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Assistive Technology for Elderly Care: An Overview

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ABSTRACT Global demographic changes have resulted in a growing technological demand to meet the arisen social needs. In particular, the increasingly ageing population requires assistive technologies to stay at home for longer independently while receiving continuous healthcare. In this sense, a wide academic and industrial research is taking place, introducing these technologies in hospitals and rehabilitation centres. This paper aims at providing an overview of research projects for elderly care and assistance, focusing on cognitive and robot assistants due to their popularity in the area. More precisely, physical and/or cognitive rehabilitation are presented. This paper also discusses their limitations and the open challenges to be tackled in order to be successfully integrated in our society.

INDEX TERMS Assistive technology, cognitive assistants, robotics, healthcare.

I. INTRODUCTION

Recent studies from United Nations show a demographic change due to an increase in elderly people in front of a decreasing amount of births [1]. This fact leads to diverse socio-economic issues like the inability of families and government to support medical costs and overburden medical services. In addition, medical advances have led to a longer life expectancy without reducing the age-related diseases (e.g. hypertension, osteoporosis or Alzheimer). As a result, elderly people are forced to live in nursing homes, even when they desire to keep an autonomous and active life [2].

With the aim to mitigate these issues, technology may be a cornerstone providing assistance and, consequently, allowing elderly people to safely and independently stay at their homes. Nonetheless, there are still adverse feelings towards these technological solutions since elderly people often refuse to use them, even in case of a great improvement in their quality of life and well-being, as pointed out in the study presented by Baisch *et al.* [3]. Thus, the key for success is to properly introduce these technologies to the elders and their caregivers, while providing a tailored solution that properly addresses their needs and expectations.

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Keeping in mind the requirements for the elderly acceptance, the proposed technological solutions must be carefully designed to be easily integrated into the elder's life. Thus, it is essential to correctly identify the platform goals, specially in terms of assistance, as well as the environment to interact with. In this sense, several studies have been carried out with the purpose of analyzing which features make a technology be accepted. So, for instance, Etemad-Sajadi and Gomes Dos Santos [4] conducted a study with 605 seniors to evaluate their acceptance of connected healthcare technologies in their homes. From that, they concluded that the degree of usefulness, trust and intrusiveness played a main role in the elder's acceptance of these technologies. Another aspect to be taken into account is the social capabilities of the developed technology since they significantly influence in its acceptance [5], [6]. From a robotic point of view, Cha *et al.* [7] concluded that the acceptance levels are tightly related to the robot features, preferring robot assistants to just task performers. However, the negative perspective portrayed by movies and television shows, puts up an initial barrier in the acceptance of robot assistants [8]. For their part, Hebesberger *et al.* [9] observed that the elders were open to use robotic assistants when they were correctly advised and guided by their caregivers, highlighting that most of the acceptance problems came from the caregivers.

Therefore, the developed technologies should be useful, social and easy to use. Using the division provided in a previous work [10], according to its usefulness and social component in elderly care, technological assistants can be fitted into two categories:

- **Medical or rehabilitation assistants**: designed to assist in medical tasks with little social features (like complex communication);
- **Social assistants**: designed to engage the elderly by means of high-level conversations while helping them perform simple tasks.

In this context, two technologies have mainly emerged: Cognitive Assistants (CAs) and Personal Robot Assistants (PRAs). Both technologies have a user-centred design aiming at:

- Allowing elders to live in their preferred environment by increasing their autonomy and mobility;
- Up-keeping the health and functional capabilities of the elders;
- Engaging the elders in a better and healthier lifestyle;
- Keeping the elders secure and accompanied;
- Supporting caregivers, families and care organizations.

The main difference between CAs and PRAs lies in the hardware they use such that the first ones use appliances to interact with the user like smartphones or smart-televisions, while PRAs use robots.

From this starting point, this paper presents an overview along with a discussion of multi-domain developments aimed to meet the societal needs for allowing elderly and disabled people to independently stay at home for longer. For that, an in-depth research was performed such that a selection of research projects covering different spectres of the two considered technologies ready to be used, is presented. So, the rest of the paper is organized as follows: Section II describes technologies aimed to develop systems with more care functionalities; Section III describes the new advances about social abilities; Section IV discusses the limitations of the overviewed technologies and outlines the open challenges to be pointed out for a successful societal integration; while conclusions are presented in Section V.

II. MEDICAL OR REHABILITATION ASSISTANTS

A significant part of elderly population suffers from some sort of physical and cognitive impairment. As a consequence, technologies complementing and strengthening healthcare services have gained great interest in the literature. So, the underlying idea in these developments is to reinforce the elder's autonomy, decrease their vulnerability and improve their physical and cognitive condition, while respecting their privacy. In this case, the social component is quite limited.

This is the case of PersonAAL [11], a cognitive assistant for physically active lifestyle that uses wearable sensors to remotely measure the vital signs and assess if there is a decay in the elder's health status. With the aim to encourage the elder, PersonAAL is dynamically adapted from an Exercise Motivations Inventory (EMI) questionnaire together with the elder's biosignal data. So, different suggestions in the form of health-related messages and articles, motivate the elder to maintain an active and healthy lifestyle. In addition, these suggestions can be adjusted by the elder's caregiver. Regarding the monitoring of the elder's health status, PersonAAL provides the caregiver with supervising tools and reports about the elder's health condition, as illustrated in Figure 1. An advantage of this platform is its possibility to be integrated with external tools such that its visual interface can display each sensor or service value with just a simple configuration process. Similarly, the monitoring content is also directed towards the caregiver, giving insightful information about the care-receiver health status. The authors have conducted a 7-participant study which has resulted in a general acceptance (an overall average of 5 in a 1 to 7 scale) by the elders, although some (not specified) have complaints about the interfaces' usability. This is an important disadvantage since all the interaction takes plays through the interface. In addition, due to the difficulty in correctly put wearable sensors, false alarms and wrong data could be generated.

