

# Luxembourg United Qualification Document for RoboCup 2017

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**Abstract:** This is the qualification document for the new team, and first team of Luxembourg, called “Luxembourg United”. This is also the team’s first attempt to qualify for a RoboCup competition. First, a general description of the Luxembourg United team is presented, along with its members and the equipment owned by the team. Second, the mixed team option is considered and potential eventualities suggested. Third, the Luxembourg United team thankfully acknowledges its use of the B-Human code, and lists its original contributions to this code as well as to RoboCup 2017. Fourth, The activities of the team that contribute to Luxembourg United are outlined. Fifth, the impact of the team’s participation and research in RoboCup is described as it applies to the SPL community, to Luxembourg University and SnT Research Center, and to the whole country of Luxembourg. We conclude this document with considerations pertaining to the path that brought us to RoboCup, and present futur perspectives.

## 1 TEAM INFORMATION

This is the qualification document for the new team called “Luxembourg United” headed by its team leader Dr. Patrice Caire. Luxembourg United was established in January 2016 with the aim of carrying out research in the fast growing fields of humanoid robotics, distributed artificial intelligence, human robot interaction (HRI), Localisation and navigation.

Luxembourg United aims to address all the relevant topics required to run and play autonomous soccer games in the Standard Platform League (SPL), while focusing on a subset of specific research areas. The Luxembourg United team is part of the Social Robotics Laboratory headed by Dr. Caire, itself part of Prof. Voos 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 Professor, one Research Associate, one external member, one PhD student, three

master students and two bachelor students. The qualification video is available at our Luxembourg United website “Events” page <sup>1</sup> and alternatively at the following address <sup>2</sup>.

- Holger Voos, Professor
- Patrice Caire, Research Associate, Luxembourg United Team Leader
- Sebastien Cagnon, External member
- Gary Cornelius, PhD student
- Yan Medernach, M.S. student
- Claudio Cimorelli, M.S. student
- Guendalina Palmirotta, M.S. student
- Alexander Eyjolfsson, B.S. student
- Ivan Tishchenko, B.S. student

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 look forward to apply this research to communication among robots.

<sup>1</sup><https://luxembourg-united.uni.lu/Events>

<sup>2</sup><https://vimeo.com/193756871>

We also plan to use some of our previous research relating to coalition formation (Caire et al., 2011; Caire et al., 2013a; 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., (Reichel et al., 2008; Voos, 2008; Wangmanaopituk et al., 2009; Voos, 2009; Wangmanaopituk et al., 2010; Wangmanaopituk et al., 2011; Voos and Wangmanaopituk, 2013; Wangmanaopituk et al., 2010; Li et al., 2015), as well as experience with UAV computer vision, autonomous driving and space robotics.

Finally, some of our previous work on norm negotiation (Boella et al., 2009; Caire et al., 2013b; Bikakis and Caire, 2014) would provide interesting input for addressing game strategy challenges.

## 1.2 Infrastructure

Luxembourg United is composed of the following robots:

- 1 Pepper
- 2 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 organise 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 MIXED TEAMS

We are very interested in participating in the mixed teams competitions. Indeed, we currently are a relatively small and new team. However, we are dedicated to enter the game and improve ourselves to be able to compete as soon as possible in full autonomous games.

During the RoHOW 2016 event, we met with a number of teams, and discussed the possibility to propose a mixed team. Although it is too early for us to specify to which team we could best contribute, we can however express our intent and pursuit to create a mixed team.

As mentioned in Section 1, Luxembourg United is building a field in its prestigious SnT Research Center in the heart of Luxembourg City European Headquarter, which conforms to the official RoboCup norms. This is an interesting aspect for our potential partner team. Indeed, this will allow our mixed team to play and test right on our premisses. As a central hub in Europe, our location is at an easy reach for many potential Partner teams from many European neighbouring countries.

## 3 CODE USAGE

### 3.1 Code re-use

Luxembourg United code is based on *B-Human* code release 2015. We use the special movement files previously released by *rUNSWift*, translated to the *B-Human* framework.

### 3.2 Research and advancements

Following the introduction of the black and white ball, we developed two new modules: a ball detection module and a tracking module. Due to the challenge of distinguishing the black and white ball from the field, we are trying different algorithms for detection.

The first algorithm consists of a combination of template matching and articulated ball model. It looks for the black spots on the ball in the image, and infers the position of the ball through the model, as shown in Figure 1.

The next step will be to assess feature based object recognition (i.e. SURF). We believe the features on the ball will make such methods robust.

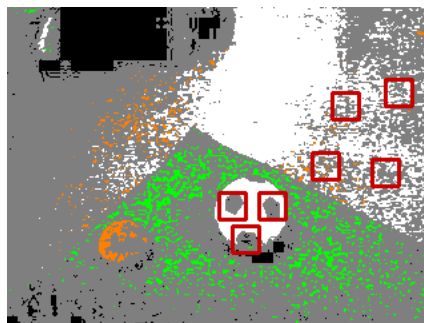


Figure 1: Example of filtered results for the template matching algorithm

Another module that we will implement is the walk engine which should take into account the height of the field surface and the stickiness.

Furthermore, we plan to develop a dynamic role assignment according to global strategy and battery optimization. Based on the outcome of the the first half of the game, we would like to choose either more aggressive or more defensive configuration of the team. Additionally, if the battery power decreases and becomes too low, the robot should try to go into a defensive role and keep its battery life to catch the ball.

