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Project Abstract

The RAPP project will provide an open-source software platform to support the creation and delivery of Robotic Applications (RApps), which, in turn, are expected to increase the versatility and utility of robots. These applications will enable robots to provide physical assistance to people at risk of exclusion, especially the elderly, to function as a companion or to adopt the role of a friendly tutor for people who want to partake in the electronic feast but don't know where to start.

The RAPP partnership counts on seven partners in five European countries (Greece, France, United Kingdom, Spain and Poland), including research institutes, universities, industries and SMEs, all pioneers in the fields of Assistive Robotics, Machine Learning and Data Analysis, Motion Planning and Image Recognition, Software Development and Integration, and Excluded People. RAPP partners are committed to identify the best ways to train and adapt robots to serve and assist people with special needs.

To achieve these goals, over three years, the RAPP project will implement the following actions:

- Provide an infrastructure for developers of robotic applications, so they can easily build and include machine learning and personalization techniques to their applications.
- Create a repository, from which robots can download Robotic Applications (RApps) and upload useful monitoring information.
- Develop a methodology for knowledge representation and reasoning in robotics and automation, which will allow unambiguous knowledge transfer and reuse among groups of humans, robots, and other artificial systems.
- Create RApps based on adaptation to individuals and taking into account the special needs of elderly people, while respecting their autonomy and privacy.
- Validate this approach by deploying appropriate pilot cases to demonstrate the use of robots for health and motion monitoring, and for assisting technologically illiterate people or people with mild memory loss.

The RAPP project will help to enable and promote the adoption of small home robots and service robots as companions to our lives. RAPP partners are committed to identify the best ways to train and adapt robots to serve and assist people with special needs. Eventually, our aspired success will be to open and widen a new 'inclusion market' segment in Europe.

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List of Abbreviations

ABBREVIATION	DEFINITION
RAPP	Robotic Applications for Delivering Smart User Empowering Applications
RApp	Robotic Application
GAADRD	The Greek Association of Alzheimer Disease and Relative Disorders
MCI	Mild Cognitive Impairment
WHO	World Health Organisation
ADL	Activities of Daily Living
IADL	Instrumental Activities of Daily Living
UR	User Requirement
BDI	Beck Depression Inventory
STAI	State Trait Anxiety Inventory
MMSE	Mini–mental state examination

Executive summary

The present document is a deliverable of the RAPP project, funded by the European Commission's Directorate-General for Communications Networks, Content & Technology (DG CONNECT), under its 7th EU Framework Programme for Research and Technological Development (FP7).

As our societies are affected by a dramatic demographic change, in the near future elderly and people requiring support in their daily life will increase and caregivers will not be enough to assist and support them. Socially interactive robots can help to confront this situation not only by physically assisting people but also functioning as a companion. The increasing sales figures of robots are pointing that we are in front of a trend break for robotics. To lower the cost for developers and to increase their interest on developing robotic applications, the RAPP introduces the idea of robots as platforms. RAPP project will provide a software platform in order to support the creation and delivery of robotic applications (RApps) targeted to people at risk of exclusion, especially older people. In the context of the RAPP project, WP1 aims to comprise the basis upon which the RAPP Platform will be developed. Upon its completion, WP1 is intended to provide a complete package of requirements and specifications for the design and development of the RAPP platform. To this purpose, a bottom-up approach will be adopted, starting from the involved user requirements. This document is the first deliverable of WP1 (D1.1) and provides involved user requirements specified by the actors themselves and under the perspective of gaining significant benefits from the implementation of RAPP. These actors are mainly people at risk of exclusion and especially elderly people, along with their families, caregivers, physicians, etc. Within this task users' requirements and preferences will be collected and analyzed. These requirements, along with the non-functional requirements shall better define the focus of RAPP, as well as the specifications and basic functionality of the RAPP platform.The current document aims to provide the basis for extended analysis of our proposal and introduction of novel research.

1. Introduction

The aim of RAPP project is to provide a software platform in order to support the creation and delivery of robotic applications (*RAPP*s) targeting people at risk of exclusion, especially older people and elderly with Mild Cognitive Impairment (MCI). There are a number of users expected to gain significant benefits from the implementation of RAPP; the present deliverable is committed to the collection and analysis of requirements from the users' perspective with emphasis on elderly end-users. Within this task, these users will be identified, and their requirements and preferences will be collected and analyzed. These requirements, along with the non-functional requirements shall better define the focus of RAPP, as well as the specifications and basic functionality of the RAPP platform.

The users primarily targeted are elderly people above 65 (65+), with the following characteristics:

- Technology illiterates
- Diagnosed with MCI
- With physical impairments (operated for prosthesis or a hip fracture, hospitalized to recover their mobility functionality)

The pilot users come from specific sites/institutions in Greece and Spain and were involved in a user requirement collection process, based on a methodology described in detail at this deliverable.

RAPP will develop the fundamental computational techniques that enable the design, implementation and evaluation of applications targeted to robots (Robotic APPlications, or *RAPP*s) that encourage social, emotional and cognitive empowerment in people at risk of exclusion and in particular elderly people, including those with social or cognitive deficits. The need for this technology is driven by critical societal problems that require sustained, personalized support that supplements the efforts of caregivers, social workers, clinicians and relatives attending elderly people.

RAPP"s social objectives can be summarized as following:

- Create an accessibility and usability ecosystem for robotic applications development, linking interface developers, device makers, service providers, environment designers and user communities.
- Provide robotic software solutions for augmenting the independent living of the older persons.
- Integrate real-time monitoring of user needs to improve user experience and learning potential and adapt contents and interfaces.
- Design for all people at risk of exclusion, notably elderly persons, and provide novel accessibility solutions for them, enhancing their quality of life.
- Support the creation and deployment of innovative robotic-based solutions: a) to lessen or eliminate persons "functional" disabilities regardless their impairments, b) to motivate and "include" those affected by other societal factors, and c) to facilitate acquisition of skills on the use of robots.

2. Characteristics of the users

RAPP aspires to provide advanced technological support, aiming either to treat a specific disability factor or provide alternative interaction methods for the elderly. *RAPP* will take into consideration the *real needs and expectations of the elderly persons*, and will provide a framework of high motivation and trust for the elderly persons. The proposed technologies will be integrated, taking into consideration the *importance of the surrounding social environment*. *RAPP* will offer solutions that help older people to remain socially active while increasing their capacity for independence and autonomy. *RAPP* will decrease the lack of knowledge, economic cost and attitude that prevent technologies to be adopted by the elderly.

Aging reflects all the changes that occur over the course of life. As we grow older, some of these changes are positive as we develop and mature but some are not so welcomed as are the physical decline and diseases. There are a lot of theories about aging but its true nature is still to be found. Unfortunately, we cannot avoid its negative aspects but we can always try to make them easier [1].

2.1 Age - related Sensory and Motor Changes

It is generally accepted and documented that during the aging process, sensory and/or motor abilities gradually decline [2] Elderly are not able to see, hear, feel, taste or smell with the same capability they had when they were young, and this abilities decrease as years go by. It's a natural process and usually family and caregivers are the first to notice that seniors cannot easily read a book or newspaper without bifocals, watch television in the loudest volume or season their food more than usual and more than they should do for their health. Seniors themselves gradually understand all these changes and the new adjustments and adaptations they need to make in order to age better [2], [3].

2.1.1 Vision

Significant decrease of vision, the most important of senses, can affect quality of life, the ability to live independently and the social life of the elderly. Elderly people show a reduction in [4]:

- The width of their visual field
- Light sensitivity
- Color perceptions
- Resistance to glare
- Dynamic and static acuity
- Contrast sensitivity
- Visual search and processing
- Pattern recognition

Several eye problems that can affect all people at any age become more common for elderly. Vision loss among elderly is a major health problem as one in three persons above 65 suffers from a vision disease [4], [5], like:

- Presbyopia: inability to see close objects or small print.
- Dry eyes: tear glands lose their ability to make enough tears or produce poor quality tears. The resulting dryness can cause itching, burning, red eyes and rarely some loss of vision.
- Tearing: having too many tears because of light sensitivity, wind or temperature changes.
- Cataracts: cloudy areas that cover part of or entire lens inside the eye.
- Glaucoma: too much fluid pressure inside the eye that can lead to permanent vision loss.

Retinal disorders, conjunctivitis, corneal diseases, eyelid problems and temporal arteritis are some more eye disorders that worsen vision of elderly and even lead them to total loss of this sense[1].

2.1.2 Hearing

Hearing declines with age progressing and effects vary from difficulties in perceiving high frequency sounds to hearing sounds in general [2]. Elderly, as well as their family and caregivers, often feel frustrated when trying to communicate and face difficulties due to hearing problems. Poor hearing can lead to misunderstandings and feelings of being "cut off" which lead to withdrawals and isolation. Trying to listen to a conversation often makes older people feel tired, as they unsuccessfully try to follow what others say [2], [6].

[1] http://www.webmd.com/eye-health/vision-problems-aging-adults

2.1.3 Motor skills

Aging brings along decline in motor skills including both: a) motor skills that involve fine movements (fingers, toes, lips, wrists, tongue) and, b) motor skills that involve larger muscles (arms, legs, trunk, and feet) and "big" movements such as running, jumping, hopping, and walking [7], [8], [9], [10].
Poor motor skills can lead elderly to frailty and deterioration of their daily life. People with frailty are more likely to become disabled, face serious health problems and be hospitalized. Frailty [11] is characterized by:

- Low physical activity
- Muscle weakness
- Slowed performance
- Fatigue or poor endurance
- Unintentional weight loss

2.2 Cognitive changes

Getting older can also deteriorate the capabilities of cognitive functionalities. Some elderly present a slight cognitive decline that is perceived as relative to age and thus "healthy". Some elderly "start to forget more"; this memory loss increases with age but does not prevent performance of daily activities (Mild Cognitive Impairment). For others, cognitive deficits are severe and impede their everyday life and ability to live independently (Dementia) [12], [13], [14], [15].

