Fostering the NAO Platform as an Elderly care Robot

First Steps Toward a Low-Cost Off-the-Shelf Solution

Jessica P.M. Vital
Engineering Institute of Coimbra
–RoboCorp,
Coimbra, Portugal
A21200422@isec.pt

Nuno M. M. Rodrigues
Engineering Institute of Coimbra
–RoboCorp,
Coimbra, Portugal
A21200432@isec.pt

Micael S. Couceiro
Engineering Institute of Coimbra
RoboCorp, Department of Electrical Engineering
Coimbra, Portugal
micael@isec.pt

Carlos M. Figueiredo
Engineering Institute of Coimbra
RoboCorp, Department of Electrical Engineering
Coimbra, Portugal
cfigueiredo@isec.pt

Nuno M. F. Ferreira
Engineering Institute of Coimbra
RoboCorp, Department of Electrical Engineering
Coimbra, Portugal
nunomig@isec.pt

***Abstract*— Depression and loneliness among the elderly are one of the biggest problems affecting the world population. This leads to elderly isolation which is a major risk factor for suicide. Moreover, if isolation is coupled with physical illness and incapacitation, such a risk increases exponentially. To fight back this problem, roboticists have been proposing solutions to autonomously monitor, support and even promote physical activities among the elderly. Nevertheless, those appear as very high-cost and complex solutions that require an advanced technical expertise. Recent off-the-shelf solutions, such as the well-known NAO robot, emerged as possible alternatives. An extension to the NAO robot, denoted as RIA, is being developed at the Engineering Institute of Coimbra (ISEC). The RIA is not only built for a social interaction with the elderly but also as an autonomous tool to promote professional care through the analysis of health and environmental parameters. Therefore, the RIA robot is an adapted NAO low-cost platform equipped with several sensors that can measure different parameters like body temperature, blood pressure and heart rate. By validating this valuable platform, the foundations were laid for a whole new paradigm in elderly care.**

I. INTRODUCTION

Depression and loneliness among the elderly are now one of the biggest problems affecting the world population [1]. Moreover, the increasing isolation of the elderly, whether in rural or urban society requires extra care and monitoring of qualified professionals to ensure the welfare and health of this population. However, it is difficult to ensure the constant presence of professionals. Also, that care may not reach every user, especially those living in poor and disadvantaged means. To combat this difficulty, many researchers have been addressing social robotics as a possible solution.

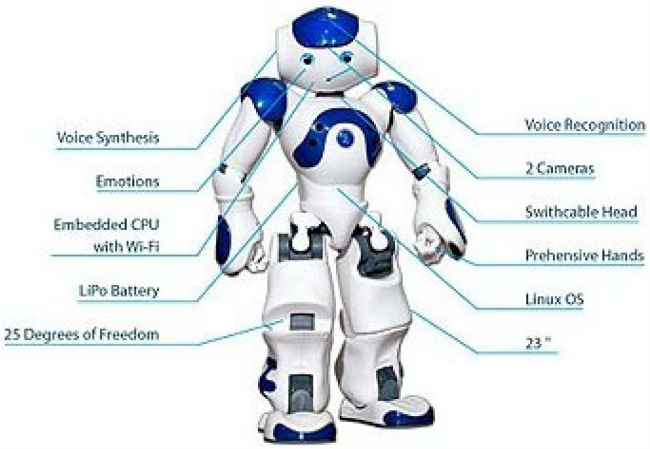

Figure 1. Robot NAO.

This paper will present the NAO robot (Fig. 1) as a social platform ideally fitted to monitor and promote the physical activity within the elderly population. To this end, the platform must be able to able to replicate human motion with twenty five degrees-of-freedom (*DOF*) so as to promote physical activity among the elderly. The platform should also be able to prevent osteoarticular diseases, i.e., arthrosis and osteoporosis, as well as cardiovascular diseases, *e.g.*, acute myocardial infarction. Moreover, and to protect the elderly from possible treats, the platform should also be able assess the environmental-contextual information.

