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SMART BUILDING
Using EEG Signal Controller
(First Controlling Method)

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***Abstract*—At the root of all our thoughts, emotions and behaviours is the communication between neurons within our brains. Brainwaves are produced by synchronised electrical pulses from masses of neurons communicating with each other and they change according to what we're doing and feeling.**

Brainwaves are detected using sensors placed on the scalp. such as the EEG sensor which record the human brain's electric field .

This work aims to study the possibility of controlling the smart building using Mind wave Mobile Headset to provide easy way to control the whole building, specially for people who have physical impairment.

This paper describes part of an integrated project for implementation of smart building controlled by several ways, which is considered as a First Method to control the building.

Keywords—EEG signal, Mind wave, Android application, Smart building.

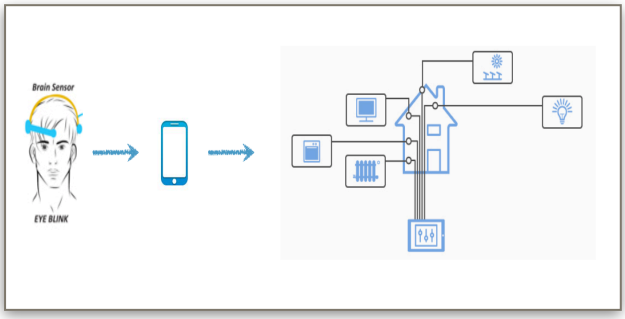
I. INTRODUCTION

In general a smart building is any structure that uses automated processes to automatically control the building's operations including heating, ventilation, air conditioning, lighting, security, entertainment audio & video systems, TVs, computers, camera systems and other systems that are capable of communicating with one another and can be controlled remotely from any room in the building, as well as remotely from any location in the world by phone or internet.

Smart building incorporated common devices that control features of the building. A concept on smart building application and development includes various implementation techniques and is ever growing. Smart building 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 have been achieved. building automation is a new concept that encompasses the ability to control electrical and electronic devices at home remotely so providing ease of access to the users. This concept may be applied in various manners to fit the requirement of a smart building.

The Brain-Computer Interface technique is treated as a communication system that serves the person to operate the devices by using his or her own thoughts. The data flows from brain to the outside machinery. Different research groups have examined and used different methods to achieve this. All these method uses electroencephalography (EEG) signals which are taken from the scalp. The different brain states are the outcome of the various arrangements of neural interaction. These pattern leads to the waves that are characterized by various amplitude and frequency values.

This work aims to use a new innovation " Mind Wave Mobile Headset " which is put on the head of a human and takes the mind signal, interoperated and converted it to an electrical signal used to control the whole building utilities through an Android application, as shown in Fig1.



1. Intelligent Building Diagram

This work is organized as follows: Section II covering the main concepts of the EEG system controller. Section III representing important information about Mindwave Mobile Headset. Then the Android Application is defined in section IV . Section V contains the practical part of Mindwave Mobile Headset and Android Application. Finally section VI drawing the major conclusions from this work.

II. EEG SYSTEM CONTROLLER

Electroencephalography (EEG) is an electrophysiological monitoring method to record electrical activity of the brain. EEG measures voltage fluctuations resulting from ionic current within the neurons of the brain. In clinical contexts, EEG refers to the recording of the brain's spontaneous electrical activity over a period of time [1].

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EEG sensor is the first recording of the human brain's electric field with amplitude ~ 100 μV when measured on the scalp, and about 1-2 mV when measured on the surface of the brain. The bandwidth of this signal is from under 1 Hz to about 50 Hz.

The EEG is performed by placing electrodes all over the subject's scalp, and then reading in the electrical signals for analysis.

The total cost associated with recording instrumentations is very low which makes EEG perfect for use as a brain-computer interface (BCI). The technical demands on equipment for recording EEGs are relatively modest and are for a basic recording setup, restricted to a set of electrodes, a signal amplifier, and a system for signal analysis.

Today, with all of this technology packed into a compact form factor that is the MindWave and the MindWave Mobile.

