

June 2013

Simplified EEG

At the TU Braunschweig a light weight electrodes-helmet was build and used to simplify by mobile and wireless transmission the analysis of the electrical brain activities significantly.

With the EEG helmet brain signals can be measured directly without electrical contact between electrodes and head. This is possible because of the new kind of capacitive electrodes.

It is already the third generation of electrode-helmets developed by the Institut für Elektrische Messtechnik und Grundlagen der Elektrotechnik (EMG). The new helmet weighs only 500 gram, uses 24 electrodes and can be adjusted individually to different users. Using 3D printers it is no problem to produce fast high numbers of helmets. "The helmet is not pre-commercial yet, but it can be used for studies at clinics and surgeries." says Prof. Meinhard Schilling of the EMG.

The new technology is distinguished by a very good signal-to-noise-ratio. It combines the capacitive measurement of the brain signals and special elimination methods of electrical interference from the environment. Using the capacitive electrodes no direct contact to the head is needed preventing time-consuming preparations with contact gel. This helmet is directly mounted and the EEG is measured. [1]

For a few years the Institut für Elektrische Messtechnik und Grundlagen der Elektrotechnik has investigated biomedical sensor technology and is cooperating with the Charité Berlin and the information scientists of the TU Berlin. The aim is to achieve a fast, simple and wireless instrument to record brain signals that can be used in the medical diagnosis like for example to diagnose epilepsy quickly or in the research of sleeping laboratories. Furthermore, new applications as human machine interfaces, like steering computer games or controlling other devices are thinkable just as potential usage for neuro-ergonomics. In future the concentration state of persons in critical situations can be measured, for example in the cockpit of an airplane or at the control panel of a large factory building.

[1] Extraction of SSVEP Signals of a Capacitive EEG Helmet for Human Machine Interface
Martin Oehler et. al., Proceedings of the 30th IEEE EMBS, Vancouver, 4495–4498, 2008 .

↓ New simplified EEG helmet for capacitive measuring of brain signals



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2. 3D Print/Production
3. Application: Writing with Brain Signals
4. Institute

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EEG/SSVEP

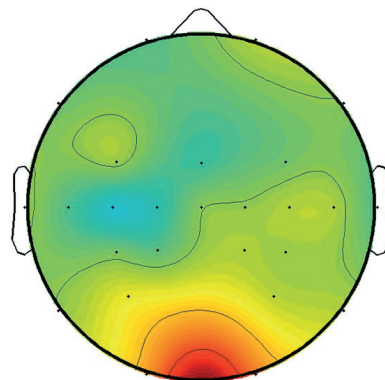
Electroencephalography is a routine method of the medical diagnostics to appraise the human brain activities. The electrical signals caused by activities of the neurons in the brain are measured on the scalp. Thinking is a complex cooperation of electrical signal processing and chemical signal storage of the brain. Certain parts of the brain are closely related to certain activities of the body for example the signals caused by the eyes are treated in the visual cortex at the back of the head.

Those electrical actions running all over the brain and their signals are superposed outwards. They are measureable due to the electrical potentials on the skin. Usually there is an elastic cap that takes care for a good contact of the electrodes for a record of an electroencephalogram, though the electrodes can measure the potentials that are a few millionth Volts high.

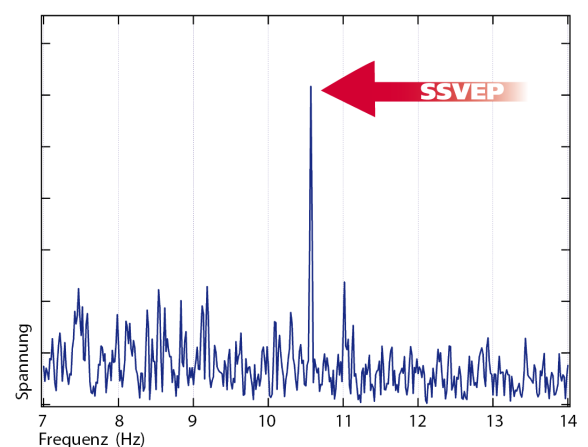
The signals of normal sight are too complicated and too weak to be measured with an EEG. But if the eyes are focused on a pattern flashing with a frequency between 8 and 15Hz, higher electrical potentials are generated in the visual centre of the brain. This procedure is called pattern-reversal stimulation. Those signals can be recorded with EEG, filtered by the computer and be processed. Those signals provoked by an external specified impulse are called visual evoked potentials (VEP), or when they are steady-state during a long time stimulation steady-state visual evoked potential (SSVEP).

Those signals can be mapped, so that the higher signal activities at the back of the head during processing visual signals can be seen clearly. In addition, the frequency spectrum is relevant for many applications to identify focused flashing frequencies.

↓ Map of electrical brain waves with activity at the back of the head.



↓ Frequency spectrum of brain signals with SSVEP peak at the stimulated frequency of 10,5 Hz.



