Investigating Biometric Response for Information Retrieval Applications

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Abstract. Current information retrieval systems make no measurement of the user's response to the searching process or the information itself. Existing psychological studies show that subjects exhibit measurable physiological responses when carrying out certain tasks, e.g. when viewing images, which generally result in heightened emotional states. We find that users exhibit measurable biometric behaviour in the form of galvanic skin response when watching movies, and engaging in interactive tasks. We examine how this data might be exploited in the indexing of data for search and within the search process itself.

1 Introduction

There is currently significant interest in the topic of *context* in information retrieval (IR). It is widely held that taking account of the context in which IR takes place might be used to increase search effectiveness. There are a great range of context features which could potentially be incorporated into the search, although these in general all seek to better express and exploit the user's information need within the IR system. Such features include information details such as the ongoing interests and previous searches of a specific user, but of interest in this paper are features associated with measurable biometric responses to information presentation and the search process.

Recent neuro-scientific research has demonstrated relations between measurable physiological attributes and psychological states (often related to emotional or affective states) [1] [2]. A number of measurements can be made which are shown to be related to these states, including galvanic skin conductivity (GSR), skin temperature and heart rate. These features can be used to measure variations in user arousal (activity levels) and valence (positive vs negative response) which have been shown to be correlated with affective state [3]. Using these measurements studies have demonstrated a number of results of potential relevance in IR. For example, using machine learning, models can be built that enable a predefined group of emotional states to be recognized with good reliability [4], a user's frustration response to interacting with a poorly performing computer application can be recognised [5], and variations in physiological responses to different images presentation to a user can be captured [6].

In this paper we describe two of our current experiments to capture biometric information which can be exploited in IR applications. The first of these relates to the indexing of data and the second explores biometric response in search.

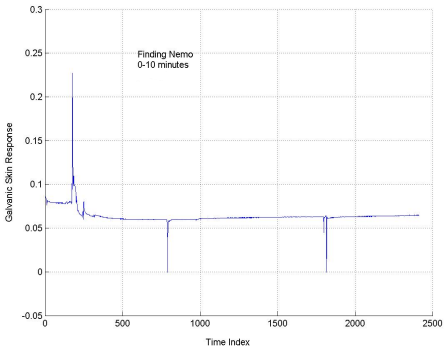

Fig. 1. *Finding Nemo*: Viewer 1

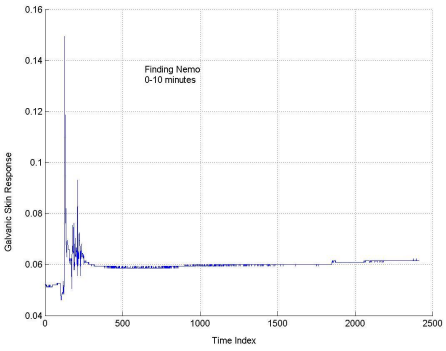

Fig. 2. *Finding Newo*: Viewer 2

2 Measuring Biometric Response

The biometric responses most easily captured and associated with emotional stimuli are GSR, skin temperature and heart rate. In our work we are currently using a SenseWear PRO2 armband produced by BodyMedia Inc. [7]. This monitors GSR, skin temperature, heat flux (loss), and acceleration. The SenseWear PRO2 armband is a small lightweight device which straps unobtrusively to the back of the upper arm. Sensors on the back of the device monitor user response. GSR is measured using electrical skin conductance (in μSiemens) between two electrodes placed on the skin - associated with sweat gland activity. Changes in the levels of sweat in the eccrine sweat glands have been shown to be linked to measures of emotion, arousal, and attention. The rate of sampling can be varied, and we informally optimised this to capture short variations in signals. The captured data is uploaded to a PC for analysis and further processing. We find that GSR is more significant than skin temperature, and for reasons of space only include GSR results here. We are also exploring the use of separate heart rate monitors, but we do not describe results of this work here.

3 Measuring Affective Response to Movies

Documents in IR are conventionally indexed in terms of objective features appearing in the documents; words or phrases in text documents, or objects and named individuals and places in images and video. Indexing features can potentially be augmented by describing more subjective features such as their emotional content or user response. In related work our group are currently exploring the affective labelling of movies [8] based on their audio-visual content. Indexing using features of this type enables searching, for example, for exciting or sad sections of a movie. In this paper we introduce our study of movies based on user biometric response.

