Robot Soccer: A Review

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Abstract : The robot soccer competition is a popular game that offers a set of challenges for intelligent agent researchers using a friendly competition in a dynamic, real-time, multi-agent domain. Soccer is a dynamic game where things change fast and randomly so it cannot be predicted i.e. the robots cannot be pre-programmed. A lot of work has been done in the field of robot soccer to keep the game as close as possible to the real game of soccer. This paper is concentrated on various strategies used in robot soccer.

Key Words : Robotic Soccer, Fira, Kalman Filter, Q-learning, Co-ordinate theory, Android

1. INTRODUCTION

The development of robots not only provide a great deal of business opportunities of technology industry, but also have great impact on areas such as national defense, security, domestic life, medical treatment, rescue works, exploitation in deep ocean, etc. According to different applications, robots can have different contribution in different areas. One of the challenging issues in robotic research is the cooperation, coordination, and negotiation among distributed agents in a multi-agent system.

To speed up the development on this challenging issue, a group of Korean researchers initiate a robotics soccer game called *Fira* in 1995. Later the league becomes a well-known world competition, called *Federation of International Robot Association (Fira)*. A soccer robot is a specialized autonomous robot and mobile robot that is used to play variants of soccer.

A robot soccer system is multi-agent intelligent control system composed of two or more robots, vision system, communication equipment and a computer. Each robot in this system has its own movement mechanism and therefore it can move independently as well as cooperate with other robots. In order to allow researchers to consider many different possibilities, several various leagues are formed by FIRA-

- Soccer Simulation League
- Small Size League
- Standard Platform League
- Middle Size League
- Humanoid League.

Besides the above mentioned leagues some more leagues have been introduced during recent years which focus on different applications than soccer playing, i.e. rescue scenarios, educational robots, and human-robot interaction.

2. OVERVIEW

In general, the architecture of robot soccer has following different sections-

- Vision System
- Strategy System
- Communication System
- On board Control System
- Robot System

Following figure shows the general configuration as mentioned above-

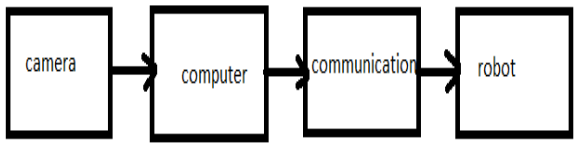

Fig. General System Configuration

The vision system consists of a camera which is used to capture the real time images from the field & transmits the information to computer. The strategy system allows the robot to determine the next action to be taken depending on the information obtained from vision system. The on-board control system receives data from communication system and accordingly action is taken. The robot system actually controls mechanical elements like actuators, sensors, etc.

Up till now, various platforms & techniques are used in order to make the robot soccer as same as possible to the real soccer game. This paper is focused on the following different techniques used in robot soccer-

- 3D coordinates theory & measurement of angle between robot & object or goal.
- Adaptive Q-learning.
- Color tag identification.
- Artificial immune network based action selection method & reinforcement learning mechanism.
- Path planning algorithm based on Bezier curves.
- Rete algorithm.
- Kalman filter algorithm.
- Fuzzy logic & Genetic algorithm.

2.1 3D Coordinates Theory & Measurement of Angle between Robot & Object or Goal: In this method, the obstacle can be avoided by developing an algorithm using 3-dimensional coordinate system. Here few calculations are made by using coordinate theory inclusive of –

i) Distance of goal from current position of robot.
ii) Distance between the robot & nearest obstacle. e
iii) Angle between the current position of robot & goal.
iv) Angle between the current position & nearest obstacle.

The above mentioned calculations are done on the basis of the real time data received from vision system. Depending on this data, the robot generates linear as well as angular velocity.

The object is detected by the real time image data & then reconstructed to interpret the original information. For this purpose, three dimensional coordinate system is

used as it does not depend on current position of robot. The origin of the 3-D camera coordinate system can be selected randomly by the focal point of the camera. The coordinates can be determined by using stereo technique which requires two images of the same object from different orientation. Both the images should be such that corresponding pixels from the image region must detect the desired object. Stereo triangulation uses these geometrical conditions & in this way, the distance of the robot from the object is determined. When the coordinates has been determined, the robot will follow the algorithm & execute the best action possible according to the algorithm.

