Avatars in Assistive Homes for the Elderly
A User-Friendly Way of Interaction?

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Abstract. Designing user interfaces for elderly people has become a prominent research topic. In the context of Assistive Homes the development of user-friendly and alternative interfaces for the improvement of usability and acceptance is an important goal. Applying avatars shall provide notable benefits. This paper describes the implementation and evaluation of a "photo-realistic avatar for people with mild cognitive impairment and dementia". The findings of the user trials show positive effects such as raised user's attention, increased likeability but no effects on memory functions. Also other approaches from Germany and Spain with less anthropomorph-looking avatars are presented and their results discussed.

Keyword: Avatar, Usability, Dementia, Elderly, Assistance.

1 Background and Motivation

The successful application of a new technology depends on many factors; especially for the group of elderly end-users the interaction, its usability and even emotional feelings are very important criteria for it being accepted. These features become even more important as soon as technology starts playing a crucial role concerning safety and independence, e.g. in Ambient Assisted Living (AAL) environments where the acceptance of the applied technology is the crucial factor if the user can derive a benefit from the applyed technology or not. Beside the fact that the benefit of using new devices must be appreciable, in order to provide a motivation for its use [1], there can even be "a need for an emotional relationship" between the users and their Assistive Technology as described by Wu P. 2005 [2].

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There are many ways of possible interaction methods between the user and a Smart Home environment. Some applications use touch terminals or touch panels [3, 4] which seem to be easy to use especially for elderly users who have never used a computer before [5] and others put focus on the usage of TV sets with (user-friendly) remote controls since TV sets constitute a platform elderly are most familiar with and do use very frequently [6]. In many of these cases the output is symbol and/or text based [4] sometimes with additional recorded text messages [3]. Speech input is still rarely used and evaluated. This paper focuses on the communication towards the end-user (i.e. the output).

Even though feasibility studies on basic technical aspects of Smart Home environments are available from various sources (e.g.: the Gator Tech Smart House [7], the Independent Life Style Assistant [8]), the requirements for new strategies to make Information and Communication Technology (ICT) and in this case Smart Home technology likely to be used by the elderly population is underestimated and not observed sufficently. The key factor to success is the interface to the Smart Home's features and services. This was also stressed in the "Design Guidelines on Smart Homes" [9]:

> The user interface is the single component in such systems, upon which everything else will be judged. If the interface is confusing and badly designed, the system will be thought of in that way. Indeed, to make such systems appear simple is an extremely complex goal to achieve. It is, nonetheless, very important to do so.

Until today computers and their application programs have been operated by using predefined command sets. Although this is tried to be hidden more and more by applying different kinds of user interface technologies (Graphical User Interfaces, Tangible User Interfaces, Ubiquitous Computing) human-computer interaction is still limited since the user has to adapt to the computer and its commands. An inverse way would be to model the human character sets of communication by information technology [10].

In addition the paradigm shift from "the computer used as a tool" to "the computer used as an assistant", the vision of ICT for everyone without any barriers that might cause a "digital divide" and the request to make technology friendly, polite and fun to use [10] have caused a widespread use of avatars in many fields (e.g. internet pages, movies, computer games and kiosk situations).

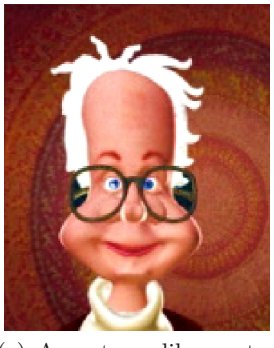
An avatar can be seen as consisting of "body and mind" (compare to [10]):

- A software agent builds human models like emotional states, models of cognition and knowledge. The software agent can be seen as the mind of the avatar.
- These models are presented to the exterior using visually human models. This visualization can be seen as the body of the avatar.

In the field of Human-Computer Interaction for elderly end-users most user interfaces are still based on the WIMP model (window, icon, menu, pointing device), but in the recent past also embodied conversational agents [6, 11] have

(a) A realistic virtual character rendered on a common television set [6]

(b) A more human like avatar used within the ALADIN project [12]



(c) A cartoon like avatar used within the ALADIN project [12]

(d) A photorealistic talking head used in our approach

Fig. 1. Different Avatars

been applied as a user interface component as an attempt to make the interaction more natural.

In most projects these embodied conversational agents (=avatars) are not very photo-realistic (see fig: 1(a), 1(b)) [6, 11] and sometimes they are even presented in a cartoon-like way (see 1(c)) [12, 13].