Along this line, Emerald [12] is focused on the physical aspect of an elder. In this case, the data of a wristband is used to estimate the level of elder's stress and emotion (with still a medium level of accuracy) when performing physical exercises. This kind of sensors is easy to put, overcoming the issue of false alarms and wrong data present in the previous project. However, the exercise monitoring is considerably restricted given that a wrist sensor is not able to provide information about all the body parts involved in the done exercise. With that aim, this cognitive assistant shows the elder how to perform each exercise and warns them if they are performing badly or are reaching peak levels of stress, as seen in Figure 2. This is powered by a suggestion platform based on the iGenda project [13] that gathers the information about the performance of each exercise and, thanks to machine learning methods, adjusts the set of exercises to each elder, providing the caregivers with regular reports about the elder's health condition and exercise performance. In the paper, the authors claim that they are conducting a study with elderly people, but the data was not available at the time of publishing.

[14]–[16] approach and study the domain of Ambient Assisted Living (AAL) with the aim to improve the elderly's quality of life and support them with daily activities. While this is not specifically a project related to an assistant, it touches in an important aspect of the real-world implementations, such as early intervention at home or minimization of the health long-term consequences.

Going a step further, PHAROS [10], [17] removes the need of wearable sensors. This combination of a robot and a scheduling/suggestion system allows monitoring elders while performing physical exercises and correcting their posture in real-time. To do this, it uses a commercial Pepper robot as the visual actor of the platform, which is a friendly looking medium-stature robot. So, the robot is in charge of engaging the elder into performing exercises by interacting with

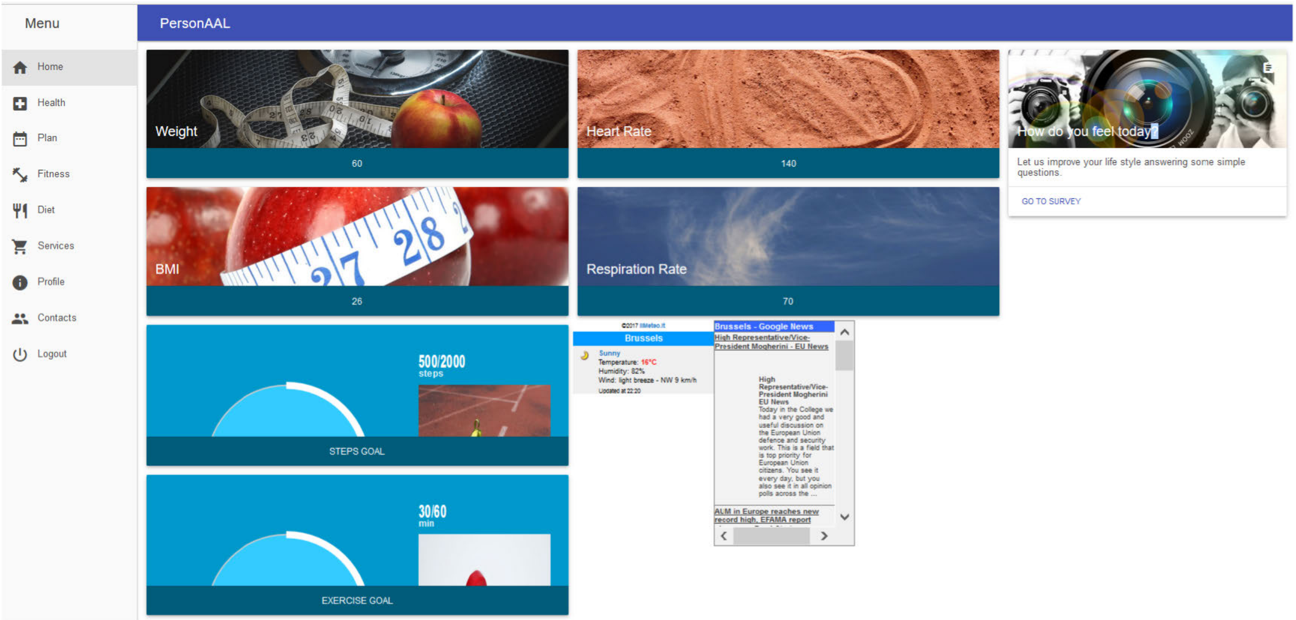

FIGURE 1. PersonAAL user (left) and caregiver (right) interfaces [11].

them and encouraging them with positive messages. It only uses the robot's cameras to extract body and limb placement and automatically detects when an exercise is started and stopped, resorting to Deep Learning methods to achieve high accuracy values. In terms of the scheduling/suggestion system, PHAROS learns each elder's limits from the continuous gather of information, adjusting the set of exercises to the ones each elder is able to perform and scheduling them in key hours of the day. Additionally, it provides the caregivers with a configuration portal where they can adjust the platform settings to each elder and proactively notifies caregivers of possible physical problems, by contrasting the decay levels with certified clinical guidelines. In the paper [10], an acceptance study with 8 elderly persons is done. The data collected about their opinion about the exercises and interaction is very positive, an 4.5 of 5 (average).

