A Survey on Wireless Body Area Network and Human Machine Control
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Abstract:
The increasing use of wireless networks and the constant miniaturization of electrical devices has empowered the development of Wireless Body Area Networks (WBANs). In the senet networks various sensors are attached on clothing or on the body or even implanted under the skin. The wireless nature of the network and the wide variety of sensors offer numerous new, practical and innovative applications to improve health care and the Quality of Life. The sensors of a WBAN measure for example the heartbeat, the body temperature or record a prolonged electrocardiogram. Using a WBAN, the patient experiences a greater physical mobility and is no longer compelled to stay in the hospital. This paper provides a survey of body area networks, its architecture, advantages, and human machine control with its techniques. First, we focus on wireless body area network and its architecture. Then the communication in a WBAN and its positioning technologies is discussed. Finally, the need of control system is pointed out.

Keywords: Wireless Body Area Networks (BAN), Electrocardiography (ECG), Electroencephalography (EEG), HCI Human–computer interface.

I. INTRODUCTION
Over the past few decades, there is an exponential growth in the field of information processing and wireless data transmission for patient monitoring system [1]. Wireless Body Area Network (WBAN) is a network which employing wireless sensor technology that forms a system to continuously monitor the patient situation. Specific sensors for each physiological data are placed near to the human body, but it limits the patient mobility. A body area network (BAN), also referred to as a wireless body area network (WBAN) or a body sensor network (BSN), is a wireless network of wearable computing devices. These network devices may be embedded inside the body, implants, may be surface-mounted on the body in a fixed position. Wearable technology or may be accompanied devices which humans can carry in different positions, in clothes pockets, by hand or in various bags [2]. The wireless network is necessary to design for monitoring the mobile patient within specified area.

This gives freedom to the patient to move without medical professional within the campus. This network is a wireless sensor network that provides the patient monitoring to anyone within coverage area. Mobile patient are moving and creates less predictable topology and link instability that’s make routing an important task for mobile patient monitoring. Wireless body area networks (WBANs) signify emerging technology with the potential to revolutionize health care by allowing unobtrusive health monitoring for extended periods of time [3].

A typical WBAN consists of a number of inexpensive, lightweight, and miniature sensor platforms, each featuring one or more physiological sensors: motion sensors, electrocardiographs (ECGs), electromyography (EMGs), and/or electroencephalographs (EEGs). The sensors could be located on the body as tiny intelligent patches, integrated into clothing, or implanted below the skin or muscles [3].

II. WBAN ARCHITECTURE
The general architecture of the WBAN network has three tiers: Intra-WBAN, inter-WBAN and beyond-WBAN [4] (Figure 1).

Figure 1: Communication Tiers in a Wireless Body Area Network [4]

Figure 1: A three-tier architecture for WBANs.
In the WBAN, the devices are scattered all over the body in a centralized network architecture where the exact location of a device is application specific. However, as the body may be in motion (e.g. running, walking) the ideal body location of sensor nodes is not always the same; hence, WBANs are not regarded as being static. The communication architecture of WBANs can be separated into three different tiers as follows:

• Tier-1: Intra-WBAN communication
• Tier-2: Inter-WBAN communication
• Tier-3: Beyond-WBAN communication
Tier-1: Intra-WBAN communication – Tier-1 depicts the network interaction of nodes and their respective transmission ranges (~ 2 meters) in and around the human body. Fig. 1 illustrates WBAN communication within a WBAN and between the WBAN and its multiple tiers. In Tier-1, variable sensors are used to forward body signals to a Personal Server (PS). The processed physiological data is then transmitted to an access point in Tier-2.

Tier-2: Inter-WBAN communication – This communication tier is between the PS and one or more access points (APs). The APs can be considered as part of the infrastructure, or even be placed strategically in a dynamic environment to handle emergency situations. Tier-2 communication aims to interconnect WBANs with various networks, which can easily be accessed in daily life as well as cellular networks and the Internet.

