

András István–Rajcsányi-Molnár Mónika–Németh István Péter (Szerk.)

SZIMBOLIKUS

KÖZÖSSÉGEK

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The examination of the application possibilities of brain wave-based control

Abstract: Several research groups all over the world are currently aiming to develop technologies that could create connection between humans and other devices through brainwave detection. With the method of brainwave evaluation defined by the procession of brain signals, a number of non-existent or incipience applications can be developed in the future. The traditional EEG device used for brainwave measurement is expensive and difficult to handle. Cheaper, user-friendly and wearable EEG devices have been initiated in the last years making it simpler to determine brainwave intensity. These devices can be used in numerous application fields as seen in our comprehensive map.

Keywords: Electroencephalography, EEG, brainwaves.

Összefoglalás: A világon jelenleg több kutatócsoport dolgozik olyan technológiák kifejlesztésén, amelyek az agyhullámok érzékelése segítségével teremthetnek összeköttetést az ember és más berendezések között. Az agyból származó jelek feldolgozásával meghatározható agyhullámok kiértékelésének módszereivel számos, jelenleg még egyáltalán nem, vagy kezdeti stádiumban lévő alkalmazási lehetőség láthat napvilágot a jövőben. Az agyhullámok meghatározását lehetővé tevő hagyományos EEG készülékek drágák és használatuk körülményes. Az utóbbi években megjelentek olyan olcsó, könnyen kezelhető és felhelyezhető EEG készülékek, melyek segítségével az agyhullámok erősségeinek meghatározása egyszerűen elvégezhető. Ezen eszközök számos alkalmazási területen felhasználhatók, melyekről összefoglaló térképet készítettünk.

Kulcsszavak: Elektroencefalográfia, EEG, agyhullámok.

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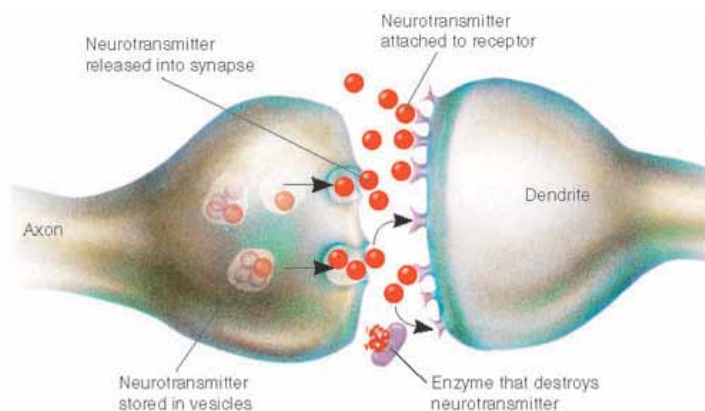
[1] Kéri Sz.–
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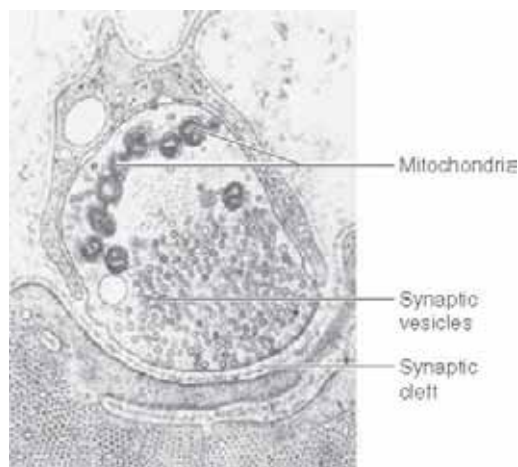
Introduction

We can say linked to the brain that the determined functions during the brain function are well-known. The interpretation of the brain waves could never develop to a high level without getting acquainted with the brain function from which we would like to extract and interpret the brain waves created by the brain activity. The brain activity is observable through the examination of the electric and magnetic phenomenon of neural activity and one of the most widespread methods of it is the electrophysiology. The examination of the brain activity and the brain waves and the observation of the neural activity are made with EEG and the processing of EEG signals is executed with EEG quantitative method mostly where the frequency- spectrum of the EEG signals is examined.

