CPE Lyon Robot Forum, 2016 Team Description Paper

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Abstract. Numeric convergence around robotic of service and IoT (Internet Of Things) lead our school to highlight the robotic thematic. To do so, several actions have been taken; the emergence of a formal robotic major and a research focus on Human and Robot Interaction. Participating in the Robocup@Home challenge becomes obvious to increase our experience in the robotic fields and to build a high level experimentation platform for both teaching resources and research purpose.
Robocup@Home is for us an opportunity to share Human Robot Interaction experience, discover current state of the art on effective robotic platforms and associated solutions. In addition, it is a gentle way to expose and discuss about our current research and get feedback from an involved and skilled international community.
With our experience in the robotic field, we are fully invested in the Robocup@Home challenge, both in engineering and research works.

1 Introduction

In the field of service robotics, Robocup@Home brings excellence and passion together. We want to take advantage of it in both teachings and research. In order to improve our teaching, we based our student robotic projects on sub Robocup@Home Challenges like, people identification, voice localization, voice recognition, environment mapping, arm motor control, text semantical analysis. These problematics improve our students skills in the following robotic thematics: vision, navigation, sensors data fusion, robot modeling. Students feel more involved in their project when their are integrated in a big picture. The Robocup@Home challenge offers us this central goal. Human and Robot interaction research is still open. Currently focused on this thematic, the creation of an experimental platform becomes mandatory to validate our theories. Based on the Robocup@Home objectives and constraints, we hope that our platform will well reflect reality concerning robot and human cohabitation.

Thanks to more than 5 years experience in robotics around ROS (real robots and simulation), a first robotic competition experience at the Robocup@Work in 2014 (third place) and strong research involvement (both on Human Robot Interaction and Robotic & Health), we are fully invested into the Robocup@Home challenge.

This paper is organized as follow:

- Research and engineering interests
- The team
- Robot description
- Robot software description
- Current results
- Work in progress

2 Research and engineering interests

2.1 Teaching skills

Our project is linked to CPE Lyon, a private institution that holds the status of a non-profit association. Although CPE Lyon is a "Grande Ecole" in French Higher Education system, we intend to federate in a close future with some other institutions among the universities of Lyon. CPE Lyon offers a new "robotics of service" major, based respectively on software developpement for robotics (the robotic framework ROS),embedded systems, and a bit of mechatronics. The courses are based on a lot of practical work on different platforms and, to finish their training, students have to work on a robotic project. Robocup@Home is a convenient opportunity for students to work on a challenging global project, so we decided to keep working on this Robocup@Home project in the next years. Our major receives from 25 to 40 students every year, and it has about 400 hours of courses distributed along two semesters. This is a list of the robotics plateforms on which the students work: Baxter, Youbot, Turtlebot, ArDrone, NAO, ...

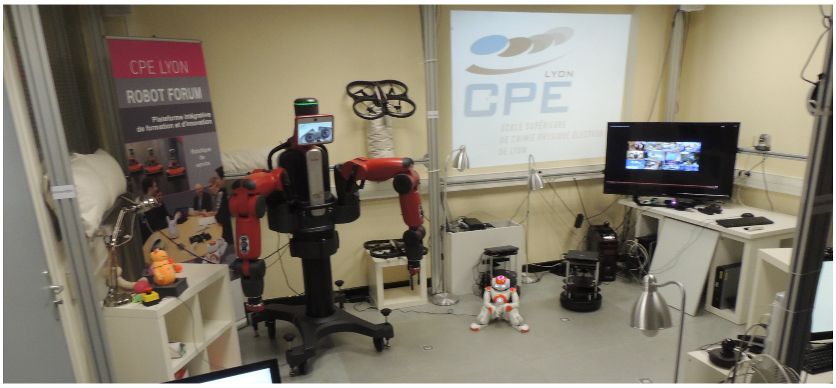

Fig. 1. Smart room including various robots

2.2 Research interest

Members of the CPE Lyon Robot Forum are involved in research laboratory. Jacques Saraydaryan and Fabrice Jumel are associate members of the Chroma team (`https://team.inria.fr/chroma`) (leads by Olivier Simonin) in the CITI INRIA Lab (`http://www.citi-lab.fr/`). They work on management of fleet of robots in crowd environments and developed a general framework called "robots waiters problem", in which a fleet of robots has to distribute services (could be an interaction, such as delivering an object, food or drink) to a crowd in a fair way [1].

