Information architecture for an Alzheimer's communication monitoring system (ACMS)

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M. Rahimi, M. Vaughn-Cooke. Information architecture for an Alzheimer's communication monitoring system (ACMS). Gerontechnology 2007; 6(1):42-55. This paper describes the design of the information structure for a communication monitoring system to be used for wandering patients with early-stage dementia of the Alzheimer type. Recent technological innovations have provided new capabilities for patient communication, monitoring and safety. ACMS is envisioned as a three component communication, alert and patient information management system. The system integrates GPS and biosensor technologies into its locator and communication system components. Hierarchical task analysis was used in order to study the accessibility of device functions for rapid response in emergency situations. A preliminary set of interviews were conducted to complement the task analysis, leading to the interface design and interaction framework. Several recommendations are made for future developments in tracking devices for Alzheimer's patients.

Keywords: early-stage Alzheimer's, wandering behavior, independence

It is estimated that about five million Americans are currently living with Alzheimer's disease, and another 360,000 new cases are diagnosed each year. The hallmark of Alzheimer's disease is a progression in cognitive decline, characterized by the destruction of nerve cells and neural connections in the cerebral cortex of the brain and by a significant loss of brain mass[1]. Interventions in the initial phases of the disease play an important role in the treatment and development of the disease at later stages[2]. The Global Deterioration Scale (GDS) for primary dementia is a clinical rating tool used to identify the onset and progression of Alzheimer's disease. In the first stage of the GDS, patients appear clinically normal and do not exhibit traits of cognitive or physical decline. It is for this reason that most patients are not clinically diagnosed until the second stage, where the first signs of memory deficits appear. Patients begin to forget familiar names and object locations; however, there is no objective clinical evidence of memory deficit present at this stage. In the third stage, defined by mild cognitive decline, concrete memory deficits are identified through clinical testing. Decreased performances in social and employment situations are also apparent. In addition, the patient may wander and become lost when traveling to unfamiliar locations[3]. The tendency to wander and become disoriented may pose serious risks for patient safety, including injury and death as high as 46% after 24 hours[4].

In the fourth stage, defined by moderate cognitive decline, patients exhibit decreased knowledge of their personal lives and recent events. Complex tasks and activities that involve concentration are performed less accurately and efficiently. In addition, the ability to travel alone is decreased. However, at this stage patients retain the ability to distinguish familiar faces and travel to familiar locations. In the fifth stage, defined by moderately severe cognitive decline, symptoms of early dementia are exhibited. Patient assistance is required to complete everyday activities. Also, communication is restricted because patients are frequently unable to recall information about themselves or people in their lives. In stage six, defined by severe cognitive decline, extreme personality and emotional changes occur, with an increase in memory and communication deficits. Stage seven, late dementia, is characterized by the loss of verbal ability and psychomotor skills[3].

In the earlier stages of Alzheimer's disease, delaying admission to a treatment facility allows the patient to spend a longer period at surroundings that are familiar and prolongs patient independence. Research has shown that independent activity could delay the onset of the more debilitating stages of the disease[2,5]. From a patient safety point of view, it is also estimated that 60 to 70% of dementia of the Alzheimer type (DAT) patients will wander from their residences at some point during their illness[6]. Previous research on wandering shows that DAT symptoms, in particular wandering due to memory loss, are poorly tolerated by caregivers[7]. A variety of surveys from caregivers identified the problem of wandering as somewhat serious to very serious[8,9]. It is now believed that wandering of confused Alzheimer's patients poses considerable management problems for caregivers.

Technological innovations have led to the development of new patient monitoring systems, which can substantially enhance safety management strategies for caregivers and nursing facilities. These developments show that the caregivers' coping mechanisms would be enhanced with appropriate assistive technologies that are designed not only for the patients, but also designed with caregivers in mind[10-12]. The trend in using technological innovations for assistive living has necessitated new developments in Alzheimer's monitoring and communication systems. The Alzheimer's Communication Monitoring System (ACMS) described here allows patients to maintain self-directed activity, while giving the caregiver the ability to monitor patient location and wandering behavior continuously, thus enhancing independence for both types of users.

Safety concerns

The main concern for Alzheimer patients wandering away from home is on safety risks and personal injuries. Studies have shown that persons with Alzheimer's disease appear to feel the need to keep moving, a phenomenon that seems even more pronounced in the later stages of the disease[13]. Since the patients' ability to integrate environmental information is impaired, they frequently are unable to retrace their steps[13]. In addition, there is a high potential for loss of balance, which poses a large risk for personal injury. Individuals with Alzheimer's disease react more slowly than normal, which makes it difficult for them to regain balance if they start to fall[3]. Impaired thermoregulation, leading to hypothermia and hyperthermia, is a concern for older individuals, with a higher risk for elderly Alzheimer patients[14]. Research has suggested a link between Alzheimer's disease progression and the loss of temperature sensitivity[14]. Older individuals have a lower basic metabolic rate and activity level than the young; thus, it is more difficult for them to maintain normal body temperature during stressful thermal climatic conditions[15]. The above problems have been categorized by caregivers as serious patient management issues[8]. With the advent of new technologies, especially Global Position Systems (GPS) and wireless technologies, it now becomes possible to locate and determine the conditions of these patients with a high degree of accuracy.