The EEG signal is a complex, periodical curve consisting of more components in which relatively big amplitude dominates and belongs to 8-12 range at rest. The exact mechanism of the formation of EEG is not known with total elaboration until today. It is likely that it is the consequent of lots of, more thousands of neuron's total electric activity which settles in the peripheral part of the cortex. The bioelectric signals that are originated in the brain, the activeness of the electric neurons induce small electromagnetic fields. This means that therefore during the activeness of the small-signal cortex voltage variations happen. In the cells the flow of protons, electrons, ions induce electric power, which on the resistance of the medium where it is flowing creates voltage (*Figure 1*). [1]

1. Figure. Events at the synapse.





Source: www.txtwriter.com

Brain wave

The brain function appears in the spectrum of the measurable EEG signals. If our brain “becomes excited” its “speed” becomes quicker just like in a case of a person.

The “message” of the brain appears in the mostly low frequency waves, about 1 to 12-14 Hz ranges. The alertness level determines the presence of certain frequency-components: in case of increased alertness high frequency components are present mainly, while in the deep stage of sleeping for example the intensity of the delta-waves are bigger. In the following chart (*Table 1*) the features of certain brain waves are visible. [1]

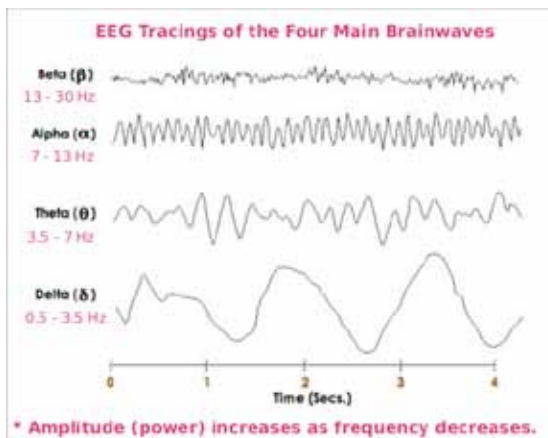
[2] Buzsáki Gy. (2006): *Rhythms of the Brain*. Oxford: Oxford University Press.

Table 1. The frequency and amplitude ranges of brain waves.

BRAIN WAVE TYPES	FREQUENCY RANGES (Hz)	AMPLITUDE(μ V)	SIGNIFICANCE
Delta	0,1 – 3,0	100 - 200	deep, sleepless sleeping unconscious state cognitive task linked to the frontal lobe
Theta	4,0 – 7,5	<30	REM sleep, dream 1-6 ages physiological cognitive task linked to the frontal lobe(Fourier-analysis) Intuitive, creativity
Alfa	8,0 – 12,0	30 – 50	the „base rhythm” of the brain to the impact of stimulation a big frequency rhythm replaces (Alfa-block) relaxed, but not sleepy, calm state
Beta	13,0 – 30,0	<20	sensory and emotional impacts harmonious, watchful, uneasy, excited, thoughtful states
Gamma	30,0 – 50,0	<10	High mental activeness

The examination of the brain signals happens in most cases with Fourier-analysis where the electric signals aroused by the brain, the brain waves can be taken apart to several frequency components. (Quantitative EEG) The certain brain wave frequency- components have special significance which can be seen on the *Figure 2*. [2]

2. Figure. Frequency components.



Source: www.meditation.org

MindFlex EEG headset

The MindFlex is an innovative device created for EEG based control which is constructed to the ThinkGear technology developed by NeuroSky and it was introduced in the autumn of 2009. The device consists of one course unit and an EEG headset without cable. On the course unit one ball had to be gone through by fluttering and the guidance of the wobbling is based on the evaluation of the brain wave types we get by the process of electric brain signals perceived by the EEG headset. The algorithm that runs in the micro-chief of the EEG headset does the evaluation of this perceived brain wave intensity. The device contains 3 sensors and one of them measures the potential of the frontal lobe, the other two have to be inserted as a reference point to the lower part of the ear. The signal processing unit that can be found in the headset is able to show the change of the concentration/attention with the help of the ThinkGear technology and with these influences the wobbling of the ball. The EEG headset passes the processed signals on to the play unit on wireless connection but with the help of a not standard WiFi connection. [3, 4]

[3] NeuroSky Inc. (2009): *Brain Wave Signal (EEG) of NeuroSky*. California: NeuroSky Inc.

[4] NeuroSky Inc. (2010): *Mindset Communications Protocol*. California: NeuroSky Inc.

