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Applying Mobile Application Development to Help Dementia and Alzheimer Patients

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Abstract—Caregiver anecdotes attest that music and photographs play an important role for family members diagnosed with Alzheimer’s disease (AD), even those with severe AD. Tablets and iPads, which are prevalent, can be utilized with dementia patients in portraying favorite music and family photographs via apps developed in close partnership with geriatric facilities. This study addresses cognitive functioning and quality of life for people diagnosed with dementia via technology. Research has shown that technology instruments such as iPods, help stimulate those with dementia. This study focuses on innovative devices such as iPads and tablets, which are mainstream and easy to use, cannot only help determine stage of dementia, but also provide stimulation to improve cognitive functioning. It is hoped that this research will analyze that specially created apps and existing assistive software can be used to decrease the symptoms and improve cognition of older adults suffering from AD or other dementia related diseases. Via service-learning courses, students developed an easy-to-use application for tablets to help older adults with disabilities more readily use the technology. This research will discuss student developed mobile applications in the scope of helping improve the quality of life of patients with AD or dementia.

Keywords- *Accessibility, Aged User, Assistive Technologies, Computer Science Education, Elderly, Older Adults, Senior Citizen, Software Engineering, Sundowning*

I. INTRODUCTION

A. Population Facts about Dementia and Alzheimer’s Disease

Approximately 5.4 million Americans of all ages have Alzheimer’s disease (AD), where 5.2 million are 65 and older. [1] This number will continue to rise as the percentage of the population 65+ increases. Nearly 13% percent of those aged

65+ and almost 50% of the 85+ population has AD [1].

Cases of dementia and AD are rather common cognitive impairments that residents are diagnosed with in a large majority of geriatric facilities across the globe. The prevalence of these illnesses will not decline anytime in the near future; in fact, there are strong indications that there will be a dramatic increase of these cases. Currently the number of older people with dementia in the world is estimated at around 25 million which will surge to almost five times that amount at 114 million by 2050 [2]. Considering the prolongation of the average life expectancy, studies have shown that 1 in 4 globally will be diagnosed with cognitive impairments after reaching 85 years old [3].

B. Dementia and Alzheimer’s Disease

Dementia is a term that describes a number of syndromes, and not a specific disease. Dementia refers to when the brain does not function normally in terms of memory, behavior, and clear thinking for daily activities [1]. Dementia is a disorder characterized by impairment of memory and at least one other cognitive domain (aphasia, apraxia, agnosia, executive function). A type of dementia is AD, which begins deep in the brain (entorhinal cortex) [4]. The entorhinal cortex is located near to the hippocampus [5]. Neurons located in this region of the brain start to lose efficiency and their ability to communicate with other parts of the brain. Throughout the progression of the disease, this process spreads to the hippocampus, the brain region that plays a major role in learning and is involved in converting short-term memories to long-term memories [6]. Understanding about dementia and its progression of the disease, makes programming apps to be better inline of capabilities, needs, and creating customized strategies for truly targeted software.

C. Challenges for this Population

With the average life expectancy rising in most developed nations due to steady advances in modern medicine, it does not necessarily ensure that health risks or illnesses common with old age will not affect the growing elderly population. On the contrary, older adults are feasibly susceptible to diseases that are not life-threatening but can deteriorate their cognitive abilities, causing them to be more reliant on assisted living facilities and personnel.

As the proportional shift of the world's population is leaning toward the elderly as making up the majority, the imminent need for residents with cognitive impairments to rely on assisted living resources is irrefutable. Further the importance of allowing technology to play a role in promoting the quality of life of the elderly should also be taken into strong consideration in order to address the challenges discerned in the interaction between the caregivers and the residents. To identify how to address the difficulties associated with caring for dementia and AD residents, it is necessary to examine the symptoms of these illnesses and determine how agitation and other interpersonal hindrances occur.