Assistive technologies

Currently, there are several technology research and developments that aim to increase patient safety and reduce the burden of caring for individuals who live with

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Alzheimer's disease. The most advanced ones seem to be the Assisted Cognition Project and the Activity Compass device designed at the University of Washington, which attempt to provide cognitive aids for Alzheimer patients in their everyday activities through artificial intelligent systems[16]. There are also wide ranges of medical alert and monitoring devices available that target user populations of elderly and disabled individuals as well as Alzheimer and dementia patients. Current medical alert systems, such as Vitalink[17], Medical Monitoring USA[18] and Lifefone[19], have central command emergency response systems, but are limited to the range of the device console, generally restricting the patient to stay inside their homes. Another noteworthy support tool is offered through the Alzheimer Association's Safe Return Program, which provides patient identification bracelets and caregiver support services. This is maintained through a national database of Alzheimer patients and their caregivers to aid local law enforcement when a patient wanders[20]. Safe Return Program is now being considered for the next generation communication capabilities using wireless devices[21]. There are also GPS tracking devices available that specifically target Alzheimer patients and others in risk populations, such as the GPS Wherifone[22], G-Locator, Nova Pearl, Digital Angel and Project Lifesaver[23] with strong presence from companies such as Signatron and SIDSA. However, we found very little research on any currently available systems, using the principals of information architecture as the basis for developing the hardware components and integration. For example, patient information is not readily available through a portable monitoring device. Moreover, these devices do no offer multi-user verbal communication as well as initiation of contact through the device by all users. There are no current systems that offer an interface for the caregiver population, allowing them to access updated patient information 24 hours a day. We also found very little research on how historical patient information should be presented to the caregiver and command operator. Finally, these devices do not possess the capability for long-term assessment of utility and changes in symptoms or behavior of the patients, based on their wandering patterns.

Information architecture

Architecture overview

The ACMS system integrates the communication needs of the three user groups (patient, caregiver, central command) with 24-hour patient monitoring via compatible technologies. The ACMS system is designed to allow patients to perform independent daily activities outside of the home while also maintaining full monitoring and communication functions for the caregiver and central command operator. To accomplish these objectives, we have utilized a user-centered methodological approach, often used in the field of human-computer interaction design. This approach offers customized interaction capabilities and device functions based on an in-depth analysis of patient, caregiver and central command requirements and limitations[12,24].

In this system, the patient data are transmitted to the caregiver device, which displays the information on a 5 x 7 PDA screen in the form of an interactive menu. The system analyzes the GPS tracking data as well as the heart rate, body temperature and galvanic skin response (GSR) data transmitted from the biosensors to determine if there are any abnormal patterns. The system then provides the patient location at various time intervals using point locator on a map with textual overlay (street name). In case of any location or health vital abnormality, a warning alert is transmitted to the central command computer and the caregiver device. The patient can also initiate interaction, by pressing the panic button on the wristband to speak to a central command operator, or the operator may initiate contact if a warning alert

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is received. In the event of an emergency or system alert; the central command operator can request an emergency 911 response or transfer responsibility to the caregiver, based on a procedural assessment of the situation and previous individualized patient needs.

Task description
The information architecture detailed in Figure 1 is based on a user-centered methodology, well established in the software interface design community[25]. Briefly, user-centered design is an engineering design approach that maintains focus on the end-users of a product at all stages of the design process. It provides a deeper understanding of how the users will use and interact with the device, and ensures relevant and useful functionality in all system components, for instance, an application to a portable GPS locating and way-finding device[26]. System models and user task analyses were utilized to define the basic interactions required among the users and the system components, while providing insight into the steps performed to complete specific tasks[27].

User modeling
During the early stages of Alzheimer's disease, patients are faced with deteriorating cognitive abilities, disorientation and special temporal problems[28]. Therefore, the system must take into account the possible spatial disorientation and mental overload that can be caused by environmental and physical factors[1,29]. The projected prevalence of mild Alzheimer cases is currently 1.21 million and is estimated to triple in the next 45 years, based on a multistage projection model[30]. Patients who are further along in the progression of the disease (Stage 6 and 7 of the GDS) will need 24-hour close supervision, which is beyond the design requirements for this system. The procedural situation assessment and initiation of contact is determined from the 3-node communication functions among the caregiver device, patient wristband, and central command system. The level of interaction for each user is based on optional central command, patient and caregiver communication. This is determined by the global deterioration scale (GDS) assessment in conjunction with an individual patient functional evaluation as well as caregiver preference. The interaction is detailed in the interaction situation diagram shown in Figure 2, which demonstrates the user data needs and the resultant actions based on a step-by-step evaluation.

In this user-centered approach, the patient's concerns are central to the overall design process. In our approach, the patient has the option of transmitting two types of messages to the central command operator. First, the patient could activate a panic button during an emergency. Second, the patient could engage in a conversation with the central command operator through a cellular walkie-talkie, which is activated automatically by the panic button activation.