Robocup@Home is for us an opportunity to work on a real robot with unlimited cases of interaction between the fleet of robot and people.

Fig. 2. Robot waiters

Additional collaboration has been established with the INL lab (`http://inl.cnrs.fr/`), a biomedical sensor team. This collaboration aims to discover how to improve desease detection with the help of sensors and robotic information. Current works focus on building a living lab acting as a robotic exoskeleton in order to measure relevant human activities [2,3,4].

Moreover, in our previous work, we proposed an architecture of service which acts as a hub of robots, sensors and actuators services. Having in mind the heterogeneous communication and service composition, we introduced and developed a middleware, allowing service discovery and composition [5].

3 Robot Description

The robot moves using a commercial mobile base (it also has a spare base, designed from scratch, using a electrical wheelchair). The arm and the torso were entirely designed by our own. The figure 3 presents some pictures of main robot parts. In addition, the figure 4 shows the set of devices used for the Robotup@Home challenge.

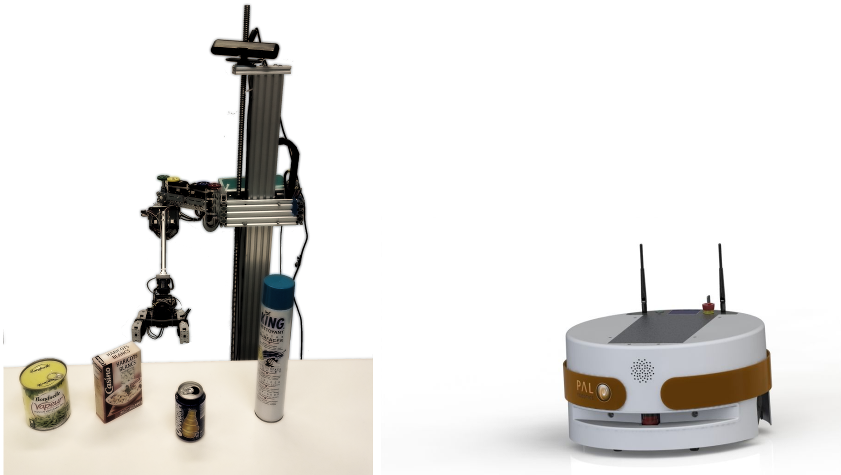

Fig. 3. The Robot

The robot is composed of the following parts:

– Base: Pal Robotic PMB-2, 1m/s max speed, 0.54m x 0.54m x 0.3m, 50kg payload
– Laser Sick Tim561 for the navigation purpose
– Torso: Prismatic movement over 1m (DC motor and and a ball screw.) .
– One central arm: Mounted on torso. 6 DOF, revolute joints with MX-106 and MX-64 Dynamixel motors, Maximum load: 1.5 kg.
– Head: Expressive Eyes
– Robot dimensions; height: 1.5m (max), width: 0.6m depth 0.6m
– Robot weight: 40kg.

Furthermore our robot has the following devices:

– Kinect v2 for people detection and tracking
– Asus Xtion Pro Live for object detection
– Homemade gripper (at this time, based on 4 AX-12 dynamixel motors)
– Lot of proximity sensors
– Homemade microphone for sound localization (based on ST MEMS MP34DT01)
– 2 Shure PGA81 microphone and one ART Dual Pro USB for analogical to digital conversion

4 Robot's Software Description

Our robot is mainly based on the ROS middleware. ROS offers the ability to connect a set of programs through synchronous and asynchronous communication. Moreover, by allowing a set of heterogeneous components (probes, actuator, services) to communicate in a normalized way, processing program can be reused.

the figure 5 shows the different bloc of the software architecture.