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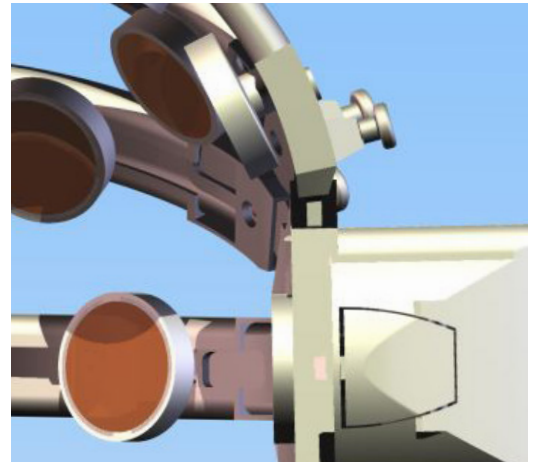
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Production using 3D Print Methods

A light helmet for EEG applications should be build out of plastic parts that are on the one hand solid and on the other flexible enough to be adjusted for very different types and sizes of heads. The best method to produce such plastic parts is die casting, but the moulds are extremely expensive, so that producing prototypes in that way is not profitable.

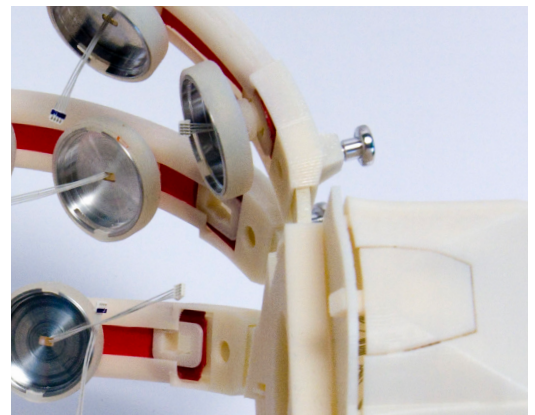
Therefore, methods of rapid prototyping are used instead of die casting. With assistance of so-called 3D printers even the production of very complex three-dimensional objects is possible.

All parts of the helmet discussed in this press release are produced with a 3D printer. The electronics of the single capacitive electrodes was installed in the printed helmet parts. The adjusting of the helmet to different heads is implemented in a mechanism. The wires of the electrodes and the electronics are hidden by the bows of the helmet. Above the ears are two boxes including the accumulators and the electronics including the Bluetooth interface.

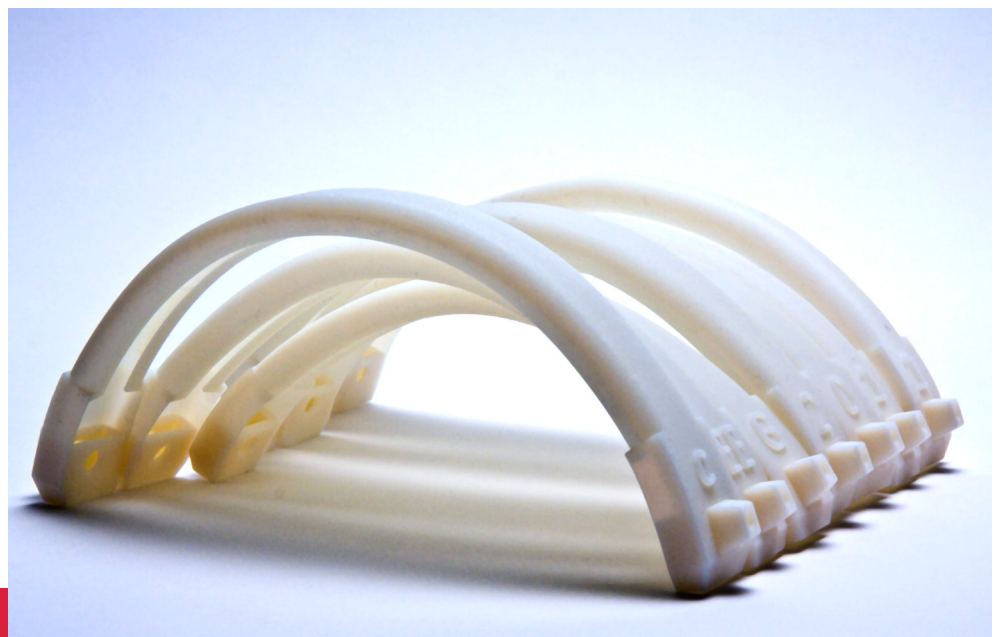


↑ CAD-Model.

↑ Plastic parts with installed elektrode housings.



↓ Helmet brackets.



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Colour Dependent BCI: Writing with Brain Signals

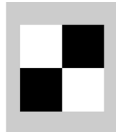
For some people usual communication is not possible anymore because of serious illnesses of the central nervous system (locked-in syndrome). For such cases a communication due to the analysis of brain signals (brain computer interfaces by EEG) was developed. Such systems are based on the principle that a computer gives a selection of letters and the patient chooses a letter by generating a measureable signal in the EEG. Such an application was implemented and tested with the capacitive EEG helmet, too.