The central command operator is a secondary user and is primarily responsible for making emergency situation assessments based on incoming patient data. The operator initiates contact with the caregiver via telephone in the case of an emergency. The information obtained from this communication is used as the decision factor for any actions taken after this point, such as contacting emergency services or directing the caregiver to pick up the patient. If the procedural assessment reveals that the situation does not require immediate attention, the operator may decide to take no action. Contact may also be initiated with the patient after contacting the caregiver using an interaction script derived from behavior expectations, to acquire additional information about the patient's well-being. The central command operator is considered to be an expert user, trained in communication with Alzheimer patients and evaluating data in high-stress situations. In addition, the operator has

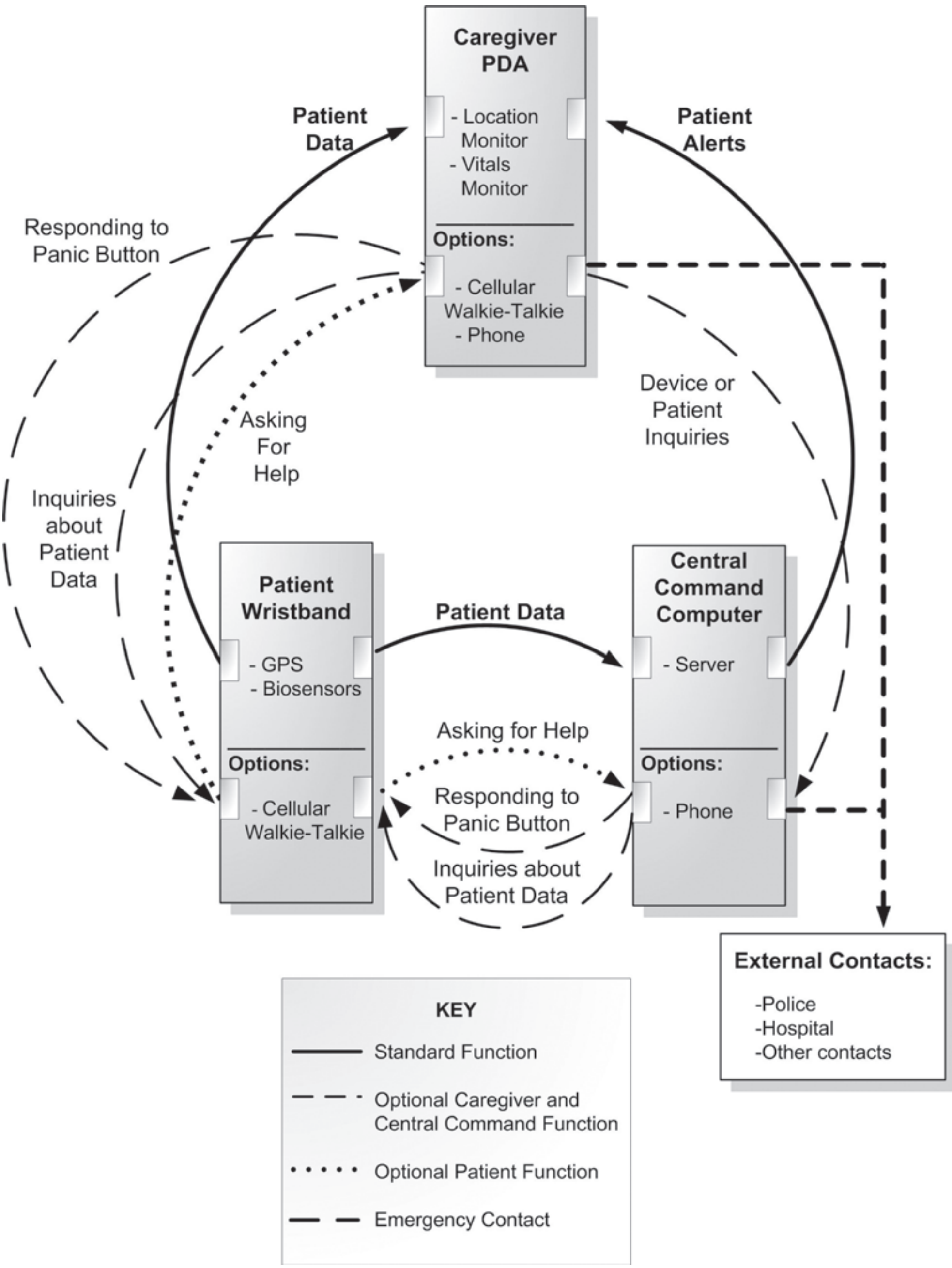

Figure 1. Data Flow Diagram showing a three node interrelated communication network for the ACMS system. Patient data is acquired through biosensor and GPS technology and is transferred to the central command system, where location and health vitals information is analyzed for data abnormalities

direct access to individual patient details, including the patient's medical history and behavior predictability, in order to effectively resolve an emergency situation.

