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Review Article

Robotic Assistive Technology Augmenting Dementia Care: Technology Design and Preliminary Acceptability

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Abstract

The growth in the aging population and nursing staff shortage is driving the need for provision of care for the elderly. As the technology is advancing, clinicians and scientists are looking to robotics and other sensor based technologies to aid caregivers to provide decent care services for old people. In this pilot study, we are proposing a humanoid robot care giving assistant that is integrated with several wearable and non-wearable sensors in provision of care of individuals affected by dementia. This solution will track, identify and monitor the affected person's daily living activities at the initial stages of dementia, and as the disease progresses, our system to assist them with their daily living activities and works as a reminder. As soon as a person is diagnosed, with dementia, our robotic solution will be assigned to this person and the robot will serve as a companion for the rest of the affected person's life. In addition, all the sensors and the robot in our system will work in sync to work proactively rather than reactively in prediction of Behavioral and Psychological Symptoms of Dementia (BPSD) to prevent wandering and other BPSD behaviors. In this paper we will share the initial acceptability of a humanoid robot by individuals.

Keywords: Alzheimer's robot acceptance; Dementia and robotics; Robotics and assistive robots

Introduction

The employment of robotics in healthcare has been urged due to the lack of nursing staff and growing need for providing cost effective health services for elderly [1]. Although the use of robots in healthcare is slow to be adapted in the United States, the rest of the world is quicker in adaptation. The incremental growth in research in therapeutic assistive technology is providing substantial evidence of the benefits of robotic assistive technology in the care of the elderly [2-6]. The motivation to employ robots in healthcare is clearly driven by the needs of care giving and the rise in healthcare costs. In addition, the societal pressure to improve healthcare, reduce time of recovery, and bring healthcare in rural underserved areas added to the momentum in the impetus to invention is driving the commissioning of robots as service and care robots [7]. The HIPAA regulations and the fact that the robots would be mainly deployed in assistance of vulnerable populations, such as patients with cognitive disorders, chronic ailments, disabilities or simply patients, who are sick and unable to speak for themselves are some of the reasons why the expansion of robotic assistance has been slow in the healthcare industry.

Every year there are 7.7 million new dementia cases worldwide [8]. It has been estimated that by 2050 the number of people affected with dementia would be over 115 million people, this coupled with hundreds of billions of dollars of cost for its formal and informal care presses dire need for technologies to help supplement and ease its care giving burden. With these many researches in the domain of socially assistive robots for health care are aimed at aiding elder people with dementia. Shortage of caregivers demands for an alternative solution that can provide physical support (e.g. helping with movement), cognitive support (e.g. identifying the objects) and emotional support (e.g. providing emotional intimacy) [9]. Assistive robots not only can save money by taking care of caregiver burden, also it increases patients' self-steam, and improves their quality of life [9,10].

It has been argued that robots, as machines are incapable of human sense of decision-making and unable to have the passion, care and ethical values as a human [1]. These are facts and no one can argue about these but the point to be argued is why put the burden of care giving on human caregivers only; why not have a robot companion that can assist the caregiver in providing care. We are proposing a mobile humanoid robotic solution with integrated sensors that constantly monitors and track various aspects such as vitals and physiological changes, surrounding, environment and transfers the obtained data to the caregiver and clinicians as well as use this information in making knowledge guided decisions in providing care.

This paper will first describe the assistive robot and then define the functionality of the assistive robot and then the preliminary data gathered for this study are shared. Lastly, the paper will discuss the pros and cons of humanoid robotic care in providing assistance to individuals affected with dementia. Our robotic assistive technology does not intend to replace human caregivers but instead asserts on augmenting and enhancing care.

