Voice User Interfaces for Elderly People

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ABSTRACT
The demographic transition is a growing challenge in many developed countries. The group of older adults is consistently growing and projected to exceed the mark of 1 billion people worldwide by 2030. The need for caregivers is increasing and retirement facilities are trying to meet the demand. Several research projects are facing this challenge with different approaches reaching from software applications to complex humanoid robots. Voice User Interfaces are a common method to allow an easy access for elderly and impaired people. Besides that the aspects of Interface Design focusing on older adults have gained more attention in recent research. Moreover, several projects develop solutions for an enhanced autonomous lifestyle. The current development of different smart devices for elderly care shows the importance of this research area.

Author Keywords
Voice User Interface; VUI; elderly; seniors; speech recognition; smart home; ambient assisted living; assistive robots

INTRODUCTION
Many industrialized countries are currently facing a demographic transition which brings the large amount of baby boomers to full-time pensioners [29, 30]. The population aged 60 or over has increased from 8% in 1950 to 13% in 2017 and is growing 3% per year according to the United Nations [28]. Europe has the greatest population within this group at about 25%. But demographic transition will occur in all parts of the world and the population at ages 60 or above is projected to be 1.4 billion in 2030 and 2.1 billion in 2050.

The demographic transition is presenting new challenges resulting in an increasing pressure on caregivers and the task of improving the quality of life for the elderly [24]. Also the elderly population wishes to live in their own home even with increasing loss of autonomy [30]. The research community has addressed theses challenges with various ambient assisted living (AAL) applications for elderly users. The development of smart home has shown a promising way towards in-home daily assistance [19, 8].

Even though smart home concepts have shown some potential in this area, complex Graphical User Interfaces (GUI) with small buttons and large menu hierarchies can prevent the access for the elderly and especially vision impaired users [27, 30, 32]. Voice User Interfaces (VUI) can overcome the learning process of complex computing procedures and enable an easy access to technology and information [22]. Moreover VUI can help people with reduced mobility or in emergency situations to interact hands-free and distant with digital devices.

Although VUI can open easy access to smart devices, they are creating new challenges such as working in noisy conditions, real time functionality or respect for privacy [29].

This review aims to provide an overview of studies and applications of Voice User Interfaces for elderly people. Starting from the first appearance of voice interfaces as communication technology to the highly advanced humanoid robots for assisting caregivers during their work or elderly in their home life.

METHODOLOGY
The data collection was processed in four steps. First research studies and papers specialized on VUI for the elderly were searched. As resources the platforms Google Scholar, ACM Digital Library, IEEExplore, Semantic Scholar and Science Direct were used. The publications of the first step spread from the year 1986 to 2016.

In the second step a more general view was used to collect publications that were not specifically concentrating on elderly care, but have at least mentioned some depending aspects on older adults. The total amount of publication was raised to 51, from the year 1980 to 2017.

In the third step all publications were categorized to one of the categories listed below (see table 1).

Category	Subcategory
Ambient Assisted Living	Robots, Smart Home, Others
Interface Design	-
Rehabilitation	-
Speech Recognition	-

Table 1. Categories of publications

After the categorization, the milestones of each category were recognized due to their amount of citations in other papers and regarding their publishing year. This resulted in a final amount of 36 publications.

The following section reviews these papers following the chronological order inside the corresponding category.

RELATED WORK

Studies on VUI for the elderly have spread in different ways over the past decades. While the first publications in the 1980s and 1990s dealt with more general approaches towards easy interaction methods between elderly and computers, newer publications, especially those after the year 2000 also showed voice interfaces as a part of humanoid robots. Moreover, the newest publications specialise in more human-like interaction than on VUI as a general replacement of ordinary input devices. Also the use of smart home and smart speaker is a common application used in current studies. The following section will review the first studies on voice interfaces for elderly people, including first steps towards using VUI in computer interaction.

