D3.4 4-Connect My Hobbies Module

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Executive Summary

Deliverable D3.4 describes the robotic applications (apps) that are deployed on the Mario Kompaï robot, which provide some focused functionalities, such as play music and games, display the latest news updates, and practise physical activities. The development and selection of these apps was driven by the desires and requirements identified by end users, that is, people with dementia, and caregivers. This report follows the following schema for each developed app: *Requirements, Vision and Objectives, Application Design, and Privacy and Security Aspects*. This deliverable also presents details on: i) why we opted to build all these apps from scratch and not utilise existing apps from the market, ii) why our apps are different from existing widely used apps in the market and iii) how the robotic apps are different from apps developed/available for a smart device e.g., a tablet. Therefore, we specify why these apps do not just allow people with dementia to just play music, games and videos, same as other people might already be accustomed to. In the MARIO project, this is done in a way which is different from existing apps, which is specialised for people with dementia and at the same time exploits all the potentials that a robot as a platform provides to the end user.

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1. Introduction

This deliverable comprises the basic Mario Kompaï (Mario) robot functionality and requirements for the edutainment and personal development module being implemented. The goal of **Task 3.4**: *MARIO human network for the mitigation of loneliness, isolation and dementia*, is described in the Description of Work as to create a network to agree ways of facilitating connectedness with service robotics and to advance knowledge about ways of fostering social inclusion by means of connecting researchers and stakeholders to establish best practices across European countries. In this respect, the role of the Galway Dementia Network will be important as it will provide advice and ensure that the voices of Persons with Dementia (PWD) and carers are at the forefront. An advocacy role will be taken here, where their expertise has been sought within each of the activities of this task. The research team will also be advised about the experiential and feasibility aspects of the project.

1.1 Work Package 3 Objectives

This WP investigates how service robots can be used to change perception of loneliness, build resilience, and be a tool for the prevention, mitigation and support the independence of persons with dementia. Beyond the end user individuals, WP3 also aims to provide the necessary foundations that will contribute to a change of attitude in the way that service robots are employed as a means of promoting and maintaining connectedness to the community, reducing isolation and loneliness, and reducing risks related to being alone rather than being seen as a replacement for human contact. As such, WP3 objectives are:

- To investigate and determine how service robots can best be used to change perceptions of loneliness, to build resilience and to address challenges surrounding dementia
- To work with end users to determine the issues of importance to them, specifying what matters to them to enable the specifications of what a robot needs to be able to do so as to develop the 4Connect + modules associated with their community, a person's social network and a person's hobbies and interests.
- To address understanding, attitude, and acceptance related to service robots
- To construct a network of researchers in this topic domain that outlasts the project

Deliverable 3.4 reflects the output of the first and second objectives above.

1.2 Purpose and Target Group of the Deliverable

The purpose of this deliverable is to describe the selected applications that constitute the 4-Connect My Hobbies module, specifically:

- Music Playing app: helps living the moment, eliciting positive feelings, reducing loneliness, depression and anxiety stimulating the person to connect to the present and socialise;
- News Update app: being updated with what happens in the local community (sports, events, etc.), stimulates social interaction and inclusion;
- Play a Game app: stimulates cognitive activities;
- Physical Activity app: reduce symptoms of depression and cognitive decline.

This deliverable is targeting several parties that are interested in service companion robots. For example, robotics experts will be interested in all aspects of how such robots work, health experts will be interested in how these robots can improve the lives of people with dementia, software engineers will be interested in the technical details of the apps, pilot users will be interested in how such robots can help them in their everyday life.

1.3 Relations to other Activities in the Project

The present Deliverable is a result of the work carried out as part of Task 3.4 (as already listed above), led by partner National University of Ireland, Galway (NUIG). In addition, WP3 receives as input user requirements, system architecture, information management and ethical framework from WP1. From WP2, a service robot will be available. An iterative design process involving the RDI WPs (WP3-WP6) will enable bringing the progress of these other WPs (moods and expressions from WP6, semantics from WP5, a holistic approach and assessment from WP4) into the development cycle of WP3. WP3 will provide as output (for integration in WP7 and validation in WP8) modules that bring Mario's capabilities to stakeholders and also the science dedicated to the treatment of PWD/loneliness/isolation. The human network in WP3 will fold into the larger MARIO Stakeholder community project-wide in WP10.

1.4 Document Outline

This deliverable is organised in 8 Sections, where the first one gives an Introduction to this deliverable in the context of the MARIO project, whereas the second section presents the Background and Motivation behind this deliverable. Section 3 discusses the Application Design and Development, whilst Sections 4-7 present detailed information about the four robotic applications developed about Music, News, Playing a Game and Physical Activity. Conclusions reached from this deliverable are provided in Sections 8.

1.5 About MARIO

MARIO addresses the difficult challenges of loneliness, isolation and dementia in older persons through innovative and multi-faceted inventions delivered by service robots. The effects of these conditions are severe and life-limiting. They burden individuals and societal support systems. Human intervention is costly but the severity can be prevented and/or mitigated by simple changes in self-perception and brain stimulation mediated by robots.

From this unique combination, clear advances are made in the use of semantic data analytics, personal interaction, and unique applications tailored to better connect older persons to their care providers, community, own social circle and also to their personal interests. Each objective is developed with a focus on loneliness, isolation and dementia. The impact centres on deep progress toward EU scientific and market leadership in service robots and a user driven solution for this major societal challenge. The competitive advantage is the ability to treat tough challenges appropriately. In addition, a clear path has been developed on how to bring MARIO solutions to the end users through market deployment.

2. Background and Motivation

Dementia is characterised by impaired: mental functioning, language and thinking. These impairments are often accompanied by personality, functional and behavioural changes, that impact on a person's ability to use and understand technology. In addition exclusionary attitudes towards people with dementia have led them to be seen as incapable, without personhood resulting in exclusion, stigma and poor care outcomes. Spector and Orrell (2010) report that many people with dementia experience "excess disability", beyond that caused by disease processes, while others, who have significant pathology at post-mortem, have no clinical manifestations of dementia. They suggest that there are other protective or destructive psycho-social factors at play and that social engagement and activity is crucial to improving outcomes. For people with dementia, the world can become a lonely and isolated place. Therefore, innovative ways of engaging the person with dementia in meaningful activities, for example listening to their preferred music, playing their preferred games and providing them with opportunities to stay connected to society and build resilience, are required.

Resilience, defined as a "dynamic and amendable process" Luthar and Cicchetti (2000) encompasses positive adaptation within the context of major adversity. It focuses on modifiable intra-personal skills and protective factors aimed at increasing a person's 'hardiness', i.e. the ability to remain psychologically and physically healthy, or 'resilient', in the face of adversity. Originating within the field of child and adolescent developmental psychology (Masten and 2008). Resilience theory has now been extended to other health care disciplines, including the field of mental health and people with dementia (Clare et al 2011; Harris 2010). Resilience building in dementia as with resilience building in children and adolescents focuses on strengthening personal attributes and external assets. This involves focusing on the abilities of the person with dementia and helping the person to retain these, (rather than focusing on deficits) and using external assets such as, relationships with families, friends, and the wider community to enable the person to, as it were, 'bounce back' and to cope with the life challenges brought on by dementia.

Psychosocial interventions (PSI) are non-pharmacological interventions which include behavioural therapies, educational programmes, psychotherapy and social support interventions. PSI's are thought to optimize mental functioning and enhance the quality of life of people with dementia (Clare & Woods 2003) and thereby build resilience. In summary, the overall aim of PSI's is to improve and maximise functioning, promote social connectedness and autonomy and ultimately build resilience. One approach used to deliver PSI, which focuses on promoting social connectedness and reducing isolation, is via the use of enabling technologies, such as companion robots.

Companion robots have been defined as being useful and possessing social intelligence and skills which enable them to interact with people in a socially acceptable manner Dautenhahn (2007). Research has also found that companion robots have a positive psychological effect and can help forge social relationships (Wada et al 2009). They companion include robots, such as PARO, Giraff, PaPeRo, Palro and Pepper. Paro a seal-like robot was developed for patients with severe dementia, and has been successfully used to enhance social interactions and reduce social isolation (Wada et al 2009; Klein and Cook 2012; Chang et al 2013; Takayanagi

et al 2014; Sung et al 2015). Giraff, a mobile telepresence robot with internet connectivity and skype was developed for use with older people to promote social interaction and connectivity with family and friends. Subsequently Giraff, was assessed for feasibility of use with PWD (n=6) through observing them making 6 calls during a 6 week period (Moyle et al 2014). It was found that participants' emotional response and engagement improved and they found Giraff enjoyable to use and it improved their social connectedness. Papero was designed to interact with people of all ages, subsequently if has been tested as a means of providing information support to PWD (n=5) in their homes. It was found that some PWD experienced difficulty using the system but made positive remarks about having fun conversations with it and it being 'pretty smart and great' (Inoue et al 2012). Palro, was designed as a research and hobbyist robot. It can walk, play music and games, dance, and take photographs, connect to the internet for information on news, weather forecast and remembers users after communicating with them (Inoue et al 2014). Recently these researchers demonstrated Palro in a nursing home day room with 6 males and 19 females with dementia. Participants were then encouraged to interact with it and the interaction was observed. The findings reveal that participants with mild dementia responded better than those with more advanced disease and that Palro effectively encouraged communication, activity and fun. Finally one of the more recent companion robots availabe on the market is Pepper. This is a humanoid robot designed to communicate and entertain and read human emotions Again this robot was not specifically designed for use with PWD, but it has recently been reported as succesfully carrying on simple conversations with PWD and being able to remind them to take their medicine.

The evidence to date indicates that older people with dementia are on the whole accepting of robot companions and interact with them and they have a positive effect on promoting social connectivity. However, apart from Palro none were developed specifically for use with PWD. Furthermore the reported evaluations of use with PWD frequently involve small sample sizes, conducted over short time periods and appear to be rarely conducted in real world settings.

Mario is specifically developed and designed for use with PWD, and PWD and caregivers have been involved in its development from start to finish. At its heart, Mario aims to provide companionship, cognitive support and promote social connectedness. Unlike other companion robots, Mario will be tested and evaluated over an extended period eg 12 month by PWD and caregivers in three real world contexts, acute hospital setting, peoples own homes and long stay residential care. The key functionalities currently under development that in combination provides Mario with its unique capabilities are outlined in Table 1.

Table 1: The MARIO Robot system

Speech as a primary mode of interaction. Like several companion robots, Mario communicates primarily through speech allowing non-contact and at a distance interaction.
Entertainment functions. As with several home oriented companion robots, MARIO is equipped with entertainment functions for PWD in the form of games, music, audio books and videos. However, unlike most systems currently on the market, these entertainment functions can be configured by the primary care-giver to be personalised to the needs of the individual PWD. A unique capability of Mario is the ability to engage the PWD in reminiscing about their

past as well as people and places with emotional significance.

