UTBot@Home 2018 - Use of the robots Pioneer LX and Pionner AT to emulate emotions and manipulate objects*

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Abstract— **This TDP describes the hardware and software implemented to allow Pioneeer robots available at UTFPR to execute domestic tasks related to the Robocup@Home initiative. The robots used are one Pionneer LX research robot (also known as "Z"and one Pionner AT(a.k.a. "Apollo"). These robots have sensors, such as a laser scanner and a Kinect 3D sensor, that are used to execute navigation, object recognition, environment mapping, auto-localization, and object manipulation. The robots are programmed to execute various Robocup@Home tasks, such as voice recognition, and object manipulation (using a robotic arm). An innovative human-robot interaction interface, using different facial expressions based on simulated emotions, is also presented. All the programming uses ROS (Robot Operating System), so that the same control programs can be executed in both robots with minimum alterations.**

I. INTRODUCTION

Robocup@Home is a competition that aims to foster the development of robots that will help people in domestic environment, being the biggest competition for service robots on the planet [1] [2]. In order to perform household tasks, human-robot interaction, navigation, map construction on dynamic environments and computer vision are under development, among many other fields of robotics [1].

To accomplish these tasks, two Pioneer research robots are being used: an Pioneer LX (aka "Z") and an Pioneer AT (aka "Apollo"). Both robots are being programmed with ROS (Robot Operating System), and a set of software libraries and tools that help to develop applications for robotics [3]. The decision making are being developed using the LIDA (Learning Intelligent Distribution Agent) framework, based on a conceptual model of human cognition, which in turn implements the Global Workspace Theory (GWT). The control system of the robot is responsible for acquiring and interpreting various sensors used in both robots and, from these data, make decisions to fulfil its tasks.

In this document, the partial results and expectations of projects under development for the robots are presented. Section 2 presents a description of the robots hardware, including their specifications and characteristics. The software already developed, and what is still in development, are described in section 3. Conclusions and future perspectives for the development of the robot are presented in section 4.

II. HARDWARE OF THE ROBOTS

A. Robots Specifications

One of the robots used as base for the project is the Pioneer LX, which is a research platform based on the industrial robot Adept Lynx. This 60 kg robot can carry up to 60 kg of payload, and travel at a maximum speed of 1.8 m/s, and has a autonomy of 13 hours of continuous operation. The dimensions of the Pioneer LX robot are: 50 cm wide, 70 cm deep and 45 cm high. A computer with Dual Core 1.8 GHz processor, 2GB DDR3 RAM and Wireless Ethernet are included inside this robot. The final assembly includes the sensors detailed on the next topic, as well as a Genesis TAD model GT-7305 tablet, with a resolution of 1280x720, which is used to display faces simulating the robot's current emotions. Figure 1 presents this robot.

The other robot, based on a Pioneer P3-AT research robot, is a simpler and more easily transported research robot. It weights only 12 Kg, with 12 Kg of payload, and maximum speed of 0.7 m/s. Its autonomy is of 2 hours, with 3 12 volts standard batteries. Its dimensions are: 50 cm wide, 50 cm deep and 28 cm high. Inside the robot, a computer similar to the one found inside the Pionner LX also controls this robot. Figure 2 presents this robot.

B. "Neck"Support

On each robot's surface is a support constructed of aluminium (as seen in Figures 1 and 2). These supports have 1,2 meters, allowing for the positioning of the tablet and the Kinect sensor close to a height comfortable to interact with people (1,5 meters approximately, in both robots).

C. Sensors

Some sensors are also embedded in the robots: "Z" has a 270-degree rangefinder laser sensor, with a high precision and big range (up to 25 meters) [1]. In addition to this sensor, that is used for localization and mapping, a Kinect depth sensor has also been incorporated. With this sensor it is possible to create a deep image, identify silhouette of persons, and objects, among other functions [5]. In order to establish the communication between the Kinect sensor and ROS the Openni Kinect open source project was used[6]. The data generated by Kinect and the laser sensor that are published in topics in ROS are key to the operation of most

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of the algorithms used in this project, since it is from the interpretation of these images that the robot takes a large part of its decisions. “Appolo” does not have the same high quality laser sensor, but uses a low cost laser sensor in its place.