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Background

The earliest use of robots was in the industry in the 1960's [2,11], with the first robot that can be employed in the manufacturing being built by general motors' in 1958 [12]. The industry was much ahead in adoption of robots in manufacturing than the healthcare system. The healthcare industry witnessed robots first in their surgical procedures in 1985 [12] for accuracy and reach in areas that are humanly difficult. In the recent years the drive to employ robots in healthcare has been revisited by several scientists and has had a rebound and is being built stronger. Upon reviewing literature, it was found that there are few assistive service robots although the need for these robots is clearly identified khan, robots in healthcare [13]. Japanese cultures have been most accepting of robots and are doing vigorous work in robots for health care specifically [14,15]. Though others were hesitant with the idea of a social robot [14], they are gradually moving towards it considering the need and usefulness of a social robot to augment therapy in a health care setting. The usefulness and feasibility of the use of robots has been established by many studies [14,16], together with multiple evidence of psychological stress recuperation especially in dementia patients in the presence of social robots [14,15,17]. There is also evidence that using robots in clinical setting results in not only reduced stress in patients but less stress and burnout for working staff as well who are providing care [16]. Use of paro, the seal robot, for dementia care has evinced many therapeutic effects on the patients [18]. In a study AIBO, a robotic dog, was used to examine the acceptability of a social robot among dementia patients. The outcomes showed a general perception of harmlessness and friendliness among the patients for the robot. In addition, patients with more acceptability towards new technology also showed acceptance towards the usefulness of robots in their daily life [19]. Researches on social robots show improvement in cognitive capabilities of the dementia patients which help them to perform their tasks better and also has shown supporting evidence of the robot successfully able to maintain cognitive attention and boost cognition in the patients [20].

A survey of physicians across the United States on the efficiency and use of chat bots reported that there was a mixed response with both positive and negative responses. The physicians recognized the cost effectiveness and the usability of chat bots in specific roles and situations to be beneficial, especially in the area of scheduling appointments, providing support, motivation and encouragement, education, and assisting caregivers. On the other hand, the physicians also reported concerns on the ability of the chat bots in understanding the emotional status of the patients, human intelligence can be helpful [21]. Mild Cognitive Impairment (MCI) is the earliest diagnosable stage of dementia. Assistive technologies can help patients who are involved with MCI with their daily living activities and making them more independent [10,22].

This paper describes a humanoid mobile assistive robot that can help augment care of people affected with dementia. We have used a prebuilt robot, called Pepper manufactured by Soft Banks robotics, to serve as our mobile robot. The decision to use a prebuilt robot rather than building a robot was made to hasten the delivery of a deployable robot to assist in care giving. Building a robot from scratch would be a tedious and time consuming task that would waste valuable time in bringing the assistive robot in a deployable form. Additionally, there are scientists and manufacturers who are working on building mobile robots that have the sole task of building the robots. Our design not only involves a humanoid mobile robot but also includes wearable sensors that track vitals and various physiological changes, and also includes non-wearable sensors that track position, time, temperature and motion. Hence the three main components in our solution are:

- A prebuilt robot- Pepper
- Wearable sensors

Non-Wearable Sensors

Functionality

Wearable sensors: The wearable sensors will continuously collect the vitals such as heart rate and blood pressure. In addition, the wearable sensors will also track heart rate variability and the skin's electrical conductance to measure the stress levels and any other physiological changes that may occur. This data will be analyzed and sent to the robot for communication.

None-wearable sensors: The room or space where the person affected with dementia resides will be equipped with sensors to track motion, motion, and room temperature, along with time stamps.

Robot: Pepper robot is equipped with several sensors such as cameras, touch, infrared, switches, sonar, inertial, and LEDs. In addition, Pepper is equipped with several actuators that help with movement (Figure 1).

Figure 1: Interruption in program.

Robot-sensors: The sensors on the robot, will track the movement and behavior of the affected individual and record and learn from this tracking. Motion tracking and vision recognition sensors will identify and track the activities of daily living. Machine learning algorithms will be applied to learn these activities of daily living and record them so they can be retrieved at a later time.

Robot communication: The robot will communicate with the caregiver, the caregivers and the person it is monitoring. The robot will log all the data that can be later reviewed by the clinicians or the caregivers.

Robot data analysis: The data gathered from the robot's sensors will be continuously analyzed to ensure that patients' vital signals are within the normal range. Data coming from Pepper cameras can be used to monitor patients' changes per each activity while analyzing and tracking the physiological data are indicators of health status of patients. Over a period of time this corroboration will reveal relationships that will help us predict certain behaviors such as wandering, agitation, and, etc.

Working

The humanoid mobile assistive robot will provide continuous and real time monitoring of the person affected with dementia. Our robot will work in the following way:

As soon as an individual is diagnosed with Mild Cognitive Impairment or MCI, the person will be assigned our robot with a set of wearable and non-wearable sensors. The affected person will be asked to wear the wearable sensors and the non-wearable sensors will be installed in the space where this individual resides. Our robot is programmed to follow the affected individual and track and monitor the following:

Learning and recording patterns of daily living

The data from the sensors on the robot in combination with the motion tracking and location sensors that are installed in the living space were used to identify each of activities of daily living and then these activities are to be recorded over a period of time. At the MCI stage, the affected individual still has his or her activities still intact, meaning that the affected individual still remembers their activities of daily living but as dementia progresses the individual will start to forget their activities of daily living. While the robot identifies and learns the activities of daily living in the initial stages of dementia, these activities will be recorded and reminded of in the later stages of dementia as the affected individual starts to forget their activities of daily living.

