# LyonTech, Team Description Paper RoboCup@Home 2020 Social Standard Platform League

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https://robocup-lyontech.github.io/,
Qualification video : https://www.youtube.com/watch?v=6DnTP3k-580

**Abstract.** LyonTech consortium is ready and motivated for RoboCup @Home thematics. Strong of 2 successful participation in SSPL (Montréal 2018, Sydney 2019), we are ready for Bordeaux 2020. Our team gather : i) highly qualified researchers in several areas of robotics (robot navigation, robot control, computer vision); ii) a fruitful collaboration between researchers and engineers; iii) past participation in the competition; iv) the integration of a large number of highly qualified students from different engineering schools (eq. Universities); v) expertise on ROS and Naoqi frameworks; vi) software contributions on github.

## 1 Introduction

La Doua - LyonTech is the main technology campus of Lyon, France. This campus is home to 25000 students, 1500 researchers and 1200 PhD students. The LyonTech team members belong to three teaching entities, two research laboratories :

- CPE Lyon, Engineering school[1], former RoboCup team in 2013 and 2016
- INSA Lyon, Engineering school[1], candidate for RoboCup 2016 organization
- Chroma research team from CITI Lab., Centre of Innovation in Telecommunications and Integration of Service (INRIA)
- LIRIS, Vision and information system laboratory (CNRS)

[1] eq. University

This paper is organized as follows:

- Research and engineering interests
- Previous results and contributions to RoboCup and RoboCup@Home
- Our solutions for the SSPL
- Conclusion and references

## 2 Research and engineering competences

The LyonTech consortium consists of highly qualified teachers-researchers in computer science (AI, vision, navigation) working with students. Two laboratories are involved in the LyonTech team.

CITI is an academic laboratory associated with INSA Lyon and INRIA. The members involved in the LyonTech project are part of the "human-aware navigation and multi-robot systems" chroma team led by Olivier Simonin.

LIRIS is a laboratory of the *French Center of National Research* (CNRS) from University of Lyon. The members involved in the LyonTech project are part of the Computer Vision Group (*Imagine*).

The RoboCup@Home challenge is an opportunity for team members to work on their specialties (image analysis, navigation, robot fleet management). It helps them to define use cases to drive research focus. For example the cases of robot waiter and tour guide robot are directly considered in our study benchmarks for navigation.

## 3 Previous results and contributions to RoboCup and RoboCup@Home

We have participated the to the RoboCup competitions since 2013:

- "Lyon CPE" team : **$3^{rd}$ place at RoboCup@Work**, Joao Pessoa, Brazil, **2013**
- "CPE Robot Forum" team : **$15^{th}$ place at RoboCup@Home OPL**, Leipzig, Germany, **2016**
- "LyonTech" team : **$5^{th}$ place at RoboCup@Home SSPL**, Montreal, CANADA, **2018**
- "LyonTech" team : **$3^{rd}$ place at RoboCup@Home SSPL**, Sydney, AUSTRALIA, **2019**

Contributions at the robocup Symposium :

- People management framework using a 2D camera for human-robot social interactions, **Best scientific paper** [1], **2019**
- Towards S-NAMO: Socially-aware Navigation Among Movable Obstacles [2], **2019**
- Context Aware Robot Architecture, Application to the RoboCup@Home Challenge [3], **2018**

Additional contributions have been made to help the RoboCup organization and promotion:

- Lyon city and INSA was candidate for the organization of the RoboCup, in 2016 (co-led by O. Simonin from Chroma/CITI team).
- Fabrice Jumel (CPE Lyon/CITI) is a RoboCup@Home evangelist for France, linked with the application of Bordeaux for RoboCup 2020. He was OC chair and co-chair in 2018-2020 and TC of RoboCup@Home in 2017-2018 and OC member of RoboCup@Home since 2017.

## 4 Our solutions for the SSPL

### 4.1 Overview

The architecture of LyonTech's embedded AI software is shown in Figure 2. It contains modules which have been developed in different research groups of the consortium, completed by off-the shelf modules which tackle standard tasks, as well as engineering bricks interconnecting these modules. The scientific expertise of the consortium is broad and targets the needs of the competition:

**Perception** Our computer vision experts bring knowledge in gesture recognition [4], activity recognition from third person [5] and first person video [6], articulated pose estimation [7], semantic segmentation [8] and object recognition [9] ,see Fig. 1. A large part of these methods are capable of running on real time and have been integrated in our platforms of mobile robots. Our combined work allows us to be aware of the objects present in a room, their locations, as well as the ongoing activities in this room.