Other kind of physical rehabilitation refers to speech therapy sessions. In this context, Castillo *et al.* [18] proposed a social robot to guide in Apraxia rehabilitation such that it focuses on improving the planning, sequencing, and coordination of muscle movements for speech production. So, a friendly companion robot advises the user (elder or others) without any judgement, while evaluating their performance and correcting them when necessary. For that, two stages are required: the first one is aimed to detect and normalize the elder's mouth information in order to properly train a set of parameters; while the second stage consists in capturing the mouth movements and evaluating its key-points through Deep Learning methods to properly carry out the therapy sessions. In this case, no study about its acceptance and/or its use in a real environment has been performed. Moreover, this system can only be used under the supervision of a professional.

From a cognitive point of view, CoME [19] allows an early detection of Mild Cognitive Impairment (MCI) development based on the presence of risks as well as anomalies in behaviours. With that aim, a mobile platform with different functionalities to improve and manage the elder's personal life is designed. As illustrated in Figure 4, this mobile platform includes cognitive games, health status monitoring (supported by wearable sensors) and suggestions for a healthy lifestyle. In addition, the elder is frequently prompted with questions about their daily activities and life events and knowledge. As previously, false alarms about the elder's health status can be provided due to a misplacement of the wearable sensors. Another negative aspect is that no study about its use or acceptance has been provided.

For their part, caregivers and relatives receive personalized reports about the platform usage, the elder's health status and their progression. Apart from that, professional caregivers can create tutorials to guide and support relatives and informal caregivers in their assistance tasks.

When Traumatic Brain Injury (TBI) is considered, MyMemory [20] could be used. This mobile augmented memory system aids elders in recovery from their memory impairments and, more specifically, from their autobiographical memory deficits. This is achieved with the combination of a scheduler and a game. Thus, each elder or caregiver can easily schedule reminders of a later date or a daily activity. That is, the elder is able to insert an eventful memory in the application and categorize it accordingly, as shown in Figure 5 a). Then, this memory will be used in the flashcard visual interface (see Figure 5 c)) such that the brain is stimulated to remember that event by exercising the elder's short-term memory. In addition, caregivers are also able to record memories in the application by sending an email,

