The EnrichMe project: a robotic solution for independence and active aging of elderly people with MCI

Claudia Salatino[1], Valerio Gower[1], Meftah Ghrissi[2], Adriana Tapus[3], Katarzyna Wieczorowska-Tobis[4], Aleksandra Suwalska[4], Paolo Barattini[5], Roberto Rosso[6], Giulia Munaro[6], Nicola Bellotto[7], Herjan van den Heuvel[8]

[1] IRCCS Fondazione Don Carlo Gnocchi Onlus, Milano, Italy
{csalatino, vgower}@dongnocchi.it
[2] Robosoft Services Robots, Bidart, France
meftah.ghrissi@robosoft.com
[3] U2IS, ENSTA ParisTech, Université Paris-Saclay, Palaiseau cedex France
adriana.tapus@ensta-paristech.fr
[4] Uniwersytet Medyczny im Karola Marcinkowskiego w Poznaniu, Poznan, Poland
kwt@tobis.pl, asuwalska@gmail.com
[5] Kontor 46, Torino, Italy
paolo.barattini@kontor46.eu
[6] Elettronica Bio Medicale, Foligno (PG), Italy
{rosso, munaro}@tesan.it
[7] University of Lincoln, Lincoln, United Kingdom
nbellotto@lincoln.ac.uk
[8] Stichting Smart Homes, Eindhoven, Netherlands
herjan.heuvel@gmail.com

Abstract. Mild cognitive impairment (MCI) is a state related to ageing, and sometimes evolves to dementia. As there is no pharmacological treatment for MCI, a non-pharmacological approach is very important. The use of Information and Communication Technologies (ICT) in care and assistance services for elderly people increases their chances of prolonging independence thanks to better cognitive efficiency. Robots are seen to have the potential to support the care and independence of elderly people. The project ENRICHME (funded by the EU H2020 Programme) focuses on developing and testing technologies for supporting elderly people with MCI in their living environment for a long time. This paper describes the results of the activities conducted during the first year of the ENRICHME project, in particular the definition of user needs and requirements and the resulting system architecture.

Keywords: Robotics, AAL, User requirements, Residential Care, Long Term Human Robot Interaction, Gerontology, Non-invasive physiological monitoring

1 Introduction

The population of the western countries is ageing. Age-related changes in mental and physical abilities can make living independently at home challenging or even impossible for the elderly. Mild cognitive impairment (MCI) is a state related to ageing, and sometimes evolves to dementia. A subgroup of people with MCI will not develop dementia and will not experience the deterioration of cognitive functions over time. As there is no pharmacological treatment for MCI, a non-pharmacological approach is very important [1]. These measures include lifestyle changes, such as diet modification and smoking cessation, and an increase of intellectual, physical and social activities [2]. The use of Information and Communication Technologies (ICT) in care and assistance services for elderly people increases chances of prolonging independence thanks to better cognitive efficiency [3]. Moreover Tapus et al. [4] showed that an in-home socially assistive robotic agent can improve the ability of the patient to function at home and within society. Over the past decades, many robots for the elderly have been developed, aiming to support a range of different activities of elderly people: robots are seen to have the potential to support the care and independence of elderly people [5]. An interesting systematic review [6] recently investigated robots being developed to support the elderly in their independent living and categorized these robots based on their Technology Readiness Level (TRL). Only a few projects including mobile autonomous robot companions operating in real life have been implemented in Europe so far. Additionally, only some of them have been designed for users with cognitive impairment.

The project ENRICHME "Enabling Robot and assisted living environment for Independent Care and Health Monitoring of the Elderly" (www.enrichme.eu, funded by the EU H2020 Programme) among other research works on the same topic focuses on testing technologies for supporting elderly people with MCI particularly in their living environment and for a long time. It tackles the progressive decline of cognitive capacity in the ageing population developing an integrated platform with a mobile service robot for long-term human monitoring and interaction, which helps the elderly person to remain independent and active for longer by enriching his/her day-to-day experiences at home. The key research questions of ENRICHME are the following:

- Which are the best robotic and AAL services enabling older people with Mild Cognitive Impairments (MCI) to remain independent and safe?
- How can we provide experimental long-term evidence demonstrating that robotic and AAL services are effective to prolong the independent living of the elderly at home and in community dwellings?
- How can we provide experimental long-term evidence demonstrating that older people and caregivers accept robotic and AAL systems?

