Robotic concept design for dementia care

Abstract—This paper reaches into the possibilities that robotic technology can provide to be applied into dementia care, proposing a concept design on how technology can meet the needs of caregivers and those affected with dementia. Through the use of touch screen technology and telepresence robotics the needs for memory aid, reminiscence therapy and communication can be fulfilled with through the application of available technology into a robotic design. These are to be applied into an alternative medicine therapy for caregiving and assisting the independence of demented patients.

Keywords—dementia care technology; telepresence robot; alternative medicine

Introduction

Dementia is the term used to describe the symptoms of a large group of illnesses that cause a progressive decline in a person’s cognition and ability to function. It is a broad term to describe a loss of memory, intellect, rationality, social skills and what would be considered normal emotional reactions [1][2]. All of these changes affect the social life, physical ability, emotions and independence of the person affected with dementia, also affecting family members, friends and those surrounding them.

It is estimated that 35.6 million people is affected with dementia worldwide. There are 7.7 million new cases of dementia each year, 45% are extreme-severe, 35% moderate and 19% mild dementia [3]. Dementia is not a normal part of ageing, however, 87% of demented patients are over 65 years old. [4]

Dementia is usually divided into 8 classifications, depending on their origin and way of affection [5]:

Alzheimer Disease: The neural connections between brain cells get tangled, preventing information to travel to areas in the brain, causing memory loss and physical impediments.

Vascular Dementia: A sequence of brain strokes causes brain damage due to poor blood flow to the brain.

Lewy Bodies: Abnormal structures inside the brain cells called Lewy bodies interfere with normal functionality of brain communications and cause hallucinations to those affected.

Fronto-Temporal Lobar Degeneration: Frontal and Temporal parts of the brain are affected, the patient loses its ability to communicate verbally or with written words (Aphasia and Semantic Dementia “loss of the meaning of the words”) and slow shrinking of the brain (Pick’s disease)

Huntington’s Disease: Due to brain cells being affected, patients display involuntary muscle movement of the limbs or face, behavioral disorders, intellectual impairment, loss of verbal fluency, bipolarity and more

Parkinson’s Disease: Brain affections cause stiffness in the joints and limbs, difficulty on physical action, speech impediments and involuntary rhythmical muscle movement on any part of the body.

Korsakoff’s Disease: Through excessive alcohol ingest, the patient can develop irreversible brain damage

Creutzfeldt-Jakob Disease: This is a really rare (one in a million) cerebral affection, caused by a protein particle called prion. Patients display memory loss, behavior changes, lack of coordination, involuntary muscle movement, limb weakness and blindness. Brain shrinkage also may be present.

Among the 8 classifications, Alzheimer disease is the most common kinds of dementia types, affecting in between 50% to 70% of all demented patients [6].

Dementia care depends directly on several factors like type of dementia, level of impairment, past and present skills and abilities on the patient after being affected by dementia, patient’s personality after being affected (some patients can turn aggressive after being affected by dementia) and the skills and motivation of the people around the patient. As a caregiver (not as a physician) it is really important to provide activities for the demented patients to improve their life quality, keeping their brain active.
Alternative medicine care, such as reminiscence environments, multisensory therapy rooms and memory aids, has proven to be effective in dementia care, but have fewer side effects than the traditional medical way for the dementia affected patients [2][3]. Dementia is not a curable disease. This kind of alternative medicine care will only aid their daily living but won’t be able to reverse this degenerative affection [7]. Alternative medicine care is also where technology developers can assist in dementia care, for the patient and the caregiver.

Interactive technology has been implemented to assist dementia-affected patients, having positive and surprising results. For example, touch screen technology is used to restore the bridge in between the relationships that were broken by the irreversible affections caused by dementia [8][9]. If properly focused, technology can be used into assisting the daily living of demented patients and their care givers, to constantly stimulate the patients’ brains, giving them a feeling of accomplishment, with small tasks that will keep an open bridge of communication and interactivity with the caregiver. [10]

This paper reaches into the possibilities that robotic technology can provide to be applied into dementia care, proposing a concept design on how robotic technology can meet the needs of caregivers and those affected with dementia. Section 2 of the paper briefly describes medical applications of robotics and the needs for dementia care that robotics can cover; Section 3 and 4 presents our robotic concept design for dementia care with telepresence robots. In particular, two versions of telepresence robot, TRiC mini+ and Wobots are presented. Finally, Section 5 concludes the paper.

