Application of Sixth Sense technology in Prevention and Delay of the Progress of the Alzheimer's disease

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Abstract

Alzheimer's disease is a degenerative disease the cause of which is not known, and neither is there any cure at present. But it is possible to control the progress of the disease. The main aim of this paper is to propose the blue print of a wearable device using sixth sense technology, to ease the daily life of the patient as well as the care taker. The functionalities of the device range from facilitating mentally stimulating activities, to help in daily activities like bathing and eating. This technology, when implemented, can make the patient more independent and make it easier for the care takers to nurse them. It can also cut unaccounted expenses on the care, to a large extent. The functionalities can be potentially expanded based on the patients' requirements.

Keywords

Sixth-sense technology, wearable devices, Alzheimer's disease

1 Introduction

Alzheimer's disease (AD) is the most common cause of dementia in the elderly. Projections indicate that the prevalence of Alzheimer's disease (AD) and other dementias will increase two to three fold in the coming decades[1]. AD is pathologically characterized by β-amyloid (Aβ) plaques within the brain parenchyma and Aβ accumulation in blood vessels (cerebral amyloid angiopathy; CAA), as well as by the formation of neurofibrillary tangles and neurodegeneration[2] . The neurons in the brain do not regenerate, hence there is no cure[3]. The memory cortex of the brain gets most affected, to the extent that the patient cannot remember family members, how to perform daily activities, and loses track of date and time. It is a progressive disease whose early symptom is forgetfulness among old people. The more advanced stages make reading, writing, speaking, dressing up, and such simple tasks very daunting for the patient. The cause for the disease is not known, and neither is the cure. along with the traumatizing effect on the patient, the caregiver also has a sense of burden and responsibility towards the patient.[4]. Although the cure of Alzheimer's is not known, there is ongoing scientific enquiry on prevention by repeated cognitive stimulation, a healthy diet and exercise regime, and an active social life[3][5]. The application of the sixth sense technology[6] proposed in this paper aims at providing good cognitive stimulation, and helps maintain repetition in daily activities, so that even in advanced stages, the patient can do most activities independently[7,8].

2. Design and Working

This technology comprises of two major components: the main wearable device, like a Bluetooth headset, and the auxiliary digitalized clamp that can be clipped on to any plain surface like a sheet of paper and thus provides a visual and haptic interface for the patient to respond. The main wearable device which is the headset plays two roles: one that of regular and deliberate mental activity and two that of planning and presenting the daily schedule of the patient so that s/he can carry out majority of the daily activities independently even after being diagnosed with the disease. In terms of mental stimulation for the patient, the wearable headset should be loaded with algorithms for games and puzzles that the wearer can solve. It is coupled with the auxiliary digitalized clamp, so that when the clamp is clipped onto a plain sheet of paper, the interface for the game or puzzle appears on the paper, and using simple touch screen technology, the wearer can perform the activity. The device sends display related data to the clamp, and the projector in the clamp brings it out on the screen. For example, if a person is playing chess using this technology, then s/he has to make the gesture of making a move on the paper, and the corresponding pawn will move. The combination of a motion sensor and micro phones in the clamp analyses the movement of the hand as an analogue signal, processes and sends it to the wearable device, which, is in fact the second player in the game, responds with its counter move. The move can be seen on the sheet of paper that the clamp has been attached to. This can be generalized to any activity that the user may perform on the haptic interface. In the cases where the person has been diagnosed with the disease, the wearable device can act as a daily planner to help the patient remember the sequence of important activities. The combination of the internal clock, a database used to store the activities that need to be performed, along with how to perform them; an analogue to digital converter, a digital to analogue converter, an inbuilt speaker and the external digitalized clamp perform this function. The care giver records the instruction into the machine, so that it gives a reassuring and personal touch when the patient listens to it [9]. The internal clock sets off when it is time for a particular activity to occur, and appropriate instructions are given from the speaker so that the patient just has to follow them, and there will not be a need to exercise their diminishing memory. One of the major losses that an Alzheimer's patient undergoes is the loss of orientation and direction. Free outdoor movement sometimes helps the condition of the patient.[5] To battle the risk of the patient going missing, the device should provide directions for the patient through the speaker, as though the caretaker is guiding them through the roads. The care giver should enter the patient's residential address, and with respect to that, the device should compute the position of the patient, and direct him/her. The address should be entered into the interface that the digitalized clamp creates, and the clamp automatically sends this data to the device which is then stored in the Global Positioning System (GPS) unit [7],[10]. The device should have a navigation (GPS) system so that the position of the patient is always recorded and instructions are given accordingly. The device processes the position and gives out instructions, but the instructions should be in the voice of a family member or known person to avoid confusion and agitation. The device should have a finger print scanner and bio sensors which will detect whether or not the device has been put on. The finger prints and name of the patient are fed into it. The unique identification of the device with respect to the patient will come especially in handy when there is more than one patient with Alzheimer's. The sensor detects that the device has not been worn and an alarm goes off, notifying the care giver. The wearable device is monaural in nature [14]in the sense that it will be put onto one ear. The block diagram of the device is as shown below. AD conversion refers to Analogue to Digital conversion.

