*Note:For full proposals, the cover page, and sections 1, 2 and 3, together should not be longer than 70 pages. All tables in these sections must be included within this limit. The minimum font size allowed is 11 points. The page size is A4, and all margins (top, bottom, left, right) should be at least 15 mm (not including any footers or headers).*

**COVER PAGE**

**Title of Proposal** ROBOHOME2.0 (Temptative)

**List of participants**

*Participant No \* Participant organisation name Country*

1. *ITA UMIL – Coordination + Games for physical and cognitive activity and for education (gamification)*
2. *SWE OREBRO University – Intelligence (2.0 part)*
3. *SWE GIRAFF Giraff Technology – Robot + Integration*
4. *GB PLY Plymouth – HRI, behavior analysis (in collaboration mainly with PCL, SAS and MUN)*
5. *ITA SXT srl - sensors*
6. *ITA PCL Policlinco Hospital, geriatric Department. Elder psychology and clinics, GP network.*
7. *ITA POLIMI Politecnico Sensors data interpretation (cellular phone data processing?). Design of instrimented objects for controlled monitoring.*
8. *SWE MUNIC, Orebro municipality. Tests in real environments, sociological aspects?*
9. *ESP BDIGITAL Community development.*
10. ESP – SAS, Evaluation and diffusion of the results. Pilot. To be confirmed
11. FRA Service company – <http://www.groupe-korian.com/>, Korian group (e.g. Segesta in Italy). Alternatively,Sarquavitae, a Spanish large service provider for the elfers: <http://www.sarquavitae.es/en/>. Under exploration.

\* Please use the same participant numbering as that used in the administrative proposal forms

**Table of content**

**ABSTRACT**

ROBOHOME2.0 develops, integrates and field tests an innovative robot based assisting platform, which assists the elders at home actively promoting a healthy lifestyle. The main idea is to assemble off the shelf components in a robust and reliable way to get a low-cost system that can be deployed massively at home. The platform consists in three hierarchical levels: 1) a community of stakeholders that provides a tight connection between elders and formal and informal caregivers, and promotes socialization; 2) an intelligent virtual caregiver that proposes activities according to the elder idiosyncrasies and needs, adapting them according to the elder status on a daily basis; 3) a service level, centered on a Giraff service robot that works as an active companion. The system is complemented by a set of sensors that capture possible risks and lifestyle information and provide a controlled evaluation of the physical/cognitive capability through gesture sequences signature. A fully body-free approach is pursued to provide maximum adherence to the system. Giraff cooperates with a smart activity center to provide adapted personalized activities. The most adequate physical, cognitive and social activities will be identified and the proper mix of activities for each elder will be suggested on a daily basis to provide the maximum effectiveness. Activities will be implemented resorting as much as possible to the gamification paradigm to stimulate the maximum adherence and motivation. A pilot is designed to evaluate the effectiveness and suitability of ROBOHOME2.0, and to obtain a continuous active evaluation and refinement of the technical specifications since the beginning of the project.

**Workpackages:**

WP1 – Management

WP2 – User and technical requirements (PLY: functional specifications elicited by stakeholders and clinical partners: SAS and PCL in collaboration with MUNIC, technical offer provided by tehnological partners: UMIL, BDIGITAL, OREBRO, POLIMI, technical specifications will follow functional specifications, refinement of implementation specification throughout most of the project)

WP3 – Virtual care giver (OREBRO, ……).

WP4 – Smart activity center (UMIL, ….)

WP5 – Community (BDIGITAL, ….

WP6 – Monitoring (POLIMI, SME…..)

WP7 – Integration (GIRAFF)

WP8 – Pilot (MUN or SAS or PCL, …)

WP 9 – Dissemination (UMIL)

**1. Excellence**

**Your proposal must address a work programme topic for this call for proposals.**

***This section of your proposal will be assessed only to the extent that it is relevant to that topic.***

**1.1 Objectives**

• Describe the **specific objectives** for the project, which should be clear, measurable, realistic and achievable within the duration of the project. Objectives should be consistent with the expected exploitation and impact of the project (see section 2).

In Europe, the share of people aged 65 years or over in the total population is projected to increase from 17.1% to 30.0% and the number is projected to rise from 84.6 million in 2008 to 151.5 million in 2060. Similarly the number of people aged 80 years or over is projected to almost triple from 21.8 million in 2008 to 61.4 million in 2060[[1]](#footnote-1) and the availability of nurses is already becoming an issue in the US[[2]](#footnote-2).

Physical activity, cognitive stimulation, social inclusion, balanced diet promote a lifestyle that guarantees a slow progression of decline, thus enabling the elder to live at his home healthy for a longer time. This is becoming a priority in Europe as recognized by the EC community [QUOTE documents, SOCIAL and GERIATRIC contribution required]. Managing frailty and functional decline through targeted interventions, enhancing participation and independence, and promoting systematic-routine screening for pre-frailty are among the specific objectives of the Action Plan on “Prevention and early diagnosis of frailty and functional decline, both physical and cognitive, in older people” of the European Innovation Partnership on Active and Healthy Ageing (Bruxelles, November 6, 2012).

Physical activity, cognitive stimulation, social inclusion are highly inter-twined[[3]](#footnote-3). Regular physical exercise has been shown to be effective at maintaining and improving the overall health of elderly individuals[[4]](#footnote-4),[[5]](#footnote-5),[[6]](#footnote-6).[[7]](#footnote-7). Physical fitness is associated with higher functioning in the executive control processes[[8]](#footnote-8), correlated with less atrophy of frontal cortex regions[[9]](#footnote-9), and with improved reaction times[[10]](#footnote-10) compared with the sedentary. Social interaction, and specifically high perceived interpersonal social support, has also been shown to have a positive impact on general mental and physical wellbeing[[11]](#footnote-11), in addition to reducing the likelihood of depression[[12]](#footnote-12),[[13]](#footnote-13),[[14]](#footnote-14),[[15]](#footnote-15).

Although several approaches have tried to address some of the required features [EXPANSION WITH QUOTATION OR DELETED], only a comprehensive holistic approach, addressing all these three components, can maximize the promotion of a healthy lifestyle.

At the same level of importance is monitoring the elder to detect early decline. This would help avoiding depression and falling with risk of fractures that are two of the main causes of fast early decline [GERIATRISTS CONTRIBUTION].

Indeed, the annual incidence of falls in community-dwelling patients older than 65 is around 28-35% and reaches 40% in ≥ 75 years old [Ref: Rubenstein LZ. Falls in older people: epidemiology, risk factors and strategies for prevention. Age Ageing 2006;35 Suppl 2:ii37-ii41]. Falls are responsible for 56% of the hospitalization for trauma and for 6% of urgent hospitalization in patients older than 65 years of age [Ref: Tinetti ME. Preventing falls in elderly persons. N Engl J Med 2003;348:41-9.]. In about 1% of the patients with falls, a femur fracture occurs with a 20-30% one-year mortality and negative impact on functional capacity [Ref: Marottoli RA, Berkman LF, Cooney LM. Decline in physical function following hip fracture. J Am Geriatr Soc 1992;40:861-6.]. In 30-70% of the cases a depressive syndrome occurs, due to the fear of a new onset fall, with consequent disability and institutionalization. Ambulatory problems and muscle weakness are recognized as risk factors for falls [Campbell AJ, Borrie MJ, Spears GF. Risk factors for falls in a community based prospective study of people 70 years and older. J Gerontol 1989;44:M112-M117]. Although the reduction of muscle strength is part of the physiological aging process, much of this reduction is probably attributable to the presence of co-morbidity and to physical inactivity.

The literature that addresses the area of assistive robotics for the elderly is limited. Representative work includes robots that focus on providing assistance for functional needs, such as mobility aids and navigational guides. Dubowsky et al. developed a robotic cane/walker device designed to help individuals by functioning as a mobility aid that provides physical support when walking as well as guidance and health monitoring of a user’s basic vital signs [29]. Montemerlo et al. designed and pilot tested a robot that escorts elderly individuals in an assisted living facility, reminds them of their scheduled appointments, and provides informational content such as weather forecasts [30].

Researchers have also investigated the use of robots to help address the social and emotional needs of the elderly, including reducing depression and increasing social interaction with peers. Wada et al. studied the psychological effects of a stuffed seal robot, Paro, used to engage seniors at a day service center. The study found that Paro which was always accompanied by a human handler, was able to consistently improve the moods of elderly participants who had spent time petting it and engaging with it over the course of a six-week period [31]. Kidd et al. used Paro in another study that found it to be useful as a catalyst for social interaction. They observed that seniors who participated with the robot in a group were more likely to interact socially with each other when the robot was present and powered on, than when it was powered off or absent [32].

Matsusaka et al., developed an exercise demonstrator robot, TAIZO, to aid human demonstrators teaching simple arm exercises to a training group [52]. However, this robot was not autonomous: it was controlled via key input or voice by the lead human demonstrator, and did not have any sensors for perceiving the users. Hence, the system did not provide any real-time feedback, active guidance, or personalized training.

A step forward is represented by the SAR System by Mataric et al., in which principles of good Human Robot Interfaces (HRI) have been incorporated in robotis interaction. However a whole address of elder needs is still missing.

A few EC FP7 funded projects have tried to address this needs…

COMPANIONABLE

ROBOT ERA

GIRAFF PLUS.

Motivation of using Giraff plus:

* Costs.
* Advanced navigation and integration of 3D sensoring that can be used also track human activities.
* Good Gui desing.
* Semi-autonomous navigation.
* Scalability and flexibility

…….

Clear pathway to the market exhists as Giraff Technology has already licensed the robot [GIRAFF TECHNOLOGIES AIMS AND PLANS]. This is a friendly service robot, ….

A few companies besides Giraff Technology, have already entered in the market. One of the robot closest to Giraff is … by Robosoft.

However, these robots are mainly meant as companion robots, with limited capabilities with respect to the needs of lifestyle.

# General Objective

ROBOHOME2.0 has the ambition to go beyond the available prototypes and devices to achieve two accomplishments: promoting healthy lifestyle and monitoring the elder in a comprehensive and integrated way, leveraging novel ICT technology. It will assemble off the shelf components in a robust and reliable way to get a low-cost system that can be deployed massively at home. To achieve this, several steps have to be completed.

We aim at developing a modular low-cost robot-based system to assist physical training allowing 3D gaming experience integrated into a sensorized home. The system will conform to the health status and the personal needs of the single subject. The system will assure a home monitoring, both during exercises and daily living activities, in order to adapt the exercises proposed to the elder to her actual conditions, within a predefined range, and eventually to alert the caregivers, the family and the general practitioner about the changing situation. Interoperability with most of assisted living devices’ standards, such as alarms, devices for therapy adherence, remote control of home settings as well as the integration with a telemedicine platform will be considered as prior requirement. The design will aim at the user experience of a friendly control and interaction with the system. A set of multiple applicability scenarios, spanning from the old independent adult to the chronic disable person living at home will be defined. A cohort of XX end-users, care-givers and physicians, will be involved both in the definition of the requirements of the system and in testing the system. An extended evaluation will be set for each scenario within a within a living lab; the evaluation will include the acceptability by the users and their caregivers and, when applicable, also the evaluation by other actors, such as the family doctor, the physiotherapist, etc.

AN ADDITIONAL LEVEL OF DETAIL IS REQUIRED

**[**

Figure 1 - The structure of RoboHome2.0

Community of stakeholders

GP, geriatrists

Social services

Care givers

Virtual Caregiver elder 1

Virtual Caregiver elder 2

Virtual Caregiver elder N

Intelligent ambient monitoring

Giraff

Activity center

**[WE HAVE TO ADD USER AND HOUSE AT THE BOTTOM and CAREGIVERS on THE TOP OF THE FIG]**

Therefore we aim to develop and validate a system that can promote a longer staying at home by integrating the patient into a stakeholder network that helps his monitoring from the clinical, habitude, physical and psychological aspects, providing also telemonitoring support from the different stakeholders. The system is integrated with an at-home system that supports the elder, supervises critical house tasks, monitors physical, cognitive and social aspects and promotes a healthy lifestyle with the help of serious games. Business solutions envisaged as service providing based on cloud computing will be fully explored.

RoboHome communication will be based on most used standards, like for instance SSH communication for secure communication, or ?? The community will be based on ???. In general all software used will be built as much as possible on components released under GPL license. Semantic and interoperability standards will be defined and permeate the system as much as possible. For instance we will store the monitoring data into a local data-base that provides standard access at many different levels.

Characteristic of RoboHome is a tight integration of monitoring inside everyday life of the elder with no impact on him. Monitoring and activity results are used to refine the activities inside the virtual caregivers, but they produce valuable data for the remote caregiver, clinicians, and social service who may want to intervene to advice the patient and to steer the virtual caregivers. Video-communication with elder and data transfer to the virtual caregivers will be made available.