Voice-driven interaction

The first time voice interfaces were mentioned as an appropriate way for the elderly to interact with computers was, to the best of our knowledge, in Danowski's and Sacks' publication [6] on computer communication and the elderly. Their main focus was to evaluate the reactions of elderly to computer systems in their living area, impacts on social interaction and key facilitators and inhibitors of interaction. Even though no voice interfaces were used during their research, they already faced the type of command messages to interact with the computer as a major inhibitor to the elderly's interaction. They also mentioned *voice interactive computers* as a maybe better way, but those systems were not spread widely at that time.

Further research showed voice input as a preferred method over the keyboard input method by elderly as well as young adults [17]. In this study, also no voice interface was implemented but rather than placing a human using a typewriter in a different room for transcribing the user's utterances. This was called a *listening typewriter*. The results showed no improvements between elderly and younger adults on the task of composing letters using the listening typewriter. Apart from that the listening typewriter was described as the preferred input method over traditional keyboard input by both groups.

GLOBE

GLOBE is a speech-driven document retrieval engine for a database of 86,190 articles from the *Boston Globe* [2]. This engine was built to evaluate methods for browsing for information especially for the elderly. The study showed one of the first approaches to build an acoustic model from elderly voices. For this mean, 297 elderly speakers with an average age of 79 were recorded, resulting in a total of 78 hours. In contrast, a 80 hour non-elderly model was used to evaluate the impacts in speech recognition.

The study showed that elderly speech was better recognized by the elderly-model. Apart from that the age has no significant effect within the elderly group, meaning users in the groups 65-79 and 79+ could easily use models trained on the other group with little loss of accuracy. In addition, it was shown that men had a worse recognition accuracy than women, which also could not be optimized with a gender-dependent model. Regional accents also proved to be an important factor. Furthermore, it was shown that all speakers could retrieve documents by voice, but some could not achieve this goal by using the keyboard due to typing weaknesses. Equally to [17], the study showed that speech was much more preferred over typing.

Interface Design

The first step towards an interface design is usually to describe the anticipated user profile [16]. While most studies do not separate between younger and older user groups, there are some reasons to consider designing interfaces for older adults:

- Decrease in physical, visual and cognitive skills may avoid older adults from using certain common input mechanisms.
- Elderly people may have different motivations for using computers.
- Computers can enable social activities, which is a common need of older adults.

Zajicek [32] investigated the aspects of interface design for older adults aged 70 and above. The study discussed design principles, especially for age-affected disabilities like cognitive and visual impairment. To handle these problems, a Voice Help was built upon the speech output web browser *BrookesTalk* for visually impaired users [34]. Previous studies showed that 82% of older adults were unable to get up and running *BrookesTalk* in it's original form [35]. Due to memory impairments, the users could not remember the sequences of actions they had done before [32]. Therefore a Voice Help was constructed for guiding (talking) them through their interaction. The users were told where they are and which actions are possible. It showed that the Voice Help can enable users to achieve interaction to which it was previously impossible. Nevertheless a personal off-line support was important for first-time usage. It also showed that older adults had problems to accommodate the differences in length of the messages. Therefore, it was important to take the length of the messages into account during the interface design process.

The discussion [32] also addressed the fact that requirements for older user groups differ more between individuals than they do for younger users. This was explained by the growing amount of impairments within this group. As a result, a new design paradigm called *Designing of Dynamic Diversity* was announced which takes the dynamic nature of the interaction parameters into account. The paradigm was later specified and formalized for further usage [9]. The paradigm acts as a counterpart to the *User Centered Design* paradigm where a static set of user requirements are defined. *Designing of Dynamic Diversity* is based on the *Pattern Language* which is based on the publication by Alexander [1] and which is nowadays widely used in Interface Design.

Following the *Designing of Dynamic Diversity* paradigm Zajicek [33] presented eight sample patterns for speech systems for the elderly. Relating to the previous experimental work [32] the following four guideline statements to develop these design patterns were established:

1. Keep output messages as short as possible.

2. Reduce choice wherever possible.

3. Use mnemonic letters to indicate key press menu selections.

4. Insert confirmatory statements wherever possible.

These statements were later applied in the design of a speech dialogue system. The eight design patterns were provided for common use cases such as *Menu Choice Message*, *Confirmatory Message* or *Default Input Message* with specific recommendations and examples. These pattern cover the aspects *Use when*, *Why*, *How*, *Example* and *Tradeoff*. A cutout of the pattern for *Confirmatory Message* is shown in figure 1.