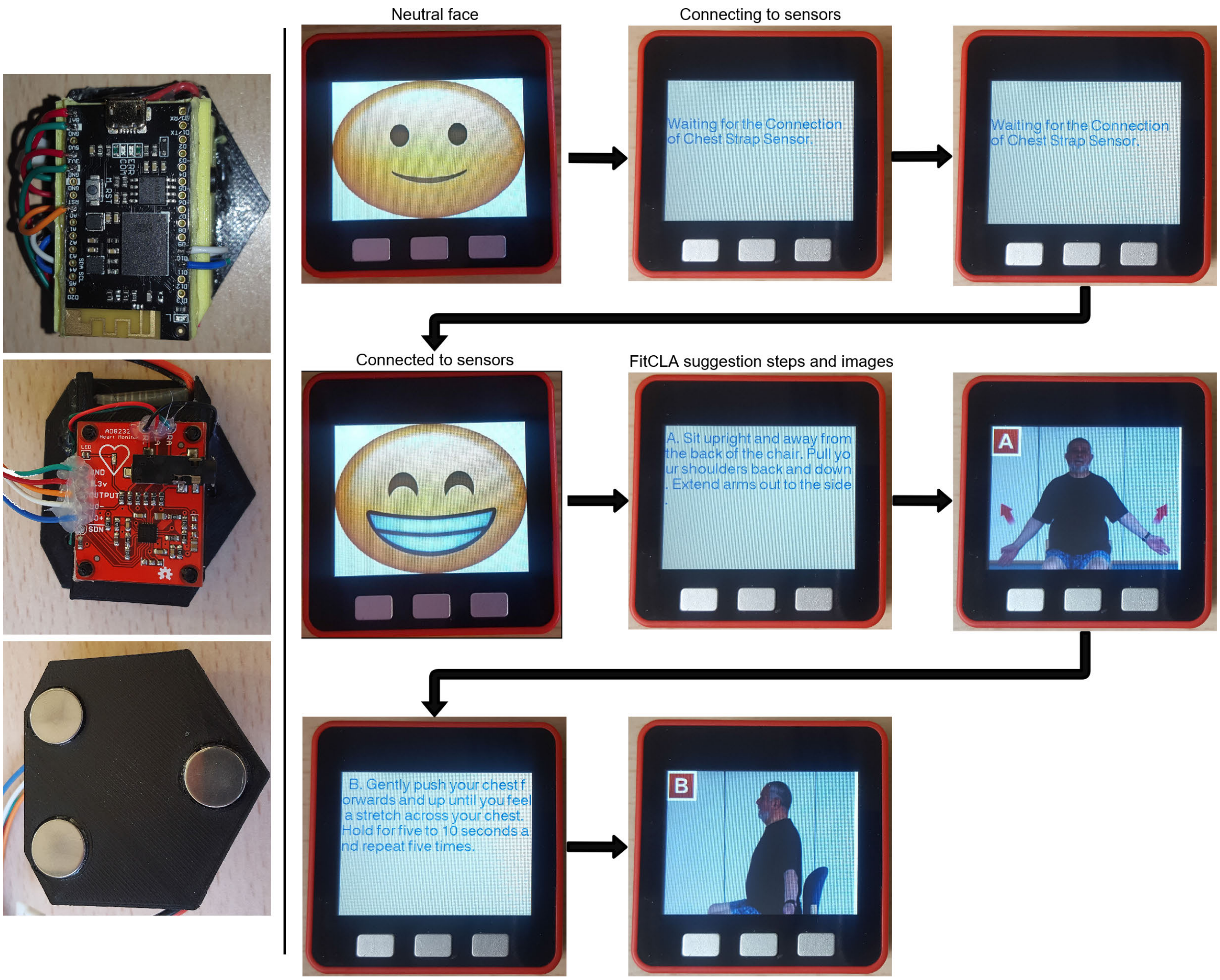

FIGURE 2. **Emerald wristband prototype and visual interfaces [12].**

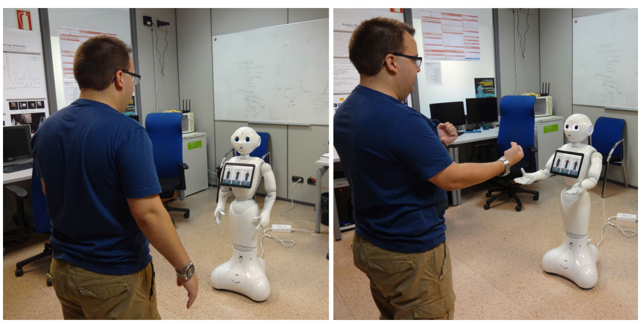

FIGURE 3. **A sample of rehabilitation session by using PHAROS [10].**

as displayed in Figure 5 b). This will also be used in the flashcard exercises.

The results of a conducted study seem promising as care-receivers have said that their memory function and autobiographical memory had improved along with their well-being and most of the 6 participants have accepted the application (after using it for 8 weeks). Nonetheless, care-receivers showed a general neutral feeling towards the application as it did not reduce their work and demanded more pro-activity, by regularly requiring inputting information in the application.

Alternatively, cognitive and physical aspects could be considered simultaneously. This is the goal of StayFit-Longer [21], a research project focused on physical and cognitive exercises for the elderly with the purpose of keeping them active for longer. For that, it suggests gamified activities and serious games through mobile devices. In addition, virtual reality is used for assisting and explaining the exercises to the elder, engaging them in the activity. Its utility and design has been validated by 128 people aged 60 and over from different European countries.

Figure 6 shows a range of different interfaces related to cognitive and physical exercises that have been adapted to the elder's dexterity and impairment levels. Although, at first glance, it may seem that this is no more than a multi-game application, it innovates by allowing the personalization of games and exercises, including an in-game chat system that

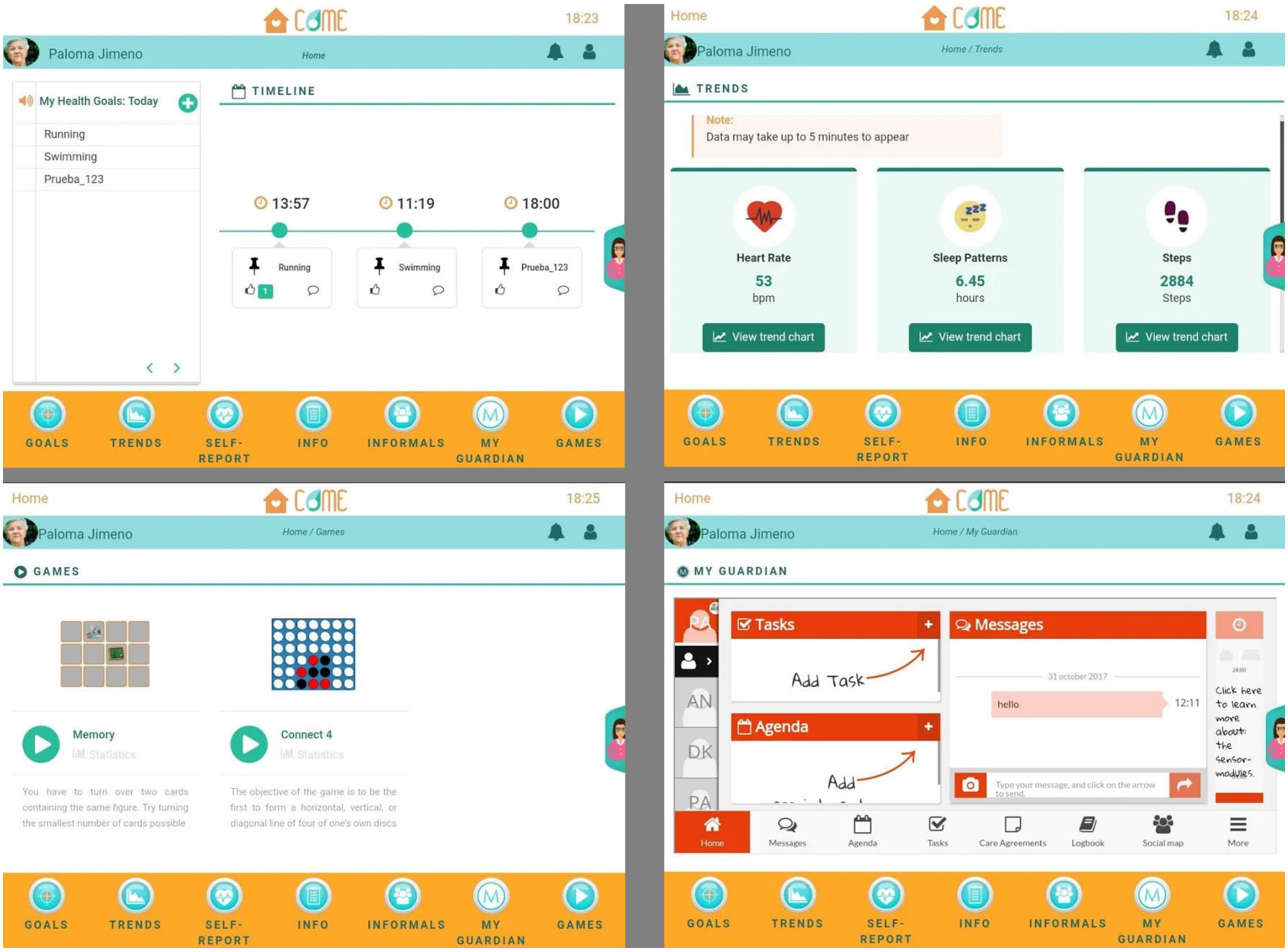

FIGURE 4. CoME visual interfaces [19].

