

# Towards Dynamically Crafted Affective Experiences Through Emotional Response Player Modelling

**Pedro A. Nogueira**

Artificial Intelligence and Computer Science Laboratory – University of Porto, Portugal

GAMER Lab, University of Ontario Institute of Technology, Canada

pedro.alves.nogueira@fe.up.pt

## Abstract

Designing adaptive games for individual emotional experiences is an elaborate task due to the necessary dedicated hardware, complex signal processing and unique emotional bonds each player may forge with the game. The research work I propose focuses on developing a novel affective interaction scheme where players' emotional reactions are learned by a computational model that leverages this information to influence their future emotional states. To this end I aim at interpreting the causality relations between physiologically measured emotional response variations and their eliciting events. I then plan using these reactions to build each player's individual emotional reaction model, which will guide the game engine's logic on how to plan future game events, in order to elicit a target affective experience. Ultimately, I expect this technique to allow game designers to focus on defining high-level rules for generating their envisioned affective gameplay experience, rather than in manually tuning it in a repetitive and time-consuming fashion.

## Introduction

The creation of emotionally engrossing or immersive games is a complex task generally devoid of guidelines or standard practises. It falls upon the game designer to understand (or assume) how his target population will react and carefully build the game's flow of events accordingly. However, this process is time-consuming and requires continuous input from a large population of gameplay testers.

In an earlier study Ermi *et al* (2005) have inquired on what motivates gamers to play and what constitutes a good gaming experience. Ultimately, the authors came up with the conclusion that video games are played either to: *a)* live out a fantasy, or *b)* to relax from the problems of everyday life; at most times a combination of both. In either of these cases, a common trait is often considered: *good video games must provide an engrossing experience, through which players can immerse themselves in the virtual world.*

In this interdisciplinary research between the fields of human-computer interaction, artificial intelligence and psychology, I propose that human emotions can be used as a means for eliciting more immersive gameplay experiences. I believe emotions are a powerful tool with a high potential that has yet to be fully explored. As they occur at a deep and sometimes instinctive or subconscious level, emotions influence humans in a very meaningful and critical way, often even overriding rational thought. In fact, both Ermi *et al* (2005) and Brown *et al* (2005) have corroborated this idea as they found that emotions are one of the final barriers players need to overcome in order to achieve the highest possible levels of immersion. Therefore, I believe that the usage of the players' emotions as catalysts for a reactive system embedded in a game engine can be used to *a)* guide the player's emotional state towards the envisioned ones by the game and *b)* consequently improve the user's overall user experience.

## Related Work

Since my research is divided in two main modules, I will be discussing the related work in two separate sections. The two following sections provide a brief and representative sample of the state of the art in their respective field.

## Emotion Recognition

Several of the most successful attempts on emotion recognition have been made through physiological computing (Leon *et al.* 2007; Haag *et al.* 2004; Vinhas *et al.* 2009; and Mandryk 2005). In fact, the study presented in (Drachen *et al.* 2010) confirms that relatively simple features extracted from SC and HR measures are indeed highly correlated with reported affect ratings in gameplay scenarios.

Vinhas *et al.* (2009) proposes a system capable of measuring both arousal and valence in real-time, using the subject's SC response and HR derivative. Parallel to this and in an attempt to deal with the ambiguous nature of physiological data, Mandryk *et al.* (2005) presented an

elegant approach based on fuzzy logic to classify arousal and valence based on EKG, EMG and SC measurements.

## Biofeedback & Experience Modelling

Relating to the use of emotions in interactive multimedia applications and videogames, work has been done in the fields of biofeedback (Kleinsmith et al. 2009; Kuikkaniemi et al. 2010; and Nacke et al. 2011), agent and character modelling (Cavazza et al. 2009; and Hudlicka et al. 2009). Bernhaupt *et al* (2007) also managed to successfully use the player's emotional states – although interpreted via facial expressions – to directly control a simple game logic. These approaches serve as proofs of concept that it is possible to implement emotion reaction mechanisms in videogames and other multimedia applications. They have also proven that this kind of interaction does influence and can indeed benefit the user's overall experience.

However, the current work focuses in reactively triggering certain events based on fixed rules once a certain emotional state has been observed (Kuikkaniemi et al. 2010; Nacke et al. 2011; Cavazza et al. 2009; and Bernhaupt et al. 2007), or in mimicking emotional responses on behalf of an AI agent (Kleinsmith et al. 2003; and Cavazza et al. 2009). These approaches are limited because the application provides the user with affective information, but does not take into account the reactions elicited by that same information. As a result, the system has no feedback on how this information is perceived and what mental state it inflicts on the user, so it is unable to learn from these interactions and adapt to each user. In our bi-directional interaction scheme the application strives to adapt its responses based on the reactions observed in the user, thus truly implementing both Gilleade *et al* (2005) ACE model and Hudlicka *et al* (2009) affective engine requisites:

1. Recognise a wide emotion gamut in real-time
2. Provide mechanisms to respond to affective states
3. Dynamic construction of affective user models.