Older adults impaired with dementia and AD are diagnosed with a loss of brain function which degrades the ability to think cognitively, communicate, make reasonable decisions, behave in a lucid manner, and recall memory. Their speech patterns change as they develop the habit of repeating themselves and losing track of what was being said. Especially for those with late-stage dementia, memory loss, incoherent speech, and often irrational behavior are common. One's speech deteriorates even further by gradual loss of speech where only a few words are spoken or one can only communicate by crying out [8].

Communication challenges are common in patients with dementia, yet effective communication improves the quality of life of people with dementia [9]. An early sign that a person's ability to communicate is compromised by dementia is that he or she cannot find the right words, particularly names of objects. The person may substitute an incorrect word or may not find any word at all [10]. As the disease progresses, communication difficulties become more and more severe, eventually leading to a complete inability to communicate. Behavioral symptoms of dementia, which can include depression, aggression, anxiety and sleep difficulties, can be accentuated by this loss of communication. Meaningful attempts at communication through the use of technology can help abate these symptoms and perhaps lessen their severity. Up to 30 percent of dementia patients can experience delusions [11]. This shift in perception can be particularly distressing to both the patients and the caregivers. Helping a patient to reorient through the use of technology, such as showing pictures, YouTube clips of familiar television shows, presidential addresses, etc. can help to soothe a patient that is scared and overwhelmed by feelings of confusion.

As these symptoms grow more severe, dementia residents become less able to function on their own and turn

increasingly dependent on the care of those around them; the need to place them in nursing homes is critical with their round-the-clock staff and specialists. Their caretakers focus their attention on addressing any agitation or discomfort they may be experiencing. Hospices and residential homes have speech and language therapists on hand to improve communication with them. Individual attention, increased physical activity, and excessive hand activity can reduce any aggression and confusion dementia residents' experience.

As people impaired with dementia become heavily reliant on those around them, caring for them increases stress in the family and for the caregivers. Residents would project signs of paranoia or feel threatened from those who are offering to help. It is not unusual for nursing staff to face hostility when taking them for showers, restroom, or walks. The increased agitation contributes to stress in the interaction between caregivers and residents. With that and the incoherent or limited speech that is often adopted as these illnesses progress, geriatric facilities can become an environment conducive to immense stress and tension.

D. Projected Care Costs for Dementia Patients

Another challenge not unique to dementia patients but one that can perhaps more acutely affect them is a lack of resources to help this population. As our population ages, available resources will continue to be stretched.

The RAND Corporation estimates in the U.S. 15 percent of those 71 or older have dementia [12]. Meanwhile 22 percent of those 71 or older are diagnosed with mild cognitive impairment, which approaches, but has not yet reached the early stages of dementia [12]. According to the research published in New England Journal of Medicine, total costs to provide adequate care for those diagnosed with dementia in 2010 ranged between \$157 and \$215 billion of which Medicare paid for approximately \$11 billion [13]. The cost for dementia care varies annually between \$41,000 and \$56,000. RAND's findings produced higher cost projections by 2050, putting total costs at \$1.2 trillion. They estimate direct health care expenses for dementia to be around \$109 billion in 2010, surpassing direct health care costs for heart disease and for cancer. Further the cost for informal care provided by family members range from \$50 to \$106 billion. The economists who determined this amount accounted for the income a family member would give up or the amount that would be paid to a professional caregiver. Research projects total costs will balloon to double by 2040 to between \$379 billion to \$511 billion due to the population increase; the cost for each individual case will increase by close to 80 percent by 2040 [12].

Family members often play a key caregiving role, especially in the initial stages of what is typically a slow decline. The staggering numbers of home health care are on top of an already struggling health care system, one that has not made the strides necessary to address this inevitable future. Scientists agree that new and effective treatments and prevention strategies need to be developed or these numbers

will increase significantly in the coming years. Seeking alternatives to one-on-one care by evaluating whether technology can help to connect dementia patients and treat them not only in a way comparable to one-on-one care but perhaps one that is even superior to is imperative to ensure the ongoing care of this vulnerable population. Using technology, the patient and caregiver can individualize the care to their own needs, empowering this entire patient population.

