

mPCA – A Mobile Patient Care-Giving Assistant for Alzheimer Patients^{*}

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Abstract

The use of pervasive computing elements such as java smart phones and multi-modal sensors in smart homes of the future can potentially assist patients with Moderate Alzheimer's Disease (AD). The utility of this technology particularly in the elderly group of patients is currently hoped to reduce the huge economic toll on the ailing Medicaid system. We present an ongoing research project whose goal is to create a cognitive assistant to improve the independence of home-bound AD patients. We present the architecture of the Mobile Patient Care-Giving Assistant (mPCA), which integrates local-positioning systems, J2ME-based smart phones as well as other wireless and visual sensors. The mPCA system is targeted towards AD patients in their early to moderate stages of the disease (Global Deterioration Scale, or GDS = 4 or 5).

Introduction

Alzheimer disease is a dementing disorder, characterized by cognitive and behavioral problems. It involves the damage, breakdown of connections, and death of the brain cells. It affects the parts of the brain that control memory, thought, and language. It usually begins at age 60. Some of the signs include loss of memory, difficulty with abstract thinking, disorientation, loss of judgment, and personality changes. It progresses from mild to moderate to severe. People with mild AD can usually live alone. People with moderate AD may have great difficulty functioning without supervision. People with severe AD can no longer take care of themselves (2000 Progress Report on Alzheimer's disease). Until a cure is found, people with Alzheimer's disease need care-giving.

According to the director of University of Florida's Institute on Aging, 1 in 10 elders (4 millions) suffer from AD. It is also estimated that 1 in 5 elders will have AD by 2050. Also, a study made at the University of Pennsylvania, estimates that in 2002 AD will cost American businesses more than \$61B [3]. This cost is broken down as follow:

- The cost of family care-giving including absenteeism, productivity losses, and replacement losses (\$ 36.5 billion).
- The business share of health and long term care expenditures (\$ 24.6 billion).

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One of the goals of the Alzheimer’s Association is to reverse this course by providing support for family caregivers to release them from the overwhelming load they face with their family and employer [4]. At the University of Florida RERC center we are exploring the use of pervasive and wireless technology to create a mobile patient caregiver assistant (mPCA). Our goal is to create a tool to reduce the caregiver load, therefore decreasing the cost of family care-giving.

The mPCA assistant is a smart phone that interacts with a set of sensors in a smart space, in which most of the computation, decisions, and events take place. This tool will benefit the patients, assisting them to overcome difficulties in carrying out daily activities by means of reminders, orientation, and context-sensitive teaching, and monitoring.

Related Technology

In-door Tracking system. mPCA is based on an ultrasonic indoor tracking system, already implemented in an elder house model at the CISE department of the University of Florida. It operates in the ultrasonic range (40 KHz). The system, shown in Figure 1, consists of: (1) four fixed devices (known as pilots or monitors) located in each corner of each room in the house, and (2) two moving devices (known as tags or beacons), which are placed in the shoulder blades of a light-weight “net” vest worn by the elder. The four pilots acts as receivers that receive signals from the beacons. The position of the beacons is calculated based on the two shortest times that the ultrasonic waves take from the beacon to the pilots and a *trilateration* technique (see line labeled 1 and 2 in Figure 1). By using two beacons, the system not only is able to detect the position of the elder, but also his/her orientation. Other related technologies include smart phones and other sensors, but we do not see it necessary to report on those technologies in this short paper.