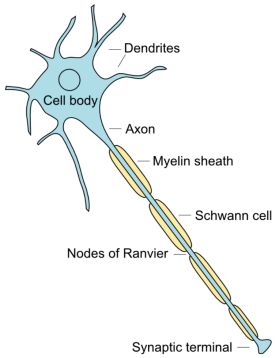
The MindWave and MindWave Mobile are all wireless devices used to record EEG signals. All devices utilize identical chips, also they use the same sensor technology[2].

The MindWave uses RF to transmit data, and includes an RF USB dongle compatible with both Mac and Windows. The MindWave is usually compatible with PC and Mac only [2].

The MindWave Mobile can be used with PC, Mac, Android, and iOS. It sends a corresponding signal of the brain waves to the device connected with it via bluetooth connection [2].

A. Source of EEG signal

EEG measures voltage fluctuations resulting from ionic current flows within the neurons of the brain. The neuron is the basic functional unit of the nervous system. The neuron consist of a cell body, the *soma*, from which two types of structure extend: the *dendrites* and the *axon*, as shown in Fig 2.



2. Neuron

Dendrites can consist of thousands of branches, with each branch receiving a signal from another neuron. The axon is a single branch which transmits the output signal of the neuron to other neurons. The transmission of information from one neuron to another takes places at the *synapse*, a junction where the terminal part of the axon is in contact with another neuron. The signal, initiated in the soma, propagates through the axon encoded as a short, pulse-shaped waveform, the action potential. Initially electrical signal is converted in the presynaptic membrane to a chemical signal (neurotransmitter) which diffuses uses across the synaptic gap and is then reconverted to an electric signal in the postsynaptic membrane of another neuron. [3]

The electric potential generated by a single neuron is far too small to be measured by EEG. So EEG measures electrical field as the summation of the synchronous activity of millions of neurons that have similar spatial orientation. The electrical field is mainly generated by currents that flow during synaptic excitation of the dendrites, the excitatory postsynaptic potentials. [4]

B. Brainwaves

Brain is constantly producing electrical signals while it operates, as the cellular components of the brain (neurons) communicate with each other. They produce a range of frequencies that scientists have found relate to particular mental states. For example, a sleeping person's brain produces an abundance of delta waves, whereas an alert and awake person concentrating hard on something will produce far more beta waves.

The Mindwave headset picks up the brain's electrical activity and divides the signal by frequency into various types of waves, allowing it to infer human mental state. The table1 gives a general synopsis of some of the commonly-recognized frequencies that tent to be generated by different type of activity in the brain [5]:

I. FREQUENCIES OF HUMAN BRAINWAVE

Brainwave Type	Frequency range	Frequency range
Delta	0.1Hz to 3Hz	Deep, dreamless sleep, non-REM sleep, unconscious
Theta	4Hz to 7Hz	Intuitive, creative, recall, fantasy, imaginary, dream
Alpha	8Hz to 12Hz	Relaxed, but not drowsy, tranquil, conscious
Low Beta	12Hz to 15Hz	Formerly SMR, relaxed yet focused, integrated
Midrange Beta	16Hz to 20Hz	Thinking, aware of self & surroundings
High Beta	21Hz to 30Hz	Alertness, agitation

The difference between these waves can be more easily understood in Fig3.

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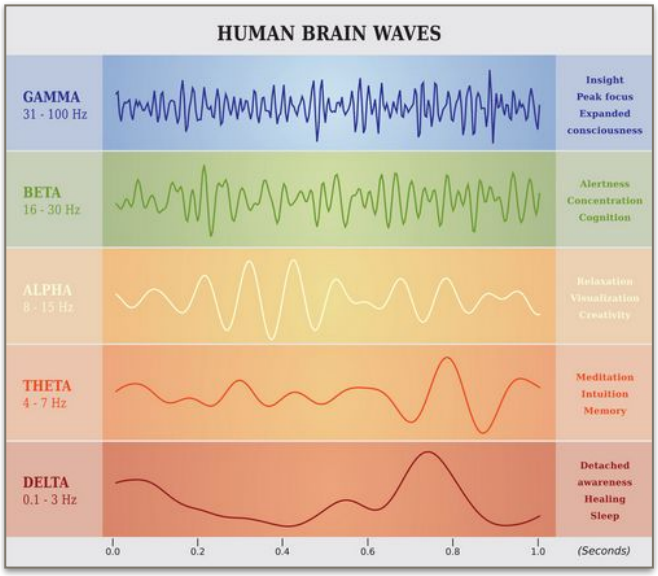


3. Human Brain Waves

C. *MindWave Mobile Technology*

In the proposed system as shown in Fig4, a NeuroSky brainwave sensor is used to analyse the EEG signals. The BCI is a direct communication pathway between the human brain and an external device.

