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Abstract Robots have begun to assist elders and patients suffering dementia. In particular, recent studies have shown how robots can benefit Alzheimer's disease (AD) patients. This is a novel area with a promising future but lot of researching needs to be done. The RobAlz project is aimed to assist AD patients and their caregivers by social robots. This project is divided in three phases: the definition of the requirements and scenarios, the development of a new robotic platform, and the evaluation. This work presents the results obtained in the first phase, in which several meetings were conducted with a set of subject-matter experts in the areas of Alzheimer's Disease and social robotics. The meetings were classified according to the application areas they covered: general aspects, safety, entertainment, personal assistance, and stimulation. The meetings ended up with a repertory of scenarios where robots can be applied to Alzheimer's patients and their caregivers at their home or in longterm care facilities. These scenarios present different psychological, social and technical concerns that must be addressed for the design of the robot. In this work we perform an analysis on the scenarios and present the technical requirements for the development of a first robotic prototype. This prototype will be constructed and tested in real environments in the subsequent phases of the RobAlz project.

Keywords alzheimer · dementia · elderly · social assistive robot · social robot · assistive robot

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1 Introduction

According to Antila et al. [1], nowadays Alzheimer's disease (AD) is the most common cause of dementia. The World Health Organization reported in 2012 that 36,5 millions of persons suffer from dementia in the world [2], that is 0,5% of the total population (data from 2010). As stated in recent studies, the number of people in the United States with AD will increase dramatically in the next 40 years [3]. A similar evolution may be expected for the rest of the world.

Alzheimer's is a progressive disease that worsens over time, causing problems with memory, thinking and behaviour. It can be divided into three stages:

– Mild: In this phase, the most noticeable deficit is memory loss, which mainly affects to the short-time memory (inability to remember recently learned facts and acquire new information).
– Moderate: In this stage the patient becomes unable to perform most common activities of daily living.
– Severe: During the final stage of AD, the person is completely dependent upon caregivers.

Since Alzheimer's gradually renders patients incapable of tending for their own needs, caregiving becomes essential. Besides, the majority of the affected people age 65 years or older and they mostly prefer to stay at home instead of being at nursery homes [4]. This implies that the role of the main caregiver is often taken by the spouse or a close relative and, in most cases, this is a very stressing task for them, both physically and emotionally.

Although Alzheimer's disease develops different for each individual, there exist some general treatments such as the adherence to simplified routines or the realization of stimulation exercises. These treatments cannot stop the disease from progressing, but they can temporarily slow the worsening of dementia symptoms and improve quality of life for patients and caregivers.

Several robotic research projects have tried to help patients and also caregivers. In this line, a new kind of robot has been defined: the Socially Assistive Robot (SAR). A SAR is defined by Tapus et al. in 2005 [5] as the intersection of Assistive Robotics (AR) and Socially Interactive Robotics (SIR). ARs are robots that give aid or support to a human user. On the other hand, SIRs are those whose main task is some form of human-robot interaction (HRI from now on). Therefore, SARs are intended to provide assistance to human users through social interaction.

SARs have already been used for designing therapies for people with dementia (including AD). The studies presented by Tapus et al. [6, 7], show that using a biomimetic robotic system, some patients improved their cognitive attention, their cortical neurons activity, their feelings and their ability to overcome stress. Moreover, the patients needed less supervision while interacting with the robot and, consequently, their caregivers also reduced their stress levels. [7, 8].

The work presented in this paper was developed under the frame of the *RobAlz* project, where the *RoboticsLab*, at the Carlos III University of Madrid (Spain), and FAE (the Spanish Alzheimer Foundation) are involved. The goal of this project is to develop a SAR to be used at AD patients' homes or at care facilities. It is intended to assist patients in the mild stage of AD by carrying out certain tasks because in more advanced stages of the disease the cognitive symptoms of the patient may be too severe to even interact with the robot. Besides, it is also intended to help the caregivers by facilitating their daily labour and giving them some free time.

This project comprises three phases:

1 Definition of the scenarios and the robot requirements.
2 Robot construction.
3 Experiments and results evaluation in real environments.

This paper presents the results of the first phase, in which several meetings with a team of subject-matter experts took place. The meetings were used to discuss different features and tasks of the robot in the fields of:

- Security: to help the caregiver to watch the situation of the patient.
- Personal assistance: to help the patient with his daily activities relieving the caregiver's burden.
- Entertainment: to provide amusement to the patient so the caregiver is relieved for a certain time.
- Stimulation: activities to slow down the progress of the AD.

The results of these meetings ended up in a repertory of scenarios where a SAR can assist AD patients and their caregivers. These scenarios were discussed and approved in subsequent meetings by all the attendees.

After defining the scenarios, an analysis was performed on the technical, psychological, and social constraints that arise from each of them. Based on this analysis, some scenarios were selected for obtaining the technical requirements for a first robotic prototype to be built in the second phase of the project, and tested with real users in the third.

The rest of the paper is structured as follows: Section 2 presents previous studies and works where robots have been applied to help elders affected by dementia. Besides some studies about the elders' perception of robots and their applications are detailed too. In Section 3, we detail the methodology we have followed in this work. Afterwards, Section 4 describes how the meeting were carry out and their structure. Then, Sections 5 and 6 present the results extracted from the meetings, including the repertory of possible scenarios. The proposed scenarios are carefully analyzed in order to select the most appropriate ones for a first experiment with AD patients (Section 7). Based on the conclusions of the discussion, a list of the technical requirements for a first prototype is provided in Section 8. Finally, the conclusions and the future works are discussed in Section 9.

2 Related Work

SAR for elderly people is a field of research continuously increasing its relevance. There is a large number of social robots designed to assist elders in their daily life or to improve their socialization. These are the cases of Giraff Plus[1], Care-O-Bot[2], Hobbit[3], Mobiserv[4], Accompany[5], Domeo[6], Robot-Era[7] and many others. Furthermore, numerous researchers carried out studies focused on the perception of robots by elders without using an specific prototype. Some of the most relevant studies are detailed in Subsection 2.1. In Subsection 2.2, we describe several of the representative existing SARs designed to assist or interact with elders with dementia and some of the studies conducted with them.

[1] http://www.giraffplus.eu
[2] http://www.care-o-bot.de
[3] http://hobbit.acin.tuwien.ac.at/
[4] http://www.mobiserv.info/
[5] http://accompanyproject.eu/
[6] http://www.aal-domeo.org/
[7] http://www.robot-era.eu

2.1 Studies on the perception of robots by elders and caregivers

Numerous researchers have studied the relationship between robots and elderly people. In particular, some of them have focused on the proper appearance of a robot interacting with elders. Wu et al. [9] explored how the elderly perceive robots with regard to robot appearance. At the beginning of the experiment, participants discussed about their initial perception of robots. Afterwards, they saw a presentation with 26 different robot pictures displayed on a screen and a set of video clips comprising some robots in action. Finally, each participant chose their 3 favourite robots. The results showed that the participants generally preferred small robots with human/animal traits. In a post-experiment discussion, most of them expressed rejection, even fear, towards a robot conceived as a substitute of the human care provided.

Continuing this line, other researchers have analyzed the possible functionalities of a robot to support elderly people. Mast et al.[10] carried out a survey by using a questionnaire, designed by the authors, to quantify the usefulness of 25 robot services supported by illustrations or pictures. The participants in the questionnaire were elders and caregivers from Germany, Italy, and Spain. Elderly people rated emergency assistance, physically strenuous housekeeping and mobility-related tasks as the best services. On the contrary, the services focusing on social, interactive and emotional tasks received the lowest mark. Specifically, the worst rated services were playing games with relatives through the robot and companionship by the robot. Moreover, caregivers rated items related to reminder functions and emergency assistance most highly, but they rated negatively the service based on walking assistance. Summarizing, elders and caregivers have some common preferences (e.g. emergency assistance) but they mainly differ in the services they demand. The different results between elderly people and caregivers show that both groups' opinions need to be considered for the definition of the functionalities of a SAR for elders. Frennert and Östlund confirmed this idea in their review of the matters of concern about social robots and elders [11]. They warned about the general role of elders during the development of robots for their assistance: "*Old people are definitely considered but not consulted*". They stated that the matters that concern elders are different from the preconceived ideas about their needs. Consequently, they proposed to include elders from the beginning of the design process.

