RoboSoccer Analysis

Part III: The Past, The Present and The Future

Introduction:

The Field of RoboSoccer has seen interest and development for over two decades, but its speed is nowhere near to be slowed.
RoboSoccer has grown, both in technical areas as well as a community. Where in the Past, any feasible path of entertainment was limited and even difficult in terms of team play, it is now very well-considered normal to have multiple bots in sync, autonomously handling complex tasks which would have required a room-sized computer a few decades ago. Not only the technical aspect but in terms of community, there are now many competitions, even on the international level as a branch of sports, with all of them having a common goal for the future, Humans versus Robots.

This report would try to provide a brief overview of what is the current pace of RoboSoccer as a field of Interest, with competitions pushing it further, as well divulge into what the future might hold.

The Past

In 1997, when IBM Deep Blue defeated a Chess GrandMaster, RoboCup was organised as the first-ever international event for RoboSoccer, with over 40 teams. The idea of robots playing soccer was first mentioned by Professor Alan Mackworth (University of British Columbia, Canada) in a paper entitled “On Seeing Robots” presented at VI-92, 1992. and later published in a book Computer Vision: System, Theory, and Applications, pages 1-13, World Scientific Press, Singapore, 1993. A series of papers on the Dynamo robot soccer project was published by his group.

Independently, a group of Japanese researchers organized a Workshop on Grand Challenges in Artificial Intelligence in October 1992 in Tokyo, discussing possible grand challenge problems. This workshop led to a serious discussion of using the game of soccer for promoting science and technology. A series of investigations were carried out, including a technology feasibility study, a social impact assessment, and a financial feasibility study. In addition, rules were drafted, as well as prototype development of soccer robots and simulator systems. As a result of these studies, the researchers concluded that the project was feasible and desirable. In June 1993, a group of researchers, including Minoru Asada, Yasuo Kuniyoshi, and Hiroaki Kitano, decided to launch a robot competition, tentatively named the Robot J-League (J-League is the name of the newly established Japanese Professional soccer league). Within a month, however, they received overwhelming reactions from researchers outside of Japan, requesting that the initiative be extended as an international joint project. Accordingly, they renamed the project as the Robot World Cup Initiative, “RoboCup” for short

The Present

RoboCup

RoboCup is an annual international robotics competition proposed and founded in 1996 by a group of university professors. The aim of the competition is to promote robotics and AI research by offering a publicly appealing – but formidable – challenge.

The official goal of the project:

> **By the middle of the 21st century, a team of fully autonomous humanoid robot soccer players shall win a soccer game, complying with the official rules of FIFA, against the winner of the most recent World Cup.**

RoboCup is a research and education initiative. It is based on the attempt to promote intelligent robotics research by providing a standard problem where a wide range of technologies can be integrated and examined. In addition, RoboCup is being used for oriented educational projects. For a robot team that will be able to enforce a real soccer game, various technologies must be incorporated, including: design of autonomous agents, multi-agent collaboration and strategy acquisition in real-time, robotics and vision systems.
RoboCup is an activity for a team of multiple fast-moving robots under a dynamic environment. Although soccer is the standard problem, they will concentrate and integrate a wide range of efforts, competition is only part of the activity of RoboCup.

RoboCup has also been a favorite for the community as a testing ground for new ideas and concepts that might later define the very future of Robotics.
One such idea, which is now realized, is the Multi-Agent Planning System.
The system operates without explicit communication of strategy between agents, relying upon observation of team members to produce meaningful coordinated behavior. Each robot is coordinated with the others by MAPS choosing goal actions that most benefit the team.
The system was used on the UQ RoboRoos robot soccer team that came second in the small size league of RoboCup '98 in Paris and third at the Pacific Rim Series of RoboCup in 1998.

RoboCup has various kinds of Leagues that allow a team to strategize and develop in a particular way to improve their chance, as well as allow people from all levels of expertise to enjoy the experience.
The Leagues are divided as follows:

- **Standard Platform League (formerly Four-Legged League)**

  The RoboCup Standard Platform League is a soccer league where all teams participate using the same robot, the NAO robot from SoftBank Robotics. These robots play completely autonomously and each one takes decisions separately from the others, but they still have to play as a team by using communications. The teams play on a green field with white lines and goal posts, with no other landmarks, and the ball consists of a realistic white and black soccer one. These game characteristics generate a very challenging scenario, which allows improving the league every year.

