Smart Phone Based Cyber-Physical Social Network Interface for Older Adults

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***Abstract*—With the Baby Boomer generation quickly approaching the retirement age, there has been an increase in demand for assisted living facilities. Despite the improved services and various group activities within these facilities, a number of studies indicate that over half of the residents are experiencing some type of loneliness. Recent results suggest positive social benefits of social networking websites such as Facebook for the members who are in immobile or socially isolated circumstances. In particular, online social networking appears to be the silver bullet for loneliness in older people. However, studies find that the main challenge for getting the older population to participate in online social networking is in overcoming the knowledge gap with regards to the technology.**

The goal of our project is to conduct research and development in enabling broader social interactions for frail elders through easy access to Facebook. We are integrating online communication with families and friends (through Facebook) and physical social interactions within the facility. We have developed a novel mobile-phone based social networking framework, called ALFBook that makes use of wireless network technologies to provide a user-friendly interface that requires minimal user input. The natural user interface design emphasizes flexibility by supporting diverse ways of capturing user intentions including location, motion and voice commands. TVs in public rooms are used, as they are familiar output devices. Privacy concerns are addressed through advanced context and preference reasoning approaches, so that information can be selectively shared among seniors.

In this paper, we present the key components of the ALFBook framework and the current prototype, an augmented Facebook messaging interface developed for older adults living in assisted living facilities. We discuss remaining work and research directions.

***Keywords*-human-computer interfaces, smart phones, geriatric computing**

I. Introduction

The U.S. Census Bureau reports that the old age dependency ratio–the number of people 65 and older to every 100 people of traditional working age–is projected to climb rapidly from 22 in 2010 to 35 in 2030. This rapid growth is due to the large population of baby boomers who are quickly approaching retirement age. Many older people are choosing to live in specialized residential communities that can provide varying levels of assistance. In order to meet the increasing demands, many new and existing facilities are starting to embrace recent advances in technology. Technology adoption and integration are becoming increasingly important, as traditional approaches with human caretakers will not be able to handle such rapidly growing needs.

In order to support such demand for technology, researchers are developing new ways to improve the physical well-being of older people. One technological area leading to such improvements has been the use of practical and effective methods of locating elderly people or sensing their biometric information. These techniques are supported by coincidental advances in low-cost computing devices, wireless communications, and sensors. Using such techniques, researchers have invented several new ways to accurately predict imminent health problems and to rapidly locate people with serious conditions. These new research areas promise significant improvements in physical well-being of older people over what is being done today. However, there has been relatively limited work done that focuses on how technological innovations can improve the *psychological well-being* of impaired, older adults in residential facilities.

Studies in assisted living facilities (ALF) indicate that over half of the residents are experiencing some type of loneliness or depression, which seem to be major factors in degradation of other physical aspects of older people [1]. Many studies also suggest that promotion of social interactions between the residents and their families and friends as one of the few promising strategies for improving their well-being. Although such social factors are relatively well understood, it has been very difficult to promote social interactions through traditional methods. Some researchers have investigated use of wireless sensor networks for finding locations of seniors and prompting social activities in assisted living facilities [2].

However, these approaches do not cover families and friends as they focus on physical interactions among facility residents only. Other researchers have made use of online social networking sites where seniors communicate with each other through the Internet [3]. These approaches are effective only to experienced computer users, as many older people either do not know or have difficult time learning how to use computers and Internet. Furthermore, physical interactions among residents are ignored in such strategies.

In sum, although both cyber communications and physical social activities are important, most existing work focuses on either aspect separately and limits the people that seniors can interact with. There has been limited research on integrated strategies for promoting both cyber and physical social interactions or an integration of the two. We hypothesize that such integrated strategies can significantly extend social capabilities of less mobile residents as they broaden channels for social interactions and can cover more people including families, friends as will as other people in the facility.

The goal of our work is to conduct research and development creating technologies that enable broader social interactions for frail elders by giving them a novel integrated system for both cyber and physical social interactions. Our initial research platform leverages the most popular online social networking system, Facebook, for promoting quick cyberspace interactions [4]. We are developing the prototype system called ALFBook that attempts to seamlessly integrate physical interaction between ALF residents with the activities they engage in on-line. ALFBook actively collects messages or news from families and friends on Facebook, allows ALF residents to conveniently share interesting news or messages with the community, and allows sharing of residents' activities and messages with their families and friends on Facebook.