Cognitive changes in elderly affect attention, learning and memory. Seniors react selectively to external stimuli as their awareness of the events in their environment is limited. As a result, learning new concepts and patterns becomes more difficult. Their ability to store and use new information decreases and memory faints [15], [16].

2.3 Social changes

Getting older sometimes equals to start living marginalized. Retirement, health issues or disabilities due to aging, loss of spouse, driver's license revoking, suddenly situate elderly to the edge of society. Children have grown up and have their own families and elderly find themselves living alone at home or unluckily, in geriatric institutions. When lacking a role in society and socially isolation rises, depression and despair make their appearance, which in turn lead to health and cognitive deterioration and consequently in more isolation. This cycle of social isolation and exclusion is something that needs to be addressed seriously. Elderly are an active part of society as well a new world economy (silver economy) that cannot be ignored [3], [17], [18], [19].

3. Social Inclusion and Robots

3.1 From exclusion to inclusion

Exclusion according to World Health Organisation [20] "consists of dynamic, multi-dimensional processes driven by unequal power relationships interacting across four main dimensions - economic, political, social and cultural - and at different levels including individual, household, group, community, country and global levels". As a result, a cycle of inclusion/exclusion is triggered that leads to inequalities in health and rights; a process in which individuals or entire parts of the society are deprived from the rights, opportunities and resources that are normally available to its members.

Elderly, facing the threat of losing their independence due to aging and its consequences (health, cognitive, social and financial), are in high risk of social exclusion. Social exclusion in the form of deprivation from activities that offer joy, fulfilment and sense of belonging, can lead to frustration, depression and health decline. Developing policies to confront and prevent social exclusion has been a major concern for the World Health Organisation and all European countries.

There have been numerous projects suggesting actions and methods to enhance social inclusion of the elderly and advance their well being. The use of information and communication technologies was involved in many of these projects, promoting solutions to support integrated healthcare services in elderly homecare, memory and cognitive enhancement through computer-based exercises and support of social activities. In recent years, a new approach was introduced to confront social exclusion with the help of **assistive robots** [21], [22], [23], [24].

3.1.1 Robots vs. computers

The use of new assistive technologies allows elderly to face the difficulties of modern life and get over the barriers that limit their social and emotional well being, assisting them to have a more qualitative living [25], [26].
To enhance and support social inclusion of the elderly, this project aspires to: a) facilitate their social life with the use of emails, Skype calls, social media and internet, b) assist their effort for enhancing and maintaining attention and memory through cognitive exercises and, c) support and improve their mobility. Assistive robotics were alleged to be more effective towards this direction comparing to computers for a number of reasons [21], [27], [28], [29], [30]:

- Computers need training in order to be used by elderly or require a person (caregiver) to use it on behalf of the elder or helping him.
- Learning is one of the cognitive functions that decline with aging, making new information and skills difficult to be acquired. Such difficulties can lead sometimes to withdrawals from training and consequently frustration and depression.
- Sensor and motor declines triggered by age can also make it difficult for the elderly to use computers. Monitors have certain lighting that can either be insufficient or harmful for the eyes of the elderly suffering from specific vision diseases like cataract, glaucoma, dry eyes syndrome and many more (figure 1). Using the keyboard or mouse can be tricky if they have lost their fine motor skills (aging, medication, disease etc), painful if their fingers are deformed from arthritis or even embarrassing if they suffer from Parkinson's and tremors.
- In order to use the computer, elderly have to be sited and this generates a number of difficulties for those suffering from their back or neck and can elicit a number of dysfunctions and pain for elderly that don't sit according to safety rules.

Figure 1 Cataract and glaucoma vision

On the other hand, assistive robots can be used by elderly without intensive training and physical effort. They could have immediate access to a number of applications and direct connection to internet, social media, email, Skype calls etc. All they need to do is just ask the robots to do it for them [31], [32].

Figure 2 Paro robot

Moreover, their humanoid appearance gives a sense of having a companion rather than a machine and decreases loneliness and social deprivation. Companion robots like Paro, should be cited as they have been proved to positively affect social skills of elderly and increase social interactions as well as the emotional well being of the users. Paro is a small robot resembling a seal that can sense user's touch, recognize a limited amount of speech, express a small set of vocal utterances, and move its head and front flippers [23], [28].

The development of robotics has already created a number of abilities to current products enabling robots with the ability to recognize objects and faces; hear and speak; move around; pick up and grasp objects; express emotions.
RAPP project will use Aldebaran's **NAO humanoid robot,** a 58-cm tall humanoid robot that moves, recognises users, hears and speaks, and the INRIA's **ANG walking aid robot** in specific pilot sites in Greece and Spain.

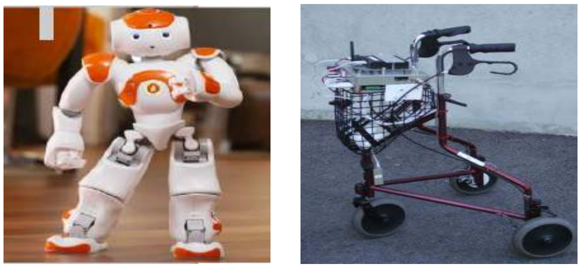

Figure 3 NAO and ANG rollator

4. Description of the pilot sites

4.1 Ormylia Foundation

ORMYLIA" Foundation has been founded in 1996 under the auspices of the Sacred Convent of the Annunciation, Dependency of the Monastery of Simonos Petra at the Holy Mountain. The mission of the Foundation is to contribute towards the wellbeing of mankind and the enhancement of culture through impartial personal struggle and charity actions as well as to comfort and alleviate the suffering of human beings without preference to race, religion, gender, or creed.

"ORMYLIA" Foundation is a non-profit, non-governmental institution supervised by the Ministries of Development, Culture, Education and Health. "ORMYLIA" Foundation, in its two divisions, the Diagnosis Centre and the Centre for Social Advancement, Medical Prevention and Research, "Panagia Philanthropini", has an average number of more than 1000 of individual external users per year (mainly minorities and impoverished). From its inception the Foundation has sought to collaborate with premier medical centers from around the world so as to insure that the standardized medical service be of the highest quality possible.

In the 1990s the European Union recognized "ORMYLIA" Foundation as a European Union Center of Excellence and included the Foundation in the networks for cervical and breast cancer. The Center continues to be a member of this European consortium and is a contributing author of the European Guidelines in both fields.

Currently, in the context of RAPP, Ormylia Foundation is responsible for employing two (of the total three) pilot cases: one for technology illiterate seniors and one for MCI (Mild Cognitive Impairment) seniors. For this purpose we have organised a small computer lab at a Community Seniors Center in New Moudania of Chalkidiki (a small town in North Greece) where a group of 20 seniors attend computer courses and lectures for robotics while helping us outline essential specifications for RAPP applications. At the same time, we have established communication with the Greek Association of Alzheimer's Disease and Related Disorders in Thessaloniki, aiming to define new memory training interventions with the help of the NAO robot and enhance social inclusion of its users.

For the needs of RAPP pilots, Ormylia Foundation is going to collaborate with two social partners; they are independent social centres with which Ormylia Foundation has an open communication and collaboration. These are:

- Community Seniors Center in New Moudania of Chalkidiki (Greece)
- The Greek Association of Alzheimer Disease and Relative Disorders (GAADRD) in Thessaloniki (Greece)

4.1.1 Community Seniors Centre in New Moudania of Chalkidiki

Community Seniors Centers were first founded in Greece during 1979 under the auspices of the Ministry of Health. Their abbreviation in Greek (ΚΑΠΗ) stands for the Centers for the Open Protection of Elderly. Since 1982 they run under the auspices of local management of Municipalities around Greece. Their aim is to protect senior citizens from exclusion supporting their life in community (family, friends, and local society) and prevent them from institutionalization. In this context, their activities are:

- Prevention of biological, psychological and social problems of the elderly, in order to remain equal and active members of society

- Information of society and specific stakeholders about the issues and needs of older
- Research (gerontology, health, social inclusion)

4.1.2 The Greek Association of Alzheimer Disease and Relative Disorders (GAADRD)[2]

The Greek Association of Alzheimer Disease and Relative Disorders (GAADRD) is a nonprofit organization that was founded in 1995, by relatives of patients suffering from Alzheimer Disease as well as by doctors of all specialties - mainly by Neurologists and Psychiatrists and also by other experts (such as psychologists, social workers, physiotherapists, etc) that deal with the problems caused by this disease and by other types of dementia. Today, GAADRD operates 4 Day Care Centers in Thessaloniki and has over 2.500 members. GAADRD is also a member of Alzheimer Europe and Alzheimer's disease International (ADI).

4.2 Matia Foundation and Matia Institute (INGEMA)[3]

Matia Fundazioa started out in 1881 when the Basque shipbuilder and trader, born in Llodio, José Matia Calvo left his worldly goods to set up a foundation with the following aim:

"Providing a secure future for the elderly and disabled people who cannot work over their entire lives, helping them with their illnesses."