## Specific Objectives

**In particular, here are the specific Objectives of RoboHome2.0:**

1. **To promote elders education to healthy lifestyle, self-empowerment, and increase their perceived usefulness in the society aiming at improving quality of life of the elders and their formal and informal caregivers**
2. **Monitor and prevent frailty, age-related cognitive and physical decline and social exclusion based on a sensorized home for a non-intrusive evaluation of activities of daily living and behavior.**
3. **To develop a single user intelligent virtual caregiver able to profile the system to user interests and conditions, suggesting motivated exercises and context driven activities.**
4. **To develop a multi-user gaming platform to propose interactive training activities.**
5. **To field test a complete ecosystem, involving all stakeholders, to gather evidence of Robohome2.0 benefits.**
6. **To demonstrate the cost-effectiveness of technology and develop a proper business models for the technology transfer to massive use within a sustainable healthcare system.**
7. **Non intrusive evaluation of the elder status on a daily basis.**

To address these challenges ROBOHOME2.0 will develop the following set of devoted technologies methodologies ingredients aimed to create an ecosystem to support prolonged life at home:

To address these challenges ROBOHOME2.0 will develop the following set of devoted technologies aimed to create an ecosystem to support prolonged life at home:

1. **STAKEHOLDERS COMMUNITY.** A community that promotes socialization and exchange between elders, thus avoiding isolation and promoting healthy lifestyle. The community will provide structured knowledge and suggestions in structured domains, like diet and managing sickness and will allow to support discussion and communication between clusters of elders with similar profiles that self-organize inside the community. The community will also support multi-player gaming functionalities that will be the basis to let those elders who cannot go out socialize and also learn new acquaintances. It will also act as shared repository of cognitive activities that can be structured and returned into reports that can be made available outside the community.
2. **SERVICE ROBOT** The system will capitalize on Giraff robot[[16]](#footnote-16) that will be further extended to meet the project challenge. Giraff will be endowed with an embodied cognitive system fully interacting with the elder, the sensorized home and with the community of stakeholders.
3. **VIRTUAL CAREGIVER Design and implement a intelligent system** which analyzes the elder status and history and suggests structured and unstructured physical, cognitive and social activities to the user. It adapts the level of difficulty of the activities to current status of the user, as monitored by the sensorized home and by the interaction with the robot and the gaming system. Personalization will aim at attaining the maximal motivation, involvement, and attention of the user favoring health benefits. Adequate algorithms from machine learning domain will be used to profile the patients activities and detect early meaningful deviations from typical behavior, providing also information also to clinicians and caregivers and eventually change the overall Robothome 2.0 user scenario.
4. **HUMAN ROBOT INTERFACE Implement the most natural human-robot interaction interfaces, which** will be used for natural and simplified communication, provided according to different degrees of functional impairment of the elder.
5. **ACTIVITY CENTER. Design and implement a personalized activity service system**, based on the gamification paradigm and fully integrated with the robot and with the community of stakeholders. The center will provide cognitive, physical and social activities and it will also support education towards healthy lifestyle, promoting knowledge and self-empowerment of the elder.
6. **SENSORIZED HOME. Identify, design and network a set of sensors that allow to detect risks and to monitor the elder status**. This will require, for instance, to instrument some of everyday life objects (e.g. the cane, the trolley, or other everyday use instruments) to derive patterns of interaction with them. A specific more complex set-up will be identified to identify the signature of the elder in certain daily activities to early detect decline.
7. **BUSINESS MODEL. Define a sustainable business model to massively deploy Robohome2.0.** Evaluate the actual market and available services and elaborate a possible model that takes into consideration the variety of actors that can be involved: from public to commercial entities, non-profit, philanthropic and other forms of social organization. Costs and benefits will be made explicit, analyzing also hidden costs in the actual model. This will regard the whole platform as well as its constituent and will be carried out throughout the project development.



We are targeting elderly subjects who are at risk of frailty, cognitive impairment, dependence and social exclusion. **Frailty** syndrome is defined as a state of excessive vulnerability to environmental factors accompanied by a progressive decrease in the functionality of many organs and body systems [Ref: Fried LP, Walston J. Frailty and failure to thrive. In: Hazzard WR, Blass JP, Ettinger WH Jr, et al, eds. Principles of Geriatric Medicine and Gerontology. 5th edition. New York, NY: The McGraw-Hill Companies;2003;1487-1502]. Beyond this classical phenotype definition, the term frailty is operatively used in geriatric medicine to identify older adults who are at increased risk for future poor clinical outcomes, such as development of disability, dementia, falls, hospitalisation, institutionalisation or increased mortality [Ref: Of. Frailty. In Principles of Geriatric Medicine and Gerontology, 4th; Hazzard W.R., Bierman R.L., Blass J.P., Ettinger W.H. & Halter J.B., eds; McGraw Hill, New York, NY USA, pp. 1119-1156]. According to the Cardiovascular Health Study (CHS) index definition, an individual is classified as frail if he/she meets three or more of the following five criteria:

• Weight loss (>5% in last year)

• Exhaustion

• Weakness (decreased grip strength)

• Slow walking speed (>6 to 7 seconds for 15 feet)

• Decreased physical activity (males <383 kilocalories); females <270 kilocalories)

When one or two of these characteristics are met a condition of **pre-frailty** exists. Otherwise, the person is classified as robust. [Ref: [http://now.aapmr.org/med-rehab/geriatrics/Pages/Geriatric- Frailty.aspx](http://now.aapmr.org/med-rehab/geriatrics/Pages/Geriatric-%20Frailty.aspx)]

Subjects will be eligible for the ROBOHOME2.0 project if:

* pre-frail subjects
* with more than 65 years (75 years????)
* without a cognitive impairment at baseline (Mini Mental State Examination score ≥ 24)
* living at home.

Possible case scenarios:

* subject meeting the eligible criteria living at home with a non-married son who works for 8 hours a day
* subject meeting the eligible criteria, still mostly autonomous, living alone (no close relatives), affected by multiple morbidities, at high cardiovascular risk (e.g. diabetes mellitus, hypertension, hypercholesterolemia, atrial fibrillation) but without a previous major event
* subject meeting the eligible criteria, living at home with a sitter, with relatives living in a different house in the same city, with a previous stroke with mild residuals (mild strength reduction of left limbs, walking with a cane to feel safer)

The elder can be more or less dependent on a real caregiver in interacting with ROBOHOME2.0.

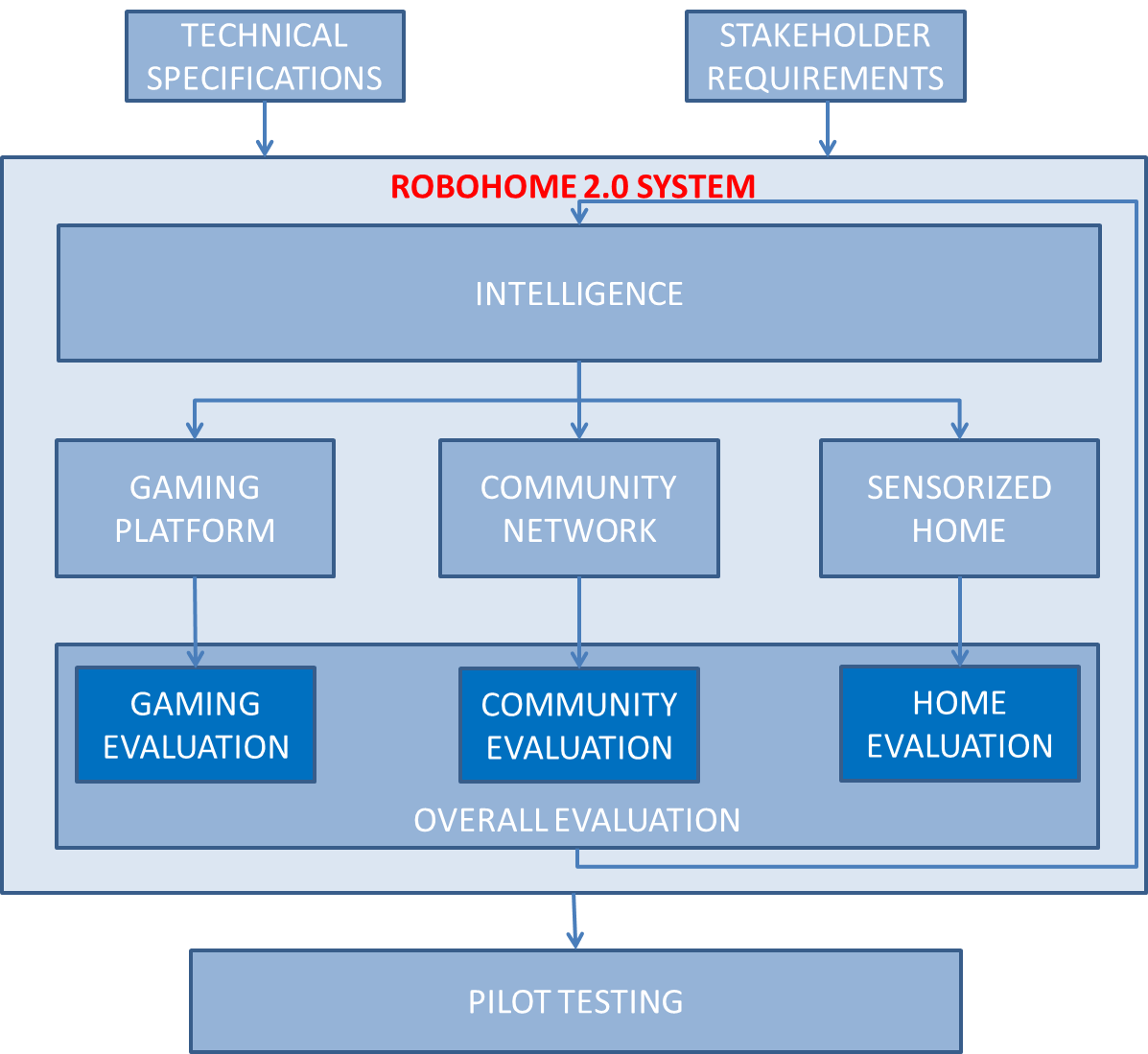


Figure 2 - Development of RoboHome2.0

Conclusion + scenarios still missing here

# Relation to the work programme

*• Indicate the work programme topic to which your proposal relates, and explain* ***how*** *your proposal addresses the specific challenge and scope of that topic, as set out in the work programme.*

**The call mentions the following risks for ageing population: 1) cognitive impairment, 2) frailty and 3) social exclusion**

Frailty syndrome is the most important in the elderly population and is defined as a state of excessive vulnerability to environmental factors accompanied by a progressive decrease in the functionality of many organs and body systems. This functional loss occurs gradually, resulting in disability situations that diminish the quality of life and can even lead to death (Fried LP, Walston J. Frailty and failure to thrive. In: Hazzard WR, Blass JP, Ettinger WH Jr, et al, eds. Principles of Geriatric Medicine and Gerontology. 5th edition. New York, NY: The McGraw-Hill Companies;2003;1487-1502).

Gender and ethical issues should be paid due attention.”

**How ROBOHOME2.0 will reduce the risk of cognitive impairment?**

ROBOHOME2.0 system will include different gaming experiences modulated on the single user condition. These games will comprise pphysical exercises, training fitness programs as well as cognitive exercises such as playing cards, memory games and making puzzles, recognize the sequence of a cooking receipt etc.

**How ROBOHOME2.0 will reduce the risk of frailty?**

ROBOHOME2.0 will stimulate the elder and keep her active. In addition, the scores obtained during the games along with some data derived from the sensorised home, will be used to assess the status and the level of activity of the user to monitor it and promptly register a possible physical and cognitive decline. Specific validation of these decline alert parameters will be included into the project activities. These feedback parameters will be functional to 1) adapting the system to the changing conditions of the user; 2) follow up the user status keeping the carers informed and eventually favoring appropriate and timely interventions.

**How ROBOHOME2.0 will reduce the risk of social exclusion?**

About the problem of social exclusion of the elderly, ROBOHOME2.0 will set a community of users, so that they will be able to connect each other, to make multiplayer games and also to exchange the experience of using the system. ROBOHOME2.0 intelligence will make simple suggestions to the users including solicitation to stay in touch with the relatives, the friends, etc., following the specific setting of the single user.

**How ROBOHOME2.0 will improve independence?**

ROBOHOME2.0 will assure the elder keeping active with an everyday cognitive and physical training, properly calibrated on the single user’s requirements, assuring rewarding experience and confidence of the subject in her/his capability.

In addition, ROBOHOME2.0 will help the elder in some simple but basic tasks related to independent living such as finding the keys, the glasses and the mobile phone, remembering the time for having meals, remembering the medicines to assure prescription adherence.

**- quality of life, that of those who care for them?**

The quality of life will be changed by the positive interaction of the user with the system , into a single user setting able to match the interests of the elder and to stimulate her/him in keeping active and connected. The carers will be helped in the care practice (prescription adherence especially for informal carers like the relatives could be not so much easier that for the elder), and they will perceived help both in the effort to keep the elder active and in monitoring her/his health status and decline.