**Motion planning and Decision making** Our expertise in robotics relates to motion planning in dynamic and uncertain environments, mapping, localization and decision-making for single and multi-robot systems. The work focuses on autonomous navigation in crowded environments (human-aware navigation) and in urban traffic (autonomous vehicles) for human assistance [10–12]. We also explore robot fleet cooperation for human scene observation [13, 14], 3D environment mapping, transport and service delivery [15]. We experiment and evaluate the models with Pepper humanoids, fleets of mobile robots and UAVs, and two equipped/autonomous cars (see `https://team.inria.fr/chroma/en/plate-formes/`).

**Human-Robot Interactions** We have been working for years on different interactions with robots (from teleoperation to multi-robots orchestration [16, 17]).

**Integration** The ROS Middleware is used to integrate components (customized packages and LyonTech packages), set of functional block are orchestrated through a General manager [3]. The section 4.2 detailed the set of tools and software used. In addition, the naoqi sdk, provided by softbank/aldebaran with the Pepper robot, gives a set of API that is mainly used for Robot and Human interactions (speech recognition, text to speech, robot behavior

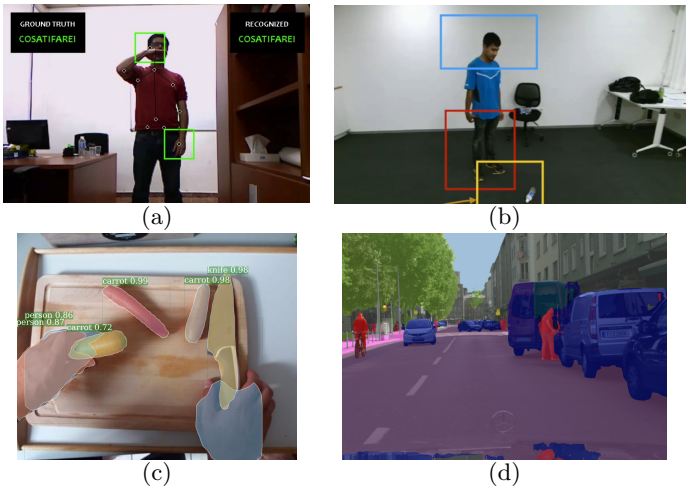


**Fig. 1.** Original recent work on visual perception done by the consortium: (a) gesture recognition [4]; (b) activity recognition with deep networks [5]; (c) first person activity recognition [6]; semantic segmentation [8].

feedbacks). In order to highlight the robot activity, the Pepper tablet gives visual feedbacks (javascript framework). We developped for sydney edition, a framework to combine speech recognition and tablet interaction capabilities. A innovative feature is to give feedback to operator on what is expected and give temporal information in order to improve the reactivity of the operator. During short trials, correct management of the operator is crucial to not waste time during interaction.
The Robot Navigation Manager is in charge of localizing the robot and allowing dynamic navigation (obstacles avoidance). The analysis of the robot environment is performed by Object Detection and recognition modules, mainly deep neural networks developed inhouse [9] or off-the-shelf modules like YOLO 9000 [18]. Labeled object positions are provided to other blocks. All human robot interactions are managed by the Robot Human interaction block embedded in the robot. The robot also maintains a knowledge database about its environment (humans, objects and points of interest positions). Finally, the general manager block works like an orchestrator and gives order to other blocks in order to achieve scenarios.

### 4.2 Contributions and $3^{rd}$ party dependencies

Our solution is composed of a mix of existing and customized solutions, as well as full contributions. We share a GitHub repository [19] pointing to every other repository as submodule.