Today Matia Fundazioa is a non-profitmaking organization with over 130 years' experience looking after old people, employing around 1000 highly qualified professionals. Matia Foundation's mission is to support people during their aging process to improve their wellbeing, generating knowledge and personalized services that promote autonomy and dignity. Its proven track record and work performed by its professionals has allowed Matia Fundazioa to develop its own model, the Person-Centered care Model, focused on promoting each user's autonomy and dignity, depending on their personal situation, their preferences and their capabilities.

To do that, Matia Fundazioa also generates knowledge and innovation from an integral view of the aging process through its institute, the Matia Gerontology Institute, a unit of the Matia Fundazioa dedicated to creating knowledge that can be applied and disseminated throughout society (RTD+i). Therefore it is a vehicle for Matia Fundazioa to realize its strategic vocation to generate applicable knowledge and promote its transfer, specializing and promoting the application of its own knowledge. This distinctive aspect makes Matia Fundazioa stand out from other institutions specializing in the aging process.

This centre, unique in the Basque Country with over 10 years of experience, is a member of the Basque Science and Technology Network, as a Healthcare Research Unit, and also a unit associated with the Aging Research Group (GIE) from the CSIC, in order to carry out joint scientific work in the field of aging and dependency.

Matia Gerontology Institute aims to generate interdisciplinary scientific knowledge to maximize personal autonomy, independent, health and quality of life for old people, disabled people and their careers.

In order to carry out their work, Matia Gerontology Institute has a team of 22 people with vast experience in research projects both nationally and internationally, highly qualified and entirely implicated. The interdisciplinary team is made up

[2] http://www.alzheimer-hellas.gr/

[3] http://www.matiafundazioa.net/es/home

of professionals that include geriatrics, neurologists, neuropsychologists, doctors, physiotherapists, sociologists, occupational therapists and experts in accessibility with vast research experience.

4.2.1 Centres and Services at Matia Foundation

Today, Matia Fundazioa offers a wide range of services in an attempt to cover all the needs that old people, their family members and carers might experience throughout the process. Those services and centres that could provide information and possibly users for the RAPP project and the mobility scenario in an institution environment are described below. Though, there are also some other home oriented services offered by Matia Foundation that could be useful in a near future and perhaps for another project, once the ANG MED rollator and its functions have been evaluated and validated at residential environment.

Institution oriented services	Home oriented services
Gerontology and Day Centres	**Sheltered Housing**
Hospital Ricardo Bermingham	**Cohabitation units**
IZA Centre for the Disabled	**Integral Home Care Service**
Orto-geriatric service	
Rehabilitation Centres	
MATIA Orienta Service	

Table 1 Centres and Services at Matia Foundation

Hereinafter the most relevant services of Matia Foundation are described taking into account the aim of testing the ANG rollator of this pilot site.

4.2.1.1 Gerontology and Day Centres

There are 8 gerontology centers with their day centers. In both services, Matia Fundazioa works with a person-focused care model.
The focus point of the care and therefore all organization and care processes around it, is the person and their life project. Respecting their dignity, their rights, their preferences and seeking their personal wellbeing are essential values. The person is supported in terms of promoting their autonomy and independence through everyday life activities. Care is provided based on a Full Individual Assessment and designing a Care and Life Plan drawn up jointly among the centre's professionals, the person and their family. The Centre Team is interdisciplinary and is made up of professionals highly qualified in caring for Old People. The user and their family will have a contact person to refer to among the centre's care team.
Some of the residents use a rollator as a daily basis to support their walking function.

4.2.1.2 Hospital Ricardo Bermingham

The Ricardo Bermingham Hospital is a medium and long stay hospital focusing its work on caring for non-surgical pathologies, fundamental chronic rehabilitation programmes for neurological and trauma pathologies and palliative care for terminal oncology patients.
The Hospital is made up of the following Units:

- Convalescence unit
- Psychogeriatric unit
- Rehabilitation unit
- Palliative care unit

Here, only the rehabilitation unit will be considered as suitable for the RAPP project due to the fact that almost all patients in this unit have to use a rollator for functionality recovery.

Rehabilitation Unit

This unit has 41 beds and its main target is assessment, treatment and prevention of patient disabilities targeting functional recovery or improvement as efficiently as possible to be able to readjust to everyday life, offering individualised, continual and complete care that takes into account the physical and functional aspects of the disability, the patient's comorbidities, and any mental, emotional and social conditioning factors.
Specific targets are:

- Having passed the acute stage of the illness, provide them with the services they need to get as much functional recovery as possible.
- Return them, with the maximum quality of life possible, to their family environment or to the most suitable social / healthcare resource, guaranteeing the continuity of the care they require at all times.
- Educate the patient and their family on how to handle any residual disability.

This unit has set up the Ortho-geriatrics project. In 2010 the ORTHO-GERIATRICS unit was set up to care for patients with broken hips discharged early from the San Sebastian Hospital and Bidasoa Hospital trauma service, bringing about a positive change in the Rehabilitation Process by widening the patient profile to a group with better prior psycho-physical situation.

Centre for the Disabled, IZA

Located in San Sebastian, the IZA Centre is specialised for people with a level of physical disability accompanied by other pathologies, aged between 18 and 60 years old. This centre is open to the community, within an urban environment, offering different resources adapted to the changing needs of its residents and their family members.

It is structured into different modules to facilitate user movements, and respect their needs and wishes (personalisation, intimacy, ability to choose, etc.) and that therefore seek out accessible and friendly environments as well, just like home. The aim of the care is to improve quality of life for residents and their families.

Although most of the centre users use a wheelchair to move there are some that can use a rollator.

5. Identification of actors and users

5.1 Actors and users for the NAO robot

For the RAPP purposes we are mainly going to work with members of Community Senior Centres and the Greek Association of Alzheimer Disease and Relative Disorders (GAADRD). We aspire to extend our actors by including the members/users of our medical centre who are women at the age of 65 plus but this is a future plan that still needs to be analysed and defined. All of the users are independently living in their houses or near their children. Our goal is to assist them in their everyday lives through the use of new robotic-based technologies, so that they can continue independently living at home even if they have physical or cognitive disabilities. Companion robots like NAO demonstrate a positive impact for older people at risk of exclusion provoked by the deterioration of their physical capabilities or cognitive abilities [27], [33], [34], [35]. They have positive effects regarding the feelings and mood of elderly as they feel less lonely [23], [30]; their stress alleviates and their immune system response increases [36]. Many studies report that companion robots, through their interaction with the elderly, elicit memories about the past and advance relations between elderly as well as between elderly and their family [28].

Figure 4 Elderly meet NAO

The profiles of the elderly that are going to interact with NAO during the RAPP project are the following:

- Elderly (65+) who live independently at their homes and take part in activities of Community Senior Centre at

New Moudania, a small agro touristic city at the peninsula of Chalkidiki, North Greece.They are active members of the society and our aim is to extent this period for as long as possible.

- Elderly (65+) who live independently at their homes in Thessaloniki (a big town in Northern Greece), and have been diagnosed with Mild Cognitive Impairment (MCI). They attend cognitive exercises at the GAADRD and our aim is to enhance their memory and improve, if possible, their cognitive abilities.
- Elderly (65+) living in various areas of North Greece (mostly agricultural) who visit our medical centre. They are all females attending prevention examinations for breast and cervical cancer.

5.1.1 Community Seniors Centre

Figure 5 meeting at Community Seniors Centre

Seniors from the Community Centre will participate in the pilot testing RAPP scenario for technology illiterate people. Their computer knowledge is non-existent or minimum; they don't know how to use email, Skype or social media. We are going to prove our hypothesis that NAO can improve their social life connecting them with friends and family faster and easier than learning how to use computers. We are going to demonstrate how easily NAO can accomplish this connection while conventional computer training can not apply in all cases as it is time consuming. Moreover, we are going to examine if NAO, as a companion robot, can improve the psychological status of the elderly and have positive effect on their mood and emotions.

In order to test our hypothesis, a group of 18 elders are already taking part in our research. This group is attending computer and technology related classes and their performance is going to be compared in two levels:

a. time needed to learn how to use email and Skype calls using computers comparing to time needed to learn how to use NAO and access these applications through the robot and,
b. time needed to learn how to use NAO and the above applications comparing to a group that did not have any technology or computer classes at all and are also technology illiterates.

To ensure strength and consistency for the pilot test, we are going to use a focus group of 6 persons, selected from our group of 18 elderly and in particular those who are frequently attending our meetings. Another group of 6 participants will be chosen among the elderly of the Community Seniors Centre to serve as the control group.

The **Beck Depression Inventory (BDI)**: a 21-item, self-report rating inventory that measures characteristic attitudes and symptoms of depression as well as the **State Trait Anxiety Inventory (STAI)** that measures general anxiety, consisted by twenty items for measuring state anxiety (STAI.S) and twenty items for measuring trait anxiety (STAI.T) will be distributed to elders before and after their experience with NAO, in order to evaluate any changes to their mood and emotions.

5.1.2 The Greek Association of Alzheimer Disease and Relative Disorders (GAADRD)

Seniors from the GAADRD will participate in the pilot testing RAPP scenario for elderly with Mild Cognitive Impairment (MCI). Applications generating cognitive exercises will be used to test their effect on cognitive stimulating and improvement for individuals with MCI. Exercises will be in a gaming form and NAO is going to interact with individuals in a playful mode making this training procedure fun. Both cognitive and emotional outcomes will be evaluated as we expect that NAO will be more effective than simple written or computer exercises, creating less stress while activating more joy and satisfaction. Moreover, cognitive exercising with NAO does not necessarily involve trainers or computer knowledge making it easier to use in a daily basis and hopefully less costing in the future.