2.2 Robotic applications for elders with cognitive impairment

In this section, we focus on robots that have been applied to patients suffering some type of cognitive impairment (including AD patients). These kind of robots are more centered in aspects like social interaction in an affective way, cognitive assistance and physical and psycho stimulation. This is the case of *Paro* (Fig. 1a), a baby seal robot developed in Japan [8][12]. Its main objectives are to reduce the stress in patients, to promote their socialization and to improve their motivation. According to Wada [12], pet robots provide similar benefits as those of a real animal using "animal therapy", but without requiring the care real ones need. Paro robots have been tested with elders with and without dementia in numerous centres. Many patients showed an improvement in their stress levels and interaction not only with their caregivers but also among them. Furthermore, caregivers reduced their stress too because patients needed less attention while they were interacting with the robot [8].

Other recent therapeutic robot is *Babyloid* (Fig. 1b), a baby robot designed to be looked after by the patient with dementia [13]. Its goal is to reduce the psychological stress and increase the motivation of the patient, giving him the role of caring a "baby" but without the risk that a real baby involves. In this case, the idea is to apply a "doll therapy" since it has been proved that improves the mental status of the patients. The first results in relation to the acceptance of the baby robot showed that some of the patients had concerns about "taking care" of the robot. Even though, Babyloid was liked by the participants.

The previous robots, Paro and Babyloid, have been mostly evaluated at nursing homes. On the other hand, there are other assistive technologies that are intended to be applied at homes. This is the approach presented in the project *CompanionAble* [14], which combines a mobile robot and a smart environment. In this project the robot *Hector* (Fig. 1c) offers different services as an agenda, video calls, and cognitive training. The smart home provides other functionalities like tracking the user's position at home or detecting if the patient falls down. The results were that not only the people with dementia obtained benefits but also their caregivers (partners) alleviated some of their burden.

There are also many studies with commercial robots that are not specifically designed for interacting with elders, but they are used as platforms for this goal. This is the case of the work presented by Kanamori et al. [8] where they applied the commercial robot-dog *Aibo* (Fig. 1d) to "animal therapy". They found that stress and loneliness of the elderly people were reduced after several sessions in a nursing home. Authors concluded that since Aibo is not designed for therapy, interaction was not sufficiently encouraged and required more intervention from the therapist.

Nevertheless, Martín et al.[15] used the robot *Nao* (Fig. 1e), a general purpose commercial humanoid robot, as a cognitive stimulation tool in the therapy for dementia patients. As a humanoid, Nao is useful, for example, for physical therapy by performing movements that can be directly mimicked by patients. In this case the therapy sessions were controlled and designed by therapists. They defined the combination of music, movements, and lights shown by the robot. Their preliminary results showed that some symptoms of the patients tended to improve in comparison with the results obtained using classic methods.

The majority of these works focus on a specific aspect of the assistance: some of them are centered on the affective engagement, what impacts their design and functionality. Others prioritize the realization of certain tasks, such as reminders of daily activities or stimulation exercises, but their looks are more *robotic* and less *tender*. The majority of them take into consideration the needs of the patients in their design, but not those of the caregivers, who suffer a great burden and do not have time for themselves. Broadbent [16] conducted a study where professional caregivers completed a questionnaire and were interviewed about several tasks an assistive robot could perform in a retirement home. The results showed that residents and staff clearly have different preferences. In the *RobAlz* project

The *RobAlz* project differs from the previous projects in two main aspects:

First, we follow a similar approach to Broadbent but we rely on a group of multidisciplinary experts from the very beginning of the project. Their insights are fundamental in order to introduce a real robot that is going to stay all the time with the AD patients in their particular homes or nursing homes.

Second, it aims at providing a wide range of functionalities and usage scenarios to meet the needs of both the patients and the caregivers. The goal is not to specify a list of hermetic tasks for a SAR, but to facilitate the development of different possible robots for this collective. Hence, robotic researchers who wish to develop a robot to assist dementia patients and their caregivers, do not have to do it from scratch: they are provided with some outlines in the form of usage scenarios and general aspects to consider in their designs.

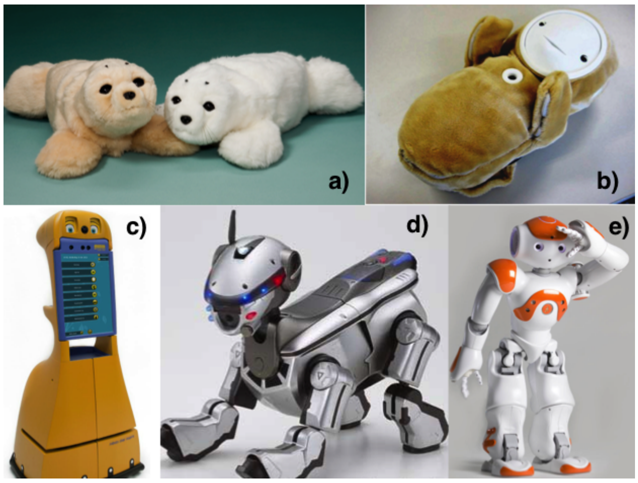

Fig. 1 SARs: (a) Paro, (b) Babyloid, (c) CompanionAble Hector, (d) Aibo and (e) Nao.

3 Methodology

As mentioned in Section 1, this paper is framed under the first phase of the *RobAlz* project. The goal of this phase was to define the functionality and general design of a new SAR with the purpose of helping AD patients and their caregivers at home or at nursing facilities. In order to achieve this goal, there is a necessary process of requirement extraction. In general, this process involves the following steps (Figure 2):

1. First, it is necessary to carry out an analysis of the needs of both AD patients and their caregivers.
2. Second, it has to be established how a SAR can attend to these needs: in which scenarios it can be applied and which are the general features it has to fulfil.
3. Third, knowing the use cases and non-functional characteristics, a study on the feasibility of each of them must follow. This will determine the short-term and the long-term requirements.

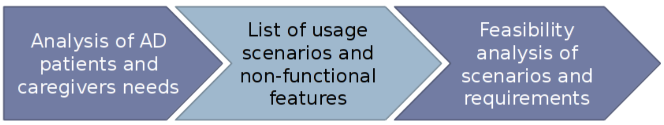

Fig. 2 Diagram of the general steps for requirements extraction

These steps can be performed in different manners. In our case, they were carried out following a participatory design approach, which is a well-known technique in human-robot and human-computer interaction fields. This approach focuses on collaborating with the intended users from the beginning, rather than designing a system "for" them.

According to Mayer and Zach's *Lessons Learned from Participatory Design with and for People with Dementia* [17], realistic prototypes ease the process of eliciting user needs and allow design evaluations with people with dementia. In they work, they first interviewed four experts to gain insight on how to best approach and work with people with dementia. Another important fact regarding their work with dementia patients is that eliciting user needs is hard because people with dementia often do not want to admit, are not aware, or cannot communicate their problems, weaknesses, needs and current practices.

