Conveying Believable Emotions Through Control Modulation

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ABSTRACT

Virtual characters in video games can portray a wide range of emotions. A common challenge of developing narrative-driven games is balancing interesting gameplay with the expression of the artist's vision in the character. A player's relationship with their character depends on this balance of agency and emotional expression, and so the player's control over the character is at the forefront of how these two elements interact. This work explores how a computational model for modulating the player's control over his character affects their relationship with said character, particularly how the level of empathy they feel towards them is impacted. In general, the developed model appears to not affect the player's empathetic relationship with their character in any major way. However, there seems to be a tendency for the model to increase the player's positive emotional response related to their character's negative emotional expression. Moreover, the player's control choice seems to have a significant impact in the relationship with its character, signifying that this choice should be taken into account when developing interactive experiences in which player-character empathy is a focus.

KEYWORDS

emotional expression, control modulation, empathy, movement

1 INTRODUCTION

Modern video game characters are able to express a large range of emotions with a high level of detail. Artists have found new and interesting ways to get us invested in the characters they create. The audience has responded in kind, looking for experiences that are ever more engaging, meaningful and exciting.

Players can now relate to the emotions their character portrays in a game, empathizing with them and understanding them. They can extract this information from the plethora of visual and audio queues that the character is able to produce. As such, there has been increased effort in the games industry to ensure that this expression of emotion in characters is present not only in cinematic fashion such as in cutscenes, but also permeates other aspects of gameplay. These emotions are usually tied to the player's intent and the actions the character performs depend solely on the desires of the player, much like how a puppet is controlled by the puppeteer. It is the job of the game designer to ensure that these game mechanics do not go against what they want the character's emotional expression to be.

The characters people control in video games usually obey the player and their actions and disposition usually represent solely what the player tells them to do. This can make them seem mindless or not have a will of their own, making them harder for players to relate to and empathize with. How should game designers balance the agency of the player's desires and the expression of their character's emotional depth? Also, how does the degree of control a player has over their character affect their relationship with it?

We suggest that including a computational model in which a player's character's behaviour depends both on the player's input and the emotions that character is feeling regarding the game environment will increase the level of empathy felt by a player towards their character, thus increasing their attachment to the character and the game in question. Moreover, we hypothesize that modulating the control a player has over their character's movement to more closely match the character's emotion, for example by making the character move slower when approaching something that it's afraid of, will be particularly effective at achieving this increase of the player's empathy. In this work we will be focusing specifically on the increase of situational empathy, being that this is the form of empathy which relates to external stimuli, such as playing a game, and is not dependent on the individual's inherent predisposition to feel empathy, or dispositional empathy. We will be testing these hypotheses with two scenarios:

- Control Scenario: the player's character obeys the player input and behaves exactly as expected, following the player's desires as if they were merely an extension of the player.
- Dynamic Scenario: the player's character will take the player's input as a suggestion, modulating the player's desired behaviour, its movement and emotional display to be more in tune with its emotional state.

Assuming the hypotheses we previously described, we expect that the level of empathy will be higher in the Dynamic scenario.

2 EMOTIONAL EXPRESSION

2.1 Gaze

Having a meaningful gaze model in a virtual character's expression arsenal can significantly improve the quality of communication that an individual perceives when interacting with said character[21]. Fukayama et al. even go as far to suggest that humans have developed neural mechanisms for the sole purpose of gaze processing, obtaining information related to the gaze movements of others[19, 20].

While mutual gaze is a common occurrence in individuals that want to connect with others[2], increasing one's gaze can also be taken as a sign of aggression, dominance or as a threat. Exline and Winters studied the effect of positive, neutral and negative conditions on an individual's gaze in an interview setting[17]. They found that participants in the negative condition significantly reduced looking at their aggressor, while those in the positive condition increased mutual gaze.

There are two main approaches to model lifelike gaze behaviour - parametric and data-driven[38]. Parametric models rely on an analytic model of the phenomenon, with a specific number of parameters. Data-driven approaches instead query the data itself to return new samples for use in the application. While data-driven models such as the one developed by Lee et al.[26] can yield very promising results, using a data driven approach has some drawbacks, as it requires gathering data over a specific period of time and is highly customised to a specific context.