Previous studies also indicate that the operator's contact with the patient may not be effective for some patient conditions, due to communication difficulties with unfamiliar voices[3]. For these patients, this

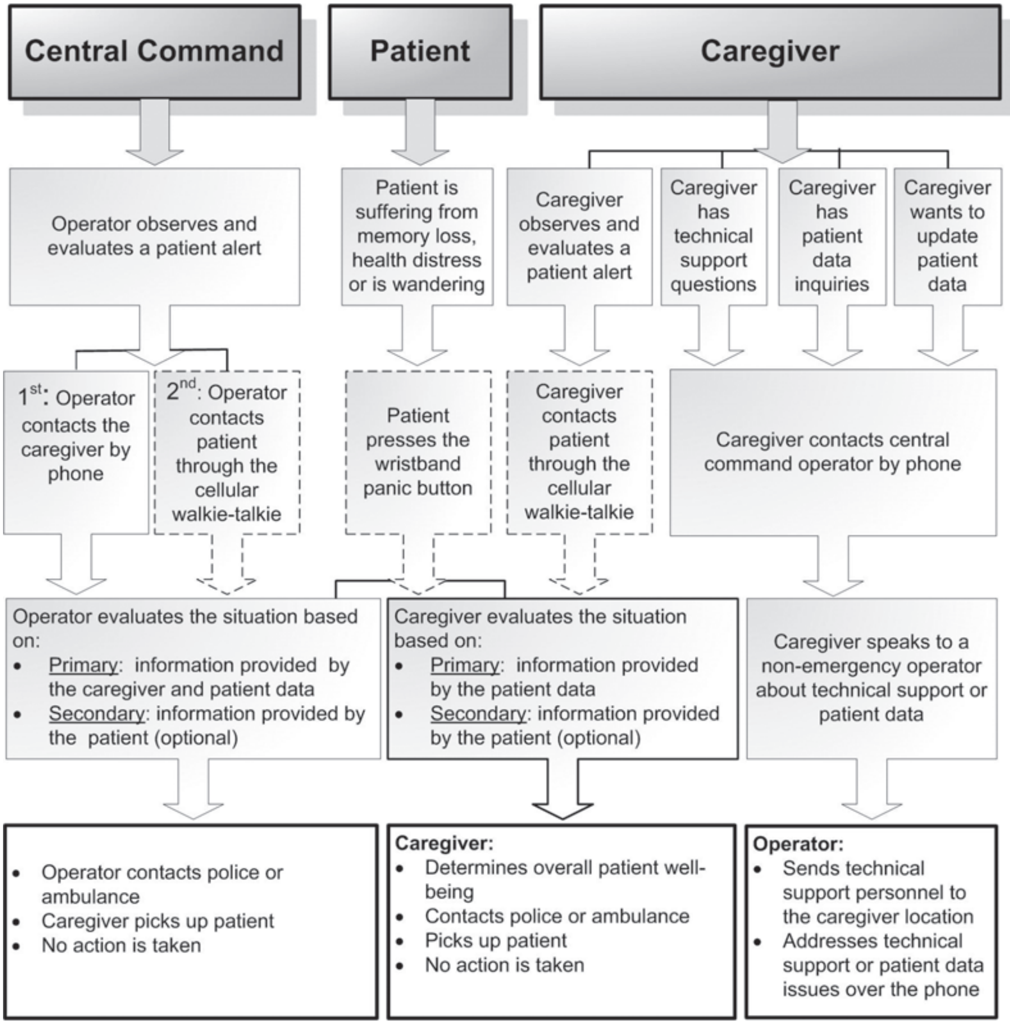

Figure 2. The interaction situation diagram details the situational assessment and user response based on functional ACMS system capabilities. The patient, central command operator or caregiver may initiate emergency or non-emergency interaction with another user device to address patient data or technical support issues. The dotted lines indicate optional patient communication

function is optional, and its addition to the system is specified by the caregiver. The patient's ability to communicate should be determined using the Global Deterioration Scale for an assessment of disease progression[3]. The functional evaluation, used in conjunction with a GDS evaluation, assesses the patient's cognitive and behavioral skills as well as mobility to determine if the patient is capable of utilizing the cellular walkie-talkie option[4]. The ongoing patient assessment ensures that the communication facilitated by the ACMS system, between patient and operator as well as patient and caregiver, does not negatively influence device usage.

In general, Alzheimer caregivers are family members and home care or assisted living facility nurses. Family members such as a spouse, sibling or adult child account for 80% of direct caregiving[31]. Nearly a third of these family members provide care coordination, independence maintenance, and socialization for elders from a distance of more than 60 minutes of drive[32].

The average caregiver is over 55 years old, so their declining physical conditions may affect their interaction with the interface. In addition, caregivers are considered to be novice users, thus the simplicity of device functions and interface interaction is an essential part of the ACMS system design. Interaction between caregivers and elderly care recipients is shown to have a strong effect on the perceived usefulness of the device and the user experience[33]. Also, older individuals and novice users tend to reject assistive technology if there is a lack of knowledge about the device usage as well as an inappropriate fit with their environment and their needs[12,34]. This factor was also taken into account throughout the design of the system and the information architecture design at the device interface.