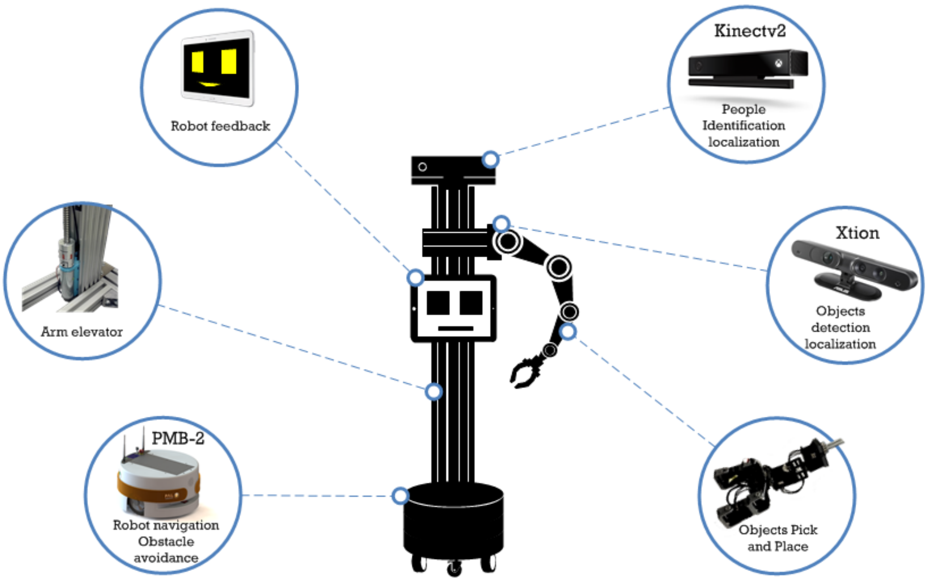

Fig. 4. The Robot devices

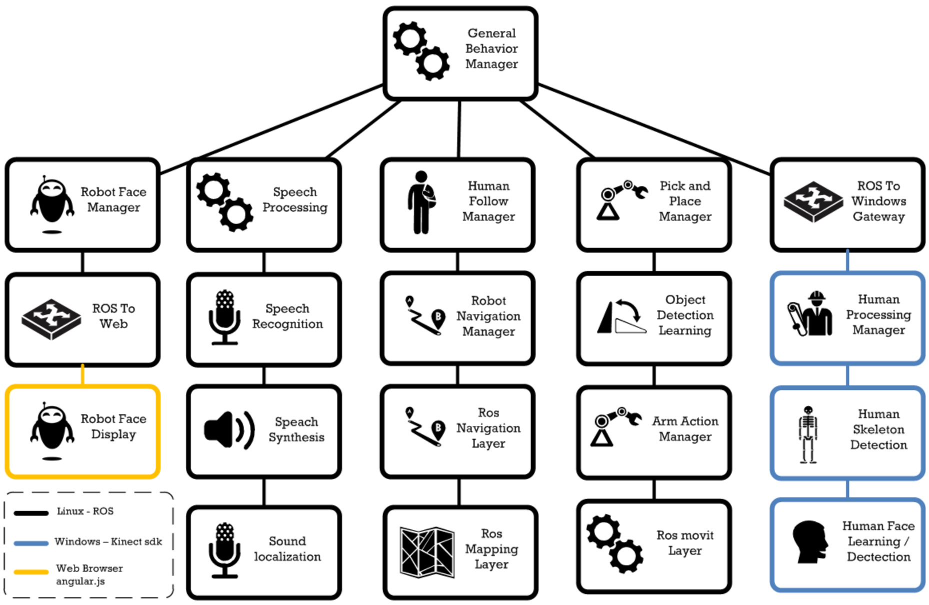

Fig. 5. Robot Software Architecture

4.1 Human Processing

In order to interact with human, our robot needs to collect information about people around. To do so we used the Kinect v2 from Microsoft to capture a set of human information. The main advantage of this sensor is the ability to detect human joints and associated orientations. The Human processing part is made in Windows according to the Kinect v2 sensor constraints. We used the Kinect v2 sdk to process human skeleton detection, human face detection, human face orientation detection. In addition we use OpenCv base face detection and identification processes. By detected human skeleton and associated face (RGB image) where are able to filter data for face identification processing (OpenCv). All information are sent to the general Behavior Manager with the help of TCP socket between linux (ROS) computer and Windows host.

4.2 Robot Navigation

Our robot navigation is mainly based on ROS navigation layer. This tools allows the robot to map the environment (occupancy grid), and navigate on it (A* on global map, global cost map) avoiding dynamic obstacles (local cost map). A human follower planner has been created to allow the robot to follow a targeted people. The program take into account the current human position and manage a security distance between the robot and the human.