Using the parametric approach can produce compact and economical models based on the data, but it has the issue that the analytic model may fail to capture important aspects inherent to the data. However, studies like the ones by Garau et al.[21] and Fukayama et al.[19, 20] show that even simple gaze models can elicit lifelike responses from individuals.

Deng et al. argue against the use of parametric models due to their failure to capture important aspects in the data[39]. However, studies have shown that parametric approaches can have a significant effect on the perceived quality of communication with a virtual character. As such, simple parametric models may be sufficient for the design of gaming characters.

A character's face may not be sufficiently close to the player's view to discern its detailed features. This means that incorporating complex eye movement into our solution may not have a significant impact on the emotional perception of players. However Other simpler and more body movement focused models can have a positive impact.

2.2 Posture

The posture of a humanoid agent relative to its facial expression has an effect on subjects' perception of the portrayed emotion. Congruence between the emotions portrayed by the two modalities facilitates the recognition of the category. Subjects still rely mainly on the facial expression to recognize the emotion category presented, while they rely on the posture to make judgments about the emotional activation.

Using a data set of 224 video clip recordings of actors and actresses, Wallbott was able to identify certain behavioural cues specific to certain emotions. In cases of portraying shame, sadness or boredom, for example, an erect posture was rare, where the actors instead used a collapsed body posture. In cases of anger, a posture with raised shoulders was typical, but moving the shoulder forward was seen to depict fear and disgust[36].

Kleinsmith et al. conducted a statistical analysis of emotional posture produced by Japanese actors[24]. They found three main dimensions that explained the variation of posture: arousal, valence and action tendency. Low arousal postures tend to have a bent head and arms placed to the side of the body. Low valence postures consisted of the head bent forward and the hands raised in front of the face. High valence postures had a raised head and hands held high and away from the body. In passive postures, the hands were raised near the face and the body was kept narrow, whereas in active posture the elbows were bent out to the side of the body and the hands were kept around the hips.

The most common way to generate postures is to use a predefined posture library (e.g. [22]). Some randomness is used when choosing postures to ensure that there is sufficient variety in posture. A standard motion transitioning method can be used to transition between postures. There are also procedural posture generation methods that generate posture without the need for a data library, such as using "posture functions" to coordinate the rotations of body joints[14].

The importance of our character's posture will be paramount when designing their animations and patterns. The amount of research available on the emotional expression resulting from posture is quite large. Some of the works in this area[6, 10, 13, 24, 28, 33, 36, 36] give concrete insight into what visual queues individuals extract from other's posture to ascertain their emotional state.

2.3 Movement

Chen and Bargh observed that approach-like muscle movements of subjects were faster when presented with positively valenced stimuli, and slower when faced with negative stimuli, with the opposite being observed for avoidance-like muscle movements[8]. A virtual agent that mimics this behaviour could be used to help players more intuitively recognize its emotions in the context of a computer game.

Wallbott[36] and Montepare et al.[29] have conducted studies to explore the use of body movements, posture and gestures as indicators of individuals' emotional state. Energised movements were characterized by participants as typical of joy, anger and fear, while less movement was associated with despair and shame. Results indicated that neutral clips were identified with a higher degree of accuracy than emotional clips. Angry clips were characterized as jerky, stiff, fast, hard, expanded and full of actions.

Animating expressive body movement involves taking a particular type of motion and applying a style to it. A style can represent many things, such as an emotional style of movement or the personal style of an individual. One approach to represent movement style is to learn a style from one or more examples and then apply it to a new, neutral motion[1, 31]. Another is to use a physically-based simulation of human movement which has a number of parameters that represent style[27]. The major drawback to these techniques is that it is not clear that the movement style can be completely separated from the action being carried out.

The use of body movement to express emotion is, quite literally, at the core of this work. Not only will the accurate expression of our character's emotion through its movement patterns be one of our main objectives, work's like those by Chen and Bargh[8], Wallbott[36], Dittmann et al.[15] and Montepare et al.[29] are especially relevant to the way in which we plan to apply filters to the player's input.