**- and the sustainability of the health and care system?**

The progress of the physical decline of elderly people sometimes is abrupt, such as in case of dramatic events (stroke, falls, psychological traumas) but sometimes it is a slow progress which might be even negliged by the relatives. The lack of recognition of worsening could provoke dalyed interventions which amplify the decline itself, inducing a negative loop which impact on the requests to the health and care system. ROBOHOME2.0 project will include into the system also a validating set of activity measures (based on the games and on measures of daily activities) capable to monitor the cognitive and physical decline of the user and will communicate a periodic report to the family doctor, so to allow prompt and tuned intervention in case of worsening, slowing down the progression.

For the most severely impaired users, specific supervisions of clinical measures (blood pressure, glucose) will be included into the ROBOHOME2.0 system so to alert critical situations, so to permit anticipated discharges and limit the risks of relapses. ROBOHOME2.0 will communicate the data, when dangerous, directly to the clinicians.

**The challenge is to develop new breakthroughs for active and assisted living based on advanced ICT solutions.**

Hereafter, an analysis of the crisuial ingredients of the aim of the call wth respect to the ROBOHOME proposal is detailed.

**Service robotics:** The ROBOHOME project is based on a commercial off-the shelf service robot (GIRAFFE), which will be enriched with a multiplayer gaming engine and will be integrated into a system of sensorized home.

**Assisted living environment:** proper environmental sensors will be integrated into the ROBOHOME2.0 system to monitor subject behaviors and recognize situations. The data from sensors will be usedto choose what to propose to the user by the robot and also to keep a continuous monitoring of the subject’s status to alert the carers as well as the family doctors or clinicians.

**The project should combine multi-disciplinary research involving behavioural, sociological, health and other relevant disciplines.**

- *behavioural discipline:* partner PX PLY has a strong background on Human Robot Interaction evaluation and will contribute to ROBOHOME2.0 from the design of the user requirements, to the design of the metrics to evaluate the user acceptance , the user experience and also the carers’ feedback. They will extensively participate to the evaluation of the project with the pilot study.

- *social discipline:* social scientists from MUN and PCL will assure both in the design and in the evaluation phases that the project has a positive impact both on the social inclusion of the user and on the external society (including the family, the carers, the family doctor, the clinicians involved in the care as well as the society, in more extended sense)

- *health discipline:* two teams of clinicians (PCL and SAS?) and a group f bioengineers (POLIMI) will collaborate to the project in order to set how the games and the activity acquired by the environmental data will be used to monitor the health status of the user focusing on parameters to monitor the cognitive and physical decline. Specific clinical need of the user will be integrated into the system upon request to monitor comorbidities. Physical trining is included into the game engine to reduce the most relevant risks (like falls), the burdening of mild disabilities (also cognitive) to the physical decline. For the most severe disabled, simple home-based rehabilitative treatment will be included into the game platform, reducing the days spent in hospitals and preventing relapses.

**The expected characteristics of the solution:**

- *modularity:* this is typical of robots, e.g. to be differently combined with the sensorised home and depending on single user needs

- *Cost effectiveness:* We must have in mind an acceptable final target price. This, of course, depends on what we are offering but some external feasible limits should be clearly known and considered (they could be something about 5 to 10 kEuro, but Simona is doing a sort of market research on this)

- *Reliability*: the system has to reliably acts upon a finite variety of scenarios. Note that reliability and safety will somehow be counterpart of the intelligence of the system and its automatic adaptation.

*-Adaptivity.* We should provide at a certain level, a system that can learn from users feed-backs. For instance it can learn preferred activities for users or her idiosynchrasies.

- *Flexibility:* of course flexibility could be devolved upon the onboard intelligence of the control system to adapt to changing scenarios, but a robot could be extremely risky in terms of safety and safety is another expected characteristic. We can develop the concept on a scenario based: a sort of list of scenarios can be compiled, each having a well defined configuration of the system and allowing some automatic behavior but not that much to comply with reliability and safety. The scenarios could be defined, depending on the physical condition of the user. A crucial way to address the broadest flexibility is interoperability of the system with standards, so the system is conceived to be easily operated in a bespoken complex, integrated service. Note that flexibility is required also to a range of social expectations (to be clarified).

- *applicability to realistic settings:* home setting will be the final target. To evaluate the real applicability at home of the proposed solution (which is indeed a prototype and not a commercial device) the idea would be to carry and extended (in time and number of users) evaluation within a living lab for the multiple scenarios (OREBRO, SAS and PCL might host these).

- *acceptability to end-users*: psychologies and sociologies will define this point. Acceptability to user should include the elderly users but also the caregivers and for the scenarios where it is applicable also other actors, such as the family doctor, the physiotherapist, etc.

From the expected impacts, I just highlight one note: - the **global leadership** in advanced solutions will be achieved by a specific attention to Intellectual Property (this activity should be emphasized in WP1, MGT. It is not only the patenting issue but also how patent can be exploited, this is more on DISS WP)

# Concept and approach

• *Describe and explain the overall concept underpinning the project. Describe the main ideas, models or assumptions involved. Identify any trans-disciplinary considerations;*

*• Describe the positioning of the project e.g. where it is situated in the spectrum from ‘idea to application’, or from ‘lab to market’. Refer to Technology Readiness Levels where relevant. (See General Annex G of the work programme);*

*• Describe any national or international research and innovation activities which will be linked with the project, especially where the outputs from these will feed into the project;*

*• Describe and explain the overall approach and methodology, distinguishing, as appropriate, activities indicated in the relevant section of the work programme, e.g. for research, demonstration, piloting, first market replication, etc;*

*• Where relevant, describe how sex and/or gender analysis is taken into account in the project’s content.*

*Sex and gender refer to biological characteristics and social/cultural factors respectively. For guidance on methods of sex / gender analysis and the issues to be taken into account, please refer to* [*http://ec.europa.eu/research/science-society/gendered-innovations/index\_en.cfm*](http://ec.europa.eu/research/science-society/gendered-innovations/index_en.cfm)

The project capitalizes on the results of the project: FITRHAB and REWIRE on the part of gamification and EXCITE and GIRAFFPLUS for the part of service robots.

One of the results of REWIRE has been IGER, that is …. Description.

GIRAFFPLUS has produced the Giraff robot, that ….

# Ambition

*• Describe the advance your proposal would provide beyond the state-of-the-art, and the extent the proposed work is ambitious. Your answer could refer to the ground-breaking nature of the objectives, concepts involved, issues and problems to be addressed, and approaches and methods to be used.*

*• Describe the innovation potential which the proposal represents. Where relevant, refer to products and services already available on the market. Please refer to the results of any patent search carried out.*

TO BE FILLED

Our aim is to move elder far from just watching TV passively. We dream a society in which all the people can feel an active and useful part and not simply a higher weight as they increase their age. The collection of memories, the bank of time, the suggestions to youngers are all elements that would contribute to a less eager and more giving society.

Patent Search

# Implementation

## 3.1 Work plan — Work packages, deliverables and milestones

Please provide the following:

• brief presentation of the overall structure of the work plan;

timing of the different work packages and their components (Gantt chart or similar);

• detailed work description, i.e.:

o a description of each work package (table 3.1a);

o a list of work packages (table 3.1b);

o a list of major deliverables (table 3.1c);

• graphical presentation of the components showing how they inter-relate (Pert

chart or similar).

*Give full details. Base your account on the logical structure of the project and the stages in which it is to be carried out. Include details of the resources to be allocated to each work package. The number of work packages should be proportionate to the scale and complexity of the project. You should give enough detail in each work package to justify the proposed resources to be allocated and also quantified information so that progress can be monitored, including by the Commission.*

*You are advised to include a distinct work package on ‘management’ (see section 3.2) and to give due visibility in the work plan to ‘dissemination and exploitation’ and ‘communication activities’, either with distinct tasks or distinct work packages.*

*You will be required to include an updated (or confirmed) ‘plan for the dissemination and exploitation of results’ in both the periodic and final reports. (This does not apply to topics where a draft plan was not required.) This should include a record of activities related to dissemination and exploitation that have been undertaken and those still planned. A report of completed and planned communication activities will also be required.*

TO BE FILLED

## WP2 – User and technical specifications

**To be filled**

Identification of groups of elders that are suitable to the study. Inclusion / exclusion criteria have to be defined. In particular, compliance with technology has to be appreciated. These should be fragile elders who, without any assistance, have the risk of degeneration.

A proper set of activities that counteract social, physical and social decline will be defined. The most promising activities will be selected for implementation. At least four activities for each domain will be defined for the implementation.

For **Physical activities,** the following review is interesting:

Wayne PW et al. Effect of Tai Chi on Cognitive Performance in Older Adults: Systematic Review and Meta-Analysis. JAGS, 2014; 62: 25.39.

For **cognitive training** in the elders (ACTIVE study):

Rebok GW et al., JAGS, 2014; 62: 16-24.

**Definition of Usability**

According to the ISO 9241 part 11, the following definition applies to **USABILITY:** “Extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use” (it is extremely important to design and devise the user-centric process based on an in-depth, clear-cut understanding of the context of use and the expected nature of user).

Usability is the study of the ease with which people can employ a particular tool or other human-made object in order to achieve a particular goal.”

According to ISO/IEC 9126 Usability is “a set of attributes that bear on the effort needed for use, and on the individual assessment of such use, by a stated or implied set of users”. Among these attributes are:

 Understandability

 Learnability

 Operability

 Attractiveness

**Virtual Caregiver Avatar**. A continuos feed-back to the elder is one of the fundamental elements to keep her engaged [REFERENCES]. Several approaches to this have been proposed. REVIEW.

Particular care will be put in designing a virtual caregiver avatar, such that it does not fall in the so called “**uncanny valley**”[[17]](#footnote-17). Its aspect will be stilyzed so as the subject clearly understands that the avatar is a humanoid being, but does not really pretend to be a human being.

For gaming 2.5DD silhouettes will be required, such that the patient sees clearly himself inside the VR environment. For games that require full 3D movement, a set of avatars that does not fall inside the uncanny valley will be designed.

In the REWIRE project, patients can choose among several possible virtual therapist avatar, according to their idiosynchrasis: some preferred a puppet, to stress the game nature of the interaction, while others felt more reassured seeing on the screen an avatar resembling a doctor [QUOTE]. In both cases, the Virtual Therapist represents an embodiment of the therapist and it is equipped with 3D face and lips animations and text-to-speech technology to make interaction more real.

|  |  |  |
| --- | --- | --- |
| hannah | piggy | C:\AlbertoW\Eudora\Embedded\1d6e6b.png |
| (a) | (b) | (c) |

Figure 3 -The Virtual Therapists used in the IGER system: a) a humanoid avatar, Hannah, b) a mascot, Piggy, and e) a real therapist.

Careful attention to issues of size and contrast will be put to design games that match the level of visual ability of the patient and avoid unnecessary difficulties added to the game. For this reason **game** **elements will be made parametric with the possibility to scale them to the actual patient** **visual ability** and/or motor abilities.

We will give one step further and we will design all the interfaces and the robot itself to maximize the degree of compliance of the robot with the elder. This has been indeed shown as a promising factor to stabilizing the emotional unbalance in people affected by Alzheimer and in autistic people, who see the robot companion as a friend, while still reacting nastly to other human people [QUOTE]

We will design two sets of avatars that can be used. One avatar will be the personal trainer and will supervise the activities of the elder; the second avatar will be the virtual companion of the elder and acts in the vest of a caregiver.

**Task 2.x: User and technical requirements of Community services [BDIGITAL]**

Within this task the functions to be supplied by the ROBOHOME community will be identified. The user roles which will be able to use the community will be defined. Different types of components will be involved in the development community. Basing on the technical specifications of these components technical requirements will be defined in this task. These requirements will be related with the services provided by the WP6. Taking into account the possible actors which will be participating in the usage of the ROBOHOME platform, the user requirements will be defined. The output of this task will be used by the WP6 during the ROBOHOME community development.

STATE OF THE ART ON HRI AND BEYOND (TO BE USED IN THE APPROPIATE SECTION)

Given the growing number of human-robot interaction systems for the elderly, assistive robots for disabled children, and robot use in educational context, there has been a growing interest in the design of effective interfaces to support human-robot communication.

One key feature of the multimodal interface will be the integration of the user’s explicit and implicit feedback, as in any assistive, cooperative, or interaction-based tasks, user feedback is critical to task performance (Broz et al. 2013). The most commonly used form of explicit feedback for interactive service robots consists of providing information to the user directly in the form of language, possibly with accompanying visual information (Li & Wrede 2007). As for implicit feedback, Breazeal et al. (2005) demonstrated that the use of implicit communication by a robot could improve task performance and robustness to errors. Implicit feedback can be based on the user’s motion and gestures, her gaze.