II. BACKGROUND

A. *Technology Bridges Gap to Improve Quality of Life*

As individuals age or begin to suffer from disabilities, the challenges between those individuals and their families increase. Social communications through traditional methods decrease and cause frustration. However, technology can improve the quality of life for individuals suffering from cognitively debilitating disease. Through proper training and technique, the social anxieties of using technology decrease, thus improves the interaction between individual and technological device used.

Previously, society has viewed the geriatric community as technologically disconnected. However, new research is showing otherwise. As the number of ‘baby boomers’ reaching the age of 65+ continues to grow, thereby increasing the senior citizen population in the U.S. by 79 million, more will become digitally connected to the rest of the world. With this stated, many older adults are harnessing the power of the Internet and social networking to communicate with others [14]. Whether it is staying connected to old friends or family, shopping online, or playing games; computers are continuing to stimulate the cognition of older adults. The stimulation of cognition and memory are crucial to the health of older adults, especially since there is a significant increase of older adults suffering from AD and dementia.

B. *Service-Learning*

In an era where Alzheimer’s and dementia in older adults are increasing, caregivers are researching new solutions to mediate the crisis. One of these new solutions is the use of mobile devices to stimulate the cognition of older adults and patients suffering from AD. New research has proven that the use of brain, memory, and solving problem games help stimulate the brain and reduce symptoms of AD. In an adult day care facility in Spain, the use of the computer game, *Smartbrain* improved the cognition in AD patients. In addition, researchers noted, that when regular treatment and computer brain games when used together, “greatly augmented the traditional psychomotor stimulation”. The cognitive benefits were also extended to 24 weeks [15].

The use of the brain games and other computer-based stimulation therapy has given new light to healthcare professionals, caregivers, and the patients themselves. Research and therapy programs from around the world and the U.S. have created a new market for healthcare professionals

and software developers. The increased use of the Internet by older adults has also spawned a new age of Web Accessibility (WA) and Assistive Technologies (AT). Previously, older adults and people with disabilities often struggled to cope with the demand integration of Information Technology (IT) in their daily lives. For many older adults complex menus, small fonts, and the fear of a breaking the computer, unwanted feedback from a device or the Internet caused many to avoid these technologies all together. However, as society continued to advance into the Digital Age and more users expressed frustration, developers pushed for the development of computer AT and WA. New assistive technologies and web accessible features have improved the usability and accessibility of the Internet and computer devices. Unfortunately, despite these improvements, these technologies have yet to fully transition into mobile tablet computers.

C. *Real-World Projects*

Technology has rarely been employed as a tool to help dementia patients and caregivers. The elderly often are not very experienced with or capable of handling computers, which makes this medium an unlikely solution to appease the interaction between dementia residents and their caregivers. However, the simplicity of the tablet, as well as its accessibility through its touchscreen function can be user-friendly to even the most inexperienced. Applications can be designed to facilitate communication when coherent speech cannot be articulated. The concept of utilizing tablets as a medium to address the needs of dementia patients is not largely explored. Creating apps for dementia patients is not necessarily viewed as “sexy”, it can still be appealing to student programmers because it is different and distinctive compared to the normal programming assignments. Moreover, the idea of creating solutions to real-world problems creates an environment where the time put into the coding feels far more valuable than if it were solely pursued for the purpose of grades.

D. *Student Work*

Students are challenged to form teams of diverse skill sets to complete their term projects. Computer Science students more often than not, do not have the artistic skills or desire to design icon and symbols that are aesthetically pleasing. Students soon realize the advantages of working with others in different disciplines, which is sometimes beyond their comfort zone.

