Luxembourg United
Team Description Report 2017

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Abstract. This is the Team Description document for "Luxembourg United", the first team from Luxembourg to enter the RoboCup Competition. This is also the team's first, and successful, attempt to qualify for RoboCup. In this document, we first provide a general description of the Luxembourg United team, along with its members and the equipment owned by the team. Then, we thankfully acknowledge our use of the B-Human code, and list our original contributions concerning: strategic positions, kicker election, target selection and passing, kick selection and pose to kick. Finally, we review our past history and hightlight our impacts.

1 TEAM INFORMATION

Luxembourg United as a robot soccer team is a relatively recent team, only one year old. Shortly after being created, in March 2016, it won a first price at a Mind and Market Innovation Forum, Luxembourg June 2016. It then continued it's moving up by qualifying for the German Open and the WorldCup 2017. During the German Open, Luxembourg United won the first place at the Challenge Shield. The motivation for Luxembourg United is to carry out research in social robotics, distributed artificial intelligence, machine learning, human robot interaction (HRI) and optimization.
While Luxembourg United seeks to address all the relevant topics required to run and play autonomous soccer games in the Standard Platform League (SPL), it also focuses on a subset of specific research areas summarized in this Team Description paper. Luxembourg United is part of the Social Robotics Laboratory headed by Dr. Caire, from the Automation and Robotics Research Group of the Interdisciplinary Centre for Security, Reliability and Trust (SnT), University of Luxembourg.

1.1 Team

The team consists of one faculty member, one post-doctoral Research Associate, one PhD student, six master students and undergraduate students. The qualification video is available at our Luxembourg United website “Events” page [1] and alternatively at the following address [2].

Team Leader / Staff: Patrice Caire

Students: Claudio Cimarelli, Yan Medernach, Ana Patricia Marquez Sanchez, Gabriele Sartor, Gary Cornelius, Alexander Eyjelfsson and Monia Chowdhry.

Fig. 1. Luxembourg United Team.

Among the research areas pursued by the team members, we highlight the following: Communication among robots, actuators and sensors was addressed by our team members in the context of Ambient Assisted Living, such as in [Bikakis et al., 2016], and we plan to apply this research to communication among robots.

Furthermore, We also plan to use some of our previous research relating to coalition formation [Caire and Bikakis, 2014] [Bikakis and Caire, 2016] to address cooperation among robot soccer players. Robot cooperation has also been addressed by our ARG team although in industrial and manufacturing settings. However, knowledge transfer can be applied to RoboCup and we plan to leverage some of this research on multi-robot for our robot soccer team, e.g., [Voos, 2008] [Voos, 2009]

[1] https://luxembourg-united.uni.lu/Events

[2] https://vimeo.com/193756871

1.2 Infrastructure

Luxembourg United is composed of the following robots:
- 5 Naos V5
- 5 Naos V4

Luxembourg United recently built a full field to the official RoboCup norms. This will allow our team to play and extensively test our code. Up to now, all our tests have been made on a scaled down field, of on encounters such as in the RoHOW context. Moreover, we plan to organize regular friendly competitions with other teams. As a central hub in Europe, our location is at an easy reach for many teams, and offers a very international environment.

2 CODE USAGE

2.1 Code re-use

Luxembourg United code is based on *B-Human* code release 2016 [Röfer et al.,] [3]. Additionally, we translated some of the special movement files previously released by *rUNSWift* [4] into the *B-Human* framework.

2.2 Our contributions

Our team truly believes that, in a competition, behaviors can be decisive in the outcome of a game. Thus, we focused our research on cooperation among teammates with the aim of creating more opportunities to score. Of course, we know that, to capture informations from vision systems, more advance techniques are needed. For this reason, we are also involved in studying Fast-Learning Shallow Convolutional Neural Networks to adapt them to the low computational power of NAOs.

3 STRATEGIC POSITIONS

At the current stage of development, we keep the robots in a single well-balanced formation, using two robots for the attacking phase and three for the defensive (counting the goalie always inside the penalty area).
The whole strategic placement has been planned taking into consideration our experience about the evolution of a normal football match. We try to translate this into proper movements for the individual roles.
All the following behaviors are active only when a robot is not elected for the task of kicking the ball(see section KICKER ELECTION). Hence, we rely on the assumption that there exists always one robot going towards the ball with a planned target for shooting (see section TARGET SELECTION AND PASSING), such that the placement depends mostly on the kicker robot.