Proper performance of actions is key to alert others of our intentions and of the desired outcome of our actions. Humans use a wide range of paralinguistic cues to signal intention. Eye gaze, preparatory gestures, body language, etcetera are used to signal actions and goals. Robots that operate in public settings (e.g. homes and care homes) can be safer and more effective at performing work if they are designed with similarly human-readable behaviours (Breazeal et al., 2005). Unfortunately, care robots are severely limited in this respect. Their appearance does not evoke anthropomorphisation and their behaviour, alluded to earlier, is not conductive for human-robot interaction. An important aspect of the ROBOHOME2.0 project is studying how behaviour can be tailored so naive users can use behavioural cues to form an understanding of the beliefs, intentions, goals and abilities of the robot. The challenge is to make the robot’s thought processes external and thus observable. There are promising studies that show that principles from animation, such as anticipation and follow-through, can be used to achieve this goal (Takayama et al., 2011). ROBOHOME2.0 will develop multimodal HRI interfaces, integrating speech, touch interfaces and implicit feedback mechanisms.

Given the crucial need to design an integrated user-centred robot system supporting long-term interaction with the user, the project will put strong emphasis on the following issues:

(i) Long-term interaction and acceptance: current HRI systems tend to be based on single-session interaction. In robot assistive scenarios, where the same user interacts with a robotic companion for multiple sessions, it is important to include a memory system that keeps track of the history of interaction and support subsequent tasks in a predictive way, in accordance with the predicted user’s behavior and expectations (Belpaeme et al. 2013).

(ii) Matching of perceived and actual ability: acceptance of robots is strongly influenced by the discrepancy between perceived ability and actual ability of the robot. Matching user expectations can be achieved through either physical design of the robot (e.g. a strong looking robot will be expected to be able to lift objects and people, if in reality this expectation is not fulfilled this has a negative impact) or through setting correct expectations in users by the people introducing the robot.

(iii) Readability: users should be able to read the robot’s “cognitive processes”. Humans are finely tuned to cues and signals communicating our actions and intentions in inter-human interaction, but these cues are generally lacking from robots and this hampers natural HRI (Takayama et al., 2011). ROBOHOME2.0 will study how the behaviour of the robot can be generated to provide feedback and signal intentions and goals.

(iv) Responsiveness: typical performance of a robot involves a considerable amount of processing (for example for automated speech recognition and natural language interaction), which inevitably leads to perceivable delays. As such during processing the robot seems to be inactive. Conversational fillers and back-channel feedback can be used to create the illusion of responsiveness, which is highly influential on acceptability. ROBOHOME2.0 will study how users respond to varying perception of responsiveness.

None of the above mentioned qualities can be considered in isolation: long-term interaction and acceptance, readability, responsiveness and matching of perceived and actual ability all impact on each other. As such it is impossible to develop one quality while neglecting the others. Our research and development on the HRI aspects will focus on incrementally improving these HRI qualities through implementing the latest insights in the field of HRI and field testing with naive users.

Moreover, for the design of linguistic communication capabilities in the assistive robot, the same integrative approach will be used, whereby the robot is trained in parallel to develop sensory-motor and manipulation capabilities, and to acquire linguistic capabilities.

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PLY SUGGESTED TASKS

**Task 2.? HRI and User Requirements Analysis**

This task will provide the user requirements for the ROBOHOME2.0 to facilitate natural interaction between the robot and the users. This will inform the design of the interaction features, the HRI multimodal interface, and the design and analyses of the experimental sessions. The task will combine the use of questionnaires to reach a larger group of potential users in the different countries of the ROBOHOME2.0 partners’ sites. In addition, individual interviews and focus-group sessions will be conducted to investigate specific design interaction issues in more depth.

These methodologies will lead to the definition of the user requirements, the design of the metrics to evaluate the user experience, acceptance of the robot, and also the carers’ feedback

**Task 2.? Multimodal HRI interface design**

This task will concern the design of the multimodal HRI interface to allow the user to integrate the facility of the Giraff robot and the integrated smart environment systems and the virtual carer module. The interface will combine various interaction modalities as speech, touch screen (DOES THE GIRAFF++ HAVE A TOUCH SCREEN? OR WE COULD DEVELOP A COMPLEMENTARY TABLE-BASE INTERFACE). Greta focus will be placed on interface facilities to manage the the user’s explicit and implicit feedback, as we have previously shown (Broz et al. 2013) , user feedback is critical to task performance in any assistive, cooperative, or interaction-based robot systems. The interface will localize and track the user’s face (IS THIS FACILITY IN GIRAFF?) and also user’s gestures (DOES GIRAFF HAS A KINECT-TYPE SENSOR). These social signals will be used by the interface and speech dialog system to facilitate interaction. On the other hand, the interface will provide speech-based feedback to and to ask questions to solve pragmatic ambiguities

**Task 2.3 Behavior analysis (in collaboration mainly with PCL, SAS and MUN)**

This task will be responsible for the behavioural analyses of the HRI experiments. This will be primarily based on standard analyses of the user’s behavior (gaze direction, gestures, speech) through video coding methodologies. The analyses will also follow the developed in Task 2.? On HRI and user requirements. In addition, a set of controlled experiments will be carried out with the explicit manipulation of targeted conditions (e.g. speech-only interaction vs. speech+touch interface) to evaluate different features and functionalities of the interface and of other

## WP3 –Virtual Caregiver (OREBRO, ……).

One of the characteristics of Robohome2.0 is to develop a collaborative intelligence, upon which a continuous interaction between stakeholders and the system is obtained.

A profiling of the elder is obtained and the best match between the activity made available in the gamification center and the profile will be spawned. The profile will be used also to configure the activities to maximize the enjoyment of the elder.

Artificial Intelligence techniques will be used twofolds. They will be used to identify clusters activities in terms of intensity and challenge levels along the physical, cognitive, social dimension. One possibility is to resort to fuzzy clustering systems that allow some overlap between the clusters obtained. A second grouping is required to identify clusters of elder people with a similar profile in terms of idiosyncrasys, to better tune the activities proposed. Such profiles are further refined through the feed-back produced while executing the activities so that the most enjoyed activities can be proposed more often.

The virtual caregiver will also try to browse through the community to identify which would be the elders who might match the elder profile best and try to make new connection creating new sub-groups of the community.

The virtual caregiver collects all the sensors and behavioral data and extracts a picture of the current psycho-physical state of the elder. This information can be compared with past history and used to define a mix of activities that are most suitable to the elder. When large deviations occur, warnings can be sent to the caregivers and / or to the GPs.

We may envision a structure for which human intervention can be minimal,. This could still be required, for instance, some general themes upon which to develop activities can be provided on a regular basis by the system manages. Indeed a direct video communication is guaranteed between GPs and the elder in case a consultation is needed and between remote relatives and the elder.

## WP4 – Smart Activity Center (UMIL, ….)

Many existing self-management support programs consist of series of seminars or workshop that promote healthy lifestyle. Such interventions are not followed by a day-by-day help and their effect would be vane without daily intervention. ICT intervention, tailored to individual patient’s needs and delivered regularly at home have the potential to support a greater change in individual attitude and behavior.

The smart activity center provides activities, personalized by the virtual therapist, to the elder. The activities suggested in terms of exer-games are aimed to exercise physical / cognitive aspects and to promote social activity, suggesting a healthier lifestyle. The activities will be negotiated with patient empowerment strategies, such negotiation of the life style, goals of activities, and feed-back from monitoring and exercising itself.

Feed-back from activities will be gathered in an informal way by both the game center through Q&A provided by the virtual trainer (avatar associated with the gaming center) and through Giraff through touch screen interaction that provides a reacher feed-back.

The Smart activity center is heavily based on gamification. Gamification involves the use of game design and game mechanics for a purpose other than entertainment[[18]](#footnote-18). “Gamification techniques strive to leverage people's natural desires for competition, achievement, status, self-expression, altruism, and closure[[19]](#footnote-19)”.

Relationship with Exer-games. TO BE WRITTEN.

In a non-competitive setting, gamification leverage on designing gameplay such that the user feels rewarded when accomplishing a task. To this aim, various and targeted reward systems can be devised, for instance: points or coins gained, achievements and levels reached certified by virtual badges, improving in completing a game (e.g. a puzzle). Such rewards can be shown by a progress bar [ADD REFERENCS – cf. Wikipedia] and spent inside a community of players, showing relative achievements through ranking or leader boards [ADD REFERENCES].

Explicit competition is another element of gamification. This is implemented especially in some sports games (e.g. rowing [QUOTE]) in which two or more people can compete between them using a machine (e.g. a rowing machine), being in different places. Such virtual competition is considered extremely challenging and it allows athlets from different parts of the world to compete and compare their performances [REFERNCES NEEDED].

In both cases, a proper challenge level is required to allow users to enjoy gaming and achieve effective gamification. If too challenging player would give up soon, while if the task is too easy the game becomes boring and uninteresting soon.

Another crucial ingredient of gamification is the game design and the gameplay itself. A proper level of detail, natural interaction, attractive graphics, meaningful plays [QUOTE], all contribute to make gaming attractive to the user.

All these elements contribute to enter the player in a state of flow [CZEMISK,…] such that he forgets problems and becomes totally immersed into gaming such that even pain stimuli could be neglected [QUOTE].

In the latest years, gamification has been gaining a lot of interest from very diverse fields and it can thus be found everywhere[[20]](#footnote-20): from car fueling systems to ATMs, to environmental campaigns, to workplaces around the world. At this speed, every aspect of our lives will likely be affected by gamification in the near future[[21]](#footnote-21).

Gamification has received a strong push by the novel tracking devices, like the Nintendo Wiimote Controller and Balance Board, the Sony Move, and the Microsoft Kinect, that have revolutionized the way people play video games, making interaction much more intuitive. It was soon recognized [CLARKE] that these devices allow the acquisition of motion and interaction data of good quality that be useful in many domains. Two of these are indeed fitness and rehabilitation. [DESCRIBE games for fitness, Wii-Fit in particular].

Alongside, powerful games engines have been made available recently under open source license, or with limited costs (e.g. Unity or Panda3D). This have made game development a job that could be carried out by any University student for leasure, and therefore has been moved outside the big corporations.

Rehabilitation is more challenging as it requires additional functionalities: (i) A continuous monitoring of the correctness of the motion is fundamental to avoid patients’ maladaptation that might induce joint pain[[22]](#footnote-22) making rehabilitation more harmful than effective. (ii) A feed-back to the patient is required for several tasks (inviting him to the therapy, summarizing the results, advising him when maladaptation occurs, encouraging and so forth); this is even more important when rehabilitating at home, as there no real therapist sitting with the patient. As already recognized by several approaches[[23]](#footnote-23),[[24]](#footnote-24),[[25]](#footnote-25). Adaptation should match the game challenge to the actual patient status. This can take place at (iii) configuration time, when the therapist chooses a proper difficulty level according to patient’s residual abilities and (iv) in real-time with the difficulty and the gameplay adapting to the patient’s current status to limit frustration or boredom. Lastly, (v) all movement and interaction data of the patient have to be logged to be later summarized and shown to the clinicians who assess the therapy outcome, tune it and advise the patient. Interestingly, among these issues, only adaptation has been fully studied in the most recent years.

The application of serious games to improve patients‘ health is currently a very active research area. Several EU projects aimed mainly at rehabilitation are based on the concept of stimulating and motivating the people with games. The REWIRE project is developing, integrating and field testing an innovative rehabilitation platform based on video-games that allow patients who have been discharged from hospital to continue intensive rehabilitation at home. In the SCRIPT project, games are combined with small robots and are aimed at guiding patients in the rehabilitation of wrist and hand functions. Also should be mentioned the project H\_CAD, which was aimed to rehabilitate cognitive dysfunctions was carried out through tasks used in occupational therapy inside a controlled environment. In the EU project BACKHOME, how to provide cognitive rehabilitation tasks to people with severe disabilities is investigated. Currently, three categories of cognitive games have been taken into account: perception; attention and concentration; and memory. It is beyond the scope of BackHome to develop, validate, and illustrate clinical outcomes, however the intention is to validate the efficacy and stability of the proposed solution within a future evaluation. CUPID, … All implement games to guide rehabilitation. However, the games, often developed by companies, do not match these requirements; they are often games tailored to specific population and cannot be extended, have limited configuration and adaptability and often no variability so that gamification, especially, for prolonged time cannot be supported.

The IGER game engine[[26]](#footnote-26), developed inside the REWIRE project coordinated by UMIL, has provided a new generation game engine that provides in an integrated and coordinated way, all these functionalities. IGER integrates methods of computational intelligence for patients’ monitoring and adaptation, providing the required elements to make rehabilitation at home feasible and robust. IGER games are fully configurable so that they can be tailored by the clinicians to the patient needs and rehabilitation goals, and they are continuously adapted in real-time to the patient’s performance through a Bayesian framework that updates game parameters to provide an adequate difficulty level while keeping the patients within the therapeutic constraints specified by the clinicians. The gameplay is continuously monitored using a fuzzy system (leveraging the therapists’ knowledge) to avoid wrong postures or wrong movements, which would make rehabilitation more harmful than useful. A novel color coding feed-back is used to inform the patient on wrong movements. IGER also integrates a personalized virtual therapist avatar that advises the patient and guides him through the rehabilitation sessions. Controlled randomization of assets, targets, voice feed-back avatar choice, and facial animation are all aimed to increase compliance with the therapy[[27]](#footnote-27). Finally, several input devices can be interfaced to IGER thanks to its specific input abstraction middleware. Besides this, from videogames, IGER has borrowed the concept of game engine: a set of tools that, on one end, make the games run on the machine they are designed for and, on the other end, help the developer in creating games that share the same features. Therefore, IGER has allowed a fast prototyping of new games, reusing the gaming functionalities that been developed for previous games. IGER offers therefore a good starting point to RoboHome.

