Embodied Conversational Interfaces for the Elderly User

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IHCI '16, December 07-09, 2016, Mumbai, India
ACM 978-1-4503-4863-8/16/12.
http://dx.doi.org/10.1145/3014362.3014372

Abstract

This paper describes the design and development of an embodied conversational agent (ECA) that provides a social interface for older adults. Following a user-centred design approach, we implemented a multimodal agent consisting of a virtual character and a robot. This so-called "bi-bodied conversational agent for elderly" was iteratively refined and developed through participatory design and rapid prototyping in 3 consecutive focus groups with a total of 21 elderly users. In addition to the two bodies, a Wizard-of-Oz control panel was developed, enabling researchers to control both bodies so as to respond to the user's instructions, questions, and remarks. The research resulted in a platform that can be used for future research on elderly-robot and elderly-avatar interaction. In addition, the research resulted in insights about elderly users' preferences regarding the appearance and design of a virtual and a robotic ECA (Embodied Conversational Agent), described in results that can be reused in future experiments involving ECA for elderly users.

keyboard, mouse, or touchscreen [1].

At the same time, societies are struggling with aging populations causing a major increase in the burden

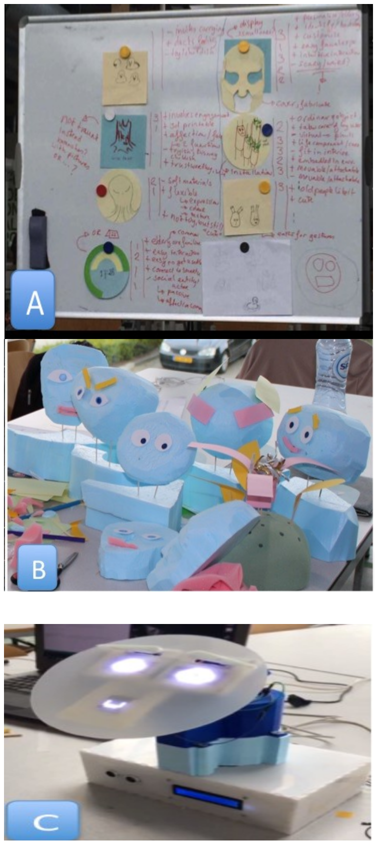

Figure 1: Paper prototypes (A), physical-prototypes (B), final robot design (C).

placed on our health care systems. State-of-the-art solutions developed as part of elderly (health) care solutions and interventions, such as smart homes and eHealth applications, often contain complex technology, which users are expected to interact with. Briefly put, there is a need for an intuitive interface for elderly people to interact with the smart technologies that are slowly penetrating contemporary (health) care systems. A possible solution to this issue might be the use of an embodied conversational agent (an artificial personal assistant) that functions as the user interface to these applications. Research [2] has shown that elderly people have no trouble interacting with an embodied conversational agent (ECA). In other words, if we can use an ECA as a user interface for elderly people, they may be able to interact with their high-tech environments in a natural and intuitive manner.

The body of an ECA can be either a physical body (robot) or a virtual body (avatar). Both have their advantages and disadvantages, and both are expected to affect the relationship between the user and the agent in different ways. To investigate such differences, the research presented in this paper describes the design and development of an experimental set-up that enables us to compare these two bodies in a variety of settings.

The research objective of this study was to design and develop a bi-bodied ECA that is appealing and acceptable to elderly users. The outcomes of this research project are described in the rest of this paper.

Method

We conducted a preliminary survey with 22 older adults (11 male and 11 female Mean age = 67.43 years, SD = 2.5 years) from the Netherlands, Turkey, and India over the Internet. We asked them about their practices to organize daily routines and understand their experiences with the current technology. We also conducted 3 focus groups with 14 older adults (9 men and 5 females, Mean age = 71.32 years, SD = 2.1 years) from the Netherlands and Germany. An informed consent was taken from all focus group participants. The participants in the focus groups were all highly educated (university level) and did not have any important cognitive or motor impairments, although some participants had hearing aids and/or visual impairment. Participants of the focus groups were interviewed for their interests and concerns, definitions of robot and avatar, quality factors, functions and features, appearance and aesthetics, personality, movement features, and feedback about existing robots (NAO, iCAT, Flobi, FurHat and XIBOT) [3]. Two paper prototypes were presented during the first two focus groups. The first prototype showed a humanoid face on a screen that was embedded in a sphere. This sphere represented a kind of head that was attached to a neck. Participants were informed that the facial expression of the robot could change depending on its programmed mood. The second prototype showed robots that were plant-like or object-like (vase-like). We also developed a simple GUI for the Wizard of Oz to control either of the bodies, depending on which body is connected to the control panel, see Figure 1. The whole panel was designed using MyRobotLab software [4]. Part of this control panel is also the functionality of "talking" to the user through a speaker set (independent of robot body), by typing text into the control panel and using text-to-speech synthesis software. ALICE 2.0 bot AIML scripts were used for conversation of speaker set.