[3] https://github.com/bhuman/BHumanCodeRelease/
[4] https://github.com/UNSWComputing/rUNSWift-2015-release

The last German Open competition 2017 showed us the strong and weak points of this approach, where the latter is mainly the non-adaptability to the current situation of the game. Hence, we next plan to develop a dynamic role assignment module so that robots can coordinate themselves in other kinds of formations as well.
For all of these roles we defined a single module to constantly update the robots' positions in the field, changing it with respect to different features such as the distance to the ball and the kicker shooting direction.

Goalie We decided to keep the goalie guarding most of the time inside the goal area, at least while it does not have to kick the ball. It computes a position relative to a pivot point, placed in the middle of the two goal posts. As the ball gets closer to the penalty area, this pivot moves in the horizontal direction so the robot stays always behind the more probable line of shooting for an opponent.
Additionally, the goalie always tries to predict when an attempted shot is going to be dangerous, in which case it performs a dive. After calculating the point in which the ball could end, he decides whether to dive frontal or lateral depending on the angle of the velocity vector of the ball.
For this we use the classic equation of motion $x = x_0 + v_0 t + 1/2 a t^2$, for t when $v = 0$ and a equals to the field friction parameter.

Defender To help the goalie and not leave it alone in a difficult situation, we opted for the solution to keep *some* robots around the penalty area.Thus, we fixed two pivot points (one for the *left defender*, one for the *right defender*) close to the penalty area. The idea is that defenders move from this point only if they are elected as kicker.
In the future, we will allow defenders to double team and better communicate with the goalie in order to choose their positions.

Supporter The supporter places itself depending on the role and position of the robot elected as kicker. Whenever the robot with the task of kicking communicates that it is going towards the ball, the supporter looks whether its role is as striker or not.
In the first case, it finds its position along the line of shooting when the target is the goal, or tries to reach the position designated as target in the case of a passing (further details about passing behavior will be presented in section TARGET SELECTION AND PASSING).
In all the other cases the supporter finds an advanced position relative to the ball, choosing left or right depending on its current position's horizontal coordinate and the position of the kicker, preferring to be on the opposite side of the field.

Striker The striker behavior is similar to the supporter in the way that his position depends on the kicker robot.
The idea is to have a role that receives the ball from one of the defenders or the goalie in the own side of the field and brings it into the opponent side. This is done by either walking with the ball or kicking. Currently, in

the matches we played, we gave preference to the kicking option, because of the uncertainty we still experience with the former skill and also to create more chances to score.
Hence, the striker usually places himself with its back to the goal when a defender is kicking the ball close to them. Otherwise, he finds the right spot along the line between the ball and the shooting target of the kicker.

4 KICKER ELECTION

To dynamically switch the task to attack the ball and kick, we implemented a distributed algorithm for the election of a single robot as *kicker*. In this algorithm, inspired by the work of [Sng et al., 2002], fuzzy logic is used to choose the role inside a formation with other robots, and achieve better collaboration.

Hence, the idea was to make sure that the right robot goes for the ball and kicks. To do so, we compute a value for the priority, used in the distributed election system, summing up different components in a multi-cost function. In particular, we add the angle necessary to rotate towards the ball, the one to the selected target, the angle to the nearest obstacles along the direct path to the ball, weighted by the distance to the ball. Moreover, we decided to add to the final priority a factor related both to the role and to the current global position of the ball. Once the priority is calculated, it is shared with all the other robots.

When the election algorithm starts, every robot is in a DUMMY state, that means not elected as kicker. As soon as a robot receives the messages containing the priorities, it checks whether its own value is higher than all the others. If not it remains in the DUMMY state, else it changes its state to LEADER, represented as arrow A in Figure 2.

To avoid oscillation from LEADER state to DUMMY, we choose to add a third state called CANDIDATE. If a robot is in the LEADER state and finds another robot with a higher priority than its own, it switches to the CANDIDATE state (arrow B).
The state will then change to DUMMY, after a time frame inversely proportional to the distance from the ball (arrow C), or switch back to LEADER if the other teammates have lower priorities (arrow D).

5 TARGET SELECTION AND PASSING

Depending on its role and position on the field, each robot has different options to aim for a kick. This target, once selected, has a direct influence on the Kicker Election algorithm and on the kick selection process. Additionally, the coordination behind the ball, explained in the subsequent section, has to take the target position into account.