3 CONTROL MODULATION

"Control Modulation" is the process by which we take a player's input and apply filters to it before applying the result of those filters to the virtual character the player is controlling. This way, the actions the character performs are not necessarily directly proportional to what the player inputs into the system, more so the input is taken as a suggestion to the character, who can then decide what to do about that input relying on a number of parameters.

Games with interactive cutscenes like *Final Fantasy XV*[1] and *The Last of Us*[2] limit the player character's movement in certain

[1]Final Fantasy XV is an action role-playing game developed and published by Square Enix.
[2]The Last of Us is a 2013 action-adventure game developed by Naughty Dog and published by Sony Computer Entertainment.

story sections to guide the player along follow a predefined path. This creates a sense of control over the character while maintaining the linear structure of the story intact.

Control modulation is often used to reflect the emotional state of the player's character. Close to the end of *Journey*'s[3] story, the player becomes progressively slower and harder to move as the player moves forward in a field of snow. This reflects the character's physical struggle, as its limbs become progressively colder and start to freeze, as well as its despair.

Other games incorporate this modulation of player control into actual gameplay mechanics. When a player consumes alcohol in *Grand Theft Auto V*[4], for example, their character's movement becomes erratic and thus harder to control. This even translates to the driving controls, with the player significantly more likely to crash his car if driving in this state.

While not directly related, we can find analogous techniques to adapt the gameplay to what the player is doing in the field of procedural content generation. the study of player skill progression modeling, for example, can shed light on how modulating aspects of a game to adapt it to the player and the current play-through might affect the overall experience.

A progression model that takes player skill progression as its core feature was suggested by Bicho and Martinho. The model records skill progression using pairs of a challenge and a mechanic, according to player decisions on which mechanics to use when facing a challenge. By measuring the player performance on these dimensions, it is possible to increase game difficulty on the dimensions the player is better at, while at the same time pushing the players to improve less developed skills.

4 EMPATHY

Preston and De Waal define empathy as the capacity to perceive, understand and respond to others' emotions in a manner that is more suitable to those perceived emotions than one's own[32, 37]. Coplan more narrowly defines empathy as a set of features that the subject must present to experience it[9].

Some studies suggest that in order for games to elicit empathy from a player, interactivity must be reduced[7]. Removing some control over the character the player is embodying simulates the idea that the character has a will of its own. This allows for the player to more easily identify the character as a self contained entity with personality traits.

The relationship between Player and Character in video games can exist under many forms and elicit different emotions from the player. Papale proposed a division of the types of Player-Character relationship into 5 main types[30]:

- **Identification**: the process by which a player takes on the role and mindset of the fictional character they are embodying.
- **Projection**: the opposite of identification, the process by which a player molds a character and their understanding of it to better suit his desires.
- **Sympathy**: the feeling of emotions toward a character, related to their circumstances.
- **Empathy**: the sharing of emotions with the character, rather than judgement of the other's circumstances (sympathy).
- **Detachment**: a lack of emotional connection to the characters that the player is portraying.

Empathy can be divided into two primary types: dispositional and situational. Dispositional empathy is often described as an individual's intrinsic tendency to imagine and experience the feelings and experiences of others[11, 25]. In short, it is the inherent capacity of an individual to feel empathy. Situational empathy is the specific empathic response of a person to a particular situation. People with low dispositional empathy can still have strong empathic responses in certain situations. Our proposal will explore subjects' responses to a situational stimulus i.e. playing a game, so this type of empathy will be the most relevant when evaluating this work.

When trying to assess situational empathy, several challenges arise. This internal quality of empathy makes it difficult to clearly discern by simply observing a subject. Some work has been done in the field of psychology to deduce features of a subject's empathic response from bio-metric data such as heart rate and breathing[16, 23]. Given the scope of this work, such a setup would not be reasonable, so other options should be considered.

Self-report techniques are widely used for their low technology requirements, portability and ease of administration. They are inherently less reliable, given that they are filled in by the subject of the study. There are few self-report methods in psychology developed for measuring situational empathy, and most of them ask the participant to reflect on events that occurred many weeks prior[3, 12, 34].

