Inner-Active Art: An examination of aesthetic and mapping issues in physiologically based artworks

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Abstract

Much art seeks to describe or stimulate the feelings and emotions of the viewer, through both abstract and literal representation. With the exponential increase in computing power over recent years we also seek new ways of interacting with technology and exploring the virtual world. Physiological signals from the human body provide us with a view into the autonomic nervous system, that part of the nervous system largely unmediated by the direct intentions of the viewer. With the appropriate choice of signals and processing, we can even develop systems with the ability to interact with us on an emotional level - machines that know how we feel and can react accordingly (Haag *et. al.,* 2004). This gives us the ability to see into and map the interior worlds of artists and viewers through a direct and visceral connection, the human body itself.

A key issue in the development of physiologically based artwork is to make the observer-artwork dialogue meaningful to the observer, a question of translating the input bio-signals to visual, auditory or experiential events. We have yet to develop a suitable language for this dialogue and so this paper seeks to explore some potential mappings for bio-signal art, illustrated using several case studies from past and current works (Knapp *et.al.,* 2008) (Gonsalves, 2009).

We also examine some of the other philosophical and artistic issues involved in 'affective' and bio-art such as monitoring emotion *v.* engendering emotion, the involvement of the observer in creating and contributing to bio-signal art and strategies for effectively developing such works.

1. Introduction

To begin let us make clear that this paper is not intended as a discussion of what constitutes beauty or aesthetic pleasure in art, it is more a technically oriented meta-discussion of the aesthetics of control and mapping in co-active artworks and installations. The final decision as to the aesthetic success or failure of a work must always rest with the viewer.

Artists strive to communicate with their audience and with new technological developments come new tools, techniques and metaphors that can enhance or confound this artist-audience dialogue. With the advent of the 'silicon age' we have seen the rise of participatory interactive digital artworks and entertainment, from shoot-em-up computer games[1] to sophisticated mixed reality and multimedia experiences[2]. These same advances in computing power and technology now enable artists and engineers to access information about the viewer that was previously the realm of medical technologies; information as to their physiological and affective state.

Artworks that seek to utilise these sensing technologies become not only interactive or enactive but *co-active*. A performer may also choose to work with biosignals to create or perform a work, however this is a far more specific and personal interaction, with the need for explicit interaction between performer and work not necessarily as important as with a generalised set of viewers/participants. Nonetheless performers utilising biosignals should consider how important is audience comprehension of their control strategy in the work, such as the mapping of gesture to sound (Tanaka 2002).

The semi-conscious nature of physiologically based interaction creates issues unique to this type of work (aside from considerations of content or visual/auditory aesthetics) those of the aesthetics and design of the interaction and participation with the work, and for certain works mapping of high level behaviours (meaning, concepts) from low level control signals (pulse, respiration).
In our experiences with physiologically based installations we have found that much of the satisfaction for users comes from exploring the boundaries of their interactions with the work, learning to 'play' it and play *with* it, and it is for this reason that we mainly focus on relatively explicit mappings.

2. Acquiring and Mapping Biosignals

Broadly speaking we may categorise sensors as perceiving physiological events that are *External*, such as cameras, pressure sensors and microphones, or *Internal*, such as ElectroEncephaloGram (EEG) or Galvanic Skin Response (GSR). All sensors have individual characteristics that may preclude or commend their use in given situations, for instance ambient conditions (light, noise) or installation design (the issue of unobtrusive physiological sensing is far from trivial).
Systems such as the Arduino[3] or Infusion Systems I-CubeX[4] allow the artist/developer to build

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1 Doom, iD Software, 1993, http://www.idsoftware.com [Accessed 12/06/09]
2 Can you See Me now? Blast Theory, 2002, http://www.blasttheory.co.uk/bt/work_cysmn.html [Accessed 12/06/09]

3 http://www.arduino.cc [Accessed 12/06/09]

4 http://www.infusionsystems.com [Accessed 12/06/09]

custom sensor arrays and pass the data from these to any number of commercial or custom software and hardware systems for processing and subsequent output e.g. Max/MSP[5]. Many of these developers now also supply compatible sensors[6] and there are a large number of resources available for those wishing to build their own (Petruzellis, 2006). Physiological sensors are now also entering the home health and entertainment sectors (Wii Vitality[7]) and could soon be implemented in portable computing devices like the iPhone.

