Robotic Soccer:
a real challenge for cooperative robotics

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Abstract

This paper gives an overview on the challenges presented in the RoboCup competitions and how them can improve cooperative robotics in a non-controlled environment. Below a solution is presented by the CAMBADA team, a robotic soccer team created for the RoboCup Middle Size League (MSL), to deal with the MSL challenges. This paper presents an overview of the internal software structure of the CAMBADA agents, mainly in what concerns coordination and cooperation among the agents, and the proposed solution for the RoboCup 2012 MSL Technical Challenge, where the CAMBADA team attained the first place.

1 Introduction

To overcome great obstacles, people have learned that cooperative work is a powerful tool, and many work nowadays have to be done in teams. However, it is not just the number of workers that dictates the success of the operation, it is also their ability to communicate with each other and coordinate their efforts. With the increasing availability of robots in different areas of human activity, it is natural that they start to mimic human behaviour, becoming more independent and capable. Progresses in wireless communication technologies enables teams of robots to share information in real time and coordinate themselves, while longer lasting batteries and smaller components make possible the creation of simple robots for domestic use.

Because technology is still not in a level where humans can rely completely on robots for daily tasks, there has to be another reason to encourage researchers to develop better algorithms and better equipments. In this area, the RoboCup competition acts as a catalyst for teams to show each year new discoveries and innovations on specific areas, such as robotic soccer, domestic challenges, rescue simulations and others. By starting with a specific goal in a controlled environment, and then increasing the complexity yearly, researchers face one challenge at a time instead of being confronted with multiple problems at once, which would increase the difficulty degree exponentially.

Keeping in mind the participation in these challenges, the University of Aveiro created the CAMBADA team (acronym of Cooperative Autonomous Mobile Robots with Advanced Distributed Architecture), a robotic soccer team that participates in the RoboCup Middle Size League (MSL).

The CAMBADA coordination model is based on sharing the world state between all robots, by the use of their communication capabilities and a real time database. The decision architecture is based on Roles, that provide a way to perform high-level tasks. Each role is a combination of Behaviours that compose the high-level tasks [1].

This paper presents the effectiveness of Roles on the CAMBADA software architecture as well as their influence in the RoboCup 2012 Middle Size League Technical Challenge, were the team achieved first place. The organization of the paper is the following: Section II explains the software architecture responsible for the coordination of the robots and the available roles. Section III presents the MSL technical challenge for 2012, the rules and the created roles for the team to complete the challenge. Finally, Section IV discusses the results and Section V concludes with final thoughts and future work.

2 Coordination Between Robots

The CAMBADA robots follow a distributed approach, both in their hardware architecture and their software architecture [1]. The hardware is distributed in three layers witch facilitate replacement and maintenance. The software is constituted by five processes executed concurrently, and these communicate by mean of a Real Time Database(RTDB) [2] which is physically implemented in shared memory. An illustration of the software architecture can be seen in Fig. 1.

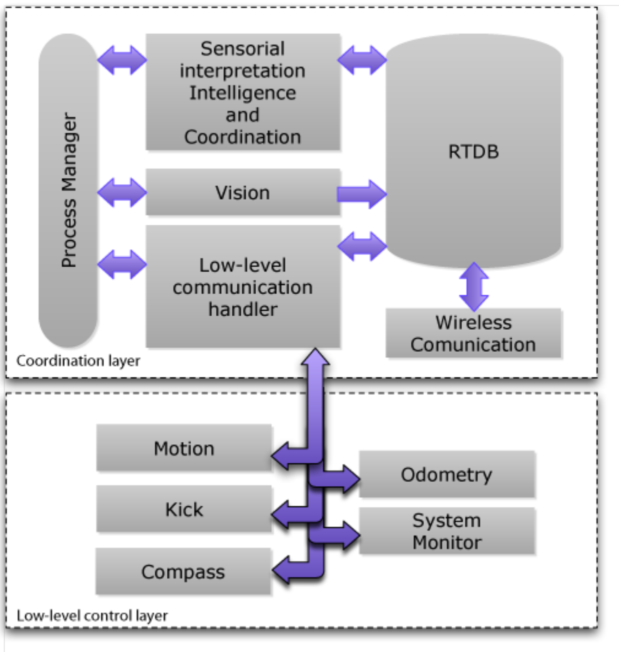

Figure 1: The CAMBADA software architecture

Being responsible for the internal communication of the five processes, the RTDB is one of the most important features of the software architecture. It contains essential state variables divided in two sections, a local section that holds the data needed by the local processes and is not to be broadcasted to other robots, and a shared section which is divided between all running agents and contains sub-sections with data of the world state as perceived by each one. Each agent transmits its own shared section, thus keeping all RTDBs with updated information. Moreover communication is done wirelessly by means of Wifi.

The choice of making the robots communicate by Wifi is the best solution because it is a technology that has proven to be robust and adaptable to many situations, also there is a large range of hardware that supports it.

The ability that each robots has to communicate to the rest of the team their data is an important asset when making decisions, as each robot is capable of deciding which role they are assuming, knowing their teammates roles. This makes another important feature of the CAMBADA software architecture, a dynamic role-based architecture with formation [1].