1.1 The Avatar - A Multi Modal Output System

Speech and non-verbal gestures form an important part of human communication. Hence, the "digital divide" between a user and a system can be reduced by using an embodied conversational agent with appropriate verbal and non-verbal behavior. While speech input to a machine is often erroneous and limited due to insufficient quality of automatic speech recognizers, audio speech output by speech synthesisers has already achieved a reasonable quality with respect to intelligibility under normal conditions. However, the application of audio speech in systems for elderly end-users cannot be seen as a normal condition: The transmission of verbal information may be degraded by environmental noise, reduced

capacity of hearing and reduced ability to concentrate. Additional visual speech and non-verbal output can enhance several aspects of quality of the interface:

1. As also known from natural speech [14] synthetic visual speech increases the intelligibility when added to audio speech [15].
2. Less effort is needed when listening to a talking head compared to pure audio speech [16].
3. The perception of prominence (e.g. to emphasise particular words in a sentence) can be clarified [17].
4. The identification of the intended expression to be transmitted can be enhanced [18].
5. An embodied conversational agent can improve user satisfaction and engagement and enhance the interaction with a system [19].

The face and the voice do not necessarily need to have the same degree of naturalness to achieve best results with respect to intelligibility; an avatar with artificial appearance combined with natural sounding speech can be highly intelligible [20]. However, the impact of the pairing of face and voice with respect to naturalness/artificialness is still in the scientific discussion: in [21] users prefer avatars with face and voice both being natural or both being synthetic whereas in [22] users prefer a more natural voice even with an obviously artificial face.

By all means the agent's behaviour must be coherent in the audio and in the video display to guarantee consistent information: In case of incoherent verbal [18] and non-verbal [17] gestures the information to be transmitted can be severely altered, i.e. the meaning that reaches the user is not the one intended by the system, whereas coherent multi-modal gestures lead to robust output.

1.2 Avatars for Assistive Homes - State of the Art

The idea of using avatars for the user interface of Assistive Homes for elderly (and especially for persons with Alzheimer's disease) was not often addressed by research [23, 24]. The application of avatars for subsets, e.g. for giving advice via the TV has been tested in more projects (e.g. by Krämer 2008 [11], Carrasco et al. 2007 [6] and Berry et al. 2005 [25]).

Two German Approaches. Krämer presents results of two studies where the effects of virtual assistants on elderly people have been investigated [11].

In the first study users (n=87, age 16-73) were asked to program a video recorder. One part of the group (n=71) was assisted by a virtual helper, the other part (n=16) had to use the handbook. Irrespective of age the users assisted by the avatar completed the task with less mistakes than those using the handbook.

In the second study presented in the same paper, a virtual assistant was evaluated that allowed naturally spoken commands to program a TV and VCR. The users (n=65) could select transmissions either by using natural voice or in the conventional way. The output varied: one group got text messages, another group got speech output, a third one got an anthropomorph agent and the fourth

group could select one of these modalities. The result was that the acceptance and efficiency of the different styles did not vary much, but the test subjects using the avatar-like output were more likely to make naturally speaking input than the other groups.

Spanish Approach. In Spain avatar interfaces have been evaluated with the target group of mild cognitive impaired persons and persons with Alzheimer's disease [6, 26]. TV sets were used as front end in this approach and one of the implemented avatars could express some emotions. Besides lip movements also eye motion and blinks, head motion etc. were applied to support the life-like character of the avatar. Voice output was based on a text-to-speech synthesiser. As far as known these trials have only been carried out as laboratory trials. Assistive Homes with avatar interfaces implemented are still not in sight.

1.3 Expected Advantages Using Avatars in Ambient Assisted Living

There have been many studies related to possible advantages of the use of avatars instead of other (conventional) interface approaches. The expected benefits (some have been validated by the authors) are [27]:

- Social interaction: interactions between a human being and a machine are fundamentally social; interaction in a natural way (like with other human beings)
- User attention: animated characters are capable of attracting user's attention
- Naturalness: illusion of liveliness and interacting with a real person is generated
- More information in the transmitted message: facial expressions contain a lot of information
- Trustworthiness and believability: level of trustworthiness is increased by the personification of the agent; a realistic face is rated more intelligent, engaging and likeable

A further reason why the approach of using avatars is expected to be suitable especially for the elderly users and for laypersons is based on the fact that the user does not have to learn something new or adapt to new ways of communication [11].

2 Methods

In the following an approach and ongoing research performed by the Austrian Research Centers in cooperation with the Berlin Institute of Technology is described. Photo-realistic avatars (see Fig.2) are used as part of the Graphical User Interface for Assistive Homes for people with dementia.