- **Middle Size League**

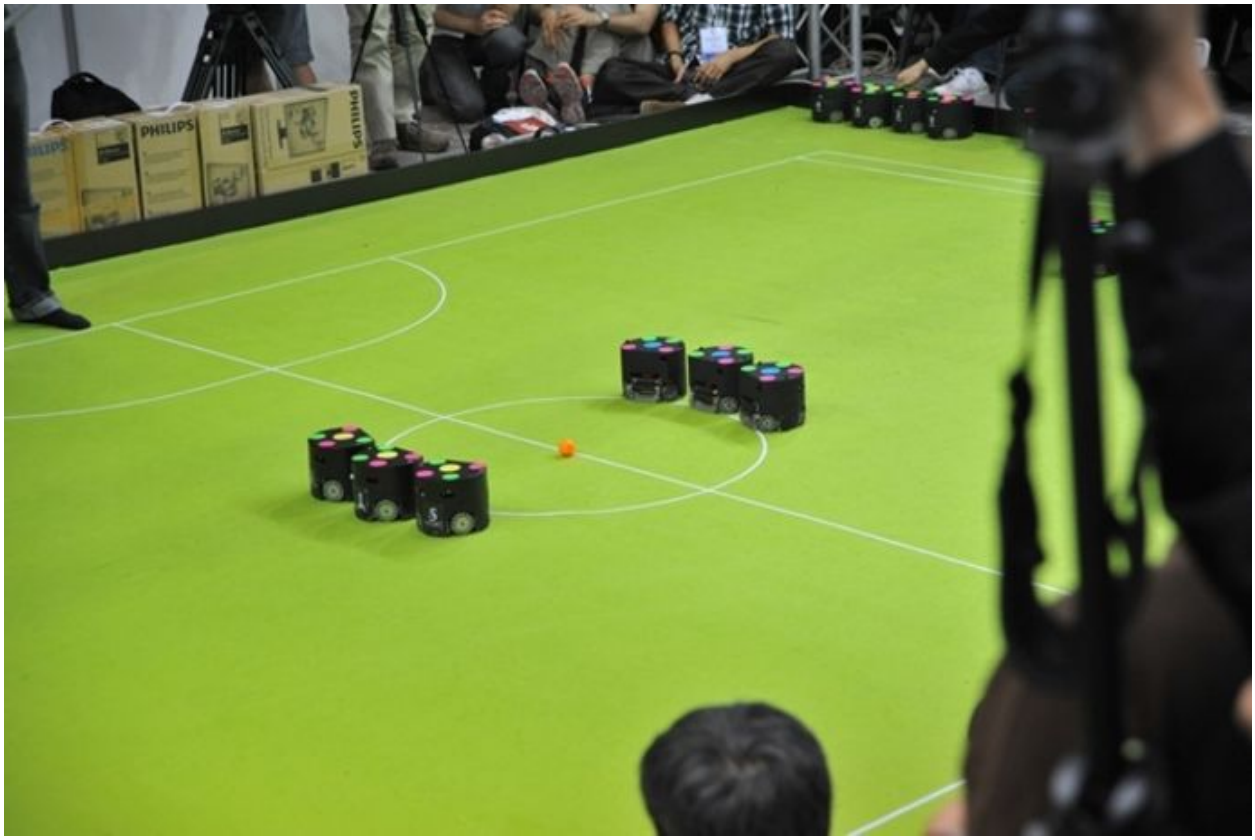
  In RoboCup middle size league teams of five fully autonomous robots play soccer with a regular size FIFA soccer ball. Teams are free to design their own hardware but all sensors have to be on-board and there is a maximum size and weight for the robots. The research focus is on mechatronics design, control, and multi-agent cooperation at plan and perception levels.

- **Small Size League**

The Small Size league or F180 league as it is otherwise known, is one of the oldest RoboCup Soccer leagues. It focuses on the problem of intelligent multi-robot/agent cooperation and control in a highly dynamic environment with a hybrid centralized/distributed system.

A Small Size robot soccer game takes place between two teams of six robots each. Each robot must conform to the dimensions as specified in the F180 rules: the robot must fit within a 180 mm diameter circle and must be no higher than 15 cm. The robots play soccer with an orange golf ball on a green carpeted field that is 9 m long by 6 m wide.
All objects on the field are tracked by a standardized vision system that processes the data provided by four cameras that are attached to a camera bar located 4 m above the playing surface. The vision system - called SSL-Vision - is an open-source project maintained by the league's community.

