# LeonRobot Team Description Paper. RoboCup@home 2016

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**Abstract.** This report aims to show the capabilities of the Spanish team named Orbione-Bot gathered to participate in the RoboCup@Home competition. It shows the background of our team members, the robot that we will be used (RB1) and the contributions to the RoboCup@Home goals that we are expecting. It also describes our software architecture the visual object recognition system, our autonomous navigation based on RGB-D sensors, the dialogue module that includes context awareness, and the mobile manipulation abilities. These components have been tested in periodically open demonstrations held in our lab where we have built a mock-up apartment.

## 1 Introduction

The research goal of our team is how to create more acceptable socially assistive robots. RoboCup@Home competition will let us validate our results by external reviewers, and contrast them with other teams' ideas, before deploying them in real home environments, and after testing them in our mock-up home.

The background of our team in robotic competition is the Watermelon Project. This project was initiated at at the University León's Robotics Group in 2012. In 2013 the Universidad Rey Juan Carlos's robotic group joined the team.

MYRA - Mayores y Realidad Aumentada in Spanish ("Elderly and Augmented Reality" in English) was the code name given to the original project more than two years ago. The main goal was to build an assistance robotics platform that would be suited to the needs of old people, such as helping them to take the right medication at the right time. We intended to study the human-robot interaction using augmented reality, and a target demographic with usually little experience with robots or technology overall.

The Watermelon team was established at the end of 2013, in order to participate in the RoCKIn@Home camp that was going to take place in Rome on January the next year. Since the first moment, we focused our efforts on adding new software and hardware solutions, or improving the existing ones, in order to adapt MYRA for the competition. Thus the MYRABot robot [5] was created, and it has been continuously reshaped ever since.

## 2 Hardware Platform

Our team will enter 2016 competition using RB1 (see figure 1). It is a mobile manipulator built by Robotnik. The hardware description of our platform is presented at the end of this TDP and in Robotnik's web page [6] or in ROS web page [2].


**Fig. 1.** RB-1 platform. Left picture shows 7DOF Dinamixel arm, right picture presents the $JACO^2$ arm mounted on RB-1 torso (ready from April 2016, Image courtesy of Robotnik).

RB-1 is designed as a mobile manipulator for indoor environments. Its shape is similar to other robots as Fetch or Tiago, but RB1 mounts a 7DOF arm with Dynamixel Pro servos. Since March of 2016, RB-1 mounts a 6DOF $JACO^2$ arm with three fingers.

## 3 Scientific Contributions

### 3.1 Architecture

We have a three layer architecture based on ROS and BICA [1]. The lower layer corresponds to ROS, and is in charge of hardware management. The intermediate layer provides the robot skills in order to carry out specific duties (perception, navigation,...).

The top layer presents BICA. It is a component-based for generating behaviors architecture. This node coordinates the various capabilities of the robot

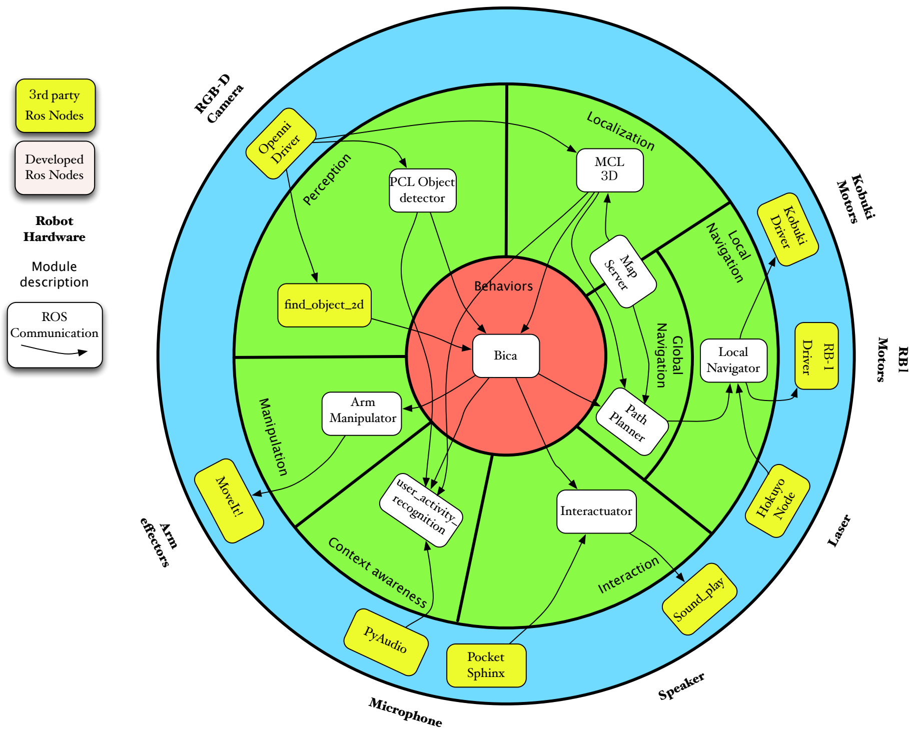


**Fig. 2.** Software architecture for RoCKIn competition.

depending on the task to be carried out by the robot. Figure 2 shows the overall architecture of the software we have developed for participating in the RoCKIn competition.