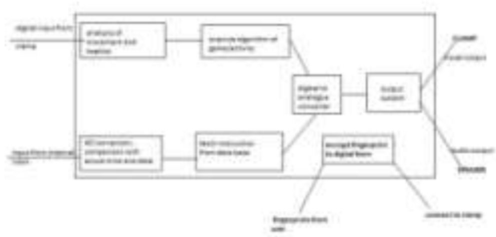

Fig 1. Block diagram of wearable device

The auxiliary clamp looks much like a regular paper clip, but with a micro chip embedded into it. Its major functions are to provide a visual and haptic interface for the patient, record the touch of the finger on the paper, convert it to a digital signal and send it to the device. The clamp also has a finger print identifier that uniquely identifies the user[15,16]. The fingerprint identity of the user is the basis for the interconnection between the device and its corresponding digital clamp. The block diagram of the clamp is as shown below.

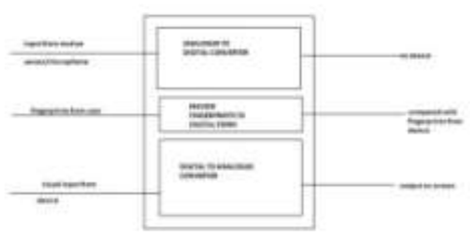

Fig 2 Block diagram of digitalized clamp

3. Connections and Networks

The main wearable device and its auxiliary digitalized clamp work on Bluetooth technology, using short wavelength ultra high frequency radio waves [11,12,13]. Their interconnection is of master slave type [17]. The roles of master and slave are not interchangeable. They are restricted to the device being the master and the clamp being the slave. Similar to a Bluetooth scatter net verification process [16], the master encrypts the analogue fingerprints of the user into a digitalized code, and sends it to the clamp via short wavelength ultra high frequency radio waves. The clamp receives finger prints from the user, encrypts it into long binary numbers, compares it with the message received from the master, and then gets connected to it. If the connection fails due to difference in fingerprint, the projector shines like a small LED lamp notifying that fingerprints should be recorded again. The fingerprint recording provides a secure connection based on the Bluetooth Simple Pairing.[16] It works in a three way handshake mechanism [18]. First the device sends encoded fingerprints to the clamp, then the clamp compares it with the finger print data it received, and acknowledges the connection, and finally the device sends a confirmatory signal that a secure connection has been established. When a secure connection is established, the display related data stored in the device, such as visual instructions on how to eat without spilling, becomes instantly available to the clamp, so that the display process is speeded up due to the proximity of the clamp to the screen/paper with respect to the main device. When the connection is destroyed, the clamp should immediately and automatically delete its memory content. This way, confidentiality of data is maintained, and even if one clamp is missing, the same device can connect with another clamp for the same patient.

4. Hardware Requirements

The hardware requirements for the device and its clamp remain same to the most extent, except for few minor changes.

4.1 Wearable Device

Memory

The device should have a permanent memory of 1GB and a 1GB dynamic RAM for fast processing.[19] The Bluetooth in the device should be version 2.0 or higher with profile AVDTP[20,21,22]. It is the same for the clamp. The baud rate achieved with this profile will be between 1Mbps to 3 Mbps.

Micro-processor

PIC 16C5X[26,27] can be used as a micro controller for the device and the clamp. The device should be capable of connecting to the internet, as in a mobile phone.

Internal Clock

The internal clock used for alarms must be a quartz crystal oscillator fixed to a frequency of 5.185MHz.[28]

Signal Conversions

Digital to analogue conversions involve conversion of digital data to voice and display. Analogue to digital conversions include conversion of touch screen gesture[26,27]to its equivalent binary form.

Speaker Quality

The inbuilt speakers should vary from levels of 50 decibels to 120 decibels so as to maintain the threshold of hearing of the human ear between 2000Hz to 5000Hz. [28,29,30]

Device Skeleton

The body of the wearable device and clamp should be made from plastic to ensure water resistivity. Acrylonitrile butadiene styrene (ABS) is a typical grade of waterproof plastic used for the manufacture of electronic devices.The good strength and impact resistance of ABS makes it an excellent material for cover of the device, and its low cost and ease of manufacture shows that it is feasible to make the covers on a large scale. Additionally it has good aesthetic qualities[31]. The device should include a special quartz crystal oscillator whose vibrations detect the proximity of the device to the ear[32].

Battery

The device and its clamp should work on Lithium ion batteries such that they can be charged either through the conventional plug or through USB cable, so that the caretaker can charge the device for the patient very easily, from any available source of power. The typical capacity of lithium ion battery is 3.2V and a current of 400 milli Amps.[33]

Fingerprint Recognition Unit

Fingerprint recognition plates need to be included in both the device and the clamp.