Sensors which detect external expressions of physiology or affective state such as cameras or speech analysers have limitations in that they can 'fooled' by the participant through exaggerated gestures or behaviours and have limited fields of focus (Cooperstock *et. al.*, 2008). Biosignal based sensors, generally worn on the body, detect the correlates of emotional and intellectual states which are usually outside the control of the participant, who literally becomes 'plugged in' to the work. These types of sensors also have their disadvantages; they are very susceptible to electrical 'noise' generated by muscle movement, may require precise positioning for accurate detection and are also subject to a version of the 'White Coat Effect', in which the very act of wearing sensors may cause changes in the physiological signal being measured (Pickering et al, 1988).

These sensors may also require calibration for each individual user in order to ensure accurate state detection, many such systems require a 'learning' period to establish the system boundaries for a user and map these to parameters such as affective state. One strategy to obviate the need for calibration is to build systems that detect and respond to *changes* in physiological state, as opposed to requiring sensors to pass arbitrary thresholds.

Especially relevant for performers using biosignals is the disparity between test situations and real-world deployment. In general stress levels are higher during performance which may require recalibration of physiological sensors. Environmental factors may also lead to unexpected changes, such as show lighting causing excess sweating which could lead to short circuiting of sensor electrodes.

Although the necessary hardware is now more accessible, the software processing necessary to accurately extract meaningful physiological information from multiple sensor inputs, in real time, is still significant in terms of power and expertise. We have found that using sensor systems of this type usually requires a dedicated machine and a high level of technical knowledge, even before

5 http://www.cycling74.com [Accessed 12/06/09]

6 http://www.biocontrol.com [Accessed 12/06/09]

7 http://www.nintendo.com [Accessed 12/06/09]

questions of content or aesthetics.

Aside from the potential technical pitfalls, we should also consider the aesthetics of interaction and interpretation of the work. With interactive systems we should attempt to provide a meaningful user experience in which the viewer/participant can perceive their effect on the system, whether that effect is explicit or not, or else there is no *meaning* to the interaction (Koch, Gaw, 1990) and by extension the viewers participation in the work.

The lack of concious awareness of changes in ones own physiology can be a barrier to development of these meaningful interactions, as well as the issue of how to represent physiological data as aesthetic content.

3. Strategies

When considering the purpose of working with biosignals in artworks, the creator should ask what is the purpose of the work. Is it to create a system that *responds* to the viewer (monitoring affect) or a systems that *provokes* responses in the viewer (engendering affect)?

In developing artworks that respond to physiology one must always be aware that one is in effect creating a feedback loop (as detailed in Fig 1).

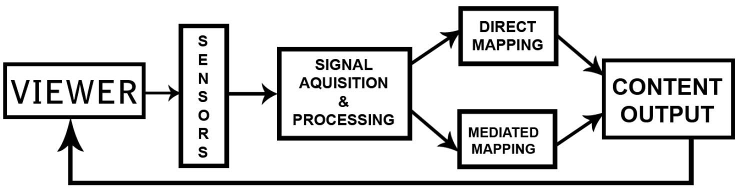

Fig. 1 Viewer → Content Feedback Loop

This can lead to states in which the viewer and work become ‘stuck’, trapped in a biofeedback spiral with the work amplifying the emotional state of the viewer which in turns amplifies the response of the system and so on. To avoid this one might consider working with responses that *contradict* the physiological or emotional state of the viewer, or building in fail-safe responses that allow the work to break out of these loops e.g. after a given time or when a particular threshold is reached.

