UChile HomeBreakers 2015 Team Description Paper

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http://www.robocup.cl/athome.htm

Abstract. The UChile HomeBreakers team is an effort of the Department of Electrical Engineering of the Universidad de Chile. The team has participated in the RoboCup @Home league since 2007, and its social robot Bender obtained the @Home Innovation Award in 2007 and 2008. As a team with strong expertise in robot vision, object recognition, and human-robot interaction, we believe that we can provide interesting features to the league. This year our main research focus is object recognition and its manipulation, because one of the principal abilities of a service robot is the interaction with objects. For this reason the team incorporated a new manipulation system, using the ROS package MoveIT!, and carried out a comparison among object recognition methods. Another important improvement in our social robot is a new face that allows it to more easily display emotions. Additionally, a long-term memory to store non-redundant information about people and objects with which the robot has interacted, as well as places and dates where sessions have been carried out, was implemented.

1 Introduction

The UChile robotics team is an effort of the Department of Electrical Engineering of the Universidad de Chile in order to foster research in mobile robotics. The main motivation of the team is working on the continuous development of technologies for service robots and thus participate in international competitions of robotics, in which the team can acquire and share knowledge with other research groups, and test the quality of technology developed. In addition to testing and showing progress achieved in competitions, the team conducts industrial projects, publishes papers and provides educational activities with children.

2 Background

The team is involved in RoboCup competitions since 2003 in different leagues: Four-legged 2003-2007, @Home in 2007-2014, Humanoid in 2007-2010, and Standard Platform League (SPL) in 2008-2014. UChile's team members have served

RoboCup organization in many ways (e.g. TC member of the @Home league, Exec Member of the @Home league, and co-chair of the RoboCup 2010 Symposium). One of the team members is also one of the organizers of two Special Issue on Domestic Service Robots of the Journal of Intelligent and Robotics Systems.

As a RoboCup research group, the team believes that its contribution to the RoboCup community is not restricted to the participation in the RoboCup competitions, but that it should also contribute with new ideas. In this context, the team has published a total of 30 papers in RoboCup Symposium (see table 1); in addition to many other publications about RoboCup related activities in international journals and conferences. Among the most important scientific achievements of the group are obtaining three RoboCup awards: RoboCup 2004 Engineering Challenge Award, RoboCup 2007 @Home Innovation Award, and RoboCup 2008 @Home Innovation Award.

This year we will continue using our social robot, Bender, which obtained the RoboCup @Home Innovation Award in 2007, 2008 and in 2012 obtained the 6th place in the RoboCup competition. For the 2015 competitions, the main improvements in Bender hardware and software are: a new object manipulation system, a new face that allow shows emotions better and a long term memory.

Robocup Articles	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Oral	1	2	1	1	2	3	2	2	-	-	1	1
Poster	1	1	1	-	3	2	-	-	2	1	2	1

Table 1. UChile articles in RoboCup Symposia.

Bender has been used as a lecturer for children [1], as a robot referee for humanoid robots [2], and a natural interface for Internet access [3]. Finally, it is worth to mention that during the last 8 years Bender has given talks to more than 2,000 school children. Also Bender frequently participates in public technology trade fares and events for promoting technology among children and the general public (see Figure 4).

Table 2. Bender participating in trade fairs and events.

3 Research

3.1 Object Recognition for manipulation task

The recognition and manipulation of objects is of paramount importance in service robotics. Recent approaches used in service and/or domestic robots are mainly based on a pipeline that first detects horizontal surfaces (e.g., a table or the floor) for restricting the search area of the possible object's positions, and then it computes features in order to recognize the objects.

In this context, we believe that it is important to analyze the performance of these different approaches in domestic setups by considering real conditions. Those conditions must include variability on the typical objects to be manipulated in domestic contexts, variable illumination, dynamic backgrounds, occlusions, among others.

3.2 Long Term Memory

An important aspect of human-robot interaction is the capability of the robot to acquire, store, and update its knowledge of a working environment. This includes the ability to remember places and dates, recognize people from previous interactions, and identify objects that it had manipulated in the past. Furthermore, the robot should be able to use this information in order to maintain a relationship with humans.