Tier-3: Beyond-WBAN Communication – The design of this communication tier is for use in metropolitan areas. A gateway such as a PDA can be used to bridge the connection between Tier-2 and this tier; in essence from the Internet to the Medical Server (MS) in a specific application. However, the design of Tier-3 for communication is application-specific. In essence, in a medical environment a database is one of the most important components of Tier-3 as it includes the medical history and profile of the user. Thus, doctors or patients can be notified of an emergency status through either the Internet or a Short Message Service (SMS) [4].

A. Advantages Using WBAN

There are several advantages introduced by using wireless BANs which include:

– Flexibility: Non-invasive sensors can be used to automatically monitor physiological readings, which can be forwarded to nearby devices, such as a cell phone, a wrist watch, a headset, a PDA, a laptop, or a robot, based on the application needs.
– Effectiveness and efficiency: The signals that body sensors provide can be effectively processed to obtain reliable and accurate physiological estimations. In addition, their ultra-low power consumption makes their batteries long-lasting due to their ultralow power consumption.
– Cost-effective: With the increasing demand of body sensors in the consumer electronics market, more sensors will be mass-produced at a relatively low cost, especially in gaming and medical environments [15].

III. COMMUNICATION CONTROL IN WBAN(BRAIN COMPUTER INTERFACE)

Your Any natural form of communication or control requires peripheral nerves and muscles. The process begins with the user’s intent. This intent triggers a complex process in which certain brain areas are activated, and hence signals are sent via Brain–Computer Interfaces [5]. BCIs measure brain activity, process it, and produce control signals that reflect the user’s intent. A BCI offers an alternative to natural communication and control. A BCI is an artificial system that bypasses the body’s normal efferent pathways, which are the neuromuscular output channels. Figure 2 illustrates this functionality.

Figure 2. A BCI bypasses the normal neuromuscular output channels.

Instead of depending on peripheral nerves and muscles, a BCI directly measures brain activity associated with the user’s intent and translates the recorded brain activity into corresponding control signals for BCI applications. This translation involves signal processing and pattern recognition, which is typically done by a computer. Since the measured activity originates directly from the brain and not from the peripheral systems or muscles, the system is called a Brain–Computer Interface.

A. Measuring Brain activity

Brain activity produces electrical and magnetic activity. Therefore, sensors can detect different types of changes in electrical or magnetic activity, at different times over different areas of the brain, to study brain activity. Most BCIs rely on electrical measures of brain activity, and rely on sensors placed over the head to measure this activity. Electroencephalography (EEG) refers to recording electrical activity from the scalp with electrodes. It is a very well established method, which has been used in clinical and research settings for decades. Figure 3 shows an EEG based BCI. EEG equipment is inexpensive, lightweight, and comparatively easy to apply. Examples are bioelectrical activities caused by eye movements or eye blinks (electrooculographic activity, EOG) and from muscles (electromyographic activity, EMG) close to the recording sites [5].

Figure 3. A typical EEG based BCI consists of an electrode cap with electrodes, cables that transmit the signals from the electrodes to the biosignal amplifier, a device that converts the brain signals from analog to digital format, and a computer that processes the data as well as controls and often even runs the BCI application.

B. Signal Processing

A BCI measures brain signals and processes them in real time to detect certain patterns that reflect the user’s intent. This signal processing can have three stages: preprocessing, feature extraction, and detection and classification.

• Preprocessing aims at simplifying subsequent processing operations without losing relevant information. An important goal of preprocessing is to improve signal quality by
improving the so-called signal-to-noise ratio (SNR). Transformations combined with filtering techniques are often employed during preprocessing in a BCI.

- Feature extraction can be seen as another step in preparing the signals to facilitate the subsequent and last signal processing stage, detection and classification.
- Detection and classification of brain patterns is the core signal processing task in BCIs. The user elicits certain brain patterns by performing mental tasks according to mental strategies, and the BCI detects and classifies these patterns and translates them into appropriate commands for BCI applications.