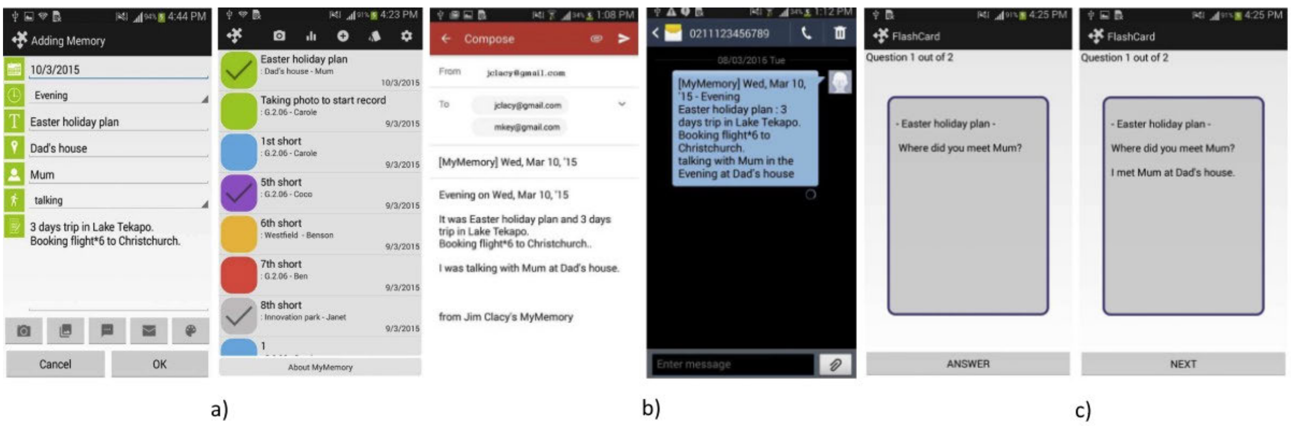

FIGURE 5. MyMemory visual interface: a) user event creation, b) caregiver event creation and c) flashcard exercise [20].

elders can use to communicate and share items, and obtaining items that are only available through continuously game playing and game achievements.

III. SOCIAL ASSISTANTS

Social assistants are endowed with social abilities together with their utility. This fact can aid the elderly in mental and psychological issues such as isolation, affect, stress and solitude, improving their welfare at great extent.

In this context, we can find Mabu [22], a personal healthcare companion robot released in 2015. Its main goal is to aid elders to manage the several issues related to chronic diseases as medication intake. For that, it has been provided with a friendly, social personality together with therapeutic actions

FIGURE 6. StayFitLonger visual interfaces [21].

learning features. So, from the social interactions with the elder and based on classic behavioural models of psychology, Mabu is able to create personalized conversations designed for each user. By introducing small nudges and positive enforcement without negative phrases, the authors believe that the elderly will accept and adopt the platform suggestions in their daily life. Note that, although issues related to chronic disease are implemented, no monitor actions take place. So, it acts more as a reminder than as assistant since its cornerstone is the social component. Furthermore, given that no data is gathered, any report about the elder's health status is provided.

Focused on elderly care, researchers from the College Trinity Dublin developed Stevie [23], a human-like robot able to engage in social interaction through a combination of gesture, speech and facial expressions, as shown in Figure 7. After a positive and promising evaluation over several focus groups, this robot is provided with the necessary social abilities required to accompany elder people, while improving their well-being. Among its functionalities, it can be found the reminder of the time for medication take, or assistance for the access to certain technologies. However, as pointed out by the authors, there is still some work to be done to achieve a robot to autonomously keep a small talk on any topic. A study using combined 34 persons that were able to interact with the robot for about a period of two hours reveals that the acceptance levels are high (74–95%). It is worth mentioning that sensory data is used to better interact with its environment and people, but there is no monitoring activity, what considerably restricts the assistive tasks.

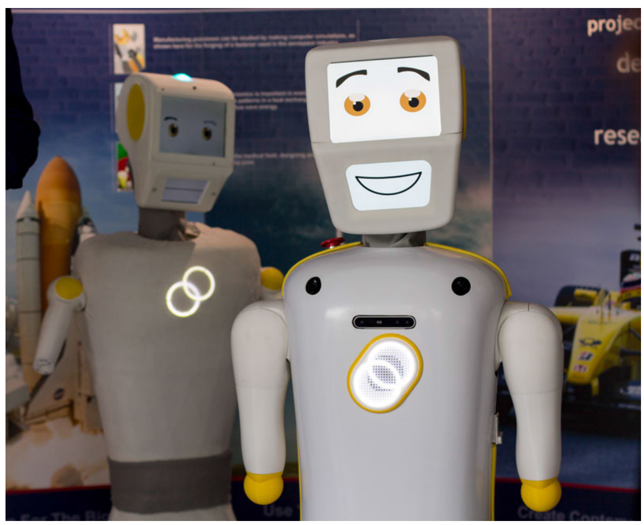

FIGURE 7. Stevie robot from the College Trinity Dublin [23].