Results

In the preliminary survey, when asked about their practices to organize daily routines most of the participants said they do not follow any such practices. However, 4 people said they usually take down notes that they plan for the day. On asking about the prototype of the robot their opinions varied hugely on what kind it should be: 31.8% preferred it to be humanoid, 45.5% for animal-like, 13.6% for plant like and rest, 31.8% preferred it to be more abstract like.

In the second survey, participants were asked about their knowledge of robots and avatars. 75% of the participants reported to have no knowledge of avatars; 25% believed an avatar is a kind of automated system. 88% of the participants described robots as machines used in industry, for household chores, or as toys – not as social agents. Participants rated the humanoid design most positively, saying it was appealing, helpful, pleasant to interact with, and not scary.

In the focus groups, most participants shared the opinion that the ECA should present a friendly personality, but there is no need for a life story or a strong character. The participants emphasized the importance of social contacts with humans, which is not replaceable, and also the relevance of not overtaking their existing abilities, but instead stimulating them (e.g. to be more active physically or to exercise their memory skill). The usefulness of the robot, as well as its appearance, is strongly related to the purpose, features, and functionality of it, and it should be distinct from a smartphone. The functionality may also vary based on individual preferences, so both the personalization and customization of the robot need to be considered. Able-bodied users (e.g. without cognitive impairments) emphasized that their requirements for interaction are very different from users with dementia or communication impairments, such as aphasia, still, common impairments in older adults, including hearing and visual impairments should be generally considered.

Both survey and focus group results showed us that the distinction between avatar and robot is not clear for elderly. Therefore, in the scope of this study, we focused more on the design considerations. We aimed to have a similar look for both the robot and avatar that we can use later for the comparison studies.

Paper-based prototypes

Seven paper-based prototypes were defined in the initial stages of design (Figure 2 - A). A brainstorm session was conducted by the research team to propose eight alternative design formats for the ECA and to discuss their main advantages and disadvantages.

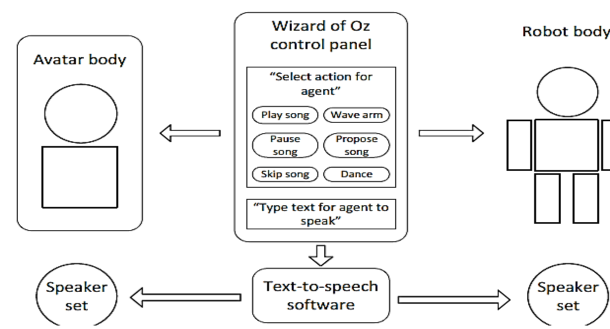

Figure 3: Conceptual architecture of the developed system

The alternative formats (looks) ranged from human-like, to animals, plants, and abstract shapes. The sketches of the formats proposed and discussed are

Preparation of Robot:

1) **For parts Head, Eyebrow, Eyes** and **Mouth:**

Material: translucent nylon circle 3d printed in translucent ABS

Electronics: Servo motor for rotation, 2 8x16 LED matrixes (white), 1 8x8 LED matrix (white)

2) **For Neck**

Material: 3d printed structure blue PLA on a foam support

Electronics: Servo motor

3) **For Body**

Material: laser cutted white 3mm Delrin rectangular box

Electronics: LED display, Proximity sensors3 Arduino Uno boards

presented in Figure 2 – A (top). The key advantages and disadvantages of each format were discussed among the researchers. The human-like appearance would be more familiar and friendly to users, but they are often more complex to implement, especially to achieve a realistic solution, which could also be perceived as creepy by end users. The animal-like format was judged as funnier and friendlier, but could also vary in acceptance depending on individual's preference (i.e. not all elders would like to have a pet at home). Object-like shapes and abstract formats had the main advantage to be unobtrusive, by being embedded in the environment, however they were complex to be designed, as communication features are unconventional for these objects, and more inventive solutions that are not familiar to users would be necessary. Also, some of the objects-like ECA discussed in the brainstorm session were static (e.g. a lamp or a frame), so the user interaction would be often restricted to a single physical space of users' houses. As a result, the researchers selected two designs: a human-like design (Figure 2 - B) and also a plant-like design. To assess the acceptability of the design, four focus groups sessions were conducted with older adults (65+), most participants preferred the human-like design, and the plant-like got immediate rejections. In the focus group, the participants also reported that a nuanced solution would be preferred, i.e. both the look and the behaviour of the robot should not try to represent a human being in all its characteristics, as the older adults would feel uncomfortable interacting with an artificial entity that tries to fully replace a human being.

Physical prototypes

A prototype made out of foam was created to evaluate the different shapes and facial expressions for the robot. Figure 2 - B illustrates alternative face and body designs for the robot. As a design decision, the researchers chose to express the robot emotions through facial expressions combining different eyebrow movements, eye and mouth designs. Also, head movements in two axes were defined (horizontal - left to right movements and vertical - up and down movements). The final prototype (Figure 2 - C) was constructed with electronic pieces, controlled in a time-basis (sequence of facial expressions) and through switch controls as well (head movements).