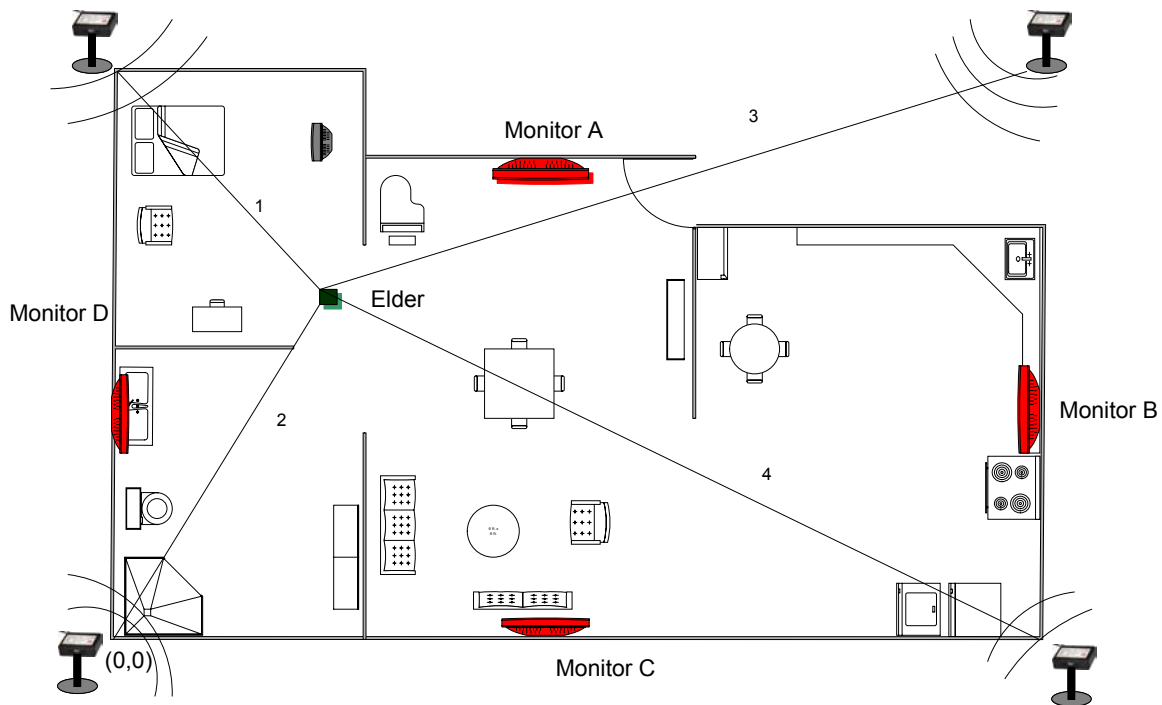


Figure 1. Smart Elder House

mPCA

The mPCA system is designed as a smart phone with a static IP address and a speaker phone. It is also assumed that the battery of the smart phone can last for a full day. This is not currently possible without using additional standard batteries. The mPCA assists AD patients by performing the following four functions, as needed or as requested:

- As a reminder for critical tasks (to take medications, to eat at meal times, to go see the doctor, to call son on his birthday, to feed pet, etc). This function is proactive and obviously does not require patient initiation.
- As a teaching tool to perform step by step tasks. For instance, to cook a meal or to instruct a microwave oven. Also, to perform hygienic routines or operate a VCR. This function is also proactive but requires context information. For instance, time and location information can trigger the step by step hygiene procedure reminder. Context information is supplied by the smart house.
- As a location tracking mechanism to locate the patient in the house as well as important objects such as bottles of medicine or patient's pet. Some of this functionality is passive, requiring the patient request. For instance, the AD patient is worried about her pet and needs to locate her. Another example is when the AD patient is reminded to take his medication but has difficulty locating the medicine bottle.
- As a monitoring tool to record the activities performed by the elder. Here mPCA acts proactively but does not interact with the elder.

Attention Capture

One of the major challenges in this project is to design a scheme to capture the attention of the AD patient, before sending any type of assistance. Based on the retained neuropsychological abilities described by Tammy Hopper [1], *“individuals with moderate AD may be able to sustain attention and selectively attend to stimuli presented in visual and auditory modalities, at least for short periods of time”*. We have worked with University of Florida AD experts to understand the extent to which our sought assistant can be used effectively. Consensus was to first attempt to solve the attention capture problem. For intervention to be effective, the AD patient should be prepared to receive the intervening action or message. Therefore, a protocol that would try to capture the attention using alternative means is needed. The protocol should also confirm to the system (the smart phone or smart space or both) that the patient attention is secured. The state machine depicted in Figure 2 describes a protocol to capture AD patients' attention.