Robotic Applications to Meet the Needs of Dementia Care

Over the past few decades, robotics has been moving forward in aiding human daily tasks. Modern medicine has been using robotic assistance for several tasks in homecare and medical applications. Depending on their core functionality, robotic applications for medical care can be classified into training, surgery, diagnosis, consultation, monitoring, rehabilitation, therapy, assistance, communication, pharmacy and prosthetics [11].

There are some important needs for dementia care that robotics can cover, as numbered below:

Reminiscence therapy: Therapy based on recollecting past experiences or events through an audio-visual experiences [1] [12]

Memory aid: Through audio-visual reminders and assets to keep the oriented while doing their daily tasks. [1]
Communication: Research has shown that demented patients have express they feel lonely [13][14], although this problem is not exclusive for demented patients but also between the elderly population of the world.

Among the types of robotic applications for medical care, communication robots have proven to meet the needs for dementia care [15]. Communication robots came through the idea of robots with videoconference features embedded in them [16]. For medical purposes, these robots are used as a doctor-patient communication bridge or caregiver-patient bridge. Considering the needs for dementia care, tele-presence robots came to the picture. Through the aid of telepresence robots, demented patients can be assisted to overcome their loneliness and open a bridge of communication between them and the caregivers or family members [17].

The term telepresence is used to describe a set of technologies, such as high definition audio, video, and other interactive elements that enable people to feel or appear as if they were present in a location which they are not physically in [20]. This allows caregivers and demented patients to communicate and interact in those cases when family or caregivers cannot be present at the location were the patient is at.

**Robotics Concept Design for Dementia Care**

Based on the concept of a communication robot a telepresence robot design for dementia care could be a game changer in the care-giver/patient relationship, taking with it the touchscreen based concept [18] for daily care of demented patients [9]. We can take advantage of options that tablets have brought to our daily living, being a really reliable tool when used properly.

The Gerontechnology Research Center of Yuan Ze University has been developing a Telepresence Robot for Interpersonal Communication (TRIC). The purpose is to open a bridge of communication between the caregiver and care receiver. As shown in Figure 1, “TRiC _mini_”[19] is a small lightweight telepresence robot designed for the caregiver to be able to deliver care and monitor their patients, taking advantage of the tablet computers.
Robotic concept design for dementia care

TRiC\textsubscript{mini} allowed users to combine several care tools within the telepresence robot. Instead of having a computer attached to a robot, the tablet is used as the central controller of TRiC\textsubscript{mini}. It is a detachable feature of the robot to be used as a normal tablet as well. The tablet can be used for vital sign monitoring of the patient and share this information with the caregiver or doctor online. It also allows local users to use the tablet as a memory aid, as keeping them updated with date and time;

Taking advantage of the high-resolution graphics that a tablet provides, TRiC\textsubscript{mini} provides a set of emotions and facial expressions that combined with the mechanical motion of the body of the robot to duplicate the three-dimensional face-to-face communication experience. With such features in the robot, dementia affected patients can find a character, personality and even a name for their “new friend” keeping their brain active, and aiding to the reminiscence experience that the robot can bring through the audio visual interaction. The telepresence robot also keeps communication open between the caregiver and the patient.

Figure 2 shows the information structure of TRiC\textsubscript{mini}. The remote user manipulates TRiC\textsubscript{mini} through the user interface on a smart phone/tablet/PC to freely move it around and communicate with the local user, who is staying with the robot in the home environment. By providing both verbal and nonverbal elements of interpersonal communication, the robot can better serve as the avatar of the family members or caregivers for expressing their care to the older adults at home.

\begin{table}[h]
\centering
\begin{tabular}{|c|c|}
\hline
Height & 41.1 cm \\
Width & 27.6 cm \\
Length & 24.5 cm \\
Battery weight & 1.0 kg \\
Total weight & 3.6 kg \\
Moving speed & 9.2 cm/s \\
\hline
\end{tabular}
\end{table}

\textbf{Figure 1. Prototype and basic specifications of TRiC\textsubscript{mini}}
TRiCmini+ has an innovative system structure which separates the “brain (a tablet)” and the “body (the robotic vehicle)”. Tablet is used to receive commands from the remote site via the Internet, perform audio/video conferencing, as well as the “face” of TRiCmini+. The robot control software is an android App on the tablet. The robotic vehicle is equipped with a power management module and a robotic movement module to provide omnidirectional mobility. The robot movement commands received by the tablet are relayed to the robotic vehicle via Bluetooth.