Taking all this into account, it was clear the need to involve experts in the project from the beginning. There are national entities in different countries, whose purpose is to assist, aid and represent AD patients and their caregivers. That is the case of FAE, the Spanish Alzheimer Foundation[8], a non-profit national entity founded in 1991. They work in several projects involving the improvement of the quality of life of AD patients and they can offer a well founded opinion on this collective needs. FAE is also a member of the robotic spanish platform *HispaRob*[9], so they are familiar with different types of robots and robotic projects.

Together with them, it was agreed to establish the following working methodology in order to extract the requirements for the final SAR:

1. The first step was to gather a group of experts to discuss about the needs of AD patients and their caregivers and the desired functionalities for the robot. FAE stated that it was difficult to involve AD patients in this initial process due to their cognitive impairments, which prevent them from abstract thinking. So it was decided to start with a multidisciplinary team of experts with different professional and personal perspectives to cover all Alzheimer's disease areas. This group was formed by: two members of *FAE*, two psychologists, two therapists, one professional caregiver and four family caregivers. Also, six robotic experts were involved in the group to contribute with their insight. The details of the participants are presented on Section 4.1
2. During five months, a set of periodic multidisciplinary meetings were held, in which all the participants expressed their opinions, proposed functionalities for the SAR and discussed different alternatives for its design. Details on the methology of the meetings are described in Section 4.2.
3. From these meetings, a list of possible usage scenarios was extracted as well as some general considerations about the robot's appearance and behaviour. These were intended as a starting guideline to design a useful SAR for AD patients and caregivers (Sections 5 and 6).
4. Based on the general considerations and the proposed scenarios, the robotic experts conducted a feasibility analysis. They defined the different concerns and limitations, both technical and social, of each scenario and the viability for the short-term implementation of them. This step is paramount to determine the most suitable scenarios to start to work with (Section 7).
5. After the aforementioned analysis of limitations, a subset of the proposed scenarios was selected, serving as a base to detail the technical requirements for an initial prototype to be built (Section 8).
6. Finally, this initial prototype will be evaluated with AD patients themselves, permitting this way their partipation with something tangible, rather than asking them for abstract thinking. This will be an iterative process in which different functionalities and designs will be tested. For that purpose, this initial prototype has to be low-cost and configurable (more than one prototype may be considered even). In this evaluation, we contemplate to control the robot following a *Wizard Of Oz* style. This approach allows us to test several features, such us the appearance or some functionalities, before we develop a final version. This will be carried out during the second and third phases of *RobAlz* project.

[8] http://www.alzfae.org
[9] http://www.hisparob.es/

4 Meetings

As it has been introduced, different meetings with subject matter experts in the fields related to Alzheimer's disease and robotics took place with the goal of discussing the possible funcionalities and usage scenarios for the design of the robot.

4.1 Attendees to the meetings

This group was gathered thanks to FAE, which has a multidisciplinary professional team to attend the different needs of patients and caregivers and which is also in touch with several family caregivers who collaborate in their projets. From the beginning, the participants were explained the goals and methodology of the project and that their participation would be voluntary and not remunerated.

Specifically, the attendees to the meetings were:

- The two founders of *FAE*, with more than 30 years of experience in the field and who have been also

members of *Alzheimer Europe*. They also have background on medicine and caregiving respectively.
– One cognitive psychologist of young age but with experience working with FAE for at least five years.
– One clinical psychologist with also 30 years of experience who, apart from collaborating with FAE, has also a private psychological practice, focused on the needs of AD patients and caregivers.
– Two therapists, one of whom has a greater background in social work whereas the other focuses on occupational therapy aspects. Both of them work with FAE on a regular basis and have experience with AD patients.
– One professional caregiver who is also a relative of an AD patient and works in a day-care centre specialized in elders suffering dementia or other cognitive impairments.
– Four family caregivers with different roles: spouse, son and daughters of an AD patient. The disease status in each case was different, ranging from mild state to more advanced symptoms.
– Six robotics experts with different backgrounds and academic degrees led by professor Salichs, head of the social robots research group at *RoboticsLab*, with almost 40 years of experience in the field. The other technical staff were a doctor in robotics, two PhD students, a hardware technician and an industrial engineer, also members of the same research group.

4.2 Methodology of the meetings

There were five official meetings in total, one per month, of an approximate duration of two hours each. The meetings took place in a FAE facility in Madrid and they were moderated by professor Salichs, who has wide experience in this matter.

Before starting with them, an informal visit was organized so the participants could learn about the robots and work developed in Carlos III of Madrid University, specifically, in the *RoboticsLab* group. They were shown different types of robots: from mobile to static ones, humanoids, cartoon-like robots, etc.

The official meetings were organized as follows:

A **first meeting was used to gather the group** and present the different backgrounds of the participants. In this meeting, the goal was **to define the principal fields of interest** to be discussed during subsequent meetings with the purpose of defining a list of usage scenarios for each one. The structure of this meeting was the following:

1. Professor Salichs introduced the project to all the participants so the main goals were clear for everyone.
2. Then, the different participants were asked to do some brainstorming, exposing the principal needs of patients and caregivers from their point of view.
3. Finally, the last part of the meeting was used to categorized these ideas into the corresponding fields of interest.

A summary of the conclusions of this meeting and the areas defined is presented subsequently:

– **Safety**. One of the main concerns of the caregivers was to keep the AD patient watched. It was discussed that AD patients get disoriented and can enter in dangerous rooms (e.g. the kitchen), can fall down, or even leave the house. Caregivers cannot be constantly monitoring the patients, so a SAR could be useful in this area.
– **Personal Assistance**. Psychologists pointed out that the adherence to routines is important for AD patients and the whole group agreed that a robot which had some functionalities of a personal assistant could be very useful, specially since AD patients have problems with short-term memory.
– **Entertainment**. This area was brought up mainly by caregivers, due to the fact that AD patients tend to demand a lot of time from them. If a SAR could provide some entertainment to the patient, the caregiver could have some gap of free time to attend to his own needs, which is mainly what they pine for.
– **Stimulation**. Finally, the therapists indicated that some physical and mental stimulation is useful to try to slow down the progression of the disease. Nevertheless, they also stated that these exercises must be careful designed for each patient and monitored by an specialist.

The subsequent four meetings were centered on each of the aforementioned fields and were used as a brainstorming process in which the functionalities and the characteristics of the robot were discussed. Following each meeting, the robotic experts took the ideas discussed and defined a list of possible usage scenarios of the robot for the corresponding field. The detailed organization of these meetings was as follows:

1. At the beginning of each meeting, the resulting scenarios from the previous one were evaluated and approved by the group unanimously. The discussion was an iterative process in which some modifications could be introduced in an scenario until the whole group accepted it.
2. Once these scenarios were agreed, the meeting continued with the following field of interest. Each of

the participants suggested different usage scenarios they considered useful to include in the robot. As it was a brainstorming process, different ideas, funcionalities and general aspects arised too.
3. After each meeting, the researchers organized the ideas into a set of usage scenarios for a SAR as well as some general aspects to include in its design. For each scenario, its goals and limitations were also stated. Figure 3 shows and example of a template that was filled with the characteristics of each scenario.
4. The minutes of the meeting, including these templates with the scenarios and the general aspects discussed, were sent to each participant before the following session took place.

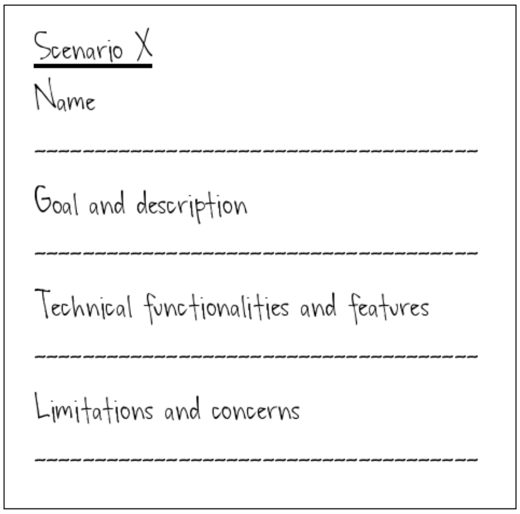

Fig. 3 Example of the template used to defined the scenarios

During the five official meetings, various of the robotic experts were taking exhaustive notes of all the presented ideas and the discussions.