Vitals and physiological changes

The sensors work in sync in monitoring the vitals and physiological behavior of the affected individual. For example our system will collect the physiological data over a period of time and will use this data to train to identify any behavioral and psychological symptoms of dementia that are a leading cause for wandering behavior [23,24]. Hence our system will be capable of predicting wandering behavior instead of just identifying it. Our system works in proactive preventive behavior rather than reactive behavior.

Before deploying the robot we conducted a preliminary study where we explored the acceptability of our robot. This acceptability study was based on simply the appearance of our robot. We were curious to see the responses of adult individuals to the desire to take the robot home with them.

Priliminary Data

The robot was taken to a populated student center between 11:00am-2:00pm, where the students, faculty and staff that were walking by and had an opportunity to interact with the robot. There are no risks associated as no one will be performing any actions or touching Pepper. There was no age or any other restriction for this pilot study and any person walking by pepper would be able to participate. On a table next to the robot there were two bowls- one marked "I would like to take the robot home with me" and the other marked "I do not want to take the robot home with me". In the middle of the bowls were placed a large pile of buttons. Passersby were asked to drop a button in the bowl of their choice.

Results

Interuptions causing the program to terminate

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When Pepper was running an app having a conversation with one person, if another person comes in her vision range and she hears a sound she turns to find a face. Thus, she interrupts her program and begins to respond to the other person. For example, person A was conversing with her and she heard person B walk towards her and turned to person B and was ready to interact with person B leaving the conversation hanging with person A even though she did recognize the word that person A had said as seen at (Figure 1).

The conversation started normally as seen in the log and then the interruption happened (by the red line) at which point she stopped listening to Person A and then when person A was in vision again although she heard this person she restarted the program.

Results of robot acceptibility

Qualitative results: We considered individuals acceptance and rejection responses. Pepper started to make conversation with the participants by asking or answering questions. Those participants that showed their eagerness to take the robot to their house found it helpful, cool, interesting, new world, cute, good accompany, reminder, good for old people, patients, and lazy people, funny joke tellers, like Wall-E!, like its appearance (friendly appearance), need a friend or a companion, help with homework, good for people who usually lose their stuff or are forgetful, entertaining, fun, not feeling lonely. Whereas, participants who did not like to have Pepper companion mentioned that it's scary, feeling uncomfortable, needing improvement in its functionality, fear, AI is scary, getting data from the cloud. In general, more "Yes" responses were received from the participants than "No". Overall, the total number of "Yes" responses for college students is seventy-seven, while the total number of "No" responses for college students is thirty-two.

Quantitative results: The total number of "Yes" responses for University for Senior students is twenty-one, while the total number of "No" responses for University for Senior students is six. What this tells us is that the majority of the responses accept pepper and believe that the pepper companion would be helpful, while a considerably less amount find her to be scary or unnerving. It seems that seniors are more interested in taking the robot to their home because they need a friend or a companion to talk to and make them amused or have fun (Table 1).

	No. of "Yes" response	No. of "No" response	Percentage of "Yes" response	Percentage of "No" response
Without age limit	77	32	%70.6	%29.4
With age limit (over 65)	*21*	6	%77.8	%22.2

Table 1: Qualitative results.

Discussion

Although the need for robotic assistive technology is clearly evident, stakeholders are hesitant due to the liabilities and ethical decision making concerns this may raise. We are aware of these concerns and bearing them in mind we are proposing a robotic care giving assistant that is integrated with several wearable and non-wearable sensors in provision of care for individuals affected with dementia.

Conclusion

As the population ages there is a clear need for caregivers. There is also evidence of reduction and lack of family caregivers in addition to professional givers. Hence, an alternate solution that would help supplement care giving is warranted. We are proposing one such solution that will revolutionize care giving and relieve some burden off the family and professional caregivers. Our solution is to augment care and not replace human care givers. Inspired by the studies involving socially assistive robots for dementia care, we believe that coupling it with wearable sensors for objective health monitoring of the patient would serve as an innovative way to supplement the care giving and easing its burden. As previously indicated that in the presence of a social robot to interact with the patient the care giving is less exhausting for the caregivers [16], therefore along with social interaction if the robot could perform monitoring activities within its scope it would be even less weary for the care providers and could increase the efficiency of the care giving.

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