In terms of cognitive assistance, LIZA [24] is a cognitive assistant aimed to improve the elder's reasoning and decision-making abilities. For that, its interactions via text-based natural language (about 66 topics) are the means to teach the elder about one or various topics, auto-correcting its guidelines in a subliminal way by asking composed questions and adapting to each elder's needs in each interaction, as shown in Figure 8.

This technology was tested with mostly higher-education graduates (65 subjects for a period of 45 minutes) and the results were very promising since the students' qualifications

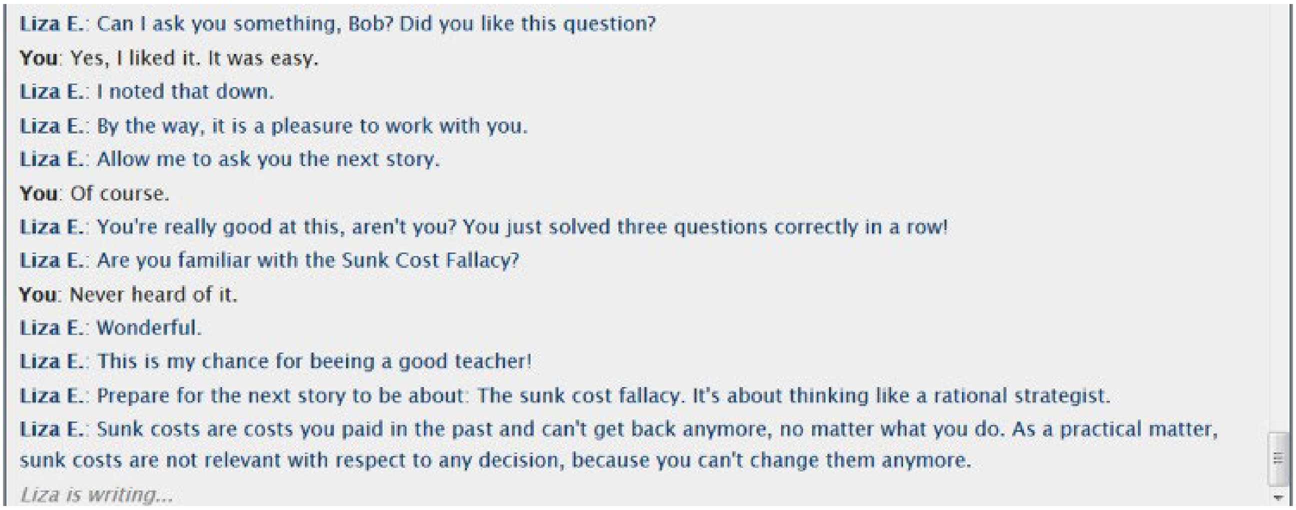

FIGURE 8. **LIZA text-based interface [24].**

were improved when LIZA was used (about 10 to 20%). A side effect was the fact that students rebutted the information provided as most of them questioned thoroughly about the reasoning LIZA's procedure. Consequently, it is unclear what is the true improving factor, the direct help of LIZA or the research done by students to rebut LIZA's arguments.

Another example is the work of Andriella *et al.* [25] who presented a Socially Assistive Robot (SAR) to motivate and encourage elders about specific tasks or cognitive exercises like Syndrom Kurztest neuropsychological battery (SKT), from a productive interaction. For that, the developed robot interacts with the caregiver in order to set up the elder's mental and physical impairments and indicate the exercise goal. Then, the robot interactively plays a game with the elder suffering from MCI. The robot uses cameras to monitor a *replacing-blocks* game board and can use its arm to correctly place the game pieces, helping or correcting the elder's mistakes. Note that, although the initial personalisation provided from the initial interaction with the caregiver, the robot can adapt to different elder responses and provide support and assistance at different levels of the interaction. In the paper, the authors present results of simulations with synthetic user, thus further testing is required to access the real acceptance levels.

Another application in this context is the use of a social assistant to facilitate human-to-human engagement in an older community. So, Ostrowski *et al.* [26] conducted a three-week study at a California-based assisted-living community with a total of nineteen participants. In this case, they used Jibo [27], a commercial social robot designed for assistance and attendance to people as a helpful companion. So, all the community members (participants or not) could freely interact with the robot every weekday while social connection were analysed. Their results evidence that social robots can successfully enhance people engagement and social connectedness. However, they also reveal security and privacy concerns, fear and collective worry about social robot technology. In addition, they highlight the need of using different design tools for older people with different cognitive and physical abilities to make the social robot appropriate for each one. In terms of numbers, the authors have conducted a study with 19 elderly people, exposing them to the robot for 3 weeks. The result is that, overall, 53% enjoyed the company of the robot and would like to continue interacting with it.

IV. DISCUSSION

The socio-economic change suffered in the last decades has led to a growing social demand to properly attend an ageing population. In this sense, Sander *et al.* [28] defined three main challenges: optimize the retirement age, retain a high level of physical and mental capacity in late stages of life; and provide elderly people with the opportunity to live with purpose and dignity. With that aim, academic and industrial research is actively developing technologies to properly carry out the required assistance. In particular, this paper has overviewed some recent advances in cognitive assistants and personal robot assistants, covering the last two Sander's challenges. Table 1 shows an overview of each project's positive and negative aspects, while Table 2 compares them.