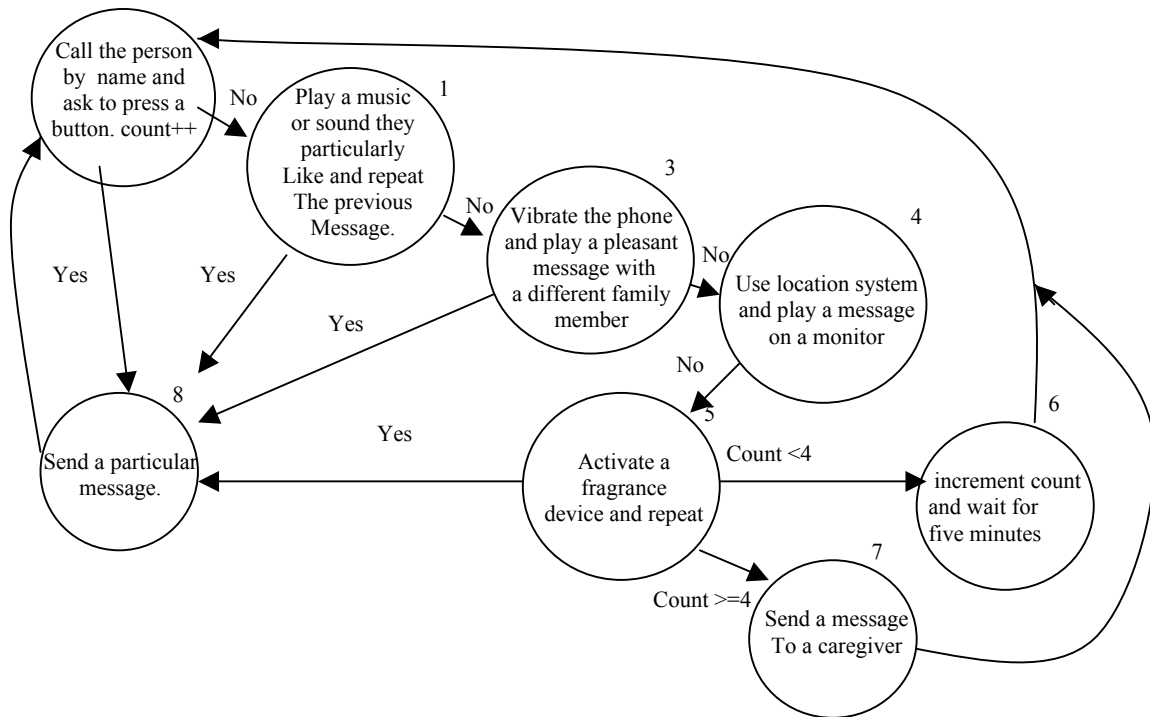


Figure 2. Attention Capture State Machine Diagram

The attention capture in mPCA attempts alternative mechanisms in an increasing order of intervention and interactivity. This ranges from simply calling the elder's name (MIDI Audio output) requesting the elder to respond in certain way (e.g. press the "9" key on the smart phone). If attention is not secure, richer audio is attempted by playing special songs and special sounds and then repeat the name calling and confirmation request. If this fails, actuate the vibrator on the smart phone and output the name calling using pre-recorded sounds of loved family members. The protocol progresses to using visual cues by playing a video clip on the video monitor most facing the elder (we assume the use of multiple video monitors). The ultrasonic system is used to determine the orientation of the patient, and to subsequently select the ideal monitor to play the video clip.

Certain messages could also use fragrance as an attention capture stimuli. Artificial food fragrances are believed to be particularly effective if squirted before meal reminder messages.

The state machine can be tuned to loop over the alternative states until a valid confirmation is sent back by the elder.

Components of mPCA

Figure 3 shows the different components of the mPCA system. A Home computer (server) is connected to local sensors such as monitors, fragrance squirting devices, speakers and an ultrasonic location tracking system. The home server is also connected to the Internet through a broadband technology. A smart phone with routable IP is also connected to the smart house through a wireless data service plan. The smart phone coordinates with the home server to detect contexts, respond to AD patient's request, or

to capture attention and deliver a message to the patient. Additionally, a remote monitoring facility can be attached to mPCA to store history information on patient activities. Patient interaction with mPCA can also be logged to provide data to us to study the effectiveness of the mPCA tool.