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Bearing these ideas in mind, this paper paves the way toward the direction of a novel robotic platform denoted as RIA, from the Portuguese *Robô Idoso Activo* (*Elderly Active Robot*). The idea behind RIA is to equip the NAO robot with several sensors in order to passively monitor multiple parameters such as glucose levels, blood pressure, heart rate, body temperature and, at the environmental level, monitor the temperature, humidity, gas measurement and fire detection.

Yet, as a first step, this paper revolves around the choice behind the NAO solution. In a broad sense, this robot can accomplish several basic actions like sitting down, walking, pick up things with hands, among others. Those are the minimum necessary requirements for such a task of taking care of someone. Nevertheless, those are not the only main features from the NAO platform. Next section describes some of its main applications around social robotics.

II. Applications

The NAO robot has been used in many applications but this paper focus on the ones regarding the interaction with humans – an area usually known as social robotics. However, it should be noteworthy that the NAO platform has been used in many other applications, such as the traditional robotic soccer (*e.g.*, [2]).

a) Austism children

The NAO platform has been used to help autistic children in improving their behaviour [3] [4]. These two articles presented a detailed information about the capabilities of NAO under such applications. The authors in [3] presented some interesting results about the use of analyzing the influence of NAO robot in children with autism. The authors stated how a basic human interactive robot is able to suppress the autistic behavior during human-robot interactions and that the child is able to maintain visual contact with the robot. Similarly, the authors in [4] presented some identical results concluding that children did not exhibit autistic behaviors while interacting with the NAO platform (Fig. 2). Although the number of studied cases is fairly small and cannot return conclusive results, one may conclude that the use of the NAO robot within such applications is still an alternative.

Figure 2. Interaction with children.

b) Visual Interaction

An interesting feature inherent to the NAO robot it is the visual capability, being one of the fundamental requirements for social robotics. The authors in [5] presented a real-time visual system to interact with humans. The system was based upon probability models that use color and the shape of the object to be recognized. This algorithm is quite computationally simple which means that it can be processed in real time. Also, their object recognition was not only guided by the distribution of color but also by the spatial distribution of pixels, thus meaning that there was an improved control of various objects and reasoning about occlusions.

c) Interaction with humans

The interaction with humans (Fig. 3) is one of the main attributes of NAO platform [6] [7] [8] [9] [10]. The authors in [6] proposed a technique for programming the movements of NAO's entire body through observation. This was accomplished using Jacobian matrices and a new form of optimization of joint trajectories with B-Spline, thus generating optimal whole body movements. The authors in [7] showed how the NAO's vision and hearing features are important for teaching tasks in a social environment. Through this study one were able to withdraw some interesting conclusions such as that the direct visual access to the robot tends to build mental models of auditory cues that help to improve the performance of the instructor. This provides accurate information about the internal state of the robot. The study revealed that people easily constructed mental models in natural environments, but with an incomplete knowledge of how the robot operates / works.

The work in [9] concluded that the study provides evidence that large mutual influences between cognitive neuroscience and social robotics enable a better understanding of man which leads to an increased acceptance of future robotic companions in society. The authors in [10] presented a transportation system of humanoid robots based on learning. The objective of this study was to successfully transport an object using two NAO robots by means of cooperation. Preliminary results showed that this approach was very effective, hence highlighting the cooperative capabilities inherent to NAO (e.g., communication).

Figure 3. Interaction with humans.

III. COMERCIAL ALTERNATIVES FOR ELDERLY CARE

This section presents several alternatives to our proposed solution inspired in the robot NAO. This section allows withdrawing some conclusions regarding the choices carried out in this paper, thus highlighting the low-cost advantage of NAO.

a) Telehealth

The project Telehealth being currently developed by ISA (Intelligent Sensing Anywhere) is one of the most interesting solutions. However, it is the authors' opinion that the project still presents some gaps. It provides several measurements with a high reliability regarding the patient's environment. This system focus on a more reliable record savings than in the social aspect regarding the elderlies needs. Hence, although its usefulness, this project still lacks on one of the biggest problems in our society: the loneliness of the elderlies. Our project aims on using a lower number of sensing information but plays an important role on the social aspect.

b) Ambient Assisted Living

Ambient assisted living is one of the most recent research areas. Such projects are interesting solutions to monitor elders' behavior. Nevertheless, to the similarity of Telehealth, the authors highlight the problem of being static solutions. In other words, the solution and the various sensors that are included in those designs can be installed in houses, but cannot be transported to any other location. The proposed solution, on the other hand, has the portability ability being easy to transport anywhere and with autonomous navigation capabilities. Moreover, it still allows monitoring vital signs and following up in person anywhere.