**Aims of WP**

Build an intelligent gamification center based on IGER that provides:

- personalized and adapted structured and unstructured activities on demand. - educational games.

**Beyond the state of the art.**

**Task 1 – Introduce layered personalized motivation inside the game engine [This is related to WP3].**

We aim to increase the gamification level inside the game engine by layering the game engine and introducing additional gamification issues related to the virtual community support and the profiling of the elder. This will take fully advantage of IGER being a game engine and therefore able to build the game from assets that can be loaded at run-time according to elder idiosynchrasies.

Different layers of gamification are placed inside the activity center, in order to address all aspects of motivation: intrinsic and extrinsic, short-term and long-term.

At the basic layer are the *exergames* themselves, physical and cognitive exercises are hidden under the hood of compelling and fun mini-games. ‘*Make a step to the right’* may be a valid therapeutic balance and posture exercise, but if it is translated as *‘catch the fruit with the basket on your head before it falls’* or ‘move that shell on the bucket’ may be more enjoyable, while still retaining its validity. We couple the exercise goal to a fun gameplay goal, tailored to the elder and to the general theme set, letting the elder performing the exercise inside a virtual environment inside which, music, playful sound effects and hand-painted 3D graphics all contribute to attractiveness of the game [REF: MATARIC, ALTRI]. Intrinsic motivation is thus reinforced by the enjoyable experience of play. The theme of the games can be adapted also from the feed-back of the elders themselves who rate the exercise experience at the end of each session. This rating is used inside the Virtual Caregiver to tune the exercise difficulty or even to automatically change the game theme according to an evolution paradigm widely explored in [REFERENCE??].

The exergames represent only a first gamification aspect, however. We will also provide short-term extrinsic motivation under the form of verbal praise from the Virtual Caregiver Avatar that is constantly monitoring the patient, giving advice on the exercises and praising her when she performs her exercises correctly. Short-term extrinsic motivation is also empowered by additional gaming-like solutions: points and high-scores, colorful and meaningful feedbacks and personalized content, according to elder profile.

Long-term motivation represents a major issue when activity prolonged in time is required: games may get old soon and lose their appeal after a period of a few days of repetitive play, and the kind words may not be enough to keep the patient engaged for months. We will tackle this by developing a *‘bigger game’* container, inside which locate the different individual exergames, transforming the single exercises into small bricks that build the big game’s actual, slower, gameplay. This is the same mechanism that fuels famous and highly successful casual games such as FarmVille[[28]](#footnote-28). We will fully take advantage for this of the community support and allow elders to play the bigger game with pairs in a cooperative or competitive way [FURTHER ELABORATION REQUIRED].

To avoid repetitive stereotyped sequences of situations, we will fully explore here **Finite State Machines[[29]](#footnote-29)** that allow game transition from one state to the other to complete a given task. This allows managing complex interactions with limited computation effort. Although many issue arise when many characters and many machines interact among them, to maintain a player engaged and have a rich game play in virtual reality games, the challenge is to maintain the subject engaged with simple environments, simple games to repeat these tasks over and over again without distressing. The solution explored here is a controlled randomization of some aspects of the game (environments, tasks, actions) such that the stimuli are balanced over the different rehabilitation trials. Stochastic finite state machines are a powerful tool to achieve this**45**, and they **will be** **explored to create variants of the game that would never tire the patients.** This same model will allows monitoring the patient’s choices during the game and tune the game play to force the patient to execute also the less chosen actions. **This would be a tool that allows** **maintaining a game balanced also in front of stochastical variability.**

**SCENARIO**

Therese has never liked the mountains. In his youth times she always liked to go to Porto Palo beach in Sardinia. This information is inserted in her inclinations in the environment cathegory. The game engine addresses it and, whenever it possible, chooses scenarios and games assets related to the sea-side. For instance for the memory games a sea-side scenario with shells is provided [REF MAINETTI].

**Task 2. Develop full mirror viewing.** Foreground to background segmentation is fundamental to isolate the silhouette of the elder and paste it inside the virtual environment. It has been shown that this makes the virtual reality environment extremely pleasant [REF UNCANNY VALLEY], provided that no appreciable delay is introduced. This modality has been explored with 2D cameras inside the Duckneglect project[[30]](#footnote-30), in which patients reported a very high sense of immersion (cf. Figure 4). Such clean silhouette could be obtained only when controlled background could be obtained, and this is beyond the use inside a common house. Kinect has raised the expectation of a robust foreground segregation, but this was not the case and several solutions have been studied. Kinect 2.0, to be released early this year promises to have a batter foreground separation. In case, this would not be possible, we will fully develop the prototype solution developed by UMIL[[31]](#footnote-31) that combined good quality with speed compatible with real-time operation.



Figure 4 - Silhouette extraction and integration inside a Virtual Environment

Whenever an activity can be played in a modality compatible with mirror view, the silhouette of the elder is used as his avatar instead of a synthetic one.

**Task 3**. **Design and implement physical activities.** These will be mainly based on the exer-games developed inside the REWIRE project. An important step forward will be the addition of exercising with a caregiver either remotely or inside the house. In these situations the elder stands in front of Giraff with the Kinect sensor aiming at the elder. The elder will see on the Giraff monitor the targets inside the virtual scene that he has to get. A different set of exercises will be based on generating complementary movement to those of the avatar or imitating gestures, for instance to realize a theatre piece.

**SCENARIO: Robert gait is becoming slower and less stable. Giraff identifies that Robert needs to move more and identifies exercises for balance and posture as the best remedy. It proposes to him a set of games to be played for a quarter of an hour for at least one week. It also shows to Robert all the other elder in the community that has entered in the same program and the results and trends to motivate him. This information is sent also the his caregivers and to his GP.**

**Task 4**. **Design and implement cognitive activities.** Cognitive activities will be based mainly on teouch screen interaction. Puzzle, Simon … A set of cognitive activities will also be promoted at random to keep the elder alive. Life for instance asking the date, the month, the name of the daughter and so on, at random times.

**Task 5**. **Design and implement social activities.** Card games are most popular among the eldest. They combine three important aspects: cognitive stimulation (memory, strategy), social interaction and competition with pairs. It is not always possible to get together to play and RoboHome2.0 can help the elder to achieve this. Aim of this task is to build a client that supports multiplayer card-games, that can be played in person. BETTER REFINE THE IDEA. How to represent the cards on the table? How interact with cards? Do we need real cards?

PICTURE REQUIRED.

CARDS ON THE TABLE

CARDS IN HANDS

NOTE: In the figures 4 videos can be played, in each one the patient can view either himself in his own environment. CARDS will be stylized.

**SCENARIO: Anna is calling her friend less often in the last week. Giraff (ROBOHOME) identifies that Anna has to be suggested more social activities and suggests her more social activities, suggesting playing cards, give calls to Michela or Mary, who has not heard about since a long time, or to go with her friend to the violin concert of her nephew to which she was invited.**

**SCENARIO: Anna is listless today. She is invited by the smart caregiver to contact her friends for a card game. Anna starts playing with Emma, Michela and Lina but Emma realizes that Anna is slower than usual to play her card and she is not at here best level. Emma herself leaves a message to her virtual caregiver that transmits the gentle message to Anna’s relatives.**

**Task 6** **Design and develop educational games.**

Serious games can also be used to educate the elder to a healthy lifestyle. Very recently a first attempt in this direction is represented by ―badblood[[32]](#footnote-32), which is aimed generally to educate healthy people on the most dangerous illnesses. Such educational games can be easily embedded in the social dimension. In fact, experiences with applications oriented towards promoting active lifestyles on seniors highlight the importance of social motivational instruments[[33]](#footnote-33) to overcome the barriers of acceptance in older adults.

**We will explore here the use of serious games to teach the edlers on their actual mix of activities and their lifestyle program and educate them on the effect and results of adhering to the program.**

**To enforce compliance, the elder should be protagonist of his own lifestyle management**. For this reason, the elder should learn about the effect of the different medicaments so that he can better appreciate them and take them on a regular basis, and learn on the results of the physical / cognitive and social interaction. This would fully implement the concept of empowerment. Such approach will also explore an innovative way to create educational stories that can be updated and provide always different scenarios to the patient. Variability in this process can be obtained by using stochastic finite state automata that have been extensively explored to generate procedural stories[[34]](#footnote-34),[[35]](#footnote-35),[[36]](#footnote-36).

The establishment of common goals that have to be obtained through the collaboration with the elder’s proper ecosystem. This can be the basis for **the adoption of social inclusion drivers, which will represent an incentive for game adherence on seniors**. Reputation, which emerges in the interaction between the members of a community[[37]](#footnote-37), can be a key factor.

In particular, in RoboHome we will explore how the increase of knowledge in lifestyle, possible connection with illness and decline (through gaming and social interaction) and the overall increase in the compliance to the cure can be used for increasing the reputation inside the on-line community and the trust in the RoboHome system, increasing therefore the patient‘s motivation to education, compliance and exercising.

Gaming will be provided by a gaming centre that will be fully integrated inside the RoboHome infrastructure, thus providing valuable data to the stakeholders and to the Virtual Caregiver for tuning the mix of activities and advising the elder.

**Exercising:** Structured exercise training is a commonly prescribed for recovery heart failure[[38]](#footnote-38), chronic lung disease, and arthritis patients. It is also required to counteract natural decline with aging. Therefore**, the elder at home will be required to perform exercises regularly, whose intensity and difficulty will be tailored to his condition.** A Virtual Trainer will guide the elder through them. This Virtual Trainer will interact with the Virtual Caregiver, and introduce the elder to the social community. In this specific framework, exercising is completely intertwined to education. Given that much care should be put in making these games attractive in order to achieve a strong treatment adherence, **controlled statistics will be massively introduced in terms of Bayesian network and graphical models in general to provide at each instant of time, a proper challenge level inside the game**.

**Gaming also allows accomplishing cognitive training**, and in particular training of memory and cognition. Simple exercises, linked to daily lifestyle actions can be designed, like for instance preparing three courses, Italian meal inside a virtual kitchen as was suggested in the FITREHAB project or spot questions that are provided, from mini-mental tests for instance, during physical games, like “what season are we in now”.

Serious games are focused on increasing elder knowledge about their condition and risks, including self-management skills and information about the medications and activities related to their condition. In addition, these serious games will try to produce behaviour changes in the elders towards a more active and healthy lifestyle. They will be complemented with elder empowerment strategies such as negotiation of the goals, communication with pairs, and feedback from the execution of exercises. Such games will be used **to educate and inform patients**. This is the role of serious games implemented in vocational training, of which the most popular is possibly the “flight simulator”. However, vocational training based in Virtual Reality has extended to other fields like business (negotiation skills), construction, mining, sports, education and so forth.

It has been also applied in the clinical domain, in which surgeon training has become common practice[[39]](#footnote-39). Serious games can provide a strong support on vocational training and **we will take this novel perspective to games to educate and motivate elders to an adequate lifestyle.** Very recently, a first attempt in this direction in the health field is represented by ―badblood[[40]](#footnote-40), which is aimed generally to educate healthy people on the most dangerous illnesses. Such educational games can be easily embedded in the social dimension. In fact, experiences with applications oriented towards promoting active lifestyles on seniors highlight the importance of social motivational instruments[[41]](#footnote-41) to overcome the barriers of acceptance in older adults. **We will explore here the use of serious games to teach the elders on their situation and lifestyle program and educate them on the effect, results and outcome of adhering to their prescribed lifestyle and risk if not adhering to it. To enforce compliance, the patient should be protagonist of his own well-being**. For this reason, the patient should learn about the effect of the different medicaments so that he can better appreciate them and take them on a regular basis. This would fully implement the concept of patient empowerment. Such approach will also explore an innovative way to create educational stories that can be updated and provide always different scenarios to the patient. Variability in this process can be obtained by using stochastic finite state automata that have been extensively explored to generate procedural stories[[42]](#footnote-42).

To trackle this issue we will begin from two starting points: the identified profiles of the elders and the associated lifestyle mix of activities defined and the identification of suitable frameworks that can be familiar for the elder and depends on her idiosynchrasies, like for instance a classical environment of a fairy tale or a virtual Olympic competition or a travel around the world. Such environments will constitute the containers inside which the activities will be accommodated [THIS PART IS MORE RELATED TO VIRTUAL CAREGIVER]. We will explore the possibility of developing automatically a narration that can sustain the activities for prolonged time. The story will assume, possibly the form of a tale, and chain different mini-episodes. We will do automatically defining a graph of the possible allowed choices at a certain point of the story and resorting to optimization through graph cut. Such approach has already successfully explored in chaining long animation sequences[[43]](#footnote-43), to choose in real-time which would be the best next animation sequence in real-time, optimizing an adequate cost function. Here we will extend this approach defining a cost function that describes how best each mini-episode fits the current narration point and the story in general [REF] in terms of coherence and consistency. We will go one step beyond introducing inside the cost function the main concepts related to the flow theory first defined by Mihaly Csikszentmihalyi [REF], which has been widely accepted by the game design community. In particular, it states that when the skills of the user are matched by the level of challenge posed by the game, the user enters a state of complete focus and immersion in which it loses track of time. Gaming alternates moments of difficulty and moments of easiness of play [DRAMA CURVE, REF]. The benefit of the flow state is that the user becomes completely focused on the game and everything else vanishes. Studies also show that physical pain is also reduced when flow state is reached [REF, FLOW ALREADY INTRODUCED AT THIS POINT].