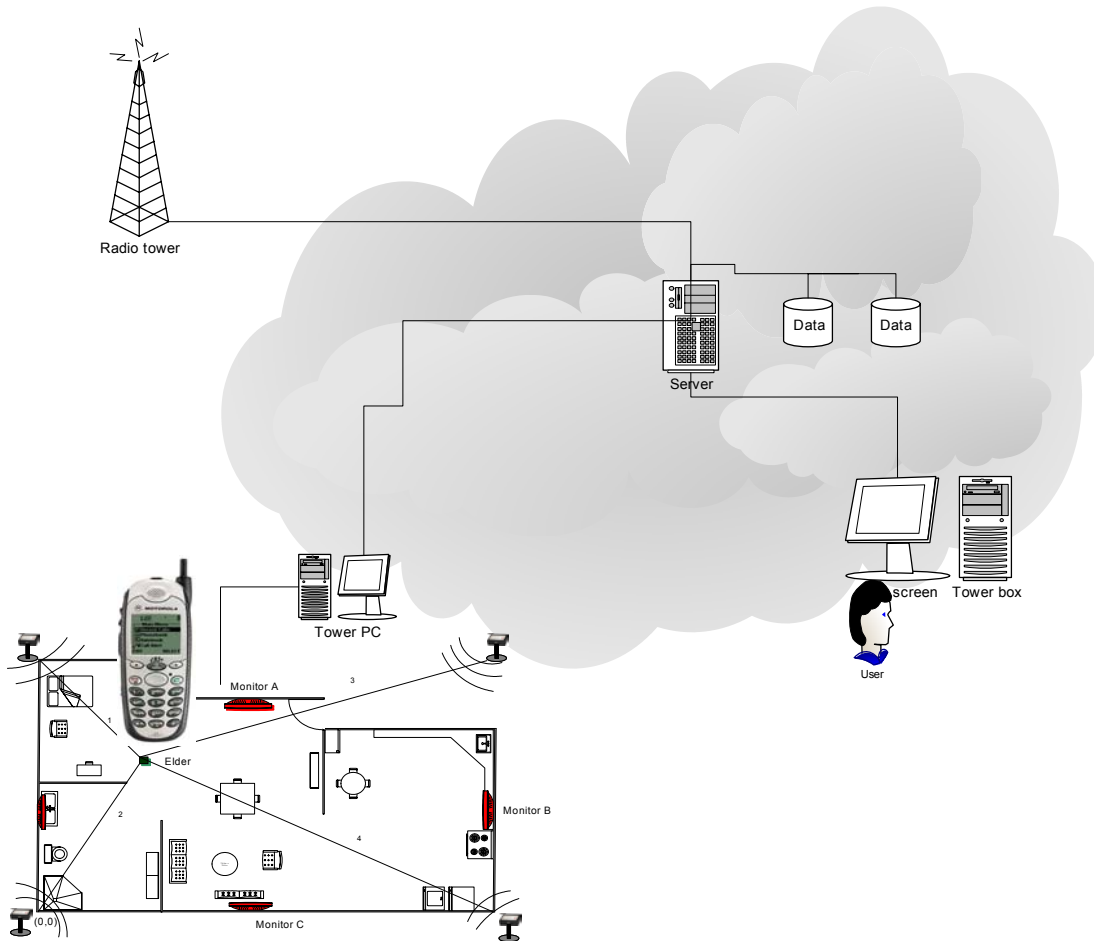


Figure 3. Components of the mPCA

Conclusion

The integration of multi-modal sensors, smart phones and smart spaces, provide a unique opportunity for us to create tools that would enhance the performance of the daily activities done by an elder or an AD patient. Using location sensors, the smart home will be able to locate the elder and infer important context information. We designed and are currently building mPCA, a smart phone assistant that can proactively take predefined actions, or passively assist the elder/patient on demand. We designed a protocol for attention capture and confirmation based on a state machine approach. The protocol captures the attention of the elder to guarantee that a given message sent by the system

will be effective when received by the patient. The tool will hopefully reduce the cost of family care-giving for AD and elder patients. We are currently finishing the implementation of mPCA. We will report more details on the system when completed and will plan and conduct clinical studies to measure its effectiveness.

References

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