Francisco J. Lera[1], Victor Rodrguez, Carlos Rodríguez, and Vicente Matellán[1]

Universidad de León, Facultad de Veterinaria 25, 24004 León, Spain

Abstract. The basis of this project was to create a platform for social interaction based on augmented reality able to be deployed in elderly homes. Two main components are presented: the robot platform and the software architecture built on ROS software. The first part developed was an easily and accessible robot, in terms of price. In the other hand the software system that is based in ROS, displays virtual information in the interface for interaction with elderly.
The purpose of this study is to validate the platform and the augmented reality in elderly people. To evaluate it we deployed two tasks in the system, an assistance system and a drug dose control system, and we tested it in a real environment.

1 Introduction

Social robotics has been growing up during last years. In particular "ambient assitant" in elderly 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 belong to this programme, like us, but has served as an inspiration for a new ways to improve the eldery quality of life or technology that is related to them.

Our proposal, a prototype that could help elderly in daily life, it is not a novel solution. Other researchers presented their solutions as the robot Flo [20], the nursebot Pearl [21] , the aibo robot from SONY and this last years Paro [22], RIBA robot [24] or the Huggable [23]. In our case, the robot has been thought for assisting caregivers in control of medication of elderly people using augmented reality.

The Augmented Reality [1] (since now AR) and neither a novel solution, 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 case, we want to show virtual information over the normal pillbox of a person under treatment. The computer screen of the robot would show a virtual figure overlaying the real world, pointing the correct medication that the patient has to take in a given moment.

In this article we suggest that the use of AR can improve different tasks in elderly people and to prove it we also develop a robtic platform. Our proposal is to develop an assistance system and a drug dose control with AR . In the prototype described in this paper we will use ArUco [9], a free software library designed at Universidad de Cordoba, to implement our AR sub-system. So, in this way, our second suggestion is that robots can also improve the assistance to elderly people.

In the first experiments we used the TurtleBot robot built by Willow Garage[17], this is a cheap and extended platform at present time. In our lasts experiments we use a modified version adapted to elderly needs as we can see in experiments sections.

The rest of the paper is organized as follows. In section 2, the general prototype is showed and the software architecture designed is presented. In section 2.2, we present the prototype built, In section 3, we present the preliminary tests made to validate our development, and its usability and the possibility of implementation in real environments. Finally, section 5, presents conclusions and further work , highlighting the main outlines of our work and its future development.

2 Prototype description

In summary, we present a software and hardware prototype to make easier the use of a medical drug dispenser (pillbox) by 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 pair of computers on-board a mobile robotic platform.

There are another systems with similar goals. For instance, PAUTA [7] is more focused to the specific problem of pillboxes for elderly people. Major drawback from out point of view is the high cost of this type of device and its maintenance. In our solution any pillbox is liable to be modified and used as augmented pillbox. This is the first main contribution, we implements a low cost way to help in daily medication using augmented reality.

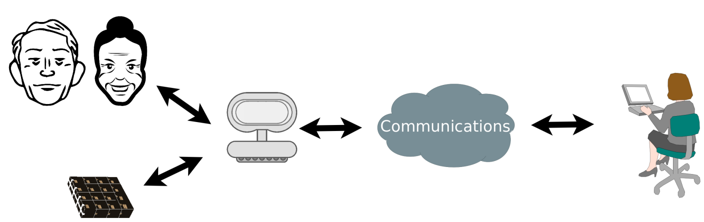

Fig. 1: General Approach

In the picture 1, the general concept of our proposal. In one side the elderly has the interaction with the robot and the pillbox. With the AR the taks could be improved. By the other side, somebody can control the robot and offers assistance to elderly, using the cameras speakers and phone from robot onboard, it is possible to speak with elderly.

Therefore, the first high level architecture approach taking in account the elderly environment can be seen in figure 2

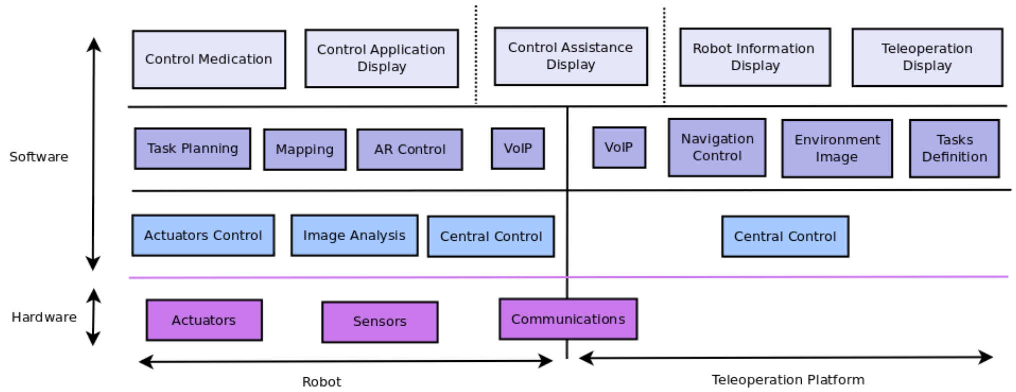

Fig. 2: General Approach

2.1 Software description

This section presents the software developed for system and based on two main modules: ROS (Robot Operating System) and MYRA. ROS [13] is the set of libraries and tools used to build specific control software for robot developed by Willow Garage. MYRA is our interaction architecture, MYRA 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.