The ENRICHME robotic solution will be based upon an existing robotic platform: the Kompaï robot [7] developed by one of the project partners: Robosoft. This paper describes the results of the first year activities of the ENRICHME project, in particular the definition of user needs and requirements and the resulting system architecture.

2 The ENRICHME Approach

The ENRICHME project is aimed at developing and testing a novel coupling of a socially intelligent robot with unobtrusive and unencumbering activity tracking devices that, together, provide real-time, adaptive and readable feedback to users. Novel context-aware Human Robot Interaction (HRI) will provide tools for cognitive stimulation and social inclusion, which improve over time by learning from and adapting to the state of the user. A professional infrastructure of networked care will widen the social sphere of intervention in support of elderly and caregivers. An iterative design process goes through the duration of the whole project for the collection of user requirements, verification of the developed system and validation in collaboration with end-users (elderly, formal and informal care personnel, family members, etc.) to guarantee the adherence of the project to real world situations and settings.

2.1 Evaluation of User Needs and Requirements

Since the evaluation of robot-related needs and requirements of elderly individuals is a complex task, it is crucial to combine different methods to increase the validity of the results. A mixed method, with quantitative-qualitative evaluations has been used to analyse the robot-related aspects of everyday life, so that the strengths of each are emphasized [8]. The objective was to assess whether ENRICHME concept in the whole and its functional requirements could be acceptable for potential users, to which extent, and if additional requirements were needed. To measure subjects preferences about system functionalities and characteristics, quantitative evaluations were needed; in order to give the respondents the opportunity to be proactive, the evaluation was designed to survey their free thoughts.

Based on the literature review and the expertise of the ENRICHME project partners [9,10], the Users' Needs, Requirements and Abilities Questionnaire (UNRAQ) was developed [3]. The UNRAQ is composed of four parts. Part 1, the introductory part of the questionnaire characterizes the responders. Part 2 concerns the appearance of the robot and the willingness of the participant to own one. Part 3 includes a list of statements to which the participant is asked to express his/her level of agreement-disagreement. These statements pertain to four areas: the interaction with the robot, the role of the robot, some social aspects, and the assistive role. Answers are structured using a 5-point Likert scale. The final part 4 of UNRAQ is the creativity box. UNRAQ was developed in English and then localized into the other five languages of the ENRICHME consortium (French, Greek, Italian, Dutch, and Polish). Pictures of the Kompaï robot were shown to the end-users before the survey, in order to give them a more realistic image of the robot concept.

A focus group discussion was chosen as the qualitative method to elicit user needs and requirements. The focus group interviews were organised on the basis of a detailed script prepared for this purpose. The script was written in English and translated into Greek, Italian, and Polish to be used in each country. The script included an introduction and a warm-up exercise to elicit a discussion about the attitude of the participants towards new technologies. The main part of the focus group interview started with the presentation of short videos about the robots. The discussion that followed had two sections focused on two scenarios created by the consortium partners describing a typical daily routine of two potential users of the ENRICHME system.

For both interviews and focus groups, the inclusion criteria for elderly individuals were the following: being aged 65 years and older, being able to understand and answer the questionnaire or to take part in the focus group; researchers also tried to include the same number of women and men within the sample. Caregivers were both informal [those who take care of someone with no professional background in care] and formal caregivers [those who are professionally prepared to provide care]. Respondents were recruited among those who were interested in sharing their opinions regarding the use of robots to assist elderly persons living at home and who accepted to take part in the study. The participants were selected in senior clubs, care centres, out-patients' clinics. The inclusion was based on their informed consent to participate. As a whole 327 individuals in all 6 countries of the ENRICHME consortium were involved; 126 participants were elderly (mean age 75.3) and 201 were caregivers.