However, questionnaire developed by Batson et al.[4], that consists of 24 adjectives in which users are expected to rate how they felt about each, has since been applied to other studies in psychology with positive results[5, 35]. However, this questionnaire seems to be more tailored towards negative experiences, such as situations of discrimination, and something more positive or neutral such as an action/adventure game may not be fit for the use of this questionnaire. For this reason, a more direct questionnaire may be a better fit for our work.

5 TEST SCENARIO

To test the effectiveness of the solution, a small game was created alongside Afonso Vieira with elements from Adventure[5] games, Hack and Slash[6], *RPGs*[7] and Action games[8]. Overall the game was designed with the idea of being as simple as possible without any complex game mechanics, so that the player can instead focus on the hypotheses being tested. In the game, the player controls a character which can move around the level, jump, interact with

[3]Journey is an indie adventure game co-developed by Thatgamecompany and Santa Monica Studio, published by Sony Computer Entertainment, and directed by Jenova Chen.

[4]Grand Theft Auto V is a 2013 action-adventure game developed by Rockstar North and published by Rockstar Games.

[5]An adventure game is a video game in which the player assumes the role of a protagonist in an interactive story driven by exploration and/or puzzle-solving.

[6]Hack and slash, also known as hack and slay (H&S or HnS) or slash 'em up, refers to a type of gameplay that emphasizes combat with melee-based weapons (such as swords or blades).

[7]A role-playing game (sometimes spelled roleplaying game; abbreviated RPG) is a game in which players assume the roles of characters in a fictional setting.

[8]An action game is a video game genre that emphasizes physical challenges, including hand–eye coordination and reaction-time.

specific objects, attack enemies with a sword and defend itself with a shield.

Figure 1: Screenshots of the developed game.

To ascertain the effect of the developed solution, two versions of the game were created: one with movement modulation present, and a control version, with movement modulation system disabled. The movement modulation component is part of the larger emotional expression system that was developed in the context of this work, and which will be fully described in section 6. This system subscribes to the events of an arbitrary emotional generation subsystem, such as the one developed by Afonso Vieira. Such a subsystem provides two events, one related to an "active" emotion, which represents a change in the character's internal emotional state, and another related to a "passive" emotion, which represents a change in what the character is currently perceiving. Each of these events provides an emotion object to the receivers, which has the following structure:

- **Stimulus**: A set of parameters describing the stimulus that generated the emotion.
  - **Source**: a reference to the position in world space of the entity that resulted in the emotion being generated.
  - **IsActive**: Whether the previously mentioned source is active within the world.
- **Mood**: Represents the overall valence of the character's emotions (a spectrum from -1 to 1, "Sad" to "Happy" respectively).
- **Magnitude**: Represents the overall strength of this emotion, in a spectrum from 0 to 1.

6 EMOTIONAL EXPRESSION SYSTEM

The developed emotional expression system is comprised of several components that are responsible for each part of the character's emotional expression, which are listed below:

- **Movement Modulation**: Responsible for modulating the character's movement based on the current emotional state.
- **Gaze**: Responsible for conveying the character's center of attention.
- **Posture**: Responsible for affecting the character's posture to reflect the current emotional state.
- **Trembling**: Responsible for making the character tremble in situations of extreme negative emotion.
- **Stabilization**: Auxiliary components meant to stabilize interactions between the main components.

Each of the listed components subscribes to the emotional generation system's active and passive emotions' events. When a new emotion is generated, each component stores a local copy of the provided emotion object, overwriting any emotion that had previously been saved for that event. While this behaviour is consistent among the components, the way each one chooses what emotion to display between the current active or passive emotions differs from component to component.

6.1 Movement Modulation

The Movement Modulation component limits or intensifies the character's movement speed depending on what direction they are moving in relation to the emotions they are currently experiencing. The component applies the modulation in two steps, first a directional step depending on the direction the character is moving, and second a constant step with a constant multiplier.