For this purpose an episodic long-term memory model has been developed. This model enables the robot to collect, in a database, autobiographical memories in order to improve its capabilities in social behavior based on past experiences, since they can be stored and retrieved.

4 Experiments and results

4.1 Object Recognition for manipulation task

Different setups are used for evaluating the performance of the different object recognition methodologies under comparison [4]. The possible setups differ in the following conditions: (a) image background: white(S1,S2,S5) / brown(S3) / different backgrounds(S4); (b) Illumination: normal(S1,S3,S4,S5) / low(S2); and (c) occlusion: no occlusion(S1,S2,S3,S4) / 50% occlusion(S5).

Recall/Precision results are shown in Table 3. The mean of the results of recognition of one object shows that VFH is the method with the highest recall, but L&R SIFT is the best visual method by having a good recall and an excellent precision. Methods obj_rec_surf and obj_rec_surf seg require a considerable processing time and have a limited precision, then the L&R SIFT variants perform better.

	SIFT	SURF	SIFTseg	SURFseg	OR-SURF	OR-SURFseg	VFH	OUR-CVFH	Hist.	SIFT-VFH
S1	0.76/ 0.96	0.39/ 1	0.53/ 0.98	0.24/ 1	0.84/ 0.72	0.82/ 0.51	0.63/ 0.58	0.64/ 0.65	0.45/ 0.56	0.78/ 0.91
S2	0.36/ 0.97	0.09/ 1	0.21/ 1	0.06/ 1	0.29/ 0.70	0.27/ 0.41	0.67/ 0.58	0.69/ 0.65	0.29/ 0.53	0.66/ 0.88
S3	0.31/ 0.96	0.12/ 0.91	0.21/ 1	0.04/ 1	0.19/ 0.57	0.25/ 0.40	0.72/ 0.75	0.67 0.69	0.02/ 0.27	0.61/ 0.78
S4	0.22/ 0.92	0.03/ 1	0.21/ 0.94	0.05/ 1	0.17/ 0.75	0.29/ 0.53	0.67/ 0.72	0.67/ 0.70	0/ 1	0.66/ 0.88
S5	0.58/ 0.98	0.31/ 1	0.44/ 0.99	0.21/ 1	0.57/ 0.77	0.65/ 0.43	0.29/ 0.25	0.22 0.21	0.22/ 0.31	0.58/ 0.85
Mean	0.45/ 0.96	0.19/ 0.98	0.32/ 0.98	0.12/ 1	0.42/ 0.70	0.46/ 0.46	0.6/ 0.58	0.58/ 0.58	0.20/ 0.53	0.66/ 0.86

Table 3. Recall and Precision of object detection on a table.

4.2 Long Term Memory

Regarding to the long-term memory's storage system, this allows the robot acquire, filter, store and update episodic knowledge of its working environment. In particular, the robot is able to store in a database non-redundant information about people and objects with which it has interacted, as well as places and dates where sessions have been carried out.

