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Review On: Smart Home for Disabled Using Brain Computer Interfaces

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Abstract

Advance technologies such as brain imaging have started to provide us with the power to interface with human brain directly through some sensors. These sensors have the ability to monitor some of the physical processes that occur within the brain that correspond with certain forms of thought. In these systems, users explicitly manipulate their brain activity instead of using motor movements to produce signals that can be used to control computers or communication devices.

The future of home automation is moving forward towards the development of ideal smart home environment. Home automation system has also been designed for certain situations in which someone needs a special attention such as old age person, sick patients, and handicapped person. BCI in humans has used scalp-recorded electroencephalography or intracranial electrocardiography. The use of brain signals obtained directly from stereotactic depth electrodes to control a BCI has not previously been explored.

In this paper, I present a smart home automation system using brain–computer interface. The scope of this research work will include the control and monitoring system for home appliances from Graphical User Interface (GUI) using brain–computer interface that use an input source and being controlled wirelessly. The research methodology involved is application of knowledge in the field of radio frequency communication, microcontroller and computer programming. Finally, the result will be observed and analyzed to obtain better solution in the future.

Keywords: Brain-Computer Interfaces (BCI); Electroencephalography (EEG); Functional Near Infrared Spectroscopy (FNIRS).

1. Introduction

A concept on smart home application and development includes various implementation techniques and is never limited. Smart home systems are created based on analysis on client needs and budget to cater for the system. With technologies available today, efficient integration of this system could be achieved. Home automation, also referred to as smart home concept, it is not new to consumers. It encompasses the ability to control electrical and electronic devices at home remotely thus providing ease of access to home users. This concept may be applied in various manners to fit the requirement of a smart home. Now, advancement in wireless technology introduced new ideas such as Bluetooth and Internet linking; Wi-Fi, which has been slowly replacing the conventional wired technology which requires wire bonded interconnection between electrical devices. The main advantage of wireless interlinking includes diminishing the need of wires for connection.

Smart Homes, also known as automated homes, intelligent buildings, integrated home systems or domestics, are a recent design development. Smart homes incorporate common devices that control features of the home. Originally, smart home technology was used to control environmental systems such as lighting and heating, but recently the use of smart technology has developed so that almost any electrical component within the house can be included in the system. Moreover, smart home technology does not simply turn devices on and off; it can monitor the internal environment and the activities that are being undertaken whilst the house is occupied. The result of these

modifications to the technology is that a smart home can now monitor the activities of the occupant of a home, independently operate devices in set predefined patterns or independently, as the user requires. Smart home technology uses many of the same devices that are used in assistive technology to build an environment in which many features in the home are automated and devices can communicate with each other.

2. Brain Imaging Technologies

There are two general classes of brain imaging technologies: invasive technologies, in which sensors are implanted directly on or in the brain, and non-invasive technologies, which measure brain activity using external sensors. Although invasive technologies provide high temporal and spatial resolution, they usually cover only very small regions of the brain. Additionally, these techniques require surgical procedures that often lead to medical complications as the body adapts, or does not adapt, to the implants. Furthermore, once implanted, these technologies cannot be moved to measure different regions of the brain. While many researchers are experimenting with such implants, we will not review this research in detail as we believe these techniques are unsuitable for human-computer interaction work and general consumer use. We summarize and compare the many non-invasive technologies that use only external sensors in. While the list may seem lengthy, only Electroencephalography (EEG) and Functional Near Infrared Spectroscopy (fNIRS) present the opportunity for inexpensive, portable, and safe devices, properties we believe are important for brain-computer interface applications in HCI work.

3. Electroencephalography (EEG)

EEG uses electrodes placed directly on the scalp to measure the weak (5–100 μV) electrical potentials generated by activity in the brain (for a detailed discussion of EEG, see Smith 2004). Because of the fluid, bone, and skin that separate the electrodes from the actual electrical activity, signals tend to be smoothed and rather noisy. Hence, while EEG measurements have good temporal resolution with delays in the tens of milliseconds, spatial resolution tends to be poor, ranging about 2–3 cm accuracy at best, but usually worse. Two centimeters on the cerebral cortex could be the difference between inferring that the user is listening to music when they are in fact moving their hands. We should note that this is the predominant technology in BCI work.