6.1.1 Directional Step. To choose which emotion to react to, the component calculates the distances to current active and passive emotion's stimuli. If the distance to the active emotion's stimulus is within a predefined range and the stimulus is active, the active emotion is chosen. Otherwise, the same is applied to the passive emotion. If no emotion is chosen, this step's factor is set to 1.

If an emotion was chosen the component then calculates an alignment factor, f_a. This factor is calculated from the dot product between the normalized version of the player's input direction and the normalized version of the vector from the character to the emotion's stimulus. Then the component calculates a modulation factor, f_m which indicates how strong the modulation will be, as shown below in equation 1.

$$f_m = f_a \cdot intensify(mood, I_{mood}) \cdot intensify(mag, I_{mag}) \quad (1)$$

In this equation, $mood$ and mag represent the chosen emotion's mood and magnitude respectively. This notation will be used in subsequent equations throughout the following sections. $intensify$ is an intensification function which can be further inspected in section A.1. I_{mood} and I_{mag} are the parameters (typically ≥ 1) used to intensify the chosen emotion's mood and magnitude respectively. This notation will be used in subsequent equations throughout the following sections. After this the component can calculate the final value for this step's factor, f_d, as shown below in equations 2 and 3.

$$r_{pos} = min\left(1, \frac{\vec{s} - \vec{p}}{||\vec{s} - \vec{p}|| \cdot range}\right) \quad (2)$$

$$f_d = \begin{cases} lerp(1, m_{d+}, f_m \cdot (1 - r_{pos})) & \text{if } f_m > 0 \\ lerp(1, m_{d-}, |f_m| \cdot (1 - r_{pos})) & \text{if } f_m \leq 0 \end{cases} \quad (3)$$

In these equations, $m_{d+}(\geq 1)$ and $m_{d-}(> 0, \leq 1)$ are parameters representing the upper and lower limits respectively that the directional step's factor is mapped to. $lerp$ is a conventional linear interpolation function (see section A.2) which receives origin and target values and an interpolation factor between them.

6.1.2 Constant Step. To calculate the constant step's factor, f_c, this component first chooses the emotion between active and passive with the highest magnitude, which is then used in equations 4, 5 and 6.

$$mood_i = intensify(mood, I_{mood}) \quad (4)$$

$$mag_i = intensify(mag, I_{mag}) \quad (5)$$

$$f_c = \begin{cases} lerp(1, m_{c+}, mood_i \cdot mag_i) & \text{if } mood_i > 0 \\ lerp(1, m_{c-}, -mood_i \cdot mag_i) & \text{if } mood_i \leq 0 \end{cases} \quad (6)$$

6.1.3 Output. The component uses f_d and f_c to calculate the final modulation factor to be applied to the character's movement in the current time step, f_t. To do so it calculates a value interpolated through time between the current modulation factor being applied and the desired factor, as is described in equation 7.

$$f_t = lerp(f_{t-1}, f_d \cdot f_c, l \cdot \Delta_t) \quad (7)$$

In this equation f_{t-1} is the modulation factor that was applied in the previous time step and l is the linear interpolation's strength, with higher l values signifying that new modulation factors are more quickly applied to the character, so this parameter should be decided depending on how fast the transition to the factors resulting from new emotions should be. f_t can then be applied as a multiplier to the character's movement component's speed, with an option scaling step to scale the overall strength of the movement modulation.

6.2 Gaze

The gaze component is responsible for displaying the character's current center of attention by affecting its upper body's joints' rotation. To do this, it only requires access to the current passive emotion, as this emotion is more closely related to the character's current perception of what is around it.

First it checks if the current passive emotion's stimulus has a source and if it is active. If so, it can then begin to calculate where the character's gaze should focus its attention. In order for the character to have believable gaze behaviour, it must not be allowed to rotate its head and upper body in ways that a human would not be able to, so we must first establish limits for its neck and head rotation.