Within a master's thesis [23] a prototype for a day structuring tool for people with dementia was developed using a photo-realistic avatar as output component. The idea behind using an avatar in the user interface for people with Alzheimer's disease was to bind the user emotionally to the system. This was tried to be stressed by making the avatar look like familiar and known informal or formal caregivers [24].

2.1 Technical Implementation

The avatars were created by the use of MASSY [28], a tool developed by Sascha Fagel at the Berlin Institute of Technology. MASSY generates videos of an articulating face from a photo of a real person. The synthetic articulation is realised by deforming a mesh based on MPEG FAPs defined on the face. A generic articulation model for German assures that the visible movements match the spoken phones. Avatars created with MASSY currently generate only verbal movements, i.e. the facial expression does not change and only the mouth region is animated. Animating a specific face to phonetically match a synthetic voice takes various advantages of audiovisual perception: while verbal information that is mainly transmitted by audio is supported by mouth movements, the face reflects many properties of the person's identity [29] such as expression [18] and age [30]. The technology to generate audiovisual speech from a photo makes it possible to easily and rapidly create avatars of specific persons which is necessary in a caregiver application for users with Alzheimer's disease.

These avatars were used as GUI component for the day structuring tool described in [31].

2.2 Trials Performed

The trials consisted of a pre-study and a usability study. Both were performed in a day care center for people with dementia as well as in a nursing home for elderly people, both located in Linz, Austria.

Fig. 2. Screenshot of the Avatar GUI showing a formal caregiver

In total 10 subjects accepted to participate in the project. Not all tests could be performed with all subjects due to illness, absence or giving up the participation in the project. The group (n=10) consisted of 6 female and 4 male subjects, 8 of them with a diagnosis of dementia (Mini Mental Rating from 15 to 23, average 20.75) and for two subjects dementia was not diagnosed but supposed. The average age when the tests were performed was 82. At the day care center tests and interviews were carried out in a separate room. In the nursing home, subjects were visited in their own living environment.

The pre-study consisted of three meetings with the following aims: Meeting 1: interview and memory game. Aim 1: To get to know the subjects and to get a feeling for their daily life situations. Meeting 2: Sorting Easter eggs into different nests following instructions given on a screen by text, graphics and human and synthetic speech. Aim 2: To test if information presented via a GUI with synthetic speech can be understood and processed by the users. Meeting 3: Selecting the preferred photo out of a set of familiar and unfamiliar persons. Aim 3: To identify the preferred head to create an avatar from.

Based on the outcomes of the pre-study, the following tests were performed using the talking heads created based on the photos selected in the third meeting.

Test 1: The aim of the first test was to find out, if talking heads were liked as advisors for certain tasks. The first task was to sort medicine. It was performed with 7 users. It was divided into 4 subtasks, two using text and an avatar and two subtasks based on text and speech only.

Test 2: The second test consisted of putting forms of different colors and shapes into the right order, following the instructions given by the GUI with or without the avatar. The aim was to find out if the success of task guidance differs when using avatars or not.

Test 3: Observations during the second test concerning how users reacted to new scenes built the basis for the third test. Subjects (n=5) were reading a text and were interrupted by the system, either just by voice and text or combined with a talking head.

The tests were performed using a computer screen mounted into a wooden frame with loudspeakers. The tests were done in a "Wizard of Oz" way.

3 Results

The pre-study showed that synthetic speech (in this case MBROLA [32]) can be applied for speech output and is understood by elderly users. Different styles of information presentation should be provided, combinable and adjustable to the preferences and needs of each single user. In the photo selection test of the pre-study (where the photos for the avatar were selected) it turned out, that only photos of familiar persons are preferred to be used as talking heads. Photos of relatives and known formal caregivers seem to be the preferred ones of the subjects.

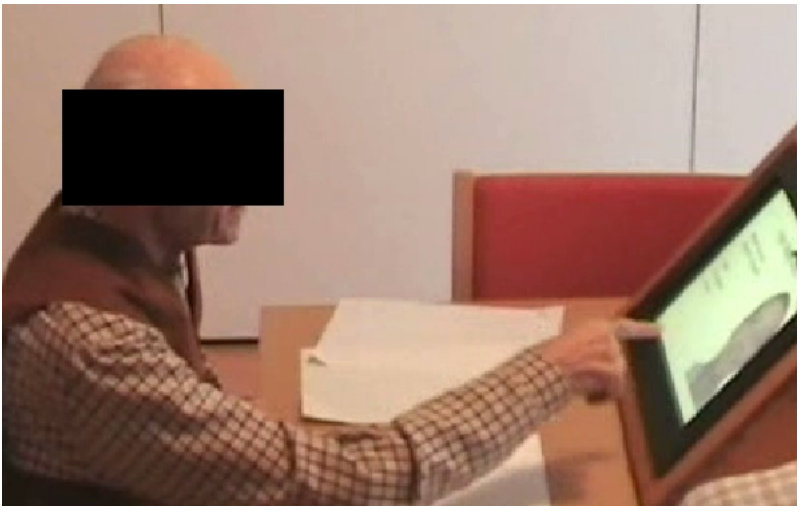


Fig. 3. The figure shows a test candidate talking to the avatar

The usability tests revealed the following results:

