June 2008

PRESS RELEASE

Brain Computer Interface

Control with Brain Waves

The dream of a simple interface between brain and machine came true. Researchers at the TU Braunschweig developed a helmet which allows everyone to control a model car by means of brain signals.

Electrode helmet for controlling a device, here a vehicle

The new technology is based on the capacitive measurement of brain signals, which was combined with special measures to suppress environmental electrical disturbances. Capacitive measurement means that there is no direct electrical contact to the head, so conductive gel is not required.

The project is supported by the BMBF (Federal Ministry of Education and Research) and is done in collaboration with Prof. Dr. Gabriel Curio of the Department of Neurology of the Charité Berlin and Prof. Dr. Klaus-Robert Müller of the Fraunhofer Institute FIRST in Berlin. The possibilities of a quick and simple recording of the brain signals for medical diagnostics as well as for new applications, e.g. control of computer games and further devices, are studied in this productive and interdisciplinary cooperation between neurology, computer sciences and electrical engineering.

A basic task of the device is the complex evaluation of signals, by means of which the relevant parts are filtered from the innumerable different brain signals using modern methods of signal analysis. The control information is extracted from these data and transmitted to the vehicle.

Contact

Prof. Dr. Meinhard Schilling

Telefon 0049.0531.391-3866
Telefax 0049.0531.391-5768

eMail
m.schilling@tu-braunschweig.de

Technische Universität Braunschweig
Fachbereich Elektrotechnik

Institut für Elektrische Messtechnik
und Grundlagen der Elektrotechnik

Hans-Sommer-Straße 66
D-38106 Braunschweig

Postfach 3329
D-38023 Braunschweig
http//: www.emg.ing.tu-bs.de

cEEG Infos

Overview

BACKGROUND INFORMATION

Contact

Prof. Dr. Meinhard Schilling

Telefon 0049.0531.391-3866
Telefax 0049.0531.391-5768

eMail m.schilling@tu-braunschweig.de

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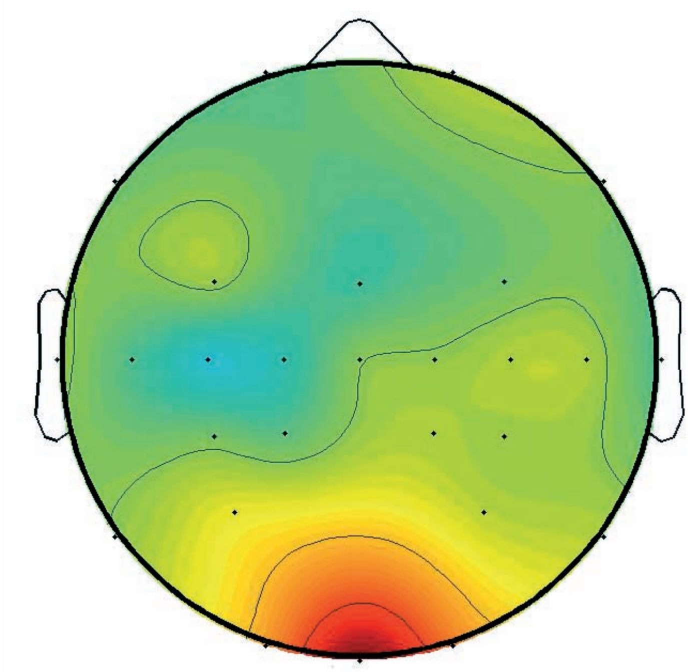
cEEG 01

Visually evoked Potentials (VEP)

BACKGROUND INFORMATION



Map of electrical brain waves with activity in the centre of the brain, measured with the 28 electrodes integrated in the helmet

Electroencephalography is a routine method of medical diagnostics for assessing human brain activity. The electrical signals, induced by activity of the cranial nerves, are measured on the scalp. Thinking consists of a complex interaction of electrical signal processing and chemical signal storage in the brain. Certain parts of the brain are clearly related to activities of the body, e.g. the processing of eye signals used here which takes place in the visual cortex in the back of the human brain.

Such electrical processes occur in all parts of the brain and they interfere with each other. They can be measured by accompanying voltage on the skin. With the electroencephalography, caps are usually used for applying electrodes which can measure the voltage of a few millionth volts.