There are two main situations during a game, freeplay and set pieces. In freeplay are used 2 roles: the striker which is the robot closer to the ball and the midfielder which assumes a defensive position behind the striker. In set pieces a combination of 2 roles is used, the replacer which passes the ball and the receiver who receives it. In both situations there is always another robot performing the goalie role.

Besides the dynamic roles, there is also a dynamic formation. Using Delaunay Triangulation (DT) each robot is able to chose the best position to be according to the position of the ball. With this feature the coach create tactical positioning for every robot in an continuous space.

In real life football, the entity most responsible for the coordination of the team is the coach. In this version of robotic soccer there is also a coach, that can be a computer outside the field making indirect decisions. For example, it is not allowed for the coach to directly order a robot, the decisions have to be taken by each player. The function of the coach is for example to change the DT tactics according to information gathered by the players.

3 The Technical Challenge

RoboCup is a competition that involves many leagues and competitions. This paper focuses on the RoboCup 2012 MSL Technical Challenge. The challenges are different every year, and this year it was composed by three active robots, one stationary goalkeeper and at least three obstacles about the same size as a robot from this league. Here is a simplified procedure for completing the challenge with respective steps:

- Robot B searches for the ball (step 1)
- Robot B passes to Robot A (step 2)
- Robot A receives the ball, dribbles for 3 meters, and passes to robot C (step 3)
- Robot C receives the ball, dribbles for 2 meters and then shoots it into the predetermined goal where the goalkeeper is standing (step 4)

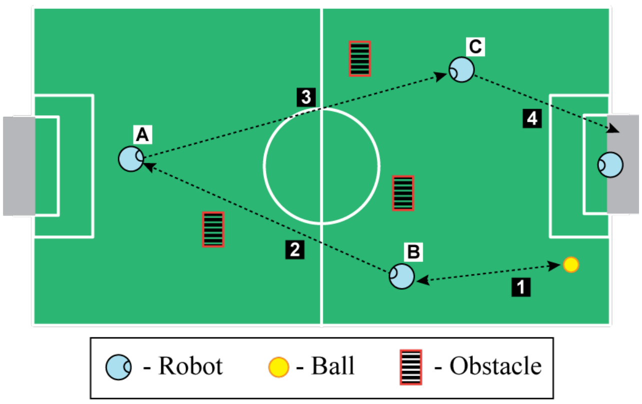

Figure 2: Sequence of steps necessary to complete the challenge.

Fig. 2 shows an illustration of the challenge. The robot positions, except the goalie, are random as well as the ball and obstacles positions. The arrows represent passes or moves done by the robots, numbered to create a sequence. The robots are also identified by the letter beside them.

Each team has three chances to complete the challenge, and the final score is the sum of the three runs. Penalties are also involved, for example: the robots cannot cross the mid-field, the ball can not go out, and the robots can not touch the obstacles, among others. The team starts with 6 points in each run, and any penalties subtract 1 point from the total, making a possible perfect score of 18 points.

For this challenge three new roles were created, Role A, Role B and Role C. Very specific instruction were given to each robot, and the ability to communicate with each other was crucial when advancing to the next step in the procedure, specially when the robots had to agree on a position to create a clear passing line avoiding the obstacles.

4 Results

By creating a challenge with three rounds and cumulative score, the RoboCup organization were rewarding consistency, for example 1 good run and 2 bad runs would only give about one third of the perfect score, to ensure teams were capable of replicating the results as many times needed, not only one lucky time.

By using shared variables though RTDB, CAMBADA robots could coordinate the passes and warn other teammates when it was their time do act. Other teams used the ball position in the field and relative distance to calculate what the next step would be, for example if the ball was is in the predefined own half of the field it probably was Robot A turn to act, and if it was on the other half of the field it would be Robot B or C turn to act. This procedure is much more risky and gives room for more errors.

CAMBADA faced serious difficulties with the vision system during the competition, as well as the other teams, because the illumination conditions were poor, and for the length of the competition serious problems affected the ball grabbing system. Nevertheless, a conservative programming allowed the team to complete the three runs with some success, finishing the challenge twice, and sending the ball out in the other after hitting an unseen obstacle. The team finished the challenge in the first place.

5 Conclusion

The ability to communicate with each other through the Real Time Database [2], the dynamic role system and the Delaunay Triangulation positioning have proven to be the best assets the CAMBADA team has to surpass its challenges. Also its distributed approach allows for a quick adaptation, either in this more familiar challenges or in other cases, like the adaptation of a CAMBADA robot to participate in the @Home competition since the RoboCup 2012.

At this point, the robots have the tools to share their knowledge with each other in an efficient way, however, using this information to make optimal decisions is the real challenge.

For future work there are two main objectives that would boost the cooperative behaviour greatly. The first would be to allow the coach to decide the best formation according to his knowledge of the world and change it during the game. In this moment there is a static formation decided at the beginning of the game. The other objective would be for the robots to coordinate passes in a more dynamic way. Currently, the destination of the pass is given by the current position of the receiver robot, but the game would be much more interesting if the robots had the ability to do through passes, for example, if two players could agree on a pass destination even before the receiver is there.

References

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