Expectancy and Emotions in Synthetic Characters

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Abstract

Believable interactions between synthetic characters are an important factor defining the success of a game relying on the player being able to create emotional bonds with the game characters. As important as the character being themselves believable is that the interaction with or between such characters is believable. Although research in synthetic characters has developed several models to improve character believability, interactions are generally not the focus of such works. This may be one of the reasons why state of the art models from Academia are still not being used in commercial products. In this thesis, we bridged affective computing and traditional animation principles and create a model for character interaction based on anticipation and emotion that allows for precise affective communication of intention-based behaviors. We also present a study with 52 subjects supporting that our proposal is able to increase scene believability when compared to traditional approaches.
Keywords: Believability, video games, emotions, anticipation, agent interaction

Introduction

In today's cinematographic world, many movies conquer the audiences and create an imaginary world where the audience lose themselves in. This is called immersion, "state of being deeply engaged or involved."[1]

But how can movies create such immersion? Let's take for example movies like "The Lord of the Rings"[2] and their fervorous battles, when a character moves or attacks mid-combat it is always clear for the viewer its intention, either by the movement of their eyes or their body. This flow creates anticipation in the audience and a sense of presence, where the audience can feel as being there, which refers to what is called the suspension of disbelief, the notion that the implausibility of something can be suspended for the sake of enjoyment.

Many video games try and succeed in creating the suspension of disbelief by introducing pre-scripted scenes and narrowing the player's playable area and actions, giving it a more cinematic feel, but in open-world games this kind of immersion is hard to achieve, mainly because of the interactions between synthetic character and the player. Often the way one can interact with the characters is by a set of predefined actions, these interactions appear unnatural and often break the suspension of disbelief and annoy players.

The same applies to when a battle is under way. Many times there is no verbal or non-verbal communication between characters, creating a mechanical and over simplified battle sequence with no sense of immersion. It is good to point out that many of the human's communication is made in a non-verbal way, by the movement of the hands or eyes, indicating the other person's intent. Emotions are also essential to correctly perceiving and delivering an intention, and many of the times such is not shown in video games, except for pre-scripted scenes.

These interactions lead to what we can call scene's believability. Opposed to the character's believability, which focuses on the believability of a specific character in a scene, the scene's believability, as the name suggests, is focused on the overall believability of a scene, including the environment, the characters and their interactions, meaning that just for having a very believable character does not mean the audience will be immersed in the scene. Let's take for example a scene where a very believable character interacts with an unbelievable one, while the former has a coherent discourse, the latter babbles about, breaking the suspension of disbelief.

Additionally the scene's believability can also involve the characters' interactions with the environment and even the behavior of the characters in that environment, meaning that the charac-

[1] Dictionary.com: `http://dictionary.reference.com/browse/immersion`

[2] Created by J. R. R. Tolkien and distributed by Jackson from New Line Cinema

ters should act differently in different environments. One acts differently in a bar with friends and at work with his colleagues.

In most games today, there is little concern with non-scripted real-time scene believability. Character interaction in such scenes is often superficial or neglected. The non-existence of a clear anticipatory representation of the synthetic characters' intentions, as well as the scene affective context associated with such a representation, prevents the scene from having a deeper emotional meaning to the player watching the interaction or actually interacting with the synthetic characters. In this work, we strive to create a model dynamically supporting such believable and detailed interactions, with the goal of creating more believable scenes for games whose play experience heavily relies on.

In this work, we aim at creating an anticipatory and affective behavior model for synthetic characters bridging traditional animation principles with modern affective and anticipatory modeling to allow the creation of more believable interactions and consequently more believable scenes. Our main hypothesis is that by explicitly modeling the traditional split of an action animation into anticipation, action, and follow-through stages, we will be able to communicate both the intentions of a character in a clearer way as well as give a richer emotional context for all the characters involved in the scene, consequently improving the scene's overall believability.