Finally, we have extensively been testing different kinds of walk. Two of them being presented in our video available on our Luxembourg United website “Events” page<sup>3</sup> and alternatively at the following address<sup>4</sup>.

## 4 PAST HISTORY

We just participated to the RoHOW 2016 in Hamburg, where 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 specified field. Moreover, we practiced the role of assistant referee for example in the Berlin United vs. the Hulks game.

We plan to participate to a number of open competitions such as: Iran Open and German Open, and various local initiatives, particularly from neighbouring countries, such as Germany, Netherlands, France, Switzerland, etc.

Furthermore, we plan to organise friendly competitions on our own soccer field here in Luxembourg. This full size field built following the RoboCup 2017 specifications, will be finished by end of year (2106), which will allow us to start scheduling games in the first semester 2017.

Finally, we regularly organise demonstrations of our Luxembourg United team for public events. For example, once per month during the “Football Hal-lelujah!” travelling exhibition at the Luxembourg Museum of History (MHVL), we scheduled six public demonstrations, one each month, in the museum for the 6-months duration of the exhibition. Some highlights of past demonstrations are:

- November 13, 2016: Penalty shootout of our team at the Luxembourg Museum of History (MHVL) for the Netherlands vs. Luxembourg human soccer World Cup at the Luxembourg J. Bartell stadium. As we own seven robots, we created two teams of three robots: one for Luxembourg with

our jerseys, and one for the Netherlands, with orange jerseys. Luxembourg robot team won 3-2 whereas, at the J. Bartell stadium, the Dutch human team won 3-1.

- October 6, 2016: We organised demonstrations of kicking, passing ball and goal keeping at the “Museum Nights”. 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. The latter included some cheerleading and sport stretching animations. 3500 (three thousand and five hundred) enthusiastic visitors were counted by the museum; many watched from outside as we were demonstrating in the museum atrium, storefront to the street.
- 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. We demonstrated autonomous kicking behaviors, walking and goal keeping along with some animations. Five thousand students and guests attended the event.
- 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 organised by Luxembourg National Fund for Research (FNR), Deloitte and Luxinnovation.

Earlier events, and activities are described in Section 6, Events.

## 5 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.

### 5.1 Luxembourg United impact on SPL

Our participation to RoboCup 2017 brings a new team and a new country to the SPL community. Furthermore, as we are building 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 organise a Luxembourg Open competition which would increase the impact of the SPL.

<sup>3</sup><https://luxembourg-united.uni.lu/Events>

<sup>4</sup><https://vimeo.com/193756871>

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.

## 5.2 Impact on Luxembourg University

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

- As this Luxembourg United soccer team project is rooted in the SnT-University of Luxembourg, this expands the influence of the SnT-University, which are now joining the international universities participating to the RoboCup competitions such as Carnegie Mellon (CMU), ETH, Bremen, Linköping, APU Japan, etc.
- The SnT-University is gaining in international visibility, attracting students, researchers and professors
- While choosing the NAO league, Luxembourg United is contributing to:
  - Increase the leverage of the already acquired knowledge of the lab in this field, and
  - Be the base to a larger engagement in other robots leagues, e.g., the @Home, 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. Students are currently enrolled in this course and work on building further modules, testing and working on our code. Additionally from this course, we have been able to recruit one new student to work for Luxembourg United and two Master students who decided to do their thesis with Luxembourg United, on robot soccer SPL topics.

Following the success of this course, 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.

## 5.3 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 <sup>5</sup>, a number of other sponsors, such as museums, banks, innovation centres, incubators 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 <sup>6</sup>, 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.

## 6 OTHER

After a number of projects such as the ones described in our Luxembourg United website <https://luxembourg-united.uni.lu/Social-Robotics-Lab> on cooperation in Ambient Intelligent Systems, we started developing a number of demonstrations based on the Nao's interaction capabilities.

In June 2014 we started designing a set of demonstrations based on the cooperation between robots of different kinds, such as Humanoids and UAVs, thereby leveraging the knowledge of our Automation and Robotics Research Group in the domain. We then were able to test the robustness and safety of our systems by doing demonstrations to the public every hour, 12 hours per week, for six months (July 2015-January 2016) in the notorious Luxembourg museum of modern art MUDAM.

This experience helped us start our robot soccer team, Luxembourg United, and by May 2016, the

<sup>5</sup><https://luxembourg-united.uni.lu/Sponsors>

<sup>6</sup><https://luxembourg-united.uni.lu/Press>

team was awarded the first prize at the Mind and Market Innovation Forum by the Banque de Luxembourg. We then decided that we needed to invest in the necessary testing area. We planned a football field in our SnT Interdisciplinary Center for Security Reliability and Trust at the University of Luxembourg, situated next to a number of high-profile European Institutions. Simultaneously, we started recruiting and training new team members.

As a number of our Social Robotics Lab involve Human Robot Interaction (HRI), our interest in Pepper was a obvious. Based on the quality of our research with Nao, our laboratory was selected in June 2016 by Softbank Robotics to be among the first research institutions to receive a Pepper robot for research purposes.

We are currently using our knowhow in HRI, acquired through our work with Nao, to pursue further research with Pepper in the framework of our project with the City of Luxembourg for its Museum of History of the Ville de Luxembourg MHVL. This 3-year project aims at developing models and applications for a museum assistant interacting with the public. Further project perspectives involve mobile service robots in the areas of wellness, and various kinds of public buildings and institutions.

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