Figure 6 NAO ready to interact

We are going to use a minimum number of 2 participants from GAADRD, as it is difficult to engage persons with MCI for a long period; usually they are not very positive in taking part to research tests as they feel stressed with their impairment.
We are going to evaluate their performance in three levels: a) performance to cognitive games according to their scores, b) cognitive changes using the **mini–mental state examination** (**MMSE**): a brief 30-point questionnaire test that is used to screen for cognitive impairment as well as similar tests provided by the GAADRD and with their help and, c) the **BDI** and **STAI** tests as they were described above, to detect any psychological effects or changes in mood and emotions.

5.1.3 Medical Centre of Ormylia Foundation

Ladies visiting the medical centre of Ormylia Foundation could also take part in testing pilots. The inhibitory factors are that they are not frequent visitors of the centre, they live in different areas of North Greece and transportation can be an issue for them. Additionally, they are females only and gender issues can arise. Nevertheless, they can take part in a future scenario that will not request time or repeats.

5.1.4 Testing NAO at home

There is a plan for testing NAO at home but this is something that we are going to examine in detail in future months. NAO needs WIFI and most elderly do not have WIFI connections at their homes; needs a flat surface to walk on; he is quite small and may not be clearly seen by the elder among furniture. Also after 45 to 60 minutes its battery discharges, so the elder must not forget to charge it often, something that is difficult for elderly suffering from MCI. We are going to examine the possibility of a home pilot testing with the discrete presence of a researcher. For safety reasons, we will start from the controlled environment of Community Seniors Centre and GAADRD premises.

5.2 Actors and users for the ANG robot

Taking into account the different users and patients in Matia's installations, there are mainly three kind of user profiles from the **orthogeriatric service** that are considered suitable to participate in the RAPP project and test the Smart Rollator that will be developed by INRIA, these profiles being:

- Neurological patients. Usually these are patients that have had an ictus and have a lower extremity affected.
- Syndrome of bedridden. Patients that have been confined to bed for long time due to different reasons and consequently need to recover strength to walk again.
- Trauma patients. Patients that have fractured the hip because of a fall and need rehabilitation to learn to walk again or patients with a knee replacement or prosthesis.

Usually these patients remain hospitalized for approximately 20 days, during which they are taught to use the walker aid and try to recover their mobility functionality so that they can go home. Most of them return home with the rollator mainly for safety and to avoid risk of falling, even though they would be able to walk with crutches and some support and guidance of their family members. Some continue with outpatient rehabilitation.

Surely there are user profiles coming from other services of Matia such as nursing homes or the IZA Centre for disabled with other needs that can be considered as candidates to participate:

- Nursing homes: "autonomous" patients living in nursing homes. Actually, the majority of older people living in nursing homes suffer from dementia and could not use a smart walking aid as the ANG MEDas they wouldn't understand its functioning. However, there are some (not many) residents without cognitive impairment and with mobility problems that can benefit from such a robot.
- The users of the IZA Centre for disabled are younger than those living in a nursing home (18-60 years old) and their mobility problems have a different origin but can still use the rollator to improve their strength and balance.

During the visit of INRIA to Matia, the different services at Matia Foundation were visited, guided by the physiotherapist of the ortho-geriatrics and the responsible person in each service or floor, in order to better investigate the user needs and to analyze which one would be the most suitable user profile to participate in the RAPP project and test the ANG robot.

5.2.1 Hospital Bermingham, 4th floor

The 4th floor of the Bermingham Hospital is devoted to rehabilitation. Most patients have a hip fracture and need rehabilitation before returning home. There is a gymnasium to do exercise and the patients have a walker to walk along the corridor. Most patients' cognitive function is not deteriorated. Two wheeled standard walker is the most used for indoor usage, where patients are not allowed going out because of falling risk. The position of the patient when using the walker is very important; if the patient is too close, there is risk of falling backward, if he/she is too far there is risk of falling forward. The walker is quite light and patients tend to lift it when turning, which also increases falling risk. More than one patient could use the walker with rehabilitation purposes.

Figure 7 Two - wheeled walker

5.2.2 Bermingham Care Centre, 1st floor

Figure 8 Four-wheeled walker

At this residential care centre for elderly people live more deteriorated patients that are not familiarized with the use of a walker. They don't like it because if they get tired they cannot rest, as the standard walker does not have a seat. The four wheeled walker has a seat but they find it too heavy and they can't control it well, as they are not able to use the brakes. Just 1-2 people would be able to participate in the pilot case with the walker because of the deteriorated health and cognitive condition of the residents.

5.2.3 IZA Care Centre for disabled people

People at the IZA Care Centre are younger, ranging from 18 to 60 years of age. Their disability is in most cases a consequence of brain injury or a neurodegenerative disease. After talking to the physiotherapist and neuropsychologist of the centre we decided that this user profile is not suitable for pilot cases as the majority does not use a walker but a wheel chair, and those who can use a walker have their cognitive function deteriorated.

In addition to these already described profiles, the possibility of testing the rollator at home with hospital discharged patients was taken into account. Although considered very interesting for research purposes, this possibility was ruled out due to the difficulty of controlling the experiment, having the risk of falling during the use of the rollator and considering the lack of WIFI in most homes of the older people in San Sebastian (Spain).

After the visit and during the discussion among the different professionals at Matia, researchers from INRIA and Matia Institute decided that the most suitable user profile was that of the rehabilitation floor at the hospital for various reasons:

- Number of available users for the trials
- Need of use of a rollator
- Health and cognitive status
- Safety
- Need to control the parameters in the trials

The table below summarizes the user profile suitability

Where	Numbers in 2013	Comments	Suitability
Hospital's rehabilitation unit **Average stay: 24 days**	Ictus 51	• No data about use of rollator	X
	Hip fractures 252	• All use rollator • Most without cognitive impairment	✓
	Prosthesis 42	• No data about use of rollator	¿?
Care Home	About 50 older people	• No data about use of rollator • Deteriorated people	X
IZA	74 people with disability	• Age 18-60 • Only 2 use rollator • Cognitive impairment	X
Home	Hospital discharge	• Difficult to control, unsafe • WIFI is not common in olders' homes	X

Table 2 User profile suitability

Therefore, the users will be older people hospitalized in the functional/rehabilitation recovery unit at the Matia's Bermingham Hospital (4th floor) who need rehabilitation to recover their mobility functionality and go home. The patients have to learn to walk again after they have been operated for prosthesis or a hip fracture. They are over 65 years and their cognitive function is not deteriorated.

6. User needs and requirements

6.1 User needs and requirements for the NAO robot

In this section we will describe the methods that we have used to extract user needs and requirements and we are going to present the needs and requirements that were elicited.

6.1.1 Methodology Description

We have used small focus groups for this research where interviews were the most appropriate tool. We reserve the possibility to extend our participants in future stages of the project and in that case questionnaires are going to be additionally used [37], [38], [39].

Personal and group interviews were arranged to facilitate the participants sharing their opinion without restraint. Some of the interviews were structured and some unstructured, depending on the participant and his ability to answer and describe needs. The purpose of this research was explained to them in detail and all questions were answered during our first meeting. All participants have signed a consent form (available at the annex of D1.5).

All the interviews were set up at the Community Seniors Centre as interviewing members of the GAADRD was not permitted at this stage. To balance this factor, we decided to attend daily activities at the premises of GAADRD and use observations that will help us to recognise some of the needs of elderly with MCI. Interviews involved mainly elderly; they all live independently and family and caregivers participation did not seem extremely important at this point; for this reason it is planned to be examined in future stages of this project.

The results and outcome for user needs and requirements are the following:

UR1: RAPP should be constructed with a user friendly mode that will enable elderly to use its applications with simple actions. The elderly should feel comfortable to use its menu, a procedure that must be effortless. Elderly present memory decline which is considered "healthy" and relatively to aging but they still would not be able to memorize and interact with a complicated menu [12], [13].

UR2: the robot should be able to present RAPP front-end functionalities to its users by orally describing them as there is not an embedded display to show the list of choices. Users should be able to use RApps and pick them without intervention from a third person. Having them written is out of question as vision impairments will prevent them from reading and soon the users will quit the procedure [4].

UR3: the robot should provide easy access to RAPP applications through specific voice commands. The robot should be able to hear and understand specific commands from users. If elderly speak in a low voice or use difficult idioms that cannot be recognized by the robot, it should address them in a discrete and kind manner to ask for repeat. A menu of phrases should be used that will not be offensive or firm in order to avoid making elderly feel uncomfortable or lacking ability of communicating and therefore withdraw from interaction (i.e. "Sorry, that was difficult for me. Can you repeat?" instead of a "repeat…repeat") [40], [41], [42].

UR4: the robot should be able to recognise the user and salute him using his name, creating a sense of intimacy between them. Elderly lack social interaction and establishing "warm" relations with the robot will enhance their attachment and consequently diminish feelings of loneliness and isolation [35], [42], [43].