Although Hudlicka *et al* do not discuss how such a system could be built, I address all of the indicated requirements in my research.

## Current Progress

In my thesis I suggest that computational models of players' emotional reactions to game events can be used to regulate their affective experience. However, in order to answer this question, I must first address the following tasks:

1. Develop a method for quantitatively measuring emotional states in real-time
2. Create a test-bed game where I can collect player's reactions and later test the created models

3. Use the collected emotional reactions to create players' emotional reaction profiles.

Summarising, my main hypothesis is that:

*"It is possible to regulate players' affective experience in digital videogames based on computational emotional reaction models that feed a biocybernetic feedback loop."*

*Furthermore, this biofeedback loop will not only allow designers to focus on more higher-level affective design guidelines, but also contribute to more engaging user experience ratings."*

## Framework Architecture

To investigate our research question – whether emotions can be used to regulate players' affective experience – we have proposed the Emotion Engine (E<sup>2</sup>) biofeedback loop system (Nogueira et al. 2013a).

Each of these issues is addressed by a separate component of the architecture (see Figure 1 for a brief description of its general working principles). However, since a full description of the architecture is outside the scope of this research summary I will focus on its main components over the next sections and refer the reader to see (Nogueira et al. 2013a) for further details.

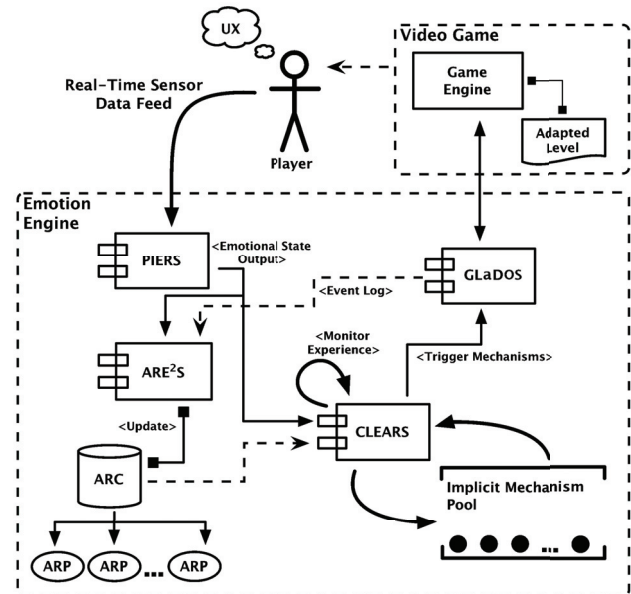


Figure 1. General working principles of the E<sup>2</sup> architecture.

## Emotional State Recognition

The first step in the emotional regulation process is determining an, although simplified, relevant to our needs image of the player's current emotional state. To this end, we have developed and validated a physiological-based system that classifies the user's emotional state in terms of Russell's arousal/valence (AV) space.

The system classifies players' AV ratings through a two-layer classification process (see Figure 2). The first layer applies multiple polynomial regression models to each of the four physiological inputs (SC, HR and facial EMG). This allows us to concurrently normalize these inputs and correlate them to the AV dimensions. The second classification layer then combines the arousal and valence ratings obtained from the previous step into one final rating by weighting the models' residual sum of squares (RSS) error.

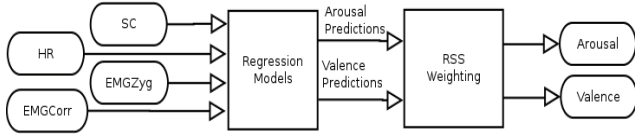


Figure 2. The emotional detection system's architecture.

Using this methodology, I have achieved accuracy ratings of 85% for arousal and 78% for valence the specific multimedia content type used in the described case study – horror and survival videogames (Nogueira et al. 2013b).

One important aspect of using the AV space is that it is not able to cover every possible emotion. However, given the limited emotional spectrum of my case study, the AV space has proven itself sufficiently broad for the emotions reported by the players. Future work should focus on generalising this process, possibly through the inclusion of domain-specific contextual information (e.g. player goals, game state) to help differentiate between similar situations.

