Augmented Reality in Robotic Assistance for the Elderly

Francisco J. Lera, Víctor Rodríguez, Carlos Rodríguez and Vicente Matellán

Abstract The basis of this research was to create a platform for social interaction based on augmented reality, ready to be deployed in the homes of elderly people. Two main components are presented: the first one is an affordable robot platform built from TurtleBot robot. The second one is the underlying software system built on top of ROS, in charge of the interaction interface and the user tasks, called MYRA. The purpose of this study is to test the platform and the augmented reality in real environments and how it can be used effectively and without complications by elderly people. With this goal in mind we prepared our platform to be able to do two different tasks: a generic assistance system, and a drug dose control system. Both were tested in a real environment.

1 Introduction

Social robotics have been growing up during the last years, in particular in the field of assistance to the elderly in everyday environments. The Ambient Assisted Living (AAL) association was founded in September 2007 and stablished a new European funding programme for research and technological development. Not all projects applied to this programme, but it has served as an inspiration to explore

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new ways to improve the quality of life of the elderly, or the technology that is related to them.

Our proposal, a prototype that could help elderly in daily tasks, is not a novel solution like the one that we can see in [1]. In this work, the authors made a categorization of assistive robots for elderly in two groups: rehabilitation robots and assistive social robots. In the second group we can find the service-oriented robotic platforms as the robot Flo [2], the nursebot Pearl [3], RIBA robot [4] or Hector [5]. Other new plataforms as Florence [6] or Giraff [7] were introduced during last years under the AAL projects and have been tested in some elderly homes during last year around europe. The category of companion robots is included in assistive robots, there we can find AIBO robot from SONY, the more recent Paro [8], the Huggable [9] or the Homie [10]. In our case, the robot has been designed to assist caregivers in the control of medication of elderly people using augmented reality.

The Augmented Reality [11] (AR from now on) is a live view of a real-world scenario whose elements are augmented by computer-generated information such as sound, video, graphics, etc. In this article, we suggest that the use of AR applied in a robotic platform can improve the lives of elderly people, and we try to demonstrate it. For our proposal we developed an assistance system and a drug dose control with AR. In the prototype described in this paper we used ArUco [12], a free software library designed at the University of Cordoba, to implement our AR sub-system.

As a robotic platform, we started our experiments with the TurtleBot robot built by Willow Garage [13], an open platform which is one of the cheapest and most expandable robotic platform at present time. Later, we use a modified version adapted to elderly needs as we can see in Sect. 4. New open robotics platforms (ROP [14]) intended for assistance are being introduced constantly, like AMIGO [15] or like NimbRo-OP [16] that will be introduced in the future as companion robot.

The rest of the paper is organized as follows: in Sect. 2, the general prototype and the software architecture design are presented. In Sect. Sect. 3, we present the prototype built for the tests, Sect. 4 showcases the preliminary tests made to validate our development, its usability and the possibility of implementation in real environments. Finally, Sect. 5 presents conclusions and further work, highlighting the main outlines of our work and its future development.

2 Prototype Description

We present a software and hardware prototype intended to make the usage of a medical drug dispenser (pillbox) easier for elderly people. Its main component is a multi-platform software application based on ROS, OpenGL, and ArUco, running on a hardware platform consisting in a computer on-board a mobile robotic platform.

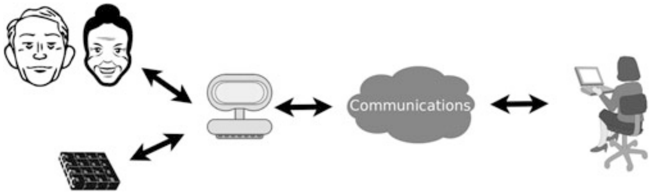

Fig. 1 General approach

Figure 1 shows the general concept of our proposal. In left side the elderly has the interaction with the robot and the pillbox. With the use of AR, the task could be improved. To the right, somebody can control the robot and offer real-time assistance to the elderly, using the camera speakers and phone mounted onboard.

2.1 Software Description

This section presents the software developed for the system, which is based on two main modules: ROS (Robot Operating System) and MYRA. ROS [17] is a popular and widespread set of libraries and tools used to build any kind of control software for robots, developed by Willow Garage.

MYRA is our interaction architecture, short for "Elderly and Augmented Reality" (in Spanish *Mayores Y Realidad Aumentada*), and it has been created at the *Cátedra Telefónica—Universidad de León* to help and improve the daily lives of elderly people through the use of AR using only a computer and a camera.

The MYRA architecture is a hierarchical architecture with three main levels. The *Model* level encompasses the software needed to connect to other libraries that MYRA needs, as for instance: OpenCV, ArUco, pjproject libraries or ROS ecosystem. These libraries provide image recognition, augmented reality and VoIP services respectively. ROS provides support for getting images from a Kinect sensor, and sending commands to the hardware platform to control the robot movement. The *Controller* level consists of different subsystems that process the received data, and generate the information that will be fed to higher levels of the application, that is, to the View component. The *View* level builds the interface that interacts with the users, that will be shown in the robot's display.