Believability

We'll focus on creating believable characters that act on their own, creating a believable scene without explicit declaration. Therefore, for this work, the working definition of a believable scene is

"A scene is as believable as the characters and the interactions between them."

We'll be letting out the interactions with the environment, has they are not the main focus of this work.

But what is believability? The Oxford dictionary of English defines the verb 'to believe' as "accept that (something) is true, especially without proof"[3], yet there is still no generally agreed or precise definition of believability, instead, there's a "family of related meanings denoted by the same word"[14]. In its more obvious linguistic denotation, believability means that something can be believed by someone. The entertainment industry gradually linked believability with the audience's engagement in a performance, often defining believability as the empathy with the characters emotions and problems. In the context of Artificial Intelligence and video games we can add that something about a character or even the character itself is believed to be real by someone.

Believable Agents

Believable agents are the software embodiment of the believable characters previously mentioned, therefore it is important to define them.

Given the multiple definitions of believability, several authors, from different fields, gave their definition of a believable agent. We'll only consider the ones most relevant to this work:

Bates (CMU, 1992): Believable agents require "only that they not be clearly stupid or unreal". Such broad, shallow agents must "exhibit some signs of internal goals, reactivity, emotion, natural language ability, and knowledge of agents...as well as of the... micro-world"[1].

Ortony (NWU, 2003): "Believability entails not only that emotions, motivations, and actions fit together in a meaningful and intelligible way at the local (moment-to-moment) level, but also that they cohere at a more global level – across different kinds of situations, and over quite long time periods"[10].

Using this definitions we determine that a believable agent must have its own goals, be reactive and emotional, and be aware of himself and the world he's in, remaining consistent at a local and global level.

Principles of Traditional Animation

Even after defining believable characters and knowing their components, if they are not properly presented they can lose the audience's attention. The principles of traditional animation, first introduced by F. Thomas and O. Johnston in their book *The Illusion of Life: Disney Animation*[5], are based on standardized practices followed by Disney's animators and allow the creation of a more believable animation, both traditional and computer animation[7].

- ***Timing***, or speed of an action, defines how well the idea behind an action will be read by an audience. More importantly timing defines the weight of an object, as in the example "a giant has much weight, more mass, more inertia than a normal man; therefore he moves more slowly. (...) he takes more time to get started and, once moving, takes more time to stop."[7].

  One can also define the emotional state of a character by it's movement, where the varying

[3] Oxford Dictionary of English: `http://www.oxforddictionaries.com/`

speed of an action indicates whether the character is lethargic, excited, nervous or relaxed.

- ***Anticipation*** is the preparation for the action, for example, if a character wishes to grab a cup of coffee he first raises his arm and stares at the cup, broadcasting his intentions, which leads those watching to expect the character to pick up the cup before the action is done. Without anticipation many actions are abrupt, stiff and unnatural.

  An exaggerated anticipation can also emphasize the heavy weight of an object, when a person has to bends down to be able to pick up a heavy crate, or show a characters emotional state, when one is scared or anxious of doing something he must do.

- ***Staging*** "is the presentation of an idea so it's completely and unmistakably clear"[7]. This principle declares that to clearly stage an idea the audience must be lead to be paying attention exactly to what the creator wants them to, otherwise the idea will be missed.

  When staging an action, it's important that only one action be passed to those watching, to do that there should be a contrast between the object to focus on and the rest of the scene, for example, in a big crowd walking in the side-walk, a person standing still will attract the viewer's attention.

- ***Follow Through and Overlapping Action*** – Most of the times an action does not come to a sudden stop after it is complete, in many movements like a jump there is the termination of the action or Follow Through.

  An Overlapping Action can be variations added to the timing and speed of the loose parts of objects or an action that overlaps the previous one, which makes the objects seem more natural and maintains a continual flow between the phrases of actions.

- ***Exaggeration*** is self-explanatory, but it has to be done with care. It can work with every component, but not in isolation. The exaggeration of various components must be balanced, where some elements are exaggerated and the others are used as natural elements for the viewer to use has comparison, so that the scene remains realistic.