Figure 4. Nursebot.

Figure 5. PARO Therapeutic Robot

c) Nursebot

The Nursebot project (Fig. 4) is a mobile, personal service robot that assists elderly people [11]. That robot provides a research platform to test out a large range of ideas for assisting elderly people such as intelligent reminding, telepresence, data collection, mobile manipulation and social interaction. For instance, this robot can advertise the patients to do not forget to take medicine. Nevertheless, contrarily to the herein proposed platform, it does not possess any kind of sensing capabilities regarding both environmental and health information. Moreover, the NAO robot is a human-like platform, thus hastening its identification and interaction by the elderly. It is also noteworthy that the NAO platform is considerably less expensive than the Nursebot.

d) PARO THERAPEUTIC ROBOT

PARO (Fig. 5) is a therapeutic robot baby harp seal [12]. PARO is an advanced interactive robot that fosters the benefits of animal therapy to be administered to patients in environments such as hospitals and nursing homes. PARO can reduce the patient stress and stimulates the interaction between patients. The similarities with the NAO extension end here. As previously mentioned, besides social interaction, we aim at acquiring data that may be useful, *e.g.*, measure the healthy parameters, and at promoting physical exercises. Moreover, the cost advantage regarding NAO still remains.

IV. FROM NAO TO RIA

The previous sections briefly presented the features and applicability of the NAO robot. Despite all its advantages over other alternatives, the NAO is not prepared for an elderly care task.

This section briefly summarizes our strategy to turn the NAO robot in the ideal low-cost tool for the elderly care. This will be a completely remodeled platform with several new sensors, both environmental and health sensors. The next topics give a brief overview on the sensors that will be equipped on NAO by mean of Arduino-board and WiFi communication:

- Smoke detector: this sensor will allow detecting possible fire outbreaks, alcohol, and different types of gas. In case of detection, NAO will alert the patient, as well as

the agents in charge of it. Furthermore, it will plan alternative paths to some predefined safe locations and guide the elder toward those. This sensor has a high sensitivity, fast response, and the output directly connects to any analog input;

- Temperature: the NAO robot will be able to sense two different kinds of temperatures: the environmental and the patient. If the corporal temperature of the patient is
- not regular then the robot NAO will alert the patient and the agents in charge of it. Regarding the environmental temperature, the robot NAO may alert for irregular levels to make a better environmental place for the patient. This sensor is a precise integrated-circuit for temperature measurements, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature of the environment. Also, it offers advantages over linear temperature sensors calibrated in Kelvin, as the user is not required to subtract a large constant voltage from its output to obtain a convenient value. It also has other characteristics like an analog output that operates from 4 to 30 volts in which 10mV /ºC (e.g., 25 ºC = 250 mV) and can measure -55 to 150ºC while draining less than 60 mA. To give us the correct temperature value in Celsius it it necessary to program the controller with a simple mapping as:

$$T = (S \times 500) / 1024, \qquad (1)$$

wherein T represents the temperature which can be sent by serial port from Arduino.

- Photoresistor light sensor: This sensor employs a photoresistor that can detect the ambient light. If the values of luminosity are not appropriate for the health of the patient, the robot NAO will send an alert informing about those levels. Also, the sensor allows the detection of fire outbreaks by acquiring the brightness of flames. With this sensor one may choose between a digital or an analog output. In this project, we intend to use an analog output.
- Humidity: This sensor measures the humidity that exists in the environment. If the values of humidity are not appropriate for the health of the patient, the robot NAO will send an alert with those levels.
- Others: Health sensors that may monitor the blood pressure, glucose and others will also be studied.