4.3 Human and Robot Interaction

Our robot should interact with human. To do so, a processing chain allows the robot to localize voice source, filter other noise, transform the voice into text, and processing the text to convert it as order for the robot. To improve the interaction, set of feedback between the person and the robot can occurred involving a text to speech node and Robot Face Management.

For the voice recording we use conjointly the Honda HARK technology (sound localization) and Nuance Recognizer product (Voice to text). Nuance product will be also used for Text to speech operations.

Human needs to get feedbacks to understand each other. Robot should communicate its current "feeling" and what it's expecting to do. A dedicated node is in charge of collected information from the General Behavior Manager, getting current and future global actions and robot states (in action, expected order, in failure...). This data is converted into associated visual that are provided to a web-based application (angular.js)

4.4 Robot Pick and Place

The subset arm & gripper movement is ensured by different controllers including one homemade. These controllers are linked with the Ros Moveit Tool. To succeed a pick and place action, we developed an Object Detection program based on a composition of pictures and points cloud processing approach (SURF,3D object recognition) from open source libraries such as OpenCv and PCL. Our object detection algorithm is an incremental process that detects all flat surfaces (using ORK Tabletop library), then a surface selection is applied based on the RGBD camera viewfinder. When a surface is selected, only 3d points of objects above are kept and segmented. This step allows us to group for each objects associated cloud points and rgb image. Finally a set of object detection algorithms is applied (e.g OpenCv surf, Pcl point cloud comparison).

Our robot arm is a 7 DoF (1P + 6R) custom arm made of 1 prismatic joint (elavator) and 6 revolute joints. The prismatic joint is moved by a DC motor and a ball screw. Thanks to this joint, the robot can reach objects on the floor or on a top shelf (1m80). The 6 revolute joints are made with MX-106 and MX-64 Dynamixel motors. The shoulder design make it cost-effective and energy-effective. The arm payload is 1.5Kg in the worst position (straight) The arm is controlled with moveit and use invert kinematics

5 Current results

The first version of the object detection and the grasping are operational. We are able to detect and take objects previously learned and stored into database (RGB picture and Point Cloud). We developed a first stage grasping strategy based on ROS move-it for the arm trajectory and a homemade solution for the grasping. The tracking of people is performed by a Kinect v2. A set of tests were performed with a Kuka Youbot mobile base. A preliminary solution for people detection, based on face recognition, is already functional. Navigation with ROS solutions has been used for years in the lab with Kuka Youbot and Turtlebot devices. Preliminary tests had been performed for sound detection, speech-to-text and natural language analysis. Command analysis and questions recognition are near to be functional with front positioning of the speaker. A primary version of a 360 degree sound localization system is also ready. A first Speech recognition (pocketsphynx) and a text to speech (espeak,mbrola) solution had already been tested. Development is in progress to integrate the commercial solution of Nuance.

6 Work in progress

At this time (Mid February), we are waiting for the PMB-2 mobile base (which will arrive in March), so we will be able to integrate the arm on the mobile base and start the global tests, including speech order recognition. We consider that our robot will be completely operational in May, being able to succeed the major part of the stage 1 tests. The work in progress is the following:

- Navigation tests with pmb-2 base;
- Improvements on obstacle management (link with human detection);
- Speech to text and sound detection functionality in real and noisy situation;
- Improvement of Object detection and grasping from floor to shelve;
- Overall function block integration.

7 Conclusion

In the current paper, we present an overview of the approaches used by the CPE Robot Forum team to target the Robocup@Home competition. We present our robot composed of a commercial mobile platform, sensors and a 7 DoF home made arm. The robot software mainly based on the ROS framework communicates also with Web Application and constructor specific Framework (Kinect SDK). Despite it is the first Robocup@Home competition for the CPE Robot Forum, a lot of work has been done to reach Robocup@Home qualification. Major efforts will be made in the next month to propose a full competitive robot.

Such platform will signification improve our research experiments. Moreover, it will becomes an opportunity to target new research challenges an be an elegant Proof of Concept of what an autonomous robot could be for our students.

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