

Control of incoming calls by a Windows Phone based Brain Computer Interface

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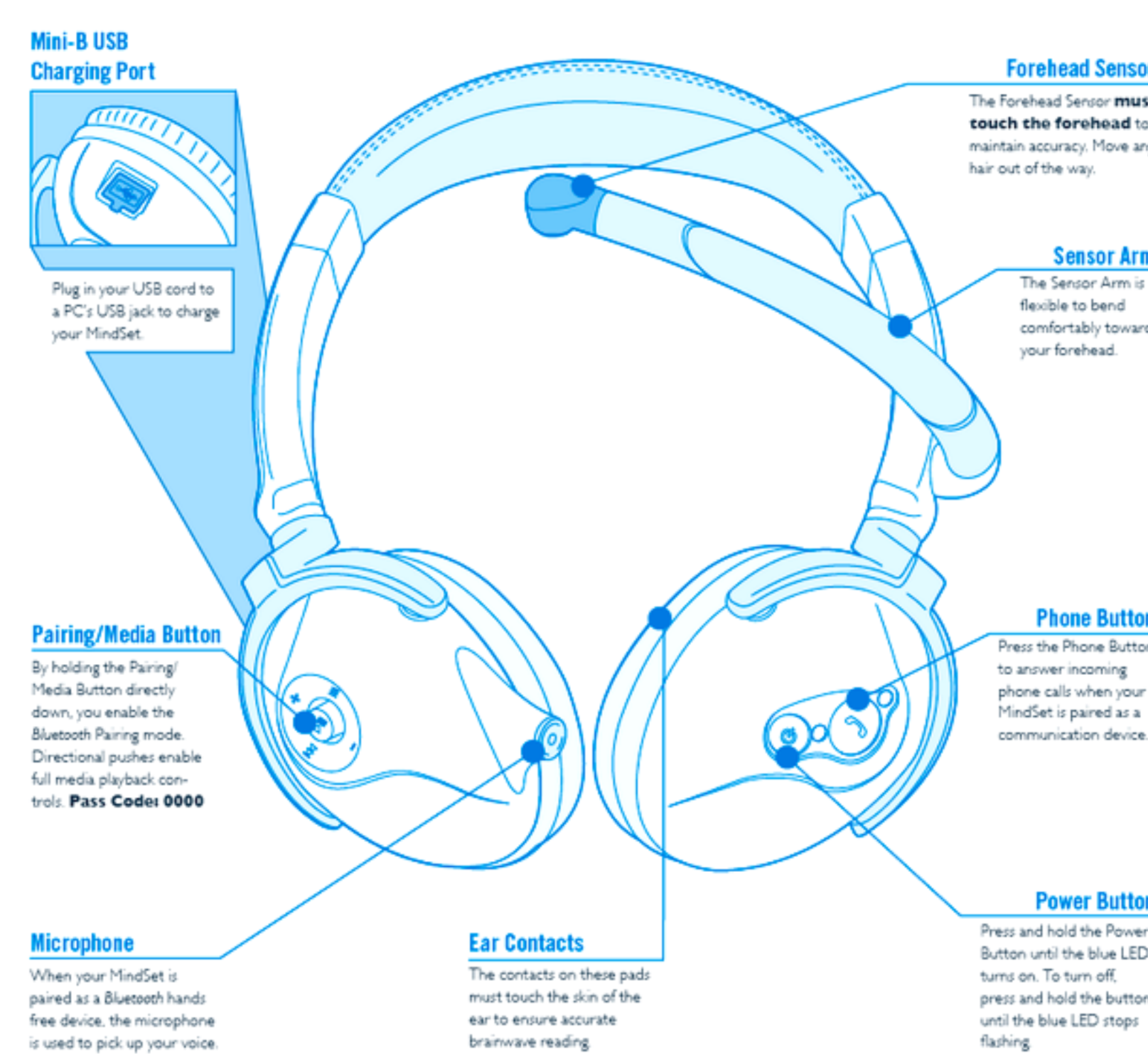
Abstract— The research area of “brain control” includes different innovative systems based on brain computer interface (BCI) technology and it is implemented, integrated, studied and tested at universities and research institutes. Using this technology, in this research a complex system has been developed that is suitable to observe EEG signals based on the observation of brain activity, the electric and magnetic signals of neural activity. Furthermore, based on the processing of the measured EEG signals, it is also suitable to implement EEG-based control and testing. Calculating the brain waves of brain activity by using quantitative EEG analysis, the developed test system can control answering and rejecting mobile phone calls.