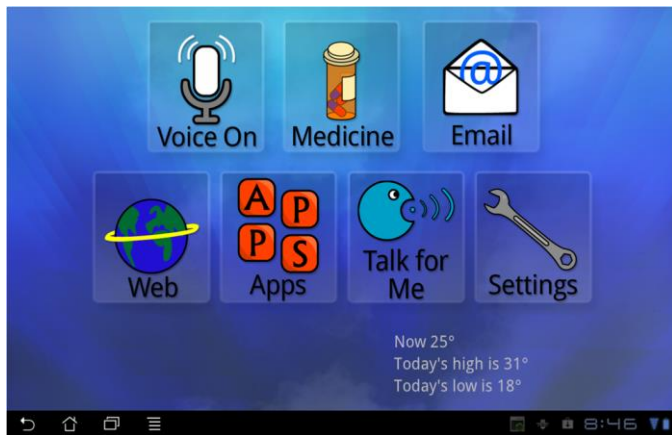


Figure 1. Original Android App developed by Peter Franceschini

In Figure 1, the original main menu of an app developed for a term project.



Figure 2. Artwork designed by John Robb

In Figure 2, shows a newly designed screen with the help of an arts and communication major with the computer science student.

III. MOBILE APPS FOR DEMENTIA PATIENTS

A. Sundowning & Agitation

Research has shown that AD and dementia patients frequently become agitated late in the afternoon or early evenings. Those in the field [16] commonly know this syndrome as “Sundowning”. Sundowning causes confusion and other symptoms to occur in dementia patients as the sun goes down. Everyday characteristics include increased disorientation, emotional stability, agitation, resistance to care, and combativeness. Institutional staff and caregivers are challenged daily by their patients and loved ones during these periods [17]. Gerontechnologists have initiated the development of “sundown” mobile applications to calm these patients and give respite to caregivers.

Decreasing agitation of dementia patients is not the only purpose of creating apps for iPads and tablets. Apps have the potential to help in decreasing depression, and improving the overall quality of life in the dementia patient. The app indirectly can help the caregiver too, especially when the patient is residing in the family home. Often the caregiver needs the time in the early evening to prepare dinner. Agitation periods often disrupt necessary household functions. If the agitation periods increase daily, the caregiver may feel at some point it would be better if the aging relative were institutionalized. Thus, apps could help to provide an environment where the dementia patient could age in place longer. Aging in place in the family home is far more cost effective than being placed in a geriatric resident facility.

iPads and Android tablets not only contain brain exercise apps to increase cognitive functioning, but also have built in apps for email, video conferencing, books, videos, photos, etc. All of these apps are neurologically stimulating!

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B. Music and Memory

Research has been shown by various organizations such as [musicandmemory.org](http://www.musicandmemory.org) that music promotes ordinarily unresponsive dementia patients to be enriched with life and talkative. <http://www.youtube.com/watch?v=5FWn4JB2YLU>

C. Busy-Boards

Busy-Boards are mobile applications that are designed to catch the attention of the user by prompting them to complete a simple task. Busy-boards attempt to calm a person when they are experiencing emotional meltdown. Individuals who suffer from AD or dementia will often experience tantrums as the disease progresses. The lack or inability of social communication, social environment, medications, or confusion can trigger an aggression. Unfortunately, these meltdowns may be difficult for family members or nurses to mitigate [18]. Busy-boards are designed to provide these individuals with a task to complete; in return of completing the task, a reward is given. For example, a busy-board app can include a collage of touch interactive animals or baby icons. By interacting and touching the right icon, a sound can played and or the description can be displayed. This can provide cognitive simulation. As the disease progresses, busy-boards can be a unique to help maintain or improve cognitive memory.

D. Existing Software Apps

There are other useful apps available that help AD and dementia patients communicate with family members and physicians. As the disease progresses, verbal communication increasingly becomes difficult. However, alternative speech strategies and therapies can improve the social interactions of AD and dementia patients. Augmentative and alternative communication (AAC), often described as an umbrella term, is

the use of multiple speech methods and assistive technologies to facilitate communication thought verbal and visual expression [19]. Unfortunately, AAC is often focused on children with autism or other social communication deficit(s). However, new research has shown that AD and dementia patients can benefit from AAC [20]. Several iPad and Android mobile apps are available on the app markets. These apps often provide an array of visual pictures illustrating emotions, common activities desired, vocabulary, automatic conjugations, as well as voice output. In addition to their features, these applications can be updated over time to suit the changing needs of the patient. The cost-effectiveness of these mobile apps is especially important for family members and healthcare facilities. Where specialized and dedicated AAC devices can range in the thousands of dollars, mobile tablets and AAC apps are significantly less, thus reducing healthcare costs [21].