5 General Considerations

In this section, we present the considerations extracted from the meetings about features or ideas related to non particular field, but all. During the development of all the meetings, the experts laid out different non-functional features the robot should include. It was agreed by all of them that the most relevant are:

5.1 External Appearance

This topic was not treated in any particular meeting, since the goal of the project is not defining a specific external appearance for the robot. However, as it was explained in the previous section, during the development of the meetings many general ideas for the design of the robot arised, including its external appearance. The general opinion of the experts was that its look should be as friendly as possible and they proposed different designs, such as animal-like, baby-like, etc. or even designs based on other existing robots.

Many of them expressed their preferences towards a design similar to the social robot Maggie [18], which they knew from their visit to the Carlos III of Madrid University. This is a 1.35 meters high mobile robot with a cartoon-like appearance, conceived to be friendly and invite people to interact with it. The robot Maggie can be observed in Figure 4

Fig. 4 Maggie robot

5.2 Patient's Activities Records

The robot has to carry out a record of the patient's activity. These records may be used by a professional to adapt the activities of the robot to the patient's preferences. Moreover, they can also be used to detect changes in the evolution of the dementia.

5.3 Customization

The robot must be endowed with a base of knowledge of each patient provided by the caregiver or relatives, so all the activities are adapted to his preferences (favorite TV programs, specific information about his house, etc.).

5.4 Scheduling

The robot's tasks have the possibility to be programmed by the caregiver or even remotely by a doctor or a technician. For example, a sequence of activities can be defined in order to keep the patient entertained for a period of time. This would imply providing a user-friendly interface which makes it easy to configure the robot's activities.

5.5 Tele-operation

The possibility of allowing caregivers or therapists to control the robot remotely, so they can manually start an scenario or give simple commands to the robot, such as *say a sentence*. This could be useful if the patient listens to the robot's suggestions better than to those of his caregiver.

6 Proposed Scenarios

This section shows a description of the proposed usage scenarios classified according to the field they belong to. All of them are shown in Table 1. These scenarios are the result from the meetings, where the subject matter experts that participated proposed and discussed useful functionalities that a SAR for AD patients and their caregivers may have. They serve as a base to design different robots, depending on which of the scenarios are selected. In this section all of them are described, whereas in the next one, a discussion follows on the requirements and limitations for their implementation in a robot.

Areas	Num	Scenarios
Safety	1	Static Vigilance
	2	Mobile Vigilance
	3	Interface with Home Vigilance
	4	Interface with GPS tracking
Personal Assistance	5	Static Location of Objects
	6	Mobile Location of Objects
	7	Reassuring AD Patient when he is Alone
	8	Activity and Major Events Reminder
	9	Locate the Patient themselves
	10	Make Simple Decisions
	11	Answer Frequent Questions
Entertainment	12	Story-Telling
	13	Active-Listening
	14	Conversation between Patient and Robot
	15	Games
	16	Newscaster Robot
	17	Multimedia Player
	18	Affective Engagement
Stimulation	19	Psycho-Stimulation Exercises
	20	Physical Stimulation Exercises

Table 1 The scenarios extracted from the meetings. Numbers are used to identify the scenarios for later references

6.1 Safety

These scenarios are related to the security of the patient. Alzheimer's patients tend to get disoriented and wander about, even at their homes, and their caregivers cannot be constantly monitoring them. That is why the scenarios of this area focus on the surveillance of the patient with different approaches.

1. **Static Vigilance** The objective of this scenario is the surveillance of the patient's position inside one room by a robot situated in a predefined location. The robot can watch one room at a time, but it can be moved among a set of predefined spots in different places of the house. For example, it can be placed in the bedside table to check if the patient leaves the room during the night (see Figure 5). It can also be placed at certain locations to watch some dangerous areas of the house, such as the kitchen (stove, sharp knives, etc.). These dangerous or forbidden areas can be defined by the caregiver. If the robot detects the patient in one of them, it tries to persuade him with an acoustic message to change his intention. For example, it could say: "Please, don't leave me alone", or "I would like you to stay closer to me". The robot also warns the caregiver (acoustically or with a call or text message).
2. **Mobile Vigilance** This scenario is similar to the previous one but, in this case, the robot can move around the house and keep the patient watched at any time by following him.
3. **Interface with Home Vigilance** In this case the goal is to keep all the house watched by means of home automation services. The robot is used as a friendly interface for the caregiver, who can use it to manage these systems. Different sensors and cameras would be placed in all the rooms and hallways of the patient's house to keep him watched. If the patient performs some dangerous activity or approaches a risky area of the house, the robot warns the caregiver.

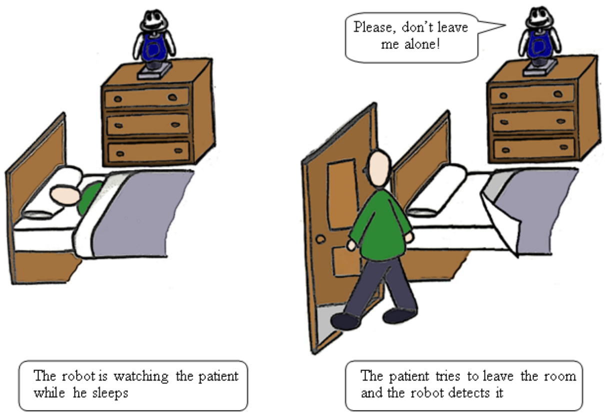

Fig. 5 Illustration of the *Static Vigilance* scenario

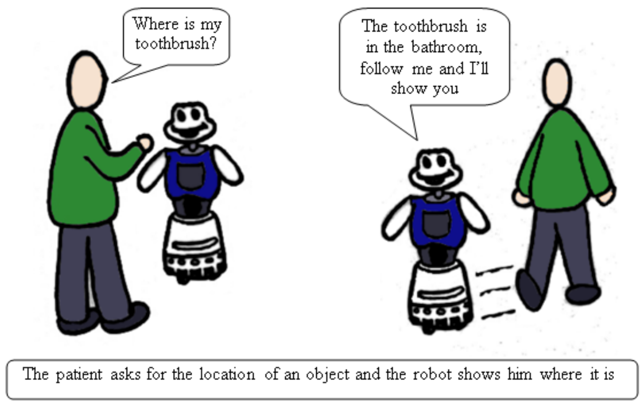

Fig. 6 Illustration of the *Mobile Location of Objects* scenario

4. **Interface with GPS tracking** The robot performs an outdoors tracking of the patient by means of a GPS-based system. The patient should wear a sensor, located in a bracelet or similar, to track him by using GPS data and provide this information to the caregiver. For example, if the patient goes out and takes longer than expected to come back, the robot can give the caregiver the exact location of the patient at that moment.

6.2 Personal Assistance

The following scenarios describe situations where the robot can help the patient with his daily activities by reminding or suggesting how to perform them. This information is provided in advance by the caregiver, who knows the preferences and tastes of the patient.