We have two main typologies of targets: targets on field and robot targets. This distinction is needed to warn the teammate robot, selected as

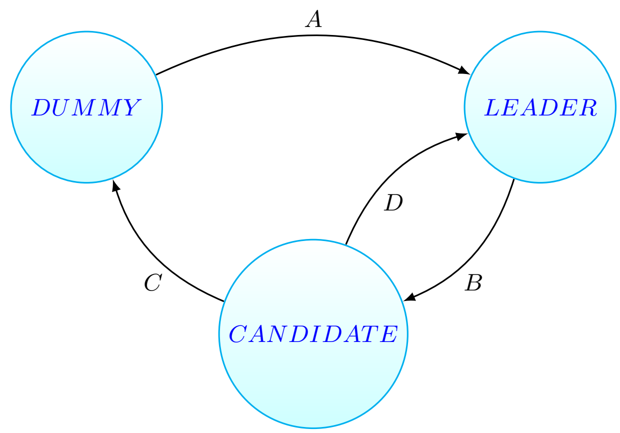

Fig. 2. Possible states of the election algorithm

the receiver of the passing, to wait for the ball or to walk to the specified position. In the first category, targets are predefined positions of the field, such as points of intersections of the lines, the penalty mark or the goal.
Every target is composed of a left and a right vector in the ball coordinate system, so that the robot has a minimum threshold for the precision in the shooting direction. These two vectors generate the maximum *angleOfView*, which is among the measures we use to state the probability that the ball could arrive at destination without being blocked before. This angle will be derived taking into consideration the obstacles in the range between the left and right vectors. Thus, we take the angle from the closest obstacle on the left side of the center line to the target, or the angle of the left vector in case there is no obstacle. The same is done for the right side. The final *angleOfView* is then the sum of the two components.

The technique behind the selection is similar to the fuzzy logic cost function explained in KICKER ELECTION. Hence, the priority is a combination of factors in which the main part is played by the role assigned to each robot. For example, a striker's target will be more likely the goal there is a clear line of shooting to one of the goal posts. Thus, we compute a score for the set of targets, each of them with a different bias based on the role. Then we add the angle necessary to rotate towards the target with the *angleOfView* weighted by the distance to the target. This distance is normalized with a minimum distance value.

6 KICK SELECTION AND POSE TO KICK

Currently, we have implemented two modalities of kicking: one powerful and long-distance kick and one less powerful but quicker to execute.

While the former appears to be decisive to score, the latter is more adapt into dribble situation. We are also working on walking-the-ball skill, though it is still not yet reliable to use in official games.
Because of this small set of kicking moves, we decided to carry out the decision process with a series of rules to manually tune the right priority for the different kicks. However, we are now working more extensively with machine learning to refine our solution and include a broader range of scenarios.

For each kick type, the position behind the ball is calculated projecting the target behind the ball with the distance necessary to kick. Lastly, we add an offset for the horizontal position, choosing in this way to kick with left or right foot.

7 PAST HISTORY

Last November, we participated to the RoHOW 2016 in Hamburg. There, we were able to meet other teams and exchange good practices and updates with the SPL community. We also tested our code, particularly the walking on the new 8mm grass surface of the field. Moreover, we practiced the role of assistant referee for example in the Berlin United vs. the Hulks game.
Then, in November 2016, we sent our application to the RoboCup Committee, and qualified for the German Open 2017 and the World Cup 2017.
At the German Open, in Magdeburg, we won the first place in the Challenge Shield. We played 6 games and scored 7 goals, while loosing only 1 goal (to Berlin United). During the competitions all our team members participated as Assistant Referees for many games. We further exchanged ideas, and strategies with the other team present at the event.
We are now working towards the RoboCup World Cup 2017 in Nagoya, increasing our contributions to the B-Human code and moving towards more original input on our part.
We plan to organize friendly competitions in our own soccer field here in Luxembourg. This full size field built following the RoboCup 2017 specifications, finished in early January 2106, will allow us to start scheduling games for the Fall 2017.
Finally, we regularly organize demonstrations of our Luxembourg United team for public events. For example, during the "Football Hallelujah!" traveling exhibition at the Luxembourg Museum of History (MHVL), we scheduled a full afternoon public demonstration every month, at the museum for the whole 6-months duration of the exhibition. More recently, we reconstructed a full-size official field at the Springbreak fair, which attracts more than four thousand visitors, among which many VIPs such as the Grand Duke and Grande Duchesse of Luxembourg and members of the government. We proposed demonstrations of 3-player games.
Some highlights of past demonstrations are:

- May 3 - 7, 2017: We won the 1st place at the 2017 RoboCup German Open Challenger Shield in Magdeburg.