Pattern name:	Confirmatory message
Use when:	After the user has input data, or made a choice or performed some other action that they might not be sure of.
Why:	To confirm that data has been input correctly or to draw the users attention to the progress of the dialogue. Research has shown that user confidence can be increased by confirmatory action and that it can aid the construction of conceptual models.
How:	After a data input event try to arrange for the output of a confirmatory message that contains the input data. In Example (1) the words in italic

Figure 1. Design pattern for elderly people [33]

Schloegl et al. [27] evaluated the general impressions of VUI for the elderly, testing the emotions of three subject groups through EmoCards [7] as a way to express their emotional reactions. These groups include caregivers, family members and service providers. The results showed that feedback and personalization mechanism should be taken into account when designing a VUI for the elderly. Also a natural way of interaction was preferred over command like utterances, as well as a female voice was easier to understand than a male voice for most participants.

Speech Recognition

Voice interfaces are commonly optimized on younger or middle-aged adults. Kwon et al. [13] aimed to investigate the factors for speech recognition among the elderly by comparing speech patterns between elderly and young adults. This included the speech rate, inter-syllabic silence length and formant frequency (acoustic and phonetic energy). They identified which areas of speech can be normalized to improve speech recognition. For their experiment a group of 80 people, 40 between 20 and 30 years and 40 of age older than 65, were chosen. Both groups had an equal number of male and female users, also none had impairments in speech.

Their investigation showed that elderly speech has a slower average speed than the speech of younger people. To fit that speech to existing VUI, the speech rate was increased during preprocessing steps. After that the accuracy could be raised by 1.9% for male and 1% for female participants. Furthermore, they detected an inter-syllabic silence that was 0.2s longer than in the younger group. These inter-syllabic parts were also removed during preprocessing. Besides that, it was shown that the formant frequency, describing vowel sounds, of elderly male voices was lower than of young adults. Due to that, the band energy was adjusted and also added to the preprocessing step. After the preprocessing the accuracy in speech recognition of the elderly could be improved from 76% to 82%.

Avatar for Voice Interaction

Avatars, also known as virtual characters, can make human-computer communication more natural and interactive [18]. Usually a 2D or 3D character appearance is used, depending on the avatars application. Ortiz et al. [18] investigated the effects of using an avatar as interface for elderly people through an empirical study. The subjects were separated into three groups: normal aging, mild cognitive impairment and Alzheimer's patients. Their results showed that all groups were following instructions given by an avatar better than by only using a speech or text interface [18]. However the avatar had no positive nor negative effect on the recall of objectives mentioned during the conversation. Beyond that, healthy elderly and those with mild cognitive impairments were able to recognize the emotions of the facial expressions of the avatar, which is an important aspect of natural communication.

Ambient Assisted Living

Ambient Assisted Living (AAL) comprises interoperable concepts, products and services that combine new information and communication technologies (ICT) and social environments with the aim to improve and increase the quality of life for people in all stages of the life cycle [20]. Elderly and handicapped people, being the key target group of Ambient Assisted Living, benefit greatly from the support these systems offer them in their daily lives. With the help of Ambient Assisted Living solutions, people with specific demands can live in their preferred environment longer. Especially home care systems can be an admittance that provides comprehensive nursing and monitoring in the regular interim to heighten the vitality and strengthen the fitness of elders [3]. These home care systems are often realized as Smart Home devices with the ability to be controlled through voice commands.

Smart Home

The term "smart house" was first used in an official way as long ago as 1984 by the American Association of House Builders. What makes a "smart home" smart is the interactive technologies that it contains. In todays smart houses, home owners can control functionalities such as lighting and heating, security systems and numerous other applications through tablets, smartphones or similar devices [10]. By simplifying daily tasks for elders and also providing the technological fundamentals to monitor their health the idea of smart homes perfectly matches the objectives of Ambient Assisted Living. Therefore, several projects which have aimed to design a smart home system allowing disabled and elderly users to command a large variety of appliances in their homes have been initiated.

