Lundheim: Exploring Affective Audio Techniques in an Action-Adventure Video Game

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ABSTRACT

This paper discusses *Lundheim*, a video game prototype made in Unity that incorporates interactive mechanisms based on affective computing techniques, which are used to control audio-visual aspects of the game. The project is based on a fictitious Old Norse realm named 'Lundheim', a place where emotions are woven into the fabric of reality. The game utilises Russell's circumplex model of affect, providing four runes which correspond with different sections of the circumplex model. The player must activate each rune by entering the corresponding emotion state, which is captured using a consumer-grade Interaxon Muse electroencephalograph (EEG) headband. Activating each emotion triggers particle effects and corresponding sonic materials including interactive music, which are implemented with the Wwise video game audio middleware software. The project thereby demonstrates a novel implementation of affective technologies and sound in a video game, contributing towards discourses in this area of research.

CCS CONCEPTS

• **Software and its engineering → Interactive games**; • **Applied computing → Sound and music computing**; • **Human-centered computing** → *Interaction design.*

KEYWORDS

affective computing, biofeedback, video games, sound design, interactive music, action-adventure games, game mechanics

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1 INTRODUCTION

As discussed by Picard [18], affective computing is a field of research that seeks to devise computer systems that recognize, respond to, experience, or invoke emotions in relation to users. Picard emphasizes the benefits such systems might offer to users, by adapting functionality in ways that make them more useful and friendly for users, who themselves are emotional beings. Drawing upon research from cognitive psychology, Picard refers to Russell's [20] circumplex model of affect, which provides a valence/arousal model, where the valence (x axis) describes the extent to which emotions are pleasant/unpleasant, while arousal (y axis) indicates the level of activation. This dimensional model of emotion has a particular utility for computer systems, since it can allow emotions to be conveniently captured or approximated using x/y coordinates in a finite two-dimensional space. For instance, in a previous project by Griffiths et al. within our research group [8], the circumplex model of affect was used to generate music playlists based on emotions.

Affective techniques such as these can also be applied in the field of video games, sometimes referred to as *affective gaming* [12, 13]. For instance, work by Garner [6] has explored the use of biofeedback technologies, such as consumer-grade electroencephalograph (EEG) headsets as a means to control aspects of the audio in horror video games, thereby creating adaptive gameplay experiences that change in terms of events and sounds relative to the affective state of the user. Whilst Garner's work provides important insights into this area, he also acknowledges that there is a need to explore how systems of this type can be applied in other video game genres and contexts [7]. Lundheim responds to this call by providing a prototype video game demo, which implements affective mechanisms in an action-adventure game.

There are many methods that can be used to create input signals from a user for the purpose of providing a game with affective information [12]. The use of brain-computer interfaces and neuroimaging techniques for games is a growing field, with a recent systematic review of 74 research items identifying that EEG is the most used technology for this purpose [11]. In terms of other technologies for identifying affect, another systematic review of 162 research articles found that heart activity was the most frequently used physiological input signal, followed by facial expression, breathing activity, electrodermal activity, and temperature [19]

Other studies in the field have sought to make use of other biofeedback mechanisms, such as detecting the amount of force applied to a gamepad as a marker of emotional arousal [21], manipulating the difficulty of a game in response to players' facial expression of emotion [9], or using galvanic skin response to infer arousal in the comparison of mechanisms by which a game's characteristics can be adapted [16]. Other work has suggested that both arousal and valence dimensions of emotion might be successfully detected via pupillary response using eye-tracking equipment [1].

Lundheim was created in the Unity game engine. The project uses various graphics from third-party asset packs, and original sounds. These sounds were implemented using the game audio middleware software Wwise, to provide enhanced capabilities for interactive sound design. The project uses Russell's [20] circumplex model

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of affect to provide a puzzle game mechanic related to concepts of emotion, using an Interaxon Muse EEG headband as a control interface. Whilst an EEG headset is unlikely to provide the same robust data as might be found in clinical neuroimaging techniques, they provide a practical mechanism that can be used outside of a controlled environment [2]. There is evidence to suggest that even consumer-grade headsets can provide useful information about physiological states [14].

The project builds on the use of a bespoke piece of software: Neural Scores [15], which provides a system for interpreting user emotion, with states being plotted on the circumplex model. Signals from the EEG device allow the user to interact with, and complete the puzzles, whilst also generating the corresponding audio-visual soundscapes. The project thereby exemplifies the possible usage of affective techniques in relation to sound and gameplay in an action-adventure game, in the mould of popular titles such as *The Legend of Zelda: Breath of the Wild* [17]. In what follows, the design of *Lundheim* will be discussed in further detail.

