HCI-HPR

Sponsored by Sheffield Hallam Alumni,
DOI: 10.5281/zenodo.11208764.

Advancement in Human Computer Interaction and Human Physiological Modelling

ISSN/ISBN-10: 1-100-22302-9

Using Multimodal Measuring Systems as a Psycho-Physiological Analytics

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Abstract

The concept of Psychophysiological measures is described as the physiological measures used in indexing psychological and cognitive constructs such as psychological processes and states. Most work has explored the mind-body relationships in scientific phenomena in a confined environment. One of the problems most study faces is the difference in latency for the physiological response for all starting points due to differences in variations in terms of individual and skin and body texture. This paper approaches this in a more confined approach by conducting an experimental setup as a pilot study and using the generated data as an input matrix to the cognitive physiological analytics that embeds multimodal sensors of physiological reading through fingerprint moisture detection. The response state is predicted using the dynamic controls that respond to basic filtered response output through a second differential equation. The resulting output is an interface that summarises the models' performance and response parameters.

Keywords: Psychophysiological response, Cognitive state, Cognitive modelling, Skin conductance response, Skin temperature, Pupil response

Accepted: 12th April, 2024
Revised: 16th May, 2024
Published:10th June, 2024

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1 Introduction

The physiological measures in an experimental study involve the direct and indirect observation of variables attributable to normative operational functions of the systems and their subsystems that make the human body. The equipment and tools for this method are different, but most of them are based on empirical observation. The parametric attributes observed are derived from the measurable properties and functions of the integrated physiological systems and their subsystems. In most users, this could include phenomena such as Electrocardiography (ECG), Skin conductance response, Heart rate, Skin temperature and Pupil response as also their biomarkers. In an unconfined environment,

But when pared to behavioural, social and psychological factors in association with communication, they can offer thoughtful insights into human perception and human behaviour. The basic fundamental concept in physiological measurements and their uses is that both the behavioural and experience aspects can be explained through a strictly confined environment with little or no external intervention. Most work in psychophysiological measures is done noninvasively with a conscious user or participants, it can take any form ranging from the above-mentioned physiological response measure. Eye movement is one of the attributes of a physiological setup because it compliments the research procedure by providing additional and incisive means to interpret behaviour patterns

2 Introduction

and their attributes, such as emotion, cognition and the interactions between them. The tools integrated into its framework offer a very flexible set of assistance to researchers and help to answer questions about the complexity of human behaviour standards relating to cognition.

3 Literature Review

The recent research, psychophysiological methods are seen to be a subject of a very large domain of both neuroscience and human-computer interaction (HCI) [[5, 18, 2, 17, 15]]. A lot of areas in cognitive neuroscience use invasive methods, such as involving lesions of neural tissue with a few active chemicals. This process is usually tedious and makes the participants uncomfortable. Other current research has adopted the use of a non-invasive method through biometric measures that can locally collect participant data wirelessly or via wired means [[6, 14, 20, 10, 7]]. Our current study also emphasizes non-invasive methods that cover multimodal techniques for applying physiological measures through the board circuit of a touchpad like a mouse pad where one can have access to the skin or body of the participants without using uncomfortable means. It will allow easy analysis and a relaxed atmosphere for the user and the evaluators to evaluate the error-free mental and behavioural processes of the participants.

In examining the relationship between physiological and subtle behaviour and the mental state of the events from the participants, psychophysiological measures do not attempt to replace both concepts in their diversity [[9, 11, 19, 4, 16, 8, 12]]. For example, a happy and relaxed cognitive state is associated with different physiological measures, but one would not say in the literal sense that the physiological measures are related to happiness. Naturally, we can make inferences about someone's cognitive and emotional state based on their self-report and overt behaviour, but sometimes the most interest is primarily in the inferences about the internal events and their occurrences and primarily in the physiological response itself. The process in psychophysiology answers these questions. The research question is: What are biometrics, and how can they be used for response evaluation? The best way to answer this question is based on self-report (subjective views) and SCR that would reveal and capture the unconscious emotional reactions [[3, 1, 13]] of the participants. The paper offers an extensive means and less cost effect dealing with psychophysiological analytics, by developing physiological analytics that respond to user response and cognitive state with the system modifications during run time. The following section discusses the process involved in dealing with this problem.