In addition to optimizing device usability and acceptance, the ACMS system supports caregiver interaction with central command personnel. This has the potential to reduce the physical and emotional toll of caregiving as well as improving health and quality of life[9,31]. In case of system alert, the caregiver may initiate contact with a central command operator for technical support issues and the updating of patient data. Similar to the central command communication, the caregiver interaction with the patient is an optional function and can be activated based on a patient assessment and caregiver preference. This function allows the caregiver to communicate with the patient through the cellular walkie-talkie and can be used if the caregiver has patient data inquiries or wants to determine the overall well-being of the patient in a non-emergency situation. Also, the sound of a familiar voice has been shown to calm Alzheimer patients in high stress situations and this function may be used at the discretion of the caregiver[29].

Interface design

The design of the user interface and the device system communication architecture took into account the specific requirements of the patients, central command operators and caregivers. These requirements are derived from a technique called task analysis. The specific device functions for each user group were derived from the top levels of a hierarchical task analysis (HTA)[35]. The HTA indicates the interrelated connection of tasks between the patient, central command and caregiver users. In addition, the interaction framework communication between users and the optional contact was determined from the HTA through an iterative system design process. The device functions were determined from individual user research and were found to encompass the most relevant tasks for each user in order to facilitate the ultimate goal of continuous patient monitoring and communication.

Patient interface

The patient device is required to have a reliable cellular connection that transmits real time location and health vitals information to the caregiver device and central command system. It should also provide an optional means of verbal communication with the patient. In order to develop the data monitoring and communication function of our system, we investigated several technologies. A viable option is to use the RFID (Radio Frequency Identification) technology, because of its reliability and unobtrusive design. The data collected from the biosensor feedback unit (heart rate, body temperature and GSR data) and the GPS receiver (patient location data) will be transmitted through RFID tags incorporated into a GPS chipset in the patient's wristband. The data will then be read and decoded by the antenna embedded in the caregiver device and central command system. The wristband panic button, used in emergency situations, will be initiated via RFID with a higher priority than patient data transfer.

The required physical form and characteristics of the device include waterproof material and shock resistance, in order to prevent device malfunction. The patient's wristband must be small and concealable in order to support user acceptance and prevent the social stigmas associated with assistive devices[34]. The wristband must also be difficult to remove due to the fact that persons with Alzheimer disease have a tendency to fidget with objects they wear. There must also be a protective casing that prevents the panic button from accidental activation. On the bottom side of the wristband, there is a safety lock, which may only be removed by the caregiver safety key. In addition, the device must contain a long lasting power source, such as a lithium ion battery. Simplicity of the design and usage criteria is also very important, since Alzheimer patients are easily overwhelmed by excessive colors and functions. Therefore, the patient wristband contains only one interactive function, which is the panic button used for an emergency situation. The device also displays the current time, visible on the front panel of the interface.

Central command interface

The central command interface is required to continually display updated patient data. This data includes the current and archived information for global positioning, heart rate, body temperature, galvanic skin response (GSR) and immediate notification for the following emergency alerts: leaving designed zone alert, wandering alert, unusual vitals alert, and loss of balance alert. The archived alerts screen of central command displays all previous patient alerts listed by date received. This information can be accessed by the operator in an emergency situation if additional information is required about a previous alert that may pertain to the situation and assist the operator in reaching a decision. The alerts are controlled by predefined boundaries for each vital sign. When a data deviation is larger than the boundary for that user, the system alert is activated[24]. The designated zone alert is specified by the caregiver and can be defined by a one-mile radius (inside a neighborhood) or a city limit. The wandering alert is activated when the location data transmitted from the GPS receiver picks up an abnormal tracking pattern, such as circular movement or a repetitive step pattern. The unusual vitals alert is activated by a body temperature, HRV or GSR value that is outside of the normal range. The normal range of resting HRV for individuals over the age of 55 is 59.5 to 78.3 beats/min[36]. The normal body temperature range for older adults is 97 to 100 degrees Fahrenheit (36.1 to 37.8 degrees centigrade)[37]. The mean value for GSR is 319±194 microSiemens. The GSR value will drop during periods of stress[38]. The default range for vitals can be set to these predefined values; however, ranges can be individualized based on unique medical conditions of the patient (*Figure 3*).

The system should also display personal information about each patient and their respective caregiver. This information includes chain of contact information, physical and cognitive abilities of the patient, and his or her medical history. The patient information screen of central command displays the physical characteristics of the patient as well as identification information and a recent photograph. This information is essential if the patient needs to be identified or picked up by anyone other than the caregiver. In addition, this information can be automatically faxed, by selecting the send button, to a local police station near the location. The central command display also contains the patient's medical history and medication information needed to asses an emergency situation. This information is essential for the operator when additional information is needed to evaluate health vitals information, and may also be given to paramedics or hospitals

The information is designed to be displayed in a format that is easily accessible during an emergency situation. The device should display the above information on a computer interface using the mouse and keyboard as input and the monitor as output with security procedures in place that protects sensitive patient and caregiver information. The first screen requests the central command operator to input their login name and password. The actions of each operator within the system are recorded and archived for later use. The second screen is the idle screen where the user waits for a patient assignment in an emergency situation. The user may also utilize the idle screen to input patient search requests in a non-emergency situation, such as caregiver inquiries or the updating of patient system information.