**Deliverables**

Deliverable 1 – A first nucleus of physical and cognitive games + silhouette tracking. M12.

Deliverable 2 – The full system for multiplayer gaming with cards. M18.

Deliverable 3 – The full smart activity center. M24.

## WP5 - Monitoring

**OBJECTIVES**

**-** HW development of unobtrusive customized monitoring devices;

**-** Development of the integrated sensorized home

- Extraction of user actual condition from the whole information gathered by the sensorized home

**DESCRIPTION OF WORK**

RoboHome2.0 will provide a set of customized and off-the-shelf very low cost devices and tools to monitor the elder behavior at home and his physical and cognitive condition. A few medical devices that measure typical information, like blood pressure or heart rate will also be integrated in the sensor network. The analysis of all of the gathered information will allow the personalization of the user scenarios that are managed by RoboHome2.0 intelligence in WP2.

The developed devices will be also used to execute, at home, standard evaluation tests like for instance, Berg-Balance test or mini-mental test [Quote]. Validation of these tests will be carried out as integral part of the project.

1. **What to measure? (POLIMI, PCL, SXT)**
   1. Sensors for monitoring:
      1. Monitoring daily activities and behavior:
         * Sensors to check the level of mobility of the user in the day
         * Cushion pressure sensor to understand how long the elder is sitting.
         * TV monitoring (how much is on and the elder is sitting in front of it).
         * Cellular phone conversations length. Pitch analysis.
      2. Monitoring exercises performance:
         * Instrumented aids (cane, walker, or tripode, etc) to measure the level of assistance during posture movement training exercises execution.
      3. Monitoring health condition
         * Few off-the-shelf very low cost medical devices to measure typical information, like blood pressure or heart rate will also be selected
   2. Sensors for promoting independent living:
      * + Simple sensors to assist tracking of everyday objects (eyeglasses, keys, mobile phone, and cane)
        + Automatic drawer for drug delivery to facilitate prescription adherence
        + Safety devices (such as gas alert)
   3. Sensors personalization: add/remove the sensors depending on single user (an initial set of sensorized objects will be selected on identified relevant scenarios)
2. **HW development of customized sensors (SXT)**
   1. Principle of HW design:
      1. Beyond wearability: Unobtrusive sensors-> the environment and objects are sensorized, but not the subject
      2. Beyond easiness of use: transparent sensors -> the sensors do not require any collaboration from the user
   2. HW development (describe technological solutions for these specific devices)
      1. instrumented aids and daily life objects
      2. Sensors to track objects
      3. drug dispenser
   3. Technical and functional testing

Describe how to do it

1. **How to integrate information from the network of sensors? (SXT)**

The network of sensors will be integrated in a middleware that will provide to the intelligence the updated information on the required parameters. The most suitable standards will be identified and used to facilitate interoperability. All of the selected and developed devices will have most different transmission capabilities and cabling the entire house cannot be feasible. A structure based on WiFi transmission will be the most reasonable. It could be based on a Hub or concentrator that integrates for instance a Raspberry card with a set of USB ports and a WiFi transmitted to the Intelligence.

1. **how to use this information to profile the users condition and behavior? (POLIMI, PCL, OREBRO UNI)**
   1. Pilot tests on ROBOHOME2.0 specific measures will be realized in order to correlate them to gold standards clinical scales. This pilot will be run all along the project duration (after the set of requirements and the definition of the focused measures) and not just in the final evaluation of the integrated system, so to assure significant sample sizes.
   2. Machine learning algorithms will be used to fuse the whole sensors information in order to extract an overall picture of the subject current condition. The current user condition, will be transferred to the virtual caregiver.

DELIVERABLES

Design and development of customized monitoring devices (prototype and test report)

Sensorized home integration

. It could be based on a Hub or concentrator that integrates for instance a Raspberry card with a set of USB ports and a WiFi transmitted to the Intelligence.

Other devices that can be integrated can be:

* Gas alert
* Drawer that opens selectively and provides the right amount of pills at the right time
* Cushion pressure sensor to understand how long is the elder is sitting.
* TV monitoring (how much is on and the elder is sitting in front of it).
* Cellular phone conversations length. Pitch analysis.

We have to consider that the elder can be not alone at home. Shall we put some WiFi tracking device on the other people in the room?

STATE OF THE ART AND BEYOND (TO BE MOVED IN THE APPROPIATE SECTION)

1)SENSORIZED HOME (SXT+BDIGITAL)

sensors; network; integration of the sensorized home into the Robohome2.0 platform

**THE SoA section and WP (SXT)**

Modern technologies already allow to create smarts domotics systems in normal home, mainly dedicated at home automation and entertainment.

In the field of the monitoring systems for independent living many studies has been published [movement analysis, fall detection… ] with different technologies, but they are still far from representing a daily usable, cost-effective solutions, with lack in the integration.

Commercial in-home monitoring systems, designed for elder-care application, are still a frontier that need to be explored. Commercial systems usually are only alarms or presence-detector systems (Philips lifeline, Medical guardian, TeleSalvalavita Beghelli ..] and rely on the elderly people’s relatives.

From the technological point of view, the development of an effective monitoring system relies on a good integration of available devices and applications with specifically developed ones.

Sensors and electronics miniaturization has made possible devices that could not been imagined few years ago. Recently apps for Smart-phone that can measure heart rate have been developed, and also easy-to-use blood pressure monitor already exists both for smartphone and iPhone devices. These are among the clinical measures that are most required by elder people. Other measures will be identified in WP2, could be for instance oxygen saturation or specific results of exams like […] for glucose concentration in the blood. Such system would allow to integrate into the monitoring network most of the clinical parameters that have been identified, using measurements that have been validated and are commercially available.

Other aspects are equally important to monitor fraility. Among these, the patterns of physical and cognitive interaction with the world is equally important. Cognitive interaction can be derived by the log carried out by the activity monitor on cognitive tests as shown in WP4. We here develop innovative monitoring modality that is embedded in the usual lifestyle such that the elder does not perceive monitoring as an activity disjointed from ordinary life.

Monitoring has to be targeted to physical activity in general, but also to fine motor activity.

MONITORING HEALTH CONDITION

On Giraffe we can integrate an easy-to-use, ergonomic system to measure blood pressure and heart rate, without using any wearable solution.

INSTRUMENTED OBJECTS

To this aim we will instrument objects of daily life that will be identified in WP2. These can be for instance the cane using to support walking or the trolley. Handle of pans or cutlery (eating is a more common practice than cooking for elderly people), handle of doors or fridge or other typical objects will be considered as well. To this aim, we will design and develop miniaturized modules that can be embedded inside such device [FIGURE of the CANE or of the PAN] and can sense the pressure in the handle position and the movement of the object itself..

Trough inertial sensors integrated in the handle of cane for instance, could be possible to analyze changing in movements, or specific behavior and or pattern modifications.

MEMS technologies are now a stable and cost effective solution: 3D, smart accelerometer and gyroscopes are wide diffused in game consoles and automotive systems. Many different models are available. The really compact design of such transducers (as low as 2x2x1 mm3) that allow to perform different kind of measure at really low power consumption.

Whit the aid of modern tactile sensing technology, will be possible to measure the pressure or the force applied to different kind of handles, in order to infer data related to the clamping force and direction, for example.

Both families can be connected or embedded with wireless modules, such as low power Bluetooth® modules (e.g. class 4.0) in order to create really low power, compact and flexible systems.

These modules will be realized with two modalities. The first will be a real-time transmission of the data and will be used for activities. For instance the cane can become a tracker inside a mini-game in which the elder has to climb a mountain by raising the cane and lowering it in specific positions. The movement in terms of velocity and pressure profile can provide very important information to evaluate the stability and control capability of the elder. In a second modality, the device can store in on-board the data related to an entire day (e.g. use of the cane in a stroll in the park and so forth). These data will be downloaded automatically when the cane is put on rest. For this aim, an approach similar to that of Giraffe and of Sony AIBOs will be used [ ]. During the rest condition, through wireless charge or standard charge technologies will be possible to recharge the systems. The new Bluetooth® Smart Technologies [http://www.bluetooth.com/Pages/Bluetooth-Smart.aspx] will be able to create extremely low power, standard transmission. Such wireless solutions are already compatible with emerging wireless charge technologies that can make really easy and safe the usage from elderly people.

A similar setting can be inserted in the handle of a pot and measure the interaction when cooking. The information from these devices can be collected directly through Giraffe, that will get close to them when they are being used, that is when variation in the transmission power or in the pressure measured is registered by the device.

TRACKING OF OBJECTS

Another element in monitoring is related to location of objects of common use at home, typically glasses, keys and phone. There are new emerging solutions based on sticks or key ring [https://www.sticknfind.com/, http://www.thetileapp.com/] to be used with specific Apps, but elderly people has to find by themselves the objects and, moreover, the mobile phone has not to be lost. The Phone can be located through GPS signal, but usually GPS signal can’t be received at home. Possible effective solutions, aimed at reaching a good standardization and integration with Giraffe, could be the same Bluetooth technologies used for the sensors. Also RFID technologies already are used for tagging objects. However, RFID tags devices require a reader to be placed inside all the rooms, with a high impact on the house, whilst new Bluetooth technologies (v 4.0) will allow to extend the range of detection, even with reduced power consumption. The alternative is to use also an active reading devices based on active tagging. To this aim a miniaturized localization device will be developed for keys and glasses. This will be based on low power Bluetooth and is hosted in a small lodge inside the frame. This system collaborates strictly with Giraffe.

Standardization of input devices.

The solution envisaged here is based on populating a data base stored inside the Virtual caregiver, that is able to store the detailed data for a fixed amount of time. History lumped data will be identified and send back to the community along with data that summarise the monitoring, exercising activity of the elder day by day. Such approach allows to use the most heterogenous input and make them available through standardized data base queries (SQL).

DRUG DELIVERY

Lastly a cooperative system in drug distribution will be developed in the form of a drug dispenser. This will be constituted of a set of drawer, each with an electromagnetic lock will be controlled remotely by the virtual caregiver. Only the right drawer is open at the time in which the elder should take prescribed pills. This approach requires that a caregiver fills the drawers at the beginning of a week, but it then guarantees that pills are not taken more than once or forgiven. At due time the virtual caregiver warns the elder through all the devices available, Giraffe, cellular phone, TV and so forth and it renew the memo every given period, until the drawer is not opened and pills are extracted [<http://www.google.com.tr/patents/US8588964>].

Additional devices will be collected through standard sensors like, gas alarm or fridge open. Pressure sensor combined to TV remote controller can be used to monitor how long an elder is sitting down watching TV. A set of these devices will be deployed and information collected.

Other devices will be considered like foot plantars, like the ones developed by Nike or the more sophisticated ones by Moticon that allow recording the pressure and the motion of a foot over 24 hours.

Cellular phone information from intertial sensors will be used to detect the movement quantity of the elder throughout the day [REF LITERATURE].

The minimal set of sensors that will be considered as fundamental in WP2 will be fully developed and integrated in WP8 inside RoboHome 2.0.

2) MONITORING INFORMATION FUSION (POLIMI)

3) PILOT TESTING (POLIMI PCL)

With the diffusion of wearable device, some of the standard tests for cognitive or physical decline have been proposed to be instrumented. EPFL has proposed an instrumented way to carry out the Berg Balance test, typically used to assess the equilibrium of neurological / post-stroke patients. Description of the test. We will define here possible standardized tests that could be implemented inside RoboHome2.0 using the devices and or the robot. For instance the QMCI test, recently developed [PCL may further elaborate on this].

Additional tests can be explored by using instrumented everyday life objects. For instance the relationship between standard tests (e.g. Berg Balance scale) and the data that can be acquired by the smart cane or by the games targeted to sit-to-stand exercises will be explored and possible correlation will be evaluated [POLIMI may further elaborate on this].

Typical tests considered are:

* Allacciare I bottoni.
* Alzarsi dal letto.
* Alzarsi e sedersi sul divano con le braccia conserte.
* ADL / IADL
* Minimental test

Integration of clinical measuring devices can be required. If we can integrate apps would be much better. We may buy applications if needed, we do not need companies.

We have to consider gender issues.