4 Method

The pilot stage of the project is designing a multimodal measuring physiological sensor with embedded control motor dynamics capable of reading multiple signals from a single source (Figure 1). The model consists of three basic mini chips or sensors that read in SCR, ST and Pupil dilation obtained from an integrated eye reading measure from a touchpad with an electrode for an input signal of moisture content on the surface of the skin. The motor sensor consists of a control motor dynamic for response detection based and time-invariant state-space model. The equation that helps to describe the dynamic of an embedded control system is stated as:

$$\begin{gathered} E_a(t) = R_a i_a + L_a \frac{di_a(t)}{dt} + K_b \frac{d\Theta_m(t)}{dt}; \\ T_m(t) = K_i i_a(t) \end{gathered} \tag{1}$$

$$\begin{gathered} T_m(t) = J \frac{d^2\Theta_m(t)}{dt^2} + B \frac{d\Theta_m(t)}{dt} + K\Theta_m(t); \\ E_a(t) = K_a e(t); E(t) = K_\delta[\Theta_r(t) - \Theta_m(t)]; \end{gathered} \tag{2}$$

The state variables for the given system are assigned as follows: $x_1(t) = \Theta_m(t), x_2(t) = \frac{d\Theta_m(t}{dt_n}$ and $x_3(t) = i_a(t)$., The state-space representation of the expressions is given in the form:

$$\frac{dx(t)}{dt} = Ax(t) + B\Theta_r(t) \tag{3}$$

$\Theta_m(t) = Cx(t)$, where $\Theta_m(t)$ is the output physiological response while $\Theta(t)$ is the input matrix with physiological response variables.

$$\frac{\theta_m(s)}{\theta_r(s)} = \frac{L(\Theta_m(t))}{L(\Theta(t))} \tag{4}$$

4.1 Experimental setup and task

A few people (ten participants) were recruited for the testing with signed consent, they were asked to place their hands on the touchpad (Figure 2). They sat facing a laptop with an embedded webcam and a module that detects their iris and also calibrates them to the screen of the laptop. This helps to track their eye movement while they interact with visual stimuli on the screen. The calibration speed is faster with a system with high memory space. The physiological reading is connected to the laptop where the system analytics synchronises the events and records response correlates. The pupil changes based on dilation and constriction are recorded with time in harmony with the other physiological responses. The cognitive state of the user can also be reflected in their pupil change and can be classified into two basic responses; stress and relaxed mood. The task is simply to respond to visual content placed in front of them by answering simple straightforward questions displayed on screen about their personality. The questions

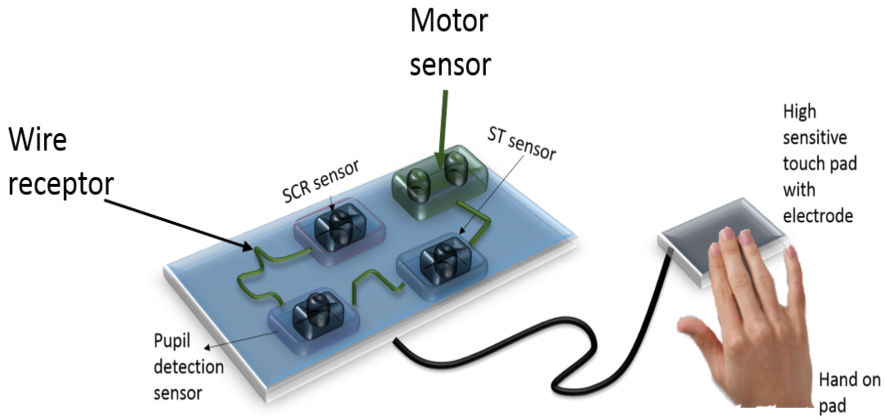

Figure 1: Multimodal modal measuring sensor with a single interface for input signal from a single source

Table 1: The task for the participant's study is a response incisive.