**Component-based Architecture for Behaviour Generation** The basic functional unit in our architecture is the Component, simple functional units that are executed iteratively at different rates. The main idea is to define components that perform just a single task, but very efficiently. A running component can activate other components, forming a dynamic hierarchy of components that implement a complete behaviour .

Components can be very simple or very complex. Simple components communicate with the underlying system methods to use sensors or motors, or some other components. Complex components can be implemented as a FSM, so the set of components that are activated depends of the current state.

Our approach uses only the required resources for a given task. When a component needs another, it explicitly calls its step() method. Components that are not being used by another component do not run, saving computing resources.

We have developed a useful tool to design these complex components. This tool generates the skeleton code for a behaviour modeled graphically. Figure 3 shows the implementation of a component as an FSM with nine states (yellow circles). In each state, another component (blue circles) are activated. From any component you can perform any communication with other nodes ROS.

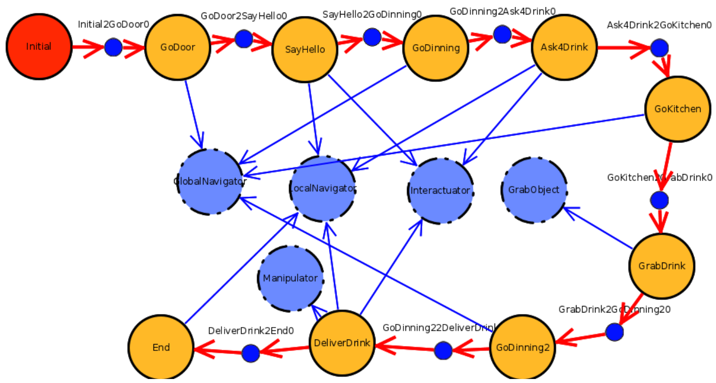


**Fig. 3.** Bica component implementing a finite state machine to define a high-level behaviour.

### 3.2 3D SLAM

We use our own self-localization algorithm based on 3D perception. Our approach consists of creating a 3D map of a cloud formed by RGB-D or ColorOctomap 3 points. When the robot is running, we use an algorithm to contrast the MCL RGB-D perception with the map to evaluate the population of particles.

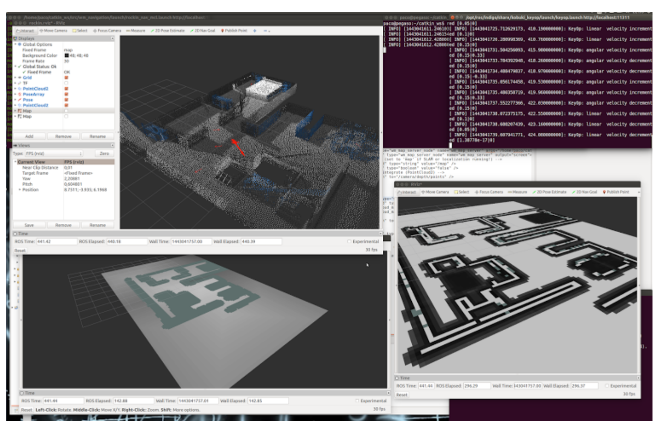

**Fig. 4.** Rviz and Gazebo running the first approach of our 3D visual navigation method.

### 3.3 Context Awareness

Context-awareness is a fundamental component in human robot interaction. Understanding the user activity context the robot improves the overall decision-making process. This is because, given a context, the robot can reduce the set of feasible actions. We consider that using an on-board microphone and gathering environmental sounds we can improve the context recognition.

For this purpose, we have designed, developed and tested a computational lightweight Environment Recognition Component (ERC). This component provides information to a Context-Awareness Component (CAC) that implements a hierarchical Bayesian network to tag user's activities based on the American Occupational Therapy Association (AOTA) classification.

The system implemented for real environment deployment works as follows:

1. The robot analyzes on runtime the environment situation and processes a set of observations.
2. For simplifying, the solution links each observation with only one action & operation. It makes that our four-layer solution became a three layers one.
3. With this information the robot calculates the conditional probability of an activity given an observation $P(A|o)$ instead of the action & operation nodes.
4. The conditional probability of the occupation nodes is defined by the associated activity $P(Oc|a)$.

