# Watermelon Project - Team Description Paper RoCKIn@home 2015

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***Abstract*—This document describes the developments of *Watermelon Project* team for the participation in the RoCKIn@home challenge, that will take place in Lisbon in November 2015. This Team Description Paper (TDP) describes: the team trajectory and the relevant research lines for facing the tasks of this competition. From the hardware point of view, we introduce here our RB1 platform designed and manufactured by Robotnik. We review its main characteristics and the capabilities for addressing service and assistive tasks. Attending the software solutions, we present here our contributions to face assistive tasks in home-like environments. This paper presents our preliminary results prior the competition.**

## I. Introduction

Watermelon Project team was originally created by the group of robotics at the University of León in 2012. In 2013 it was expanded with the addition of Robotics Group at the Rey Juan Carlos University.

Our original goal was to prove that a robotic platform could be created using low-cost materials. We wanted to validate it as a starter kit for robotics researchers in competitions like RoCKIn or other endeavours. The RoCKIn 2014 events allowed us to test our approach intensively, and introduce several improvements and fixes in our robot. Finally, we have concluded that this robot can be used in the labs for researching and for analyzing semi-autonomous behaviours in real homes.

MYRA (Elderly and Augmented Reality in Spanish) 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 formed 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 platform was created, and it has been continuously reshaped ever since.

With the robotic platform MYRABot we have participated in all the events organized by RoCKIn. For this final event, also we plan to test our algorithms in the robotics platform RB-1, which is more robust and advanced than MYRABot. Figure 1 shows both robots in our lab.

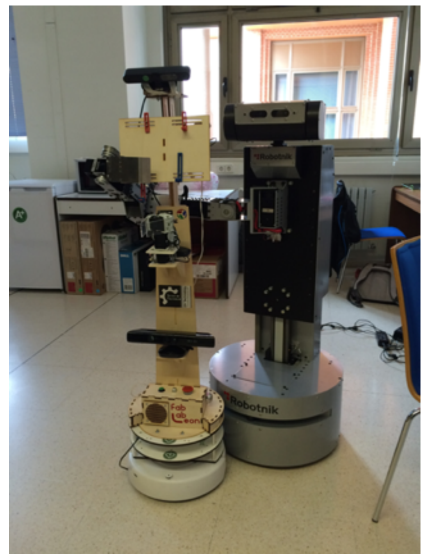


Fig. 1. MYRABot and RB-1 Robots

Throughout this document we will enumerate the current features of MYRABot and RB-1, including the improvements that have been integrated since the last RoCKIn event that took place in Toulouse last November.

The paper is organized as follows: Section II reviews our experience in robotics competitions and a brief description of team members. Section III introduces our new robot RB1 and highlights its hardware characteristics. Section IV focus on the software solutions implemented to our platform. The next section presents our RoCKIn plan and the safety requirements of our platform. Finally section VI presents the conclusions of our RoCKIn approach.

## II. Team Description

The Watermelon Project team is composed by members with previous experience in robotic competitions. Before participating in RoCKIn, they have been involved in the RoboCup Competition, in the 4-legged League and the Standard Platform League (SPL). They have been participating in these competitions since RoboCup 2005, which took place in Osaka


Fig. 2. RB-1 Robot

(Japan) until RoboCup 2011. The Watermelon Project team was born with a small roster of MSc and Ph.D. students from the ULE robotics group, mainly.

Watermelon Project team has participated in all previous RoCKIn editions: a) Camp Eindhoven 2013, b) Camp Rome 2013, c) Competition Toulouse 2014, and d) Camp Peccioli 2013.

During this process, we have published different scientific contributions associated with the evolution of our MYRABot platform [6],[8], [5].

### A. Team Members

**Francisco Lera** is a Ph.D. student in Universidad de León, creator of MYRABot and prime mover of the project.

**Fernando Casado** is a Ph.D. student specialized in electronics and hardware, and currently manipulation and grasping

**Francisco Martín Rico** is a Ph.D. from Rey Juan Carlos University (URJC), with a long experience in robotics competitions such as RoboCup SPL. His many contributions include the behaviour control system.