Figure 2 portrays the implementation of the MYRA architecture for building a robotic assistant for medication control presented using SysML modeling language. The hardware part, roomba block diagram, is adapted from [18] (we are not showing the roomba blocks concerned to sensors that we are not using in the MYRABot platform).

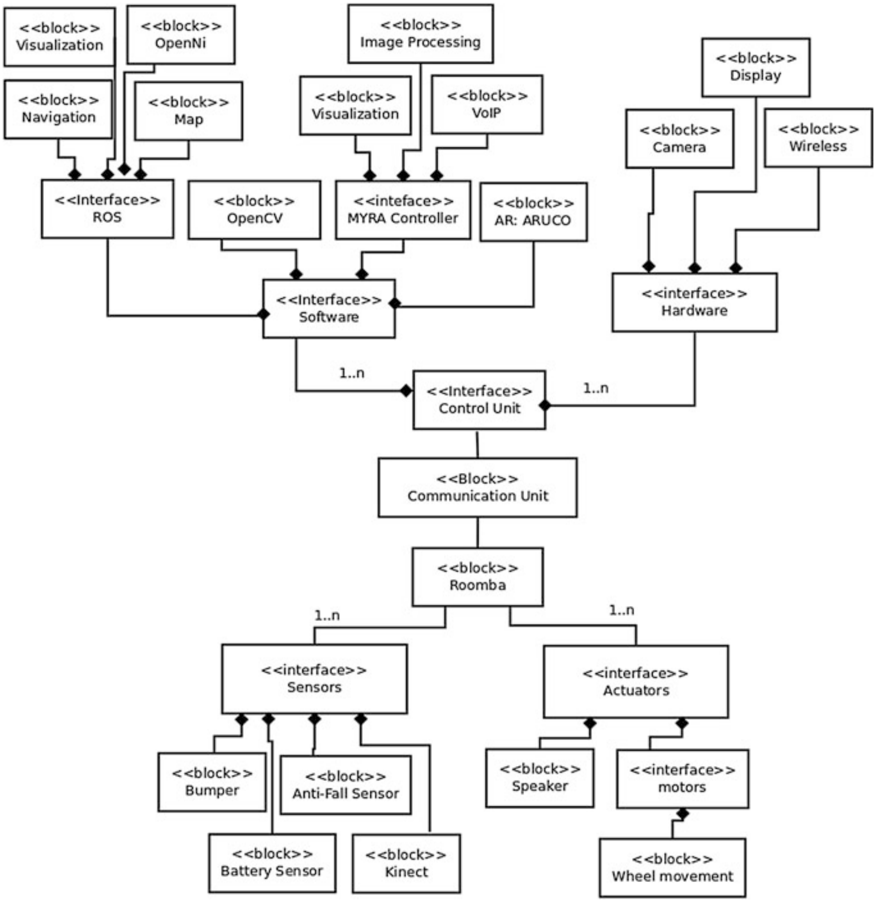

Fig. 2 High level SysML diagram

3 Prototype

In this section we present the first prototype developed using the software architecture described above.

The interface built for the prototype (MYRA display) is shown in the left picture of Fig. 3 made up by three different modules. The *Presentation* module is in charge of showing information to the user. This information is based on the images captured by the system, augmented with information added by the Controller component. The *Telepresence* module is in charge of managing the communications. In the preliminary prototype we are providing just voice calls, using the VoIP stack, which means that the remote user can be on a computer or on a phone. The *AR* module manages the information included in the Presentation interface.

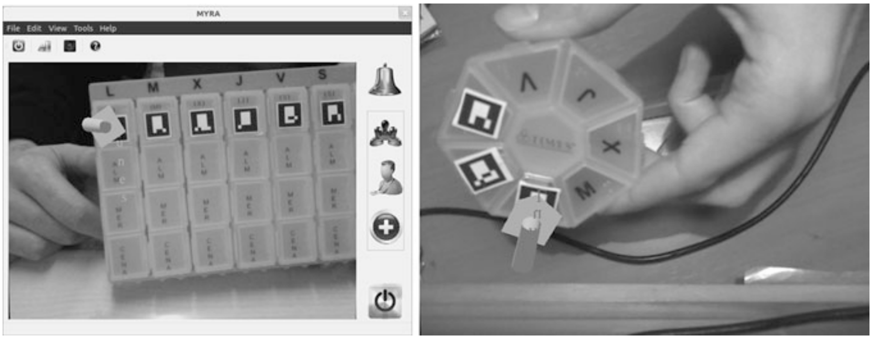

Fig. 3 Interface screenshot and simple AR pillbox example

4 Evaluation

In this section we describe the preliminary tests we made to validate the prototype. The purpose was to obtain real user feedback for our prototype, and we tried to adapt the tasks to our final architecture. The tests were made with a limited population of five people aged 59, 64, 84, 86, and 90. A brief explanation about the platform and the experiment was given to them. The tests took place in an environment well known to them: their own homes, where close relatives were present to supervise and make them feel more comfortable. The duration of each test was about 1 h.