The brain-computer interface (BCI) is a direct communication channel between the brain and an external device. The development of the brain-machine interface started with Hans Berger's work who recorded brain activity. These were the first human electroencephalograms recorded through the human scalp but the technology at the beginning of the twentieth century was not advanced enough to process and analyze these brain electrical signals. Several developments are in progress in these fields resulting the innovative devices of NeuroSky or Emotive, for instance. The devices, which measure, record and process brain signals by signal processing algorithms that define brain signals, have significantly developed as a result of continuous research. The reliability of the technology has remarkably improved.

This article demonstrates an application possibility in the area of information communication technology, a way how to control a smart phone by a BCI system. The brain-computer interface hardware unit is established with a **MindSet EEG headset**. The MindSet is a Bluetooth enabled wireless EEG signal measuring device **developed by Neurosky**. This device can determine the value of attention. The developed application is a windows phone-based software, which apart from data procession is also **able to control answering and rejecting calls**. The control program was written in **C# program** language, which can analyze and process the transmitted information by the developed direct neural interface hardware.

The following requirements should be fulfilled by the software unit:

- it should be able to **receive data sent by the EEG headset** through serial communication;
- it should be able to **check if data transmission error** caused by disturbance signal occurs during the transmission phase;
- it should store data in a previously defined, **convenient format and structure** in case of further procession;
- it should **represent the processed data** in bar charts to evaluate data;
- it should be able to **control answering and rejecting calls** according to the measured signals during brain activity with the developed BCI hardware.



MindSet EEG headset



Mobile Phone Control Software

Tests

As it is a human-controlled device, ratings in connection with its usability can only be accomplished by the test subjects and the most important parameters describing the operation of the devices can only be determined with their co-operation.

In the case studies, the device was measured and evaluated by an experiment. Both female and male test subjects participated in the testing phase: three men and two women. Two males and one of the females were less than twenty years old and one male and the other female were more than thirty years old.

Control was evaluated in accordance with two main aspects. The first viewpoint was the usability of the established system. Therefore, the test subjects were asked to evaluate it on a scale of 1-5. The other aspect concerned the most important parameter, the operation of the application. In the control of call answering, the most crucial feature of the device was the frequency of errors emerging in answering or rejecting calls.

Conclusion

The control was tested on ten call answering and rejecting with the help of test subject. The opinion about the usability of the device and the results of testing were controversial at the beginning, as the first use of the device was not very successful. According to the evaluation of the test subjects, at first they did not know how to control their thoughts, how to calm their brain activity, in other words, how to reach a calm state of mind or on the contrary, how to focus or concentrate strongly to start controlling. Consequently, they were not satisfied with the operation of the device, and the measured results were not adequate either. After about half an hour practice, the use of the device improved, as seen in table. Regarding the usability of the device, the evaluation of the test subjects improved with more than 1.5 and reached good grade. The control of receiving phone calls, especially rejection, became better after practicing how to reach calm state.

It becomes clear from the results that the test subjects had difficulties with using the device adequately at the beginning. The control of answering phone calls depends on high concentration / attention value, while rejection assigns to low concentration value. During the first attempts, the major part of answering calls were successful, but call rejection showed high error rates. It is attributable to the fact that active brain activity, such as concentration or attention is easier to reach than the calm state that was assigned to call rejection.

Test subjects	Evaluation at the beginning			Evaluation after practice		
	Usability	Errors (answering calls)	Errors (rejecting calls)	Usability	Errors (answering calls)	Errors (rejecting calls)
1.	3	30%	60%	5	10%	30%
2.	3	40%	60%	4	20%	20%
3.	2	10%	90%	3	30%	40%
4.	3	20%	70%	5	20%	20%
5.	2	20%	90%	4	30%	30%
Avg.	2,6	24%	74%	4,2	22%	28%