The signals of normal vision are too complicated and too weak to be used in the EEG. But if a large part of the field of view is occupied by a blinking pattern with a frequency between 8 and 15 Hz, stronger electrical signals of the visual centre are induced in the brain. They can be recorded by the EEG, filtered by the computer and processed. Such signals induced by external, defined stimuli are called visually evoked potentials (VEP).

The signals are represented as a map (see figure). In medical applications, the doctor makes a diagnosis by comparing the brain activity of the ill person with that of healthy ones.

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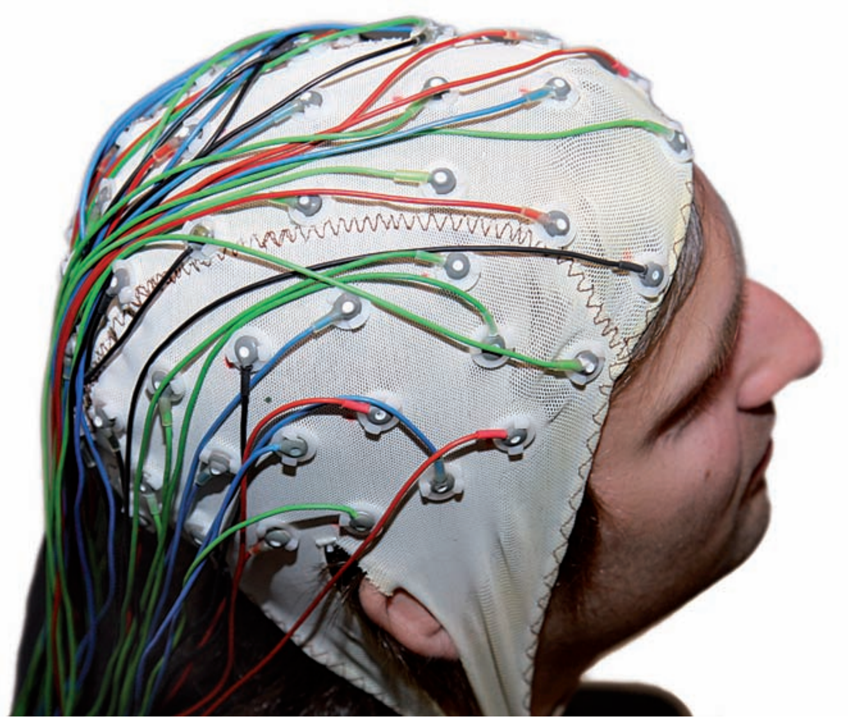
Conventional EEG Recording

BACKGROUND INFORMATION



Conventional EEG cap

Electrodes are usually used for EEG recording which minimise the contact resistance between electrode and skin surface and guarantee a stable, reliable contact. So-called silver / silver chloride electrodes meet these demands best. By means of a special conductive gel, which is applied in the hair between electrodes and scalp, the electrical resistance can be minimised and the derivation of the EEG can be optimised. Since an EEG usually requires some dozens of electrodes (figure on the right), all electrodes have to be applied to the represented cap carefully one by one and tested. For particularly good contacts, the surface of the scalp has to be roughened mechanically or abraded. The time expenditure and the required know how are considerable, so the EEG derivation is generally left for specialists and the derivation of brain waves for controlling machines so far appeared to be too complex.

Contact

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Telefax 0049.0531.391-5768

eMail m.schilling@tu-braunschweig.de

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Capacitive Elektrodes for the cEEG

BACKGROUND INFORMATION

Elektrode with aluminium housing

The effect that there are also charge displacements on the body surface due to brain activity is used for the capacitive measurement of the EEG. This change of the charge can in turn affect the charge on a metal plate close to the body. Since this electrical plate does not require direct electrical contact to the body, it can be isolated from the body. The measurement of the capacitive EEG (cEEG) is therefore also possible through the hair. A supersensitive signal amplifier is connected to this plate which amplifies the brain signal and processes it, so it can be displayed on the screen later on. Plate, amplifier and further signal processing electronic systems are integrated in the compact electrodes (30 mm in diameter, approx. the size of a 2 euro coin). The electrode is a bit larger than a standard EEG electrode.