In 1996 Valles et al. [31] designed an early version environmental control system which consisted of a central communication unit and a mobile remote control. The remote control included a touchscreen and an input/output voice and audio module. This setup enabled the user to forward voice commands to the system with the help of a wireless microphone. However, the system implied knowing the context of use of the application, i.e. the environment, the tasks and the users. The context definition was conducted by user interviews, direct observation, etc. Also, since touch screens and voice interactions were quite a new form of interaction at that time, a set of trials was conducted in order to detect possible usability problems. The implemented smart home care system with the intention to allow disabled and elderly users to command a large variety of appliances in their homes has been evaluated and accepted very positively by the real users during the project.

An experiment that aimed to assess the acceptability of a smart home equipped with audio processing technology conducted by Portet et al. [22] also resulted in positive feedback. During the experiment 8 healthy persons between 71 and 88 years of age, 7 relatives (child, grandchild or friend) and 3 professional carers discovered and interacted with the environment of the *DOMUS* smart home (figure 2).

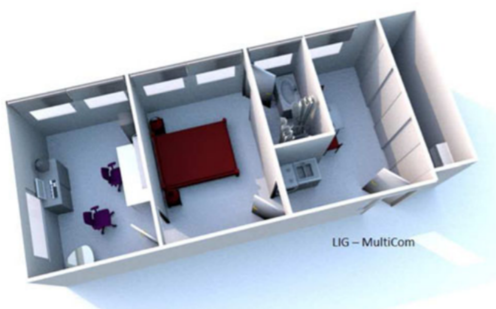

Figure 2. The DOMUS smart home [22]

This smart home was designed and set up by the Multicom team of the Laboratory of Informatics of Grenoble, France. The *DOMUS* smart home is dedicated to the observation and the measurement of users interactions with the ambient intelligence of the environment. While the participants explored the smart home, they were questioned alternating between interviews and Wizard of Oz periods followed by a debriefing on the impressions the smart house left on them. The Wizard of Oz method is a research method in which subjects interact with a computer system that subjects believe to be autonomous, but which is actually being operated or partially operated by an unseen human being [11]. The research presumed that a voice interface appears to have a great potential to ease daily living for elderly and frail persons and would be better accepted than more intrusive solutions. This assumption was verified since the participants particularly appreciated the fact that speech technology can bring more security by warning in case of hazardous situations or by allowing people to call for help in case of falling. However, it raised concerns with the aged population that such a system would make them less autonomous by encouraging a lazy lifestyle and provoking quicker degradation of health condition even through the system was supposed to bring more independence.

A newer example of a smart home implementation for elderly users is the CIRDO project carried out by Bouakaz et al. [4]. Their aim was to develop an ubiquitous home system, involving audio and video processing, making it possible to automatically detect a fall and distressed situations to call for help if necessary. The system was designed to run with complete autonomy as a background task. For the researchers it was essential that the system did not require any initialization or configuration to be done by the users. Therefore, the system continuously listened to the sound environment to recognize and detected speech that could be emitted during a distressed situation. However, since studies show that many elderly are reluctant to their speech being permanently recorded by smart homes [22], the autonomous speech recognition module included in the CIRDO project detected distressed speech while normal speech was rejected. Therefore, on the one hand the privacy of the elderly could be preserved while on the other hand the relevant voice interactions would still occur in case of an incident.

The latest approach to design a home care system for the elderly was conducted by Basanta et al. [3] in 2017. Their prototype represented a communication network framework with an environmentally friendly ambient intelligent system. It was especially designed for elder people who appreciate their living space to be well structured, safe, convenient, and intelligent. The prototype can assist intuitively to control lights, doors, or any household appliances remotely within or outside the living environment. By integrating voice recognition into the house to control the smart home appliances through the network communication, the researchers provided a safe and comfortable environment. Their setup included an Arduino micro-controller board as one of the main components which served as the interface to the appliances in the elders home (figure 3). The other main component provided to handle the user input through a user interface, but also voice commands and gesture recognition. For this task they chose a regular smartphone device (figure 3). The complete system was capable of solving "standard" tasks, that a smart home would face such as turning lights and electrical devices on and off. Additionally, the system utilized functionalities such as healthcare monitoring, family care, home monitoring and home access control. Moreover, advanced security aspects were implemented such as blinking lights in all rooms if an emergency is detected. In summary, this approach provided a feasible but, therefore, comprehensive solution for elder people to enjoy a high standard of living.