6.2.1 Angle Limiting. In our case, we need only to restrict the head's rotation in two planes - the sagittal and horizontal planes. The sagittal plane involves rotating the head back and forth, while the horizontal plane involves looking from side to side. For some starting parameters, we looked to work developed by Ferrario et al. on the head and cervical spine's active range of motion[18], and with some adjusting arrived at a maximum horizontal rotation, H_{max}, of 80°, a maximum extension in the sagittal plane, S_{max}, of 70°, and a maximum flexion in the sagittal plane, S_{min}, of 60°. With these values the component can calculate the angles representing the rotation of the character's head depending on the chosen emotion's stimulus, $\angle H$ (horizontal) and $\angle S$ (sagittal), as shown in equations 8 and 9.

$$\angle H = max\left(-H_{max}, min\left(sangle\left(\vec{f}, \vec{t_H}, \hat{\mathbf{j}}\right), H_{max}\right)\right) \quad (8)$$

$$\angle S = max\left(-S_{min}, min\left(sangle\left(\vec{t_H}, \vec{t}, \vec{t_H} \times \hat{\mathbf{j}}\right), S_{max}\right)\right) \quad (9)$$

In these equations $\vec{t}$ is the direction from the character's head to the source of the emotion's stimulus, with t_H being the projection of this vector on the horizontal plane, $\hat{\mathbf{j}}$ is the up vector in world space and $\vec{f}$ is the direction the character's body is facing. $sangle(\vec{a}, \vec{b}, \vec{c})$ is a signed angle function which calculates the angle from $\vec{a}$ to $\vec{b}$ and determines the resulting angle's sign by assuming $\vec{c}$ as the axis of the rotation.

6.2.2 Aim Constraints. The *Animation Rigging*[9] package provides a Multi-Aim Constraint component, which constrains the character's joints to make them "look at" a certain target or group of targets. By feeding the previously calculated angles to a target object and feeding it to one of these constraints we can make its associated joint point towards this target. The component also provides a weight parameter, by which the constraint's effect can be applied more or less strongly, with a lower weight resulting in the affected joints' underlying orientation being maintained. By applying Multi-Aim Constraints to the head, neck, and 3 spinal joints of our character, with lower weights as we traverse down the character's upper body, specifically 1, 0.5, 0.1, 0.05 and 0.025, we can achieve a more natural looking turning motion, with the character tilting its whole upper body to look at its target, compared to if only the head was constrained.

6.3 Posture

By applying an additive animation layer[10] on top of the character's underlying animation, we can affect specific parts of the character's motion without losing the original gameplay related animations. Several poses can be defined to represent specific emotions, and these poses are defined as offsets to the character's joints from the user's idle pose. These poses can then be laid out in one of *Unity*'s *Blend Trees*[11] so that emotion mood and magnitude parameters can be used to create an interpolated pose that is the result of the current emotional state.

We developed 4 unique poses[12] in the context of this work: "relief" (mood 0, magnitude 0), "distress" (mood -1, magnitude 0), "hope" (mood 1, magnitude 1) and "fear" (mood -1, magnitude 1). These poses were then laid out in a blend tree with 2 sub-trees, one to interpolate between the low magnitude poses ("relief" and "distress") and another one to interpolate between the high magnitude poses ("hope" and "fear"). Each sub-tree interpolates between its 2 poses based on the current mood value, and the main tree interpolates between each sub-tree's output based on the current magnitude value.

The component then only needs to feed *Unity's* animation system the appropriate mood and magnitude values for that time step, $mood_t$ and mag_t respectively. To this the posture component chooses the emotion between active and passive that currently has the higher magnitude. The mood and magnitude values are interpolated through time to smoothly transition to new emotions, as is shown in equations 10 and 11.

$$mood_t = lerp\left(mood_{t-1}, intensify\left(mood, I_{mood}\right), l \cdot \Delta_t\right) \quad (10)$$

$$mag_t = lerp\left(mag_{t-1}, intensify\left(mag, I_{mag}\right), l \cdot \Delta_t\right) \quad (11)$$

In these equations $mood_{t-1}$ and mag_{t-1} are the mood and magnitude values, respectively, that were fed to the animation system in the previous time step, and l is the linear interpolation's strength.