Based on the observation in previous work that users respond in measurable ways to visual stimuli [6], we have recently recorded the responses of small groups of viewers watching a wide range of movies using the BodyMedia device and heart rate monitors. As an example of the initial output of this work, Figures 1 and 2 show the GSR response of two viewers of the first 10 minutes of the film *Finding Nemo*. We can see considerable variation in these two graphs. This difference between individuals is to be expected, and

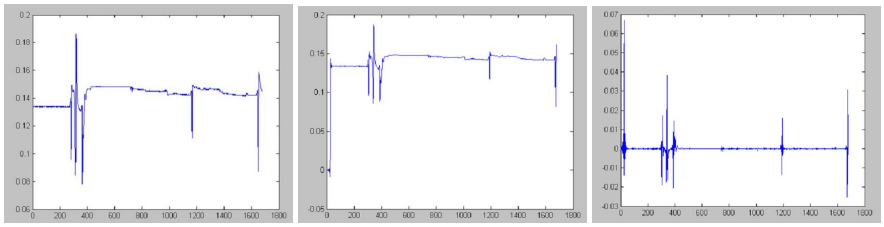

Fig. 3. Raw GSR signal. **Fig. 4.** Low-pass filtered GSR. **Fig. 5.** FFD of filtered GSR.

means that it is not possible to directly compare GSR measurements across individuals (there are no "normal" baselines). However, there is a significant consistent response after around one minute which we know to correspond to a very significant event in the film. While we can clearly see this event and discriminate from it personal variations in GSR caused by less significant events in the movie or from the user's environment, a key challenge is to do this automatically.

In order to better understand variations and detect significant events, we conducted an investigation of 10 individuals watching one movie. For the collected data we measured average GSR range, mean GSR, and the size and rate of peaks. An example result is shown in Figures 3, 4 and 5. Figure 3 is the raw signal for one subject, Figure 4 shows the results of using a low-pass filter to remove high frequency noise, finally Figure 5 shows the absolute value of the first forward difference (FFD) showing the size of changes between consecutive points. The FFD values can be thresholded to include only large changes. We explored variations in absolute and relative threshold values. Analysis across our test subjects revealed similar levels of GSR activity, although there were significant variations in mean level and variation, indicating that the GSR must be personalised to individuals.

Variations in affective state will generally be gradual, and thus it is tempting to consider applying a smoothing function to the GSR output to take account of this, as is applied in [8]. However, while affective state may vary gradually, the results indicate that GSR responses are rapid pulses. We are continuing to explore methods to identify the significant events in a GSR output. A further consideration is that in order to be able to relate biometric response to specific classes of affective state, we need to relate it to arousal and valence levels [3].

4 Interactive Task Analysis

Previous work has shown that users exhibit anticipatory GSR responses to risky decisions, before they are consciously aware that the decision is a risky one [2]. This is an interesting result for IR. For example, can we exploit this information so that a computer is aware via GSR readings of a pattern in a users search results before they are conscious of it? If there is a pattern in the search results that the user is not consciously aware of and the biometric measurements can pick up, can we use this usefully in retrieval?

In order to explore anticipatory response measurements, we set out an investigation with individuals performing a timed puzzle where a "negative reward" was administered for failure. Participants perform a Google image search to find 5 images within 3 minutes, and a strategy game to reach level 2 in 60 seconds. The result of the experiment

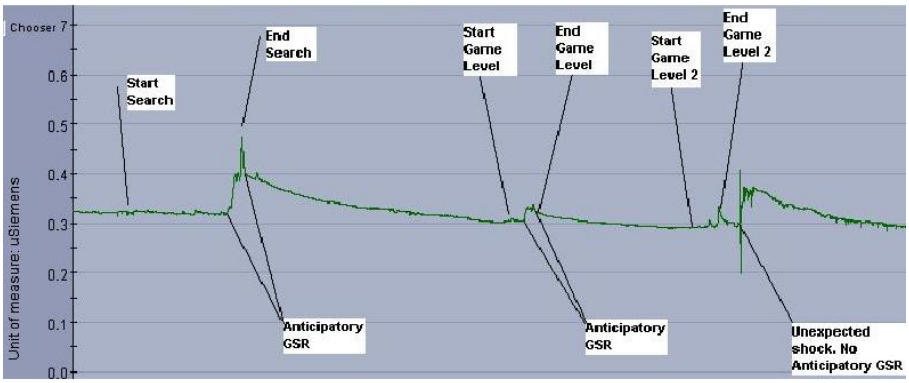

Fig. 6. GSR response for tasks with negative reward.

for one subject is shown in Figure 6, in this graph there are visible peaks in GSR before anticipated negative rewards, but not before unexpected ones. Having demonstrated that we can capture anticipatory response in a highly stressed task, we plan to investigate its potential appearance and exploitation in interactive search.

5 Conclusions and Current Work

Our investigation of biometric response has so far demonstrated that we can observe measurable features in response to events in movies, and within engaging computer mediated tasks. We are currently examining the results of our collection of biometric data for a large number of movie viewers, and exploring further methods for identifying significant features in the signals. We are also planning to record biometric signals within an image search task requiring high levels of cognitive engagement.

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