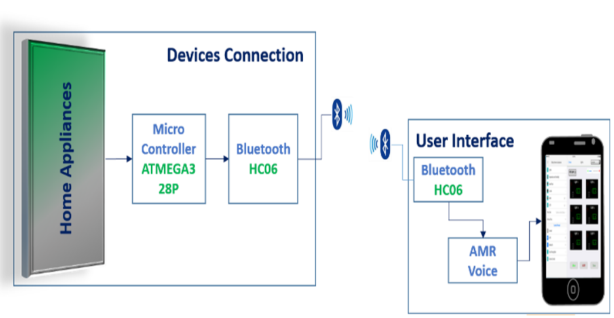

Figure 3. The Smart home setup [3]

Robots for elderly care

Until now there are several projects that integrate VUI as part of a (humanoid) robot for elderly care. Current research focuses on two groups of assistive robots for elderly, *Rehabilitation robots* and *Assistive social robots* [5] (figure 4). Latter is further separated into *Service type* and *Companion type*. *Rehabilitation robots* are primarily constructed for physical assistance and therefore usually not communicative. Examples are smart wheelchairs or exoskeletons.

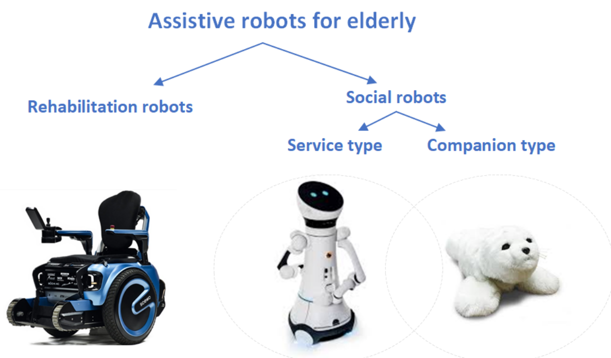

Figure 4. Categorization of assistive robots for elderly care [5]

Service type robots like *Pearl* [21] or *Care-O-Bot* [12] developed by Fraunhofer IPA are mainly constructed to support independent living and help caregivers during their work. Due to that, they are often built human-sized with robust, heavy arms and casings [21, 12]. But current service robots are also extended with social functions to facilitate the interaction. The newest generation of Care-O-Bot not only includes a voice interfaces, but rather imitates facial expressions using a display integrated on top of the robot [12]. This means not all robots can be strictly categorized to either one of these two groups.

Companion like robots are usually smaller and lighter than service robots as they focus on home usage. Furthermore, some projects focus on pet-like robots to enhance health and psychological well-being by providing companionship [5]. Examples are the soft seal robot *Paro*[1] developed by the Intelligent Systems Research Institute (ISRI) of the National Institute of Advanced Industrial Science and Technology (AIST) in Japan or the cat-like robot *iCat*[2] developed by Philips Electronics. Both are equipped with a voice interfaces and body sensors. Their design focuses on social functions to increase positive mood. Therefore, many of theses robots are equipped with sensors and actuators for movements of the eyelids and mouth.

Speech Interface for patients with Alzheimer's Disease

Alzheimer's disease (AD) is a growing challenge in many developed countries, especially in the group of elderly people [26]. For this reason several studies and projects concentrate explicitly on these Alzheimer patients. Rudzicz et al. [26] focused on this problem by designing a personal assistive robot to support older adults with AD. The mobile robot named *ED* has a height of 102cm and is equipped with a microphone and an LCD placed on top as a head-like component (figure 5). The main goal was to identify patterns of communication breakdown in speech-based human-robot interaction with AD patients during daily life.

