Measurement station for recording of different biosignals to detect emotions under mobile conditions

Wigand Poppendieck
Fraunhofer IBMT
Ensheimer Str. 48
D-66386 St. Ingbert
Tel.: +49-6894/980-170
wigand.poppendieck@ibmt.fraunhofer.de

Roman Ruff
Fraunhofer IBMT
Ensheimer Str. 48
D-66386 St. Ingbert
Tel.: +49-6894/980-176
roman.ruff@ibmt.fraunhofer.de

Eduardo Fernández
Universidad Miguel Hernández de Elche
Avenida Universidad s/n
E-03202 Elche
Tel.: +34-965222001
e.fernandez@umh.es

Klaus-Peter Hoffmann
Fraunhofer IBMT
Ensheimer Str. 48
D-66386 St. Ingbert
Tel.: +49-6894/980-401
klaus.hoffmann@ibmt.fraunhofer.de

ABSTRACT
Feelings and emotions influence our daily routine and affect our social behavior. Especially while driving a car we change our emotions very quickly depending on the situation. To understand the different mental situations, the recording of biosignals such as EEG, ECG, blood pressure, eye movements or respiration plays an essential role. Here, a measurement station is presented which can be used to detect a great variety of biosignals from a person sitting in a driving simulator. By developing suitable data processing algorithms, the recorded biosignals can be used to detect and identify the emotional status of a person.

Categories and Subject Descriptors
J.3 [**Life and Medical Sciences**] – *health, medical information systems*

General Terms
Algorithms, Measurement, Human Factors

Keywords
Biosignal Recording, Emotions, Driving Simulator

1. INTRODUCTION
Feelings and emotions are permanently influencing our daily lives. In recent years, major research has been undertaken in the field of detection and classification of feelings and emotions for the use in emotional cognitive systems [1]. For instance, Ekman has defined 6 basic emotional states which can be found in every person independent of aspects such as culture or religion [2]. In order to detect the emotional status of a person, various vital parameters can be recorded by the use of appropriate sensors. These parameters include biosignals such as heart rate, galvanic skin response, body temperature, respiration, EEG or blood pressure [3]. By suitable algorithms, the acquired signals can be processed in a multidimensional feature space, in order to reduce the data to the indispensable features which can be used to identify the current emotional state of a person (see Figure 1).

Emotional cognitive systems can be used for a great variety of applications. In this context, we would like to focus on the detection of feelings and emotions in a car. While driving a car, we typically experience a wide spectrum of emotions, ranging from fatigue to anger. The objective is to develop a mobile system which identifies and reacts on the emotional status of a driving person, in order to modulate his emotional response and to increase road safety. For instance, by the use of eye-tracking systems, increased eye blink frequency correlated to fatigue could be detected. In such a situation, an alarm signal could be generated urging the driver to take a break. To detect a state of anger, vital parameters such as heart rate, galvanic skin response, body temperature, respiration of blood pressure could be used. If the system identifies the driver as "angry", measures can be undertaken to calm him down, for instance by playing appeasing music or applying a certain enjoyable aroma.

Figure 1. Ekman's basic emotional states [2].

The development of a mobile system is especially challenging due to the high demands caused by the changing environmental conditions, increasingly occurring artifacts and the usually limited resources. In the following, a measurement station is presented which can be used to record a variety of biosignals under mobile conditions, in order to detect and identify the emotional state of a person by appropriate signal processing in a multidimensional feature space.

2. CONCEPT
The concept of the measurement station is presented in Figure 2. The central part of the system is a driving simulator (SimuTech, Bremen), which allows for driving a car with all required actions, such as accelerating, braking, changing gears or steering. The simulator is equipped with three screens to project real driving

MobileHCI'09, September 15 - 18, 2009, Bonn, Germany.
ACM 978-1-60558-281-8.

situations, providing a 180° field of view. With this system, various hazardous episodes can be simulated, and a multitude of vital parameters can be simultaneously recorded and processed.

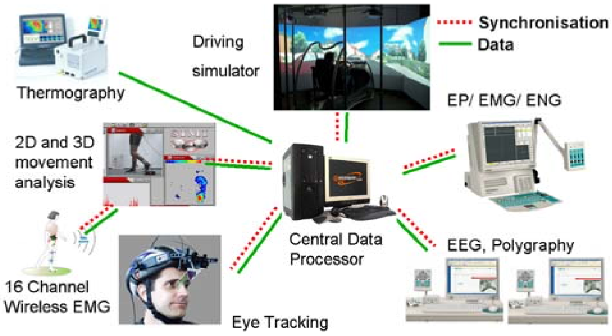

Figure 2. Concept of the measurement station.

The measurement station includes two polygraphy systems (Comlab 44, Schwarzer, München), an electrocardiograph (BT12, Corscience, Erlangen) and an electromyograph (Topas, Schwarzer, München) for multi-channel recording of bioelectrical potentials, such as EEG, EMG, EOG, ECG, evoked potentials and changes in the galvanic skin response. Moreover, signals such as pulse, oxygen saturation, respiration, respiratory effort, body position, body temperature, blood pressure, acceleration etc. can be recorded. Additionally, 16-channel wireless EMG recordings (TeleMyo 2400T G2, Noraxon, Scottsdale, Arizona) can be correlated to three-dimensional movements and movement patterns.