Starting with physical rehabilitation, three different systems have been introduced: PersonAAL, Emerald and PHAROS. Although all these systems are aimed to be autonomously used at home, their technology is different. So, while PersonAAL and Emerald use wearable sensors to evaluate the elder's health status and physical activity, PHAROS only use the visual input. It is important to highlight that the usage of wearable sensors may result in several error measurements when they are misplaced. Therefore, it is crucial to be accurately placed in the body for a successful therapy. However, this cannot be guaranteed when an older person alone is in charge of putting themselves the sensors. Furthermore, as these technologies are not intended to replace the healthcare personnel, but instead to support and assist them, daily reports about the done physical activity and its

TABLE 1. Projects' positive and negative features.

Category	Projects	Positive	Negative
Medical or rehabilitation assistants	PersonAAL	Autonomous and home-based software platform that uses wearable sensors. These type of sensors are more accurate than cameras.	Lacks a more developed platform and focuses on collecting data from the sensors, rather than providing a robust platform. Visual interfaces only present minimal real-time data.
	Emerald	Autonomous and home-based software platform that uses wearable sensors.	Although it provides useful information about the exercises' performance, it focuses on a unique task, monitor them.
	PHAROS	Autonomous and home-based software and human-like robot platform that uses cameras. Elders can perform exercises without having to wear special sensors.	Has limited features. Focuses on monitoring the exercises and provides information to the caregivers about them. The software platform is only able to schedule new exercises.
	Castillo et al.	Uses a robot to interface with humans. It features rehabilitation techniques for children and adults and intelligently values the interaction.	It only focuses on one task. The authors provide little information about the mouth-capture task, which is non-trivial. Controlled environmental conditions are needed as well as constant supervision by medical staff.
	COME	Uses a mobile platform to interact with the users along with wearable sensors. Interface provides cognitive games, daily routines and sensor information. Caregivers receive reports about the sensors and games score.	It has highly complex interfaces for the target users (elderly with possible MCI) and provides limited actions in terms of rehabilitation (only cognitive games). The information about the sensors is not used to analyse well-being markers.
	MyMemory	Able to be used independently, has easy-to-use interfaces and is designed for mobile phone, being serverless.	Its usability is restricted to a scheduling system and a flash-card game. Has two-way communication but no registry or log, thus there is no way to verify the progress of each user. Apart from the flashcards its assistant proprieties are limited.
	StayFitLonger	Presents carefully thought interfaces that are adjusted to the elderly. Has a large amount of engaging games that can be played directly on a tablet, and supports a domain-specific social network to share results and achievements.	Its domain consists only in cognitive or physical games. In terms of assistance, it main achievement is to adapt to the progress of the users and present recommendations. Does not have a caregiver counterpart.
Social assistants	Mabu	It is a simple and portable robot that is able to interact with the users using a incorporated screen, is able to have a modular and adaptive conversation with the users, cheering them if possible.	It is a tabletop robot, unable to move or have any type of anthropomorphism apart from its eyes. All interaction must be done using its incorporated tablet, requiring user's full attention and full control of their upper limbs.
	Stevie	Is an anthropomorphic robot that is able to show *facial* expressions (using a digital display), featuring events reminding and assistance through interaction in specific topics.	The software is quite limited to its domain and the assistance ability is reduced to predefined guidelines set by the authors. The robot has no ability to physically perform actions, it is limited to simple cognitive interactions and is unable to learn in real-time.
	LIZA	Has a large corpus of information and is able to rebut and discourse with the users about any topic in its corpus. Following classical conversation techniques, the assistant is able to challenge the users and even formulate jokes for pleasant interaction.	It is limited to its corpus and is unable to learn from previous interactions. The text is modulated according to specific algorithms and does not use any adaptive NLP methods. It consists in just a chat-like interaction. It is not clear that the users have directly benefited by the assistant or by studying to challenge it.
	Andriella et al.	It is medical devised and built with a single purpose, play a game with an elderly person and perform corrections when he/she has made a mistake. High-level detection of the objects and human hand, as well as accurate robotic hand positioning. Fast correcting methods and learning procedures.	Limited domain, it consists in just a set of cameras and a robotic arm. Does not have an ample communication ability, the interaction is just done by moving the game pieces. Due to its strength, constant supervision is required.
	Ostrowski et al.	High acceptance levels. Users show direct interest on the robot and its abilities. Most users would like to keep the robot as a companion.	Used a commercial robot with little control of its actions or features. The robot is social designed and although it has an enhanced communication ability, it is a tabletop robot, and it is unable to move or perform any type of actions.

evaluation is available for the healthcare personnel. Another aspect to be taken into account is that the three technologies are aimed to healthy elders in terms of cognitive abilities, what considerably restricts their use.

The following presented rehabilitation assistants are intended to specific diseases such as Mild Cognitive Impairment (MCI), Traumatic Brain Injury (TBI) or Apraxia. These focused developments can support the therapy sessions at great extent. In fact, all these technologies must be always used by healthcare professionals and the older person can only use it during the therapy sessions. This fact considerably restricts the usage of these technologies, hindering the elders' improvement at home or in an independent way.