Information provision. Several guide robots are designed to provide people with information about their immediate surroundings and directions. Mario combines these functions with functions more normally found on hand held devices, such as calendar reminders, medication reminders, personal and factual information (contacts; day of the week) and information about the location of places and objects in order to be an information resource for the PWD. As with guide robots, Mario can also guide a PWD to a specific location in case of confusion or unfamiliarity.

Social connectedness: There are several virtual presence however, Mario uses mobile telepresence to enable the PWD to maintain and extend social contact by embedding the capability within a social networking systems designed for PWD.

Adapting responses to the user's emotional state. Many robots, mainly designed to resemble animals, aim to have an emotional contact with the user. MARIO, however, does not specifically aim to engender emotional attachment but rather to try and assess the emotional state of the PWD in order to modify the nature and content of the dialogue to facilitate understanding.

Health monitoring. As with Mario, several developmental companion robots (e.g. the EC Framework 7 Accompany project) have as part of their function the monitoring of the person and collection of health data. MARIO takes this a stage further and undertakes formal assessments in terms of undertaking parts of the Comprehensive Geriatric Assessment (CGA) in order to assist healthcare professionals and to provide an ongoing assessment of the PWD's capabilities. While CGA is also undertaken by robots developed within the EC Horizon 2020 ECHORD++ project[1], these latter robots are dedicated to this single task.

2.1 Principles underpinning application development in MARIO

Mario serves as a platform capable of receiving and implementing new robot applications tailored to best meet the needs of PWD. Based on the literature and the data collected from key stakeholders to date, Mario will be equipped with a number of applications specifically designed to reduce loneliness and isolation and promote connectedness. There are four principles that underpin all the application developments for MARIO.

- The first is that the **applications are individualised**. This means that an assessment of the person with dementia takes place to identify their specific interests and the options that are then given are built around these interests. Whilst taking into account their cognitive abilities and capacity.
- The second is that **the person with dementia is given choices**. They will be facilitated to select what they would like, based on their ability and capability to make these choices. This feature has the potential to empower PWD, in particular those with mild/moderate dementia who are frequently assumed to lack the capacity and ability to make choices which is not always the case.

[1] http://echord.eu/

- The third is that the system is designed to **prompt the person as a way of maintaining memory**.
- The fourth is that the **technology** is designed so that it is **simple** and **intuitive to use**.

These applications are constituted into 4-Connect modules: My Hobbies Module, Community Module, My Social Network Module and Mario Robot CGA-Module. The next sub-section describes the first of these applications.

2.2 4-Connect My Hobbies Module

The initial interviews undertaken with people with dementia and their carers in terms of what they would like Mario to be able to do for them and how best to promote acceptability and use, highlighted the need to make Mario fun and interesting to use from the outset. They therefore suggested that the initial applications might focus on helping them to be able to **reengage with hobbies** for example **playing music**, or **games** such as golf and bowling. Facilitating people with dementia to continue their involvement with or re-engage with activities which they may have enjoyed for some time and providing easy access to personalised games, such as card games, golf games, and bowling, which activities can support autonomy, independence and overall wellbeing. PWD also wanted activities and games that were **cognitively stimulating** which would help them retain their cognitive abilities. Cognitive stimulation (CS) is an approach involving engagement in a range of activities and discussions aimed at general enhancement of cognitive and social functioning (Clare and Woods, 2004). A Cochrane review found that CS improved both cognition and quality of life, concluding that the benefits of CS enhanced those of medication (Woods et al., 2012). However the comparison among different studies using CS techniques is sometimes difficult because of a wide variability in the type, complexity, and duration of interventions, with a lack of uniformity in targeting different cognitive functions and training protocols, small sample sizes, unavailability of comparison groups, and other methodological constraints (D'Onofrio et al., 2015). As a whole, however, there is good evidence for the benefits of CS for people with dementia (Orrell et al., 2012), and physicians generally accept that CS could improve cognition and neuropsychiatric symptoms in people with dementia (Nomura et al., 2000). Mario will be equipped with different types of games, ones preferred by the user appropriate to their cognitive ability and capacity and thereby are more like to attract participation and engagement. In addition specific cognitive stimulating games such as Lightning Librarian, Brain Safari will be provided and PWD will be encouraged to participate and try out these games.

In particular PWD and caregivers alike wanted Mario to be able to **keep them connected to the present** and to on-going community events. They were quite clear that having access to local community activities such as parish football games and events would provide them with an access route to socialise more with others and feel connected. In addition awareness of current affairs and local interests and being reminded of same and prompted about them they felt would promotes their autonomy as it would give them the opportunity to voice their interest and views, feel part of a community share experiences and thereby facilitate them to stay connected. Mario will be equipped with the ability to provide access to the news and local events that the PWD has an interest and Mario will offer the person a choice, again based on their capacity and ability as to what they want to listen to or what news item they would like to hear more about.

Music is a key method used to transcend cognitive issues; connecting people, and enabling the person with dementia to live in the moment (Rio 2009). It is believed that the transformative nature of music in dementia care is due to the fact that the structures in the brain responsible for processing musical information remain intact even in the late stages of dementia. Much has been written supporting the use of music as a unique and powerful tool in dementia care (Cuddy & Duffin, 2005). Music therapy (MT) is a PSI used with Persons with Dementia (PWD) which can be active or passive (Vink et al., 2004). Active MT is a participatory process whereby the PWD participates by either singing or playing an instrument with the presence of a musical therapist (Aldridge 1994). Whereas passive MT exposes the person with dementia to live or recorded music without any active contribution (Grocke & Wigram 2007). Despite the methodological weakness of the studies exploring the effectiveness of MT the literature reveals that MT has the potential to increase quality of life of older people with dementia, reduce agitation, anxiety, and depression and improve cognitive functioning (Gerdner 2000, Sung & Chan 2005, Raglio et al. 2008, Vink et al. 2011, Blackburn et al. 2014). Sarkamo et al (2015) found that people with mild dementia who sang regularly or listened regularly to music had decreased levels of depression while listening to music for people with advanced dementia was associated with cognitive benefits. In particular personalised music lists which tap into music favourites in long term memory in people with dementia have been found to reduce agitation, anxiety (Sung, Chang & Abbey, 2006) and aggression (Ragneskog, Asplund, Kihlgren & Norberg, 2001. Listening to personalised music can also enhance verbal communication, stimulate recall and can elicit memories associated with positive feelings (Sung & Chang, 2005). These musical favourites act as a mechanism to connect the person again to the present enabling them to converse, interact and socialize. The work undertaken to date with end users-people with dementia and carers in the project (WP1 WP3) revealed that people with dementia would like Mario to provide easy access to their own music whenever they wished and in this way help people with dementia retain autonomy and help meet their social needs in combatting loneliness and isolation.

Finally, there is substantial evidence to suggest that physical activity can improve the QoL for people with dementia. Physical activity has been found to reduce the symptoms of depression (Williams & Tappen 2008) and cognitive decline (Yerokhin et al 2012). It has also been linked to the promotion of more restful sleep in older adults. A number of systematic reviews including Potter et al. (2011) have examined the effects of physical activity programmes on people with dementia. These studies conclude that different types and intensity of exercises are possible for people with dementia. Furthermore higher resilience and regular exercise are correlated with lower depression levels (Lopez et al. 2014). MARIO by providing PWD with the opportunity to engage in physical activity not only has the potential to improve their sense of wellbeing but may also facilitate social connectedness as it gives PWD the opportunity to talk about and share this experience with others, for example with family members and carers. Interviews with people with dementia and caregivers identified a desire for Mario to help them to exercise by reminding and prompting them to exercise and by showing them safe and easy exercises which they can safely undertake either in their own homes with their carer or even in a group context within a nursing home environment. Again these will be configured to the capability and cognitive ability of the PWD.

2.3 Why a companion robot?

Although many older people did not grow up surrounded by technology like we are today, the evidence from the literature is that companion robots are popular with older people. This is supported in the interview data with older people with dementia and key stakeholders in this project to date, in that most were optimistic as to the benefits of technology and in particular having a robot companion if it meant they would be less lonely and have more autonomy and independence.

With the advances in technology it could reasonably be asked, couldn't an iPad offer similar applications to that proposed in MARIO, why is the companion robot Mario needed? In short, yes an iPad and other smart phone technology could offer some of these applications but would be too complex for older people with dementia to access and use. In addition, an iPad is disembodied. Therefore, if it speaks there is no physical or recognisable source of the voice the PWD can identify with. On the other hand, Mario although cartoon like, will embody the voice and make it more acceptable. In the context of older people with dementia a more sophisticated yet easy to use technology that takes into account the cognitive abilities of PWD is required, technology that can verbally prompt the user unaided from close by, making it more likely that that the person will hear what is being said; that can navigate its way and approach and move up close to the user when needed, can talk to the person or depending on ability of the person support them to use the touchscreen interface to communicate; has the capacity to really get to, knows the users preferences, facilitate and support user choice and one to one and even three way conversations involving caregivers/family members. Technology with an easy-to-use interface so a carer, or family member who knows the user well can personalise it to the PWD's individual needs and preferences, setting the user's preferred music, games, hobbies and interests The Mario companion robot designed above all to provide companionship and offer cognitive support to users can do all of this as it seeks to help PWD stay socially connected.

The three pilot sites have PWD at various stages. Stockport (UK) and IRCCS (Italy) are more likely to have participants with mild to moderate dementia. While participants in the Irish pilot sites are more likely to have severe dementia. It must be acknowledged that depending on the stage of dementia and their capabilities there is always a risk that some PWD may have less capacity to engage with Mario. The development of Mario and the end use applications will therefore require an iterative process of testing and revision so they are tailored to best meet the requirements of PWD and carers in each site. The initial testing of the applications in the Irish pilot site has already provided important information as to the design of the interface its acceptability and usability for PWD (refer to Appendix A for reports). In addition, it was very evident that the PWD did not have the capacity to engage with the applications for longer than 15 minutes. On-going and future work therefore will involve improving and modifying the user interface based on end user feedback, and helping PWD to become familiar with the technology, in addition initial testing and development may in some contexts require more input from researchers and carers to guide the PWD.