28 electrodes are integrated in one helmet for covering different brain areas. The electrodes can be adjusted mechanically to allow the adaptation to various head shapes.

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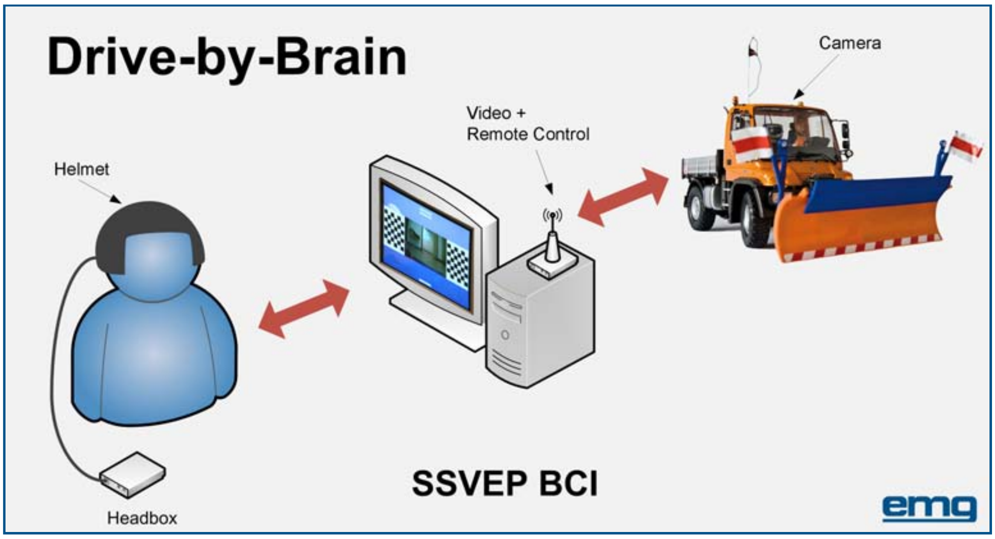
http//: www.emg.ing.tu-bs.de

cEEG 04

Brain Computer Interface

BACKGROUND INFORMATION



The control of machines by means of steady-state visually evoked potentials is done via the helmet, which records the brain signals and transmits them to the computer. It evaluates the signals and controls the vehicle via remote control.

A brain computer interface is meant to allow the direct information flow between brain and computer. For the technical implementation, signals from the brain have to be recorded. There are several methods which can be considered for this purpose. The method we use is the relatively cost-effective and simple recording of electrical brain signals (EEG) by means of capacitive electrodes.

In our system, the signals of the visual region of the brain are induced by looking at two blinking chequerboard patterns on the computer screen. If the controlling person concentrates on the blinking pattern on the left side, the vehicle is supposed to drive to the left and accordingly to the right if looking at the pattern on the right side. If none of the chequerboard patterns is looked at, the vehicle drives straight ahead. The signals for left and right differ in terms of blinking frequency (Martin Oehler, Peter Neumann, Matthias Becker, Gabriel Curio, Meinhard Schilling, “Extraction of SSVEP Signals of a Capacitive EEG Helmet for Human Machine Interface”, *Proceedings of the 30th Annual International Conference IEEE EMBS*, Vancouver, Canada, 2008).

The recorded signals are amplified and disturbances are filtered. The signals are then transmitted to the computer (wireless or via cable) and evaluated. The intention of the controlling person can only be determined from the various signals and converted into control signals for a machine by means of a computer programme. The control commands are then transmitted to a vehicle model via radio.

Advanced BCI systems, e.g. studied by our colleagues in Berlin, are only based on electrical brain signals influenced by will in the motor centre which are, however, much weaker and which are recorded with conventional EEG electrodes.

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emg

The "Institut für Elektrische Messtechnik und Grundlagen der Elektrotechnik"

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” of the 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 attached to 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 industry and international research institutes are maintained and extended.

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

For the development and testing of biochemical sensors a bioreactor is placed in a S1-laboratory, which guarantees the secure handling of microorganisms.

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

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D-38106 Braunschweig

Postfach 3329
D-38023 Braunschweig
http//: www.emg.ing.tu-bs.de

Prof. Dr. Meinhard Schilling

Head of the Institut für Elektrische Messtechnik und Grundlagen der Elektrotechnik, Technische Universität Braunschweig