UR5: lack of communication is the most serious obstacle that elderly face as by aging they suffer from diseases that reduce their ability to move and visit family and friends or attend social events. Elderly should be able to communicate with family and friends through emails or Skype calls, in a simple way and by specific oral commands, and maintain their social connections and social inclusion. Additionally, access to Facebook and social media will be facilitated to give seniors the feeling of belonging to a big virtual world that can visit anytime; establishing communication channels through social media or chat rooms and follow the news of people or groups of interest will decrease loneliness and isolation and consequently depression [44]. As in NAO's case a display monitor is missing, access to the above applications can be facilitated by using a tool like chromecast and connect robot with a TV set.

UR6: cognitive games should be available through the robot to enhance their attention and memory. Playing these games with the robot will add fun and joy at the procedure which in turn will benefit the training process. Scores should be stored and retrieved to be evaluated either by the user or by the doctor/caregiver in case of elderly with MCI. The robot should be able to store and retrieve from its database collections of object names and music files to be used in cognitive exercises [45], [46], [47].

UR7: access to the web through the robot, orally activated by specific commands, will enhance cognitive status of the elderly as one search can lead to another and this knowledge/information map can be easily followed in terms of entertainment and fun. Voice commands should be sophisticated and explicit as well as predefined; when elderly say for example: "Political news", the robot should connect to a predefined site for political news. The possibility to retrieve more than one webpage and offer the option for the user to choose should be examined.

UR8: the robot should be able to keep a calendar containing a) time to take pills, b) appointments with doctors, c) important dates of social events to be attended, and d) important "family dates" like birthdays of children and grandchildren etc. This application will address early memory deficits that come along with aging and create worries to the elderly. Informing the calendar with all the above data will enable users to remember them easier by themselves as repeating and saying loud information imprints it to memory [48], [49].

UR9: the robot should have the ability to track and bring to the users small objects that would be predefined (like glasses or the remote control). This interaction between the robot and the user will enhance companionship, confidence and familiarity.

UR10: elderly should maintain the right and ability to withdraw the robot from active condition at any time, if they feel that their privacy is jeopardized or need some time with the "machine" off [50].

6.2 User needs for older people with mobility decline

As mentioned above aging brings decline in motor skills, walking function being one of the most important human functioning for elderly people to be able to perform daily activities and avoid marginalization from social activities, loneliness and poor quality of live. Disability in Activities of Daily Living (ADL), which are the essential activities that a person needs to perform to be able to live independently, is an adverse outcome of frailty that places a burden on frail elderly people, care providers and care system. Frail elderly people have a higher risk of ADL disability compared to non-frail elderly people [51], [52], [53]

Focusing on the actual users for the ANG rollator testing, after a hip fracture, it is vital that older people recover as much as possible their previous level of mobility, lower extremity function, balance and muscle strength in order to prevent future falls. ANG rollator's and RAPP's aim is to help to the rehabilitation and functioning recovery of older people after a hip fracture. Nevertheless, the ANG rollator might address not only the needs of older people after a hip fracture, but also the needs of frail older people to improve their motor skills.

To have a better understanding of the needs of older people regarding mobility, related concepts such as frailty, life-Space mobility, activity limitation and mobility decline are here considered.

6.2.1 Frailty

Frailty is theoretically defined as a clinically recognizable state of increased vulnerability, resulting from aging-associated decline in reserve and function across multiple physiologic systems, such that the ability to cope with every day or acute stressors is comprised [11]. In the absence of a golden standard, frailty has been operationally defined by Fried et al. as meeting three out of five phenotypic criteria indicating compromised energetic [54]:

- low grip strength,
- low energy,
- slowed walking speed,
- low physical activity,
- and/or unintentional weight loss.

A pre-frail stage, in which one or two criteria are present, identifies a subset at high risk of progressing to frailty.
According to the WHAS II (Women's Health and Aging Studies) [55], although there was notable heterogeneity in the initial manifestations of frailty, weakness was the most common first manifestation, and occurrence of weakness, slowness and low physical activity preceded exhaustion and weight loss in 76% of the women who were non-frail at baseline.
A review study carried out by Vermeulen et al [56] indicated that individual physical frailty, such as weight loss, gait speed, grip strength, physical activity, balance, and lower extremity function are predictors of future ADL disability in community-dwelling elderly people. Slow gait speed and low physical activity/exercise seem to be the most powerful predictors followed by weight loss, lower extremity function, balance, muscle strength, and other indicators.

6.2.1.1 Prevalence of frailty

A recent survey of 7,510 community-dwelling older adults in 10 European countries found that prevalence of frailty ranged from 5.8% in Switzerland to 27% in Spain with an overall prevalence of 17%, and was higher in southern than in northern Europe. The geographic variation in frailty prevalence among these European countries persisted after adjusting for age and gender, which led the authors to speculate that there, may be differences in cultural characteristics influencing the perception of health and/or interpretation of the frailty questions [57].

10 European countries	N Age 65+	Frailty prevalence (%)
Total	7510	17.0
Sweden	873	8.6
Denmark	635	12.4
Netherlands	830	11.3
Germany	933	12.1
Austria	707	10.8
Switzerland	412	5.8
France	687	15.0
Italy	833	23.0
Spain	816	27.3
Greece	784	14.7

Table 3 Prevalence of frailty in 10 European countries

6.2.1.2 Behavioural precursors to the development of frailty

An overt state of frailty is believed to be preceded by behavioral adaptation made in response to declining physiologic reserve and capacity to meet environmental challenges. The causes of the loss of physiologic reserve are likely to be multifactorial, including both environmental challenges (e.g., area deprivation) and intra-individual challenges (e.g., age-related physiologic changes) [11].

Life-Space mobility

A central building block of human functioning is walking. Walking difficulties may start to develop in midlife and become increasingly prevalent with age [17].

The proportion of people over 80 years is growing rapidly. The majority of older people lives in private households and, along with increasing age and declining health, tend to spend more and more of their time inside the home or in its immediate surroundings. Eventually, mobility limitations may render them homebound which, in turn, may lead to marginalization from social activities, loneliness and poor quality of life [22].

One example of such behavioral precursor is life space mobility that refers to the size of the spatial area (bedroom, home, outside home, neighborhood, town, distant locations) a person purposely moves through in daily life and to the frequency of travel within a specific time, as well as need of assistance for that travel [58]. Life-space mobility reflects the balance between persons' internal physiologic capacity and the environmental challenges older adults encounter in daily life. Life-space can be used to evaluate transitions in individuals' abilities to live independently [58].

The Women's Health and Aging Studies (WHAS) show that compared with women who left the neighborhood four or more times per week, those who left the neighborhood less frequently were 1.7 times more likely to become frail, and those who never left their homes experienced a threefold increase in frailty-free mortality [55].

Shrinking life-space probably coincides with giving up valued activities that, maintain the social role of the person, such as visiting friends, participating in out-of-home hobbies, recreation or work, and in general with giving up accessing community amenities, a situation referred to as participation restriction [20]. However, not all older persons with functional limitations necessarily restrict their life-space, if they can find ways to compensate for their difficulties, e.g. by using mobility devices [59].

Activity limitation

As people get older, particularly persons over 70 years of age, they experience activity limitation according to the severity and types of self-care (activities of daily living, ADLs) and domestic life (instrumental ADLs, IADLs). Person level functioning is recognized as partially hierarchical. "Harder" activities tend to become difficult early in the course of physical and cognitive disabilities, whereas "easier" activities remain intact until late. For example, eating and continence, which tend to be lost late, are distinct from activities such as bathing and dressing that are lost earlier in old age (Table 4).

A study carried out by Stineman M.G. et al [18], describes the conceptual foundation and development of an activity limitation and participation restriction staging system for community-dwelling people 70 years or older according to the severity and types of self-care and domestic life (ADLs and AIDLs) limitations experienced. Data from the second Longitudinal Study of Aging (LSOA II), a prospective study with a nationally representative sample comprised of 9,447 civilian non-institutionalized persons 70 years of age at the time of the interview, were used to develop IADL stages through the analyses of self- and proxy-reported difficulties in performing IADLs. The authors define five ordered thresholds of increasing activity limitations and according to their results 42% of the population experience IADL limitations.

	Expected hierarchy of ADLs within the staging system applying LSOA II questions
Least difficult	Eating
↓	Getting in or out of bed or chair (?)
	Using the toilet, including getting to the toilet
	Dressing
	Getting in or out of bed or chair (?)
	Bathing or showering
Most difficult	Walking

Table 4 Expected ADL stage hierarchy (adapted from [18])

The relative position of the transferring activity was less certain because of a discrepancy in the published literature, so its position is in one of two places within the order as indicated by the question marks.

Lawton and Brody established instrumental ADLs to express functions important to managing one's life circumstances in the community [60]. IADLs compared with ADLs require more complexly organized locomotor, neurologic and executive functioning; they involve greater environmental interaction and performance abilities and are generally lost earlier.

	Expected hierarchy of IADLs within the staging system applying LSOA II questions
Least difficult	Using the telephone
	Managing your money, such as keeping track of expenses or paying bills
	Preparing your own meals
	Doing light housework like doing dishes, straightening up, or light cleaning
	Shopping for groceries and personal items, such as toilet items or medicines
Most difficult	Doing heavy housework, like scrubbing floors, or washing windows

Table 5 Expected IADL stage hierarchy (adapted from [18])

6.2.2 Mobility decline

Mobility is necessary for accessing commodities, making use of neighbourhood facilities, and participation in meaningful social, cultural, and physical activities.