Question Options	Question
1.	What is your name?
2.	How tall are you?
3.	What is your Cognitive Level?
4.	Are you reactive to stimuli?
5.	What is your level of sensibility?

are designed to induce latency and stimuli onset for response detection. The task is listed in Table 1.

The questions were designed to insight some response start points based on stimuli incentive. The question was set at the index of the analytics for response and physiological spikes detection that relates to events and tonic and phasic states. The proceeding section discusses the result obtained from the study.

5 Result

Figure 3 shows the window interface of a participant reading from the experimental study, the red lines represent the SCR, cyan dashed lines represent the ST, the blue lines represent the changes in pupil size and the baseline is represented by the cyan undashed lines. The image detection of the fingerprint is shown on the right side of the interface; this is where the physiological readings are recorded as the single point of contact from the electrodes of the touchpad.

The resultant display from the simulation is an interface with performance metrics from the physiological response and definition to input parameters such as the SCR, ST, mapped fixation of the visual interface (MappedFY), and pupil changes, the performance for response detection is done for all attributes and error performance for the predicted response of the stimuli state. The number of orders in the differential equation is set to three for a smooth resultant response and predicted at the rate of 0.001% for pupil dilation and a negative response less than the estimated rate for the rest of the physiological response parameters.

6 Conclusion

This paper demonstrates innovation in the field of the psychophysiological and cognitive response of the participants' response state; it touches on the psycho-physiological analytics in measurement methods through multimodal systems. This paper approaches this in a more confined approach by conducting an experimental setup as a pilot study and using the generated data as an input matrix to the cognitive physiological analytics that embeds multimodal sensors of physiological reading through fingerprint moisture detection. The response state is predicted using the dynamic motor sensor controls that respond to basic filtered response output through a second other differential equation. The resulting output is an interface that summaries the models' performance and response parameters. The state response of the model is at its initial stage and substitute modification will be applicable as a future perspective for the model's optimisation, it will be as a form of cognitive analysis for physiological analysis detection with dynamic control systems.

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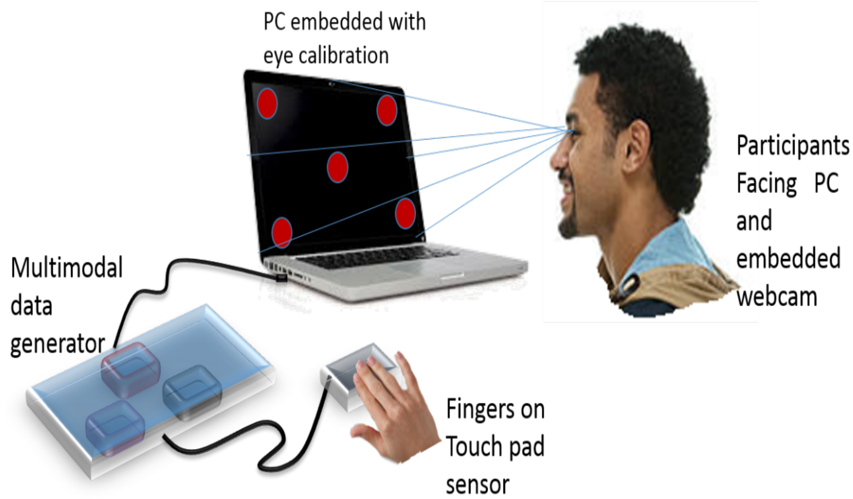

Figure 2: Participants were asked to place their first two middle fingers on the touchpad, while the eye is calibrated on the screen to track eye movements and pupil change.