  When animating characters, exaggeration is very important to transmit theirs emotional state. If a character is sad, make him sadder; if he is wild make him frantic.

- ***Secondary Action*** "is an action that results directly from another action"[7]. It is important since it add realistic complexity to the scene, but must always be kept subordinate to the primary action.

  Although secondary, this type of actions will be very important to this work, since we will consider the reply to the primary action, of those characters who watched, to be a secondary actions.

There are other principles that were not described above as they are not applicable to this work, such as **Squash and Stretch** and **Straight Ahead Action and Pose-To-Pose Action**, among others.

Emotions and Anticipation

When talking about believable characters it's impossible not to talk about emotions, being one of the major factors that makes a character believable. Unfortunately there isn't an exact definition for emotion, much like what occurs with the definition of believability. Kleinginna and Kleinginna[6] compiled ninety two disparate definitions for emotions into distinct categories pertaining to the more basic psychological theory they supported (affective, cognitive, physiological, adaptive, and so on...). Although there is no concrete conclusion to the definition of emotion, there is a consensus of the view, that emotion is considered by most theorists,

"as a bounded episode in the life of an organism, characterized as an emergent pattern of component synchronization preparing adaptive action tendencies to relevant events as defined by their behavioural meaning and seeking control precedence over behaviour."[12]

From this one can gather the limited time frame of an emotion, as well as a pattern of behaviour in response to certain stimuli.

What about anticipation? Anticipation and emotions are closely related. One of the emotions' principal function is precisely that of anticipating events, especially when those events involve the well-being of the organism. *"If I am walking in the woods and, suddenly, 'something' ahead on the path lets out a loud roar, my heart races, my muscles tense, I 'feel' afraid and ready to run away"*[8]. In this example the emotions helped reduce the number of possible actions, by eliminating most of the consequences of each from consideration a-priori. Therefore creating an **action tendency** or in other words a desire to behave in select communicative or important actions that are connected to a particular emotion.

Yet the anticipation of an event may also elicit an emotion. Let's rephrase the previous example, *If*

*I am **hunting** in the woods and, suddenly, 'something' ahead on the path lets out a loud roar, my heart races, I found my pray, today I'll feed my family, I am happy*. In this case the emotion was elicited by anticipation. These emotions are often related with expectations, commitment towards important goals, and the validation or invalidation of both expectation and goals. Therefore, the same outcome can lead to a wide range of emotional experiences, based on different types of expectations. "To be prepared for what is to come is a crucial factor in survival"[8].

Computable Emotions
Having the definition of emotion established, it's important to know how emotions can be computed. Scherer, Banziger and Roesch [12] created five general categories to incorporate different affective models, each category differences themselves in what particularity they wish to convey special relevance or the psychological theory they are backed by. Even though all of the categories are important, for this work we'll be focusing on the Appraisal theory approaches.

Appraisal Theory Approaches
Appraisal theory postulates that "all emotions come mostly from our own interpretations of events"[11], where our appraisal of the situation is the emotional response. The theory is best used in connecting awareness with emotion, focusing on the individual and it's psychological response, where his own judgment of a situation is to blame as the source of his' emotional response.

The appraisal theory approach show potential when used in a more static Non-Player Character (NPC) or Environment emotional association, which is are relevant for this work, giving a simpler and robust emotional model to the in-game interactions.

Anatomical Approaches
This approach tries to emulate the neural structure that is behind an emotional response. They tend to specialize on a single emotion, since they emotions as separate entities with their own systems, giving great importance to the systems that create the emotion.

Although a very detailed approach, they focus on a more raw and basic emotional response and tend specialize on a single emotion, limiting this model, that will make use of several emotions for it's characters.

Rational Approaches
Rational approaches "ponder what adaptive function does emotion serve"[11], attempting to incorporate an abstract version of this from its implementation in humans into a model of intelligence. This approach is typically associated with artificial intelligence research, where models using this approach are usually used to further develop machine intelligence's theories, not being appropriate for this model.