**Vicente Matellán** is a Professor in Universidad de León. Overseer and leader of the ULE Robotics Group.

## III. Robot Hardware Description

We plan to attend the RoCKIn@Home challenge in Lisbon with RB1 robot (Fig. 2). The platform is a mobile manipulator designed and manufacture by Robotnik [10], [4]. The Technical specification document[11] enumerates its main physical characteristics.

RB1 mobile platform has a differential drive steering. The platform mounts 2x200W servomotors and holds on 2 additional castors. The system with 4 contact points is hyperstatic, so 2 additional suspensions are mounted to adapt to the floor unevenness.

The robot mounts a Hokuyo URG-04LX-UG01, a 2D laser range finder for navigation and localization. It also has gyro board for enhancing navigation tasks.

The platform has an anthropomorphic manipulator with a configuration of 7 DOF and one parallel gripper. The arm workspace is defined by the 3D space situated on robot front, and it reaches until 700 mm. It has a payload of 1.5kg at its full extension and it is estimated about 4Kg in the half range.

The robot mounts a two degrees of freedom pan-tilt unit for the environment perception by means of an ASUS Xtion PRO Live RGBD Sensor.

The platform also has 1 DOF to elevate the torso up to 360 mm. It raises and lowers the robot torso, with its arm and head. This feature allows the robot to interact with objects situated at different heights. For instance the robot can fetch an object from the floor and it drop the object on a table.

The height of the robot is bounded between 1020 mm and 1391 mm. It has a round shape of 500 mm diameter. When its arm is folded, this area covers robot footprint, so this characteristic improves its movements at home. The overall robot weight is defined by Robotnik specifications as about 60 kg.

The platform is controlled by Robot Operating System (ROS). Robotnik releases a set of drivers to manage RB1 hardware. The manipulator can be controlled through MoveIt! In addition, Robotnik provides the Gazebo model to test our developments before to deploy them in real environments.

## IV. Software Description

Since the beginning, Watermelon Project Team has been using ROS as main control framework for our developments. Due to ROS characteristics and our architecture design, we can migrate our previous software developments to RB1 robot. This section describes the updated status of our software approach.