4. Functional Near Infrared Spectroscopy (fNIRS)

fNIRS technology, on the other hand, works by projecting near infrared light into the brain from the surface of the scalp and measuring optical changes at various wavelengths as the light is reflected back out. The NIR response of the brain measures cerebral hemodynamic and detects localized blood volume and oxygenation. Since changes in tissue oxygenation associated with brain activity modulate the absorption and scattering of the near infrared light photons to varying amounts, fNIRS can be used to build functional maps of brain activity. This generates images similar to those produced by traditional Functional Magnetic Resonance Imaging (fMRI) measurement. Much like fMRI, images have relatively high spatial resolution (< 1 cm) at the expense of lower temporal resolution (> 2–5 seconds), limited by the time required for blood to flow into the region. In brain-computer interface research aimed at directly controlling computers, temporal resolution is of utmost importance, since users have to adapt their brain activity based on immediate feedback provided by the system. For instance, it would be difficult to control a cursor without having interactive input rates. Hence, even though the low spatial resolution of these devices leads to low information transfer rate and poor localization of brain activity, most researchers currently adopt EEG because of the high temporal resolution it offers. However, in more recent attempts to use brain sensing technologies to passively measure user state, good functional localization is crucial for modeling the users' cognitive activities as accurately as possible. The two technologies are nicely complementary and researchers must carefully select the right tool for their particular work. We also believe that there are opportunities for combining various modalities, though this is currently underexplored.

5. Existing Smart Home Technologies

Home based system automations can range from systems as simple as for heating, ventilation, and air conditioning, Lighting control, or Audio and Video distribution to multiple sources around the house, to more complicated systems such as for security (involving presence simulations, alarm triggering and medical alerts) and robotics for home care or home management. Smart home applications; or task automations in a general household can be grouped by their main functions such as, i) Alert and sensors – heat/smoke sensors, temperature sensors ii) Monitoring – Regular feed of sensor data i.e. heat, CCTV monitoring iii) Control – switching on/off appliances i.e. sprinklers, lightings iv) Intelligence and Logic – Movement tracking i.e. security appliances v) Telecare / telehealth

– distress sensor, blood pressure monitoring Current smart home devices are usually a customized hybrid of one or more of these applications for broader applications. Access to these applications can be generally grouped into 4 access types that are the hardwired type using bus line or power line based technology, as well as the wireless type utilizing radio, infra-red or Bluetooth technology. Future smart-home appliances are moving towards the wireless environment and hence the Bluetooth and radio spectrum will be widely used. It is to date, a rather new technology that needs to be further proven in terms of stability and security. Providers of this technology will have to take into accounts used frequency bands for current appliances such as Bluetooth, cordless phones or Wi-Fi routers to ensure devices are robust from interference. The use of radio frequencies such as at 2.4 GHz for wireless LAN and 8.643 MHz (Z-wave UK) enable the systems to be designed for high bandwidth data flow. Currently one of the existing issues that are associated to smart home applications are the fact that in a home with all sorts of automated application, there will be too many remote controls or monitoring terminal, if the user installed a range of proprietary applications from different providers. There is also the fact that the access range to remotely control these devices are limited by either length of cables or wireless network coverage in a personal area network. It is a widely known fact that an important example of wireless technology application is the mobile phone technology. Mobility' is now a lifestyle adopted by all walks of the society, where a United Nation survey has recently revealed that 60% of the world population has a mobile phone subscription. Taking into account a mobile phone's necessity in the majority of our society, this solution will attempt to transfer the functionalities of a smart home device's remote control to a mobile-phone, to achieve a truly remote access convenience. Enabling a single remote access to a single corresponding server in a smart home household will also resolve the issue on 'too many control terminals' as discussed previously.

6. Problem Statement

The main objective in system is the detection of electric signal near eye area and using electrodes system will try to identify the changes in electric pulse in order to conclude the motion to be taken. As a proof of concept system will be enabled to control different platform and devices like computer or the hardware system as per mentioned below.