In summary, people with dementia as their condition progresses frequently loose the capacity to do many of the activities of daily living even for example select their own entertainment or music preferences, or indeed physically switch on a radio or music device, they therefore loose autonomy and independence and become disconnected from society. This provokes people

with dementia to withdraw further from social engagement leading to loneliness and isolation. In addition their engagement in physical activity and exercises decline and they tend to become more sedentary and remain indoors. All of which has a negative impact on their quality of life. Enabling technologies with innovative easy to use interfaces are therefore required to prompt and assist people with dementia to support their failing abilities so they can continue to have access to their personalised recorded music, hobbies and interests and retain a sense of autonomy and independence whilst also remaining connected to the present. The intention underpinning the 4-Connect My Hobbies module is to provide meaningful individualised activities for people with dementia, which supports their independence and autonomy, builds their resilience, reduces their loneliness and isolation and overall improve their quality of life and wellbeing, whilst simultaneously taking into account their complex cognitive needs and abilities. MARIO seeks to achieve this by providing and testing these applications with people with dementia not in the lab but in the real world of clinical practice. In the next sections, the application design and development is discussed (Section 3), together with the selected apps (Sections 4-7) which constitute the 4-Connect My Hobbies module -Music Playing, News Updates, Play a Game, and Physical Activity- will be described.

3. Application Design and Development

3.1 Development process

Achieving the overall goal of increasing quality of life of older people with dementia through robot-based applications requires an *incremental* and *iterative* design and development approach. The design strategy for the My Hobbies module applications aim at gradually adapting, extending and improving the available features and capabilities on the basis of a continuous assessment process driven by trial results.

The initial application design aims at supporting a *user-initiated* interaction pattern, in line with the basic principles of empowering the person with dementia and supporting his/her autonomy and ability to operate simple or more slightly complex processes with the robot. As user acceptability represents both a critical success factor and a major obstacle, the early stages of the design focus on the provision of basic functionalities and target fundamental usability issues in both verbal and non-verbal interaction modalities. The primary design objective is thus to devise and provide multimodal applications able to fulfil user needs, regardless of his/her acquaintance with technology and ability to retain procedural memory on the operation of applications, in particular after a period of non-use.

The iterative development circles will build on feedback gathered from pilot trials in order to include more functionality, provide more personalisation features, exploit knowledge of preferences and behaviours observed by the robot, etc. This way, every pilot trial of the applications will make them gradually smarter and friendlier for the end-user, ensuring that acceptability issues are not violated. In this respect, the robot will become smarter after each iteration, providing gradually more pleasurable and enjoyable experiences.

3.2 Design for a robot

3.2.1 Exploit physical presence of robot

Since the beginning, the provision of basic functionalities is enriched with the added-value coming from the capabilities of the robotic platform hosting the application. Sensorimotor capabilities are considered as a viable solution for further improving the user experience. This includes the ability of Mario to orient itself towards the user, as well as the ability to dynamically adjust its position and distance with respect to the user. The applications can in turn exploit the perceived distance from the user to adjust for example the sound volume at a comfortable level, going beyond a static volume configuration.

3.2.2 Multimodal interaction and speech recognition

Since interaction with Mario will be multimodal combining vocal and touch interface commands form the users, it is evident that the robot's capability of understanding natural language is expected to be one of the major barriers to the acceptance of the application, potentially leading to frustration and disengagement. The initial approach for mitigating these risks aims at narrowing the scope of the speech-based interaction. To this end, the application is designed to

actively drive and guide the user through interaction steps with specific limited set of options so that the recognition task reduces to the interpretation of a set of standard pre-defined answers.

Additional issues are related to Mario's ability to undertake speech-base interaction while also producing sound. Especially in the case of playing music or speaking text, it is expected that speech recognition capabilities will be affected by the presence of sound even if it produced by the robot itself. The problem of speech recognition with music or speech background interference relates to the challenging task of multiple speakers separation. Assuming the user cannot vocally interact with Mario when it is reproducing sounds represents an acceptable initial assumption. However, this simplification is gradually removed, taking advantage of the exact knowledge about the characteristics of the sounds being reproduced by the robot itself.

3.2.3 Personalisation

Mario is to be presented to users as a companion robot that will gradually learn about their life, habits, etc., in order to adjust its behaviour. This personalisation aspect is a common aspect of all applications developed and can be pursued with two complementary approaches.

On the one side, observations and data collected during the initial trials help building applications usage records to be then exploited to identify recurrent usage patterns. The goal is to relate application events with spatio-temporal contextual information. For example, user selections of a specific music genre or topics of news in the MyNews app can be associated with information about the part(s) of a day and places in the environment. This may lead, for example, to gather knowledge about user's preferences in using the apps when he is locate at a specific room of their house or at a specific time of the day. The underlying robotic platform and Mario's ability to localise itself and the user, and relate time relying on a semantic environment models and external event providers (e.g. weather conditions, public calendars, etc.) can provide added value to the capabilities of the applications.

Complementary to this, fully individualised application will be able to making available specific content or information based on personal relevance and personally meaningful events, persons, places, etc. This way the personalisation of applications can stimulate recall and elicit memories by playing music, videos, games, reading news, etc. This ability will rely on the ability to establish a relationship between application specific object instances such as music genres, artists, headline topics, games etc., with events (e.g., familial events, professional events), people (e.g., friends, relatives) and life periods (e.g., childhood, youth) in patient's life. Mario's knowledge base is therefore designed to provide a reference model for "tagging" multimedia content, life events and personal memories (considered as a particular kind of life event) and establish relationship among them. The setup of this semantically enriched set of metadata for different kinds of content and application objects requires an initial effort with the involvement of patient's relatives and close friends, but has a great potential for improving both user experience and application capabilities to meet user needs, stimulate reminiscence and produce positive emotional responses. Semantic metadata can be exploited by applications to offer personalised selections (e.g., offering on Sundays to listen to football team songs and chants that relate to user experience in attending matches at the stadium) and improve the understanding of user requests that mention people or life events (e.g., the user asking to read news related to his birthplace).

3.2.4 Robot-initiated engagement with the user

The personalisation aspects described contributes also to the design approach for the definition of *robot-initiated* engagement strategies to contrast apathy and lack of initiative. Being a social robot, Mario's abilities need to evolve to include the capability of actively prompting and engaging the user in using specific applications. Major challenges consist in the ability to autonomously identify socially and contextually appropriate moments for proposing the appropriate application. This goes beyond the application design and involves the overall robotic framework and Mario's behavioural control capabilities. Usage patterns acquired through user-initiated interactions and integrated in Mario's background knowledge represent a valuable input to devise personalised suggestions. For example, Mario's ability to detect user presence in the living room on a Sunday afternoon can lead the robot to suggest reading news about today's football matches. Similarly, semantic metadata can be exploited as outlined before to provide targeted suggestions related to significant people or life events, rather than based on usage patterns. The capabilities of the robotic platform, in particular ability to successfully locate and approach the user, are once again key enablers for leading the user to activate each application as a result of a robot-initiated interaction.

Additional contextual conditions and environmental constraints are to be considered as well in the design process, as part of Mario's ability to conform to social rules both in user-initiated and robot-initiated interactions. As an example, the tendency of people with dementia to forget the current time and get lost in a familiar environment may lead the user to interact with the application for playing games at 2 A.M. in a nursing home. Mario's behavioural control capabilities are designed to support the definition of contextual conditions and situations that inhibit unwanted scenarios (e.g., playing games is not allowed from 11 P.M. to 8 A.M.). Rather than simply disabling specific features with no explanation, the ability to orient the user in time and space serves as a basis to motivate robot's behaviour, reducing the risk of generating frustration and disappointment in the user.

3.3 Design for dementia

In designing an application for people with dementia we have to take into account two important aspects: Accessibility and Acceptability.

3.3.1 Accessibility

For the accessibility of applications in terms of the physical and cognitive capabilities of the users we opted to use Web Content Accessibility Guidelines (WCAG) 2.0[2] as the main guidelines for accessibility issues, since applications design was based on the web as a platform. However, additional recent research in the field of graphical user interface (GUI) design for people with dementia was also taken into account. To further ensure accessibility, we also designed early dummy prototypes of the applications and tested them with actual end users in Wizard of Oz style user-tests in order to get early feedback on the design off applications. These user tests involved people with dementia working on the prototypes of applications in laptops where the researcher was simulating the behaviour of the robot

[2] https://www.w3.org/TR/WCAG20/

responding to vocal and touch commands of the users. Results from these tests were included in the design of the applications and the general interaction rules.

In general most of the applications are employ a dialogue based interface where the user is asked to answer specific questions in order to achieve a goal such as listening to music. This means that usually the robot is asking vocally from the user to answer questions by presenting them on the screen the set of available answer options. This particular design approach allows us to prompt the user in terms of the available options which enables us to limit the available vocal expected commands to specific keywords so that the speech recognition system increases is it accuracy. Moreover, this dialogue based design ensures that people with dementia will be able to use the application over and over again eliminating the need to remember how to use the specific application.

In designing such dialogue based applications for people with dementia there are two different main challenges. The first one has to do with the design of the GUI in a way that can be easily understood and used by people with dementia. To ensure that, large fonts are used for displaying both questions and different options to the user and accompanies them in most of the cases with respective icons to communicate them better. Different colours are also used in order to highlight additional functionality in terms of buttons in the user interface. Finally, movement is also employed in composing each screen and provides a sense of flow in the dialogue that makes it feel more natural and enjoyable experience for the user.

The second major challenge in the design of dialogues based applications is the synchronization of audio and visual cues. In order to make this possible the GUI is also responsible for controlling the text to speech component by using the web speech API provided in Chrome browser. Through this way, events in the graphical user interface can be synchronized with vocal and audio signals while also vocal and audio signals can trigger specific changes in the graphical user interface. One of the most prominent examples of this synchronization is the use of the microphone icon to indicate the status of the speech recognition component. In the initial phases of the applications in order to avoid confusion of the speech recognition component when listening to the text to speech component speaking we disable the speech recognition while the text to speech is speaking. A big microphone icon on the top right corner of all the screens indicates the status of the speech recognition by turning red and green respectively. This way the user can understand easily that when the robot speaks they cannot vocally give commands to it. Moreover, after a period of inactivity at a specific state the user is notified of this particular aspect and is given instructions on not speaking in parallel with the robot. This way the robot teaches the users how to use it and also makes sure that they are reminded of such aspects whenever needed.

3.3.2 Acceptability

In terms of ensuring acceptability of applications there were two main strategies that were followed:

1. The first one was stripping down the functionality of applications to the bare minimum functions in order to simplify applications and not confuse users. Through this way, users will be able to use the applications, since they employed only the minimum functionality

in the first trials. Feedback gathered by these trials will guide the development of next features so that we avoid development of unnecessary and confusing features for users.

2. The second main problem in terms of acceptability has to do with the ability of users to use and reuse the applications without needing to have prior knowledge of how to use it. In order to answer this challenge the applications using a dialogue based interaction model which is very close to natural interaction with people. The interaction usually starts by selecting to use an application and gradually specifies additional parameters, if needed, in order to reach the final goal. Moreover in order to further simplify the interaction we also try to provide shortcuts to losing the final goal. In the MyNews application (further discussed in Section 5), for example the user can select a specific topic to read the headlines for it or he can just select to read the news in general. This means that the user can reach the final destination of reading news in just one step by selecting to read news in general. This is a very important feature that allows applications to accommodate the needs of people with more severe cases of dementia while also does not limit people with milder dementia to select specific topics and follow the more complex path of interaction. In any case, the first iteration of the development tried to create interaction flows that include as few as possible interaction steps to simplify interaction for the users and increase their confidence and using the robot.