Brainwaves are tiny electrical impulses released when a neuron fires in the brain. NeuroSky's brain-computer interface (BCI) works by monitoring these electrical impulses with a forehead sensor. The neural signals are input into ThinkGear chip, The measured electrical signals and calculated interpretations are then output as digital messages to the computer, or mobile device, allowing us to see the brainwaves on the screen, or use the brainwaves to affect the device's behavior [2].

- *ThinkGear*

ThinkGare should be included inside every EEG product that enable a device to interface with the wearer's brainwaves. It includes the sensor that touches the forehead, the contact and reference points located in the ear clip, and the on-board chip that processes all of the data. Both the raw brainwaves and the eSense Meters (Attention and Meditation) are calculated on the ThinkGear chip [5].

- *eSense*

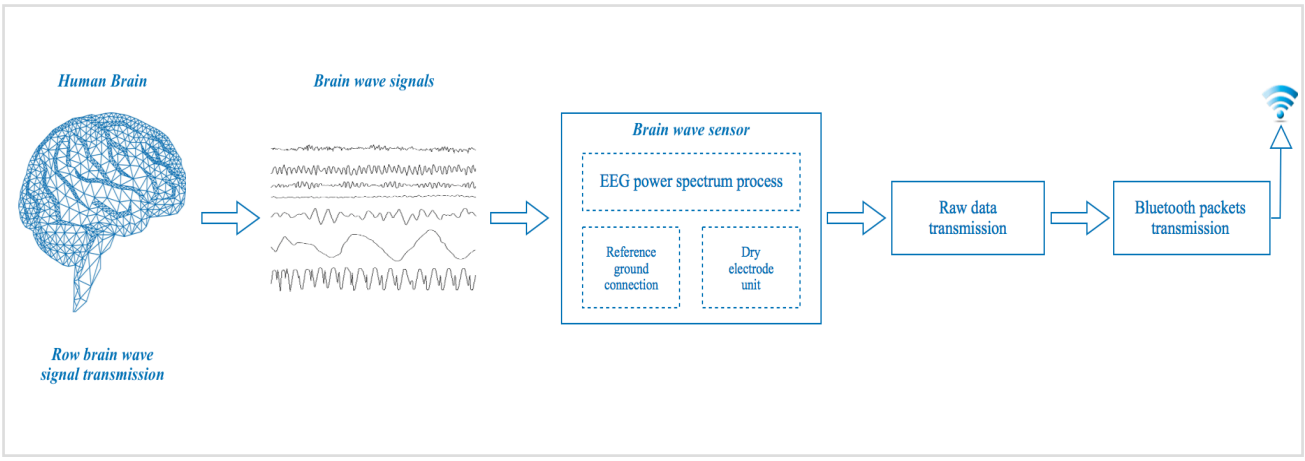
eSenseTM is an algorithm for characterizing mental states. To calculate eSense, the ThinkGear technology amplifies the raw brainwave signal and removes the ambient noise and muscle movement. The eSense algorithm is then applied to the remaining signal, resulting in the interpreted eSense meter values [5].

- *eSense Meter*

The eSense meters are a way to show how effectively the user is engaging Attention (similar to concentration) or Meditation (similar to relaxation).

In many cases, people tend to be better at one eSense than the other, that means they must try different tactics until they are successful with one. Then they will be able to duplicate the action more easily with additional practice.

For each type of eSense (i.e. Attention, Meditation), the meter value is reported on a relative eSense scale of 1 to 100. The eSense Attention meter indicates the intensity of mental "focus" or "attention". While the eSense Meditation meter indicates the level of a user's mental "calmness" or "relaxation".