5. **Static Location of Objects** Individuals suffering AD often ask for the location of different objects of the house because they cannot remember their usual place. The robot keeps a list of the most used objects of the patient (e.g. toothbrush or glasses) and their usual location, so, if the patient asks for any of them, the robot can give indications about its location. These indications can be given by voice instructions or with the aid of images or videos.
6. **Mobile Location of Objects** This scenario is similar to the previous one, but in this case a mobile robot goes to the place where the object is located instead of just explaining it (see Figure 6).
7. **Reassuring Robot when AD Patient is Alone** This scenario is based on the situation in which the caregiver must go out, leaving the AD patient alone at home. These patients can get nervous or anxious in such situations, so the job of the robot is keeping them calmed until the caregiver arrives. In these situations the robot can say calming sentences or establish a phone or video call with the caregiver. The call can be established upon request of the patient, or automatically by the robot.
8. **Activities and Major Events Reminder** This scenario is based on the fact that, in general terms, it is good for the individuals with Alzheimer's disease to adhere to simplified routines and fulfil them on a daily basis. The robot can be useful for the caregiver by helping to remind the patient of his routine. It can explain the patient the activity he must carry out at each moment of the day and how to accomplish it if necessary. This can be done with simple instructions or visual aid, such as images or videos. Examples of these routines can be the different meals or when to take the medicines.
Besides, the robot can also remind the patient of important dates or events. This can be complemented with pictures of the person or thing involved in the event; e.g. the robot says *"Today is the birthday of Teresa, your daughter"* while showing a picture of Teresa on a screen.
9. **Locate the Patients themselves** As a consequence of short-term memory loss, AD patients can get disoriented and think they are in a different place, such as an old home where they used to live. Thus, some patients frequently ask about their current location. This could be indicated by the robot with simple explanations. For example, the robot could say: *"you are in Madrid, at your house in Castellana street"*, or even refer to the room where they are located.
10. **Make Simple Decisions** Apart from getting disoriented, another consequence of memory loss is that AD patients can get anxious or nervous when they have to make everyday decisions on how to perform

daily activities. For example, it can be difficult for an AD patient to decide what to wear because he can even forget which clothes he has. In such an scenario, the robot may help by suggesting the patient what to wear, for example, based on the weather forecast. The robot explains the result of the decision basically by voice interaction, but can complement it with images or videos too.

11. **Answer Frequent Questions** AD patients often ask the same questions several times during the day, like *"what time is it?"*, or *"what day is today?"*. For his caregiver, it can be a burden to answer all the times with the same reply, but a robot can effortless answer these simple questions.

6.3 Entertainment

The idea of these scenarios is that the robot has a collection of enjoyable activities tailored for each AD patient. As already stated, this *customization* is performed with the help of the caregiver or relatives, who provides information about the patient's life. Then, in its daily use, the robot can be programmed to combine some of these activities in order to keep the patient entertained for a period of time. This could provide the caregiver with some free time to attend to his own needs.

12. **Story-Telling** In this scenario, the robot has a collection of stories, curiosities, poems, facts or events of the patient's life that it relates to the patient (a first approach of this idea was presented in [19]). The story can be chosen by the caregiver or autonomously by the robot based on a dynamic record of the patient's favorite stories.
13. **Active Listening** The goal of this scenario is that the robot performs an active listening by making the AD patient talk about his favorite topics. The robot can have a set of predefined topics it can ask the patient about (e.g. stories about his life, relatives, work, or hobbies). The robot can start the conversation with predefined sentences and then detect when the patient stops talking and invite him to talk more, using some conversational fillers such as *"right?"*, or *"tell me more about that"*. Gestures and expressions can create the impression that the robot understands and listens to the patient.
14. **Conversation between the Patient and the Robot** The objective of this scenario is that the robot and the AD patient can hold a natural conversation in which the robot "understands" what the patient says and reacts accordingly (similar to a *chatbot*).
15. **Games** In this scenario, the robot entertains the patient by playing with him to different interaction games, depending on the patient's preferences. The games can range from general (e.g. guessing a famous character [20]) to personal ones (recognizing objects of the patient's environment, or photos of close relatives).
16. **Newscaster Robot** In this scenario the robot tells the AD patient the latest news about his favorite topics: sports, culture, weather, etc. The robot can take an Internet feed and provides the news by voice or even show them visually in a screen depending on the patient's preferences.
17. **Multimedia Player** The robot entertains the patient with different multimedia content: TV shows, radio programs, personal photos, patient's favorite music, historical or religious events, or even home-made videos (e.g. birthdays of the family, weddings, etc.) (Fig. 7). The contents can be thus obtained locally or from the Internet, permitting to the patient watch his favorite programs, independently of when they are broadcasted.

Fig. 7 Illustration of the *Multimedia Player* scenario

18. **Affective Engagement** The goal of this scenario is to make the AD patient feel needed and loved by a robot which requires his attention. For example, the robot needs to be fed, makes compliments to the patient, or likes to be caressed. In this scenario, the robot should inspire tenderness in order to create an affective bond with the user, like a pet.

6.4 Stimulation

Stimulation exercises are very important in Alzheimer's treatment. Although this disease has no cure, the adherence to some routines, memory exercises and even physical therapies, can slow down the progression of the symptoms. However, it was pointed out by the therapists that each patient evolves in a different manner and the exercises have to be carefully tailored for each person's needs and situation. That is why each robot will have to adapt to the specific person it is assisting.

The two categories of stimulation exercises that were considered are:

19. **Psycho-Stimulation Exercises** In this scenario, the robot has a collection of exercises for mental stimulation and helps the patient to do them. These can be memory exercises, quizzes, etc. which the robot can explain by voice, pictures or videos, for example. The format and content of these exercises, as well as the number of sessions per day, depend completely on the patient's progression and symptoms, which develop differently for each person. Therefore they must be tailored and supervised by a specialist who works with the patient habitually.
20. **Physical Stimulation Exercises** The goal of this scenario is that the robot guides the patient through different sessions of physical stimulation exercises (Fig. 8), by showing how to perform them with its own degrees of freedom (i.e. head, arms, etc.) or with the aid of pictures displayed on a screen. These exercises must be designed and supervised by a physiotherapist who knows the patient's condition.

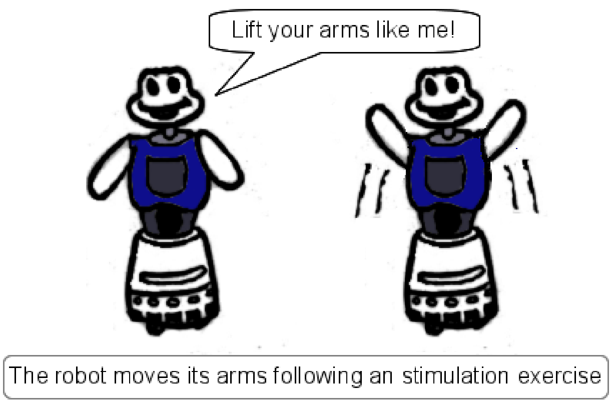

Fig. 8 Illustration of the *Physical Stimulation Exercises* scenario

7 Discussion of Scenarios

As it was introduced in Section 3, the list of scenarios are a list of desirable functionalities for a SAR to assist AD patients and their caregivers. Nevertheless, there are many possibilities on how this robot can be designed and implemented to perform those funcionalities; for example:

– A small desktop static robot that can be portable and which mainly interacts by voice and visual aids.
– A mobile robot with wheels, able to navigate in a house or nursing facility.
– A soft, tender looking robot, such as animal-like or baby-like which mainly interacts by touch and non-verbal sounds.

For each type of robot, it can be decided which subset of scenarios to implement, since not all of them will be possible for every type (i.e. a static robot cannot implement a scenario in which mobility is required). Besides, there are also other factors which must be considered, such as the technical viability of each scenario or the main social and ethical limitations they present.

This section presents a **feasibility analysis of the scenarios**, which can be used as a guideline to decide which ones to select for the construction of the first prototype of the SAR. Depending on the selection, the robot will have different characteristics and capabilities and many alternatives can be explored.