4.1 Test 1

Our first test was developed with the Turtlebot robot, and the main goal was defined as: “are the elderly people ready to interact with robotics and Augmented Reality?” We divided the test in two parts. The first one was an acceptance oriented test. We wanted to evaluate if seniors would accept the robot, and in particular if they would feel comfortable with a non-anthropomorphic robot. The second one was an interaction test where we wanted to evaluate the interaction interface, in particular the AR interface. In this part we simulated a medication event, and asked every individual to use the AR pillbox for drug dose control (Fig. 4).

4.2 Test 2

We used a modified version of the Turtlebot robot to make this test, as we can see in the left picture of Fig. 5. We wanted to establish whether or not the robot experience could be improved with a hardware modification, and if the medication

Fig. 4 First HRI test

Fig. 5 AR elderly interaction

task could really be improved with the use of augmented reality. This modification was prompted by the first experience, where the users asked for a taller platform to interact with. We named this robot “MYRAbot” because of the relationship with our software architecture.

A perfect example is presented in Fig. 5, the individual is able to see an arrow being overlaid on the pillbox, and he is pointing to the right medication for that moment.

5 Discussion

An objective evaluation was made. After each experience, we asked the elderly about the quality of the interaction. With these results we retrieved some relevant information about the users’ experience. Table 1 shows the assessment of each subject based in the Likert scale [19], where the value 1 means “totally disagree” and 5 is “totally agree” for a given sentence. The final results are presented in Table 1.

Figure 6 shows the interaction time of the subjects. We can observe that the interaction average in the first test (31.8 min) is below the 38.8 min average of time spent in the second test. The two main reasons for this improvement are that (1) in the second experiment the robotic platform was modified because it was adapted in height and (2) also, the graphics used in the AR interface were improved. We allowed to increase or decrease the size of the rendered graphics, per user request.

Analyzing the data fetched with the polls, we concluded that the use of AR had indeed positive effects in the users. Anyway, we see in Table 1 that the subjects were not comfortable with part of the solution. The reason was that they needed an extra graphical solution to get the correct drug; for instance, when the elder person needs a dose and he or she shows the pillbox to the robot, a video showing a hand or maybe a person manipulating the pillbox could be an extra help to be more precise with the correct dose.

Table 1 User valoration table

Evaluation\Age	59	63	85	86	90	Evaluation \ Age	59	63	85	86	90
Enjoyment	5	5	4	5	4	AR usefulness	5	5	4	5	3
Robotic platform	5	5	5	5	5	AR friendliness	5	5	3	4	2
HCI friendliness	4	4	5	5	5	AR functionality	5	5	2	2	2

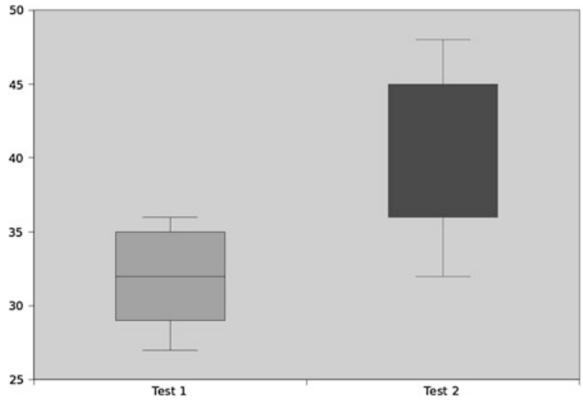

Fig. 6 Analysis of interaction time

6 Conclusion and Further Work

This paper describes the development of a robotic tele-presence system equipped with an augmented reality system for interaction. The main contribution of our research is a human robot interaction architecture named MYRA, used to build a system for elderly assistance and medical dose control that includes augmented reality to improve the interaction with the robot.

MYRA has been built using open source libraries. This was a design decision that speeded up the development, but it also has its drawbacks: we are stuck to particular versions of the libraries. The MYRA architecture developed for this project is available for downloading and testing.

As we explained throughout the paper, using our prototype it is possible to follow a simple medical guidelines to take the daily pill dose, thanks to the help given by the augmented reality, with just presenting the pillbox to our robot or to a camera if we use the MYRA computer solution. Also, the telepresence system using VoIP appears as a cheap way to communicate with family, friends or, with a many improvements, as a possible emergency service.

Future improvements could consist for example of a remote drug dose control, where the patient's doctor could change the prescription in real time. Another possibility would be to manage syrup medicine, for instance showing a video of somebody taking a spoon or a cap. In the hardware field, we are studying the installation of a low cost arm to be able to do new tasks and improve the interaction with the elder.

Hardware designs are made available by the ROS community. Our hardware improvements are also available in our project web [20].

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