We hypothesize that such Facebook interface will promote elderly interaction with families and friends. Furthermore, information sharing among elderly people will promote their physical communication within ALF. We expect that such social interactions can directly impact sense of community, and potentially improve the physical and mental well-being of older people in assisted living facilities.

We are working with ALF residents to make research contributions in three areas: (a) a novel physical infrastructure for non-invasively capturing senior intentions and supporting integration of diverse sensor information, (b) intelligent user modeling and context reasoning for promoting social interactions without compromising privacy, and (c) evaluation of the impact of ALFBook on changes in social behaviors, and mental and physical health of frail elders. The ALFBook effort will ultimately produce a unique environment that will allow natural social interaction between online and physical communities, and blur the boundary that currently exists.

II. Related Work

There exists a large body of research completed in the field of wireless sensor networks with the concept of cyber-physical systems. For more than a decade, researchers have devised various ways to support well-being [5] through direct measurement of vital signs [6] and simplified interfaces for networking [7]. More recent sensors feature small size and long life [8]. Examples of WSN research for improving the quality of life for the elderly are described in [9]. These research results have matured over the years and are being used as the building blocks of what is called ubiquitous computing [10]. Despite the large amount of work in this area, most existing research deals directly with the physical well-being of an individual. Given that the biggest issue for the elderly today is loneliness and not a particular physical illness [11], our work attempts to improve psychological and social well-being through the use of natural user interface and cyberspace services. In addition to these works, there are a few specific related works worth examining.

Kobsa and Pieper outline their methodology and findings in testing a voice-control system on an elderly and completely bed-ridden Amyothroph Lateral Sclerosis patient [12]. The primary voice-control system, like many others in common use, required user-specific training in order to gain satisfactory results. Also among the problems arising from this situation was training the elderly user in basic computer interaction which took many weeks of personal assistance. Our system overcomes such learning curve with a more simple, specialized and intuitive interface so that the users do not end up stuck in a complex decision tree. Further, it was found that the user did not want to use the computer to communicate through the Internet, and instead preferred person-to-person interaction, even if it mitigated the length of interactions. This represents another important obstacle to overcome in HCI for the elderly, which is lessened by a system integrating both cyber and physical elements to enable natural control and an automated user profile to anticipate users' reactions.

Aulas' findings expose a recurring problem of insufficient visual feedback [13]. For instance, the elderly often have difficulty seeing the blinking cursor position and consequently do not even know whether the focus is in a text box. Elderly users are also often confused about their position in a website browsing hierarchy. In general, the study demonstrates how elderly people are easily confused by a large number of objects. Therefore, our system attempts limit the number of symbolic representations to reduce confusion.

A comprehensive study on how the elderly interact with mobile phones emphasized basic communication as the primary concern of this demographic and the reasoning was primarily for connectedness with family and for personal safety is found in [14]. The study highlighted an abundance of irrelevant information and large short-term memory requirements as the primary obstacles to mobile phone use. Cognitive degeneration entailing deterioration of the mind's short term storage capacity and less ability to filter irrelevant information was cited as the cause. Other problems were related to sensory degeneration so could be corrected through larger pictures and fonts, higher contrast, louder speakers, and generally more abundant and noticeable sensory cues. Most of these issues are resolved in our system due to our research effort in replacing traditional human-computer interface with natural user interface on appliances that are familiar to the users. Our research seeks to further address these problems through automated user profiling which can be used to adapt to individual usage and interface needs.

III. The ALFBook Framework

ALFBook messaging system provides a simple, accessible means for the elderly to connect to their friends and family. Today in U.S., the majority of family and friends of the residents are most easily reached on the Internet via email or through portals like Facebook [15]. The system will provide access to audio and textual messaging, browsing friend's and family's photos, browsing suggested or requested news, media, and/or purchases, all tailored based on data collected from the user's everyday activities and system usage.

The ALFBook system consists of a Bluetooth-enabled computer running a Java applet and web page, a large TV display as output for the computer, and a smart phone device as the user's primary input device.