For its part, StayFitLonger goes a step further and integrates cognitive and physical rehabilitation in the same system. This virtual reality platform is intended to be

TABLE 2. **Projects' comparison.**

Category	Projects	Advantages	Disadvantages
Medical or rehabilitation assistants	PersonAAL	Low cost sensors. Easy to use. User's adaptation. User's motivation. Possible integration with external tools. For elderly and caregivers. Report to caregivers.	No social component. Interface's utility. Wearable sensors (difficult to attach). No feedback is provided. Only for home.
	Emerald	Low cost sensors. Wrist sensor easy to attach. Report to caregivers. Easy to use. Stress considered. Feedback about user's performance. No supervision is required for its use. Rehabilitation exercises with an agenda application.	No social component. Less information about the performance. No motivation tools. No user's adaptation. No data about its used by elderly people. Only for home.
	PHAROS	Easy to use. No wearable sensors. Feedback about user's performance. Rehabilitation exercises with an agenda application. Social interaction for engagement and feedback. Exercise adaptation. Notifications of possible physical problems. No supervision is required for its use. Report to caregivers and relatives.	Limited social component. Expensive robot platform. For home and rehabilitation sessions. Requirement of an initial workout. No personal aspects like stress are considered.
	Castillo et al.	Social component. User's feedback.	Expensive robot platform. Only tested at laboratory. Professional supervision is required. Support tool only for therapy sessions.
	COME	Easy to use. Affordable cost (medium cost). Report to caregivers and relatives. Cognitive exercises, agenda application and user's health status supervision. Early detection of MCI.	Wearable sensors (difficult to attach). No social component. Support for a proper elder's assistance.
	MyMemory	Easy to use. Affordable cost (medium cost). Game and agenda application. TBI recovery.	No social component. No feedback or report is provided. Memories have to be added one by one.
	StayFitLonger	Low cost (mobile devices). Virtual reality for engagement. Physical and cognitive exercises. Personalisation of games and exercises.	No social component. *Rigid* adaptation to elder's dexterity and impairment levels.
Social assistants	Mabu	Easy to use. Cost (free of charge for patients). Personalised conversations. Extensively tested in real users.	No social component. Interaction through robot tablet. No data about user's use is gathered. No report is provided.
	Stevie	Social component. Easy to use.	Expensive robot platform. Aimed at nursing homes and retirement communities. Limited user's assistance: conversations, agenda application and entertainment.
	LIZA	Easy to use. Reasoning and decision-making improvement. Feedback provided. User's adaptation.	No social component. Restricted topics. Tested with higher-education students.
	Andriella et al.	Social component. Easy to use. Specific tasks and exercises for SKT. User's motivation. User's monitoring. Feedback.	Requirement of an initial set-up by the caregiver. No tested with real users, only with a simulated synthetic user. No report to caregivers or relatives.
	Ostrowski et al.	Tested on an assisted-living community. Companion task. Easy to use.	Expensive robot platform. Limited number of activities. No report to caregivers or relatives.

autonomously used at home, providing different exercises' levels according to elders' dexterity and impairment. Nevertheless, unlike all the previous technologies, StayFitLonger does not include a supervision mode for healthcare personnel. That is, nobody can analyse the elder's evolution and properly set the parameters better fitting their needs.

When a social component is integrated, another kind of tasks is possible. So, for instance, a continuous human-computer interaction can aid elders to improve their reasoning and decision-making as in the case of LIZA. Nevertheless, the system's validation was performed with higher-education graduates instead of an elderly population. Therefore, a new experimental study is required to properly evaluate the real LIZA's utility.

Mabu and Stevie, however, combine social activities with other basic tasks like medication intake reminder. In this way, the elderly are provided with company and empathy, while improving their well-being in some way. The main drawback of these technologies is the short conversations about a reduced set of topics they can maintain.

In the case of the work by Andriella *et al.*, the social component is used to make cognitive exercises for MCI more interactive, although no changes in the configuration resulted from those interactions.

Finally, two different studies analysed the helpfulness of using a social robot in two research areas: therapy sessions for children with Autism Spectrum Disorder (ASD); and elderly engagement and social connectedness. In both cases, the experimental results were very promising, highlighting the beneficial effects of using robot platforms as a support tool.

Nevertheless, despite the wide research in the elderly healthcare, only a very few technologies are being integrated in hospitals, healthcare centres and/or at elders' home. So, there are some open challenges to be pointed out for a successful integration of these systems in our daily life.

One of these challenges is that most of the existing technologies are domain-specific. This fact results in the need of acquiring several systems to receive the required assistance, what makes it considerably difficult to properly manage all of them as well as to accurately monitor the elder's health status.

In addition, the use of visual input has arisen privacy concerns since the elderly have the feeling of being observed all the time. Therefore, an adequate regulation is necessary to avoid that the technologies' capabilities become a threat to the elderly private lives.

Another aspect to be considered is their cost, specially those developments including robot platforms. So, low-cost technologies are being studied in the literature in order to develop purposeful and easy-to-use systems.

The last but not the least challenge is the elderly acceptance. In fact, this is a difficult aspect since most of the elderly population is reluctant to technology mainly due to the difficulty in its use, its lack of social abilities. For this reason, the ease of handling and a social component are key issues for their acceptance. In addition, the reliability in performance and customization can also help for their acceptance.

There are several advancements in each domain that are interesting and relevant that try to tackle some previously mentioned issues. In terms of social assistants, recent academic works are [29]–[34], and commercial ones are [35]–[37]. In terms of medical and rehabilitation assistants, recent works are [38]–[43]. Despite this, there is still a lot of work to be done and we believe that in the future we will observe an exponential growth of this domain.

V. CONCLUSION

The unceasing increase of elderly population suffered in the last years has led to a great technological demand to fulfill the newly emerged social needs. In this sense, research has been very active. Thus, this paper overviews the recent works on this topic in two research areas: cognitive and personal robot assistants.

On the one hand, research is focused on providing technology with new functionalities. Thus, the assistance to older people is more appropriate and customized such that it improves their independence, well-being and quality of life.

On the other hand, research is centred on the social component by focusing on human psychological issues. In this way, the developed systems are easier accepted by the elderly since they are perceived as companions more than appliances only able to perform mechanical tasks.

Despite the advances in the two research areas, there is still a lot of work to be done to properly provide a completely autonomous elderly healthcare at home with a human social interaction.

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