement the team, we divided the field of play in a CMAC 20 x 20 grid of positions where the player can be located, and only 8 directions to where the agent can be facing. Each player was implemented as a simple Q-Learning agent. The team

performed the learning task playing against an opponent with a random strategy and against the UvA Trilearn team [7].

The parameters used were: learning rate = 0.1, the exploitation/exploration rate is 0.9 and the discount factor = 0.99. The rewards used were +5000 when the learner scores a goal, –5000 when the team has a goal scored against it and –1 when it executes any action. The goalkeeper receives a different reward: it learns by playing against different teams, receiving a reward of –5000 when the opponent teams scores a goal and +5000 when the goalkeepers catches the ball.

All the experiments presented were encoded in C++ Language and executed in a 3.2GHz Pentium 4 HT computer with 512 Mbytes of RAM memory and Linux/Ubuntu 5.10 operating system.

5. Conclusion

This Team will be tested during 3rd Robocup Brasil, and his acting will be observed. More conclusions can be extracted about the quality of the implemented methods, after this tests.

We presented the design principles and some details of the implementation of the FEISIM'06 team. Results allow us to conclude that Reinforcement Learning can be used to create Robocup Socer Simulation teams.

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