- April 23, 2017: Demonstration at the Springbreak Luxexpo fair.
- February 8, 2017: We performed our last demonstration at museum.
- November 13, 2016: Penalty shootout of our team at the Luxembourg Museum of History (MHVL) for the Netherlands vs. Luxembourg human soccer World Cup in Luxembourg.
- October 6, 2016: We organized demonstrations of kicking, passing ball and goal keeping at the "Museum Nights" (3500 visitors). We reconstructed half a field in the museum's atrium, and during six hours, we demonstrated the capabilities of our Luxembourg United robot soccer team, alternating autonomous modes and animations modes, e.g. cheer-leading and stretching.
- September 19, 2016: We reconstructed a portion of the official field, and brought in our goal for the Welcome Day 2016 of our university in Belval (5000 visitors).
- June 30, 2016: We were the 1st prize winner and were awarded the Favorite Project Award of Banque de Luxembourg for our Luxembourg United football team at the Mind and Market Innovation Forum competition organized by Luxembourg National Fund for Research (FNR), Deloitte and Luxinnovation.

8 IMPACT

The impact of Luxembourg United's participation and research in RoboCup 2017 extends from the SPL, to the community, the SnT, Luxembourg university and the whole country of Luxembourg.

8.1 Luxembourg United impact on SPL

Our qualification to the German Open 2017 and RoboCup 2017 brings a new team and a new country to the SPL community. Furthermore, as we built a field to not only develop and test our own robots, games and code, but also to invite other teams to friendly competitions, we contribute to the international expansion of the SPL. We plan for the future to organize a Luxembourg Open competition which would increase the impact of the SPL.
As a research team, we are in the process of developing and publishing our own research in specific related topics, and collaborate with the other SPL teams to bridge potential gaps, expand the state of art and deepen research.

8.2 Impact on Luxembourg University

Following are some of the impact of Luxembourg United's involvement in RoboCup on Luxembourg University and SnT research Center:

- Our Luxembourg United soccer team project is rooted in the SnT-University of Luxembourg. This expands their influence. They now joined the other international universities which take part to the RoboCup competitions such as Carnegie Mellon (CMU), ETH, Bremen, Linkoeping, APU Japan, etc.

- The SnT-University is gaining international visibility, attracting students, researchers and professors.
- While choosing the NAO league, Luxembourg United is contributing to:
  - Leverage the knowledge of our lab in this field.
  - Create the foundation for a deeper engagement in the other robots leagues, e.g., the @Home, particularly as we already own and work with the Pepper robot.
- To motivate students to become expert programmers and promote education to provide resources to the industry in Luxembourg, which is currently strongly lacking such resources.
- To support collaborations between SnT and Industries to develop industrial and commercial applications.

An important outcome from the Luxembourg United soccer team existence, is the set up of an Autonomous Robot Software course, which we designed solely around robot soccer RoboCup SPL challenges. Both Artificial intelligence topics as they related to robotics, and robotics are being taught in the course. Furthermore, we extend collaboration with other research group such as Optimization and Machine Learning. we tailor projects for these courses to use Luxembourg United as a use case. Students enrolled in these courses work on building further modules, testing and working on our code. Additionally, this is a good source of recruit.

Following the success of these courses, a new track is being considered by the faculty to allow students to: 1) get ECTS for project work on our Luxembourg United RoboCup project; and 2) enter the Bachelor program working on robot soccer, continue this work during the Master program, the PhD and post-doctoral positions. This will allow a continuity in the study related to robot soccer SPL activities through a sustainable program, and provide the students with long-term vision in this domain as well as motivation.

8.3 Impact on Luxembourg country

Luxembourg United is being funded by the SnT Interdisciplinary Center for Security, Reliability and Trust and supported by the University of Luxembourg. As mentioned on the team's website [5], a number of other sponsors, such as museums, Luxembourg Foreign Affairs Ministry, The Chamber of Commerce, EuroDNS, CargoLux and the City of Luxembourg are already supporting us. We are actively seeking further sponsors to sustain our activities and contribute to the country's development.

In the press section of our team's website [6], a number of print and web articles are listed, exemplifying the impact we have on the country's education, culture and transfer of knowledge and future technology.

Our Luxembourg United team contributes to Luxembourg international influence in the field of robotics, Artificial Intelligence, and technological (ICT) innovation. This corresponds to the axis the country has decided to champion for its current and future development.

[5] https://luxembourg-united.uni.lu/Sponsors

[6] https://luxembourg-united.uni.lu/Press

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