3 Results

3.1 Definition of User Needs and Requirements

In the following, the results of the initial evaluation phase through UNRAQ and focus groups are summarized.

Three quarters of the participants accepted the appearance of the robot. Half of the participants would like to have a robot at home, and as many as two thirds would like to use it. In the entire analysed group just one quarter of participants thought that the elderly were ready to operate the robot and able to cope with this task. Half of the participants thought that the elderly wanted to increase their knowledge about the robots so as to be able to operate them (Fig.1). A vast majority (nearly 100%) of participants thought that robots would make the life of the elderly easier.

In the opinion of the elderly and their caregivers, an important function of the robot is monitoring the safety of the home, a significant majority (approximately 95%) of participants also wanted the robot to monitor the state of health of the elderly, and call for help whenever necessary. A little over half of participants thought that the elderly persons should have control over the robot. The elderly want to be able to decide whether or not to use the robot at a given time; however, focus groups participants stressed that the robot should call the medical staff in emergency situations without following the owner's orders. There was also considerable acceptance of the fact that the robot could detain a lot of information about the user (social, medical, and other).

Opinions that the robot could decrease the sense of loneliness and improve the mood of the elderly person were basically positive. However, participants also stated the obvious, i.e. that a robot would never replace another human being. Approximately three quarters of elderly participants reported that the robot could encourage the elderly to enhance their contacts with friends. Nearly 90% of the participants expected that the robot should have entertainment functions. Around 70% of the participants thought that the robot should detect the owner's mood (facial expression). Here, doubts mostly pertained to the fact that facial expression is insufficient for reliable determination of the mood.

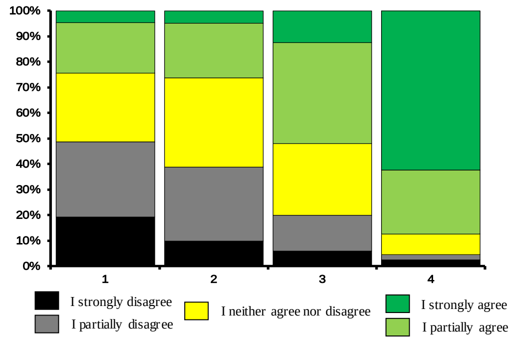

Fig. 1. Detailed opinions of participants related to the following statements: 1. The elderly are prepared to interact with a robot, 2. The elderly are able to manage with the robot, 3. The elderly want to increase their knowledge about the robots to be able to operate them, 4. The robot should instruct the elderly person what to do in the case of problem with its operation

3.2 Personas, Scenarios & Use Cases

Personas, scenarios and use cases methodology [11] has been and will be used throughout the duration of the project. Personas and scenarios presented within project proposal were defined according to the analysis of typical use cases in each country and considering those people who may have more benefits from ENRICHME experience in terms of improvement of quality of life, with some input from real-world experiences provided by the clinical partners of the project.

Personas and scenarios have been updated following the latest insights from interviews and focus groups. Fig.2 shows an example of persona. Ranking of functional and non-functional requirements was calculated on the base of percentage of agreement expressed by interviewed older adults and caregivers through UNRAQ questionnaire. Monitoring health status, reminding important tasks (i.e. taking medications), management of high risk and emergency situations are the most accepted functionalities. One of the worries of elderly people is the potential for accidents happening at home; for both elderly participants and the caregivers, social functions seem less important for the studied end-users in comparison with the assistive roles, confirming findings of Ezer et al. [12] and Faucounau et al. [13]. A selection of top-rated functional and non-functional requirements was then compared with the results of requirements and evaluation studies performed in the last couple of years in the most relevant EU projects with actual robotics and AAL systems.

Updated personas, scenarios and requirements were used to elaborate seven use cases: 1: Games & Entertainment; 2: Time Management; 3: Social Contact; 4: Medication & Nutrition; 5: Health Monitoring; 6: Comfort at Home; 7: Anomaly Detection. The results obtained by this stage generated specific requirements and concrete use cases, enabling designers and technologists to start with the development phase of the ENRICHME concept.