[9]The Animation Rigging package for *Unity* enables users to set up procedural motion on animated skeletons at runtime.
[10]Unity uses Animation Layers for managing complex state machines for different body parts.
[11]Blend Trees are used for allowing multiple animations to be blended smoothly by incorporating parts of them all to varying degrees.
[12]Video exemplifying the 4 different postures being applied to the character: https://shorturl.at/hFMOW

6.3.1 *Motion Intensifying.*

To more convincingly display positive emotions through the character's posture, the posture component intensifies the angular motion of the character's torso (swinging from side to side) when high magnitude positive emotions are being displayed. To do this, we made use of the *Override Transform*[13] component provided by the *Animation Rigging* package. With this we created an auxiliary component that scales up rotations of the character's bottom-most spinal joint and then reapplies these intensified rotations to a target object, which is then used as the source for an *Override Transform* component that in turn targets the same spinal joint.

The posture component can feed the correct weight values to this component depending on the chosen emotion's mood and magnitude values. For this purpose it only needs to feed it the product of these two values, clamping above 0 so only positive emotions trigger the motion intensifying components, and scaling this value depending on how strong the intensifying should be.

6.4 Trembling

Similar to what is done in the posture component's motion intensifying behaviour, the trembling component uses the *Override Transform* component to make the player's upper body tremble from left to right by applying it to the character's lower spinal joint.

The trembling component first chooses the emotion between active and passive with the higher magnitude. To create the vibration, we used a combination of noise and sine functions, with a high frequency sine function serving as the base for the vibration and a slower noise function as a filter, so the vibration "organically" increases and decreases through time. The angle by which the *Override Transform* component's source will be rotated, $\angle a$, can thus be calculated with equations 12 and 13.

$$e = -min\left(0, intensify\left(mood, I_{mood}\right) \cdot intensify\left(mag, I_{mag}\right)\right) \tag{12}$$

$$\angle a = A \cdot noise\left(n_{scale} \cdot t\right)^{n_{power}} \cdot sin\left(2\pi \cdot f \cdot t\right) \cdot e \tag{13}$$

In this equation $noise(a)$ is a 1D Perlin noise[14] function of range $[0, 1]$, n_{scale} is the noise's scale (larger values result in more turbulent or "faster" noise, while lower values result in more stable or "slower" noise), t is the current time in seconds, n_{power} is the exponent used for the noise function, with higher values creating a more "spike" like function, with longer stretches of low values and sudden spikes to higher values, f is the sine function's frequency and A is the maximum amplitude of $\angle a$. The source object's rotation is then set to a rotation of $\angle a$ degrees around a predefined axis in the character's local space. In our case, we chose to use the character's forward axis, so that it trembles from side to side.

7 TEST METHODOLOGY

Participants were asked to follow a link to a questionnaire[15] which included a download link for the game build. They were first asked to provide demographic information on their, gender, age, frequency with which they play video games, familiarity with the adventure game genre, the value they place in a character's emotional expression and whether they would be using a gamepad or keyboard and mouse. They were then asked to rate the valence of the emotions shown in 4 animated images[16] on a Likert scale from 1, "Very negative", to 5, "Very positive". This initial check was done to verify whether participants were correctly recognizing the intended valence of the developed emotions by the animations created for them.

The players were then instructed to run the game's executable, while keeping the questionnaire window open. The game would then load a random version of the game, and when the player would finish playing that version, a version code would appear on the game's window, instructing the player to choose it in the questionnaire. After responding to that version's questions, the player would then be instructed to return the game window and play the next version of the game. After playing all versions and answering their respective questions, players would then be asked to submit an archive generated by the game containing data collected during gameplay, so that a manipulation check could later be performed. For each version, the player's would be asked to first rate how frequent each of 4 emotions (again identified by the same 4 animated images) was during gameplay on a Likert scale from 1, "Never happened", to 5 "Happened frequently". Then, they would be asked how they felt when the character was feeling "bad" or "good". For each of the two they would be asked to rate how much they agreed with each of 3 responses, "good", "bad" and "indifferent", on a scale from 1, "Completely disagree", to 5, "Completely disagree". These 6 scales are the core of this work's evaluation, as they would provide an idea of how aligned the character's and the player's emotions were, therefore showing how the player's empathetic response towards their character was. Participants would then be asked be asked to describe two situations (one optional) in which they noticed one of the 4 emotions (identified by the 4 animated images) being expressed, providing a short description of their rationale as to why that emotion occurred.

