Music Therapist Robot for Individuals with Cognitive Impairments

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ABSTRACT

Currently the 2 percent growth rate for the world's older population exceeds the 1.2 percent rate for the world's population as a whole. This difference is expected to increase rather than diminish so that by 2050, the number of individuals over the age 85 is projected to be three times what it is today. Most of these individuals will need physical, emotional, and cognitive assistance. In this paper, we present a new system based on the socially assistive robotics (SAR) technology that will play the role of a music therapist and will try to provide a customized help protocol through motivation, encouragements, and companionship to users suffering from cognitive changes related to aging and/or Alzheimer's disease.

Keywords

assistive robotics, adaptative systems, machine learning

1. INTRODUCTION

The American Alzheimer's Association [2] reported that more than one million residents in assisted living residences and nursing homes have some form of dementia or cognitive impairment; this population is also growing steadily. The rapidly increasing number of people suffering from this disease could have a crippling effect on the healthcare services in the next few decades. Alzheimer's disease is a specific form of dementia. Dementia is a disorder that progressively affects the brain. People with dementia may not be able to think well enough to perform daily activities, such as getting dressed, eating, speaking, etc. They usually lose their ability to solve problems or control their emotions. The frequency of dementia increases with age, from 2% in 65-69-year-olds to more than 20% in 85-89-year-olds. While there is no cure to dementia, medication and special therapy may improve symptoms or slow down the progression of the disease. Non-pharmacological treatments focus on physical, emotional, and mental activity. Engagement in activities is in fact one of the key recognized means of dementia care. Activities (e.g., music therapy [1], arts and crafts) help individuals with dementia and cognitive impairment to maintain their functional abilities and can enhance quality of life. Other cognitive rehabilitation therapies and protocols focus on recovering and/or maintaining cognitive abilities such as memory, orientation, and communication

2. APPROACH

We present a new system based on the socially assistive robotics (SAR) [3] that aims to provide a customized help protocol through motivation, encouragements, and companionship to users suffering from cognitive changes related to aging and/or Alzheimer's disease. This work aims to validate that a robotic system can establish a productive interaction with the user, and can serve to motivate and remind the user about specific cognitive exercises. The research work presented in this paper focuses on the study of the adaptable social, interactive, and cognitive aspects of robot behavior in an assistive context designed for the elderly and/or individuals suffering from dementia. Therefore, in this work, we have developed a new learning and adaptation system that allows for maximizing the user's performance on a cognitive task. In addition to serving as a social and cognitive tool, the robot will also be capable of providing detailed reports of patient progress to caretakers, physicians, and therapists. In this study, we aim to address the following research questions:

- Can elderly individuals with dementia and/or cognitive impairments maintain attention to music with the help of a robot in an intervention specifically designed to promote active listening?
- How does user performance and responses compare to those of well elderly who participated in the study and elderly how have not participated in the study?
- What if any short-term effects are there of attention training with the elderly who are suffering from dementia and/or other cognitive impairments?
- Does the music-based cognitive game with the robot help the elderly individuals with dementia and/or cognitive impairments to increase desirable "positive behavior" (smiling, speaking, and participating in group activities)?

3. EXPERIMENTAL DESIGN

This experiment is designed to improve the participant's attention and consists of a cognitive game called Song Discovery or Name That Tune by finding the right button for the song, pressing it, and saying the name of the song. A physical robot and/or simulated robot uses the following transcript: "We will play a new music game. In it, we will play a music collection of 1, 2, 3 or 4 songs. The songs are separated by silence. You will have to listen to the music

and push the button corresponding to the name of the song being played. Press the button marked "SILENCE" during the silence period between the songs. The robot/computer will encourage you to find the correct song".

3.1 Hypotheses

This work aims at testing two main hypotheses:

Hypothesis 1: The social robot will help in improving or maintaining the cognitive attention of individuals with dementia and/or cognitive impairments through its encouragements in a specific music-based cognitive game. (Active listening provides a potential method for engaging cognitive skills in people with Alzheimer's and/or dementia.)

Hypothesis 2: Individuals with dementia and/or cognitive impairments will prefer the physical robot to the computer simulation. The more physically engaging the interaction technology is, the better received it is by the participant and the more effective it is in encouraging the therapeutic game. A computer is the less engaging than a human-like robot.

4. EXPERIMENTAL RESULTS TO DATE

The initial pilot experimental group consisted of 10 participants (5 male, 5 female) from our partner Silverado Senior Living care facility. All the participants were seniors over 70 years old suffering from cognitive impairment and/or Alzheimer's disease. The cognitive scores given by the Standardized Mini Mental State Examination (SMMSE) test were the following: 2 mild; 1 moderate; and 7 severe. Due to the total unresponsiveness of 6 of the severe participants, only 1 severe participant was retained for the rest of the experiments, therefore having a final group of 4 participants.

To test the role of physical embodiment of our robot and its impact on the users, the two conditions mentioned above were tested with each participant. Figure 1 (a) shows the interaction between a user and the robot and Figure 1 (b) shows the interaction between a user and the simulated robot shown on a computer screen. The first results supported Hypotheses 1 and 2: the reaction of users, the social interaction, and the task performance was improved while interacting with the robot rather than while interacting with the computer.

The objective measure used in the study is the reaction time for both song and silence detection, indicated by the time taken to push a bottom and the correctness of the selected button. The main goal is to minimize the reaction time and maximize the number of correct answers, which signifies improvement of cognitive attention relative to the baseline data collected at the start of the study. The preliminary results, based on 3 participants to date, show a slight amelioration of users' cognitive attention. This is an ongoing study; significant results from a larger group of participants will be reported in the near future.

5. SUMMARY

This research aims to develop a socially assistive therapist robot for individuals suffering from dementia and/or other cognitive impairment that will improve through the social



(a)



(b)

Figure 1: Testing Role of Physical Embodiment of the Robot: (a) Human-user interaction with the robot; (b) Human-user interacting with the simulated agent

interaction their cognitive abilities and therefore their quality of life. Our assistive human-robot interaction model is being tested with a biomimetic robotic system with human users suffering from dementia or Alzheimer's disease. Our model involves empathy and user engagement through proxemics, speech, and gesture. Engagement, in particular, is considered one of the most important elements in the dementia care. Early results already demonstrate the promises of our music therapist robot, and therefore of socially assistive robotics, a new interdisciplinary research area with large horizons of fascinating and much needed research. Even as socially assistive robotic technology is still in its early stages of development, the next decade promises systems that will be used in hospitals, schools, and homes in therapeutic programs that monitor, encourage, and assist their users. This is an important time in the development of the field, when the board technical community and the beneficiary populations must work together to shape the field toward its intended impact on improved human quality of life.

6. REFERENCES

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