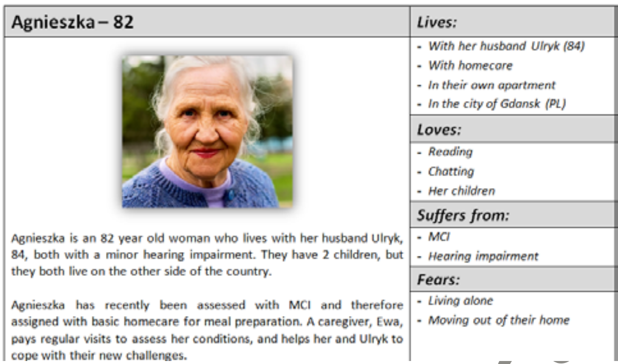

Fig. 2. Exemplification of a persona description

3.3 The ENRICHME Architecture

Socially intelligent robots are those capable of exhibiting natural-appearing social qualities. This poses a lot of new challenges because the robot must operate in open and unconstrained environments and interact with users who are not technicians. In ENRICHME, an existing interactive service robot is integrated within an assistive living environment and upgraded with the necessary capabilities and technical features to support the independent living of elders. The system will help formal and informal caregivers, as well as medical providers, to monitor and support the elderly at home, in particular those with MCI.

The ENRICHME system has three different levels of intelligence: robot, ambient, and social (Fig.3).

The integrated robot and AAL services will facilitate cognitive capability preservation through reminiscence and biography tools, long-term social interaction and promotion of leisure activities. It will regularly and unobtrusively monitor relevant physiological parameters, motion activities, and other behaviours (e.g., vocal), which are indicative of the person's state.

Some of the existing functionalities of the Kompaï robot (Fig.4) are autonomous navigation, voice synthesis and recognition, security systems (like obstacles detection, automatic stop on contact, etc.), and internet access.

In ENRICHME, this platform is going to be enhanced and customized with new equipment and functionalities: non-invasive sensors for physiological monitoring, advanced vocal and visual interaction capabilities, new software for safe navigation in home environments, learning and adaptation of cognitive capabilities to the user's preferences and needs over time for long term interaction.

The assisted living environment provides complementary sensors and actuators to: localize and monitor human's and robot's activities, reduce the risk of hazards, trigger alerts in case of anomaly detection or in case of erratic human behaviour. An RFID ecosystem is deployed tagging objects, furniture and appliances of particular interest for the everyday life of the user, and equipping the robot with an RFID reader for object localization and identification.

The ENRICHME platform for Networked Care is a visualization interface that will be accessed by the medical personnel to monitor data made available by the robot and the smart home environment and processed by the federated servers.

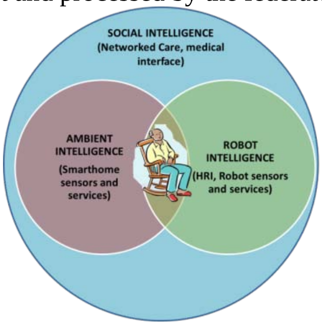

Fig. 3. ENRICHME intelligence

Fig. 4. Kompaï robot in its previous and current versions

4 Conclusions and Future Work

The work done until now provided the consortium with the necessary information to confirm and refine the system functionalities and to proceed in their development to be ready for the next evaluation steps. As the second evaluation step, the acceptability, usability and learnability of the proposed system and services, and of the multimodal human-robot interaction will be evaluated with end users and their caregivers; these tests will be held in two AAL test homes, provided by project partners SMH in the Netherlands and FDG in Italy [14]. The purpose of these tests is to identify overall usability and user-experience flaws, and to improve the actual ENRICHME services, before going for the long-term user studies in peoples' own homes. Following some system improvements, 9 ENRICHME systems will be delivered for the 12 months testing in elderly house facilities. Each testing site, LACE in Lincolnshire, UK, PUMS in Poznan, Poland, AKTIOS in Agia Paraskevi, Greece, will be equipped with 3 systems. Each of the three systems will be assigned for 4 months to a certain elderly person who lives independently within an elderly facility or at her/his own home.

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