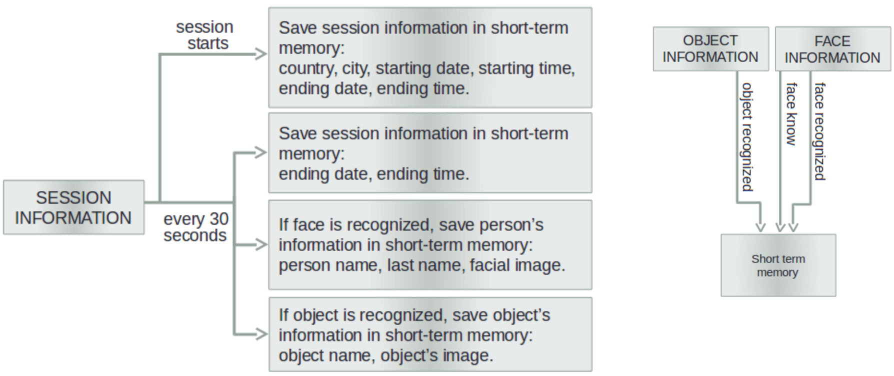

Table 4. Block diagram for long-term memory

5 Conclusions and future work

In this TDP we have described the main developments of our team for the 2015 RoboCup competitions. As in the last RoboCup competition, this year we will participate with our personal robot, Bender, which has been developed in our laboratory. In order to succeed in the RoboCup@Home league, we provided Bender with capabilities such as speech recognition, object recognition, face detection and recognition, navigation and obstacle avoidance, map-generation and self-localization, and object manipulation, among others. With these abilities and an improved set of hardware, Bender will hopefully have a good demonstration at the 2015 @Home competitions. This year, we have three important improvements in Bender: a new manipulation system, a new face that shows emotions better, and a long-term memory storage system. In addition, improvements were made in people detection using HOG, and the former device used, RGB-D (kinect and a camera), was exchanged for an Asus Xtion Pro Live.

For future work, we are conducting research on the following topics:

- The development of a high-level behavior system for the robot that uses the stored information in the long-term memory. This will allow the robot a better interaction with people, where long term relationships can be established.
- Incorporation of HARK library for sound preprocessing before performing recognition, with the PocketSphinx module, in order to locate the voice source, therefore providing robustness against noise.

Robot Bender Hardware Description

We have improved our robot Bender for participating in the RoboCup @Home 2015 competition. The main idea behind its design was to have an open and flexible platform for testing our new developments. We have kept that idea in our improvement. The main hardware components of the robot are (see Figure 1).

Specifications are as follows:

- Base: The whole robot structure is mounted on a mobile platform. The platform is a Pioneer 3-AT, which has 4 wheels, provides skid-steer mobility, and is connected to 2 Hokuyo URG-04LX lasers for sensing. This platform is endowed with a Hitachi H8S microprocessor. Two notebooks Dell Alienware are placed on the top of the mobile platform with the task of running the navigation and vision modules.
- Chest: The robot's chest incorporates a tablet PC as processing platform; an HP 2760p, powered with a Core i5-2520M Processor (2.50 GHz, 3 MB L3 cache, 2 cores/4 threads) and 4 GB DDR3 PC3-10600 SDRAM (1333 MHz). The tablet includes 802.11bg connectivity. The screen of the tablet PC allows: (i) task of running the speech and manipulation modules and (ii) visualization of relevant information for the user.

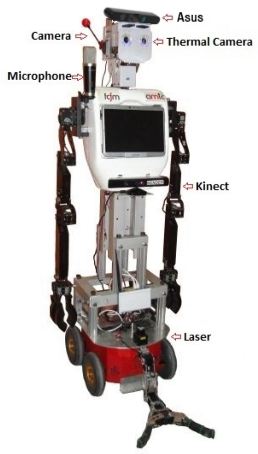

Fig. 1. Robot Bender

- Left and right arms: Mounted on torso. 7 DOF, anthropomorphic, The arms of the robot are designed for the robust manipulation of objects. Each arm has seven degrees of freedom, three in the shoulder, two in the elbow, one for the wrist, and one for the gripper. The actuators are 8 servomotors (3 MX-106, 2 RX-64 and 3 RX-28). The arm's weight is about 1 kilogram, made with carbon fiber.
- Head: The robot's head incorporates two cameras, one standard CCD Camera (Logitech HD webcam c270), and one thermal camera (FLIR TAU 320 thermal camera [5]). The head is able of pan-tilt movements and has the capability of expressing emotions. This is achieved several servomotors that move the mouth, eyebrows, and the antennas-like ears, and RGB LEDs placed around each eye and cheeks. The head movements and expressions are controlled using a dedicated hardware (PIC-based). The head's weigh is about 1.6 Kg.
- 3D Vision. The robot is powered with a Kinect sensor placed below the robot's chest and a Asus Xtion Pro Live over its head (see Figure 1). These devices allow for people detection, obstacle detection, flat surface detection, and also for object detection while grasping.
- Gripper-Arm. A gripper-arm is designed to allow the robot to manipulate objects at the floor level (see Figure 1). The gripper-arm has five degrees of freedom two in the shoulder, one in the elbow, one for the wrist and one for a dual opening gripper. The actuators are 5 servomotors (3 RX-64 for the shoulder and elbow and 2 RX-28 for the wrist and the gripper). The gripper-arm is also controlled directly from one Alienware notebook via USB. The arm's weight is about 1.2 Kg.