**From PCL:**

In monitoring it would be good to insert:

* SLEEP. Number of hours of sleep and its regularity (elders have often a disordered sleep for bad habitudes, included ipnotic medicaments, that are sconsigliato).
* FOOD. Quantity and regularity of meals (often elders eat small amounts of food and are disordered. They eat at wrong hours, assume too much sugar, ….
* DRINK. Both as quantity of liquids (problem of lack of thearsty stimulus) and as quantity of alcohol (this is underestimated but it is a large problem).
* BATHROOM. Number of times that the elder goes to the bathroom to evacuate.

Besides these standard devices, we would like to have:

* A general way to instrument everyday life objects like: cane (e.g. consider http://www.medgadget.com/2013/12/isowalk-a-smart-cane-that-adapts-to-its-user.html) or a trolley, that would provide force and motion information. In case, we could also try to instrument handles but it would be more difficult.
* Processing to detect stability in walking, especially with the instrumented cane (I GUESS THAT THIS COULD BE PATENTED).

Therefore RoboHome allows a telemonitoring capability of the elder at home, that can provide to caregivers the information to adopt preventive strategies for the patient, and send to the virtual therapist information that guide its behavior, closing the loop with the elder and with its behavior.

With the diffusion of wearable device, some of the standard tests for cognitive or physical decline have been proposed to be instrumented. EPFL has proposed an instrumented way to carry out the Berg Balance test, typically used to assess the equilibrium of neurological / post-stroke patients. Description of the test. We will define here possible standardized tests that could be implemented inside RoboHome2.0 using the devices and or the robot. For instance the QMCI test, recently developed [PCL may further elaborate on this].

The relationship between parameters that can be monitored with ROBOHOME2.0 and the following typical tests of a geriatric comprehensive assessment will be evaluated:

* Mini Mental State Examination (MMSE)
* Katz index (basic activities of daily living - ADL) and Lawton Scale (instrumental activities of daily living - IADL)
* Chair Stand test

Integration of clinical measuring devices can be required. If we can integrate apps would be much better. We may buy applications if needed, we do not need companies. Among the clinical parameters to monitor (+ alert system) we would suggest:

* blood pressure with alert system when the parameter passes certain upper and lower thresholds
* heart rate with an alert when the parameter passes certain upper and lower thresholds
* integration of glucose monitoring in case of patients with diabetes mellitus or pre-diabetes condition, with an alert when the parameter passes certain upper and lower thresholds
* reminder for assumption of pharmacotherapy with a system to track the response to the reminder/ the accomplishment of the task (possible???)
* falls??? (Is it possible to detect a fall?)

The idea would be always that the elder does not have to wear anything. He can use devices for measurements.

We have to consider gender issues.

All these data will go to the monitoring center that will analyze these data and transfer to Virtual caregiver required semantic information on the elder status. [POLI: how?].

We will go one step further and use these same devices as possible devices to execute, at home, standard evaluation tests like for instance, Berg-Balance test [Ref: Berg KO, Wood-Dauphinee SL, Williams JT, Gayton D. Measuring balance in the elderly: preliminary development of an instrument. Physiotherapy Canada 1989;41:304-311.] or Mini Mental State Examination [Ref: Folstein MF, Folstein SE, McHugh PR. Journal of Psuchiatric Research 1975;12:189-98]. Validation of these tests will be carried out as integral part of the project.

Additional devices will be collected through standard sensors like, gas alarm or fridge open. Pressure sensor combined to TV remote controller can be used to monitor how long an elder is sitting down watching TV. A set of these devices will be deployed and information collected.

Other devices will be considered like foot plantars, like the ones developed by Nike or the more sophisticated ones by Moticon that allow recording the pressure and the motion of a foot over 24 hours.

Cellular phone information from intertial sensors will be used to detect the movement quantity of the elder throughout the day [REF LITERATURE].

The minimal set of sensors that will be considered as fundamental in WP2 will be fully developed and integrated in WP8 inside RoboHome 2.0.

Another element in monitoring is related to location of objects of common use, typically glasses, keys and phone. Phone can be located through GPS signal [APP or other instruments]. Possible solutions to locate the keys and the glasses could be based on RF-ID sensors. However, these requires a reader to be placed inside all the rooms with a high impact on the house. The alternative is to use active reading devices based on active tagging. To this aim a miniaturized localization device will be developed for keys and glasses. This will be based on low power Bluetooth and is hosted in a small lodge inside the frame. This system collaborates strictly with Giraff.

**Scenario**

**Jessica does not find her keys, call Giraffs and asks for the keys. Giraff activates and ask to the virtual caregiver help. This logs the actual power of the signal from the keys and guides Giraff towards an increase of the signal. Giraff starts moving to the right towards the sitting room, that is prioritized in the list of the rooms in the house. It then moves towards the dining room and registers and increase in the signal and moves in that room until it gets close to a drawer on the top of which sits the glasses. Giraff calls then the elder to get the glasses.**

Standardization of input devices.

The solution envisaged here is based on populating a data base stored inside the Virtual caregiver, that is able to store the detailed data for a fixed amount of time. History lumped data will be identified and send back to the community along with data that summarise the monitoring, exercising activity of the elder day by day. Such approach allows to use the most hetereogenous input and make them available through standardized data base queries (SQL).

Lastly a cooperative system in drug distribution will be developed in the form of a drug dispenser. This will be constituted of a set of drawer, each with an electro-magnetic lock + a led and will be controlled remotely by the virtual caregiver. Only the right drawer is open at the time in which the elder should take prescribed pills. This approach requires that a caregiver fills the drawers at the beginning of a week, but it then guarantees that pills are not taken more than onece or forgiven. At due time the virtual caregiver warns the elder through all the devices available, Giraff, cellular phone, TV and so forth and it renew the memo every given period, until the drawer is not opened and pills are extracted [<http://www.google.com.tr/patents/US8588964>].

Maximum use of Wifi connection, typically Bluetooth connection, will be considered for the development and to have the minimum impact of the elder’s home. Local modules for transmission will be considered and Giraff’s itself will work as collector.

Task xx. Identification of available sensors.

## WP6 - Community

The virtual community would offer both a social and a healthcare support to the elder, and what is virtually surrounding the elder can be translated into an actual intervention.

- Social support, through an internet connection (or through a phone line, or what?):

* + to put the elder in contact with relatives and friends, to avoid isolation, to allow social activities, to increase the opportunities of a reciprocal monitoring
  + to allow the elder to easily access services and facilities (e.g. order food and other goods with home delivery, book ambulance/taxi for transportations)
  + to allow the elder to be informed of social and cultural initiatives that he/she can still attend and enjoy (for example undertaken by associations to which the elder can be subscribed)

- Healthcare support, through preferential pathways to produce necessary sanitary interventions. For this purpose the community around each elder will include one or more reference caregivers, the family physician, the geriatrician.

The socio-sanitary interventions will be mediated, at first, by the remote video communication capability of Giraff that will put in contact the elder with the person she needs. Interventions can be required by caregivers, by the elder themselves or by the RoboHome intelligence that monitors elder activites and continually communicates with the stakeholders. According to preset priorities, different types of alerts will trigger a different pathway. The sanitary interventions eventually delivered can include tele-visits, home-visits, and direct calls to emergency services.

The members of the virtual community around each elder will be established at the beginning of the experience to be engaged in the deliverable socio-sanitary actions. Further members can be added throughout the RoboHome2.0 life.

The ROBOHOME project aims to bring together all the major players through a unique community (see Figure X). As defined above ROBOHOME will be formed by three types of user groups:

* **Formal caregivers** – such users will be formed by the clinical staff which will be located in the hospital
* **Informal caregivers** – such users will be formed by family and carers of old people
* **Elderly people** – this is the target users of the community and will be formed by the people which have a GIRAFF robot at home

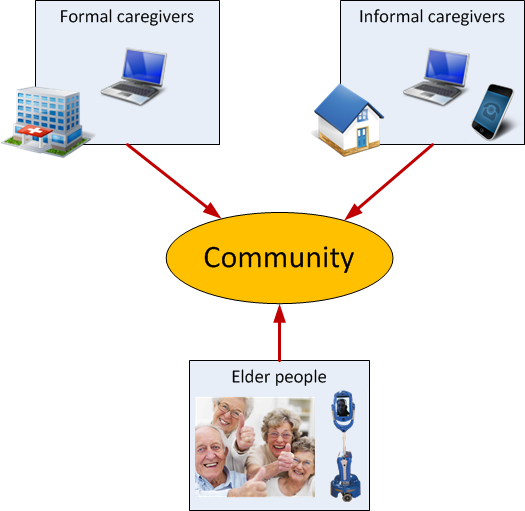


Figure 5 High level community architecture

Through the community the users will be able to interact between them, monitor activities, share information, etc. The community will have different purposes for each type of user. To accomplish this, a number of features will be developed to meet the needs of each user. Without any doubt, the most important user around which all of these features will be developed is elderly people. In this way the community is intended as a tool of motivation, adherence and cognitive and physical stimulation.

**Objective:**

Implement and integrate a social platform based on web technologies which will provide services to unify all actors involved within this system.

Possible services that will be developed will be sorted as follows (TO BE DEFINED…):

* **Elders:** 
  + Score ranking
  + Online users list 🡪 chat
  + News
  + Forum
  + Achievements (depends on the system usage)
  + Physical achievements
  + Help,
  + Calendar
  + Recommendation section (formal caregivers can suggest them to realize some tasks)
  + Videoconference
  + Organize social events with other elderly users
  + Contactme button (to contact with Informal caregivers, family, etc.)
  + VoIP calls
  + Shopping list (used for memory stimulation, e.g. elderly can select the products needed and Informal caregivers will see that information on their side, this way Informal caregivers will know what the cared person needs)
  + Generic information (e.g. weather)
  + Books and movies recommendation
  + Birthday reminders (family, friends, other elderly users)
  + Medical reminders (sent by formal caregivers)
  + Educational videos (e.g. cooking courses)
* **Formal caregivers:**
  + Alerts
  + Medical reminders management for elderly
  + Recommendations for elderly
  + Calendar management
  + News management
  + Forum
  + Videoconference
  + Elderly monitoring (e.g. number of connections/day, played games, sensors information 🡪 sleeping time, presence info, etc.)
* **Informal caregivers:**
  + Alerts
  + Smartphone application with notifications (e.g. Contactme, shopping list, alerts)
  + Calendar management
  + News
  + Forum
  + Videoconference
  + Elderly monitoring (e.g. number of connections/day)
  + Drinking water reminder
  + Food recommendation
  + Videomessage
  + Autosending messages (e.g. every morning, evening)

**State of the art**

The success of virtual communities is due to a great diversity of factors. For instance, as studied by Leimeister et al.[[44]](#footnote-44), relevant factors are focus on one target group, continuous community-controlling, definition of sources of revenue as a starting condition for building a virtual community. BDIGITAL has already been explored the use of virtual community to educate and motivate patients in several research projects. Inside the project REWIRE, a social community has been developed that allows patients and clinicians to chat using this portal, being the latter able to schedule such chats through a web application. This constitutes a good way of promoting shared clinician-patient decisions. Patients will be also able to fill in questionnaires related to clinical scales. That social community provides also further useful features such as forum, news, achievements.

In particular, STATE OF THE ART OF VIRTUAL COMMUNITY.

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**Beyond the state of the art**

RoboHome2.0 capitalizes on this community and extends it to provide a complete support of the elder at home in his physical / psychological and social behavior.

RoboHome2.0 aims at designing a set of interventions through the robots to support the elder throughout his life. The type of these interventions will be identified and profiled at project start according to the typical elder sub-populations (POLICLINICO) and will regard the social and health sphere. The socio-sanitary interventions will be mediated, at first, by the remote video communication capability of Giraff that will put in contact the elder with the person she needs.

Interventions can be required by caregivers, by the elder themselves or by the RoboHome intelligence that monitors elder activites and continually communicates with the stakeholders.

**SCENARIO**

**Sophie usually plays card with her friends at least three times a week through RoboHome, but RoboHome realizes that she has not played in the last two weeks although she was at home and no particular illness was diagnosed. A warning to Sophie’s daughter is sent by RoboHome, and she organizes her schedule to pay a visit to her mother. After insisting, she learnt that a very good friends of her just passed away, and that her mother just need to be reassured. After this visit, and a few others, Sophie restarted her active social life and to play cards with her friends, even with more joy.**

**SCENARIO**

**Catherin lately is behaving strangely. She start shouting a bit too much and to be nervous and less patinets with people. RoboHome2.0 detects a change in the moving pattern with a faster motion of her cane and less pauses. Her son also has the impression of something changing but, at first, he did not pay attention to that. After RoboHome warning, he consults with her mother’s GP and schedules a tele-visit with a geriatrist who talked with her mother at home. Unfortunately, was the beginning of a Dementia syndrome, but at least he was prepared to tackle them. He was sent to consulening and prepared to tackle the difficult future.**

The community will support the collaboration between the different stakeholders. Different stakeholders (parents, clinicians, social assistant), will be able to define a general goal of the activities mix and suggest their input to the virtual caregiver that will adapt this input to its internal state of the evaluation of the patient, for instance using a Bayesian inference model. From the infrastructure point of view, such collaboration will be supported also through a video-conference / messaging system to increase communication support between patients and his network.