4. Music Playing App

4.1 Requirements, Vision and Objectives

4.1.1 The Purpose

The purpose of the music app is to enhance the quality of life of people with dementia by giving them the capacity to select the music of their choice and the control to do this without the help of others, thereby reducing their dependence on health care professionals and family members.

4.1.2 Why this app is important

People with dementia often find it difficult to operate technology, they also forget if they have engaged in an activity or not and therefore the music app is designed as a voice activated, easy to use system that responds to the requests of the person and prompts them to engage in the activity if they have not done so within specified timeframes. The MyMusic app will enable the person with dementia to choose when they listen to music, what music they listen to and stop the music when they wish to. This capacity restores an element of autonomy to the person with dementia. This provision of music by Mario will entertain and engage people whilst also potentially reducing perceptions of loneliness and anxiety, a common problem for people with dementia (Gerdner 2000, Sung & Chan 2005, Raglio et al. 2008, Vink et al. 2011, Blackburn et al. 2014). This will differ from other music players in the market as it will take into account the simplified input required for Mario to be able to interact with the user. In addition, Mario will bring added value with such an app, for example it can adjust its position to stay at an adequate distance from the patient so the quality of the interaction is good and the volume is at a respectable level and it engages the patient by asking whether she/he would like to listen to some music, etc.

4.1.3 What the MyMusic app will do

This app will allow people with dementia to select from different music options, for example, classical music, folk, jazz or traditional Irish music depending on their preference. The person with dementia will be able to ask Mario to ‘play me some music’ and Mario will offer them a choice of music to listen to, once selected MARIO will then play the requested music. The person with dementia will be able to ask MARIO to stop playing that particular piece of music and then make another selection if they wish. Also, Mario will be able to ask the person with dementia if they would like to listen to music, prompting the person to undertake this activity. The MyMusic app therefore is designed to be responsive to the person with dementia taking into account their capabilities and preferences. An assessment of the person’s music preferences will be undertaken by the researchers and overtime the music selections will be individualised to that person. The design will enable interaction through voice and/or touchscreen. These aspects of the design enable the person with dementia to use the system regardless of their capacity to utilise the touchscreen. The voice capabilities of Mario are important because they will enable the person to interact verbally thereby making the system useful to a wide range of people with dementia. The interface has been designed so that it is simple to use, with prompts to support the person, the system is voice activated, if required. Mario is interactive and will therefore check with the user their listening preferences and volume acceptability. In addition MARIO will have the capability to engage the user by asking them if they liked the music and will note their responses which may be used later to determine other selections.

4.1.4 Anticipated Development

In the initial phases of trials the aim is to test the extent to which Mario can interact, communicate and understand the person with dementia and respond appropriately to requests to play music from a list of musical genres appropriate to the age group of the person with dementia. The intention at the validation stage of the study is that Mario will offer the person choice of music based on their individualised music preferences, play the preferred music of the respective person with dementia, respond to verbal requests for same and by building up a pattern of activity monitoring over time, will be able to identify the times the person prefers to listen to music and use this information to prompt the person to consider listening to their music if they have not done so.

4.1.5 Measuring Effectiveness

The effectiveness of the MyMusic app will be judged in three ways. The first is that a qualitative evaluation will be undertaken, asking the user how they found the MyMusic application. The second is that the usage of this application will be monitored, so that we will count the number of times the person with dementia requests music and how long the music was played for. The third is by reviewing any change in rating on the following scales. Quality of Life in Alzheimer's Disease (QOL-AD), cornell depression scale and observational measurement of engagement scale. While the impact of music cannot be identified specifically and datasets will be small, inferences may be drawn from the ratings on these scales about overall impact of this application. In addition, we will be able to measure whether people living with dementia engage with this application and how they engage with it, such as the usage patterns.

4.2 Application Design

4.2.1 General technical infrastructure

The MyMusic App is designed to enable the PWD to get entertained by listening to his/her favourite music. The overall application structure is outlined in Figure 1.

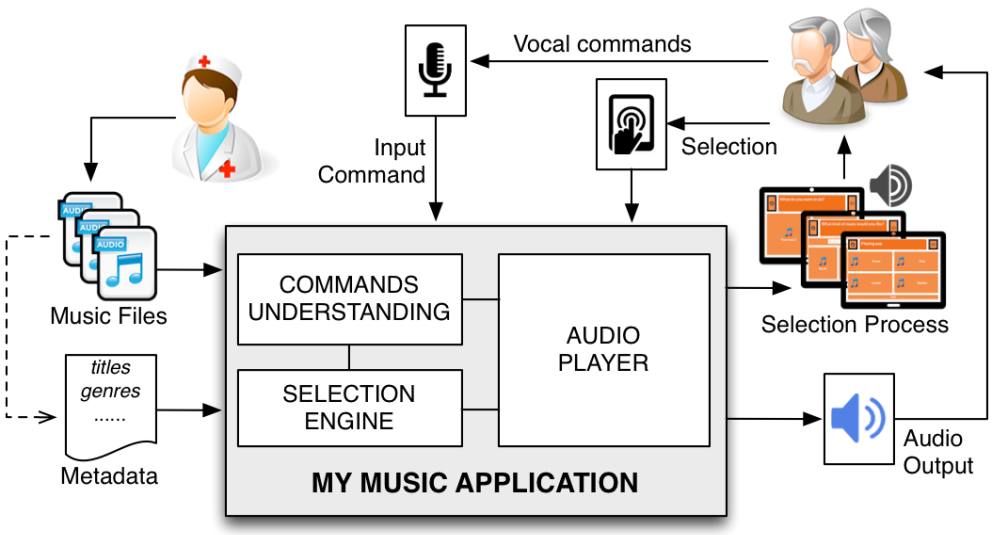

Figure 1: MyMusic App – Overall Application Structure

In line with the general requirement of providing a personalised user experience, the set of available music tracks can be configured on a per-person basis. Music tracks and related tags or metadata (such as song titles, genres, artists, playlist grouping) are thus preloaded on the robot and made available to the application during an initial configuration stage performed by the caregivers (or person with dementia's relatives/friends), involving the person with dementia in the selection process.

As already presented in the requirements, the app will be triggered as a result of direct request issued by the person with dementia, either through the GUI available on the touchscreen or via vocal commands, exploiting the multimodal interaction capabilities provided by Mario. In addition Mario could trigger the app as a suggestion to the user if specific predefined conditions are met. The user is directed through a simplified process to select and start listening to music.

The application logic in charge of guiding the person with dementia through the music selection process is designed to accommodate different needs and capabilities. The person with dementia is offered the possibility of selecting his/her favourite music genre among the available options, gradually presented to avoid/reduce the cognitive load of the selection task. By exploiting the preconfigured metadata, the application is able to dynamically build a playlist with selected tracks matching the persons' selection. Cognitive load can be further reduced by allowing the person to skip the selection process. In this case, the playlist to be played is directly generated by the application. A random selection approach will gradually evolve to take into account the person with dementia's preferences acquired over time. The strategy behind this evolution will combine the person's rating of tracks, marking of favourite tracks and behaviour observation by logging down when people for example skip tracks. Moreover, by including in the process semantic analysis of the metadata information behind the different preferred on disliked tracks, Mario could in the future identify and present new music to the user.

4.2.2 User Interaction design

The user interaction design of the MyMusic app is obviously a significant part for differentiating it from existing apps in the market. The difference with traditional music players available in the market is that they usually require from users a quite complex process for people with dementia in order to start playing music. In most cases, users will have to navigate either in a file system of the device or within lists of tracks assorted by albums, artists, genres and different other categorisations in order to select a set of track and start playing them. Most of the end users with dementia will not be able to handle the complexity of such a process which needs them to be able to understand the different available options, find and use the appropriate functionality (change volume, navigate in tracks, compile playlists) from the music players interface, etc.

That is exactly why in the application design of the MyMusic app we followed an approach of simplifying all this functionality and eliminating it to the bare minimum. In its most simple use case the user just selects to listen to music and Mario compiles a random playlist to start playing. This simplistic approach of "I just want to listen to some music" is trying to address the needs of people with severe cases of dementia who might not have the capacity to go through a music selection process. And this is also why the specific option is presented first and slightly more highlighted than the select music option. For more capable users the select music process in the first implementation of the app allows the user to select between different genres of

music. Options in this case are also limited to usually less than four and will gradually evolve based on users' preferences.

The following steps are describing how the interaction is designed in its first most simplistic implementation that will gradually evolve as Mario learns more about the user and as the user learns more on how to use Mario.

Step 1: Mario asks the user if he/she wants to directly listen to some music or select the music s/he wants to listen displaying also an accompanying screen with the 2 options.

Step 2: If the user selects to listen to music Mario starts playing music by compiling a random playlist from the music uploaded to Mario. Next step is 5.

Step 3: If the user selects to select music s/he is presented with a number of different genres to select music from. Options are read aloud from the robot through Text-to-speech (TTS) and also presented in an accompanying screen.

Step 4: When the user selects the genre to listen a random playlist with respective tracks from the uploaded ones is compiled and starts to play. The playing music screen includes 6 essential buttons for pausing and stopping the music, volume control (up and down), skipping and moving back to a track in the list.

Step 5: If the playlist ends or the user selects to stop listening the app terminates.

4.2.3 Designing for a robot app

As already presented in chapter 2, observations and data collected during the initial trials will help building personalisation features. The goal is to relate music listening activities with spatio-temporal contextual information. User selections of a specific music genre can be associated with information about the part(s) of a day and places in the environment. This may lead, for example, to gather knowledge about user's preference to listen to classical music late in the afternoon in the living room.

Further personalisation will aim to make available music items of personal relevance to each user, going beyond the simple provision of "favourite" music. Mario's knowledge base will be able to a reference model for "tagging" multimedia content, life events and personal memories (considered as a particular kind of life event) and establish relationship among them. The setup of this semantically enriched set of metadata for music content requires an initial effort with the involvement of patient's relatives and close friends, but has a great potential for improving both user experience and application capabilities to meet user needs, stimulate reminiscence and produce positive emotional responses.

In terms of *robot-initiated* engagement strategies, Mario can exploit usage patterns acquired through user-initiated interactions and integrated in Mario's background knowledge to devise personalised suggestions. It could for example detect the user's presence in the living room in the afternoon and suggest listening to some classical music. Similarly, semantic metadata can be exploited as outlined before to provide targeted suggestions related to significant people or life events, rather than based on usage patterns.