A. User Interface Design

The guiding UI design principles of this environment are visibility and familiarity as these are the fundamental obstacles to technology use in older demographics where degenerating vision and lack of technology exposure are common [14]. With this in mind, the ALFBook system is intended for display on a large TV, a common device in ALF's which provides both familiarity and a large UI for elderly users. This TV will be within the context of an ALF common area where users may simply approach the TV and begin using the system. Large, textual captioning will accompany conversational audio and video recordings to prompt the user at necessary points and to initially guide users through procedures such as logging in, communicating with peers, as well as using and locating media.

ALF residents represent a vast range of physical ability: from completely bedridden to nearly normal. Rather than attempting to create an infinitely complex system to meet each and every need, or narrowing the usefulness of the application to a single user subgroup, the ALFBook interface is designed to accept input from a range of sensors: from traditional mouse or keyboard, to coarse gestures, to voice control. ALFBook assumes only that a user can operate *an* interface device, and thereby targets the broadest group of users. This allows for flexibility in generating tailored implementations or data integration strategies on a ability/need-basis. Kobsa and Pieper suggest that this methodology, wherein a generic interface is designed that can be further adapted to specific user-types, is in general preferred, even after working with a patient with acute disabilities [12].

A smart phone device will be used to control the application's movement via touchpad, accelerometer, and/or orientation sensors. When recognized commands or gestures are performed, the Android device informs a Java Applet which generates cursor movements on a computer. The ALFBook application responds to any cursor movement and translates it to actions including but not limited to: movement between screens, selection, zooming and scrolling. In this sense, any input device capable of moving, or being made to move the cursor could conceivably control the application. Keyboard interactions will work in a similar manner.

The smart phone's voice recognition functions will be used to generate text which is forwarded to the ALFBook Java applet. The applet will then handle the text directly (e.g. as message text) or virtually press the corresponding keys, depending on the situation.

B. User Modeling and Privacy Handling

ALFBook will utilize both physical and cyber sensors to mine user data to augment user experience in various ways. One example would be eliminating the "work" portion of building cyber profiles by populating data automatically from the Internet, locally stored data, and physical sensors. Such sensors might range from GPS (or other indoor location sensors), to pressure-sensitive floor mats, which could allude to location, body type, or daily routines of the users. This added information will make the system both behavior and context-aware which translates to an enormous advantage not only in locating relevant information, but also in displaying it in an effective manner. For instance, a system that is both behavior and context-aware can implement advanced privacy even in an open user environment such as a ALF common room by detecting the presence or even identity of others in the room, through motion, microphone, and bluetooth proximity, and decide whether to display full personal messages or abbreviate them on the home page, according to a user's privacy settings.

Such extensive data mining, though invaluable to usability, raises privacy concerns. ALFBook plans to handle privacy with a very unique and literal form of data ownership which places all information captured about a user on their person. A users information is only ever permanently stored in a on their personal smartphone device, putting it directly on their person and giving them complete ownership and control over their data. A personal profile, populated with the interests, online services information, physical and computer-based activities of the user will be stored on the smart phone in a database (here we chose SQLite, as it is efficient, portable and widely available on different smart phone OSes). Data from this database is only relinquished to a node after the user physically confirms a direct request from the system.

In a typical interaction, an ALFBook node will ask the user if they want to use the service, and upon user confirmation, will create a connection between the smartphone and the computer which serves the ALFBook applet. Next, the desktop will request access from the smart phone to any user information which is helpful to or necessary for operation. If a user has never used the node before, he or she will need to further confirm the transfer of any personal information; however, if the smartphone has a record of the node and a user has already allowed details to be shared with the node, the device will send the requested details. When the user finishes using ALFBook, the session ends and all captured user information is immediately removed from memory. The next time the user approaches the node, the phone-computer procedure will repeat, but the phone will now recognize the node and accept automatically, unless the user has specified otherwise.

Normal Application Flow:

1) User approaches an ALFBook Node, a Bluetooth-enabled computer with the ALFBook applet running in a browser, displayed on a large, readable TV screen.
2) When in range, as detected by bluetooth proximity, the applet will ask the user visually and/or audibly if they would like to use the system.
3) User confirms, vocally, through a button press, or through a gesture using their mobile device, thereby connecting the smartphone to the node.
4) Node requests for an online service login, user interests to augment a search, etc from the smart phone.
5) If node is approved, data sends; If node is not yet approved, user is prompted to accept or deny user data transfer.
6) The applet will proceed to use this information, to make http requests, API calls, tailor media suggestions, etc.
7) The applet will display a opening screen, for instance: a page with pictures of a user's family, and wait for user input.