### A. Architecture

We have a three layers 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

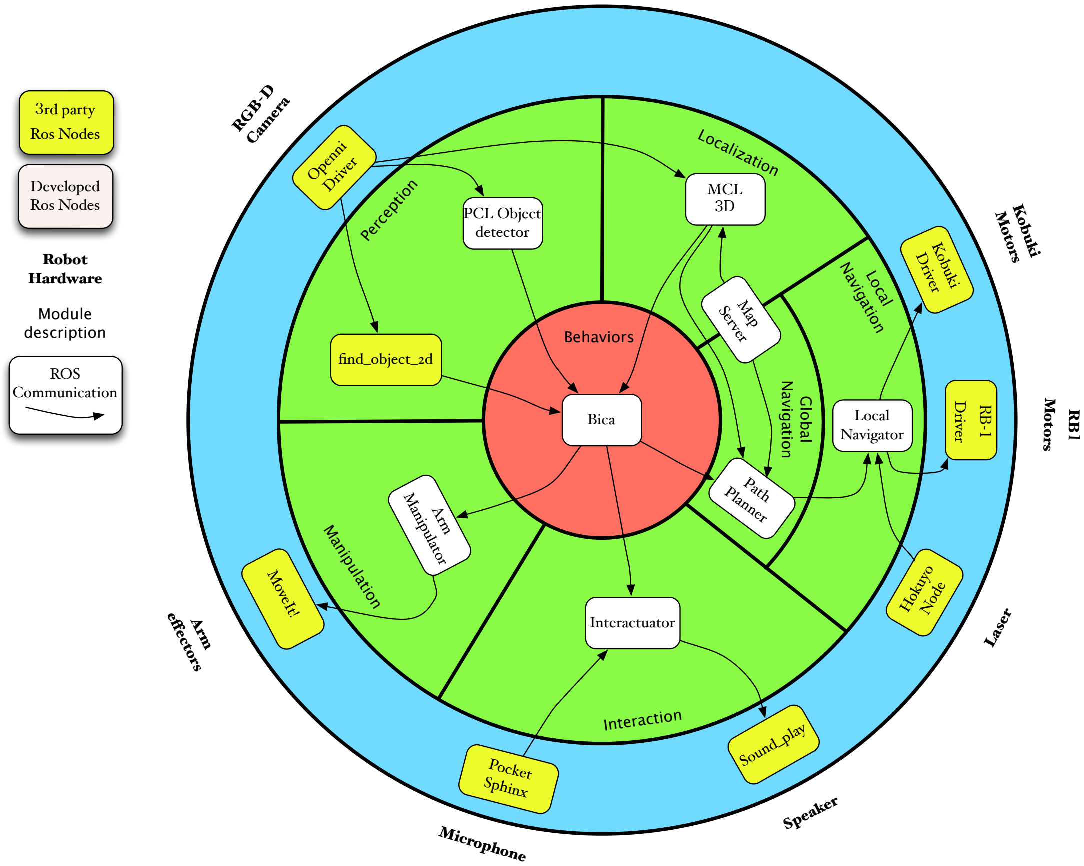


Fig. 3. Software architecture for RoCKIn competition.

robot skills in order to carry out specific duties (perception, navigation,...). The top layer presents Bica. It is a component-based for generating behaviour s architecture. This node coordinates the various capabilities of the robot depending on the task to be carried out by the robot. Figure 3 shows the overall architecture of the software we have developed for participating in the RoCKIn competition.

*1) Component-based behaviour Architecture:* We use a component-based architecture [1] to generate robot behaviour s. We recently started the integration of this approach to our platform for avoiding big and complex finite state machines (FSMs) developed ad-hoc in each ROS node.

Figure 4 describes the implementation scheme of a robotic application using our approach. There can be multiple ROS nodes containing components of our architecture, which communicate with other ROS regular nodes. Besides ROS communications, ICE can be used to interconnect any component with other processes or even to debug graphics applications.

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 .

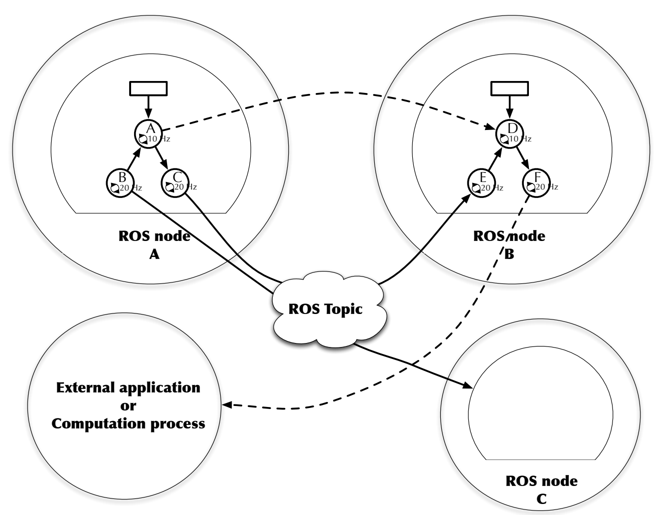


Fig. 4. Bica implementation inside ROS nodes. Solid lines represent ROS communication, and dashed lines ICE.

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 modelled graphically. Figure 5 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.