MYRA has been designed following the model-view-controller paradigm. We decided to use this kind of architecture to let independent modules be included in the system. In this way, any of the modules could be improved without interfering with the others.

The MYRA architecture is a hierarchical architecture with three main levels summarized in figure 3.

The *Model* level groups 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 Kinect and sending commands to hardware platform to do the robot movement control.

The *Controller* level consists of the mechanisms to get and use data from the model component. The software at the Controller level processes data received from the different subsystems and generates the information to the higher level, that is, to the View component.

The *View* level builds the interface that interacts to users.

In figure 3 the implementation of the MYRA architecture for building a robotic assistant for medication control is presented. In this case we use the ROS stack to control the TurtleRoomBot (the right part of figure 3). In bottom left of figure 3 we find the other libraries used in MYRA as ArUco (it adds the

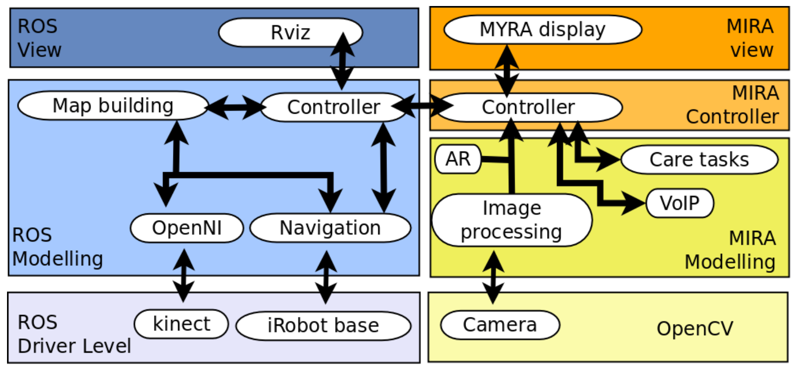

Fig. 3: High level diagram

augmented information to images), Qt (it is used for building the user interfaces), and PjProject (it adds communication capabilities).

2.2 Prototype

In this section we describe the first prototype developed integrating all technologies described above.

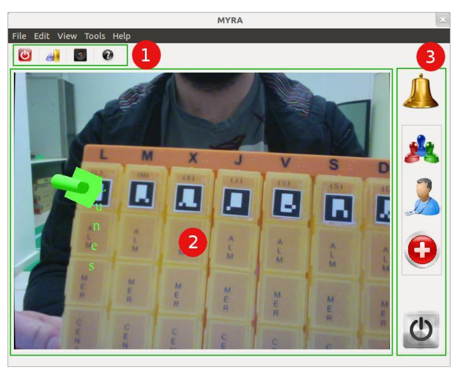

Fig. 4: Interface screenshot

The interface built for the prototype is 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.

These modules represent the main features of MYRA. To make them work we added new libraries to our prototype system and we made changes in all layers of MYRA solution to integrate this modules.

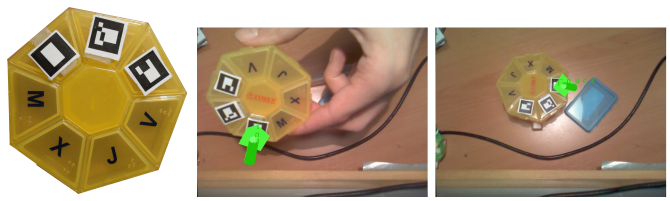

Fig. 5: PillBox and Augmented reality running

In the figure 5 we can see different snapshots of a pillbox and the AR marks added. This model is a simple one, with only seven possible cases (the days of the week).

3 Evaluation

In this section we describe the evaluation of the prototype. It was made to obtain a real user feedback from our prototype sand it was nor an exhaustive, neither statistically significant. It was just a preliminary validation test.

3.1 Test 1

Our first test was developed with turtlebot robot and 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 a "likeness" oriented test. We wanted to evaluate if seniors would accept the robot, and in particular if they would like a non-anthropomorphic robot. The second one was an "interaction test" with the robot where we wanted to evaluate the interaction interface, in particular the AR interface. The metrics to evaluate these tests were the time of the interaction between the elderly and the robot, and the answers to a questionnaire about the usability of the system.

The tests were made with a limited population of five people aged 59, 64, 84, 86, and 90. An explanation about the platform and what it was designed for was given to the group. Tests were made in a well known environment for them, their own homes. People also know the person who was supervising the test. First, the robot was set in "wonder mode" for an hour. Then a simple example about how the AR system works was presented to the group.