IV. Current Implementation

The current prototype consists of an Android smart phone application as well as a Java applet and JavaScript/HTML webpage served up by a remote server. The Android application sends touchpad or gyroscope/accelerometer-based data over WiFi to be interpreted as mouse movement by a the PC running the ALFBook applet, and speech-derived strings of text to be interpreted as keyboard input. The application also allows for immediate recognition and connection to a nearby computer based on Bluetooth range. The ALFBook applet interprets and responds to voice commands and touch or gesture motions registered on the phone. Although this research concentrates on user interaction using an Android mobile device, it is worth noting, as proof of the system's adaptability, that control has also been achieved through other devices, such as Microsoft's Kinect motion sensor.

A. User Interface

The completed components of the interface can display all the user's Facebook friends and a message dialogue, which allows the user to read and send private Facebook messages. Please refer to Figure 1 for an illustration of these components.

Currently the main screen (see fig. 1 allows the user to browse all their friends. Images are displayed on large panels, showing the profile picture and name of each friend. To allow for the large size of the friend panels, the friend screen only displays eight friends at one time. Using their phones touch screen or gestures, the user can scroll these panels left and right with a coarse, sweeping motion in the appropriate direction. On the other hand, a gentle motion moves the selector focus to a particular friend on the screen.

Figure 1. User Interface

In order to provide adequate visual feedback, the currently focused friend panel is enlarged and highlighted in red. The user can select a friend with a wave gesture to open up a message dialogue. At any time, the user may also simply speak a friend's name into their phone, which instantly opens up a message dialogue with the particular friend.

The message dialogue opens slowly from behind the friend panel to fill up most of the screen while leaving a border around it. This serves as the visual indicator of the hierarchy of the interface, clarifying that the user can easily go back to the previous screen by closing the message dialogue using the wave gesture again. On the message dialogue the user can scroll through conversation history with the friend. This history displays the time, the subject, the sender and a short extract of each message. As the user scrolls through these messages, the row of the currently selected message is enlarged and highlighted in red. At the same time, a panel below displays the full, enlarged version of the selected message. The user may also use a voice command to maximize the panel with the currently selected message.

B. Voice and Motion Controls

During the development of this prototype, we encountered several challenges and found solutions to overcome some of these challenges. The first major challenge was related to implementing voice control using the Android phone's Google Speech Input. When initially testing Google Speech Input, we quickly realized that in many cases, especially those involving people's names, it generates results that were phonetically similar to the original speech, but with drastically different spelling. To solve this problem, ALFBook uses a database of known voice commands in addition to the database of the user's Facebook friends' names. This database is complemented by three algorithms, Double Megaphone, Levenshtein Distance and Soundex, to produce the highly accurate voice recognition system in ALFBook.

This system converts the input generated by Google speech input into its Double Metaphone representation and calculates its Levenshtein Distance to the Double Metaphone of each string in the command database. The system then searches for a pair of strings that satisfies both the minimum Levenshtein distance between its Double Metaphones, currently set to 2, and the minimum Soundex similarity of the pair, currently set at 85%. If such a pair is found, the system responds to the command that is attributed to the command string in the pair. This methodology allows the prototype to phonetically recognize voice commands with a very high accuracy. Meanwhile, in order to further enhance voice recognition, several versions of each voice command have been recorded in the database. This range of voice commands makes voice control more flexible and akin to natural speech, whilst also satisfying elderly users' demand for shorter and simpler voice commands.

Another major challenge that we encountered was the need to construct a delicate balance between responsiveness, accuracy and complexity of motion controls. The first two of these factors are inversely related, since lower responsiveness increases the system's accuracy by ignoring slight involuntary movements. However, the responsiveness of the system also needs to be set high enough to cater to elderly users' reduced mobility.

On the other hand, we also had to simplify and limit the amount of motion commands necessary to control the system. Because of elderly users' decreased cognitive abilities, the complexity and number of motion gestures has to be kept to a minimum. Consequently the interface had to be designed in a manner that would bypass this obstacle, yet still offer natural access to the required features.