Communicative Approaches
The theories behind the communicative approaches focuses on the social component of emotion, that "serves an empathic objective to aid in communication and to transmit non-verbal cues"[11]. This approach is more usually used in social studies, crowd dynamics and multi-agent systems, focusing on the outward emotional display, often disregarding internal work for creating and emotion.

These approaches are a viable solution to implement emotions in this model, but because they are strongly intertwined with a social component that, although important, is not the main focus of this work, we'll not be using these type of approaches.

Dimensional Theory Approaches
Nowlis and Nowlis in their work *The Description And Analysis Of Mood*[9] analysed and concluded that there were between six and twelve independent affective states (ie. sadness, anger, anxiety, etc.) to the human psyche, introducing the concept that all complex affective states could be broken down to a simpler list. Later Schlosberg[13] hinted that emotions shouldn't be viewed as discreet and unrelated but as an end product of a system of undisclosed variables. The dimension theory approaches focuses on this view, where affective states are connected and their origins is an n-dimensional vector.

Even though "a big advantage of the dimensional approach is one can attempt to code the seemingly complex nature of human emotions as a combination of simpler internal factors"[11], it can still be quite complex, increasing focus and resources needed in more important sections of this model.

Awareness and Situatedness
It's impossible to have a believable scene and characters without the concept of awareness, "the ability to perceive, to feel, or to be conscious of events, objects, thoughts, emotions, or sensory patterns"[4]. Implying that the agents in an environment must be aware of it's surroundings and act with that in mind.

In movies and books, the authors choose what the characters and the audience are aware of, being able to surprise the audience with unforeseen events. In video games and other interactive media, the awareness of an agent is determined by other factors, since the author has no control over

[4]Merriam-Webster Online Dictionary: `http://www.merriam-webster.com`

the agents actions in run-time. If a bandit is moving slowly behind a guard, with his knees bent and his head low, it's expected that the guard is unaware of his presence, otherwise the believability of the scene would be broken. On the other hand, it should be clear to the audience when an agent becomes aware of another agent's presence, let's take for example Mickey Mouse and his dog Pluto. Whilst Pluto is napping on the carpet, Mickey comes back home, slamming the door and entering. Hearing the familiar sounds, but with no intention of getting up, Pluto raises his head and acknowledges Mickey's presence, returning to his sleep. If Pluto hadn't lifted his head the audience would lose focus, breaking the scenes believability.

It's important to this work to have an awareness system implemented, even if it's simple, this way improving character believability and subsequently improving the scenes believability.

As for situatedness, Mathew Costelo[3] defines it as "a theoretical position that posits that the mind is ontologically and functionally intertwined within environmental, social, and cultural factors", meaning that an agent's mind is not anchored in interiority, but rather an expression of the interaction between the agent and the environment.

To have a believable scene, its characters not only must be aware of the environment they are in, but also they must act and think regarding their social, and cultural factors. If a funny colleague, that is known to always be jumping around and dancing, is in a class room, where everyone is silently listening to the teacher, he will be quiet and calm, otherwise the scene would not be believable.

One must behave accordingly to where he is. For this work is important that the actions taken in a scene are correct, approving situatedness and increasing believability.

Believable Interactions Between Synthetic Characters

The title of this section refers to the work of Nuno Costa[2]. Costa proposes a new clearer approach to agent communication and cooperation. His approach will be the basis for this work, being therefore important to describe his work and why we chose it.

The core of his approach consists on dividing an action in two stages, anticipation and execution, following part of the principles of the traditional animation.

The anticipation stage serves a purpose of broadcasting the intent of an agent, so that every other "is expecting it and can prepare accordingly". After the broadcast, the agent may choose to either execute or cancel his action, based on the other agents replies. If the agent chooses to execute the action it the enters the execution stage.

The stages may overlap at any time and different agents may be at different stages in a given time. Additionally the agents must be aware of each others current state of the action, so they can effectively cooperate.