A picture of the robot wandering in the environment is shown in figure 6.

For the second test, we simulate a medication event, and we ask to every senior to use the AR pillbox for drug dose control. They had to show a pillbox to the robot and evaluate if the AR, the interface and the platform was able to help them in this task.

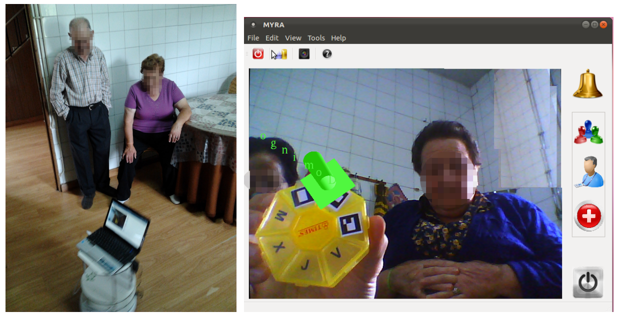

Fig. 6: First HRI test

3.2 Test 2

In this example, our two hypothesis were: Could be the robot experience improved with a simple modification? Could be the medication task be improved with augmented reality? This second approach was developed with a modified turtlebot robot. We make this new test due to the firts experience where the users ask for a taller platform to interact. We put the name of MYRAbot to this robot because the relationship with our software project MYRA.

Fig. 7: HRI with MYRAbot

This experiment starts from the same premises, the same population and the new robot as we can see in figure 7.

This time, we made the test with the augmented reality onboard the robot. We can see that the individual is able to see an arrow overlaid the pillbox signaling to the right medication of this moment (figure 8 so we finished this test with a positive valoration.

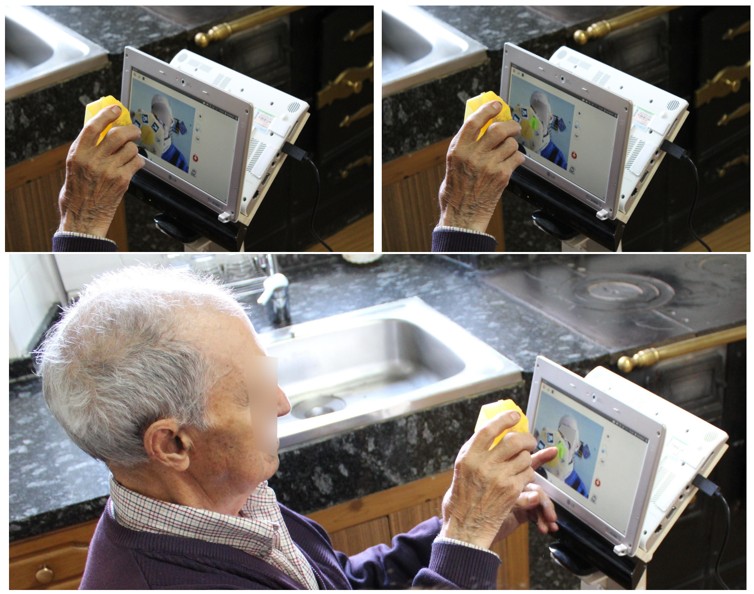

Fig. 8: AR elderly interaction

4 Evaluation

Subjectively we are able to conclude positively the experience with the AR after teh last session as we can see in figure 8.

Also an objective evaluation was taken. After each experience we asked to the elderly about the interaction. With this results we got some relevant information about the users experience.

The final results is presented in table 1. The first row, related with the attention, is the time in minutes spent for each elder in an hour of experiment. The others row's presents the assessment of each people based in Likert scale[25] where the value 1 is totally disagree and the value 5 is totally agree of a given sentence.

5 Conclusion and further work

This paper describes the development of a robotic tele-presence system equipped with augmented reality system for interaction.

Evaluation \ Age	59	63	85	86	90
Attention	50'	50'	35'	40'	35'
Enjoyment	5	5	4	5	4
Robotic platform	5	5	5	5	5
HCI friendliness	4	4	5	5	5
AR usefulness	5	5	4	5	3
AR friendliness	5	5	3	4	2
AR functionality	5	5	2	2	2

Table 1: User valoration table

The main contribution of our paper is: A human robot interaction architecture named MYRA used to build a system of medical dose control that includes augmented reality to improve the interaction with the robot and a telepresence system.

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

As we presented along the paper, using our prototype it is possible to follow a simple medical guidelines to take the daily pill dose, thanks to help given for 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 many improvements, as possible emergency system.

Hardware design is also available by the ROS community and our hardware improvements are available also in our project web.

We hope to test the prototype in depth in a real environment in the next months to get a real feedback, but we are working in the hardware changes proposed by users to height up the camera and computer to be more comfortable in HRI .

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