4.3 Privacy and Security Aspects

The Music App does not introduce specific privacy and security concerns. Music tracks and related metadata are preloaded and stored on the robot, in compliance with copyright and licensing schemes, and without any communication with external services or third parties. The app does not require nor collect any personally identifiable information that goes beyond basic user preferences and listening activity history, which allows analysing the app usage and enhancing the user experience. Collected information is not shared with nor distributed to external services or third parties outside of the MARIO software framework.

5. News Update App

5.1 Requirements, Vision and Objectives

5.1.1 The Purpose

The purpose of the MyNews update application is to enable the person with dementia to stay connected to what is going on in the world; in their local community and with the sporting activities that they have an interest in.

5.1.2 Why this app is important

While watching television, listening to news, or selecting programmes of interest may seem relatively simple to do, for people with dementia it can be challenging. As dementia progresses people often have problems with using remote controls of the television, changing channels, finding what they wish to watch, reading newspapers or remembering that something is scheduled or the time that it is scheduled for. These issues were confirmed as problems in the interviews undertaken to date in the project and identified as areas where help was required, impacts negatively on the progress of dementia. Staying connected is therefore really important. Currently, news apps are fairly complicated to set up and tend to be hard to use. What often happens when a person with dementia is confronted with the technology problems above is that they give up trying and they then slowly disengage with what is happening in their communities and they start to communicate less. The challenge however is to how keep the person with dementia engaged, to stimulate them to think about what is happening in the world and local communities. For the person with dementia, not only does that contribute to quality of life, but keeping mentally active is important in slowing down the rate of cognitive decline in dementia (Clare and Woods, 2004). Being connected is an essential part of living well with dementia and a lack of connectedness compounds loneliness.

Prior to Mario arriving therefore, an assessment of the person with dementia interests will be undertaken to identify the news and local events that they have an interest in. This information will enable the application to be individualised and the information be used to select appropriate news and update items.

5.1.3 What the MyNews app will do

Mario will give the person a choice over what they listen to or watch based on their individualised choices. The MyNews application will prompt the person that an event is scheduled and ask them if they wish to watch it. Mario will ask the PWD if they wish to hear headlines or news items and the voice activated and simple user interface with enable the person with dementia to make choices without the need to engage with remote controls or more complex technology. The person with dementia will be able to ask Mario to play the news and or they can select the news icon when Mario asks the person what they would like to do. If the person usually liked to watch the news at a certain time of the day, that information will be used so that Mario is scheduled to ask the person with dementia if they would like to listen/see the news at that time. They will be able to answer, yes, no, or later and Mario will select the news for them if wanted without the person with dementia having to manipulate technology. The person with dementia will be able to ask Mario to stop, pause or repeat that item again. The local events that the person wishes to be kept updated about will be selected by the person with

dementia and Mario will offer information about these events. For example, if the person with dementia has an interest in rugby, they can select the team they wish to follow and matches they like to watch. Mario will then prompt that person that their team are playing, and if on television, ask if they would they like to watch the game. This prompting not only enables the person with dementia to remember to watch the game but it also gives choice and control to the person with dementia. If the game is not on television, Mario will provide information about how the team performed. Mario will relay information from selected news feeds, papers, Facebook pages and Twitter. The MyNews app will also be able to select and read headlines for the person.

The pilot sites in Galway and Stockport will also identify local news feeds as a source of information. For example, in Stockport newsfeed could be linked to a mixture of national news, such as the RSS feed from the BBC News[3] as well as a similar feed from the Greater Manchester area (BBC News)[4] to give a local feel and help people feel more included, as well as from the Manchester Evening News - Stockport[5] feed which gives a very local set of information and sports updates.

5.1.4 Anticipated Development

In the initial phases of trials the aim is to test the extent to which Mario can interact with the person with dementia, select appropriate news and update items, understand the person with dementia and respond appropriately to requests for news or events information. The intention at the validation stage of the study is that Mario will select news and event items based on their individualised preferences, read or play these to the person with dementia, respond to verbal requests for news and events and by building up a pattern of activity monitoring over time, will be able to identify the times the person prefers to listen to music and use this information to prompt the person to consider listening to their music if they have not done so. For the Galway area, local news is available from the Galway Advertiser[6], whereas Irish national news is available from RTÉ[7].

5.1.5 Measuring Effectiveness

The effectiveness of the MyNews app will be judged in three ways. The first is that a qualitative evaluation will be undertaken, asking the user how they found the MyNews application. The second is that the usage of this application will be monitored, so that we will count the number of times the person with dementia requests news to be read or event and how long they engaged in these activities. If the app is not interesting then people will not use it, similarly if it not easy to use. The third is by reviewing any change in rating on the following scales. (QOL-AD), cornell depression scale and observational measurement of engagement scale. While the impact news and updating cannot be identified specifically and datasets will be small, inferences may be drawn from the ratings on these scales about overall impact of this application.

[3] http://feeds.bbci.co.uk/news/rss.xml?edition=uk
[4] http://feeds.bbci.co.uk/news/england/manchester/rss.xml
[5] http://www.manchestereveningnews.co.uk/all-about/stockport
[6] http://www.advertiser.ie/galway
[7] http://www.rte.ie/news/

5.2 Application Design

5.2.1 General technical infrastructure

The MyNews app also follows in its design he requirement for a personalised news reading application with its general architecture presented in Figure 2. Similar to the music apps, caregivers (or person with dementia's relatives/friends) will be configuring the app for each user by including an initial set of topics of interest for each user. After being configured with a set of topics the application retrieves RSS feeds using the *feedly API*[8] which provides a JSON reply of crawled RSS URLs which contain RSS news feeds relevant to the keyword query. The search if further parameterised by *locale,* and thus the news are targeting RSS news which are specific to a country/region or language. The app parses all RSS news acquired by the *feedly API* response, and extracts the *title, content, author, uri,* and *timestamp* of each news feed (albeit not all fields may be set). Once the news feeds are acquired, they are stored in a database, local to the Mario Kompaï robot, and indexed by a unique id. This way Mario is able to have a set of topics of interest to present to the user so that it narrows down the scope of the selected headlines to read.

As already presented in the Requirements, Vision and Objectives section, the application will be available for the user to select through vocal or touch interface while on the other hand it could also be triggered by Mario, based on personalised schedules and specific conditions met. After launching the application, the user is using both vocal and touch interface commands to control the flow and start reading news headlines.

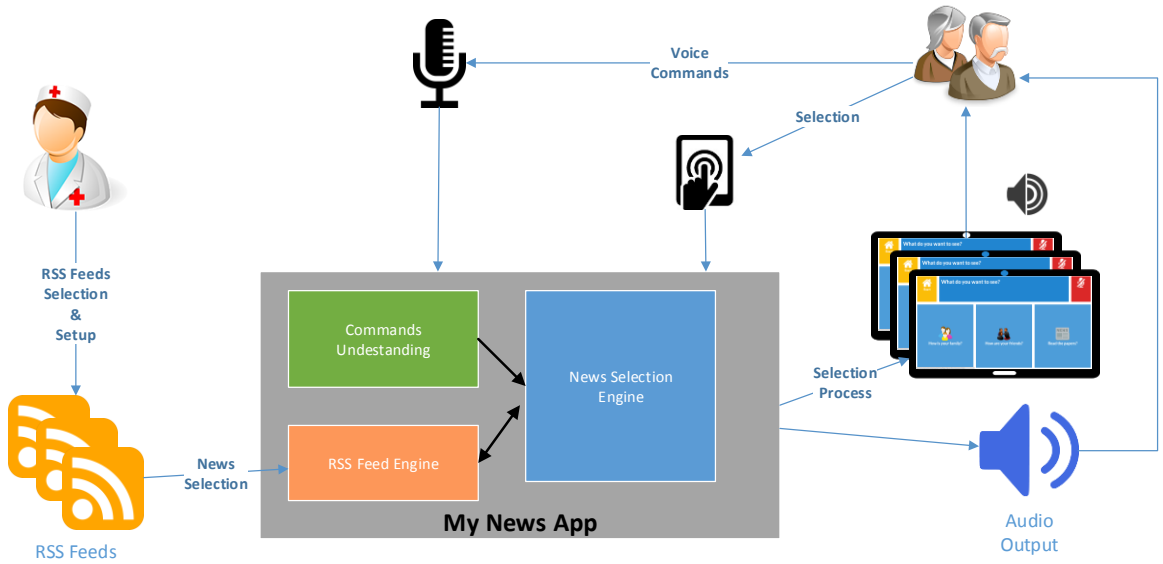

Figure 2: MyNews App – General Architecture

Once again similar to the MyMusic app, the NyNews apps allows the user to either directly start reading news headlines by compiling a list of related news based on the topics of interest and the news sources provided in the configuration. In parallel users who are more capable and

[8] https://developer.feedly.com

select to go through the news selection process will be presented with a small set of topics. The set of topics will gradually be adapted based on contextual information such as related events (e.g. European Football championships calendar, time of the day, etc.). In the initial implementations only a small set of topics will be available through configurations to the user.

5.2.2 User Interaction design

As already mentioned in the requirements section, the news reading app is actually an RSS aggregator application similar to many others that are currently available in the market. However, the challenges faced by end users when interacting with such an app in another device might be overwhelming and frustrating for persons with dementia. The process of finding, adding, and reading / filtering out news items based on someone's interest involves processes that require high cognitive effort from the user in order to remember the different functionalities available and how to use them. Moreover, issues like small letters, font contrast, big lists of headlines with infinite scrolling, too many headlines presented at the same time in a newspaper like fashion, navigation between articles etc., pose significant challenges in the interaction of people with dementia.

For all the above reasons, the design of the MyNews app in its initial implementation follows a simplistic approach aiming to help people achieve their goal in the simplest possible way. That is why specific choices are made in the implementation, such as allowing the user to directly read news headlines, presenting a limited set of topics as options, and presenting only a limited amount of news headlines at the same time so that they can easily be distinguished understood and digested easier by the user. Moreover, giving control to the user over the infinite scrolling mechanism and allowing the user to select if they want to read more headlines or exit provides an easy exit point whenever users are bored or fatigued. Finally, one of the biggest benefits of the multimodal interaction through vocal and touch interface allows the user to listen to new headlines being read aloud while also present them on screen in large font letters so that they are easily read on the screen as well.

The following steps are describing how the interaction is designed in its first most simplistic implementation that will gradually evolve as Mario learns more about the user and as the user learns more on how to use Mario.

Step 1: Mario asks (vocally) the user if he/she wants to read all available news or select a specific topic of interest accompanied by a respective screen.

Step 2: If the user selects to read all news Mario starts reading the first four headlines of the all available news headlines and waits for the user to either exit or continue on to the next page of news. If the user selects to continue to the next page the step repeats by reading the next four headlines until step 5.