7.1 Technical requirements and limitations

In this subsection, the analysis focus on the main technical requirements for each scenario and the problems that may arise due to current technological limitations. There are two tables which help this analysis; first, Table 2 relates each scenario with its requirements and, second, Table 3 summarizes the main limitations for each technical feature. Following, each table is explained and further explanations are provided.

As the reader may have noticed, many of the scenarios share common requirements (e.g. safety scenarios need cameras, conversation scenarios require voice interaction, etc.). That is why this information has been synthesized in Table 2 by organizing it as a matrix: the scenarios in rows and the requirements in columns. Nevertheless, there is an extra column for those features that are very specific of one particular scenario so the table does not become unreadable. Besides, this table includes for each scenario if it can be implemented in a static or mobile robot (or in any of them). Although this is more a design feature than a technical requirement, it has a direct influence on them (i.e. if a robot is mobile, it needs navigation capabilities). Finally, this table also specifies how necessary a technical feature is to implement each scenario:

– if it is marked with "X", the requirement is mandatory
– if it is marked with "/", is an optional requirement (useful, but not essential)
– if it is left blank, the requirement is irrelevant for that scenario

With respect to the main limitations and challenges to carry out each requirement, these have been summarized in Table 3, including also which scenarios are affected by them. In order to simplify the table, the numbers of the scenarios have been used instead of the names. For reminding which number corresponds to each scenario, Section 6 can be consulted.

One of the most important limitations is related to voice interaction capabilities, specially in the case of the scenario where the robot and the patient hold a natural conversation. State-of-the-art dialog systems do not provide the same level of understanding and reasoning as a person does; thus, dialogs with the robot must be emulated with simpler tools such as chat-bots. This can lead to disappointment with respect to both, patient's and caregiver's expectations.

A similar technical constraint arises in personal assistance scenarios; nowadays it is difficult for a robot to supervise the realization of certain activities (i.e. assess if the patient has finished or if he has correctly performed or not an activity). For example, it is extremely difficult for a robotic system to asses if the patient has taken his medicines indeed. This limitation adds emphasis on the fact that the intended robot would be an aid but not a substitute for the caregiver, since the latter would still need to supervise the patient's activities.

Another technical limitation of the perceptual systems in robots is the capacity to reliably detect the anxiety of a person. Consequently, the *Reassuring AD Patient when is Alone* presents an important technical challenge.

7.2 Social limitations and concerns

This section takes into consideration the characteristics of AD patients and the different concerns related to social, psychological and ethical factors. These limitations where pointed out by some of the experts during the meetings, specially by the psychologists.

These concerns are summarized in Table 4 for each of the scenarios. Nevertheless, a further explanation of the most relevant ones follows.

First of all, the main concerns of those scenarios where the robot is mobile (*Mobile Vigilance*, and *Mobile Location of Objects*), it may happen that the patient dislikes being followed. According to the comments received from the caregivers, the patient could feel pursued by the robot and consequently would become uncomfortable with its presence. Moreover, the robot can even become an obstacle, which potentially could represent a physical risk for the patient.

Furthermore, some ethical issues also arise from the supervision and vigilance of the patient's tasks in private areas (such as the bathroom). This concern afects also other scenarios, but in the case of a static robot it is not so relevant since it only can be moved by the caregiver, thus controlling what the robot is watching at any time.

Apart from that, in the scenarios where the robot acts as an interface (*Interface with Home Vigilance* and *Interface with GPS device*), the need for a robot is not clear: the functionalities presented in both scenarios can be implemented by a home automation system and a GPS tracking system respectively. Therefore, the advantages of interacting with a real robot over a traditional system have to be shown. Moreover, in the case of the *Interface with Home Vigilance*, it requires to deploy sensors in the patient's house, with the alteration in the domestic environment that this entails. Besides, if the patient changes his residence, all the sensors should be deployed again, which may have some economic impact too. In the other case, the *Interface with GPS device*, the patient must wear a sensor; the caregivers and relatives alerted that AD patients do not like to wear foreign items so they will possibly remove it and lose it.

The *Affective Engagement* scenario has a different type of considerations: it can create in the patient a need to be permanently taking care of the robot and a feeling of uneasiness if he does not accomplish this task. Besides, this situation can affect the patient's behaviour with respect to his environment and make him neglect his social relations, worsening his condition. In addition, this scenario may require a robot with a particular external appearance and behavior. That is, a robot with a tender look asking for hugs and cares, might be different that one proposing activities to the AD patient.

Finally, the stimulation scenarios are very particular for each patient and must be carefully designed and studied by therapists; thus, although their technical requirements can be taken into account, the specific content of the exercises must be tailored for each patient before its implementation.

Scenarios	Main Requirements							
	Static / Mobile Robot	Body Movements	Voice Interaction	Visual Perception	Visual Display	Database	LAN or Internet Connection	Other requirements
1. Static Vigilance	Any	/	/	X			/	Portable robot
2. Mobile Vigilance	Mobile		/	X			/	Robust navigation
3. Interface with Home Vigilance	Any		/	/			X	Home automation sensors
4. Interface with GPS device	Any		/	/			X	GPS wearable
5. Static Location of Objects	Any	/	X	/	X	X	/	
6. Mobile Location of Objects	Mobile	/	X	/	X	X	/	Robust navigation
7. Reassuring AD Patient when he is Alone	Any	/	X	X	X	X	X	Videoconference capabilities
8. Activity and Major Events Reminder	Any	/	X	/	X	X	/	
9. Locate the Patient themselves	Any	/	X	/	X	X	/	
10. Make Simple Decisions	Any	/	X	/	X	X	/	
11. Answer Frequent Questions	Any	/	X		/	X	/	
12. Story - Telling	Any	/	X	/	/	X	/	
13. Active - Listening	Any	/	X	/	/	X	/	
14. Conversation between Patient and Robot	Any	/	X	/	/	X	/	
15. Games	Any	/	X	/	X	X	/	
16. Newscaster Robot	Any	/	X	/	/		X	
17. Multimedia Player	Any	/	X	/	X	X	X	
18. Affective Engagement	Any	/	X	/	/		X	Tender look
19. Psycho - Stimulation exercises	Any		X	/	X	X		
20. Physical Stimulation exercises	Any	X	X	/	X	X		

Table 2 Main requirements of each scenario. The mandatory requirements are marked with "X", the desirable with "/" and the irrelevant are left blank.

Requirements	Technical limitations and challenges	Scenarios
Static Robot	It cannot watch more than one room autonomously; it depends on the caregiver to move it to other locations. It can only indicate directions with voice or images	1, 5
Mobile Robot	Stairs, doors, carpets, present technical difficulties. It needs a map of the house and robust navigation to move around it	2, 6
Body Movements	In order to accomplish human-like movements, a robot needs many joints coordinated in a natural manner, what is difficult to achieve	20
Voice Interaction	Technical difficulties to understand what the patient is saying, specially if it is out of the predefined topics	5, 6, 7, 9, 10, 11, 12, 13, 14, 15
Visual Perception	Difficult for current perceptual systems to detect the emotion or mood of the patient or to assess the realization of his daily activities	7, 8, 12, 13, 14, 15, 16, 17
Database	The database must be programmable with several information about the patient: it has to be secure for his privacy and also easy to program by the caregiver	5, 6, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 19, 20
LAN or Internet Connection	Connection depends on external factors and may be lost. The quality of the signal may not be good in all rooms of the house	3, 4, 7, 16, 17
Home Automation Systems	If connection is lost, the robot won't be able to communicate with the sensors and cameras to know where the patient is	3
GPS Wearable	If the GPS wearable connection fails, the robot won't be able to track the patient outdoors and he can get lost	4

Table 3 Main requirements and their technical limitations

Main social limitations & concerns	Scenarios
Watching the patient in private rooms	1, 2, 3
Patient may dislike being followed	2
The robot may become an obstacle and the patient may stumble into it	2, 6
Alteration in domestic environment. System that cannot be moved to another house or facility	3
Patients tend to remove foreign objects such as bracelets	4
If a patient's object is not in its predefined location, the explanations of the robot will be useless	5, 6
The reaction of the robot may not suit the patient's mood	7, 13, 14
Difficult for the robot to assess the realization of an activity	8, 19, 20
Incoherence between patient's questions and robot's answers can lead to disappointment	5, 6, 9, 10, 11, 14
Patient can get bored, what is difficult to detect by the robot	12, 13, 14, 15, 16, 17
The bond between the patient and the robot could be demanding and stressing for him	18
Exercises must be designed specifically for the patient	19, 20

Table 4 Main social limitations and concerns extracted from the meetings and the list of scenarios which have them (identified by number).