V. PROPOSED ARCHITECTURE

This section briefly presents the proposed architecture to connect the NAO robot with the sensors (Fig. 6). Based on the three sensors previously presented (smoke detector, temperature detector and photoresistor light sensor) Fig. 6 depicts the connection between those and the Arduino board by mean of analog signals. The Arduino is equipped with the Wireless Proto Shield by using SPI Communication. This allows pairing both NAO and sensorial array using WIFI 802.11, thus completing the so called RIA package.

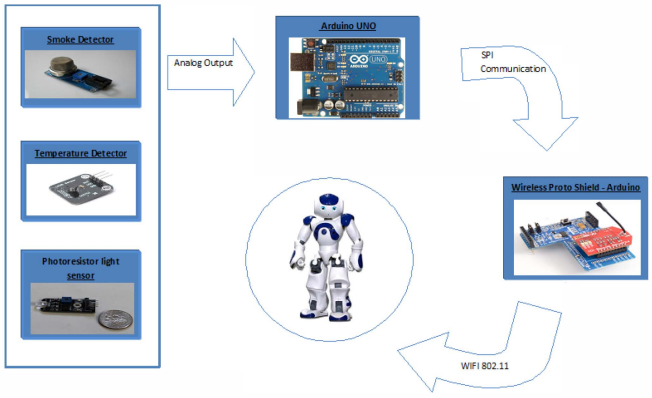

Figure 6. Proposed Architecture.

In the future, we intend to study multisensory fusion to merge all the values from the sensors to further assess environmental information. For instance, the temperature sensor may suggest the existence of a fire but the gravity of it may be assessed by the alcohol sensor that may suggest the existence of gas within the environment. Afterwards, we intend to use classifications methods such as the support vector machines (*SVM*) to inform first responders and others using contextual information.

VI. CONCLUSION

To attend the necessities of our community, the RIA robot will not leave old people alone and may give the required attention that this people need. People already have several entertainments such as television, radio and others. However, nothing compares to a humanoid robot when it comes to assist the human being on social and daily life situations. Robots can save many lives, either on a military field on in our houses.

REFERENCES

[1] J. F. d. Costa. (2012) Jornal Sol. [Online]. http://sol.sapo.pt/inicio/Sociedade/Interior.aspx?content_id=40618

[2] T. Niemueller, et al., "Providing Ground-truth Data for the Nao Robot Platform," in *RoboCup 2010: Robot Soccer World Cup XIV*. Singapore: Springer, 2011, pp. 133-144.

[3] S. Shamsuddin, et al., "Initial Response in HRI- A Case study on evaluation of schild with autism spectrum disorders interacting with humanoid robot NAO," in *International Symposium On Robotics and Intelligent Sensors*, 2012, pp. 1448-1455.

[4] S. Shamsuddin, et al., "Humanoid Robot NAO interacting with autistic children of moderately impaired intelligence to augment communication skills," in *International Symposium on Robotics and Intelligent Sensors*, 2012, pp. 1533-1538.

[5] A. Ude, T. Shibata, and C. G. Atkeson, "Real-Time Visual System for Interaction with Humanoid Robot," in *Robotics and Autonomous Systems*, 2001, pp. 115-125.

[6] A. Ude, C. G. Atkeson, and M. Riley, "Programming full-body movements for Humanoid Robots by observation," in *Robotics Autonomous Systems*, 2004, pp. 93-108.

[7] N. Koenig, L. Takayama, and M. Mataric, "Comunication and knowledge sharing in human-robot interaction and learning from demonstration," *Neural Networks*, pp. 1104-1112, 2010.

[8] A. Stoica, "Robot Fostering Techniques for Sensory-Motor Development of Humanoid Robots ," in *Robotics and Autonomous Systems*, 2001, pp. 127-143.

[9] T. Chaminade and G. Cheng, "Social cognitive neuroscience and humanoide robotics," *Journal of Physiology - Paris*, pp. 286-295, 2009.

[10] Y. Inoue, T. Tohge, and H. Iba, "Cooperative Transportation System for Humanoid Robots using Simulation-Based Learning," in *Applied Soft Computing*, 2007, pp. 115-125.

[11] J. Matthews, et al. [Online]. http://www.cs.cmu.edu/~nursebot/web/index.html

[12] PARO Robots U.S., Inc. Paro Therapeutic Robot. [Online]. http://www.parorobots.com/