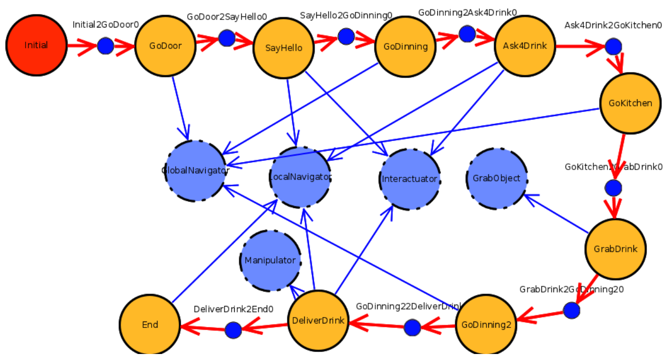


Fig. 5. Bica component implementing a finite state machine to define a high-level behaviour.

## B. Perception

We make intensive use of 3D perception. Both MYRABot as RB-1 are equipped with RGBD Asus Xtion cameras. The position of each of the cameras is perfectly modeled by transformations from its base, so that the result of perception is independent of the platform used.

Apart from navigation tasks, the perception is used for the detection and recognition of objects. For this task, we have used two alternatives.

Our first approach was to use a simple object detector called find_object_2D developed by Mathieu Labb [9]. This is ROS package that uses OpenCV with SIFT or SURF descriptors and detectors, and it is 2D based only. This approach works well, although it is focused on flat objects, not being suitable for estimating the position and orientation of objects planes.

We have developed a new system for the Object Perception Functionality successfully tested last RoCKIn camp performed in Peccioli. This 3D solution uses PCL (Point Cloud Library) and a custom recognition pipeline with global descriptors such as CVFH [2] to detect and classify objects in segmented clusters. Objects are trained from CAD models, created by hand, using multiple views.

## C. Navigation & Mapping

In previous editions of RoCKIn competition, we have integrated the 2D navigation stack from ROS[7]. This package offers, among others, adaptive Monte Carlo Localization, local and global planners, a costmap node for navigation, and a move base one that uses Trajectory Rollout and Dynamic Window approach.

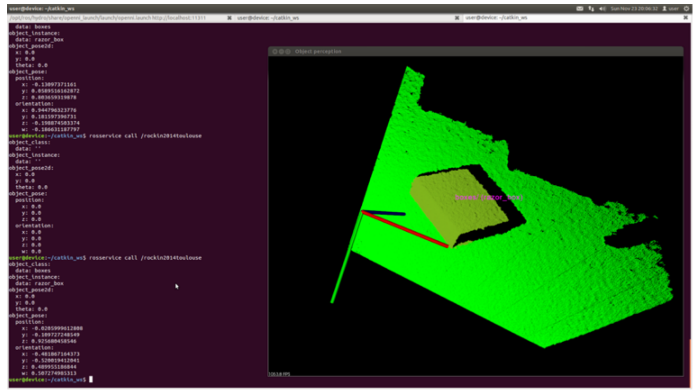

Fig. 6. Screenshot of our perception system running in lab environment.

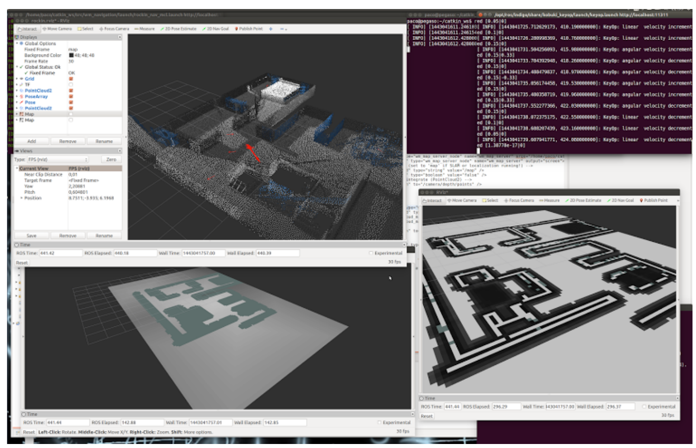

Fig. 7. Rviz and Gazebo running the first approach of our 3D visual navigation method.