C. BCI Performance

The performance of a BCI can be measured in various ways. A simple measure is classification performance (also termed classification accuracy or classification rate). It is the ratio of the number of correctly classified trials (successful attempts to perform the required mental tasks) and the total number of trials. The error rate is also easy to calculate, since it is just the ratio of incorrectly classified trials and the total number of trials. Although classification or error rates are easy to calculate, application dependent measures are often more meaningful. For instance, in a mental typewriting application, the user is supposed to write a particular sentence by performing a sequence of mental tasks. Again, classification performance could be calculated, but the number of letters per minute the users can convey is a more appropriate measure. Letters per minute is an application dependent measure that assesses (indirectly) not only the classification performance but also the time that was necessary to perform the required tasks.

D. The Need for BCIs

People affected by amyotrophic lateral sclerosis (ALS), brainstem stroke, brain or spinal cord injury, cerebral palsy, muscular dystrophies, multiple sclerosis, and numerous other diseases often lose normal muscular control. The most severely affected may lose most or all voluntary muscle control and become totally “locked-in” to their bodies, unable to communicate in any way. These individuals can nevertheless lead lives that are enjoyable and productive if they can be provided with basic communication and control capability. Unlike conventional assistive communication technologies, all of which require some measure of muscle control, a BCI provides the brain with a new, non-muscular output channel for conveying messages and commands to the external world.

E. Applications

BCIs can provide discrete or proportional output. A simple discrete output could be “yes” or “no”, or it could be a particular value out of N possible values. Proportional output could be a continuous value within the range of a certain minimum and maximum. Depending on the mental strategy and on the brain patterns used, some BCIs are more suitable for providing discrete output values, while others are more suitable for allowing proportional control [5].

The BCI is used in following examples:

a) Environmental control  
b) Speller  
c) Phone number dialling with an SSVEP BCI  
d) Computer game Pong for two players  
e) Navigation in a virtual reality environment  
f) Cursor Control

g) Restoration of grasp function of paraplegic patients by BCI controlled functional electrical stimulation.

IV. HUMAN MACHINE CONTROL

Application in electronics for instrumentation and control field is becoming increasingly. Human Machine Interface (HMI) is also known as Man Machine Interface (MMI) or Human Computer Interface (HCI). Interaction between human and machine is likely occur in a place or area of user interface system. The terms user interface actually refer to the layer that separates a human that is operating a machine from the machine itself [6]. User interface includes hardware and software components that exist in a system. It is a system that have structure provide input and output to user act as a path of communication. Interaction between human and machine can include touch, sight, sound, heat transference or any other physical or cognitive function. To easy understand about HMI, example a typical computer station will have four Human Machine Interfaces (HMI) that can includes the keyboard and mouse both interact with our hand, the monitor interact with our eyes and the speaker interact with our ears. In order to accomplish the tasks, human and machine needs a system to effectively communicate two ways for operation and control of machine [6]. Human machine interface can be easily controlled by SSVEP. The following are the techniques that are useful to control human machine interface.

A. SSVEP

Steady state visual evoked potentials (SSVEP) activity has also been used for communication and control in BCI systems. SSVEP-based orthosis control requires less training than motor imagery-based control, but also requires focused attention to the blinking lights mounted on the orthosis. Furthermore, SSVEP-based orthosis control entails a high rate of false positive (FP) detections in long-lasting resting periods or breaks [8]. SSEP is a BCI solution, which has had success in optimizing performance in terms of speed and accuracy. Known as SSVEP. Steady-state visual evoked potential (SSVEP) is defined as a resonance phenomenon arising mainly in the visual cortex when a person is focusing on a repetitive visual stimulation. For SSVEP-based BCI systems, each target presented in the field of vision was modulated by a specific frequency [9]. SSVEP-based BCIs have received increased attention because they can provide relatively higher bit rates of up to 70 bits/min while requiring little training. An SSVEP Based BCI enables the user to select among several commands that depend on the application, for example, moving a cursor on a computer screen. Each command is associated with repetitive visual stimulus that has distinctive properties.