Nevertheless, as it was stated in Section 3, in order to assess the usefulness of these scenarios, the best approach is to test them with patients and their caregivers in real environments.

8 Building a Prototype

In this section, considering the scenarios detailed in Section 6 and the issues raised in the feasibility analysis (Section 7), we present the technical requirements for a prototype SAR based on a set of selected scenarios (summary in Figure 9).

The first important decision to make for building a prototype is the type of robot to implement; mainly, if it is a static or a mobile one. Taking into account the technical limitations of mobile robots (see Table 3) and also the concerns presented in Table 4 (a mobile robot may suppose an obstacle for the patient), for the design of a first prototype a static robot is chosen.

This decision implies that the scenarios which require a mobile robot cannot be implemented; thus, the static alternative will be considered. Besides, as discussed in the previous section, there exist other scenarios which present other concerns (for example, *Interface with Home Vigilance*) or technical difficulties, such as *Reassuring AD patient when he is alone*.

Taking this into account, the initially selected scenarios are:

- Static Vigilance
- Static Location of Objects
- Activity and Major Events Reminder
- Locate the Patient themselves
- Make Simple Decisions
- Answer Frequent Questions
- Story-Telling

- Active-Listening
- Games
- Newscaster Robot
- Multimedia Player

As the reader may observe, this subset is obtained by extracting from the initial scenarios those which present less important concerns. This first selection does not imply that these scenarios are more relevant than the others, but are a point to start with and create a prototype based on them. This prototype will be tested with AD patients (as explained in Section 3) and it will incorporate more scenarios and functionalities as the technical challenges are overcome and the preferences of AD patients are stated.

Although it is not included in the initial selection of scenarios because the specific exercises have to be tailored for each patient, we have also taken into account the *Physical Stimulation Exercises* scenario for the design of the first prototype. This is because, as it can be seen in Table 2, this scenario requires that the robot has body movements, which are also useful for other scenarios. In order to leave the robot prepared for future improvements, this fact is considered for the technical requirements.

The following subsections analyze the the aesthetic aspects and technical requirements for a first prototype, based both on the aforementioned subset of scenarios but also on the general considerations established during the meetings (i.e. the non-functional requirements).

8.1 Aesthetic aspects

As it was discussed in Section 7, one of the first conclusions from the meetings and the scenarios discussion is that a static robot platform is preferred over a mobile one. The main reasons are that a mobile robot can be an obstacle for the AD patient and it also has more technical limitations. Nevertheless, despite situating the robot on a static base, it should be designed to be portable, so it can be moved among different locations inside the house or the care facility.

This static base does not have to diminish the expressiveness of the robot. As it is a social robot which main goal is to interact with the user, it is important to endow it with a great expressiveness. For this purpose, it can be equipped with various degrees of freedom to allow a wide repertory of gestures and movements and with lively eyes.

The external appearance of the robot was also discussed during the meetings and the attendees agreed that its look should be as friendly as possible. Although no external design was decided, one of the proposals was to take as reference the social robot Maggie [18]. Most of the caregivers and therapists that attended the meetings seconded this proposal. This means that our first robot prototype will have a head, 2 arms, and a body (some sketches are shown on figures 5, 6, 7, and8).

The size of the robot is a key issue too. Considering our previous experience with Maggie, such a big robot can sometimes be detrimental for the social interaction. This is because some users are fearful of the potential injures that can be caused by these big robots. Moreover, considering that the robot has to be easily carried from one room to another, the size and weight can not exceed reasonable values. Then, the height and weight of the robot should be limited in order to be able to carry it in one's arms. Taking into consideration the aforementioned, a first design would be a light, portable, desktop, robot, anthropomorphic (head, body, and 2 arms), animal-like or cartoon-like which can be easily moved by one person among several locations.

8.2 Hardware specifications

In order to fulfill the requirements of the selected scenarios, several hardware components are necessary according to the capabilities of the robot. Next, we list the required functionalities to implement the selected scenarios and the hardware devices needed to develop them.

1. **Surveillance of the AD patient:** This functionality is limited to the room where the robot is placed. As a first approach, it was considered to attach sensors to the patient. However, the experts warned that the AD patients may try to remove any *foreign* item from their body. Therefore, the included sensors have to be naturally carried by the patient so they do not cause him any annoyance.
   A different approach would be placing the sensors inboard. Since the patient can be located at any place of the room, visual sensors seem to be an appropriate solution. The well-known 3D scanner Kinect can perform this task. However, due to its narrow viewing angle, the whole room is hardly covered. This can be solved by the inclusion of the motorized waist of the robot for instance. By means of it, the robot would able to perform a scanner of more that 180 degrees with the Kinect sensor located on its body.
   In addition, a standard camera could be added in the head of the robot for the identification of the AD patient during close human-robot interaction.

In conclusion, the data derived from the combination of the motorized Kinect and the standard camera allows the tracking and the identification of the AD patient.

2. **Natural interaction** Most of the AD patients are elders without any background on technologies. Consequently, the interaction between the AD patient and the robot must be as natural as possible. That is, the human-robot interaction must be similar to the human-human interaction.
   In this project we consider two natural ways of interaction: verbal and tactile. In relation to verbal communication, in order to achieve a dialog, the robot must be endowed with microphones to "listen" and speakers to "talk". This components should be placed in the robot because, as mentioned before, patients do not like to carry *foreign* items.
   On the other hand, the robotic platform has to be able to react to the contact of the patient. Therefore, it has to be equipped with a sensitive skin. This can be achieved by a set of tactile sensors spread over the surface of the robot. Moreover, the robot can be pushed, lifted, or shaken. Then, by means of a 3-axis accelerometer and gyroscopes, this situations can be perceived.
3. **Visual interface** Several scenarios need to show multimedia content or aid the interaction with a visual interface. For example, when the patient asks for a particular object, some information related to this object can appear on a screen; or, the caregiver schedule the reproduction of a film or family tapes. Different approaches can be contemplated, such as using a display or even a projector, depending on the economic budget available. One of the cheapest and easiest solutions would be to use a tablet controlled by the robot where videos, audios and pictures could be played.
4. **Expressiveness** The quality of HRI is highly dependent on the bounds between people and robots. In order to improve it, the capacity of expression of the robot is crucial.
   One of the capabilities of the robot should be having some degrees of freedom that favor the interaction, specially taking into account some scenarios such as the **Physical Stimulation Exercises** one. Being a small desktop robot, with only the upper part of the body, these degrees of freedom could be movements of the head and neck, of the arms, or rotation of the torso. Those can be achieve by means of different servomotors, which allow to control their position and are being used in many similar robots.
   The eyes of the robot are also crucial to provide expressiveness. A possible implementation to achieve this goal could consist on two small squared LCD screens placed in the head of the robot. In these screens, different eyes with different emotional baggage can be easily displayed. Besides, these screens permit also showing different orientations of the eyes, allowing the robot to follow the user with its gaze.
   Besides, another technique that could be used to improve expressiveness would be placing various luminous devices, such as RGB leds, in certain parts of the robot's body. This allows to express several emotional states through different colours, or even communicate an alert for example in scenarios where the robot watches the patient.
   Moreover, the voice of the robot is also crucial to achieve a high degree of expressiveness. Since the majority of the interaction needed for the proposed scenarios is by voice, the sound system of the robot should permit a clear, good-quality utterance, in order to minimize understanding problems.
5. **Network** Some functions of the robot require a high speed Internet connection. At least, the Internet connection has to reach an seamless streaming media reproduction. Other Internet-based applications do not required a higher speed connection.