In an emergency situation, the information for the patient whose alert has just been received by the system is automatically displayed on a computer terminal. The title bar displays the full name of the patient along with the type of alert. The control bar located below the title bar consists of drop-down menus that allow the user to temporarily make the control list visible so that it does not obscure menu functions and patient data on the screen. The menu bar contains only the following functions, which modify the information displayed in the output window: patient information, map, medical information, archived alerts and 24-hour vitals. This information may be used by the central command user if additional information is required other that what is shown in the visible windows.

This emergency screen contains all necessary data that the central command operator requires in order to make a fully informed decision. The emergency script displays the particular behavior and Alzheimer characteristics of the patient. This is permanently visible in large font, along with the emergency contact information. There are scroll bars available if the text amount exceeds the visible area. In addition, the heart rate, body temperature and GSR are also permanently visible at the bottom of the screen. In the centre of the screen there is a large output window that is updated based on the menu selection input from the user. This output window is defaulted to an enlarged map setting, which shows the GPS location of the patient in the form of a red point locator.

The map screen of central command displays the current global positioning data for the patient location. The patient is represented by a red point locator which displays exact location address and movement pattern in a comment box when selected. This location can be selected in order to display the exact patient location address. The address comment box is transparent to facilitate visibility of the area of the map that is behind the box. The map screen is the default screen that appears when a patient alert is sent to an available operator terminal. The information displayed in the centre output screen is modified based on the menu selection on the input bar of the interface. The Contact Info, Emergency Script and Health Vitals Information displayed in the three output boxes are permanently visible and give the operator all essential patient information needed to correctly evaluate an emergency situation and reach a decision.

Caregiver interface

The caregiver interface is designed to be portable and lightweight, in order for the user to comfortably travel with the device and access monitoring and communication functions at any point in time. In addition, due to possible eyesight and hearing deficits in populations of older caregivers, the device screen must be large enough so that the visibility of the menu items and graphics does not adversely affect the user. The device should offer user options to personalize and maximize their interaction experience by offering adjustment of device settings. Caregiver device volume adjustment is important, particularly during an emergency situation where patient alerts must be clearly audible.

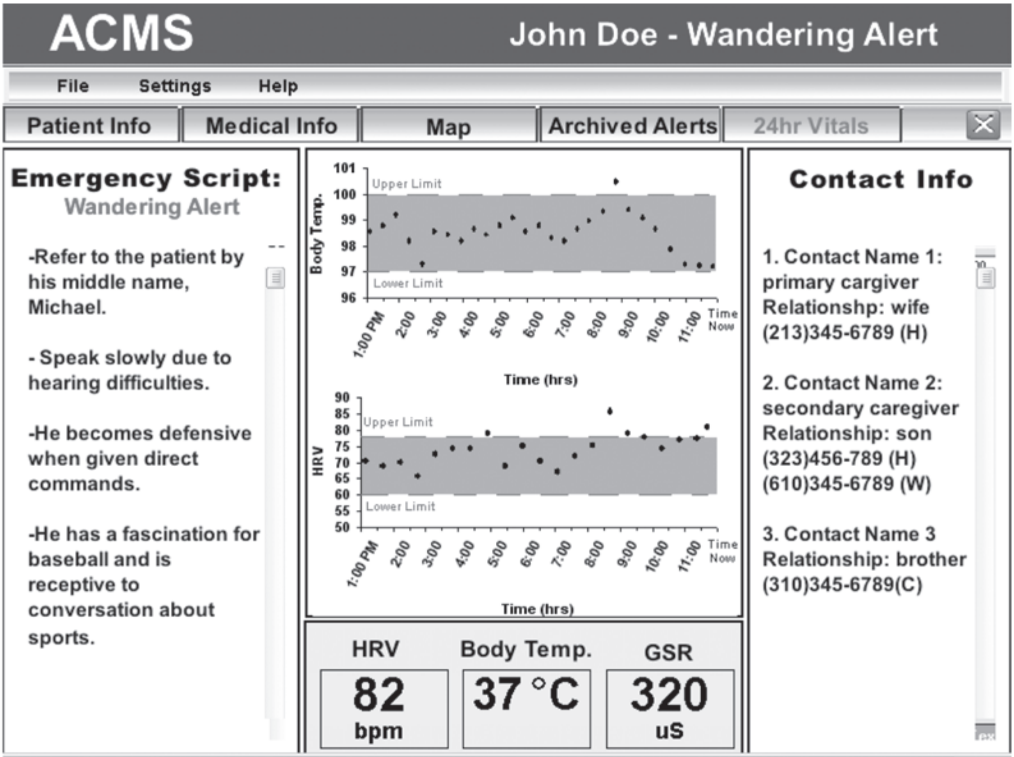

Figure 3. The 24hr vitals screen of central command displays the heart rate and temperature up to 24 hours ago. The upper and lower limits of the chart indicate the normal range of values for the data. The bounds are determined by individual patient medical history. This information can aid the operator in determining the health patterns of the patient and how long they have been exhibiting a particular health abnormality

