SABANA Herons
Team Description for RoboCup 2019

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Abstract. This paper contains all the team information and scientific contributions of the SABANA Herons team from Universidad de La Sabana that will allow it to compete in RoboCup Standard Platform League 2019 in Sydney, Australia. Among the most important results is an optimal location system based on game theory and genetic algorithms that helps to propose defensive strategies when the team does not have the ball, as well as a system that allows the robots to extrapolate the position of the ball when its actual location is unknown.

Keywords: Game Theory · Genetic Algorithm · Heat Map · Optimal Location.

1 Introduction

The SABANA Herons team is the result of the collaboration between the mechanical engineering and informatics engineering departments of the Universidad de La Sabana. The team was born out of the students' desire to carry out projects that bring together different fields of engineering in order to solve complex problems that can be compared with real-world systems, as well as their desire to form multidisciplinary groups that require teamwork. Our team was founded in 2017 and has been gaining experience in different robotics competitions, some in the national context and others internationally. In recent years, the university has been able to participate in various global competition events, such as Shell Eco Marathon Americas (Detroit 2017 and Sonoma 2018), All Japan Sumo Robot Tournament in Japan (December 2017) and RobotChallenge in Mexico (May 2018). Our next goal is to achieve the qualification and a good participation in Robocup 2019, competing with the university's NAO robot team.

To ensure a good performance in this competition the team has concentrated on the implementation of optimization algorithms to determine the location of robots on the playing field based on static and dynamic game theory [1], on the implementation of heuristic algorithms on the NAO operating system [2] and on the implementation of probabilistic models to determine the location of the ball [4]. These work areas are not only relevant in the framework of robocup but also include general problems of robotics and cooperative systems.

2 Team Information

The SABANA Herons team is a SPL team from the University of La Sabana, located in Chia, Colombia. The team leader, Andres Ramirez, is a professor in the department of prototypes and manufacturing at the university's engineering faculty. The team is composed of students from the mechanical engineering and informatics engineering programs. The team currently has 6 NAO Robots (V4 and V5 versions). The team is only preparing an individual participation and a mixed team has not been contemplated.

3 Past History

Although the participation in Robocup SPL is new for the team, testing have proven that we are in a position to compete in Austalia 2019. However, the team members had several experience in international competitions that required a high level of work and programming. For example,the construction of a highly energy-efficient vehicle, where they had to program that guaranteed a minimum battery consumption both in function of GPS signals and in function of the auto regulation of the car, as well as the programming of the driving of the vehicle (Shell Eco-Marathon Americas 2017 and 2018), and some members of the team have extensive experience in RoboSumo competitions at national and international level, the two most significant participations being those of All Japan Sumo Robot Tournament (2017) and Robot Challenge Mexico (2018).

4 Code Usage

For the participation in Robocup 2019 the 2018 version of the B-Human code release was used as a base. Several of the modules proposed by this team were used directly, while some were modified. All robot behaviors were written in their entirety by the SABANA Herons team based on the CABSL platform delivered by B-Human. These include a behavior for the Striker, the Defenders and the GoalKeeper. The kicking movements and goalkeeper's special movements were programmed in their entirety. The modules presented in this article were written in their entirety. These include a heatmap-like module, a zone representation and provider, and a implementation of an heuristic algorithm for optimizing the position of the team on the playing field.

5 Impact

The team's participation in Robocup represents a great step forward for its country in terms of robotics competitions. Although robotics competitions are organized in Colombia, none has the magnitude that Robocup has in terms of the difficulty of the proposed challenges, as well as the attendance of visitors to the event.

Even though, Universidad de La Sabana is a quite young institution (around 40 years old), is has achieved a good performance in international competitions such as Shell Eco Marathon in which it was able to build a highly efficient electric vehicle consuming only 90.1mi/KwH whereas an average car consumes

6.25mi/KwH. It is expected that Robocup SPL serves as a medium to increase the development in robotics in Colombia, as Shell Eco Marathon did with the development of electric vehicles. Furthermore, the university has set its goals to change the international reputation of Colombia from a third world country which is ending an era of internal conflicts to a country that is beginning a period of peace and resilience; Robocup would be an additional example of Colombia's efforts to pursuit this change. This also implies a very big media impact in the country, as different institutions and communication media would see the participation of the team as a change in the paradigm of the capacities of local universities in the international arena.