**Task XXXX- Structuring the community [UMIL,]** Through the community, the patients will access structured knowledge provided by the stakeholders and new knowledge can be created through the interaction among users, increasing the trust in RoboHome. To this aim, free and informed discussions between community members will be supported. The RoboHome social platform will also provide a continuous osmosis with the most popular social networks [REF]. Through conversation in the community, socialization and externalization of knowledge [REF] will take place. This, along with the increase of knowledge on the lifestyle, its benefit and the risks of aging and the degree of compliance of the elder measured by the Virtual Caregiver, will be used to compute the elder reputation inside the community this exploring a novel hybrid method to build reputation. In RoboHome2.0, the reputation system will therefore also empower cooperation as well as competition to increase elders‘ motivation and therefore be part of the gamification process associated to lifestyle adherence [REF].

The community will allow also self-organising a network of social ties among stakeholders, defined by symmetric or asymmetric relationships and will allow deriving self-organising clusters [REF] that can be used to refine patients profiling.

Educational games can also be easily embedded in the social dimension. In fact, experiences with applications oriented towards promoting active lifestyles on seniors highlight the importance of social motivational instruments [REF] to overcome the barriers of acceptance in older adults.

The adoption of social inclusion drivers such as the establishment of common goals that have to be obtained through the collaboration with the elder community and/or with elder relatives represent an incentive for lifestyle adherence on seniors patients.

**Task x.x** Build a repository of stories that can be narrated by the elders, related to a particular period of their life. This can be part of the memory activities but it has the very important impact on the elders that they can still feel important in the society [MORE COMMENTS FROM POLICLINICO]. On the other side, this can generate collective knowledge of our close past that would get otherwise lost. To this aim, an adequate infrastructure based on automatic voice recording and *speech to text translation has to be set-up [CAN BDIGITAL PROVIDE THIS? WHAT SHALL WE DO WITH THE MATERIAL? PROVIDE IT TO A PUBLISHER?].*

**Task 6.2 Services specification [BDIGITAL, UMIL, GIRAFF]**

According to the community structure defined in the Task 6.1, a set of services will be provided to be integrated within the each component used by each different kind of user. Three community component will be developed: web application, smartphone app and Giraff-based application. Each component will provide its own list of services. Moreover, depending on the type of user, the services available in each component may also vary. Through these services the users involved within the community will have access to tool to help them stay in touch at all times, display the status of the sensors and to send notifications.

The set of services which will be intended to integrate within the ROBOHOME platform would be the followings (TO BE DEFINED…):

* Alerts
* News
* Forum
* Videoconference
* Achievements
* Calendar
* Help
* Medical reminders
* Social reminders
* Notifications
* VoIP calls
* Recommendations (types of recommendations)
* Score rankings
* One way communication
* Monitoring results

**Task 6.3 SOA layer and Communications [BDIGITAL, UMIL, GIRAFF]**

The Care Station will be the central node of communication among the different platform components. This station will be a web application installed on a dedicated server, which will have access to the internet in order to accept and send communication requests to other components. Other components involved within the community architecture will be a smartphone and the Giraff robot. Communications among them will be implemented using a service oriented architecture (SOA) developed with Open Software components. The issue of confidentiality will be analyzed to be guaranteed in all communications.

*[Communication diagram]*

**Task 6.4 Care Station [BDIGITAL]**

The Care Station claims to be the base station installed on a dedicated server as a web application. All the community services and communication layer will be based on a single web platform. Other components will interact with this station through communication layer defined in task 6.3. ROBOHOME community will resort to two devices more that will communicate with the Care Station providing the overall set of community services:

* **Smartphone** – will be used by Informal Caregivers to be in touch with the people they care for and which have the ROBOHOME installed in their home.
* **Giraff robot** – will be used by Elderly to be in touch with their Formal/Informal Caregivers and also with other elderly who are users of ROBOHOME.

This station will provide different features depending on the user’s role that uses it. There will be three types of user roles defined within this application:

* **Formal caregivers** – a specific GUI will be provided for this user role, a set of specific services will be provided for users who have this role.
* **Informal caregivers** – a specific GUI will be provided for this user role; furthermore a specific smartphone application will be provided (see Task 6.5) which will be connected with Care Station.
* **Elders** – for this type of users a different GUI will be provided (see Task 6.6)

**Task 6.5 Smartphone application [BDIGITAL]**

To provide better community accessibility and usability for Informal Caregivers a smartphone application will be developed within this task. In this way the Informal Caregivers will have two alternatives to use the community, through the web application or through a mobile application. In this way the mobility benefit of this device will be used, which will offer a better use of services such as “contactme button” or “shopping list”. The mobile application will integrate some of the services provided by the Care Station and moreover will offer other complementary services that are specific only to this application. Within the Task 6.3 the set of communications will be defined between Care Station and smartphone application.

**Task 6.6 Application for Giraff robot [BDIGITAL, GIRAFF]**

In order to use the community from the device as the Giraff robot it was decided to create an exclusive access to the Care Station for the elderly. In case if this station detects a user with the Elderly user role it will display a specific and adapted GUI on the one hand for this type of user and on the other hand for such device. To design the GUI and to address issues of accessibility and usability, it will be taken into account the size and type of the screen provided by Giraff robot. Being a touch screen, it is aimed to design a GUI with large buttons, to show clear information with high contrast colors and large font.

Giraff API and plug-in support option will be explored.

## WP7 – Integration

Giraff robot.



Figure 5 - The Giraff robot (old version)

We have to clearly state which is the starting point. We believe that collection of data from the sensors (and the processing of raw data) will be carried out in WP5.

**Task 7.x: Integration and testing of the community services [BDIGITAL, UMIL, GIRAFF]**

All the services developed in the WP6 will be integrated in the whole ROBOHOME platform. Suitable tests will be performed to evaluate the provided functionalities according to the specifications defined in the WP2. Several communication tests will be performed with the purpose of ensuring the full integration of all components that are part of the community.

## WP8 – Pilot

State of the art in social care [PCL].

How can we go beyond? Which tests should be devised? What can we measure?

N-of-one trial approach can be used to use a limited number of patients [PCL can further elaborate].

Stakeholders will be consulted since project start to evaluate the evolution of the system. How many GPs? How to choose them? Which environment?

## WP9 – Dessemination and exploitation

Identify a proper metric to evaluate each component and the whole platform.

Identify questionnaires adequate to evaluate the compliance with the technology (e.g. TAM questionnaires).

If Koren enters the consortium. Business model for which the RSA becomes open structures that provide services also at home, operating as a central node, thus as a service provider.

The Continua Health Alliance[[45]](#footnote-45) is promoting the development of end-to-end, plug-and-play connectivity of personal health devices and services. It is expected that for the beginning of the pilot several devices with these specifications will be available at reduced prices and this will made easy to integrate standard clinical measurements that will be defined in WP2. This make us confident about possible approval by ethical committess of hospitals like PCL and SAS that will support our pilot.

The worldwide challenges of the long-term care of the elderly

The proportion of older people in the population is also growing, increasing the number of those with chronic health problems because of accumulated exposure to chronic disease risk factors over

their lifetime. Older people often suffer from a combination of multiple chronic diseases and social problems requiring a long-term care which is part healthcare and part social service. Long-term care to frail and pre-frail individuals encompasses a broad array of services delivered in home, community or institutional settings by paid professionals and paraprofessionals, as well as unpaid family carers and other ‘informal’ helpers. The assistance needed by these individuals includes personal care, household chores and life management activities, often entailing interaction with various parts of the medical, mental health, housing and income maintenance systems. Irrespective of the cross-national differences

encountered in policy, funding, infrastructure and provision, countries confront similar long-term care

challenges, namely fragmented services, disjointed care, less-than-optimal quality, system inefficiency and difficult-to-control costs [Ref: Kodner D. (2004) Beyond care management: the logic and

promise of vertically integrated systems of care for the frail elderly. In: M. Knapp, D. Challis, J. Fernandez & A. Netten (Eds) Long-Term Care: Matching Resources to Needs, pp. 101–118. Ashgate, Aldershot]. A response to these challenges has been sought in the development of integrated models

of care delivery, which take a more holistic view of clients and their needs. “Integrated care” has been defined by Kodner & Spreeuwenberg (2002) as a “discrete set of techniques and organisational models

designed to create connectivity, alignment, and collaboration within and between the cure and care sectors at the funding, administrative and/or provider levels”. The role of ICT in integrated care interventions for the care of the elderly is widely recognized by the EC.

The current situation of the elderly home care in Italy

It is known that due to cultural reasons, most of the Italian elderly people and their families prefer an “aging in place” option [Gori C. & Da Roit B. (2006) The Italian way to commodification of care. In: C. Ungerson & S. Yeandle (Eds) The Changing Boundaries Between Paid and Unpaid Care, pp.223–258. Palgrave, London]. Yet this preference encounters in practice the challenges of an underdeveloped community care system. In fact, even if in the last 30 years the expenditure devoted to long-term care and the provision of services in kind have grown, the Italian welfare state is still characterized by a ‘familistic’ approach where the public sector devotes a scarce amount of money to care (prioritizing cash benefits over services in kind) and the arrangement of care is largely left to families [Gori C. Home care in Italy: a system on the move, in the opposite direction to what we expect. Health Soc Care Community. 2012 May;20(3):255-64]. The cash benefit in form of companion payment represents the main public long-term care input, which, in most of the cases is used to employ migrant care workers who are the main carers for the elderly at home. The working conditions of these sitters might be very hard, and they often need to spend most of their time in helping the elder in the activities of daily living, so that some other needs of the elder are necessarily neglected. The main task of family members often consists in organizing and monitoring the work of the sitters, and the life pace of the contemporary society often prevents them from spending time with the elder. In addition, with the companion payment family carers receive a monetary support but do not receive the information and counseling that in fact all the surveys show they want, especially with regards to the diseases that affect elderly people and the provision of healthcare [Lamura G. et al. (2010) Migrant workers in the long-term care sector: lessons from Italy. Health and Ageing Newsletter 22 (1), 1–6.]. The system seems to have found an “equilibrium” as most of the stakeholders gain some practical advantages from current arrangements [Gori C. Home care in Italy: a system on the move, in the opposite direction to what we expect. Health Soc Care Community. 2012 May;20(3):255-64]. Nevertheless, this equilibrium exposes the care for the elder to the risk of an unsatisfying quality, and if it is difficult to adequately meet the existing needs, short of time and human resources, it is very hard to implement good monitoring and preventing strategies against the development of a condition of frailty and disability.

With such a background, the RoboHome2.0 intervention would represent an additional aid and resource to favor a comprehensive care to the elder at home, integrated in and integrating the community of stakeholders surrounding the elder. Establishing a network of providers of social and health care, not RoboHome2.0 would represent an additional virtual care provider but it would also promote the creation of an integrated care system.

**Methods.**

Population. Elders meeting the eligibility criteria (see above for target subjects) willing to participate (who signed an informed consent)

Intervention. RoboHome2.0 integrated in a network of social and health care providers, represented by the relatives and/or non-family home caregivers, friends, the general practitioner, the specialist in Geriatrics

Comparator. Usual care

Outcome. The primary outcome will be the development of a frailty condition (see above for the definition). According to the principles of a Comprehensive Geriatric Assessment, the following outcomes will be also measured at baseline and throughout the study:

Measures of

* physical performance
  + Tinetti scale [Ref; Tinetti ME. Performance-oriented assessment of mobility problems in elderly patients. JAGS 1986; 34: 119-126]
  + Short Physical Performance Battery (SPPB): 4-m walking speed, balance and chair-stand tests [Ref: Guralnik JM, Ferrucci L, Simonsick EM et al. Lower-extremity function in persons over the age of 70 years as a predictor of subsequent disability. N Engl J Med 1995; 332: 556–61]
* muscle strength (hand-grip strength)
* functional (ADL and IADL)
* cognitive status (MMSE)
* mood (Geriatric Depression Scale)
* nutritional status
* quality of life
* satisfaction
* frequency of access to Emergency Department/hospitalization/istitutionalization
* adherence to medications
* quality of life and satisfaction of the caregiver

Additional specific outcomes might be added according to the phenotype of the elder, the specific tasks required by the elder to the RoboHome2.0 (for example, HbA1c for a diabetic elder; number of daily naps

Follow up Time. 1 year (???)

Study design. Non-randomized controlled study on N (10???) eligible patients receiving the intervention and N controls, matched for age, gender, general practitioner, geographic area/neighborhood, home care situation (i.e. living alone or with a family caregiver, or with a migrant care worker), morbidity. The two groups of subjects should not know each others

Setting. Which country??? For example in Lombardia, one suggestion for setting and recruitment might be: The subject will be selected through the contact with general practitioners willing to collaborate and the GP will help in the selection of the elder receiving the intervention and the matched control, among his/her assisted people. The same GP will be included in the network. Alternatively (both strategies might be implemented) it is the geriatrician to individuate the subject, the subject’s GP is contacted and then, assured the GP’s willingness to participate, the matched control is selected. Personnel of the Geriatrics of the Fondazione IRCSS Ca’ Granda of Milan would act as the specialists of the network.

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