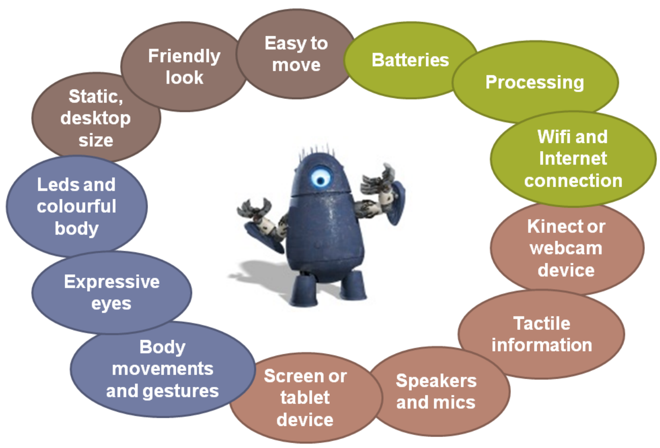

Fig. 9 Summary of the technical requirements of the SAR

8.3 Software specifications

Like the hardware specifications, there are several software elements which are needed to implment the scenarios. Following we list them.

1. **Natural interaction based on multi-modal dialogs** Likely, the key aspect to success in this project is the achievement of a reliable natural interaction.

This implies natural multi-modal dialogs, i.e. dialogs based on several ways of communication which can be easily understandable by people. For instance, if the robot wants to say *hello*, it can do it either by voice, by gestures or both at the same time.
By means of a multi-modal dialog manager, the robot is able to understand what people are saying, or why people are touching the robot. The robot is also able to detect when the AD patient is talking or muted, if he is close or far away, etc. Moreover, the robot can show a richer expressiveness by modulating its voice in order to express different emotions and moving its degrees of freedom accordingly. Non-verbal sounds, such as brething or coughing, are also paramount to endow the robot with some liveliness.
The dialog manager will be applied to calm down the AD patient when the caregiver is not present, to answer questions from the patient, and, in general, to every single communication act.
2. **Friendly interface for caregiver** Recalling, the robotic platform in this project is considered as an assistant for the AD patient caregiver. As it was introduced in Section 5, among the general considerations discussed in the meetings, the caregiver must be able to customize and program certain activities (play films, audios from the old times, medicines reminder, etc). In addition, the caregiver usually does not have technical knowledge. Therefore, there must be a friendly interface where the caregiver can configure the robot to the best of its convenience.
3. **Communication with the caregiver** One of the main concerns the caregivers expressed during the meetings was the fact that patients tend to get angitated or nervous when they are alone. Thus, the scenario *Reassuring Robot when AD Patient is Alone* is aimed at allowing the caregiver to communicate with the patient at any moment (even if he is outside the house). To achieve it, the robot must be endowed with video-conference capabilities. Then, independently of where the caregiver is, it is possible to establish a video-call to monitor the patient when an alarm is triggered, or to comply with the desires of the patient in case he is demanding the presence of the caregiver. For this functionality the robot will have to use the audio output and input, the visual device or screen to display the video, and a camera.
4. **Base of knowledge** Most of the skills developed by the robot rely on an important base of knowledge. This knowledge represents the "intelligence" of the robot and it is highly dependent of each patient. In short, the robot will need the following personal data for each AD patient:
   * Information about the patient, such as his name, age, gender, etc.
   * Knowledge about the relatives: pictures, previously taped audio messages, details for video conference call.
   * Information about important objects for the patient (details, location, route, etc.).
   * Possible locations of the patient (current location, functionality, relative location).
   * Frequent repetitive questions.
   * Repertory of stories the patient likes to listen.
   * Information about stories the patient likes to tell (about his life, his family, his jobs, his loves, football, etc).
   * List of events for the schedule of the patient: periodic tasks (eating, dressing, drug timetable), or activities such as playing videos or music.
   * Sources from Internet: the AD patient likes particular news, videos, tv shows (current and old), films, religious events (e.g. mass), music, sound recordings from the old times, commercials, and so on. The reproduction of these resources are pre-programmed by the caregiver.
5. **Teleoperation of the robot** In order to be able to test the functionalities of the robot in different environments and with different AD patients and their caregivers, it is useful to provide a way to teleoperate it. This can also permit doing some *Wizard of Oz* experiments in order to evaluate a new functionality before implementing it.
Moreover, such tool can also be used by caregivers or even therapists to communicate with the patient through the robot, to allow remote control if the therapist cannot be in the patient's home at some point, or even because the patient may be more receptive to the robot suggestions than to his carer's ones.

9 Conclusions and future works

In this paper we have presented the results from the first phase of the *RobAlz* project. They consist of the definition of a set of scenarios where a SAR can assist AD patients in the mild stage and their caregivers, improving their quality of life.

One of the strongest challenges of this project is to achieve the acceptance of the robot by the professionals and caregivers of AD patients. In particular, one of the main concerns of the caregivers was the possibility of being replaced by a robot. However, we clearly stated that the robot is intended to help and provide them with some time for attending their own needs.

From the beginning of the project, several meetings took place with subject-matter experts, including caregivers and therapists, so the real needs of both patients and carers would be taken into account for the definition of the funtionalities and requirements of the robot. The results of the meetings ended up in a repertory of useful scenarios where the robot can be applied to assist AD patients and their caregivers. These scenarios are divided in the fields of security, personal assistance, entertainment and stimulation.

Nevertheless, some general considerations common to all the scenarios include the fact that the robot must be tailored for each AD patient, so it can really be helpful and entertaining. The customization of the robot relies on the information provided by caregivers, relatives, or physicians to create the needed base of knowledge.

Besides, although many appearances could be considered, such as animal-look or cartoon-look, in general terms, the attendees to the meetings agreed that the robot should have a friendly look which invites to interact with it and does not cause rejection.

All these questions, and many others, will be answered by empirical tests with AD patients and caregivers. This is the goal of the third phase of the *RobAlz* project, after the new SAR is designed and built (second phase).

These evaluations are specially important in a project that deals with AD patients, who could not be involved in the initial meetings since their cognitive impairment prevents them from abstract thinking or the ability to fix their attention for a relatively long time. Hence, it is essential to develop a robotic prototype to evaluate the scenarios, the AD patients' responses, and see if they find it engaging and useful.

In order to do so, an initial subset of the most feasible scenarios has been selected in order to develop a first prototype. For that purpose, the main requirements and limitations of each scenario have been discussed, taking into account also social and ethical concerns. This subset of scenarios has served as a base to obtain the technical requirements for the design of the prototype. These requirements are the starting point of the second phase of *RobAlz* project, where we are currently constructing the robotic prototype. It is important to remark that this is an ongoing project, so it is foreseeable that some of these technical requirements evolve with the project after the initial evaluation with users is done.

With the current work we have provided an starting point and the initial considerations that other researchers may take into account when designing a robot to assist AD patients and their caregivers. All the results from the empirical tests with the robots implementing the different scenarios and considerations here presented will contribute to the future of SAR for people with special needs such as these collectives.

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