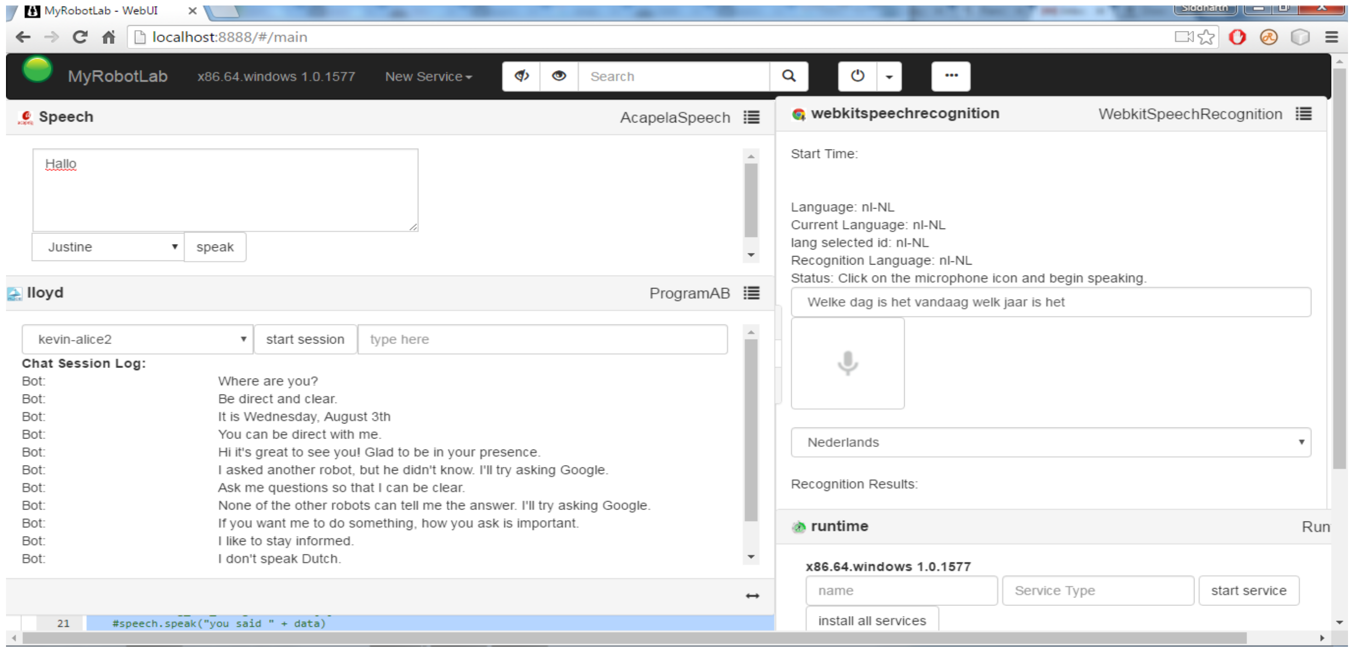

Figure 4 :Wizard of Oz Control Panel

Virtual Avatar:

A virtual avatar was created using Crazytalk software [5] to depict the behavior & functionality of the physical robot. The image of the physical body of the robot. The image of the physical body of the robot was rendered in order to produce the virtual avatar using coordinate dissection method. The avatar actions were controlled by Wizard of Oz panel based on the study by Cheong, 2011 [6]. The wizard made the agent introduce itself and then start a conversation with the user.

Future Research

Future research will employ the set-up developed in this project to investigate the differences between human-robot interaction and human-avatar interaction. Examples of studies this research set-up affords are:

- Ask people to interact with either the robot or the avatar in similar tasks and settings to investigate: What is the effect of having an agent with a physical presence compared to an agent with a virtual presence? Do people form a different type of relationship over time with an avatar compared to a robot?

- Compare the perceptions of people who have met the robot, after which they interact with the avatar as a virtual presence of the robot, to the perceptions of people who only interact with the avatar. This enables us to investigate whether and how the perception of an agent is influenced by having 'met the robot in person'.

- Ask people to interact both with the robot and with the avatar to investigate whether people perceive the robot and the avatar as the same entity.

Conclusion

Creating and designing an avatar/robot for elderly users is a complex process that requires much thought. The combined approach of participatory design involving focus groups in different steps of the design process and micro-analysis of the users' interaction with the system has shown that the users – senior citizens – are not generally afraid of autonomous systems. In fact, we can conclude, that users' attitudes actually improve after interacting with the system. Further, we were able to pinpoint more precise ideas. As design considerations for a system that would be socially acceptable, we revealed that the system should generally behave reactively and should be unobtrusively integrated into the user's home environment.

Acknowledgements

We thank all the participants who voluntarily took part in the study. We also thank all members of Design Lab, University of Twente, Netherlands for help in designing the robot.

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