Step 3: If the user selects to read news from a specific topic a list of topics is presented vocally to the user to select from accompanied by a respective screen.

Step 4: When the user selects a topic, Mario starts reading the first four headlines of the available news titles for that topic and waits for the user to either exit or continue on next page of news. If the user selects to continue to the next page the step repeats by reading the next four headlines until step 5.

Step 5: If the list of news finishes or the user selects to exit the app the app terminates. If the news list reaches to its end a respective message is presented to the user before exiting.

5.2.3 Designing for a robot app

The MyNews application aims at adapting and shaping over time the information made available to the user. In particular, user selections contribute to the acquisition of knowledge about user's preferences for specific topics (e.g., rugby), events (e.g., music festivals), people (e.g., the prime minister) or places (e.g., Stockport). Recorded usage patterns and user selections can be directly exploited to refine which news headings and information items are presented and how they are presented and made available. A personalised user experience is thus coupled with an increasingly simplified selection process. In addition, the semantic capabilities of the underlying software framework can provide an added value for the application compared to existing solutions. Machine reading and semantic parsing of dynamically collected news headings and textual information items allow locating and classifying named entities (e.g., persons, organisations, locations), while text classification techniques can be used to identify specific topics. This information can be matched with and related to the knowledge about the user (e.g., life events) available to the robot, with the potential of stimulating recall and eliciting memories. The application may, for example, prompt the user about available news on music festivals in the city where he/she spent his/her youth, going beyond the initial set of topics of interest statically defined for the user. Similarly, sentiment analysis performed over news items enables the application to rank them and identify and filter out information that can generate negative feelings and have a negative impact on users' mood.

The challenge of how to keep the person with dementia engaged, mentioned in Section 5.1, requires again robot-initiated engagement strategies that take advantage of the robotic platform's capabilities. Mario's ability to recognise user's posture, as well as to autonomously approach the user, enable the robot to actively prompt the user and stimulate his/her interest by proposing available news items. For example, the recognition of a sitting posture together with a recent lack of user interaction contributes to identify suitable situation for user engagement: detecting the user sitting in the living room in the morning could lead the robot to suggest accessing relevant news and events.

5.3 Privacy and Security Aspects

Minimal privacy and security concerns exist when using the *news and sports* app: data is stored locally, communication with the *feedly API* is encrypted via industry SSL/TLS standards, and no personal information is acquired, retained or distributed. All queries to the system are anonymous (version 0.1.0) and later in beta (version 0.2.0) will be identified by a simple User Identifier (UID), in order to index keywords of interest. No information, data or otherwise personal identifiers are distributed.

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6. Play a Game App

6.1 Requirements, Vision and Objectives

6.1.1 The Purpose

The purpose of the game application is to enable the person with dementia to select and play a game as an activity if they wish to.

6.1.2 Why this app is important

Boredom is a problem for people with dementia and many spend many hours alone doing little (Mohler et al. 2012). This was confirmed as an issue in interviews and games were identified as a way of ameliorating this. There is evidence, described above, that cognitive activity can slow the pace of the development of dementia. Games can be designed to encourage cognitive activity and stimulate brain function (Moniz-Cook & Manthorpe, 2009; Singh-Manoux & Kivimäki, 2010; Mahncke et al., 2006; Robinson et al., 2007), this application is therefore important to people with dementia. However, playing games is sometimes challenging for the person with dementia, there are two problems. The first is that they cannot operate the technology to enable them to play a game and the second is that they forget how to play the game. The person with dementia therefore can get frustrated when playing games because of these issues. This results in the person not engaging in these activities even if they have really enjoyed them in the past.

An assessment of prior interests in games will be undertaken and selection of games included will be based on individual preferences.

6.1.3 What the MyGames app will do

The MyGames app will allow the person with dementia to verbally request to play a game. The person with dementia will be able to start, stop or change the game using voice activated commands. They can then select the game they wish to play using voice activated commands/or touchscreen and will be given instructions by Mario on how to access the game and play the game using a simple touch screen. Mario will also be able to ask the person with dementia if they wish to play a game and provide a range of choices. Asking the person with dementia if they wish to play a game, what game they would like to play gives the person choice over what they do and allows the person with dementia to stay more in control. Mario will also be able to utilise the information about frequency of game playing at assessment and the person's game playing patterns. Using this information, Mario will ask the person id they would like to play a game if they have been inactive for a specified period of time and are awake.

The MyGames app will provide a voice and visual cues that will prompt the person before the game starts about how to play the game so that they do not need to rely solely on memory to play the game. If the person stops playing the game before it is finished, Mario will ask them if they wish to continue or if they would like to change the game. At the end of the game the person will be asked if they enjoyed the game and their response will be used to help make selections in the future. The MyGames app will following trial one, develop a two person preference that will allow the person with dementia to play games with another person, if they so wish, this could be a family member or staff member. Mario will therefore ask the person with

dementia if they are playing alone or with someone else. This function is designed to encourage the person with dementia to undertake enjoyable activities with others.

In Stockport it is envisaged that alongside the games within the MyLife Platform (which will be used in later app developments for the MARIO project) the games offered are easy to navigate and provide stimulus for both people living with dementia to engage with alone and also with their informal carer/partner.

6.1.4 Anticipated Development

In the initial phases of trials the aim is to test the extent to which Mario can interact with the person with dementia, select appropriate games, understand the person with dementia and respond appropriately to requests to play a game and play a game themselves. The intention at the validation stage of the study is that Mario will select game based on their individualised preferences, play a game with someone else, ask the person if they liked the game, respond to verbal requests to play games and by building up a pattern of activity monitoring over time, will be able to identify the times the person likes to play games and use this information to prompt the person to consider playing a game if they have not done so.

6.1.5 Measuring Effectiveness

The effectiveness of the MyGames app will be judged in three ways. The first is that a qualitative evaluation will be undertaken, asking the user how they found the MyGames application. The second is that the usage of this application will be monitored, so that we will count the number of times the person with dementia plays a game, what game they selected and how long they engaged in these activities. The third is by reviewing any change in rating on the following scales. (QOL-AD), cornell depression scale and observational measurement of engagement.

6.2 Application Design

6.2.1 General technical infrastructure

The Games application is a combination of a set of external third party games using flash technology and Mario's general UI structure which will guide users to select and play a specific game (as presented in the general architecture in Figure 3). This means that although the MyGames app has not developed individual games it is able to include and use external applications under the same user interaction principles. A set of specific games will be configured by the caregivers or family members of the person of dementia as options for the user. Moreover a short explanation of the each game and how it is played is also to be stored in the configuration of Mario and used appropriately. Although games used in the MyGames are web based they will be also stored locally so that we accommodate the need for playing a game even if there is no internet connection.

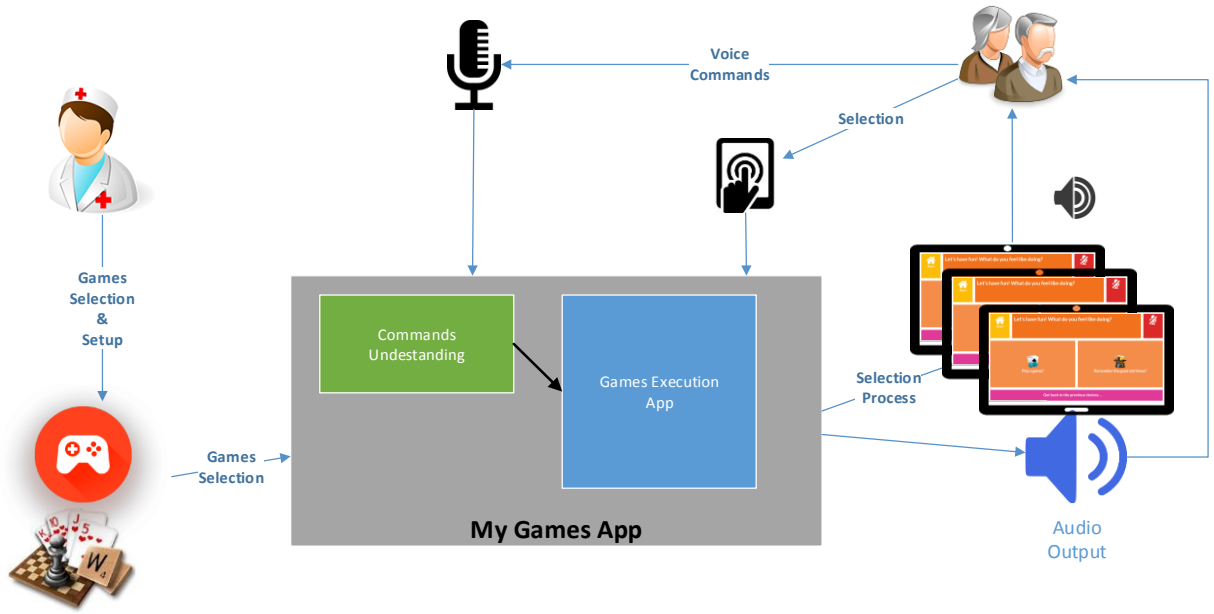

Figure 3: MyGames App – General Architecture

6.2.2 User Interaction design

It is hard to say that the games included in the MyGames app has stripped games functionality to bare minimum as described in the generic principles for the interaction design for people with dementia. However, the selection of available games is done based on already existing research that has proven the accessibility of them and also in many cases has proven their positive effects on people with dementia. Therefore, the selection of specific games to include ensures that games used in the MyGames app are appropriate for the specific users. In some cases games will be selected based on knowledge that users have already interacted and used the specific games prior to using them in Mario.

The interaction design of the wrapper around those games that allows the user to select a game, read the instructions and playing them is the one that differentiates the MyGames app from the current available process. Since most of the games are available through web, it would mean that for a person with dementia to use them they would have to be familiar with the concept of web and using a web browser. In many cases users not only do not have previous experience of using a browser but also ignore the concept of web and other needed ones such as the browser bookmarks, search engines, web addressed etc. Therefore, the application design followed eliminates the need from users to know or have the specific prior experience. When users enter the MyGames app they are presented directly with a list of specific games preconfigured by their caregivers or family members and from then on they can start plying the game. In order to also enable users to use the games even without having used them before, the app will also ask them if they want to read instructions. Therefore even if the user interacts for the first time with the game they will be able to understand how to play the game.

The following steps describe the interaction steps used in the first trial of the app and upon which more functionality will be build.

Step 1: when the application is launched, the list of available games will be displayed and prompt the user up so that the user can choose which games s/he wants to play.

Step 2: Once the user chooses a game, they will be asked if they want to read instructions of how to play the game or just play the game. If the user selects to play the game Mario skips to Step 4. Otherwise continues to step 3.