In the early stages of functional decline prior to the onset of task difficulty, older persons may be able to compensate for underlying disease by modifying their task performance and thereby maintain their function without the perception of difficulty. This stage of functional decline, that is, changes in method, frequency, or time used in task performance or increased tiredness, has been proposed as preclinical [54], [61], [62] disability. Those in the early phases of mobility decline will benefit most from preventive interventions because their own physical resources will still allow them to increase their physical activity and training on their own, without intensive support from other people.

A study on physical activity counselling concluded that it was efficacious in preventing mobility decline, especially among people who are still in the early phase of mobility decline [7].

6.2.2.1 Physiological requirements for walking

Physiological changes with advancing age affect specific body systems and may result in strength, balance or sensory impairments. From the physiological point of view, walking is an integrated result of the functioning of musculoskeletal, cardio-respiratory, sensory and neural systems. Two of the most immediate prerequisites for walking are lower extremity strength and postural balance [63], [64].

Immobility while being ill, may result in critical mobility decline. Among older people, mobility may not spontaneously recover to its pre-illness level. In an American study, it was observed that in the year during which severe disability developed, hospitalizations were documented for 72% of those developing sudden, catastrophic disability and for 49% of those developing progressive disability, while only 15% of those who were stable with no disability and 22% of those with some disability were hospitalized [65].

Progressive resistance training and balance training may help maintain or rehabilitate walking ability among older people at risk of accelerated mobility decline. Results from a study suggest that the negative consequences of acute diseases and hospitalizations may be counteracted among older people by intensive physical training [66].

6.2.2.2 Sensory factors

Adequate sensory functioning, that is, receiving accurate information about potential environmental risks through different sensory channels, plays an important role in safe walking. Rantanen et al observed that hearing and vision impairments correlated with increased fall risk and that the risk of falls was particularly high among people who had multiple sensory impairments [5], [6]. Falls may accelerate the worsening of walking difficulties even further. When multiple sensory difficulties are present, it becomes more and more difficult for the person to receive accurate information about the environment, which may eventually lead to increased fall risk, avoidance of walking, and finally to increased risk of walking difficulty [9].

6.2.2.3 Environmental barriers and walking

Environmental conditions affect outdoor mobility, especially in older adults [66]. Environmental barriers for outdoor mobility subjectively reported by older adults include, for example, poor transportation, discontinuous or uneven side-walks, curbs, noise, heavy traffic, inadequate lighting, lack of resting places, sloping terrain, long distances to services and weather conditions [68], [69]. Similar evidence exists for the association between barriers in the home and difficulties carrying out important daily activities [19]. Fear of moving outdoors was found to increase the risk of mobility decline and may be one of the underlying factors in the association between environmental barriers and mobility decline [69].

6.2.3 User requirements

In order to collect the user requirements, two different methodologies were used: a) A focus group was conducted with physiotherapist, nurses and physicians at Bermingham hospital to get the professionals point of view on the requirements of the rollator; b) 20 patients of the rehabilitation floor at Bermingham hospital, already using a rollator to support their mobility function recovery, were interviewed and also provided with a questionnaire to fill in (results of the questionnaire can be seen in D4.1)

UR1: RAPP and the rollator should be adapted to each patient/user. The height should be adjustable so it can be adapted to the features of each patient depending on his/her height of the trochanter and balance. Also handgrip should be adapted to the gripping ability of patients to avoid pain in hand and wrist, as patients often find handgrips too hard to manage.

UR2: The same rollator should have the possibility to be set up with the suitable RApps for different users so it can be used by different patients during the day. Then each patient would perform the personalized static and dynamic exercise programme.

UR3: The rollator has to be very stable and robust to avoid falling. It has to be heavy enough so that patients will not be able to lift it up while walking and mainly when turning, as they tend to do what is called “bullfighter’s turn”, a manoeuvre with high risk of falling.

UR4: The rollator has to be very easy to manoeuvre, easy to handle when turning or entering through the door as well as avoid obstacles in the corridor. It should move smoothly so the patient should not make a big effort to push, but it should always be under control without speeding up or stopping heavily; rapid movements must be avoided.

UR5: The rollator should allow performing personalized exercises to strengthen muscles and improve balance. Different exercises with frequency and intensity diversity should be proposed, personalized and tailored to each patient to train the quadriceps, buttocks, knees and ankles.

UR6: When walking with the rollator along the corridor patients get tired, but they cannot rest as there is not an aisle seat. This fact prevents them from walking because of their fear of falling when getting tired. Therefore ANG should have a seat so that the patient can sit when needed.

UR7: The patient-rollator interaction has to be very easy, as older people are not used to new technologies. Although a user interface must be present so that the patient/user may specify that he/she is willing to do a special task, the interface must not bother or distract them from the rehabilitation activity.

UR8: The walking pattern of the patient, the position towards the rollator as well as the activity performed should be recorded and all the information should be delivered to the professionals. Monitoring several parameters during the gait and the exercises such as distance walked and time spent on it, weight balance on the rollator and minimal/maximal speed/acceleration, would provide valuable information on the condition and progress of the patients.

7. Functionalities and pilot scenarios definition

Functionalities	NAO robot	ANG robot
Localization	• Rough localization of the robot and user in the house/care home	• Localization of the robot and user at hospital
Identification/personalization	• Identification of the user and adapt the functionalities to the preferences and needs	
Activity Monitoring	• Tracking irregularities in activities patterns (i.e waking up time, nutrition habbits etc)	• Walking pattern analysis when using the rollator
	• Postural failure (fall)	• Daily mobility activities with the rollator
Services	• Internet and social media access • Cognitive games • Calendar	• Correct positioning of the user with regard to the rollator • Static exercise plans • Dynamic exercise plans • User challenge plans
Communication	• With users/patients • With caregivers	
Interaction	• With users and caregivers	

Table 6 Functionalities for the NAO and ANG robots

7. 1 Functionalities and pilot scenarios definition for the NAO robot

As mentioned throughout this document, we aim to illustrate and develop scenarios and the related use cases that will improve social life and support social inclusion of senior citizens and elderly diagnosed with Mild Cognitive Impairment (MCI). RAPP applications and functionalities will be developed for and executed by NAO (Aldebaran Robotics) adjusted to the needs of technology illiterate elderly at the Community Seniors Centre and MCI participants at the Greek Association of Alzheimer's Disease and Related Disorders (GAADRD). These applications aim to support social inclusion of the elderly by connecting them with social media, email, Skype etc despite their technology illiteracy and enhance their memory with gaming exercises; all the above will be implemented with the smooth intervention of NAO and through NAO's interaction and companionship with the participants. Results are going to be openly exported and distributed to researchers and workers in social fields, suggesting and promoting an innovative approach to social inclusions of aging people.

To accomplish this task, we run through literature to discover useful information and relevant researches; we have been regularly visiting both pilot sites for NAO (Community Seniors Centre & GAADRD) and have interviews and discussions with the administrative staff as well as with professional personnel (psychologists, ergo therapists, neuropsychologist etc); we have meetings on a regular basis with the participants trying to retrieve through interviews and observations their needs and requests. A number of functionalities have been identified:

7.1.1 Localization

NAO will be moving around the meeting room at the Community Seniors Centre and a training room in GAADRD. The localization process is twofold and splits to a) the robot localization and b) the user localization.

Concerning the robot localization, NAO can use mainly its cameras for estimating in which room it is (kitchen, living room etc), in combination with the two ultrasonic sensors it contains. It is understandable that with these available sources, NAO cannot efficiently and accurately create a representation of the surrounding environment, thus the developed RApps must take into account that the robot must be functional in a small local region of the space.

As far as the user localization is concerned, NAO can perform either face recognition (understand that there is a person in the room), sound detection and estimation of the sound source orientation, as well as motion detection, which will be helpful if the user is alone in the house, i.e. nothing else moves in the surrounding environment.

7.1.2 User personalization and identification

NAO can identify its master, who is the user in our case, by face recognition. In fact once NAO has detected a face via its two cameras; it can also learn the specific face in order to identify it in the future. Apart from the user identification, it is in our goals provide personalization through specific RApps, meaning that the robot will, in cases, "learn" the preferences of the user and change its way of communication, and generally interaction, with him/her.

7.1.3 Activity monitoring

Activity monitoring contains two parts that interact with each other. Firstly NAO, through appropriate RApps, will be able, to a certain extent, to monitor the daily activities of the user. Some examples may be his/her wake up time, how often does he use the bathroom, his eating habits concerning the time of meals etc. This way it could be able to detect irregularities to the user's habits and try to interact with him/her, aiming at identifying what is wrong. The second aspect of activity monitoring takes care of extreme cases, such as postural failure (fall), no response to vocal or touch stimuli etc. In that case the robot could inform certain family members or even "call" a caregiver, the police or a hospital.

7.1.4 Object detection and fetching

NAO through its robotic vision could be capable of detecting a number of objects in the surrounding environment. Additionally, once a specific object is detected and is of a certain weight and shape, the robot can grasp it fetch it to the user. This will be extremely helpful to users who suffer from motor illnesses or degradation of mobility capabilities, as they will be able to command NAO to find an object that may have fallen on the floor (e.g glasses, keys) and bring them to him/her.

7.1.5 Calendar (reminders)

It is a very common aspect of elderly people to forget trivial or important timely milestones, due to MCI. These may include the time and type of pills they are prescribed to, important dates with his caregiver or even less important events like birthdays, national celebrations etc. NAO can be able to set discrete alerts, or notifications for any event the user want to set a reminder for. Apart from that, there is the possibility of connecting with other online calendars and fetch interesting facts.