Fig. 1. Pioneer LX (aka ”Z”) with its articulated arm, kinect sensor and the tablet that is used to present simulated emotions.

III. Software

A. ROS-Robotic Operating System

Each robot has a control notebook with the Kinect version of ROS, on the operating system Ubuntu 16.04 LTS. ROS is a system that has several tools, libraries and conventions that simplify the development of complex and robust tasks for robots [3]. In this system, you need to run a core process, *roscore*, which function as a server that manages threads and nodes. Topics are data buses through which nodes exchange messages, and multiple nodes may subscribe to each topic (receiving its data) or publishing to it (sending data). Nodes are computational processes, that process data coming from some topics, and publish results to other topics.

Each robot has its kinematics calculated, and the integrated encoders provide velocity feedback by communicating through a serial-usb cable with the notebook, where it publishes and receives data through ROS. Each robot’s notebook is configured to be accessed by secure shell (SSH) protocol from other computers so it can be monitored remotely over a wireless network. In addition, the ROS configuration to work with multiple computers [7] allows part of the processing to be done on another computer, being possible to split the processing just by attaching other notebooks to the robot, if necessary.

Fig. 2. Pioneer AT (aka ”Apollo”) with its support for the kinect sensor, and the tablet that is used to present simulated emotions.

B. Emotion Simulation

Emotions are demonstrated in the robot through faces according to the present situation, for a better visualization and interaction between robot and user. Emotions were based on Plutchik’s wheel of emotions [13], presented in figure 4. A tablet running the ROS Image Viewer application displays these faces by subscribing to a ROS topic. Figure 3 illustrates an emotion being displayed by the robot through the tablet.

Fig. 3. Simulated Emotion being presented on the tablet(face) of the robots.