2 GAME CONCEPT AND NARRATIVE

The game is set in a fictitious Old Norse realm named 'Lundheim' – a place where emotions are woven into the fabric of reality. As the player wakes, they see that the path behind them is cut off by a wall of fog; they cannot return the way they came. To escape this world and return home, they must complete a series of affective experience-based challenges further up the path. A graphical user interface (GUI) element in the bottom left corner displays the real-time affective input from the player, captured via the EEG headband (Figure 1) and interpreted by the Neural Scores application discussed previously [15]. This system runs parallel to the game, and produces values for emotional valence and arousal, plotted against Russell's circumplex model [20], which are communicated to the game via the Open Sound Control (OSC) communication protocol. The system also generates a hexadecimal colour code for the current emotion coordinates, which is used to control some emotion driven visual elements elsewhere in the game.

Figure 1: Lundheim begins with a journey along a path, where fragments of a cryptic map are collected

As the player makes their way along the path, they find fragments of a map, which once complete can be used to decode a set of stone runes marking each of the challenges. Figure 2 shows the map received by the player once each of the four fragments have been collected, which can be viewed using a graphical user interface (GUI). The map indicates four poles, each marked by runes that correspond with strong/calm and good/bad emotions. These correlate to the extremities of the valence/arousal axes of Russell's circumplex model of affect.

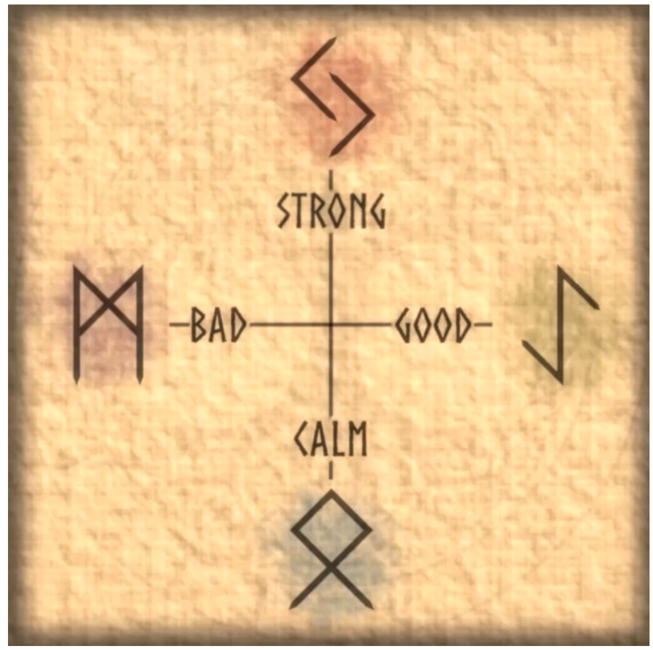

Figure 2: The map once each fragment has been collected, indicating runes and corresponding emotions

At the end of the path, the player reaches a clearing with a series of stone tablets marked with the same symbols as those on the map. The first challenge is unmarked, and the player is instructed to focus. The player must remain within a threshold of this state for a cumulative period of 10 seconds to complete the challenge. An expanding and contracting circle is given as a visual aid to guide the player to the target emotion state. Upon completion of the first challenge, the player is rewarded with the flame GUI element which changes colour to represent their emotion state (Figure 3). Following this are four challenges that require the player to enter each pole of the circumplex model.

Upon approaching each challenge, the player must use the emotion map collected previously and the rune found on the tablet to decode the target affective state. As they enter the target state, the background music fades out and a drone sound iconic to that state fades in. The drone continues to grow in loudness as the player spends more time in the target state, ultimately resulting in a 'hit' sound when they complete the challenge and activate the rune. Each rune tablet also has flame coloured particle effects that correspond with the colours on the GUI circumplex model of affect (Figure 3).

As each rune is activated, corresponding events are triggered which have an effect in the game environment. The 'calm' rune

Figure 3: The player encounters stone tablets, which generate particle effects and sounds in correspondence with player emotions

triggers a waterfall that flows down into the lake from a nearby mountain; the 'strong' rune lights a bonfire; the 'bad' rune unleashes a colony of bats; and the 'good' rune raises a bridge from the lake (Figure 4). This bridge leads to a portal, through which the player can escape, thus ending the game.