The Model

We based this approach on the work of Costa[2] and improved upon it. We'll divide an action in three stages: **anticipation**, **action** and **follow through**.

As in Costa's work the anticipation stage "serves the purpose of communicating the intent so every other agent (...) is expecting it and can prepare for it accordingly". This stage allows an agent to broadcast its intention and receive input from other agents. In Costa's work the input received from other agents was considered either positive or negative. In this work, the agent replies with an emotion (Confidence, Fear, Apprehension, Confusion, etc.), allowing the receiving agent to interpret the emotion as it sees fit.

We also subdivided the anticipation stage in two sub-stages, interruptible and uninterruptible, this allows for a single action to be more detailed. The interruptible stage, as the name suggests, is a stage that can be interrupted, exemplifying let's say that an agent throws a ball, while it has the ball in its hand it can always stop the action from developing, but in the moment it releases the ball, we enter the uninterruptible stage, where the action is not finished, but the agent can create an expectation about its end. In the example, the agent could expect the ball to hit the target, even though the ball is still flying. The uninterruptible stage is optional, since not all actions go through this step, walking, for example, is always interruptible.

The action stage is instantaneous, meaning it only exists in a conceptual view and is not implemented, that is because we consider this stage as the moment where the action gets its resolve, changing the state of the world. In the previous example, this moment would occur right after the ball hits (or misses) the target.

After the action is resolved, we enter the follow through stage, where we broadcast the result of the action, validating or invalidating the agents' expectations. This is a new stage compared to Costa's work, where previously the agent would just update its information about the event, either increase or decrease the action's confidence value, now the agent also expresses its emotions to others, allowing them to feel sorry for it, for example.

Architecture

The agent is composed of a emotional module, a decision making module and a action execution

module. An agent's behavior can be described in four steps: Perceive, React, Decide and Perform. The agent perceives changes in the world, then reacts upon them, using the emotional model, decides what to do, regarding the changes and its emotion, using the decision making module, and then perform its action, using the action execution module.

The *Emotional* module selects the emotion the agent is feeling using Emotivector[8] approach, where for each action they will expect a reward or a punishment, with this approach the agent can create expectations regarding the action's success and react upon them. This module will be called throughout the execution of an action, allow an agent to feel different emotions in the course of a single action, allowing the creation of a more believable agent. While important, the emotional module is not the focus of this work, therefore, was emulated by a script. The script only selects what emotions the agent feels at a given time, allowing us to create believable scenes while correctly simulating the emotional module.

The *Decision Making* module selects an *action* according to the agent's *Beliefs* and *Desires*, as in the BDI architecture[5]. The agent stores information regarding the action possible success, such has the amount of times the action succeeded. The action may contain additional information, for example, what is the target when performing an attack, and is then sent to the action execution module. While important, the decision making module is not the focus of this work, therefore, was emulated by a script. The script only selects what actions to execute at what time, allowing us to create believable scenes while correctly simulating the decision making module.

The action execution module allows the separation and stepped execution of an action, dividing it in its different stages. It's important to note that in each stage information is sent, regarding the stage itself and the agent's emotion at that moment, to those aware of the action's unfolding.

As previously described, when an action starts being performed it enters the interruptible anticipation stage, where after the information is sent, the agents aware of the action can reply with emotions. In this stage the agent may choose to cancel the action, allowing it to change its mind after receiving input from other agents. It's also important to note the in the current implementation the agent can not only react to the emotions but also to the actions the other agent's perform, for example, if an agent is starting to walk and expects another to follow, the agent can cancel its action if its partner does not follow.

If the action proceeds, it enters the uninterruptible anticipation stage, where the emotional information sent is regarding his expectation over the outcome of the action. This stage is sometimes skipped, because it is not applicable to every action.

The action continues and is resolved, applying the changes to the world and entering the follow through stage, where those changes are disseminated to the agents aware of the ongoing action, with the changes, the emotion of the performing agent is also sent, broadcasting the end of the action and it's consequences.

