Adaptation in Humanoid Robots Serious Games for Mild Cognitive Impairment Older Adults

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ABSTRACT

Since the number of Mild Cognitive Impairment (MCI) older adults is increasing, it becomes more and more important to provide them with support to avoid the progression of their cognitive decline to dementia. To this regard, interactive serious games can play an important role. However, while most of them have been deployed mainly through tablets, the current emerging humanoid robots are opening up novel possibilities to this regard. In this position paper we aim to describe our current research interest in better understanding the impact of humanoid robots in supporting serious games for such users.

KEYWORDS

Serious Games, Older Adults, Humanoid Robots

1 Introduction

With a senior population that is foreseen to more than double by 2050 worldwide [1], an increasing demand for high-quality elderly support is expected in the coming years. Among the disabilities typically associated with ageing, cognitive impairments are those affecting a significant part of people aged 65 plus [2]. In particular, Mild Cognitive Impairment (MCI) is an intermediate stage between the cognitive decline associated with normal ageing and more serious forms of dementia. Seniors with MCI often show memory loss or forgetfulness and may have issues with other cognitive functions such as language, attention and visuospatial abilities. The potential evolution of this disease makes it necessary to provide such people with increasing assistance over time. Thus, it is especially important to offer them timely and engaging cognitive training to slow the progression of their decline, with the aim of significantly cutting down the associated socio-economic costs as well.

While the introduction of computerized serious games for cognitive support has received several proposals [3, 4, 5], the possibilities that emerging interactive technologies may offer to such people seem largely untapped until now, also because for seniors with MCI, technology not only can provide opportunities, but may also present potential challenges because of their difficulties in e.g. visual attention and memory. Thus, to allow older adults with cognitive impairments to interact comfortably with technology and actually benefit from it, it is important to understand [6] how they approach and perceive the cognitive interventions provided through various types of assistive interaction technologies. In particular, humanoid robots seem promising since they can support more engaging interactions with users, and there have already been some work exploring the use of robots for supporting cognitive interventions [7, 8, 11], in some cases focusing on MCI users [9, 10]. Currently, we are focusing on humanoid robots and tablets to investigate how seniors with MCI relate with and perceive serious games accessed through humanoid robots, as part of a training program aimed to improve their cognitive status. To this goal, we designed and developed a quiz game to help the subjects to train their memory while receiving encouraging feedback from the application. We introduced not only the version of the game for humanoid robot but also a version for tablets, whose purpose was to represent a useful reference point for our analysis, given that the tablet is currently the most used device in cognitive training.

2 The Game

After some discussion with psychologist working on assisting and stimulating MCI older adults, it was decided to design an application requiring users to recognize songs from the years when they were young. Users can listen to a small segment of a song, and they should guess the title or the singer. After the question is displayed and vocally synthesized by the application, a musical piece is played from the beginning, and users are asked to recognize the title or the singer. They have a fixed time limit to respond, then the correct answer is shown. If they indicate a wrong answer, the right one is highlighted to them. The interaction was designed to take place in a multimodal and adaptive manner, i.e. it provides different feedback depending on whether the user answers correctly or not. Indeed, on the one hand, if the answer is wrong, the game highlights the provided (wrong) answer in red and displays the thumbs down icon in order to reinforce the negative feedback. It also shows the right answer (to allow users to learn it), with a green background and a thumbs up icon. On the other hand, if the user provides the right answer, a reinforcement sentence is shown (i.e. “very good, you gave the right answer”), and the singer and the song title are shown with a green background and thumbs up icon. While all the above-mentioned sentences are also vocally synthesized in both the considered cases (Pepper robot and tablet), one difference between

the two devices is the additional feedback that is provided by the robot after a user provides the answer to a specific question.

Indeed, the humanoid robot adapts its feedback to the older adults' inputs in terms of additional modalities such as head, body, hand and arm movements, as well as sounds and coloured leds positioned on shoulders and eyes (which become green in case of right answers, red for mistakes, and blue before answers). In particular, in case of a question correctly answered the (positive) feedback provided by Pepper includes e.g. nodding its head, or rising its arm with a closed fist while rendering vocally a "hey!" expression. Either in case of a question incorrectly answered or a timed-out question, the feedback provided by Pepper is adapted accordingly, showing different animations that better simulate Pepper's empathy in communicating a non-brilliant outcome (e.g. among others, Pepper shakes the head). Finally, when the number of correct answers exceeds a given threshold of the total number of questions, Pepper uses other gestures to render a more 'celebrating' attitude towards the user.

Figure 1: An older adult interacting with the robot game.

Such animations were identified so as to make the robot provide expressions that to some extent resemble human-like ones, so that users interpret the robot's behavior as empathic as possible, depending on the user's current game result. We chose not to use negative animations in this context, to encourage the elderly to do increasingly better. Users can end the game at any time. At the end of a session a feedback message is displayed and synthesized depending on the percentage of correct answers.

3 User Feedback

A study was carried out to assess the effectiveness of the developed game in improving users' cognitive (e.g. memory-related) skills. Such experimental test was included in the routine training session offered by the clinic. In this training program, the use of personal computers was proposed beforehand, but it was rather unsuccessful. Older adults found it difficult to use and boring, so in the end they did not find interesting and decided to abandon it. The proposal of using a humanoid robot was very well received and the older adults expressed strong interest in trying to interact with it. All of the study's participants had a diagnosis of Mild Cognitive Impairment, ageing over 65, and Italian speaking. They were invited to provide their informed written consent before the beginning of the study. For each participant, demographic, and computer experience data were formally collected in a questionnaire before the first session.

The experiment was structured in two different steps: the first one included a user's familiarization with the humanoid robot Pepper and the tablet, while in the second one users had to play the music game with the humanoid robot and the tablet. In this second phase, the users were divided into two groups, balanced according to their computer experience by the psychologists of the clinics. One group of seven participants was assigned to the group interacting with the Pepper robot, while the remaining seven were assigned to the 'tablet' group.

Overall the test results were encouraging: all the users successfully completed the training sessions, and they were enthusiastic about participating. The game was well appreciated by all users, which resulted in a very competitive atmosphere (e.g.. participants often compared their results after the training). The participants did not encounter particular problems with understanding the vocal feedback provided by the robot. The caregivers also expressed satisfaction about how this experimental training went, and the level of users' engagement.

4 Conclusions and Future Plans

In the context of interventions for reducing cognitive decline in the elderly population, technologies have been increasingly conceived as a support for patients, their caregivers and the clinicians. In this position paper we introduce how we are approaching the investigation on how seniors with Mild Cognitive Impairment relate with and perceive serious games accessed through humanoid robots, as part of a training program aimed to improve their cognitive status. At the workshop we also plan to report on the data collected in the study and further discuss their implications.

In a next version of the game we plan to introduce different levels of game difficulty. The system can record the subject's performance during the game and based on these data adapts the level of difficulty and/or suggests a new game for the user, which should be mainly focused on the problems revealed by the current game. In addition, by using a reinforcement learning approach the system can also adapt the kind of feedback provided to the user based on the answers received, by choosing the most suitable one among various types of enthusiasm/sorrow expressions.

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