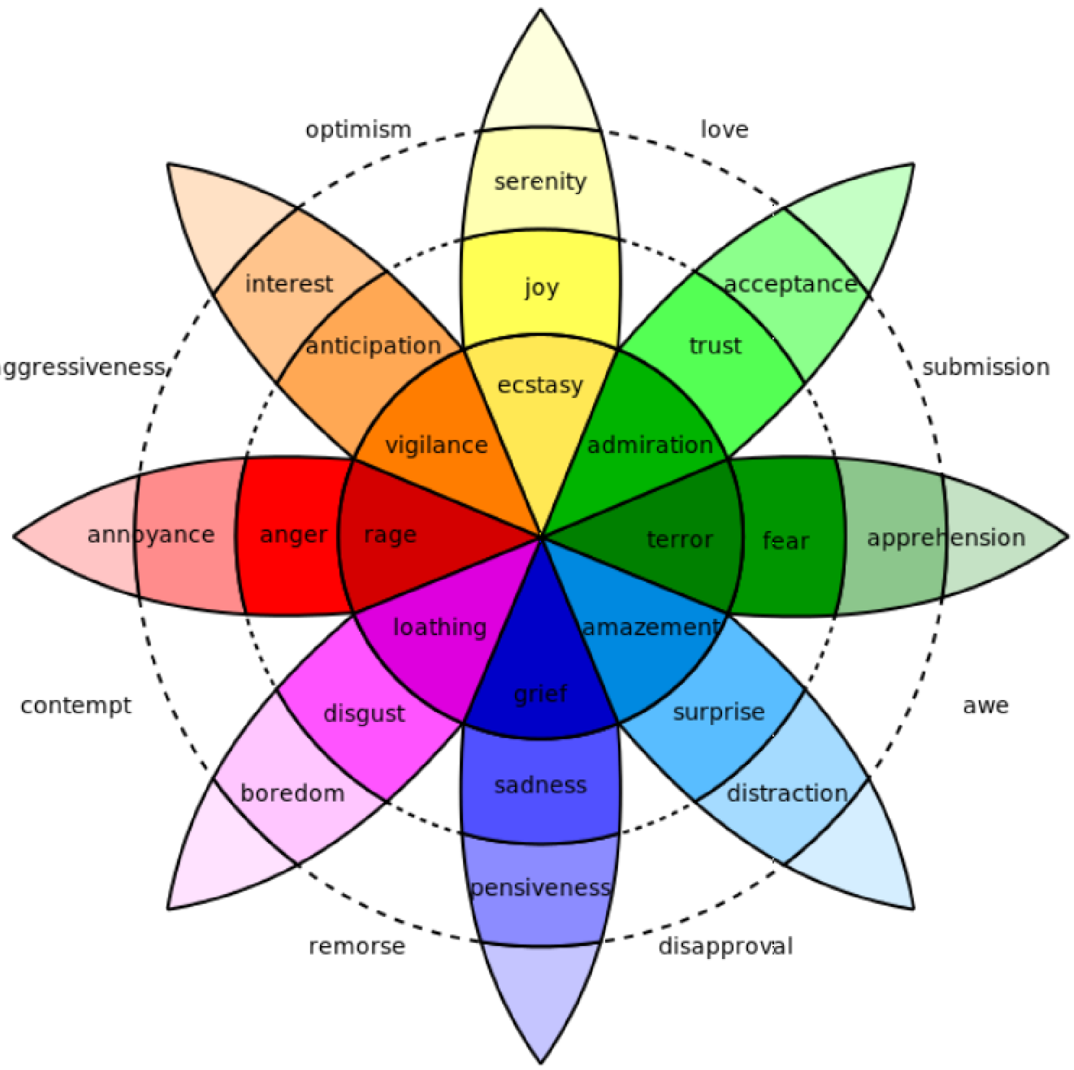

Fig. 4. Wheel of Emotions as presented by Plutchik.

Fig. 5. Examples of faces developed.

Figure 5 depict some of the faces developed to express different emotions during the interaction with people.

C. Simultaneous Localization and Mapping

Using the encoders data and correcting the estimated current position of the robot using autonomous location packets based on the laser sensor and Kinect readings, it is possible to calculate an approximate relative position of the robot. The robot observes the environment in order to create a model (map) of the environment. Measurements are then made through these observations to identify where the robot is and are defined landmarks that help the robot to locate itself within the map. Any map error will propagate errors in the location, but fortunately, location estimation errors correlate. These correlation errors are corrected through the Extended Kalman Filter (EKF) system [8], which manages to store the correlation between all estimation errors and makes the location dependent only on the initial location uncertainty of the robot.

The use of SLAM (Simultaneous Mapping and Mapping) [9] has been implemented in the robot, a technique used by robots and autonomous vehicles to construct a map of an environment at the same time as it is localizing itself. To accomplish this, SLAM has a number of tasks: extraction of reference points, data association, state estimation, status update, and reference point update. For this, among other functions, it uses the EKF. This implementation was done using ROS ready-made functions, of which the parameters were adjusted so that navigation performed well.

D. Voice recognition and synthesis

For speech synthesis, a ROS package called *espeak_ros* is being used. This package, which reproduces male and female voices, in English and Portuguese, works by running a ROS node that subscribes to the topic *speak_line*, and performs voice production based on the specified parameters. The configuration of these speech parameters is done through the *dynamic_reconfigure* package, which allows you to change parameters on ROS nodes without having to restart them. The configuration of the speech parameters encompasses several speech characteristics, such as speech speed, volume, tone (more severe or more acute), space between words, age and intonation variation. By altering these parameters, we are studying to demonstrate emotions in the robot according to the situation in which it is and in accordance with the faces displayed on its “face” (which is a tablet). The figure 3 demonstrates the result of changing these parameters, with the face presenting a simulated ”joy”emotion. Voice recognition will be performed with the PocketSphinx package [14].

E. Object Recognition and Manipulation

It is studied the use of an object recognition package, still under development, that uses the OpenNI Kinect package [6] for data collection of Kinect and an algorithm that processes and analyses the data captured. Both robots have manipulation arms capable of tasks such as gripping and positioning of small objects. The integration of the object recognition libraries and the manipulation control nodes are still in active development, but it is expected that by the time of the competition, this integration would be already finished.

IV. Conclusions and Future Work

With the current work, it is already possible to carry out several of the tests of the category Robocup@Home successfully, and it is expected, until the date of the competition, to achieve even more satisfactory results. Among the tasks to be developed are the more accurate recognition of voice commands, and the integration between maps used for navigation (SLAM). The interaction with people is expected to be the main innovation of this year robots, using the newly developed facial expressions to provoke an empathic response from people interacting with the robot. Also, some initial experiments with object manipulation are expected to be performed during the competition.

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