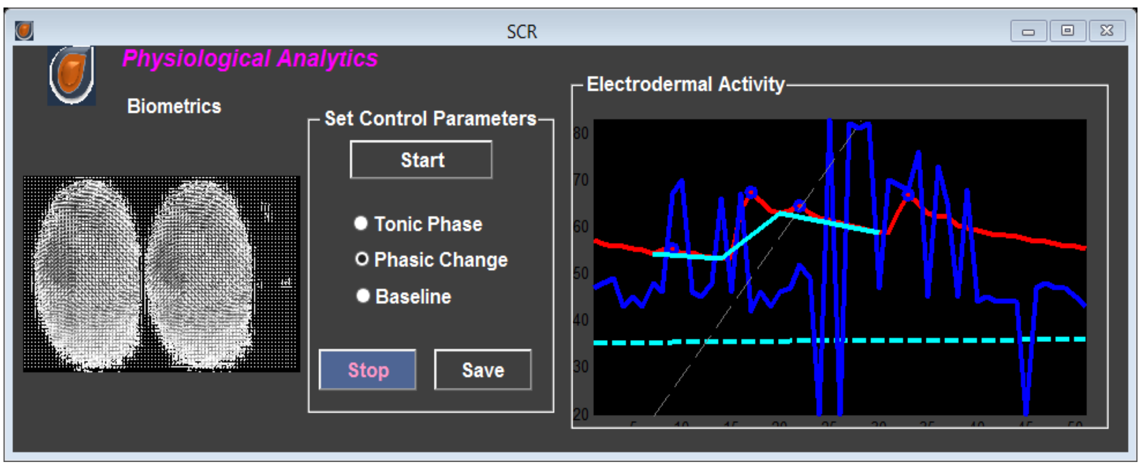

Figure 3: Window interface showing the response from the multimodal physiological measuring sensor in contact with the two middle fingers.

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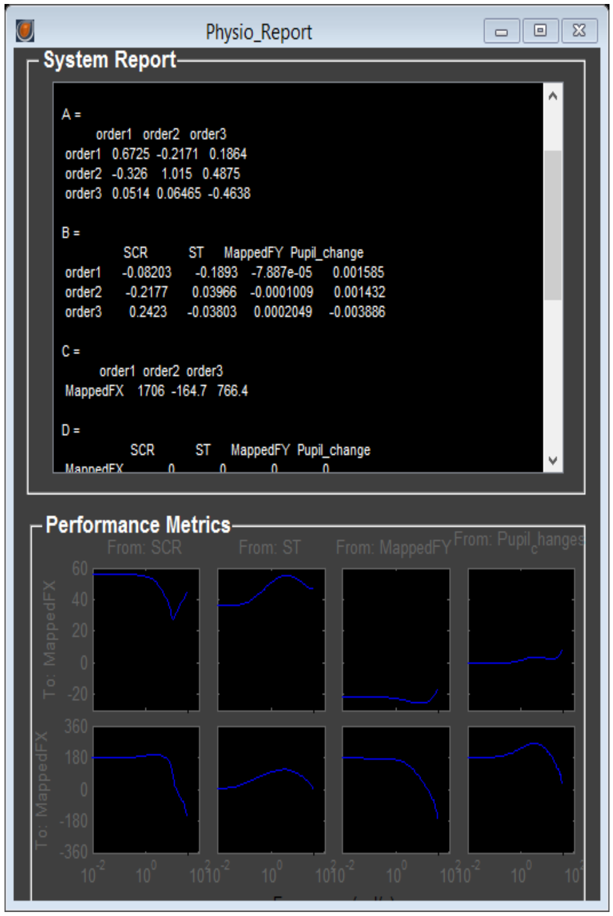

Figure 4: Resultant performance to input parameters from the dynamic control motor.

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