The design concept on the TRiCmini+ is based on an important anthropomorphic rule, in which the appearance of the robot will influence the perception of the person interacting with it will have. This is achieved by having proportional limbs and a face to interact with and look at. Following these concepts, personality and physical characteristics should be given to it through the usage or body movements and facial expressions. This design principle on TRiCmini+ is a very important feature for the reminiscence therapy, in which the patient affected with dementia can interact with TRiCmini+ also helping to overcome loneliness, offering a multisensory experience keeping the patient’s brain stimulated and active.

An Alternative Robotics Concept Design for Dementia Care

In dementia care institutions a mobile robot might not be suitable due to the spacing and clearance needed. A different approach for telepresence robot should be developed.
An extension on TRiC\textsuperscript{min}+ is being developed, which will be used in the Dementia Care, Research and Education Park in Tainan, Taiwan. This extension is a stationary robot with a more cartoony playful appeal to it called “Wobot”. As shown in Figure 3, Wobot’s concept design, facial animations and personality features have been based on the principles of character animation by [20] [21], and facial expressions have been combined with specific colors to enhance the experience for the patience through color psychology [22].

Wobot is a really different approach into tele-presence robotics. Wobot differentiates from TRiC\textsuperscript{min}+ in the fact that this is not a mobile robot. Wobot is a semi-static robot that will still have all the features that TRiC\textsuperscript{min}+ has, and will be placed on the patient’s room’s desk for them to have an open window of communication, interactivity and alternative medicine therapy near them.

**Figure 3. Wobot project, by Gerontechnology Research Center, at Yuan Ze University**

The important needs for dementia care are fed by both, TRiC\textsuperscript{min}+ and Wobot, through their various technologies integrated in them. Reminiscence Therapy, through the audio-visual aiding experience given by the different personalities integrated in both robots
design; Memory aid, through the Apps already installed in the tablet, also aiding their independence; Communication, through the integration of the telepresence system, being this the core of both robots connecting caregivers, physicians and elders affected with dementia. In the Dementia Care, Research and Education Park in Tainan, Taiwan, Wobot is to be used as a remote way of care giving between the families who live far away from the institution, being the family members the remote users, allowing a bridge of communication and care between them. Also through the telehealth system integrated in our App, doctors can keep record of vital signs of each patient through their user.

**Conclusion**

TRiCmin+ and Wobot present an integration of technologies that can aid and feed the needs of dementia care. Through the audio-visual experience that can be deliver remotely families, physicians and patients are connected through the communication system of our telepresence robot. This design is to be evaluated in the near future in dementia care institutions, hoping to expand the horizons for dementia care through technology and robotics.

Developing a concept for a robotic design to be used in dementia care, requires a simplistic yet extremely creative process. The challenge is to be able to deliver the proper tools to fulfill basic needs for the proper care of demented patients. Each robotic design should be focused, and depending on the problem to be solved that’s how the technology can be applied.

Dementia is a growing problem. Each demented patient has its own characteristics and needs. The understanding of the needs for dementia care allows technology developers to create solutions to assist and improve the living quality for those affected with dementia.

**References**


[4] Global voice on Dementia, Alz.co.uk, Dementia Statistics, Number of people with Dementia, online publication, http://www.alz.co.uk/research/statistics
Robotic concept design for dementia care

[7] Facts about Dementia, World health organization,
[12] Medical Mechatronics (Part II) -- Telepresence Robots for Medical and Homecare Applications, Jun-Ming Lu Department of Mechanical Engineering, Yuan Ze University 2006
[16] Social Robotic Telepresence, HRI 2011, Lausanne, Switzerland
Robotic concept design for dementia care


[22] The Animator’s Survival kit- Principles, and Formulas for Classical, Computer, Games, Stop Motion, and Internet Animators, Richard Williams, 2009