4. Brain-Computer Interface System

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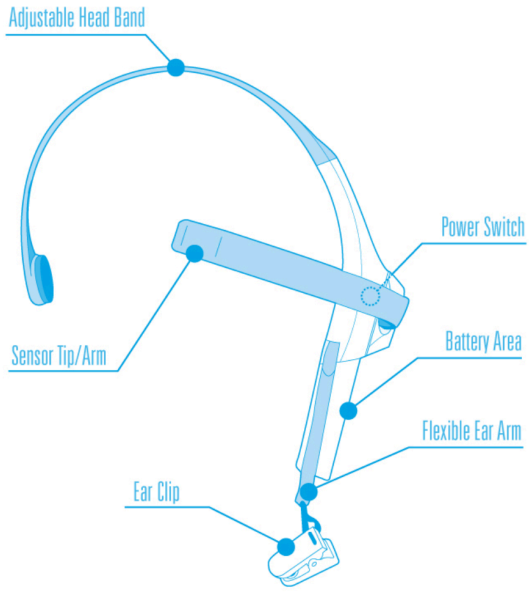
III. MINDWAVE MOBILE HEADSET

Mindwave Mobile is an EEG headset that safely measures and transfers the power spectrum (alpha waves, beta waves, etc) data via Bluetooth to wirelessly communicate with the device, and works with most modern operating systems.

The MindWave Mobile headset, can be simply slipped on to be able to see human brainwaves change in real time. For example with the Mindwave Mobile we can monitor the levels of attention, relaxation , meditation and eye blinks.

The Mindwave headset picks up the brain's electrical activity and divides the signal by frequency into various types of waves, allowing it to infer human mental state.

The Mindwave Mobile as shown in Fig5 is surprisingly simple consisting only of a headset, an ear-clip, and a sensor arm. The headset's reference and ground electrodes are on the ear clip, while the EEG electrode is on the sensor arm, resting on the forehead above the eye.



5. EEG Headset Diagram

Unfortunately human body makes a lot of other electrical noise, in addition to the activity coming from his brain. For this reason there is a 'reference' contact, in the form of a clip that attaches to your earlobe, which allows the headset to filter out non-brain related electrical activity.

To get a prepare interface the usually minimum system requirements for PC/Mac are [5]:

II. MINIMUM SYSTEM REQUIREMENTS FOR PC/MAC

	PC	Mac
Operating system	Windows XP/Vistal/7	Mac OS X 10.5.8 or later
Processor	Intel Core Duo or equivalent	
Memory	1GB or more	
Video	DirectX 9.0 or greater	Intel GMA900 or greater
Hard disk	1GB free disk space	
USB	An available USB port	

To get a prepare interface the usually minimum system requirements for iOS/Android are [5]:

III. MINIMUM SYSTEM REQUIREMENTS FOR IOS/ANDROID

	IOS	Android
Operating system	IOS 4.3.3 or later	Android 2.2 or later
Hard disk	at least iPhone , iPad or iPod Touch 3	Compatible Android phone or table
Wireless	Bluetooth	

IV. ANDROID APPLICATION

The Android application has been used in this work as an intermediary between the smart building controller and the mind wave mobile headset.

An Android app is a software application running on the Android platform. Because the Android platform is built for mobile devices, a typical Android app is designed for a smartphone or a tablet PC running on the Android OS [6].

An Android application is defined using one or more of Android's four core application components : Activity, Service, Broadcast Receiver and Content Provider [7].

- *Activity* is an application component that provides a screen with which users can interact in order to do something. If an application has more than one activity, then one of them should be marked as the activity that is presented when the application is launched.
- *Service* is an application component that can perform long-running operations in the background without a user interface.
- *Broadcast Receivers* simply respond to broadcast messages from other applications or from the system.
- *Content Providers* component supplies data from one application to others on request.

A. The Basics of Android Applications

These are the basics of Android applications [8]:

- Android applications are composed of one or more application components (activities, services, content providers, and broadcast receivers).

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- Each component performs a different role in the overall application behavior, and each one can be activated individually.
- The manifest file must declare all components in the application and should also declare all application requirements, such as the minimum version of Android required and any hardware configurations required.
- Non-code application resources (images, strings, layout files, etc.) should include alternatives for different device configurations (such as different strings for different languages).