One of the most basic and literal mappings of biosignals to aesthetic content is the literal representation of the physiological input e.g. sonification or visualisation of heartbeat (Fig. 2 AffecTech 2008) (Fig. 3). This is an explicit mapping, and straight away incorporates the viewer into the artwork without requiring any complex state evaluation by the system. This type of mapping may be made more abstract by using these raw biosignal as a controller e.g. heart rate to tempo, muscle tension to pitch (Ortiz-Perez, Knapp, 2008).

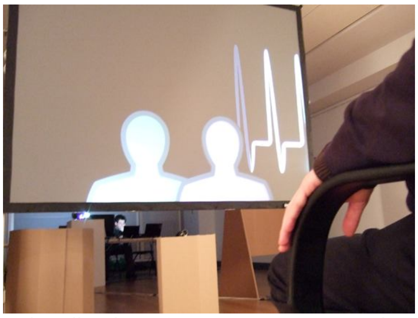

Fig. 2 Visualisation of Heart Rate & Reactive Avatars

Fig. 3 Heart Rate to Drum Beat

Moving beyond this kind of low-level mapping we may begin to use the physiological data of the viewer to make estimations as to their affective or emotional states (Haag *et. al.* 2004). This sort of affective state evaluation allows us several options in mapping them to aesthetic responses, bearing in mind the more sophisticated the response, the bigger the danger of losing the connection with the viewer. At a simple level we have mapped the arousal level of an audience to lighting colour and intensity during an theatrical/musical performance (*The Reluctant Shaman*, Knapp, 2008), changing from blue to red with low or high arousal (D'Andrade *et. al.* 1974).
One might also choose another literal representation of affect and map a state, as judged by the system, to a corresponding on-screen display of relevant text or imagery (Gonsalves 2009).

In developing systems that are intended to provoke a response in the viewer, the artist should be aware that it still difficult to differentiate subtle changes in affective state. One might consider using strong psychological interactions e.g. using imagery of spiders to provoke a fearful response (arachnophobia), in order to induce major state changes in the participant.

Other works have taken the approach of making the physiological signals themselves the content of the work, such as Christian Nold's '*Emotional Cartography*' project (Nold, 2009), in which physiological events are geo-tagged to construct an emotional map of the participants physical journey, mapping physiology onto geography.

So far we have mostly considered relatively direct mappings of biosignals to aesthetic content, however some might wish to use more abstract 'mediated' mappings, for instance navigation through a narrative, based on affective state. One option is to implement a 'Decision Tree' structure (Koch, Gaw, 1990) which sequences narrative episodes according to pre-determined, state-based rules.
As previously mentioned, when using complex mediated mappings there is a risk of reducing the perception of interactivity with the participant and this should be considered in the design of the work.

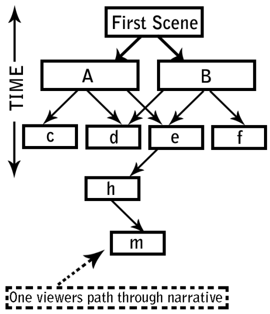

Fig. 4 Decision Tree Narrative Structure

4. Future Directions

As engineers and artists experience working with biosignals and affective sensing grows, we hope to see more sophisticated works emerging. We see key areas for further research as multi-sensor fusion, less intrusive sensing, and more sophisticated user-modelling, leading to better affective assessment.

We anticipate that one of the next major advances in home entertainment will be physiologically-aware gaming, in which difficulty levels can be modulated in response to factors such as stress. This can also be applied to e-learning, allowing a system to respond to learner frustration.

A potentially interesting application of physiologically aware art is in the field of ambient assisted living, where a 'smart' environment could adjust aesthetic content to benefit health and well-being in the home or workplace.

While it is difficult to predict how individual artists may implement affect/bio-awareness in their work, it is our hope that it will lead to interesting and sophisticated content, as well as offering the opportunity for further research into emotional and physiological responses to art.

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