Despite recent advancements in AT for desktop computers, mobile tablets (Android, Apple's iPad, etc.) have not fully implemented assistive technologies to assist older individuals, especially those who suffer from AD and dementia. Unfortunately, there are many obstacles within these tablets that challenge older adults. The obstacles include the layout and usability of the Operating System (OS), interaction, and device dimensions including weight.

While the accessibility of mobile operating systems, especially Android and iOS have increased over their lifespan, mobile platforms still fall behind their desktop ancestors. OS including Microsoft Windows and open source Linux platforms have integrated many assistive technologies into their OS. Menus have been simplified; keystrokes have been implemented to better organize and execute simple commands. Often, many visually impaired users are unable to recognize low contrasting colors. As mobile technologies continue to advance, IT professionals continue to worry about the complexity and performance of mobile operating systems. [19].

IV. USABILITY OF MOBILE APPS

A. *Tablets and Older Adults*

This sundown project involves improving the quality of life for older adults with AD and dementia through tablet technology. Each participant is exposed to iPads with their favorite music and photographs. Surprisingly, older adults learn the iPad very quickly. Participants learn to access the photo pages as the music is playing. They are enticed to talk about the photos that portray their experiences. Caretakers, mostly sons, daughters and spouses, are asked to help find family photographs to use. The hypothesis is that the dementia patients will "wake up" by starting to comment about the photos and moving to the music when their memories are aroused with familiar pictures and sound.

In a pilot last semester, patients became animated and lively with favorite music and family photos as research assistants visited with participants weekly stimulating older adult

participants with tablets. Graduate student research assistants administer cognitive and loneliness pre and post assessments to older adult participants diagnosed with dementia. Participants are normally evaluated with a historically recognized validated instrument, and a more modern tool for meticulous detection of mildly impaired individuals.

V. DISCUSSIONS

A. *Trials and Observations*

Since January 2012, students have been researching and developing mobile applications for older adults suffering from AD and dementia. Once mobile applications were developed, students interacted with patients in adult care centers assess their effectiveness.

B. *TouchScreen Challenges*

During these trials, many obstacles with the Android device were discovered. One of these obstacles included the touch sensitivity of Android tablets. Based on the experience from participating patients, the greatest challenge was the accuracy of the touch interface. Many of the patients at the adult care facility either used the top of their fingernail when touching the device.

Unfortunately, most mobile tablets, including Android and iPad, use a capacitive touchscreen panel. Unlike traditional resistive panels that only require an object to exert pressure on the panel, usually a stylus; capacitive touchscreen panels require an electrical conductor from an object, e.g. fingertip, to respond. In addition, older adults, especially AD or dementia patients, lack the capacity to understand this difference; thus, they can become easily frustrated with the application and concede using the mobile app. In addition, operating system layout and touchscreen panels can create new challenges. For example, patients became frustrated when the accidentally hit object on the taskbar, rather than hitting a user button located at the bottom of the application. Since touch accuracy is already somewhat compromised, it is important that application buttons and the taskbar be not too close together. Application sounds and device feedback can either startle or confuse patients. Device dimensions and weight is also another challenge. During our trials at the adult care centers, most patients that participate were not able to hold the device independently. Many required a tablet or a stand to prop the tablet. The majority of patients complained that holding the device is rather heavy and interacting at the same time was not possible. As older individuals continue to age, their muscle mass, strength, and purpose declines, muscle loss due to age is known as sarcopenia. In addition, screen size should not be below 10.2". Tablets with glossy screens can also glare the screen.