A PDA style interface with a standard 5x7 inches (12.7x17.8 cm) screen size was selected because it allows the device to maintain a small portable size as well as proper visibility of the GPS maps, functions and textual information. The user will be able to exit any function in the device directly through the main menu, which is shown at all times on the left side of the screen. Also this menu style reduces the chance that the user may become lost in the menu sub-functions. Since the caregiver user is assumed to be novice, main menu button icons are essential to give visual confirmation of the menu topic. The user receives two confirmations, textual and graphical, of the menu selection topic. The menu button icons were selected based on user expectations from popular icons used in similar menu topics. This will increase the learnability of menu functions for novice users.

In order for the users to know where they are at all times within the program, the page information is displayed at a title bar at the top of the screen. The name of the function or sub-function being used is also permanently displayed, which allows the user to immediately see the effect of their menu selection in the title bar. Page layout consistency is also essential for the caregiver device, so that system output matches user expectation. A large output window is used on each screen, which displays graphical and textual information based on the page content. A dialogue input box is also visible on the right side of the screen, which displays all necessary information that the user must select in order to change the information visible in the output window. In addition, sub-function buttons which modify the information displayed in the output window are located on each main menu function page below the output window.

The caregiver device also allows direct access to textual help on device operation at any point throughout the system navigation. The help button can be found in the upper right hand corner of the title bar. The location in the page navigation when the help button is pressed determines the content of the help displayed on the screen.

The caregiver interface offers the same functional capabilities and design as the central command interface, such as Vitals and Patient Location monitoring, described previously. The patient location screen for the caregiver also displays the movement pattern in the dialogue box on the right side of the screen. The caregiver has the option of viewing a normal or enlarged size of the map using the zoom in and out function, located at the top of the dialogue box. The caregiver interface includes an additional option of personalizing common addresses that the patient may visit. These locations are input to the system by central command personnel and are displayed on the 'Track recent travel' (*Figure 4*) and 'Point of interest' screen. The point of interest screen for the caregiver displays the common patient traveling locations. These locations need to be previously designated by the caregiver and the central command operator has the ability to input them into the system. The 'Archived alerts' screen, similar to the 'Central command' screen, displays alerts for the patient information listed above (*Figure 5*).

Conclusion

The ACMS system attempts to increase patient independence and safety and reduces the potential for personal injury. This system also has the advantage of minimizing caregiver distress and burden through optional reallocation of responsibility to the central command operator. The cognitive and physical tasks of the patient, caregiver and central command users were considered for the interface design in order to increase usability of the device and its patient monitoring functions. The device functions were selected based on the primary tasks that the user groups perform in order to transmit and receive location and health vitals data. A user-centered methodology was used to frame the information architecture for this system. Display screen layers and information contents were designed using the human-computer interface design principles of ease of use, learnability, information consistency and accessibility. Caregiver interviews and user evaluation questionnaires were also used to gain feedback about design specifications and utility of the system functions, targeted at each user populations.

Future considerations

Based on interviews with Alzheimer caregivers at the USC Caregiver Resource Center and further research into the functional needs of each user population, future developments have been identified in order to improve user interaction and device functionality. This includes an interface design for a caregiver device that supports multiple patients in assisted living facilities. Since these facilities typically require one nurse to be responsible for several patients, the ACMS system must support multiple patient monitoring capabilities to increase patient safety. Therefore, direct communication functions between the caregiver, central command and patient will be further analyzed through alternative interface designs. These alternative designs will include intelligent agents for a more user friendly device interaction. Finally, for long-term assessment of utility and changes in symptoms or behavior, the ACMS should include a decision support capability. In such a system, the patient's route behavior on trips must be saved and continuously compared to the next trip behavior for any potential deviation in wandering patterns. These deviation patterns have the ability to provide a better understanding of the way in which illness