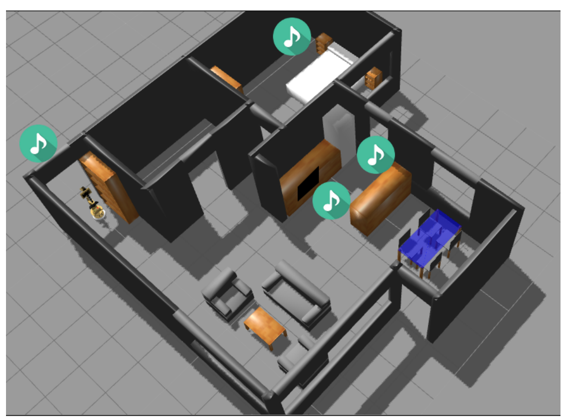

**Fig. 5.** There are different acoustic signals available in all the real environments: doorbell, oven, fridge, ...

### 3.4 Social Navigation

Navigating in a socially acceptable way is an important ability for mobile robots in populated environments that requires efficiently detecting and tracking humans to negotiate the space with. In particular, walking side by side is not a trivial problem that involves relative positioning calculations to the accompanying person taking into account the environment limitations (narrow corridors, turnings, etc.) as well as keeping its track towards its destination.

Our contributions and development in this field can be follow in [4].

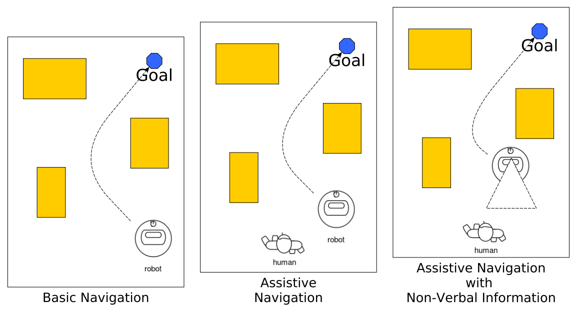


**Fig. 6.** Two methods of assistive tasks (attending the follow-me approach): guidance without users (non-follow-me), guidance with disregarded users (follow-me without attention) and guidance with attended users offering non-verbal information to user (follow-me with attention).

## 4 Contributions: Source Code Availability

We have different GitHub available to reach our solutions. As individuals it is possible to see our developments in:

- `https://github.com/fmrico`
- `https://github.com/FranLera`

As a team our developments are available after each competition in the next GitHub repository:

- `https://github.com/Robotica-ule/MYRABot`

To share information, methodologies and developments is one of our principles. Former members of our team have contributed with manuals in other fields as in PCL

- `http://robotica.unileon.es/mediawiki/index.php/PhD-3D-Object-Tracking`

## 5 Conclusions and Future Work

This TDP described the main developments of our team for the 2016 RoboCup@home competition. As in our last competition, we will participate with our robot RB1.

We also travel with our backup robot MYRABot, that is considered as our older team member.

In order to succeed in the RoboCup@Home league, at this moment we have provided to RB1 basic skills to perform dialogue (speech recognition), perception (object recognition and human tracking), navigation (SLAM, localization and global/local approaches), manipulation (grasping) and context awareness (environment activities recognition).

The skill set presented will allow us to introduce us at RoboCup@Home 2016 competition.

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## 6 Team Description

- Team name: LeonRobot
- Contact information: fjrodl@unileon.es
- Website: `http://robotica.unileon.es/mediawiki/index.php/RoboCup`
- Team members:
  - Jesús Balsa Comerón
  - Fernando Casado García
  - Jonathan Gines Clavero
  - Francisco Javier Gutierrez-Maturana Sánchez
  - Vicente Matellán Olivera
  - Franciso Martín Rico
  - Alvaro Moreno García
  - Francisco Javier Rodríguez Lera (team leader)

## 7 Hardware Description

- Robot name: RB1
  1. Base:
  2. Vision Sensors: RGB-D Xtion
  3. Range sensors: Frontal laser
  4. Dialogue Sensors: Directional microphone Rode Rycote , Loudspeakers
  5. Manipulation: $JACO^2$, 6 Degrees Of Freedom and a payload of 2,6 Kg (mid-range) and 2,2 Kg (full extension).
  6. Computer Description: Intel Core i7 with 8 GB of RAM and a 200 GB of disk
  7. Torso: +40
  8. Head: pan-tilt head.

## 8 Software Description

- Development framework: ROS
  1. Vision: ork, findobject
  2. Dialogue: Pocketsphinx
  3. BellRecognition: pyaudio
  4. Manipulation: MoveIt, self developements.
  5. Navigation: Ros stack, self developements.
- Robot Control: FSM using Bica