Chapter 6

A Real Time Attachment Free, Psycho Physiological Stress and Heart Rate Measurement System

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ABSTRACT

The challenges in the development of a system performing real time detection of physiological parameters are fundamentally aversive because of the incommodities caused by the wires and sensing attachments onto the user, making the measurement sessions uncomfortable. Another factor is that the sensing accessories influence the plausibility of the measurements. In this paper, the authors introduce a system based on a device that can acquire physiological signals from a computer user with no prerequisites, postural, kinetic, or other constraints in the environment of normal usage of the home computer for the detection of their psychosomatic state and optimally their affect and emotional responses. The authors also discuss issues that could otherwise compromise the credibility of the results. Redundancy and special adaptive and corrective algorithms have been developed to improve reliability and achieve acceptable standards of quality. Measurements include skin conductance (SC) and heart rate (HR) detected by sensors positioned on the vertical sides of a computer mouse. The system is intended for interactive educational environments, during assessment, e-learning, psychosomatic user profiling, mobile and web based interfaces, and for Human Computer Interaction (HCI) platforms.

1. INTRODUCTION

The principles of measurement and the validity of SC as a dependable method of identifying responses to sympathetic and parasympathetic stimuli of the autonomic nervous system has been validated and verified in numerous scientific publications (Venables & Christies, 1980; Cacioppo, Louis, & Tassinary, 2007) as systems employing those principles have gained approval for use in clinical practice. Clinical studies have also correlated specific responses to stimuli with those
of an emotional state of a human subject and the credibility and accuracy of measurement using various combinations of bio-medical instruments has been validated thoroughly recognizing the use of stress monitoring instruments for therapeutic procedures (Eysenck & Keane, 2005; Picard, 1997). Biomedical research in SC measurements and SC/HR combinations has classified those instruments as approved devices for valid detection of verified subconscious physiological responses of a human subject. As in clinical assessment and diagnosis, these very instruments adapted appropriately have been employed in Interactive Human Computer Interface (IHCI) environments, whereby the responsiveness, functionality and visual context of the computer environment is modified actively according to predetermined threshold levels of psychosomatic responses. The adaptation of a specifically designed environment, can respond to certain bio-feedback reactions of the user, performing specific modifications according to the actual user behavioural, cognitive or habitual profile achieving a personalisation of the interface that can improve dramatically the performance of an individual (Lekkas, Tsianos, Germanakos, & Mourlas, 2007; Kort & Reilly, 2002; Kim, 2002). The Pros and Cons amongst the principles and methodologies used for measuring psychosomatic responses through the variations of skin electrochemical composition, has also been the subject of numerous discussions with two main contenders dominating the principle of measurement; the Skin Resistance method (SR) and the SC. The SC has been adopted as the generic quantity of measurement for our system, as the optimum principle of measurement and most reliable technique compared to that of the SR, being the most accurate and dependable of the two. The continuous micro-current measurement method is used as opposed to pulse-period measurement or other computationally intensive techniques. The strong parallelism of the responses of the SC in direct comparison with that of the EEG (Critchley, 2002) leaves very little doubt that the SC measurement provides comparably accurate results coinciding in time and magnitude. The HR is the second quantity we measure as a simultaneous input to our system. The sensing circuit for the HR is based on the principle of infrared absorption reflectometry. In order to produce a system that is cost effective, computer platform independent, involving minimal adaptations and relatively simpler to make, the use of a particular DSP or Microprocessor has been circumvented and a special communication protocol has been avoided. Instead, the preconditioned signal is fed to the computer via its universal sound card and further processing components derive the parameters required for the modifications of the adaptive user environment. Our system consists of a sensing part that is accommodated onto a typical computer mouse, an analogue electronic circuit that feeds the processed signal to a typical home computer and finally a software component that translates the measurements into a predetermined format appropriate for our adaptive application platform. SC is detected by direct skin contact of the thumb and ring fingers with pellet shape sensors located on the left and right vertical sides of the computer mouse respectively. The areas of the epidermis (stratum corneum) of the fingertips as the densest parts of the human body in sweat glands and nerve endings (Gray, 1977) conveniently provide a highly reliable source for our instrument with optimal response to stress induced stimuli. The pulses of the heart are detected by infrared sensors based on the principle of reflective absorption during the changes of the coloration of the skin caused by the pulsation of the blood in the veins and arteries. The sensors for the HR circuit are located in the centre of the pellet rings on the sides of the mouse. A dual sensing circuit of the HR minimises interference or false readings and eliminates movement artefacts through correlation of the two measuring channels, while further analogue filtering and scaling ensures reliable pulse detection. Software algorithms for missing pulse detection, ectopic and offset pulse
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