7.1.6 Interaction/Communication

Interaction with participants

NAO is capable of interacting with the participants. The possible user interfaces are: a) vocal, as it uses four microphones to track sounds, and its voice recognition and text-to-speech capabilities allow it to understand and speak 8 languages, and b) tactile, as it employs touch sensors on head and each hand and foot. The above allow interaction between robot and the participant enhancing communication and companionship while decreasing loneliness and isolation.

Communication with RAPP repository

NAO will also communicate with RAPP repository in order to update its knowledge base, enrich the knowledge database with newly perceived objects in space, or even download new RApps.

7.1.7 Connectivity

NAO currently supports Wi-Fi and Ethernet, the most widespread network communication protocols. In addition, infrared transceivers in the eyes allow connection to objects in the environment. NAO is compatible with the IEE 802.11g Wi-Fi standard and can be used on both WPA and WEP networks, making it possible to connect to most home and office networks. NAO's OS supports both Ethernet and Wi-Fi connections and requires no Wi-Fi setup other than entering the password.

NAO's ability to connect to networks offers a wide range of possibilities.

NAO users can already utilize the following applications:

- Based on NAO's IP address, NAO can figure out its location and give a personalized weather report.
- When you ask NAO about a topic, it connects to Wikipedia and reads the relevant entry.
- Can connect to an audio stream and play an Internet radio station.

7.1.8 Email, Skype and Social Media Access

NAO’s ability to connect to the internet boosts its potential help to the technologically illiterate elders. Specifically It can connect to an existing e-mail account and check periodically check for new messages arrivals, or even send mails. Additionally it could connect to any web service that has the appropriate API to retrieve and post data, such as Skype, Facebook or Twitter.

7.1.9. Real life scenarios concerning NAO

Real life scenario (technology illiterates)

Mr. Aristoteles is a 76 old senior living independently at New Moudania, a small seaside town in Chalkidiki, North Greece. He lost his wife one year ago and suffers from loneliness and isolation. He has two daughters, both living far from hometown: his older daughter lives in Athens and his younger in Germany. Four months ago, and after the prompts of his friends, he started to visit the Community Seniors Center, mainly the coffee shop, to chat with fellow seniors and have a tea with them. He was not very fond of playing cards or chess and soon find himself sitting by the window, watching the sea and think about his daughters and his grandchildren. His younger grandson was born 6 months ago in Germany and he still hasn't seen him but only in photos.

The Centre's psychologist approached him one morning and talked with him about his thoughts and feelings. Mr. Aristoteles was at risk of depression and a solution should be found immediately. She suggested some computer lessons that were offered at the Centre and intrigued him with applications like emails and Skype calls that would enable his communication with his daughters. Mr. Aristoteles loved to learn new things but computers, as he thought, were not meant for him. He had arthritis and his fingers were deformed making it extremely difficult and painful to use computer mouse or touch pad. Moreover, his eyes were getting tired and blurry even by watching TV, imagine staring at the monitor of the computer. "These things are not for my age" was his response, feeling frustrated and discouraged.

RAPP's solution

The Community Seniors Centre was always supporting innovations and soon, their psychologist asked Mr. Aristoteles's permission to enroll him for a new robotic program with NAO, a small companion robot. In just a few weeks and after a short training, Mr. Aristoteles was enjoying the company and applications of NAO. He was communicating with both his daughters through **Skype** and he watched the first steps of his grandson in Germany sitting on his sofa in New Moudania; all he had to do is ask NAO to make the call and connect him. Furthermore, he found some colleagues from the bank he had been working for 35 years and started **exchanging emails** with them sharing news, photos and jokes… Every morning, he was preparing his coffee and then he was addressing to NAO: "come on son, let's check our emails". NAO was more like his digital grandson than a robotic machine and being around **never let him feel lonely again**. After a while, they decided with his old colleagues to create a group page on **facebook**, so to exchange news and photos more easily and Mr. Aristoteles addressed to NAO for creating an account and connect him.

In just a few weeks Mr. Aristoteles was a different person; happy, active, prompting his friends at the Senior Centre to start using a robot themselves. He gradually started to use all available applications that could be downloaded on NAO: updating the **calendar** and set **alarms** so that NAO could remind him when to take his pills; dates with doctors that he was forgetting lately; special events like birthdays of children and grandchildren and many more. He was also using the **"object finder"**, an application that could track specific objects like glasses or the remote control and bring them to him, objects that Mr. Aristoteles was usually forgetting where he left them.

This forgetfulness started to worry him at a point and took him to visit the Centre's neuropsychologist. After examinations there were no serious findings and he was suggested to simply use some **exercises to "stretch" his memory**. These exercises were downloaded to NAO from RAPP repository and Mr. Aristoteles started to play almost every day as he found it very entertaining. He was using a game in which NAO was reproducing popular songs and Mr. Aristoteles was supposed to recognize them and put them in order according to the decade (or year for advanced levels) that the song was released. He enjoyed it so much that he even organized a music contest at the Community Seniors Centre based on this application.

Real life scenario (MCI)

Mrs. Evanthia is a 70 years old lady, living with her husband in Thessaloniki, North Greece. A few months ago, she found herself in an uncomfortable situation as her daughter called her to complain that she had been waiting more than half an hour for her in front of her doctor's office. She had an appointment with her cardiologist and she had asked her daughter to accompany her but totally forgot about that. She found an excuse and postponed the appointment. Two days later she forgot to pick up her grandson from the school and the teacher called her to see what happened. She was sure that she was supposed to pick him up at 15.00 and not 13.30. Worried and frightened she made an appointment at the Greek Association of Alzheimer's disease and Related Disorders (GAADRD) where she was diagnosed with Mild Cognitive Impairment (MCI). Mrs. Evanthia was a strong and active woman, supporting her family and taking care of everything at home. She could not just surrender and wait for the worse to happen. She asked for every kind of training that could be provided to her, aiming at enhancing her memory and improving her daily life and indeed a number of sessions at the GAADRD were proposed to her. Unfortunately, she couldn't visit the premises of GAADRD often as she was living in the suburbs and she needed more than an hour to reach their centre by public transportation. Moreover, she was taking care of her grandchildren as her daughter was working overtimes and this could not easily change for financial reasons. She decided to visit once per week and attend a two-hour training session for enhancing her concentration and memory with no positive results. The GAADRD personnel informed her that she should increase her visits as they had noticed zero improvement. Mrs. Evanthia was disappointed and despaired.

RAPP's solution

Mrs. Evanthia discussed the situation with her neuropsychologist who was also worried for her and he suggested to her a new intervention approach: robots… They were already experimenting with NAO, a small companion robot that could download multiple cognitive trainings from RAPP repository and deploy them to patients. It was easy to use and training results were stored in a platform that her doctor could easily access to examine her performance and discuss it with her over the phone. She could exercise every day without having to visit the GAADRD centre regularly and adjust the cognitive training according to her results and her doctor's suggestions without an effort (everything was done through the cloud repository of RAPP). Mrs. Evanthia was always in fond of novelties and she agreed on having a robot at home. A few days later, NAO arrived at her house, being welcomed with enthusiasm both by Mrs. Evanthia and her grandchildren! In her free time she was exercising by playing cognitive games with NAO like:

- Listen to a story from NAO and then answer to questions based on right and wrong (i.e. was the farmer old? Was his shirt red? He had 12 cows and 23 chickens etc). Concentration was important for this game and NAO stored all her "right" and "wrong" answers. At the end of the week, her doctor could check the answers and her daily progress and proceed with appropriate adjustments.
- Listen parts of songs and categorise them according to the decade they were released or couple songs with singers.
- Create a "memory ball" with family photos, special dates, favorite poems and songs or favorite books. This "memory ball" can preserve happy memories and project them after demand. By this way, the memories will be preserved for a longer period for the patient himself and could work as a training tool or reminders for later stages (in cases that memory will deteriorate).

Mrs. Evanthia was very satisfied with NAO's training and her doctor was very satisfied with her results. Her grandchildren were also happy having a robot at their height moving around the house as it was not scary at all and resembled more to a toy. Moreover, they were proud for their grandmother that was a real "techie"….

7.2 Functionalities and pilot scenarios definition for the ANG robot

The main objective of this section is to create and develop a scenario and the related use cases that will improve mobility functionality of elderly people who need a rehabilitation to recover their mobility functionality and go home.

Within RAPP, some applications and functionalities will be developed and implemented in the ANG robot so that patients at hospital can use a smart rollator adapted to their needs of rehabilitation. This will allow patients to recover mobility functionality in a safer and perhaps faster way and will let professionals know the evolution of each patient in order to better adapt intervention to them.

After the literature review and some visits and interviews to professionals, such as physiotherapists, nurses, physicians, and neuropsychologists, various functionalities have been identified that could provide a solution to real needs of patients: localization, identification of the user and personalization, activity monitoring, exercise programs and communication with users.

Functions of the Rollator (ANG-MED)

7.2.1 Localization

The Rollator will be located at hospital and thus the patient when using it as well. Some sensors will be installed in strategic places and along the corridor at the hospital for this purpose as well as low resolution camera on the rollator and targets on the environment.

7.2.2 User personalization and identification

The walker will need to identify each patient as it can be used by different users during the same piloting period at hospital. By means of RIFD tags, the ANG robot will recognize each person and it will download the suitable settings for personalized RApps.

7.2.3 Activity monitoring

7.2.3.1 Walking pattern analysis

The rollator will measure some walking parameters of the patient such as distance walked, speed, acceleration, weight balance and others, to analyse and report the walking pattern and evolution of each patient.