Robot's Software Description

The main components of our software architecture are shown in Figure 3. Vision tasks (object, face and gesture recognition), take place in one Alienware notebook, while the Navigation and Mapping module run on the second Alienware notebook. Both notebooks use Ubuntu 14.04, and they communicate with each other using ROS Indigo [6] (see Figure 2). The Speech, Manipulation and Head modules are running in the HP 2760p are also controlled through ROS.

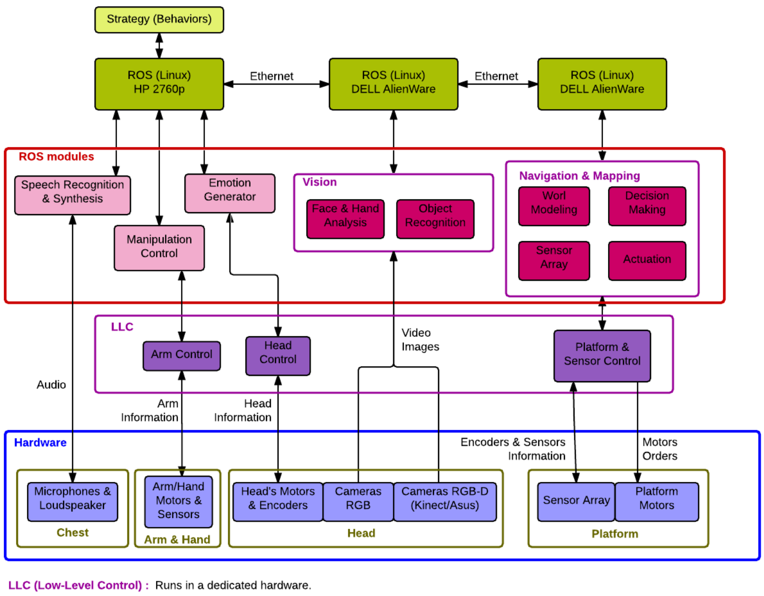

Fig. 2. Software architecture

For our robot we are using the following software:

- Navigation, localization and mapping: ROS is used to implement the functionalities required by the Navigation and Mapping module, among them localization, collision avoidance and logging, map building, and SLAM. For localization, an AMCL particle filter (autonomous monte carlo localization) is used. For navigation, a 2D costs map, with Dikjstra for overall planning and Dynamic Rollout for Local planning, is used.
- Face detection/recognition: These nodes are implemented using our own algorithms [7]. The latest addition to this Module is the robust detection and recognition of faces using a thermal camera [8] [9].
- Speech recognition: Speech Recognition is based on several languages models and dictionaries used together to improve the accuracy of the recognition.

These functionalities are provided by PocketSphinx [10] and a plugin for GStreamer [11] [12].

- Speech synthesis: To implement Speech Synthesis the Festival software [13] is used. For speech synthesis a second node is used (from a package ROS called sound_play) to make the text to speech synthesis.
- Object recognition: We use a combination of SIFT L&R and VFH. In this hybrid method, the SIFT algorithm is applied it over a subset of the image, obtained by detecting a planar surface in the depth image and then selecting only the blobs that are upper than the plane. If the blobs remain not identified, the VFH algorithm is applied on them. This algorithm is able to use both visual and shape information.
- Arms control and two-hand coordination: MoveIt a ROS package is used to communicates with the robot to get current state information (positions of the joints, etc.), get point clouds from the robot sensors and to talk to the controllers on the robot.

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