B. *The IDE for Android Application*

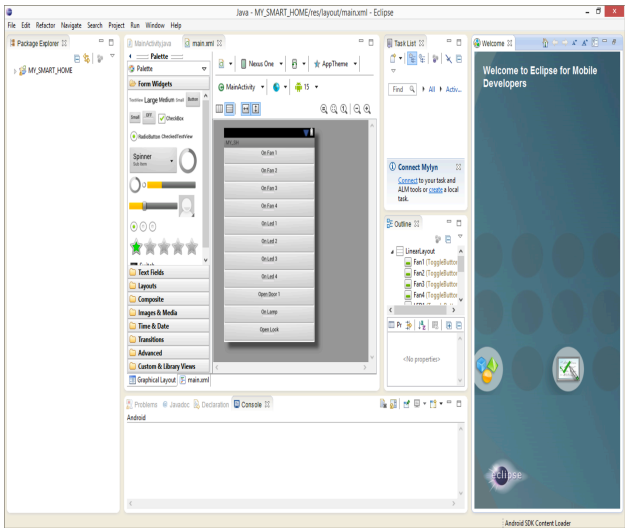
An integrated development environment (IDE) is a software application that provides comprehensive facilities to computer programmers for software development. An IDE normally consists of a source code editor, build automation tools, and a debugger. Most modern IDEs have intelligent code completion. Some IDEs, such as NetBeans and Eclipse, contain a compiler, interpreter, or both; others, such as SharpDevelop and Lazarus,. Many modern IDEs also have a class browser, an object browser, and a class hierarchy diagram, for use in object-oriented software development.

One of the most famous IDE used to develop Android Application is Eclipse IDE .

Eclipse is an integrated development environment (IDE) for developing applications using the Java programming language and other programming languages such as C/C++, etc [9].

The Eclipse platform which provides the foundation for the Eclipse IDE is composed of plug- ins and is designed to be extensible using additional plug-ins. Developed using Java, the Eclipse platform can be used to develop rich client applications, integrated development environments and other tools. Eclipse can be used as an IDE for any programming language for which a plug-in is available [9].

The Fig 6 shows the GUI of the Eclipse platform.



6. Eclipse platform

C. *Advantages of Android Application*

Android is free and an open platform built on Linux. It is an open source solution for mobile devices offering a complete software stack including operating system, middleware, and key mobile applications. Apart from its speed, scalability, and performance, there are many other advantages of Android application development which includes [10]:

- Open Source: The Android platform is open source which means the Android Software Development Kit (SDK) can be leveraged without having to worry about the licensing costs or royalty. Developers can interact with the Android developer community for the forthcoming versions which they can incorporate into their Android app development projects. These benefits make Android a lucrative prospect for enterprises, device manufacturers and wireless operators alike, resulting in rapid development of the applications.
- Customizable User Interface: A user interface can either make or break your app. Android-based applications are highly customizable and easier to manage. Google is highly focused on making its user interface customizable to help developers create custom Android apps for business. Being an open source platform, it allows developers to turn their creative ideas into reality and build innovative and interactive apps. It offers a wide array of customization options. Even the data management functions and multimedia tools can be easily updated to the app.
- Low Investment and High ROI: Android has a relatively low barrier to entry. Its Software Development Kit (SDK) is available for free to developers which significantly reduces the development costs. However, the app development costs can be bifurcated into three major parts: development, testing, and deployment. Developers are required to pay a one-time registration fee for application distribution. Thereafter, they can leverage any computer device to build and test the product on their smartphones, ensuring low investment and increased engagement among users. Ultimately, users get an interactive app and the enterprise gains higher return on investment.
- Multiple Sales Channels: Unlike other mobile platforms, Android applications can be deployed in different ways. You do not have to rely on a single market to distribute your applications. Besides using Google Play Store and other third-party app marketplaces, you can create your own distribution and sales channels. You build it, you publish it. With your choice of promotional strategy, you can reach your end users through multiple channels.
- Easy to Adopt: Android apps are scripted in Java programming language that leverages a rich set of libraries. Any developer familiar with Java can build Android applications easily. As per a developer survey, many Java experts find it easier to write apps for Android as compared to programmers with command over other programming languages.

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V. PRACTICAL PART " MINDWAVE MOBILE HEADSET AND ANDROID APPLICATION"

Mindwave Mobile headset shown in Fig7 as clarified in Section III, is a wireless device used to record the EEG signals, then it sends a corresponding data of the brain waves to the device connected with it via bluetooth connection.