Step 3: If the user selects to read the instructions a page with instructions is presented and read aloud to the user and Mario wait for confirmation from the user to proceed with playing the game.

Step 4: The user start playing the game. An exit button below the game will allow the user to exit the game's app whenever they like.

Step 5: When the user selects to exit the app the app terminates.

6.2.3 Designing for a robot app

In line with the general approach for providing a personalised experience, collected information about frequency of game playing and the person's game playing patterns (as introduced in Section 6.1) serve as a basis for refining the knowledge about user's preferences. However, the inclusion of off-the-shelf games may limit the scope of the application in gathering useful data from user interactions. Nevertheless, game playing activities require a close and direct interaction between the user and the robot (as opposed, for example, to listening to music). Therefore, in addition to monitor user interaction with the touch screen, the ability to detect and track user's presence/position can be used to assess the level of engagement. For example, having the user move away from Mario while playing a game, may suggest disengagement from the activity. Rather than having the application run indefinitely (or closed after a fixed time), Mario could approach again the user and try to suggest a different game or even a different activity.

To fully exploit the capabilities of the robotic platform and differentiate from standard gaming applications, selected games that involve a physical component can be gradually included. Specific capabilities such as gesture recognition can simplify user interaction and combine mind-stimulating aspects with physical activities. Moreover, as for music content, specific games can be related to life events and personal memories by establishing semantic links in Mario's knowledge base. The application can exploit them to suggest, for example, playing a game that reminds one the person played as a child or with his/her children.

6.3 Privacy and Security Aspects

All games selected for use are normally displayed on a web site but the games will all be downloaded locally to the Mario robot. From a technical perspective, no data on these games will be stored. The privacy aspects relating to these games are available at the following links:

- http://www.flashgames.it/help/read.php?idgruppo=17&q=265
- http://www.memory-improvement-tips.com/disclaimer.html
- http://pfreegames.com/content/privacy
- http://www.kidsmathgamesonline.com/privacypolicy. html

7. Physical Activity App

7.1 Requirements, Vision and Objectives

7.1.1 The Purpose

The purpose of the activity app is to enhance the quality of life of people with dementia by giving them the capacity to select and engage with some physical activity, thereby reducing their dependence on health care professionals and family members but most importantly increasing their physical activities.

7.1.2 Why this app is important

According to the Alzheimers Society UK[9], leading a physically active lifestyle can have a significant impact on the wellbeing of people living with dementia. Engaging in exercise is beneficial for both physical/mental health and can lead to improvements seen in the quality of life for people living with dementia at all stages.

It is clear that the there are many positive impacts of both exercise and physical activity for people living with dementia such as in the following five areas:

1. Reducing the risk of high blood pressure/heart disease by improving the overall health of the heart and blood vessels;
2. Reducing the risk of some types of cancer, diabetes (type 2) and also impact on the risks of strokes as well as the risk of osteoporosis;
3. Improving physical fitness and enabling people to maintain their physical independence for a longer period by targeting both muscles, bones and joints;
4. Improving the ability of people living with dementia to undertake their own activities of daily living;
5. Improving cognition and sleep and reducing the risk of falls and also providing opportunities for social interaction and reducing the feeling of isolation.

7.1.3 What the MyActivity app will do

This app will allow people with dementia to select from a range of activities that may include activities based in the house, stood up or sat down engaged with the Mario robot. These will be exercises that concentrate on movement, activity and balance as well as with a variety of options, such as interacting with the robot whilst standing or sitting down. There will be the choice of different levels of complexity and effort to choose from as well as the option to progress from one level to another.

Alternatively, even outside with prompts and reminders for external opportunities where appropriate, such as walking, running, swimming or outdoor sports that will need input from the person living with dementia (such as calendar appointments) or via a formal or informal care giver.

[9] https://www.alzheimers.org.uk/

7.1.4 Anticipated Development

In the initial phases of trials the aim is to test the extent to which Mario can interact, communicate and understand the person with dementia and respond appropriately to interactions and prompts to undertake exercise. This can test whether the user can react to prompts and interact with Mario and can also involve undertaking certain activities upon request. Following this stage the trials will see how the user interacts and feels about prompts or whether they find them a nuisance or not helpful. This stage will initially concentrate on home based activities that involve standing up or sitting down and will include those currently based within the Kompaï platform.

In later phases more exercises can added as well as opportunities to progress through levels and under take more challenging exercise or outdoor activities can be incorporated.

7.1.5 Measuring Effectiveness

The effectiveness of the MyActivity app will be judged in the following stages. The first is that a qualitative evaluation will be undertaken, asking the user how they found the MyActivity application. The second is that the usage of this application will be monitored, so that we will count the number of times the person with dementia engages with the app and whether they undertake any activity. The third is by reviewing any change in rating on the following scales. (QOL-AD), cornell depression scale and observational measurement of engagement scale. Using these scales, it will be possible to measure the amount of exercise undertaken prior to Mario and during the tests and see if there has been any changes or impact on physical and mental health, movement and levels of activity.

7.2 Application Design

7.2.1 General technical infrastructure

The technical infrastructure of the MyActivity app (refer to Figure 4 for the general architecture), as in the MyGames app, is also based on external content. In particular a set of videos files with exercises will be configured for each individual user. When the user selects the application will be able to see the video and follow the exercises. The interface will also include controls for pausing the activity and continuing later. This will mean that physical exercises will be also available even when the robot is out of internet connection.

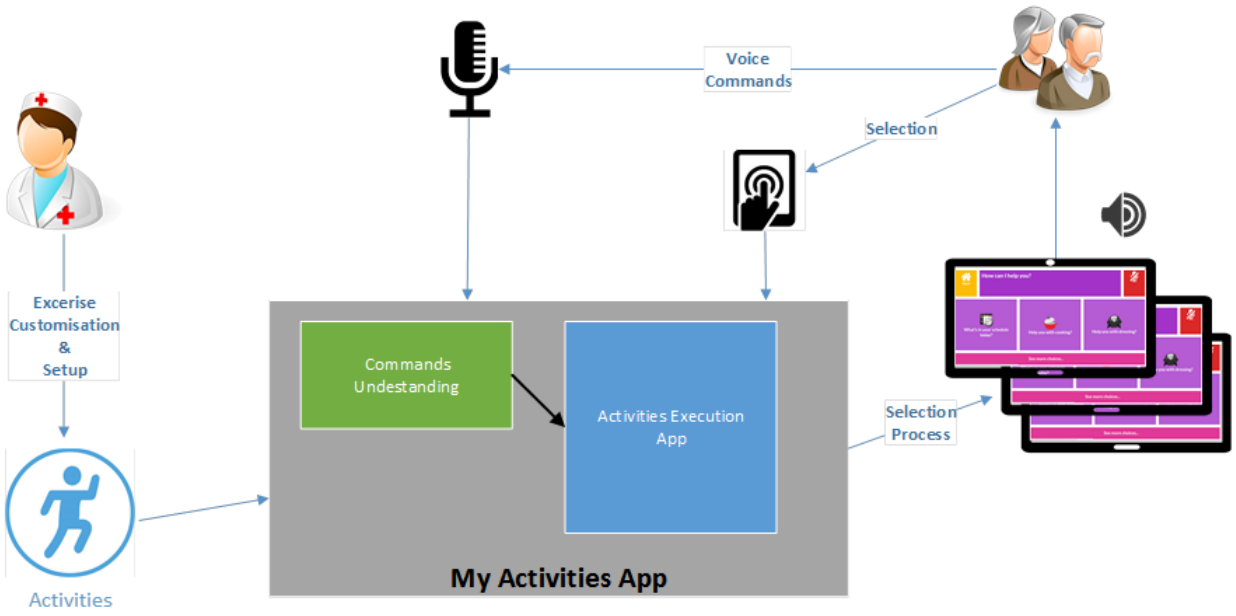

Figure 4: MyActivities App – General Architecture

7.2.2 User Interaction design

The MyActivity app, similar to the games app, is blending external content within the Mario's general user interaction. The process to select an exercise and trigger the video playing is also following the simplistic approach of stripping down functionality in the bare minimum of selecting a video.

Having said this, if a person with dementia would like to use such videos from any other platform he would face similar challenges with the ones of the music app where he should either have to search for the specific videos on the device or use a specific targeted app. However, traditional gym apps combine an extensive set of features for creating routines, schedules, keeping track of progress etc., which would overwhelm a person with dementia, if first encountered with them and possibly also confuse them. That is why the approach is to first introduce users to the applications by simply playing the exercise videos and gradually building more functionality into it. Such additional functionality would possibly include the smart creation of routines to execute specific exercises and keeping track of exercises in order to encourage users to engage and keep physically active.

The following steps describe the interaction steps of the application in its initial implementation:

Step 1: When the application is launched a list of available physical exercise will prompt up so that the user can choose which exercise he/her wants to do.

Step 2: Once the user choose a physical exercise, it will be launched autonomously and the user can do it.

Step 3: If the user selects to exit the app the app terminates.

7.2.3 Designing for a robot app

As for the case of the MyGame application, the inclusion of pre-recorded videos showing physical exercises may limit the application's ability to acquire useful data from user interactions. Personalisation and adaptation approaches should evolve in order to go beyond simply recording user selections. Mario should aim at encouraging physical activity and engaging the user in following his/her basic "fitness program" on a regular basis. In this direction, the sensorimotor capabilities of the robotic platform can provide a truly added value with respect to existing solutions. The ability to recognise user's posture can be exploited to propose different exercises targeting a standing or a sitting user. Movement tracking and gesture recognition capabilities can enable the application to detect user involvement in the proposed physical activity and respond accordingly by providing verbal encouragement. Similarly, gamification strategies based on a direct involvement of the robot can be introduced to increase user engagement. The application could transform the repetitive nature of physical exercises into a gesture-driven interaction that triggers basic robot motion behaviours. In response to user's gestures, the application can lead Mario to perform basic movements representing a concrete and observable feedback, such as slightly rotating or translating on the left when the user raises his/her left arm.

7.3 Privacy and Security Aspects

All physical exercises are normally displayed on a web site but in our case we download them locally to the Mario robot. From a technical perspective, no data from the physical exercises will be stored.

8. Conclusion

The applications that have been discussed in this deliverable – Music Playing, News Update, Playing a Game, and Physical Activity- do not fully reflect the full capabilities of the Mario Kompaï robot, but only a part of it i.e. the ones that are related to the 4-Connect My Hobbies Module. An iterative approach is being adopted by the project consortium, where the apps will be improved once we get feedback from the first trials at the pilot sites.

There is great benefit in having MARIO offering such apps to the people with dementia in a way that will help them reduce loneliness, practise their hobbies e.g., a particular online game, reminds them of past/present memories e.g., music they like, and keeps them up to date with the current events e.g., news updates. This shows that the Mario Kompaï service companion robot will not act as just a simple tablet that people are unwilling to use or can use whenever they like, but as a “friend” that can be relied on in times of need and during their day-to-day life. This will help people with dementia be more confident in interacting with the outside world and feel accepted by their relatives and friends, with Mario by their side.