Additionally, it is necessary to highlight the importance of soccer as such in Colombia; this sport is by far the most followed in the country, with which the participation of a national team in the Robot Soccer World Cup would imply an increase in the popularity and credibility of engineering and robotics as disciplines among the local population. Finally, it is also important to note that in the history of the competition, no Colombian team has participated in the Robocup SPL category, which adds an great degree of diversity to robocup as a community.

6 Team Developments

The first development of the team is an algorithm that allows to determine the optimal location of the robots on the field based on shared team information and the location of the ball by means of evolutionary algorithms (genetic algorithm). This algorithm was tested in the MATLAB environment as it is the standard for engineering implementations. The plan is to implement the algorithm on the NAO platform during 2019. The second development is a system that allows an estimation of the ball location using statistical information to perform a faster search when no robot knows the location of the ball.

The team has also worked directly on the development of behaviors for playing robot soccer, as well as on the development of different movements that allow tasks such as kicking and stopping a ball to be carried out.

6.1 Optimal Location

In order to optimise the positioning of the robots on the field, it is proposed to solve an optimisation problem with multiple objectives. Each one of the robots will solve a local problem using the information it has available at a determined instant of time. Given that for this system there are multiple agents solving multiple optimization problems that are linked together it is possible to say that it can be modeled through game theory [5]. It is important to realize that the problem that each robot is solving is local nature because even though all robots know the information about all partners, their own decisions, i.e., where they will move optimaly, only affect their own position[3].

The objective of the robots is to maximize the total team coverage area in order to be prepared in case of a rival attack or an unexpected movement of the ball. To do this, each robot seeks to minimize a cost function that depends on the position of all the allied robots that are able to interact with the ball, i.e., all but the goalkeeper, the current position of the ball and the distance to the center of the field. Fig. 1 shows an example of a set of trajectories based on the proposed strategy. In this example it can be seen how the players look for an optimal position around the ball following the trajectories represented by discontinuous lines. As expected, the optimal location that seeks to generate the largest possible area is a square. Logically, if the ball were in a position for which a square is not a feasible polygon, e.g., if it were very close to the out line, the polygon could change to maximize the given criterion.

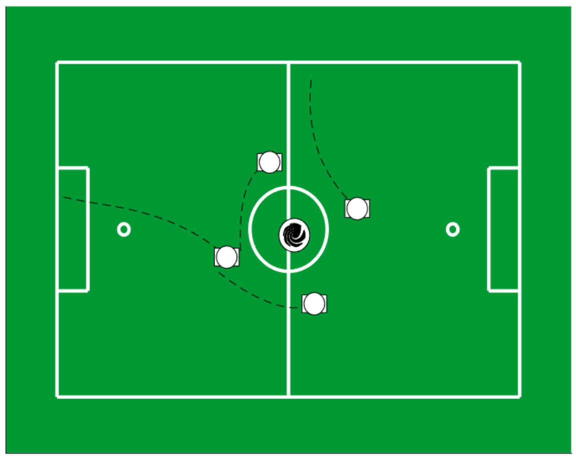

Fig. 1. Optimal location of a group of 4 robots based on the proposed strategy. In this figure, the dashed line represents the trajectory that the robots followed in order to achieve the optimal location. It is important to point out that the optimal polygon for this particular ball position is a square as it is expected.

6.2 Statistical Ball Location

During a robot soccer match it is normal that the vision of the robots fails and the location of the ball is lost. This can be due to lighting problems, other robots blocking the view or imperfections in the recognition algorithm. This is problematic as many of the game algorithms and programmed behaviours depend to a large extent on the exact location of the ball. For this reason it is proposed to create a statistical map that allows to extrapolate the approximate position of the ball independently of if it is being seen or not. To solve this problem, it is proposed to perform a systematic loading of portions of the field, based on where the ball has been when its position was known, so that the robots can determine the approximate ball position according to where it has been most of the time. However, to affirm that the ball is going to be in the place where it has been most of the time can be an error, because the match is a dynamic scenario, hence it is proposed to carry out this load in sliding time windows so that the oldest data is discarded.