7. The MindWave Mobile headset

The headset uses eSense meters for Attention and Meditation. The meter value for each type of eSense is reported on a relative eSense scale of 1 to 100.

Given that the Attention can be controlled through a focus, two actions have been chosen in practical implementation of this work " single and double blinking " which they give different range of values on eSense scale.

The headset records low frequencies of single blinking and gives small values on eSense scale while higher frequency is recording when the Human blinks his eyes twice and the values will be higher on eSense scale.

Android application is designed to communicate with the headset and it acts as an intermediary between the Mindwave Mobile Headset and the smart building controller " The Arduino ". It takes advantage of these values in order to send commands to the Arduino.

Android mobile which contains this application, receives signals from the Mindwave Mobile Headset via bluetooth connection and It also sends orders to the Arduino via bluetooth connection.

A. The Interface of The Smart Building Android Application

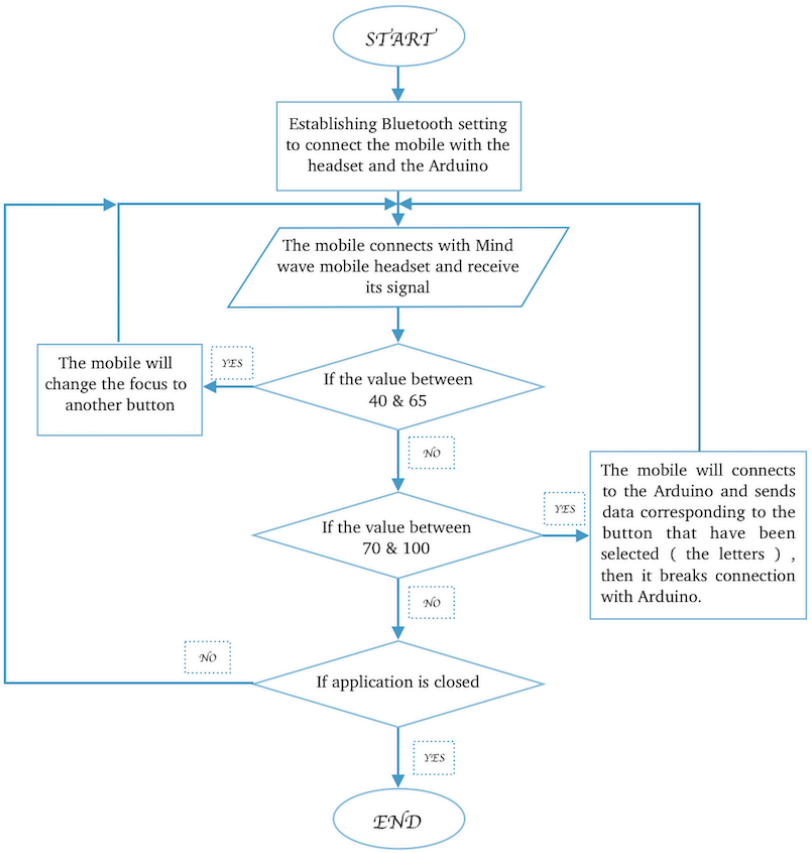
This Application includes a set of buttons as shown in Fig8 that we can select one of them and change their status through the Mindwave Mobile Headset.

8. The Interface of Android Application

B. The Android Application and Mindwave Mobile Headset Flow Chart

The flow chart in Fig9 clarifies how the Mindwave mobile headset and Android mobile contact with each other to send orders to the smart building controller.

If the user blinks his eyes once the mobile will change the focus to another button, and if the user blinks his eyes twice a certain button will be selected and the mobile will connect to the Arduino and sends data corresponding to this button (the letters).



9. Android Application Flow Chart

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VI. CONCLUSION

Mindwave Mobile headset is a wireless device used to record the EEG signals, then it sends a corresponding data of the brain waves to the device connected with it via bluetooth connection.

This work aims to use the Mind Wave Mobile Headset to control the whole building utilities through an Android application.

The Android application is designed to communicate with the headset and it acts as an intermediary between the Mindwave Mobile Headset and the smart building controller " The Arduino ".

Two actions have been chosen in practical implementation of this work " single and double blinking " which they give different range of values on eSense scale of the Headset.

The Android application takes advantage of these values in order to send commands to the Arduino.

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