Figure 4: The player can end the game by raising a bridge from the lake and passing through the portal

3 INTERACTIVE MUSIC

The use of music in this project sought to create a dynamic experience of music that corresponds with the circumplex model. There is one main musical theme, which was rendered with two different timbre profiles. These two profiles were further split into three levels of instrumental intensity – totalling six independent tracks. The emotional valence of the player controls the blending between the timbre profiles, and the emotional activation controls the blending up and down of the intensity levels. This implementation creates a rich, multidimensional blend of musical style and instrumentation that can be used to reflect multiple emotional states. Initially, the positive and negative valence profiles were major and minor versions of the main theme, whereby positive valence invoked a 'happy' major tonality, while negative valence resulted in a 'sad' minor tonality. However, this caused noticeable dissonance when the modulation occurred during non-tonic chords. To provide a more cohesive aural experience, the valence profiles were aligned with instrument timbre, so that positive valence profile features warm timbres (e.g., soft strings), and the negative valence profile features cold timbres (e.g., ominous synths). This approach was chosen because it clearly reflects changes in valence and mood without altering the harmonic structure of the theme. Additionally, there is evidence to suggest that timbre alone is sufficient to create differences in perceived affective qualities [3, 4].

This system was constructed using 'blend containers' in Wwise: a container type that allows cross-fading between multiple sound sources based on a float variable. For this project, each group of three intensity tracks were placed in two blend containers for positive and negative valence groups. Then, those two blend containers were placed in another parent blend container that controls the blending between valence-based tonality. This creates a rich, two-dimensional blending system that can morph sound in both x and y dimensions, in correspondence with the circumplex model.

4 SOUND DESIGN

Original sound effects were created for this project using combinations of various sonic materials (both existing, and newly recorded for this project). Studio One 5 and Audacity were used to process the sounds. The assets created included sounds for collecting map fragments and opening the map; various sounds related to the environment; droning sounds; and other short interaction sounds. Foley techniques played a significant role in the production of audio for this project. Some complex sounds, such as fire and water were made by layering various recordings on top of each other. For instance, the 'fire drone' recording was made using twigs, bubble wrap, balloons, cloth, and water dripping on a hot pan. These recordings were processed to remove noise, layered, and then mastered to around -18 dBFS. Various effects such as EQs, compressors, and fades were also used to shape the audio and prevent unwanted pops.

In the game, the various challenges require the player to 'channel their emotions' to complete a task. As the player spends more time in the target emotion state for the given challenge, the music fades away and a drone sound grows louder. This was facilitated using real-time parameter controls (RTPCs) in Wwise, which allow float values in the game to be mapped to real-time parameters of sound such as filter cut-off points. RTPCs were linked to the target meter associated with each challenge; as the timer increases, the RTPC shifts the sounds heard by the player towards the droning material. These drones might also help the player to concentrate, by removing other sonic distractions, and can be considered in relation to Weinel's [22] discussion of sound design in interactive meditation experiences in game engines. Once the timer ends and the challenge is completed, a 'hit' sound is played and the music returns.

Various sonic materials were used to develop a dynamic soundscape experience which changes as the player progresses through the game. Each time the player completes one of the challenges, new sounds are added to the world for the player to explore. As the player advances, the soundscape is gradually decorated with affect-themed sound sources, each with their own positioning and attenuation parameters. Upon activating the 'calm' rune, sounds of running water are heard, as a waterfall bursts from a nearby mountain. The 'strong' rune activates a bonfire, and the crackling of fire can be heard. Next, the 'bad' rune gives rise to the sounds of bats and demonic laughing, which was created using pitched-down vocal materials. Lastly, the 'good' rune opens the exit with a chiming sound and water, as the bridge emerges from the lake. In this way, each emotional event finds an iconic sonic equivalent for the player to experience and investigate.

The affective state of the player is also continuously reflected through the game's environmental ambience, which is intertwined with the background music. When the player's valence shifts from positive to negative, it begins to rain, the birdsong fades away, and the music becomes colder in timbre. When the player's activation rises, the wind begins to pick up, and the music becomes more intense. This provides a continuous experience, whereby both the soundscape and background music fluidly adapt to the emotional state of the player.

5 CONCLUSION

Lundheim is a video game prototype which seeks to implement approaches from affective computing, using a consumer-grade EEG headband, to explore interactive techniques for affective video game design. EEG technologies are not yet widely used in commercial video games but could present interesting opportunities for developing new forms of adaptive player experience. There is also scope to extend the work into the use of games for therapy [10] or helping users understand, and potentially regulate, their emotions [5]. For this to happen, advances are needed in terms of available technologies for capturing user emotion, in order for this data to be acquired conveniently and comfortably, but also, more prototypes are needed to show the efficacy and utility of affective technologies in a range of commercially viable game genres. Our discussion here has presented a small-scale prototype. Whilst further work such as user tests would be needed to validate the efficacy of this system, the current work provides a small contribution towards discourses in this area, by indicating possible design approaches that utilize emotional data for controlling events and sounds in an action-adventure game.

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