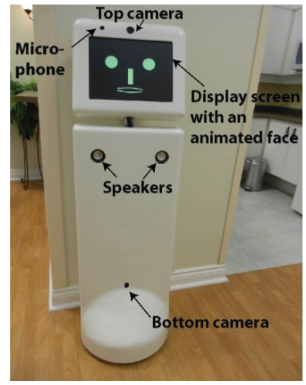

Figure 5. Prototype robotic caregiver *ED* [26]

The robot was implemented to support during different tasks like hand washing and tea making using audio or audio-video prompts. In their study [26] they analyzed indicators for a conversation with an AD patients. It was shown that interacting using the speech interface was difficult during activity of daily living due to the lack of uptake, with which many AD patients have to deal with. Furthermore it was shown that caregivers are often using multi-modal communication which was not possible to implement in *ED*.

VUI in systems for rehabilitation

Beside ambient assisted living which aims to support people with specific demands to live autonomously, rehabilitation is another important use case of voice user interfaces for elder people. Voice User Interfaces play a vital role in applications which encourage seniors in the process of returning to a healthy or good way of life. Remotely controlled serious games (SG) are a great example which support in-home rehabilitation activities. Traditional treatment approaches include exercises often considered repetitive and boring for patients. The use of computer games to augment physical and cognitive rehabilitation can offer the potential for a significant therapeutic benefit. Despite the fact that Serious Games still lacking a widely accepted and shared definition, the definition provided by Zyda is accurate: a Serious Game is a mental contest, played with a computer in accordance with specific rules, that uses entertainment to further government or corporate training, education, health, public policy, and strategic communication objectives [36]. These games counteract the consequences of the shortage of services in hospitals. In fact, the supply of services addressed to elderly is largely insufficient in all the EU Countries. Since patients are often forced to prolong their staying due to this shortage, the implementation of in-home Long-Term Care (LTC) systems would complement hospital services. [14]

SGs are not only a way to instruct people about something, but also a way to convey knowledge within a context that is

[1] http://www.parorobots.com

[2] http://www.hitech-projects.com/icat/index.php

motivationally rich. To this extent, it is of paramount importance to provide tools for designing effective user interfaces. This necessity couples with the simplification of the interaction modalities, ongoing in the HCI field, in which Voice User Interfaces play an important role.

A good example for a Serious Game in the rehabilitation context for elderly people is provided by Maggiorini et al. [14]. A prototype was designed to allow remote interaction, on a daily basis with elders (especially those living alone) to assign exercises, to verify progresses in mobility, to monitor health/environmental parameters, etc. The prototype included a Microsoft Kinect. This motion sensing input device kept track of the movements while the elders performed exercises (figure 6). Moreover the system aimed to verify progresses in mobility and was capable of monitoring health and environmental parameters. The body tacking also provided the ability to raise an alert in real-time if the elder falls and is not able to get up, does not wake up in the morning, etc. Furthermore the microphone which is built in the Kinect provided the ability to react to voice commands while a number of additional sensors allowed to track additional environment parameters including movement and presence detection as well as humidity and temperature measurements. One of the main constraints in the project was to minimize the number of devices to be put in the elder's environment. Therefore, the researchers planned to install a single set-top-box holing all required devices, to reduce the interference in the private lives of the users to a minimum. The set-top-box also interfaced the household with a caretakers control center. On the caretaker side, physiotherapists, doctors or nurses received environmental data as well as real-time flows such as video and audio, that allowed remote interaction between elderly and caretaker. If needed, multiple Kinect devices could be connected to the same set-top-box in order to monitor elder's status in a more fine-grained way. Since the system would face many unforeseeable circumstances such as random or unwanted/improper interaction with kids, pets, domestic workers, it was mandatory to explore requirements and constraints through an immersive approach.