The station also includes a video camera to detect changes in posture and facial expression (SIMI Reality Motion Systems, Unterschleißheim), and an eye-tracking system (iView X, SensoMotoric Instruments, Teltow) with a high-speed camera to record eye movements as well as the size of the pupils and the eyes. Finally, by the use of a thermography system (Varioscan, Infratec, Dresden), information about body temperature and peripheral blood circulation can be gained.

3. REALIZATION

The measurement station was realized as described above. Figure 3 shows a part of the set-up with the driving simulator as the central part.

Figure 3. Realization of the measurement station.

All recorded signals are collected by a central control unit and can be processed with respect to different aspects, such as changes of vital parameters, exceeding of threshold values for individual signals, detection of microsleep, identification of vigilance oscillations and arousal states. Individual signals can also be connected in order to obtain further information. One example is the Pulse Transit Time (PTT), which can be calculated from the ECG and the pulse curve. Moreover, the pulse can be detected by the use of thermography recordings. By applying specially adapted processing algorithms, it is also possible to detect and identify different emotional states. In Figure 4, simultaneous polygraphic recording of different vital parameters is shown as an example of the possibilities of the system.

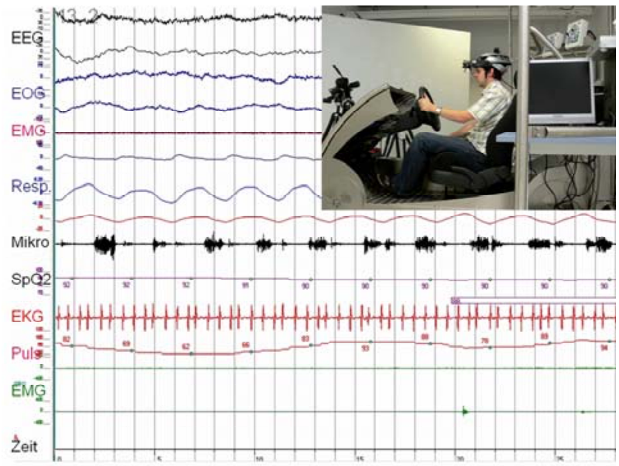

Figure 4. Simultaneous polygraphic recording of vital parameters.

The recorded parameters form a multidimensional feature space, which can be analyzed by the use of mathematical and statistical methods. By this means, it is possible to isolate the respective indispensable features which are relevant to identify a certain emotional state.

4. DISCUSSION

In this work, the successful design, development and set-up of a measurement station is presented, which can be used for a multitude of applications in the field of Ambient Assisted Living [4]. A special focus was put on mobile application in a car, therefore a driving simulator was used as the central part of the system.

The measurement station can be used to record a great variety of vital parameters and to identify the application-specific indispensable parameters. Thus, by developing suitable algorithms, the set-up provides the detection of emotional states. The use of such a system in a car bears the potential to increase road safety, as states such as fatigue or aggression can be detected and counteracted.

Future development of the presented system includes the optimization of the applied sensor technology, for instance the development of intelligent sensors (see Figure 5) including electronics for signal processing and wireless transmission [5], and capacitive, contactless electrodes [6].

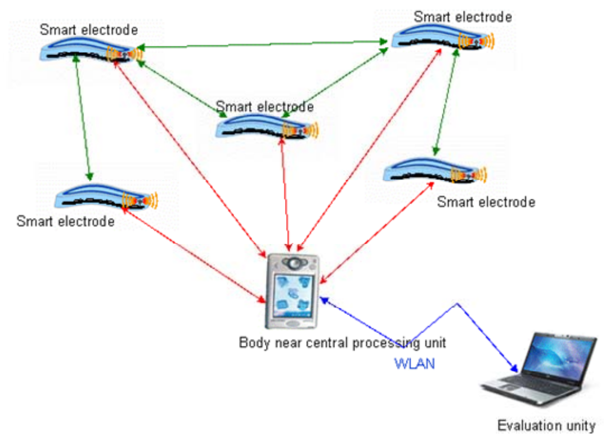

Figure 5. Wireless, self-organizing electrode compound.

Moreover, in order to use the measurement system for detection of feelings and emotions, the development of suitable algorithms will be a crucial issue in future work. With the set-up, it is possible to create stress situations or certain emotional states (e.g. anger). By evaluating the recorded biosignals, the characteristic features of these states can be identified. Techniques such as interviews and questionnaires can also be used to verify the identification of emotional states. By isolating the indispensable features relevant for emotion detection, it will be possible to reduce the required number of measurement signals. This will facilitate the integration of the system in a real car.

5. ACKNOWLEDGMENTS

This work was supported by the European Union (Projects MINET (Measuring the Impossible NETwork, EU-FP6-NEST-043297) and Feel Europe (European Expert Platform for Measuring Human Feelings and Emotions, EU-FP6-NEST-043357)), by the German Federal Ministry of Education and Research (Project Seed (Self-organizing electrode network for electrophysiological diagnostics)), and by the Fraunhofer Society (Project InMuSens (Intelligent multimodal mobile sensor systems for applications in medicine, occupational safety and well-being)).

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