C. *Usability*

One application developed, *Jungle App*, features images of animals that appear within jungle scenery. The user touches the image of one animal prompting the screen to display the

name of the animal, as well as produce animal sounds. The intent behind the *Jungle App* was to provide a stimulating activity for the residents to use and enjoy. This activity was facilitated both within a group setting and on their own. The response was greatest when the users did the activity as a group where they can comment on what they were doing with each other. Those who demonstrated little to no interest when doing the activity on their own would have a completely opposite reaction when having a companion join them whether it would be another resident or a member of the staff.

The devices themselves presented challenges of their own. An initial difficulty was having the residents become familiar with using the devices. The residents had to be taught or reminded how to touch the screen correctly without their fingernail but with the end of their finger as an example. Residents would also have the habit of dragging their finger across the screen rather than tapping it. What also presented a difficulty while using the program was the fact that the residents would tap the images while grasping onto the surface of the screen with their other hand. Tablet covers with grips can easily address this problem.

While a few residents made it easy to distinguish each animal, a majority of the residents had difficulty identifying the animals. This may be possibly due to the smaller size of some images making distinct detailed characteristics unrecognizable. In addition, the color of an image had to be reconsidered as the image of one animal easily blended with the background. The way the animals were presented was also re-examined in order to establish some form of consistency. For instance, the image of wolves was shown as a pack while the other animals were presented individually. This may have caused some confusion since some residents could not easily recognize the image as a pack of wolves.

After further usage of the *Jungle App*, the residents were more confident in working with this app. Shortly after being introduced to it, they understood how the app functioned and what to expect after pressing on each of these images. Their cognition consequently improved in responding to the app.

VI. CONCLUSIONS

A. Effectiveness on Student Development

Despite these challenges, there are many simple solutions to these challenges. Mobile platforms only need to turn to their desktop predecessors. Many computer assistive technologies have been developed under the desktop platform. OS themes can be adjusted to use high contrasting colors. Virtual magnifiers assist users with visual impairments and their readability of small text. In addition, dictation software and text-only web browsers have also improved the usability of applications for people with disabilities. In addition, application buttons must not be placed too close the Android taskbar. While the touch accuracy of tablet screens can be difficult to resolve, Android platforms do allow users to change the sensitivity of the touch interface as well as

providing a vibration feedback when the screen is touched. Screen protectors can help reduce glare, especially in areas that are exposed to large quantities of sunlight. Rubber cases with adjustable stands can also be beneficial to patients using mobile tablets especially when using a table or lying in bed. These simple changes can reduce the frustration experienced by patients and increase the quality of life.

VII. FUTURE WORK

A. Cross Campus Teams

Future work will include cross-campus teams and more focus on creating apps to detect early symptoms of dementia. Over the summer, students collaborated with a community partner to develop an app that helped clinicians quickly determine level of dementia. Further efforts will focus on developing apps to help caregivers and individuals reveal early warning signs of dementia, thus receiving medical support and provisions. Perhaps at the very least, carefully utilizing appropriate brain exercises and nutrition.

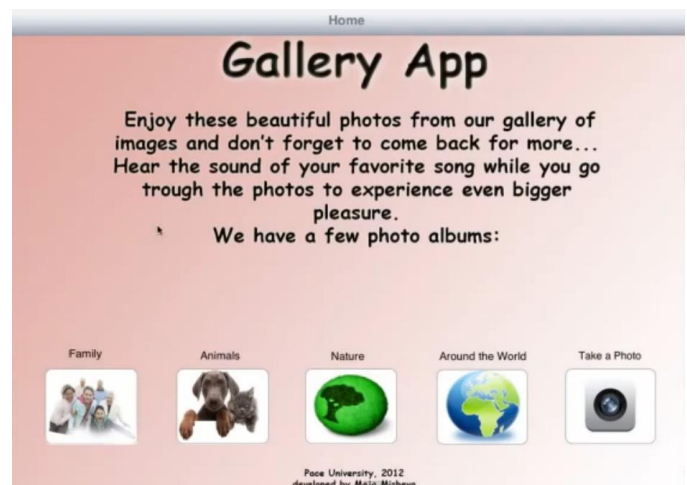


Figure 3



Figure 4

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