#### Contributions

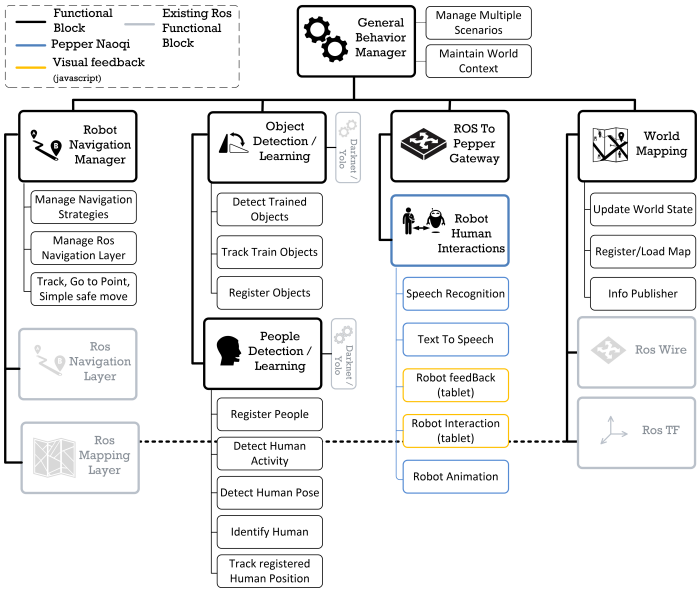


**Fig. 2.** LyonTech Software Architecture Overview

– **General Orchestrator*** **[3]** **[20]**: we developed a General Orchestrator allowing the robot to coordinate its capacities (navigation, perception, interaction) and make decision on defined scenario.
– **Navigation Manager*** **[3]** **[21]**: this functionality provide a set of navigation strategies depending on the observed context. Regarding to the context (lots of people, complex environment, large free space zone), the robot changes it way of navigation.
– **People Manager*** **[1]**: we developed a framework that allows the extraction of high-level person features from a 2D camera in addition to tracking people over time. The proposed people management framework aggregates body and person features including an original pose estimation using only a 2D camera. At this time, people pose and posture, clothing colors, face recognition are combined with tracking and re-identification abilities. These people features detection form also individual contributions:

- **Face recognition*** **[22]**: a solution was developed based on python module face recognition to automatically catch face and learn it for future detection.
- **Color detection*** **[23]**: we extract main colors of a given picture (e.g t-shirt, trousers) based on HSV format and K-mean clustering helping us to track people.
- **Pose detection*** **[24]**: based on the OpenPose data, we build a pose extractor gives us the estimate pose (stand, sit, lying down, left or right arm up,...) and even people distance.

**$3^{rd}$ party dependencies**

- Pepper navigation: Ros Navigation Stack, we reused the Ros Navigation Stack with configuration modification including: navigation optimization (mainly on local planner), costmap customization (including set of sensors like 3d. sensors)
- Pepper User Interaction: With Naoqi sdk, we use the different functionalities to interact with users including dialogue and tablet interactions.
- Pepper Perception:
  - Darknet Yolo: we use the deep neural network framework DarnetNet[25] with Yolo network
  - OpenPose: the OpenPose solution is used to detect human and estimate their position

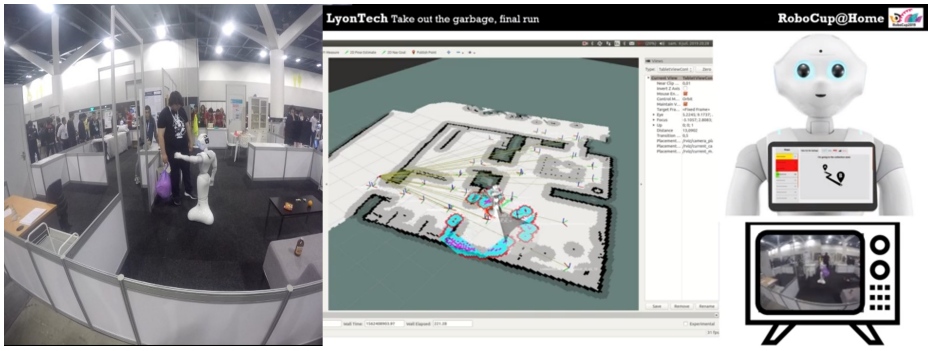


**Fig. 3.** Take out the garbage final run , SSPL Robocup@home Sydney 2019

## 5 Conclusion

We gave an overview of the approach which will be used by the LyonTech team to target the SSPL RoboCup@Home competition, including the different AI modules developed in the different research groups of the consortium. Fig. 4 and the video submitted with this paper present a scenario illustrating our ongoing work.

Based on our achievements (e.g. "Take out the garbage" trial, see Fig. 3) and our good result in Syndey (3th place in SSPL), we aim to achieve equivalent or better performances in Bordeaux, not only by improving the stage-one-like features, but also by keeping the vision of a more "general purpose" robot. We believe in the following strengths of the LyonTech consortium: i) highly qualified researchers in several areas of robotics which are vital for this competition (robot navigation, robot control, computer vision); ii) a fruitful collaboration between

researchers and engineers; iii) past participations in the competition which allowed us to gain valuable experiences; iv) the integration of a large number of highly qualified students from different engineering schools (eq. Universities).


**Fig. 4.** LyonTech robot capabilities including navigation, people detection (Yolo), object detect (customized Yolo), pose detection (openPose)

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