The selection of the letters was realized with flashing chessboard patterns. The influence of different colour combinations on the successful detection by different test persons was analyzed, too. There are significant differences between the individual results [2]. Moreover, the successful detection is dependent on the ability for concentration and the personal subjective most comfortable colour combination.

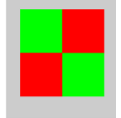
The colour patterns are assigned to the letters and by focusing on one certain pattern the flashing frequency can be detected in the visual centre of the brain. In this manner the letter can be recognized. By doing so letters can be written one by one and can built words to communicate.

[2] Subject response variability in terms of colour and frequency of capacitive SSVEP measurements, Marianne Gerloff, Meinhard Schilling, Proceedings BMT 2012, Jahrestagung, Jena, 46. DGBMT, 95-98, 2012.

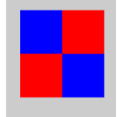
CC 1
Black (FF 00 00 00)
White (FF FF FF FF)



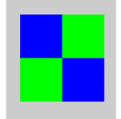
CC 2
Red (FF FF 00 00)
Green (FF 00 FF 00)



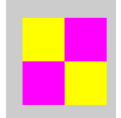
CC 3
Red (FF FF 00 00)
Blue (FF 00 00 FF)



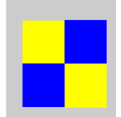
CC 4
Green (FF 00 FF 00)
Blue (FF 00 00 FF)



CC 5
Magenta (FF FF 00 FF)
Yellow (FF FF FF 00)



CC 6
Blue (FF 00 00 FF)
Yellow (FF FF FF 00)



CC 7
Brown (FF A5 2A 2A)
Turquoise (FF 5A D5 D5)



↓ Example for use: writing with brain signals.

↑ Colour patterns.

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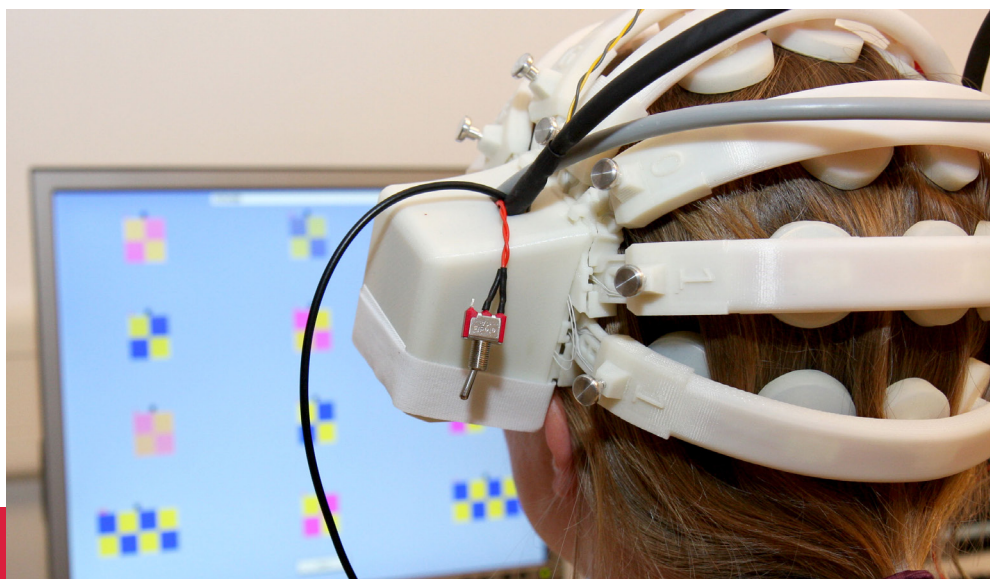
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BACKGROUND INFORMATION



At home and in cars, as well as in industry and economy: Everywhere electrical sensors are at work for many kinds of instruments. The Institut für Elektrische Messtechnik und Grundlagen der Elektrotechnik der TU Braunschweig headed by Prof. Dr. rer. nat. Meinhard Schilling investigates how sensors can be manufactured smaller, more precise and more reliable. Also new metrological concepts are developed. The sensors are produced in a modern cleanroom by means of nanotechnology and are equipped with analog and digital measurement systems. These systems are employed for magnetic field measurements, biochemical/medical applications and for the analysis of microchips working at the highest frequencies up to more than 1000 GHz. In all these areas close cooperations with national and international companies and research institutes are maintained and extended.

The **magnetic sensors and systems** are tested in a magnetically shielded room. There a SQUID magnetometer system for biomagnetic measurements of the heart and the brain is located.

There are close cooperations with biologists, chemists and clinicians for the development and testing of **biochemical sensor technologies**.

For the analysis of microchips at **ultrahigh frequencies**, a microwave laboratory with a far-infrared laser system is maintained, where also the novel terahertz-microscope has been developed.

New methods of the **nanometrology** are investigated in cooperation with the PTB in the laboratory for emerging nanometrology and analytics (LENA).

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