For the next edition, we are planning to 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. During operation of the robot, we will use an algorithm to contrast the MCL RGB-D perception with the map to evaluate the population of particles.

## D. Manipulation

Next RoCKIn we will use the RB-1 robot, which is equipped with a manipulator arm with 7 DOF. The arm mounts a gripper to perform manipulative interactions. With this kind of end-effector the manipulations task are limited to: grasping, lifting, pushing, pulling, placing and dropping. The lifting related tasks can be applied to objects up to 1kg of weight.

The robot was designed to perform torso height adjustments. We have performed different manipulation experiments in order to analyze the right torso height for developing the functionalities in an assistance environment. These experiments have included both perception and grasping steps for measuring the performance of the manipulation task. Figure 8 shows one of these experiments.

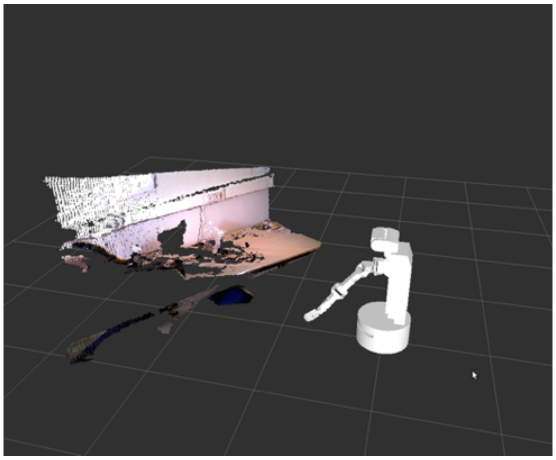

Fig. 8. Screenshot of Rviz application during the RB1 manipulator experiment.

## E. Dialogue System

The verbal human-robot interaction is performed under the same circumstances than previous challenges. However, we have changed our Automatic Speech Recognition software. We have changed the PocketSphinx solution to Sphinx solution due to its good performance in offline recognition tests.

Now, our dialogue system is made up by three components.

1) Automatic Speech Recognition Component (ASR): This component is in charge of translating spoken words into text. The system uses the CMU Sphinx Open Source Speech Recognition Toolkit, in particular the PocketSphinx engine for online speech recognition and Sphinx for offline recognition. The key points of CMU Sphinx solutions are: a) The ASR should be speaker-independent, and b) The speech recognition should have a well-defined vocabulary corpus directly related with the context, in our case the RoCKIn tasks
2) Voice generator Component (VG): This component binds with the Festival library. The Festival solution is a speech synthesis system that offers a general framework for building speech synthesis systems. It is multi-lingual but we only use the English voice package.

# V. RoCKIn Plan

*1) Hardware Specification::* RoCKIn2015 is the first competition for RB1 robot. Its features fits with the "General Specifications and Constraints on Robots and Teams" proposed by RoCKIn committee.

The platform characteristics as size or weight allow its deployment in a home-like environment. It accomplishes the rulebook restriction of "Safety Check" integrating the Emergency-Stop button (figure 9). This mechanism will be used if the referee perceives that a robot has a potential to hurt an individual or cause harm to home assets. When someone triggers this button, the system cuts the power to all joints of our platform. Under these circumstances, the robot can be moved (pushed) by team members to the area outside the RoCKIn arena.

Fig. 9. Emergency-Stop button.

*2) Benchmarks:* We are going to take part in the three functionality benchmarks proposed by RoCKIn: object perception, navigation and speech understanding. In addition we are working to participate in two of the functionality benchmarks proposed by RoCKIn: welcoming visitors, and catering for Granny Annie's comfort.

# VI. Conclusions

We have described the main characteristics of our team for the 2015 RoCKIn competition. We will attend this challenge with RB-1 platform. This platform provides us a more stable platform to take part in competitions benchmarks than our previous low-cost robot MYRABot. We have also presented the software novelties deployed in our platform. Our website maintains updated information about Watermelon Project team and our software development.


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- University of León


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