B. Electrooculography

In new days, EEG (Electroencephalography) is widely used as a digital signal processing for diagnosis of various application. Electroencephalography (EEG) signals has now been popularly used in a wide variety of applications such as seizure detection/prediction, motor imagery classification, mental task classification, emotion classification, sleep state classification, and drug effects diagnosis. EEG is quite small signal which can measured electrical activity of brain generated by nerve firing in the brain which usually contain physiological & non physiological artifacts. These artifacts typically have much higher amplitude than brain signals so it produces great difficulty to interpret the EEG signal. Brain computer interface (BCI) has a power to translate the neural command extracted
from EEG signal into machine language. So improvement in analysis of EEG signal is goal of many researchers. EEG signals of motor imagery can be seen as a new way of communication for persons suffering from severe physical handicaps [10]. Motor imagery is a mental task in which the subject imagines that he is doing an action. Motor imagery classification is very important for certain patients [11]. While most other research focused on discriminating EEG signals between left hand, right hand, toe, and tongue imagined movement [12]. It is a method of controlling the mouse cursor on a computer screen using the electrical potentials developed by eye movements known as Electrooculography. Electrooculography (EOG) signal is used to detect eye movement and blink features. The EOG signal is recorded from electrodes placed at appropriate positions around the eyes. The captured EOG signal is then analyzed to detect and classify eye movement features of interest. The detected features were then used to generate control signals to control a mouse cursor [13]. The eye can be modeled as a dipole with its positive pole at cornea and negative pole at retina. So the eye can be treated as a constant source of stable cornea-retinal electrostatic potential due to the potential difference between cornea and retina [13]. This difference is due to the large presence of electrically active nerves in the retina compared to the cornea. The process of measuring the changes in this potential is called Electrooculography.

C. Need of Control System
Humans are more integrated to machines than ever. We cannot imagine a world without the assistive hands of these machines. This necessitates direct interfacing of humans and machines particularly computers. The main limitation of the HCI device is the lack of usability for the people with disabilities including limb paralysis and those who lose their limbs in any accidents or poor development of body due to congenital defects. Such users face problems and inability to hold or moving the mouse as how normal users perform it. So the need arises to intended to give functionality to people with severe motor disabilities to control a computer by just moving their eyes. The need to design systems which would understand human cognitive processes more and act according to them. Bio-based Human computer interfacing (HCI) is a new modality to improve the lifestyle of physically challenged and severely paralyzed patients. Bio based HCI has the potential to enable severely disabled people to drive computers by bioelectricity rather than physical means. It can help specially them who have lost control over their muscles e.g. due to a progressive motor disease. Human eye is involved in almost everything he does in his day to day life. So eye can be a potential interfacing component in HCI applications involving eye tracking and eye movement features detection.

D. Cursor Control
We live in a world today where humans are more integrated to machines than ever. Human Computer Interfacing (HCI) is the study of humans and machines in conjunction. Bio-based Human computer interfacing (HCI) is a new modality to improve the lifestyle of physically challenged and severely paralyzed patients. It can help specially them who have lost control over their muscles e.g. due to a progressive motor disease known as Amyotrophic Lateral Sclerosis (ALS) resulting in a complete destruction of the peripheral and central motor system [13]. The EEG [14] based BCI uses the amplitude and frequency of the beta signal in the sensory motor to the cursor control. The Cursor can be moved in one or two dimensions by the well trained users. A hands free interface between computer and human can potentially replace the traditional human computer interface devices like mouse, keyboard etc. This technology is intended to give functionality to peoples with severe motor disabilities to control a computer by just moving their eyes. Human eye is involved in almost everything he does in his day to day life [13]. So eye can be a potential interfacing component in HCI applications involving eye tracking and eye movement features detection. Eye movement features like eye movement patterns may provide essential cognitive cues which can be detected by analyzing eye movements. There are various methods to track the movements of eye for example Scleral search coil method, Infrared-occulography (IROG), Electro-occulography (EOG), Video-occulography (VOG) etc. But we used the EOG technique to control mouse cursor by eye tracking. EOG based HCI is becoming the hotspot of eye-based HCI research in recent years due to its accuracy, ease of use and economy.

V. REFERENCES