Off-field computers for each team are used for the processing required for coordination and control of the robots. Communications is wireless and uses dedicated commercial radio transmitter/receiver units.



- **Simulation League**

This is one of the oldest leagues in RoboCupSoccer. The Simulation League focus on artificial intelligence and team strategy. Independently moving software players (agents) play soccer on a virtual field inside a computer.
There are 2 subleagues: 2D and 3D

2D Simulation:

The RoboCup 2D Simulation Soccer League is the oldest of the RoboCup Soccer Simulation Leagues. It consists of a number of competitions with computer-simulated soccer matches as the main event. There are no physical robots in this league but spectators can watch the action on a large screen, which looks like a giant computer game. Each simulated robot player may have its own play strategy and characteristic and every simulated team actually consist of a collection of programs. Many computers are networked together in order for this competition to take place

.In the 2D Simulation League, two teams of eleven autonomous software programs (called agents) each play soccer in a two-dimensional virtual soccer stadium represented by a central server, called SoccerServer. This server knows everything about the game, i.e. the current position of all players and the ball, the physics, and so on.

The game further relies on the communication between the server and each agent. On the one hand, each player receives relative and noisy input of his virtual sensors (visual, acoustic, and physical) and may, on the other hand, perform some basic commands (like dashing, turning, or kicking) in order to influence its environment.

The big challenge in the Simulation League is to conclude from all possible world states (derived from the sensor input by calculating a sight on the world as absolute and noise-free as possible) to the best possible action to execute. As a game is divided into 6000 cycles this task has to be accomplished in time slots of 100 ms

3D Soccer Simulation League

The RoboCup 3D Simulated Soccer League allows software agents to control humanoid robots to compete against one another in a realistic simulation of the rules and physics of a game of soccer. The platform strives to reproduce the software programming challenges faced when building real physical robots for this purpose. In doing so, it helps research towards the RoboCup Federation's goal of developing a team of fully autonomous humanoid robots that can win against the human world soccer champion team in 2050.

The simulation is executed in the *RoboCup Simulated Soccer Server 3D* (rcssserver3d) which runs on Linux, Windows, and Mac OS X. The underlying simulation engine is SimSpark.

The Future

The goal of the international RoboCup initiative is to **develop a team of humanoid robots that is able to win against the official human World Soccer Champion team until 2050**. In some sense, the RoboCup challenge is the successor of the chess challenge for artificial intelligence (a computer beating the human World Chess Champion) that was solved in 1997 when Deep Blue won against Garry Kasparov. Currently, there exist a number of different RoboCup soccer leagues that focus on different aspects of this challenge. The Humanoid League is one of the most dynamically progressing leagues and the one closest to the 2050 goal.

- ## Humanoid league

In the Humanoid League, autonomous robots with a human-like body plan and human-like senses play soccer against each other. Unlike humanoid robots outside the Humanoid League, the task of perception and world modeling is not simplified by using non-human like range sensors. In addition to soccer competitions, technical challenges take place. Dynamic walking, running and kicking the ball while maintaining balance, visual perception of the ball, other players, and the field, self-localization, and team play are among the many research issues investigated in the Humanoid League. Several of the best autonomous humanoid robots in the world compete in the RoboCup Humanoid League.

Beneficial ByProducts

Technological Achievement

Since the premiere of the RoboCup Humanoid League in 2002, the pace of progress and the number of scientific and technological achievements through the participating teams have been remarkable. While in 2002 almost all robots struggled with basic locomotion capabilities like standing on one leg, walking and kicking, nowadays teams of robots in Kid and Teen Size perform fast and exciting soccer games autonomously with many goals. To properly assess these achievements it must be considered that the humanoid robots are fully autonomous and the only external sensors allowed are human-like (i.e. no active range sensors and vision is limited to a human-like field of view of 180 degrees). Also, the foot area size is quite limited with respect to the height of the center of mass.

Educational Achievement

The development of humanoid robots able to play soccer is a fundamental challenge problem for robotics and AI. Since the start of the humanoid league in 2002, there have been lots of improvements in humanoid soccer robot hardware and software. This is partially due to the introduction of standards and competitions for complex simulated robots (3D Simulation). In order to have a long term goal in the learning aspects of humanoid robotics, it has been started to organize International School on Humanoid Soccer Robots in different parts of the world. The objective of these schools is to give students deep insights into the current leading approaches in the field of humanoid soccer robots. By defining International School on Humanoid Soccer Robots, the humanoid league is planning to define a project to promote the RoboCup Community.