6.1 Appliances control

This module will deal with the controlling of hardware appliances using the electronic relay based switching circuit. Actual home appliances are connected to this circuit and the circuit will be then connected to the computer. It works as a middle ware between actual appliances and the computer.

6.2 Computer cursor and application control

Likewise user can control the computer cursor and the applications using electric signals. This will enable disabled patients to have good access over computer system. To implement this there will be a microcontroller to USB interfacing circuitry which will convert microcontroller signals in to computer understandable signals which will then get processed by software program.

6.3 Sensor based security alerts

As a part of the security module proposed system will having the motion detection, gas sensor, heat sensor which will alert user in critical condition. If configured then it can send a SMS based alert to assistant user.

6.4 Web based

As all these modules work together and to make these modules accessible through the web interface, the proposed system will have a web service which can be accessed through any web client or the web browser.

7 Methodology

Human brain mainly works on electric signals transmitting all over the body to send the information in order to operate the body parts. Even while rotating eye ball body increases or decreases the resistance near eye area. This variation in electric signals can be measured using electrodes or the myoelectric sensors. By implementing these signals processor we can interface different devices to control on demand. Hence proposed system is designed to control computer and hardware system using brain waves electric signals. Proposed systems will detection the variations in electric signal strength through voltage level near the eye area and generates a wireless radio frequency signals in order to control the home automation prototype model. By implementing this system we can further

extend it to bio enabled human body parts to control through brain waves. Electroencephalography (EEG) is the most studied potential non-invasive interface, mainly due to its fine temporal resolution, ease of use, portability and low set-up cost. But as well as the technology's susceptibility to noise, another substantial barrier to using EEG as a brain–computer interface is the extensive training required before users can work the technology. For example, in experiments trained severely paralyzed people to self-regulate the slow cortical potentials in their EEG to such an extent that these signals could be used as a binary signal to control a computer cursor. (Birbaumer had earlier trained epileptics to prevent impending fits by controlling this low voltage wave.) The experiment saw ten patients trained to move a computer cursor by controlling their brainwaves. The process was slow, requiring more than an hour for patients to write 100 characters with the cursor, while training often took many months.

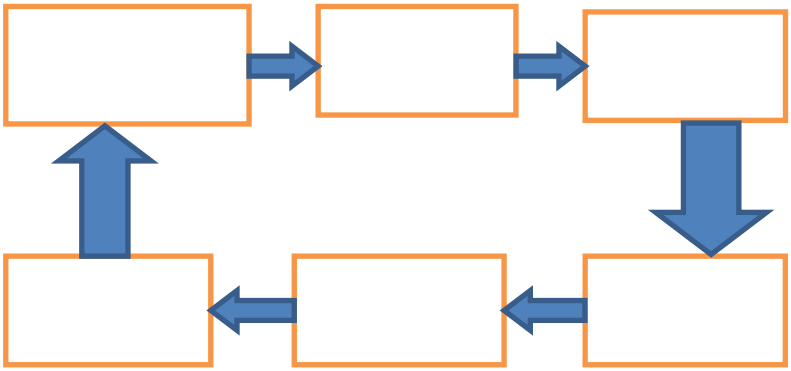

Fig 1: Schematic of a brain-computer interface system

8 Simulation And Results

Proposed System will incorporate temperature sensor, fire sensor, motion (obstacle) sensor, Light detector sensor, Water sensor. These sensors are connected to the central system and once any of the sensors gets activated then system will send alert message. Multiple sensor based home security system is very practical. It can be used not only in the home environment but also in a business environment too. It can monitor the surrounds to not only protect our properties but also our lives. Besides, it can be highly customized to suit each one's need and preference. So Multiple Sensor Based Home Security System is very useful for us as well as other people. After successful implementation of the system it is expected that outcome of the system should be able to identify the human brain wave to control the home appliances with fast reaction and it is also expected that system should react at highest priority in case of critical conditions.

The system will sense the signal from brain sensor of disabled person and follow the commands accordingly and he can comfortably operate or handle the home appliances. Complete system can be monitored externally by the person using android system as well as alert signal will also be provided.

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