2.2 Adaptive Q-Learning: Using adaptive Q-learning method, robots are able to learn from past experiences. These experiences are then used to enhance their performance. This method is comprised of hierarchical structure. In the first layer of hierarchy, role (attacker or defender) is assigned to each robot as per their position. In second layer, two algorithms are developed to assign the role depending on the decision from first layer. In third layer, each robot takes an action & completes the task as per their role. This last layer is known as behavior layer.

As the game is dynamic & random in nature, no robot is having a fixed role. Instead their roles are exchanged randomly which is based on the real time data input from vision system. Such a random exchange of roles can be accomplished by using Adaptive Q-learning strategy.

2.3 Color Tag Identification: This method uses robots wearing a jacket of specific color. Due to specific color jacket, vision system can identify the robots of home team effectively & efficiently. It also reduces the complexity of algorithms. This makes the game to be played in a real time environment.

The jacket of a robot consists of two colors - one represents team & another color represents an individual player. The vision system scans the image for these two colors & calculates the centroid of each color. The centre of gravity is then calculated by calculating the mean of both the centroids. As the central portion of the robot is painted with a light as well as dark color, by calculating the grayscale values of pixels, a value & thereby the role is assigned to each robot. This not only improves the accuracy but also reduces the complexity.

2.4 Artificial Immune Network Based Action Selection Method & Reinforcement Learning Mechanism: In robot soccer, assignment of role & action to be executed play an important role. The role assignment & action execution can be done using geometrical approach i. e. coordinate theory. But it is quite complicated to design an algorithm for action selection using coordinate theory. This can be overcome by using artificial immune network.

In this technique, the perception of the biological immune system is used to represent the perception of the robot soccer team while reaction of biological immune system is used to represent the response of robot soccer team. The field is divided into four quadrants. Like perception of biological immune system, the robot detects the closest obstacle as well as ball in the quadrants using coordinate system. Depending on this information, robots determine the strongest & nearest defender or attacker in the field.

Reinforcement learning mechanism helps the robots to decide the priority order. This method decides whether the response of the robot matches to the priority order or not. If it matches reward is given and if it does not penalty is given.

The use of artificial intelligence as well as reinforcement learning mechanism reduces the overall complexity.

2.5 Path Planning Algorithm Based on Bezier Curves: Bezier curve is generally used for animation as well as computer graphics. Bezier curves have an important property for trajectory generation. The algorithm developed using Bezier curve makes the trajectory of the robot to follow the desired path.

2.6 Rete Algorithm for Robot Soccer: The Rete algorithm is mainly used for designing expert systems those based on particular rules. Expert systems are the part of artificial intelligence capable of simulating human decision skills. The Rete algorithm is used to define the architecture of the system. It treats the low level information received from the field as high level soccer concept. As the expert system operates in an infinite loop, the Rete algorithm does not check all the rules in each cycle, rather it takes reference from previous results. Also, the rete algorithm reduces the number of tests to be carried out in each cycle as few of the rules can be shared in network.

2.7 Kalman Filter Algorithm: In soccer, the coordinates as well as the direction of the robot must be known in order to determine the position of the robot in real time. This can be done by using trigonometric functions. But such functions do not consider the noise in real time which results in an error in the position of the robot in the field.

The Kalman filter integrates the measured data into an estimate by considering that measurements are noisy. The Kalman filter smoothens the effect of noise by employing large information from the reliable source. The Kalman filter algorithm can easily combine the information from vision system & locomotive system in real time.

2.8 Fuzzy Logic & Genetic Algorithm: Fuzzy logic is generally used when the information is uncertain or vague. Fuzzy system makes decision by applying approximate reasoning depending on the vague & dynamic data. But the fuzzy system is not able to modify the rules on its own for the changing environment. Genetic algorithms can adopt based on natural selection.

Thus by combining the property of fuzzy system of approximate reasoning & the property of genetic algorithm of self adaptive learning, a hybrid system is designed that meets the expectations of robot soccer.

2.9 Android Based Robotic Soccer: Till now, the communication, object detection was based on computer technology. The same thing can be implemented on android platform. Various algorithms which are stated above can be employed on android base.

In this methodology, tagging scheme is used. The object to be followed is identified from the image by

tagging it. & then depending upon the role of each robot the task is accomplished.

3. Conclusion & Future Work

In this paper, different techniques as well as various algorithms are described which are successfully used in robotic soccer. Today's era is Smartphone's era. Use of android platform makes communication faster & efficient. The use of android can be further extended for robotic soccer. Android based object detection algorithm could be used as one of the strategy in real robot soccer competition.

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