4.2 Clamp

The hardware requirements of the clamp remain the same as that of the device except that galvanized steel wire [34] should be used for the handles of the clip.

5 Software Requirements

The software that enables working of sixth sense technology is WUW v.01 beta or any higher version [6]. The software works on a windows platform. Windows for mobile devices can be made the basic operating system of the wearable device so that the WUW software runs on its own platform. For battery conservation, the most basic version is sufficient, since the device does not require very complex computational power, but basic measurement of time, distance and position are enough for the device to work smoothly. Additionally, finger print recognition software such as those from Borland, Microsoft, Softonic or other vendors will be necessary [35].

6 Manufacture and Testing

The specifications of the device require intense regulatory measures for manufacture and testing, as depicted in [36] and [37] respectively.

7 Risks

Confirming to the nature of the disease and its symptoms, the biggest challenge is making the patient comfortable with the voice from the device. If the patient causes damage to the device out of frustration, it may cause the delicate sensors and speakers to break down, thus causing permanent failure to the device. Additionally if the device ceases to work suddenly at a crucial moment, it could endanger the safety of the patient. For example if the device does not work at the middle of crossing the road, the patient may be hit by a vehicle if the driver is not careful.

8 Ethical and Legal Issues

Patients diagnosed with Alzheimer's disease require help in simple tasks like walking and remembering in the advanced stages. But the technology discussed in this paper requires the device so manufactured to be harnessed to the patient's ear at all times. The inability to drive, the GPS and the constant feedback given by the device to the patient is an invasion of privacy and may hurt the sentiments of the subject since it affects their sense of freedom and independence. But evidence shows that other devices similar to this one has made caretaking simpler and life safer for the patient[38]. Although each of the components required are becoming increasingly economical, doing justice to intricate practical issues is an onerous task. Also, elderly patients with Alzheimer's disease are vulnerable[39], hence may be the target of a crime like burglary. Therefore additional care needs to be taken to safe guard them and valuable property to the highest possibility.

9 Role of AI in this Technology

The Alzheimer's disease is a degenerative disease in which the neurons are destroyed. Since neurons do not regenerate, the destruction of neurons manifests in the reduction of the size of the brain tissue[40]. Transcranial magnetic stimulation to the brain shows that the brain responds to magnetic fields[41,42] . Due to the fact that pulses between neurons in the brain are electric in nature, it shows that the brain is a weak magnet itself, according to Oersted's principle of electromagnetism[43]. This should be used to detect the intensity of the magnetic flux of the part of the brain that is in close proximity to where the device has been worn, either the right or left ear. In a normal brain the intensity will be higher because the size of the brain is larger, against an Alzheimer's patient's brain, because in AD the size of the brain reduces. The signals of the normal brain must not be confused with the scan readings due to the haemoglobin of the blood that flows through the brain. The device should have an inbuilt algorithm to compare the intensity of the magnetic flux in normal cases, so that the stage or severity of the disease can be predicted, i.e, if magnetic intensity of the brain at the point of reading has started reducing, then the device should conclude that it is the preliminary stage of AD, and hence all cognitive capabilities are not lost[44]. Accordingly the instructions to the patient and interaction between patient and device should be modified automatically. If it is the terminal stage of AD as recorded by very less magnetic flux, all that could possibly be done is for the system to increase the comfort level of the dying patient through soothing and reassuring words output by the speakers of the device, since the patient cannot think, but can surely experience emotions[45].

10 Improvisations

This device can be made more advanced by embedding sensors which interpret the signals from the brain that are related to outputting gestures or words to the outside world . In terminal cases of the disease the patient may not even be able to speak. In this case if the device understands what s/he is thinking, then a voice modulation unit can actually speak out the words on behalf of the patient[46]. If the Bluetooth profile is AVDTP or higher[20], it becomes capable of implementing multimedia with an acceptable quality. This can be used to enhance the capabilities of the mental stimulation unit, for new games and activities[47]. It can also be coupled with robotic arms that will control the movement of the patient's hands and legs, thus eliminating the possibility of hazards like fire or current shocks that many patients experience, due to failing motor control centers in their brain, as a manifestation of Alzheimer's disease[48].

11 Conclusions

Alzheimer's disease is a slow, progressive and degenerative disease which culminates in the death of the patient. The true cause of the disease, and its cure, are currently unknown. But it may be possible to prevent the onset, and to delay the progress of the disease. Of the many techniques which have been shown to prevent and delay the progress of Alzheimer's, regular mental stimulation and a well planned day are effective in at least a subset of patients. Here the realm of possibilities of bringing the digital world to the real world starts. With various modifications in the original sixth sense technology, we could potentially support patients with Alzheimer's and their families. This technology could render the patient to be independent to a considerably higher limit, thus could enable patients even in old age homes to look after themselves well. With all the possible improvisations on the risk factors and innovation using newer technologies, such a technology can potentially be used to help hundreds of other Specially-abled people.

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