[5] FTD
USB-UART
átalakító,
[http://www.
ftdichip.com/
FTDrivers.
htm](http://www.ftdichip.com/FTDrivers.htm).
2013. 05. 31

3. Figure. The device created for MindFlex EEG control.



Source: <http://mindflexgames.com>

As the EEG headset passes on the brain wave information through not standard WiFi connection therefore to read the EEG information from the device a construction of a special receiver unit is necessary or it can happen through some kind of direct wired connection. After the study of the inner circuit of the device we can say that the processed data by EEG headset are readable on serial line with the help of an USB-UART transformer. The readout is possible through serial line connection which is visible on the *Figure 4*. The readout on the USB port can be fulfilled under Windows operating system with the help of a serial line connection operation and a virtual serial port driver that is available on the website of the maker of the USB-UART transformer. [5]

4. Figure. Joining the USB UART transformer and the MindFlex headset.



The interpretation of the data arriving on serial line can be done by the information that contains the description of the sent data which can be found in the specification of the MindFlex device.

[6] American Honda Motor Co. Inc.: Asimo Robot. 2008, <http://aimo.honda.com>. 2013. 05. 31

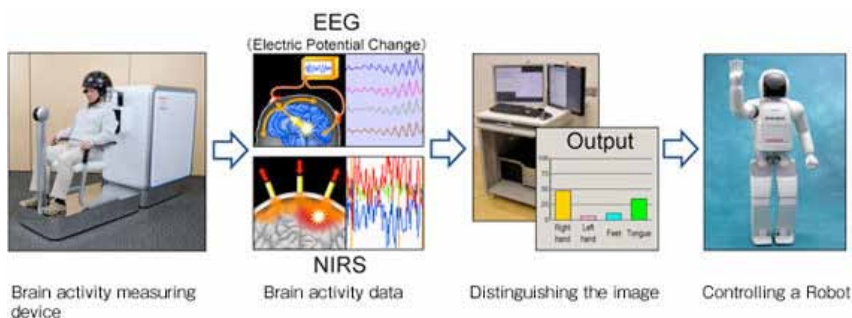
Application possibilities of the devices based on brain wave perception

Some useful and at the same time interesting application will be reviewed next.

Asimo robot

The Asimo (Advanced Step in Innovative Mobility) called mechanism is a humanoid robot similar to a boy that can be controlled by brain waves and this device uses the EEG technology too. (Figure 5.) [6]

5. Figure. Asimo robot.



Source: <http://world.honda.com>

[7] Stefan Haufe et al. (2011): EEG potentials predict upcoming emergency brakings during simulated driving. Journal of Neural Engineering. Volume 8. Number 5. 056001 (11Pp.) Online: IOP Publishing Ltd.

The help of the braking intention of the drivers

On the German Berliner Technical University a system was developed based on EEG signal process and with the help of this the braking intention of the drivers can be perceived 1000 seconds sooner compared to the braking with the press of the brake pedal.

This difference in time can reduce the stopping distance of a vehicle that goes with 100km/h speed with quite like 3,7 metres. (Figure 6.) [7]

6. Figure. A system that helps the braking based on brain wave perception.



Source: <http://www.bbc.com>

A helicopter controlled by brain waves

On the University of Minnesota such brain wave-controlled helicopter was developed that is able to go along an obstacle path.

The EEG signals was measured by a hat equipped with 64 electrodes and the movement of the helicopter was controlled by the process of different brain waves that arose in the course of the visualization of different movements. (clenching the right or left fist) [8]

Figure 7. A helicopter controlled by brain waves.



Source: <http://www.mysanantonio.com>

Summary

In recent years the technology, the sensors, the devices and the process units of the human brain wave perception developed so much that today portable EEG headsets are available.

These new devices give revolutionary new possibilities in the research of the human brain functioning or even in the field of a human brain based control/interference. In the article an EEG headset that is based on a new technology was introduced and it was briefly reviewed how the brain wave information processed by a headset could be read through serial

[8] American Honda Motor Co. Inc. (2008): *Asimo Robot*. <http://aimo.honda.com>, 2013. 05. 31.

line connection. Moreover a summary was made about what kind of main application fields of this new technology can emerge.

Besides these field it is worth to emphasize above the applications that are related to the entertaining electronics that this new technology can offer totally new opportunities to the disabled in their movement (for example the brain wave based control of the wheelchair or in their everyday activity, fulfilling other functions like turning the electrical equipment on and off) Furthermore the role that can be performed in the increase of everyday safety is also prominent, like the rectification of falling asleep.

They offer new possibilities on those application fields where new human-controlled function- because of the supply of other controlling task of the limbs- can be difficultly fulfilled. It can play an important role in several application of military technology. In the future even a guidance of a brainwave based plane is imaginable.