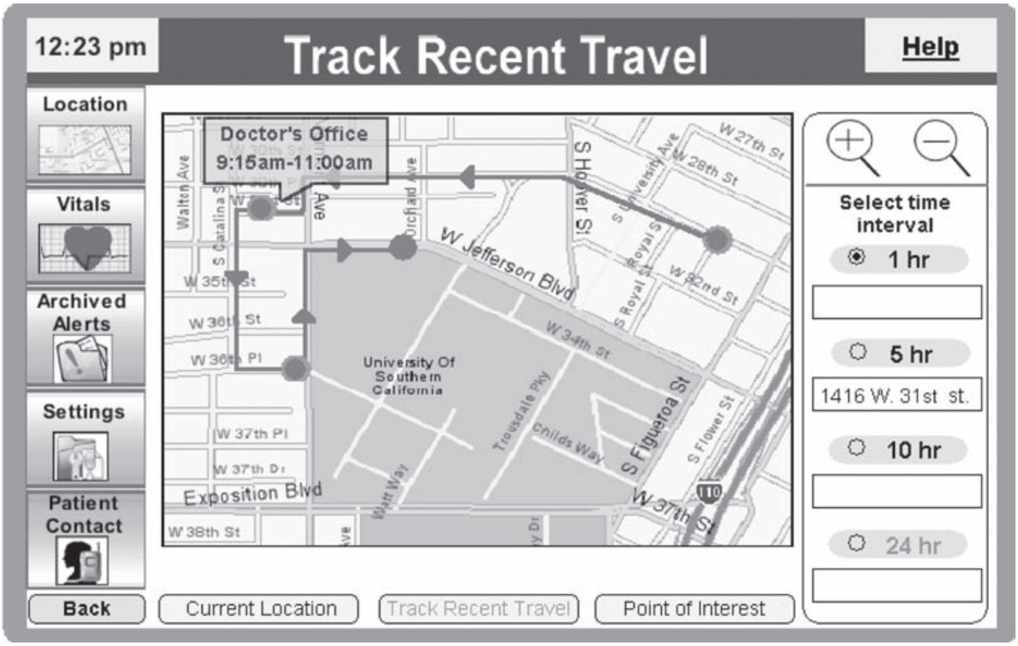

Figure 4. The track recent travel screen for the caregiver displays the patient traveling pattern (directional arrows) for specified time intervals (1hr, 5hr, 10hr and 24hr). This subfunction is accessed through the location menu and the button is found at the bottom of the screen under the output box

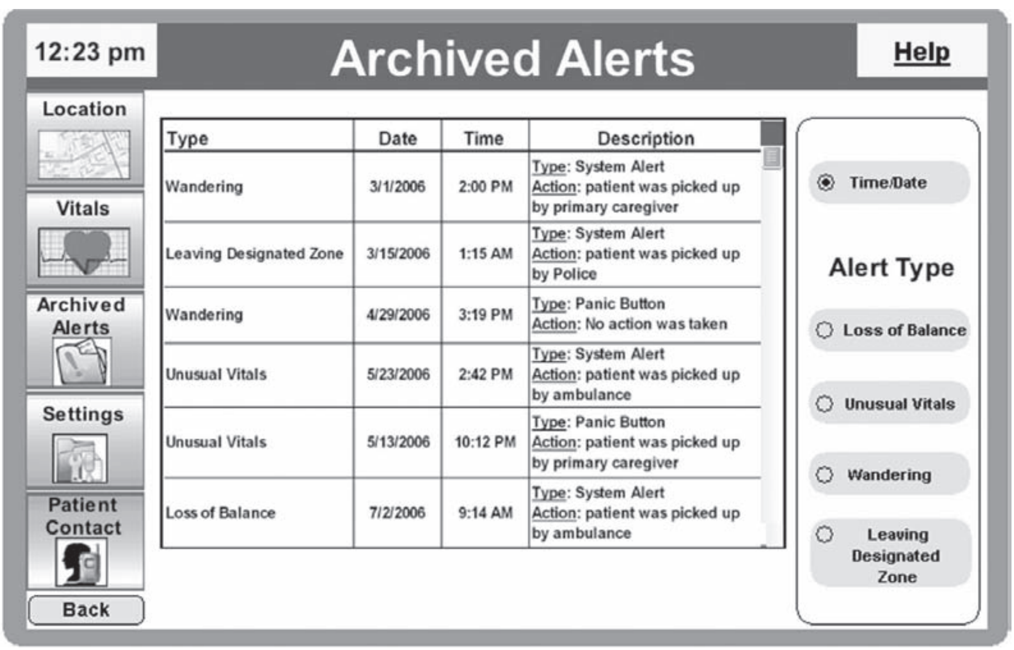

Figure 5. The archived alerts screen for the caregiver displays the patient alerts based on time, date, or alert type. Once a current alert is recognized by the user it is then archived and can be accessed here. This screen allows categorization of previous alerts, which is especially important when the number of patient alerts reaches a level that does not allow easy identification

progresses clinically. For this purpose the system should be tested and validated with a variety of deviations in wandering patterns; this might be of particular use in future therapeutic trials. Therefore, in the process of implementing software we are now using object-oriented language and a web-based application as suggested by Rialle et al.[39] and Bellazzi et al.[40].

Future experimental tests might include patient alert simulations that allow the caregiver and central command participants to respond to a predetermined emergency situation. The interface design, as well as the usability of the device functions, needs to be evaluated through a study of system design and functionality for the caregiver and central command interfaces. Realistic scenarios including all functions and screens should be simulated on a laptop computer, displaying the screen size of the caregiver device (5x7 inches) and central command interface (full-screen monitor). A set of specific tasks needs to be developed based on the main task sets generated from the task analysis. These tests need to be conducted using actual caregivers and trained operators. Finally, statistical models (for instance, analysis of variance) should be employed to detect the differences in performance of these users under different emergency scenarios.

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