Test 1: In this test the avatar requested the subject (n=7) to sort medicine into different boxes. The test showed that for four users the visual impression of the talking head influenced the acoustic perception, leading to the impression that even though synthetic voice was used it was perceived as the original voice of the person the talking head was representing. This was even the case with two subjects who were confronted with avatars of their own children. Especially if voice and face were felt as matching, the avatar based user interface was preferred.

Test 2: In the second test most subjects completed the task of sorting shapes equally well or badly, independent of the presence of an avatar on the screen. But for the subject with the most progressed state of dementia, it was almost impossible to perform the task without any help when no avatar was shown, whereas with an avatar on the screen the task was performed with success. It was observed that the one subject using an avatar of a relative was more connected to the voice in the first scene when the avatar was shown. In the second scene without the avatar the attention was put more on the text even though voice was played.

Test 3: In the third test it was observed how the participants (n=5) reacted to new scenes (with a known avatar, an unknown avatar and without any avatar) while reading a text. The longest attention was raised by the known avatar. The unknown avatar was not realized as fast as the known one, but in general even after having been focused, the user's attention remained with the screen. Without the avatar the new scene on the screen did not receive as much attention.

Within the test series also other interesting reactions were shown [23]. For one of the subject, where a talking head created by the photo of the daughter was used, the emotional binding toward the system seemed to be rather strong. When finishing one of the tests she passed a kiss by the finger onto the photo of her daughter, which was still displayed on the screen. Also in other cases, where well liked nurses were used, the subjects were pleased about the known face talking to them. One of the subjects started arguing with the avatar (see Fig. 3) when misunderstanding a task message. This pointed out that using photo-realistic avatars can also lead to interpersonal reactions - with positive and negative effects.

4 Discussion and Outlook

As overall interpretation of the results it can be stated that photo realistic avatars can be a method to make user interfaces more accepted by the target group of people with dementia. The effect can be enhanced when familiar faces are used. Furthermore, avatars can be used as eye-catchers in new scenes, in particular when using speech the origin of speech can be located more easily and the attention can be bound to the system. Due to the small number of participants the performed tests do not allow any predications about if the usage of avatars leads to better results in fulfilling a given task.

As human beings have learned to recognize emotions through facial expressions and gesticulation, a high level of realism of virtual characters is needed to achieve acceptance by the human opposite. This does not only include the photo realistic representation, but also facial expression and gesticulation [33].

There might be a limit of how realistic an avatar should become which is discussed within the "Uncanny Valley" phenomenon [34]. Future research could address if this phenomenon is also valid within the target group of mild cognitive impaired (elderly) persons. This question relates to the findings of Morandell [23] suggesting that synthetic speech was perceived as real speech when combined with a photo-realistic avatar of a known person.

In general the findings underline the results presented by the Spanish research activities [27] which show that the presence of an avatar does neither have any positive nor negative effect on recall. These results should be validated by an improved study design, enlarged samples and focusing on single aspects of memory functions. Major benefits could be found in the field of attracting attention and joy of use.

Krämer [11] states that elderly end-users initially face new technological possibilities more sceptically than younger users do. Hence, when initiating the use of new technologies for elderly end-users, in the beginning the end-users should find known interaction patterns and then be familiarized step by step with the new technology (e.g. by tutorials). Furthermore the concrete advantages (whether in a physical, medical or emotional respect [35])of the new technology have to be communicated clearly to avoid that it (in this case the avatar) is just seen as entertainment.

How avatars are perceived by persons with moderate Alzheimer's disease is still an unanswered research question.

The future work of the authors will concentrate on the investigation of differences between elderly people with and without cognitive impairments, the implementation and effects of emotion expression and on the identification of the optimum antropomorphism of avatars. A further interesting research topic might the acceptance and likability of avatars based user interfaces concerning cultural differences. Therefore especially those cultural dimensions are of interest that are connected to communication, information, interaction and dialog design [36].

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