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Appendix A

Tests on MARIO Applications carried out at St. Brendan's Nursing Home (Galway), 20th May 2016

Test Number One

Lady aged 90, diagnosed with dementia MMSE score of 19 out of 30, from test which took place 5th May 2016. Retired pub owner. Called by pseudonym Margaret in this report.
Margaret was introduced to the research assistant by carers and told about the project in general terms and then information from the project information sheet was discussed. Informed consent was obtained from Margaret to participate in this test and her willingness was continually assessed throughout. Margaret gave written consent to participation.

The test took place in her bedroom with her seated beside her bed and the laptop was place on a table in front of her. The research assistant sat on her bed slightly behind her, slightly out of her line of vision, with a note pad and mouse from which to operate the computer screen. There were no other distractions as the room was quiet.

The introductory screen was run.

During the test, Margaret sat forward in the chair and was attentive and interested in the screen. She followed the instructions from the introductory screen and spontaneously touched the screen. Notably on this occasion and on one other she touched right at the bottom right hand edge of the screen. Margaret went very still and watchful looking at the screen, she made no verbal communication with MARIO at all and did not use his name even after being encouraged to do this. This was quite surprising as she was verbally quite able in conversation with the research assistant and carers before the test.

It can be assumed that the laptop was not perceived as a robot and that the test situation was very unfamiliar to her. As the test progressed, her primary concerns came to the fore and it became clear that she had limited understanding that this was a test and not real – she focused totally on the 'contact your family' button and ignored all the others and did not want to explore the others, even when encouraged and prompted to do this.

She followed the touch screens all the way through to the contact your family section Green until it came to call your family and then said that – there was no point calling her family as she knew they would not be home at the moment and they were coming to see her (I don't know if this was actually so). Margaret remained adamant on this point and the test was stopped after inviting her to explore the other areas when she said clearly and emphatically 'no thank you'.

Margaret did not spontaneously touch the screen when the 4 choices came up – she did not realise she had to touch one of the categories to choose it. This she did when invited to do so and prompted by the researcher. She had understood the written and verbal instruction from the introductory page, as after this she did spontaneously touch the screen. This might suggest it is

necessary to repeat the instruction verbally on the 4 category page – after giving people a lot of time to read through the categories and consider their choice.

On notable point for further development is that the message 'I cannot hear you when I speak' is coming up on the screen too soon. It was appearing while Margaret was still reading, thinking and making her choice. The message was distracting and felt invasive. People with dementia take a long time processing information then deciding whether or not to act on it. MARIO will need to extend its wait time for 'instructions' very considerably and delay this message becoming visible. It is difficult to be precise as to how long this should be delayed, but I would say at least 15-20 seconds.

When the warning came up, Margaret touched the microphone icon. She thought she was being directed by the message to do this. So she clearly didn't understand the message and followed the visual prompt of the picture of the microphone.

She said she enjoyed doing the test and that it was 'quite good'. She was positive about it but her interest was of short duration and then she withdrew from the test. She did not think there was anything else MARIO could help her with. She said 'no' – she was quite happy where she was in the nursing home and she was being well looked after.

I think Margaret will use MARIO differently when it is an embodied robot.

First part

Keyword usage

1. Does the user address Mario by its name in the first time he tries to talk to it?
   No
2. If No does the "Are you talking to me screen" make the user use the name?
   No
3. How do they react to it (the Are you talking to me screen)?
   Negative passive reaction – as above, interrupted train of thought – comes too soon, and didn't understand it when tested in this context without a robot

Apps discovery and travel through apps

4. Did the user visit and discover available apps in "green" category?
   Yes
   Needed prompting to touch screen to choose one
5. Did the user visit and discover available apps in "blue" category?
   No
6. Did the user visit and discover available apps in "orange" category? (both pages)
   No visit to the category at all
7. Did the user visit and discover available apps in "purple" category? (both pages)
   No visit to the category at all
8. Can the user get back home and get to another category?
   Not attempted as test stopped by patient

9. How do they transfer to home? Not able to be tested. My impression is Margaret would not be able to use this icon.

Interaction

10. Note down the number of verbal and touch commands being used by the user. Touch no speech. 2 spontaneous – once responding to intro page; once to touch microphone icon; once to choose category but needed prompting by researcher to do this.
11. Note down how many times do they speak on top of the robot before the "Did you say anything" message None
12. How many times did they try to speak while the robot is speaking after seeing once the "Did you say anything" message? None

Second part

I asked Margaret did she want to tell MARIO to do something and she said no. She was only interested in the family button, see above.

Unable to progress to question No 13

13. Note down the path of interaction
    Direct command to get to the app (e.g. play me some music)
    Following the category-app path (e.g. I want to have some fun -> and then play some music)

Test number two

Male, aged 85 MMSE 15 approximately reported by staff, but no recent examination available. Retired farmer. Informed consent was obtained as described above. Pseudonym of Martin.

Tested in his bedroom with him sitting in chair, quiet room no distractions, researcher slightly behind to side of participant and the laptop on a table in front.

Martin spoke very little and very quietly, he exhibited no spontaneous movements or verbal utterances towards MARIO. He gave the impression he was used to be guided and following the instructions of others but was amenable to following suggestions and prompts. As the test progressed he did speak spontaneously to the researcher and was clearly comfortable with the process of the test. However his spontaneous comments were not always connected with the test. He constantly needed to be prompted by the researcher and gently refocused on the screen many times.

With encouragement and prompting he used the touch screen but would not have done this without help and prompting.

He made no response after the instructions from the introductory page had finished. After a long pause, the researcher asked Martin he wanted to hear instructions again he said ‘I do’. After these had played a second time, he said very quietly ‘now’ (part of his condition is that he can say one word intending to say another) and the researcher changed the screen as if he had caused it to change.

Martin gave no spontaneous response to the next screen with 4 categories – after a long pause and no response, Martin needed prompting that he could now choose and researcher went through the choices and explained them again. Martin said 'yes' and then 'what do you think' asking the researcher what he should choose and was reassured by researcher he could choose whatever he liked. Despite this encouragement and a long pause for thinking time, he was still unable to choose, so the researcher said eventually:

'What about lets have some fun?' and he said 'yes'. The researcher then had to remind Martin to touch the screen, saying 'So, do you want to touch the screen?' and had to repeat the instruction:

'and touch the screen on lets have some fun' and then he did touch the screen. He then spontaneously chose and verbalised that he would like to listen to some music. The screen was changed and he received the 'congratulations you have..' screen.

This suggested to me if Martin was sufficiently enthusiastic about what was on the screen he would be able to follow the instructions – he particularly likes listening to music.

Going back to four choices again, Martin was silent again and did not spontaneously choose any category.

After a long pause he said he would like to see if there is any improvement in his health and he wanted to talk to the researcher about this. (I think he was meaning that he would like MARIO to be able to help him with this). He talked about this health and how long he had been in the nursing home and had his health complaints. I think this train of thought was sparked off by the words on the screen about 'how can I help you' and Martin was more interested in talking to the researcher about this than the laptop.

The researcher asked if Martin would like to see if there was anything that MARIO could help him with and refocused back on to the laptop and MARIO, Martin agreed to do this – researcher encouraged him to use the buttons. And he did touch the screen again once, in a random place.

He then started to talk to about this wife, interrupted by the 'are you talking to me screen' – then wanted to continue talking to the researcher about his family rather than using the laptop.

He also asked if MARIO will need to be paid for and how this would happen.

When asked what he thought about MARIO he said it seemed 'alright'.

He didn't know anything about the home button when asked by the researcher directly about it. He also said he had never used a computer but his son used one.

He said he liked music but asked if he would like MARIO to help him with anything else, he said 'no' – that was enough.

Said his eyesight wasn't great but he could see the screen and what was on it clearly.

The test was stopped after about 15 minutes when researcher and Martin interrupted by returning care worker.

First part

Keyword usage

14. Does the user address Mario by its name in the first time he tries to talk to it?
    No
15. If No does the “Are you talking to me screen” make the user use the name?
    No
16. How do they react to (the Are you talking to me screen)?
    Neutral passive reaction but message was intrusive and stopped train of thought – interrupted him one time when he was about to speak. Delay this as people with dementia need more time to make decisions.

Apps discovery and travel through apps

17. Did the user visit and discover available apps in “green” category?
    No
18. Did the user visit and discover available apps in “blue” category?
    No
19. Did the user visit and discover available apps in “orange” category? (both pages)
    Only visited and used this category with a lot of prompting and then focused on the one thing that he was very interested in and spontaneously chose listen to some music
20. Did the user visit and discover available apps in “purple” category? (both pages)
    No visit to the category at all
21. Can the user get back home and get to another category?
    No
22. How do they transfer to home?
    Did not understand this button at all. See above.

Interaction

23. Note down the number of verbal and touch commands being used by the user
    Verbal – used words quietly and not obvious trigger key words
    Touch – with prompting and lots of encouragement and directed support.
24. Note down how many times do they speak on top of the robot before the "Did you say anything" message
    This did not happen message came up when person did not respond for a time i.e. when Martin was still thinking.
25. How many times did they try to speak while the robot is speaking after seeing once the "Did you say anything" message?
    Not applicable

Second part

Ask the user to tell Mario do something from all the different things he can do.

Not able to do any aspect without prompting and close support.

26. Note down the path of interaction
    Direct command to get to the app (e.g. play me some music)
    Following the category-app path (e.g. I want to have some fun -> and then play some music)
    Not applicable.

Conclusion

These test results would have been different with an embodied MARIO. Both participants had never used a computer previously. People with mild dementia will probably use MARIO's name when he is embodied on a robot platform but they may speak very quietly or not use key words appropriately even if they mean to say them. More articulate people with dementia will probably have no problem using MARIO's name – especially if it is written on him somewhere, to remind them what his name is. They may respond to coaching and support, eventually learning about how to use MARIO. People with moderate dementia will probably need support to use MARIO but will be particularly motivated when they respond and utilise choices which correspond to their particular interests or what they are currently preoccupied with and find important. Response times for people with dementia will always be longer than expected by younger people. It is unknown from this test if the message as presented is meaningful to people with dementia. It is possibly too complicated, containing too much information. This test suggests it is doubtful the home button will hold any meaning for a person with moderate dementia.

Recommendations

- Instructions about touching the screen on the button of choice need to be repeated verbally by MARIO on the screen where the 4 categories are presented.
- It may be beneficial to have an option to repeat the initial introductory instructions if there is no response from the person after 20 seconds.
- Delay the 'Did you say anything to me message.' By at least 15-20 seconds.