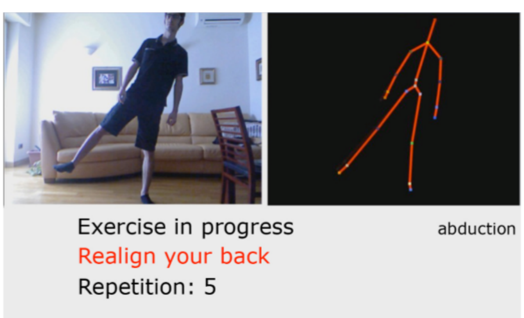

Figure 6. A wrong position is detected while performing an exercise [14]

Rego et al. [25] provided another example for the implementation of a Serious Game in the given context. It was chosen to apply new forms of interaction on one of the games from the RehaCom system. RehaCom is composed of a set of Serious Game modules (for executive function, memory and attention training, among others) and was found to be a reference system in rehabilitation serious games, for cognitive rehabilitation[3]. The game goal was to recognize a set of words that were memorized in a first (learning) phase and that after appear in a sequence of other words. The memory training game was implemented considered three forms of input: using the mouse (mouse detection), using some noise (sound detection), or using some motion (motion detection). To validate the prototype a small usability study with 20 healthy users was conducted. This study showed that most of the participants enjoyed playing all the input options, with the sound input option being the most enjoyable and the motion option being considered the least enjoyable. The users considered the sound option to be the easiest to play with out of the given three input options.

PROJECTS IN PROGRESS

Currently there are some further studies and projects in progress concentrating or surrounding VUI for elderly people.

The *KRISTINA*-Project[4] researches and develops a human-like socially competent and communicative agent to run on mobile devices [23]. It's main goal is to support migrants with language and cultural barriers as a trusted information platform and mediator with questions related to care and healthcare. The technology is focused on multimodal communication and the special needs for elderly migrants and foreign caregivers. The agent is currently implemented as a virtual character in the second prototype and has an interface for German, Spanish, Polish and Turkish Language.

French manufacturer *softbankrobotics* is currently working on a project called *Romeo*[5] which is a robot specialized on elderly care. It is built as an open platform for research on developing a personal assistant. Besides the VUI for communication it is able to climb stairs and could assist elderly people in more situations than it's predecessor *Pepper*[6] could do.

ElliQ[7] is a social companion robot developed by the 2016 founded company *Intuition Robotics*. The goal is to keep elderly encouraged and active and let them make cognitive autonomous decisions. It is built as a platform combining a head like speech interface and a display/tablet (figure 7). At the moment it is still in development.

Figure 7. ElliQ Social Robot[8]

[3] https://www.rehacom.com
[4] http://www.kristina-project.eu/en/
[5] https://www.softbankrobotics.com/emea/en/robots/romeo
[6] https://www.softbankrobotics.com/emea/en/robots/pepper
[7] https://elliq.com/

FUTURE PERSPECTIVE

Voice Interfaces and Speech Recognition Systems have recently gained more attention through their availability in smartphones and smart speakers. With the help of Machine Learning their accuracy was significantly optimized over the last few years. Nevertheless these approaches need to be trained on large voice database which are still difficult to obtain nowadays. Machine Learning will be the main technology for speech recognition in the coming years as it has shown a promising way over precursor technologies. But further optimization relies on commonly available speech databases which cover multiple languages, regional accents and age-affected differences. Mozilla is working on a commonly available open source speech database called *Common Voice*, but this can only be one step towards better speech recognition systems.

Robots

The evolution of Care-O-Bot, developed by Fraunhofer IPA from 1998 until 2015 (see figure 8), shows the success and need of assistive robots in elderly care. The general market for service robots has also been developed at increasing speed [12] during the last years. It was shown that robots get more accepted in daily lives if they behave like humans [15]. So some future work might concentrate more on these aspects, as already shown in the development of Care-O-Bot 4 which has a more human-like interface than it's predecessors [12]. This also includes a human-like voice interface and facial expressions via displays or similar.

Figure 8. Evolution of the Care-O-Bot [12]

Apart from human-like interaction, ethical aspects has to be taken into account in future projects and research. Assistive robots can not replace human caregivers, at least not in the next few years. Human-to-Human interaction will always be an important factor, especially in care sectors. The development of companion or service type robots has to focus on functions that assist caregivers and nursing staff during their daily work. The main role of these robots will be to reliably complete simple tasks and allow a physical and psychological relief for both patients and caregivers. Also, more digital assistants for home usage will be available over the next few years due to portable software applications for mobile devices and PCs.

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