This methodology was first tested on a small pilot group of 5 people. While the testing was done synchronously with voice communication with each participant, no instructions other than to open the questionnaire's link were given unless strictly necessary. After inspecting the data from this small group, obtaining some promising results, and some small changes to the questionnaire's wording resulting from some further questioning of the pilot group's participants, the testing proceeded to its final stage with the collection of a larger sample size, while including the results from the pilot stage in that sample. This stage of testing was done asynchronously to allow for more people to participate without the need for the presence of the developers, and as such the link to the questionnaire was distributed through the internet for willing participants to join.

[13] Override Transform constraint allows to override the constrained *GameObject* transform in a specific space.
[14] Perlin Noise is a mathematical function that uses interpolation between a large number of precalculated vector gradients that construct a value that varies pseudo-randomly in space or time.
[15] Link to the questionnaire: https://shorturl.at/fkmxW
[16] 4 animated images representing the emotions: https://shorturl.at/aipN0

8 DISCUSSION

Testing involved a sample of 27 people, with 74% of participants aged 22 or 23, with the rest of participants aged 24 to 28. Additionally, 89% of participants were male. Most participants reported scheduling time to play games, were familiar and enjoyed playing games in the adventure game genre, and valued both gameplay and their character's emotional expression. 59% of players chose to use a gamepad, while 41% chose to use a mouse and keyboard. Since none of the 6 scales previously mentioned could be approximated to a normal distribution, only non-parametric tests were used. In general, the presence of movement modulation did not seem to affect the player's empathetic response to their character's emotional expression. However, there was a statistically significant shift ($p = 0.011 < 0.05$) when movement modulation was present, with players presenting a higher negative emotional response related to their character's positive emotional expression when the modulation was present. This may signify that the presence of control modulation may introduce some confusion in the players' reactions to their character, as this type of character behaviour is not particularly common in games other than in specific scripted scenarios. The player may therefore have an averse reaction to the control modulation and not feel as positively about the character's positive emotional state as they would had the movement modulation not been present. This may also have been a consequence of the animations used to convey the character's emotional state not being the most appropriate (even though they were correctly recognized in the questionnaire's initial questions), with the movement modulation perhaps exacerbating this inadequacy.

An unexpected finding that arose from the analysis of the testing data was the effect that the players' control choice had on their emotional response related to the character's emotional expression. The results of a Mann-Whitney U test revealed that participants who chose to use a keyboard and mouse instead of a gamepad reported a significantly lower (Control version: $p = 0.023$, Movement modulation version: $p = 0.013$) negative emotional response to the character's negative emotional expression in both versions of the game, which may signify that the use of a keyboard and mouse resulted in the participants being less in tune with their character's emotions. This could be due to the lack of analog controls, especially in the version with movement modulation, given that the effect of modulating the character's movement is hindered by not having the full radial range of direction that a gamepad's joysticks provide, as well as lacking any control over the speed of that motion. Another cause for this may be the cultural meaning that a gamepad entails, given that it is used almost exclusively for the enjoyment of video games, in contrast with a mouse and keyboard, which are more commonly associated with general computer tasks, and thus using a keyboard and mouse may not place the player into the same mindset that a gamepad would.

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A AUXILIARY FUNCTIONS

A.1 Intensify

$$intensify(x, p) = \begin{cases} x^{\frac{1}{p}} & \text{if } x \geq 0 \\ -|x|^{\frac{1}{p}} & \text{if } x < 0 \end{cases} \quad (14)$$

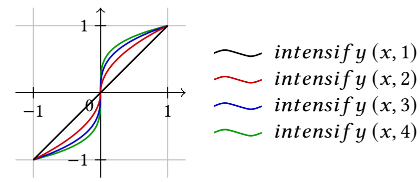

Figure 2: Visualization of the $intensify$ function with different intensification values.

A.2 Lerp

$$lerp(a, b, t) = a + (b - a) \times t \quad (15)$$