Fig. 2 shows how different portions of the field are charged as the match progresses. Areas with more red shades mean higher probability of the ball being in it, and therefore more feasible places to find the ball.

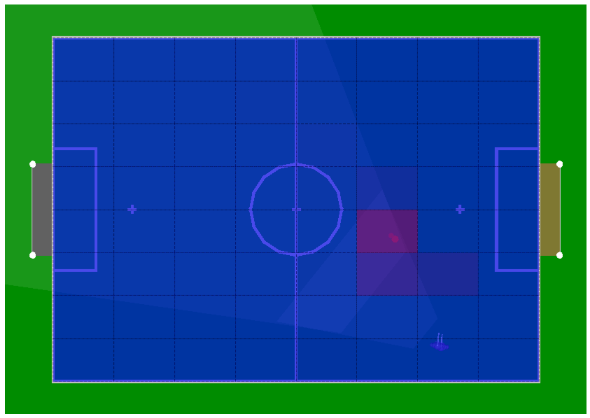

Fig. 2. After the match begins, the location of the ball begins to change, thus charging the probabilities that the ball is in one area or another. When the probability of a zone begins to grow, its color begins to move toward more red shades.

6.3 Implemented Behaviors

In order to play a soccer match it is necessary for players to understand what behaviour they must follow while on the playing field. For the Robocup SPL challenge it is proposed to implement 3 different behaviors that will function as the instructions that the robots follow during the game: Striker, GoalKeeper and Defender.

Striker For the implementation of this behavior, the base proposed in the B-Human framework was used, updating two important portions. On the one hand, it was considered convenient that a striker is never on its own side of the field so this condition was added. The behavior was also modified to add a long kick implemented by the team that will be described later.

GoalKeeper The fundamental objective of the goalkeeper is to prevent the ball from entering his own goal. For that reason, the two most important objects for this player are the ball and the goal. However, the raw goal does not provide all the complete information as it does not determine where the goalkeeper can go. For this, information about the penalty area is required. The proposed behavior for the goalkeeper then consists of two parts: The first part only looks for the player's best location when the ball does not go towards the goal itself. In this case, the goalkeeper will only seek to position himself at the intersection between an imaginary line, formed by his position and the position of the ball, and the line of the penalty area. The second half is activated when the ball approaches the goal. In this case, the goalkeeper should only try to stop it with his fists when a distance and speed threshold are exceeded.

Defender The behavior of the defender seeks to help the task of the goalkeeper, which also aims to prevent the ball from entering their own goal. However, there is a very important difference: There is more than one defender in the team. That's why all the defenders in the team work together to achieve the objective. So what the defenders do is as follows: First it is determined which defender is closest to the ball. If a player considers himself to be the closest, he will go for the ball and kick it in the direction of the opponent's goal. If a player is not the closest to the ball, he will seek to cover areas of his own field to prevent opposing players from receiving passes there.

6.4 Implemented Moves

Long Kick This move is a long distance kick that is used by the striker when scoring goals. During a normal match it is used on a situational basis, e.g., when the player detects that there is a clean shot towards the goal, and it is always used at the time of taking penalties (to increase the probability of scoring).

GoalKeeper Dive To ensure maximum goal coverage it is necessary to implement a movement that allows the goalkeeper to reach from the centre of the goal to the post. This movement allows you to do just that. The movement is composed of two parts: Initially the goalkeeper kneels to minimize his distance from the ground and then makes a jump to the right or left according to the direction of the ball. During this jump the arms are fully extended to ensure as much coverage as possible.

GoalKeeper Ground Punch During a normal match the goalkeeper should move within his area to try to avoid future movements of the ball. This means that the optimal position is not kneeling but standing in order to be able to move quickly. However, when the ball approaches him there must be a way to stop it. The Ground Punch allows the robot to quickly approach the ground (using one of his fists) to stop the ball approaching the goal.

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