The current prototype can be controlled by three different types of gestures. The first two gestures require either a quick or moderate swipe in one of the four directions to move the whole screen or the selector respectively. The last gesture simply requires the user to wave. As mentioned before, these gestures may be registered using a variety of sensors, such as the touch screen and gyroscope on the users phone, or even a Microsoft Kinect. These gestures are also very intuitive, as they are modeled after real life actions. By moving the selector according to the direction of the user's gentle movements, the system imposes a sense of pointing at a desired item on the screen. Moving your hand quickly across the screen, scrolls all the items on the screen in the opposite direction, creating a sensation of pushing something with a physical weight. Finally, waving in order to select or unselect an item on the screen alludes to a well-known greeting and farewell gesture.

V. Future Work

A. Automatic Login and User Modeling

Currently automatic Bluetooth-enabled login has not been implemented. However, we have implemented a Bluethooth based proximity and login method, but it requires user interaction. Furthermore, the ability to control the ALFBook desktop applet using an Android phone demonstrates the ease with which it is possible to send data between the interconnected desktop and phone. Consequently, the one last step required to implement automated login is implementing the secure database stored on the users' phones.

Initially this database will only store the user's Facebook login details. As the development of ALFBook continues, this database will be expanded to collect various information about the user, automatically constructing a user profile. This will allow the system to customize and individualize the users' ALFBook experience. An example of such customization is a recommendation system. In this example, the necessary data that will be collected is the relative popularity of all the information and services on ALFBook. This will allow the system to intelligently reposition the most popular information and services to make them more accessible to the user. This can be as basic as positioning Facebook friends by the order of their popularity or as complex as creating a home screen with the most popular items from different services.

B. Additional Services

Next we intend to focus on allowing image browsing and search, also through Facebook. This feature should be easy to complete as it only requires some adjustments in the existing codebase and interface design. In the same manner, ALFBook's interface for Facebook can be seamlessly integrated with access to other web portals. This will allow ALFBook to grow into an accessible platform for a diverse range of vital online services. For instance, ALFBook could provide its elderly users an online shopping experience by presenting a simplified interface to Amazon.

C. Auxiliary Feedback

Further, we will add auxiliary feedback to the user in the form of voice narration and phone vibration. The voice narration will use prerecorded audio to give advice. The system will balance the amount of voice narration according to the abilities of the user, which will be determined in real time using the user profile stored on the phone. The application will initially guide the user through its features and give them voice narrated tutorials about its interface and various methods of interaction with the system. As time progresses and the user becomes increasingly comfortable with the system, the amount of these helpful messages will be appropriately adjusted.

Along with hints and advice, voice narration will enable the application to read the messages for the user using a text-to-speech algorithm. All the voice feedback will be spoken in a clear and slow manner. This moderate pace reflects on the 'patient' approach of the whole ALFBook interface, which gives its elderly user apt time to respond to events, thus catering to their reaction rate. Finally, the application will also trigger the phone's motor vibrations at appropriate times to help focus the user's attention on a particular event.

D. Voice Controls

The current prototype's voice controls require the user to specifically press a button on their phone in order to instigate Google Speech Input. It would be ideal to automate this process so that the system is constantly listening for voice input and does not require user intervention. This will make voice control much more natural, while also making it possible to control the whole ALFBook interface solely using voice. Since Google Speech Input needs to be explicitly launched to register input, a potential solution is to exchange Google Speech Input with another resource for speech recognition. Fortunately, the ALFBook system is very flexible and can receive voice input in the form of text from any source. Consequently, a potential solution is use Windows Speech Recognition complimented by Kinect's advanced noise cancellation.

E. Testing In a Retirement Home

Once the features mentioned above are implemented, we plan to pilot-test our prototype within an assisted living facility. This will allow us to gain vital feedback from our target users, which is the best criteria that can be used to evaluate system and improve it to be more accessible. Furthermore, we will be able to define the direction of the platform's further development by inquiring about the users' most desired new features.

VI. Conclusion

This paper presents a novel technical framework that supports easy access of online social networking for senior residents. The interface design emphasizes flexibility in making use of several different interfaces that fit the given user needs. Privacy issues are discussed in terms of context reasoning and user modeling. We present the current prototype and discuss challenges including optimizing motion control with respect to competing complexity and accuracy constraints, and handling low-accuracy speech-to-text data. We expect similar approaches can be effectively used in supporting easy access of other internet resources such as news sites.

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