### Emotional Reaction Models

One of the main questions I will address during my research is whether it is possible to create individual emotional reaction models. To answer this question, I am attempting to isolate the causality relation between in-game events and the observed shifts in players' emotional states. I then plan on extracting a set of easily interpretable features from the emotional signal preceding each game event (e.g. average value, standard deviation, time difference between local maxima/minima fluctuations) to create a computational model of each ensuing reaction.

Given Noor et al.'s (2010) past success in modelling player's preferences through game questionnaires, I am currently exploring sequential and genetic feature selection algorithms coupled with multi-layer perceptron neural networks to build these models as a potential solution.

### Test-bed Game and Game Adaptation Mechanisms

As previously mentioned, to collect players' emotional responses and test the reaction models, a test-bed game was needed. Since I needed to trigger game events in real-time, it was necessary that the chosen game allowed me access to its internal logic and, ideally, level generation. According to these requisites, I have chosen to use the indie terror game *Vanish* (Figure 3) for the data gathering and model validation phases of my work.

*Vanish* is a survival terror videogame where the player must navigate a network of procedurally generated maze-like tunnels to locate a set of key items before being allowed to escape. While navigating these tunnels, the player must evade a creature that continuously stalks him. Other



Figure 3. Screenshot taken at the beginning of a *Vanish* gameplay session. The creature can be seen lurking in the distance, while avoiding to step into the light. As time progresses it becomes more aggressive and will actively stalk the player and try to corner him.

events such as, for example lights failing, distant cries or steam pipes bursting without notice, also occur quasi-randomly, in order to keep the player about his wits.

The procedural aspect of the game was also a major factor in my choice, because not only am I able to control the game's events, I can also control exactly how and when they are presented to the player. Furthermore, being able to influence the map's generation also allows for complex and dramatic player-videogame interactions that are not easily achievable in other videogames (e.g. guiding the player into a dead end, where he is forced to hide from the creature in a cramped hole in the wall as it claws at him).

So far I have been able to gain complete control over all gameplay aspects, as well as linking them to the emotional detection system's output through static rules (e.g. increasing the creature's spawn probability if arousal is lower than a certain threshold). In fact, I have tested several of these simple, static mechanisms to see if they could influence players' experience and have found statistically significant differences between emotionally adapted variations of the game and the vanilla version. During these tests I have also successfully collected a considerable amount of players' reactions (~1500) to game events.

For my next steps I have laid out some potential directions for analysing this emotional reaction corpus. As aforementioned, one possible approach is to use neural networks trained on a small feature subset of the players' emotional state signal prior to each event. Due to computational constraints, this subset will have to be approximated using one of various feature selection algorithms.

### Evaluation

To determine whether the created models are able to actually influence players' affective experience I will perform two validation studies. In the first one, I will test if, using the players' models, it is possible to identify the set of



game parameters that are most effective at eliciting a certain set of emotional states. This will constitute proof that using this methodology it is possible to: *a)* semi-automate the existing affective gameplay testing procedures by approximating a good parameter set from which to manually iterate the process, and *b)* improve each players' individual affective experience by selecting an optimal parameter set according to his/hers specific emotional reaction model.

Secondly, I plan on simulating a large set of games (200-1000) using each player's model. Here I will compare the players' estimated "emotional performance" between the game's vanilla (i.e. no game adaptation), static adaptation and active adaptation versions. Versions will be compared based on a fitness function that exponentially penalizes emotional states further from the desired ones. I am considering a simulation approach for three main reasons:

1. Using simulations, it is possible to run an exponentially larger number of trials than that possible with live studies
2. Since the game must first collect enough information to build players' models, using live gameplay tests would introduce irreversible order and habituation effects that would bias the results
3. Given that Vanish is a psychological terror game, asking participants to play consecutively for several hours, and possibly over various days would incur on even more highly biased results, an unethical amount of psychological stress and a high participant drop-out rate.

## Conclusion

By the end of my Doctoral research, I will have shown that it is possible to shape players' affective experience according to a set of target emotional states using their emotional reactions to game events. These models constitute an improvement over previous techniques based on more subjective and domain-dependant techniques. After completing this work I will have made the following contributions:

- Designed a lightweight physiological-based method for detecting the relevant to my needs subset of player's emotional states in real-time
- Developed a methodology to create computational emotional reaction profiles
- Evaluated whether adapting the gameplay according to the information provided by these models has the potential to shape players' emotional states towards the desired affective experience.

By using this methodology I believe that game designers will be able to focus on defining high-level rules for the game's affective experience, thus reducing the necessary timeframe for the current affective game testing processes.

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