7.2.3.2 Daily mobility activities performed with the rollator

The sensors installed in the rollator and also along the corridor will allow knowledge of the trajectory of the patient and which activities they perform with the rollator. The patient will be motivated to increase the daily mobility activities in an appealing way and safely, adapted to each patient's recovery and rehabilitation process.

7.2.3.3 Safety issues detection

The rollator will be able to detect if there is any problem that could require checking of the caregiver while the patient is using it and sort out an alarm to the professionals at hospital, as for example interruption of the interaction between the patient and the rollator or an uncommon acceleration.

7.2.4 Robotic services

7.2.4.1 Correct positioning of the user with regard to the rollator

The correct position adaptation of the patient, related to the rollator is very important in order to avoid risk of falling. Therefore the rollator will detect if the user's position is (or not) the right one and will give feedback to correct it. They should not be too close with the abdomen almost touching the rollator (risk of falling backwards) nor too far with the arms extended (risk of falling forwards).

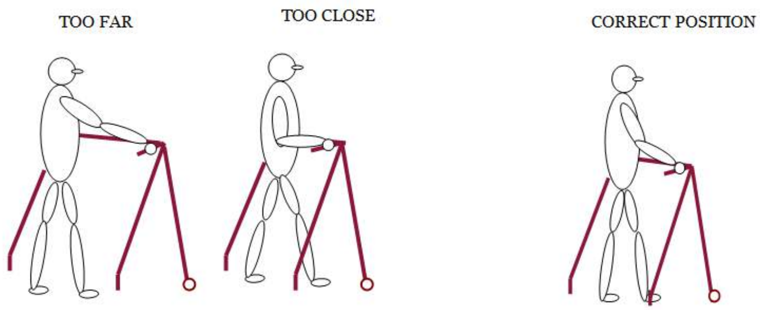

Figure 10. Correct positioning of the user

Related to the design of the rollator, and although there is no standard for rehabilitation robots as a medical device [70], we should refer to the ISO 11199-2:2005 [71], which is the ISO standard for classic rollators (walking frame with wheels) and could be partially applied to our smart rollator. Part 2 of ISO 111999 specifies requirements and methods of testing the fatigue, static load capacity, braking and static stability of rollators being used as walking aids with wheels, manipulated by the hands, without accessories, unless specified in the particular procedure. This part of ISO 11199 also gives the requirements relating to safety, ergonomics, performance, and information supplied by the manufacturer including marking and labelling. We shall consider the guidelines and tests that are applicable to ANG, for example stability tests.

Other relevant standard applicable to the smart rollator as a medical device that should be considered is the European Directive on Medical Devices 93/42/ECC [72], mandatory for certification in the European Community and to legally place a medical device on the European market. This Directive is intended to harmonise the laws relating to medical devices within the European Union.

7.2.4.2 Exercises Program

Exercise programs performed on the rollator may improve the rehabilitation progress of the patient.

- Static exercise plans
- Dynamic exercise plans
- User challenge plans

Figure 11, exercise plans

Some static and also dynamic exercises will be defined and implemented in an appealing way for the users so that they feel motivated to perform them (serious games). The aim of these exercises is to strengthen muscles and improve balance.

7.2.5 Communication/Interaction

Here communication with users will only be considered as communication between the robot and the RAPP repository will be developed in other more technical WPs. Thus, the rollator will communicate with:

a. **The patient**. Old people nowadays are not used to technologies but in the future, not very far, the profile will change and therefore it's worth to do some research also in terms of interface for the patient, although it should be very simple and easy to use, as for example simple buttons for basic commands as switch on/of, start/finish an exercise and others. A suitable user interface for patients will be defined and its acceptability evaluated.

b. **The caregiver**. Some reports on patients' activity monitoring will be generated and published so that the professionals can keep track on this activity performance and the evolution of each patient during the rehabilitation process based on a generic Rapp and adapted to the preferences of caregivers, as for example graphic information displayed on a device.

Other ways of communication and interfaces for the caregiver have also to be considered to control directly or via RApps the rollator. Several options can be developed so that the caregiver will be given the choice of using one or the other: an InfraRed TV remote control for direct interaction or a tablet or smartphone to authenticate his/her connection to the rollator, to define the exercise, to enter or read (RFID tags) the name or the patient, to review past exercises and to control what is going on via RApp.

7.2.6. Real life scenarios concerning ANG rollator

Real life scenario

Felisa is an 80 years old widow who lives on her own in San Sebastian, a small seaside town on northern Spain. She is autonomous and runs herself for activities of daily living although a girl comes home 2 days a week to do the heavier cleaning jobs. Felisa has a daughter of 50 years, Ana, who lives 20 km away and two grandchildren who visit her every week. The daughter is concerned because she has noticed that her mother has lost stability but does not want to use a cane. Although Felisa has not said anything, Ana thinks that she has lately fallen at home, fortunately without serious consequences. Ana has proposed her to ask for a telealarm to the social services to what her mother has agreed. Now that she has the telealarm installed Ana is quieter, at least if Felisa falls she can call and will be attended promptly.

Last week Felisa fell and broke her hip. Thanks to the telealarm she could call the emergency service and after quickly notifying her family an ambulance went home and took her to the hospital. After being operated she has been taken to the Bermingham Hospital at Matia Foundation where she can recover enough mobility and strength before going home.

Idoia, the physiotherapist of the rehabilitation unit has explained to Felisa that for a prompt recovery she will have to do some exercises every day and walk along the corridor. For that purpose she will have the support of Idoia. But it would be very convenient that she could perform some extra exercises on her own, although it is not always possible as Ana can only visit her after 6 p.m. and Felisa is afraid of falling again if she walks without the support of someone beside her.

To perform her daily activities Felisa has a rollator but she has never used a rollator before, so she doesn't know the correct position and tends to put herself too far. When Idoia is beside her she reminds Felisa the correct position which will be much safer a comfortable, but when Felisa uses the rollator on her own nobody will tell her to correct her posture. This fact prevents Felisa from walking as she remembers very well the intense pain she felt when she broke her hip and is afraid of falling again.

Felisa has been advised to do some exercises every day to strengthen her muscles and also improve her balance. For that purpose she uses a table or the back of a chair. But she is not very comfortable, the table is very low and the chair is not very stable to support her weight during the exercises.

Felisa has also been told to walk along the corridor as much as possible. Although she tries it, she doesn't dare to walk long distances because she gets tired easily and cannot sit down in the corridor. Therefore Felisa walks below her capacity and does not improve as much as she could.

RAPP's Solution

The physiotherapist and physician from the ortho-geriatrics service have prescribed daily use of the smart walker ANG MED.

Felisa is advised to use the ANG robot, a very stable and robust smart walker that can be programmed taking into account her needs of exercise and rehabilitation. ANG is being used every day by other three patients; therefore it will identify Felisa as a new user in order to download the suitable settings for her. Felisa will be provided with a RFID tag placed at her wrist, so the smart walker will be able to identify her and change settings when she takes it to perform her exercises. Idoia will also be able to change settings of one patient to another using her infrared TV remote control.
Felisa is very happy when using this walker as it is able to detect if her position is the correct one and if not it shows her how it should be. With this ANG robot Felisa feels safe because it is very stable and she can take a few steps without fear of falling and even if this would happen the rollator would warn Idoia sorting out an alarm so that she would be promptly attended.

Felisa has been advised to do some exercises every day to strengthen her muscles and also improve her balance. For that purpose she uses the ANG robot too. With the supervision of Idoia she has learnt how she must do the exercises. The ANG rollator is heavy and stable enough to support Felisa's weight and she feels very comfortable as the height of the rollator is adapted to her. In addition the rollator shows and guides her during the performance of the exercises that are programmed specifically for her.
With this ANG rollator Felisa is able to walk long distances and when she gets tired she can have a rest and sit down on the seat the rollator has.
Idoia the physiotherapist and Arantxa the physician can follow Felisa's evolution on their computer as the robot monitors some parameters that will give them valuable information: distance walked, speed, acceleration, weight balance, and others.

Now that the rehabilitation at hospital has come to its end Felisa is very happy as she has sufficiently recovered her walking function and when going home she will feel safe enough to walk on the street and meet her friends to have a coffee as before.

8. Conclusions

This deliverable presents the needs of elderly in danger of social exclusion and our suggestion to successfully face this issue. It is the responsibility of RAPP to continuously ask, confirm and enrich the requirements of this project as well as openly share its findings with other research teams and scientists. During the progress of this work and in parallel with pilot testing, we are going to extend our research and reach more elderly adding value with their opinions and views. We don't ignore but rather support the fact that all requirements depend on a) the different needs, capabilities and expectations of the user and the required support as well as b) the user's physical, intellectual, emotional and social state which change and in turn affect his capabilities and expectations over time.

Social inclusion and the vision of supporting independent living will be achieved with pervasive integration of new robotic technologies in the daily environment of the ageing population and the creation of new (standardized) supporting services.

The results of the *RAPP* project will have an important impact in many domains. First of all, the project being user driven and relying to real needs of real users (instead of pushing technology based on implicit assumptions about these needs) brings technology closer to elder people who have problems to interact with it. The *RAPP* project will allow people with cognitive problems to successfully perform daily activities, enhance their skills by means of memory games, assist people with mobility problems, and help elderly people to better interact with technology. Most importantly, *RAPP* will provide developers with the necessary tools and APIs to build their own assistive robotic applications, in order to advance and improve the living of people at risk of exclusion.

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