When an action is canceled it does not automatically stop, this is mainly because it is not believable or even real, an action always takes some time to stop. This way, when an agent cancels an action it enters a canceling stage, where it stays until the action finishes, only then can the agent start another action. This stage also sends information to other agents and with this it's possible to create more believable scenes.

Regarding emotion expression, in this model emotions contain information about who is expressing them and if it is a reply or not. Additionally, emotions can be considered a single stage action, meaning that expressing an emotion can take time, it's not instantaneous, and can be correlated with action execution, one agent can be doing an action and expressing an emotion at the same time.

Mental State

Each agent has its own mental state, in there it stores information about itself and other agents.

For itself, it stores what it is doing, what it is feeling, what it can do, a list of available actions, what it can feel, and a list of available emotions. This information allows the agent to act and feel, but it is as important as the information of other agents.

For other agents, it store information about what action they are performing and what stage are they in, and what emotions are they feeling. This way, an agent can predict certain behavior or express emotions to other agents depending not only on itself. More importantly, it can create knowledge gaps, where if an agent is not aware of a certain action it can act differently then if it knew.

Events

In this model, events are an important piece for allowing the information to be broadcast. There are currently two types of events, action and emotion events, and as the names suggest, they carry information about a change in an agent's state, either telling about a new action, a change in a stage of an action or the feeling of a new emotion.

[5]Belief-Desire-Intention Architecture, created by Michael Bratman: `https://en.wikipedia.org/wiki/Belief%E2%80%93desire%E2%80%93intention_software_model`

An agent uses events to send and receive information about other agents, therefore updating their mental representation of the other agents. Without events the spreading of information would be impossible.

What about perceiving an event? Agents could perceive an event as soon as it sent to them, but that is not believable, nor realistic, since humans and animals take some milliseconds to process new information, where they have seen it, but their brains have not yet reacted to it, because of this we implemented a small delay that makes the agents wait until they can completely perceive what happened.

But the different times of sending and perceiving events lead to yet another interesting situation, where for example an agent perceives that another is performing an action, but has not yet perceived its emotion. These types of situation lead us to create a timer system, allowing agents to wait for a given time until something happens or until the time runs out to do an action, therefore emulating human behavior, where not only do we not react instantaneously, but we also wait to see things unfold until we act.

Evaluation

To test this model, we used questionnaires presenting three videos, each video contained the same scene, but where the agents where different. In one video, agents used this model to act, using correctly the anticipation and follow through stages, correctly expressing their emotions, let's call it *Anticipation* video. In a second video the agents don't use the anticipation module, simulating the approach used in most models, let's call it *No Anticipation* video. The third model use this model incorrectly, failing timings of anticipation and in expressing a coherent emotion, let's call it Random video.

After each video the participants where asked to express how they felt about statements regarding their perception of the agents and how the agents perceived other agents.

- From the participant point of view:
  - I understood what the agents were doing.
  - I could predict the agents' actions.
  - I understood what the agents were feeling.
  - I could predict the agents' feelings.
  - I understood the agents' intentions.
- From the agents point of view:
  - The agents were aware of each other.
  - The agents were aware of each other's actions.
  - The agents could predict each others' actions.
  - The agents were aware of each other's feelings.
  - The agents could predict each others' feelings.
  - The agents were aware of each other's intentions.

The participant could express how they felt by using Likert scales that went from *1 - Strongly Disagree* to *5 - Strongly Agree*. The statements refer to the measuring of a agent's believability using some metrics defined by Gomes *et al*[4], which includes awareness, behavior understandability, predictability, behavior coherency, change with experience and social metrics, but also measures the ability of a agent to perceive and interact with other agents.

After these statements, the participant is asked to express how believable was the scene by using a Likert scale with the same values as the previous statements. This measure helps us to understand what the participant thought was the most believable scene overall.

The participant is also asked to write a description of what happened in the scene, allowing us to better understand if the scene was or not transmitting the correct content to the user.

Results

Testing involved a sample of a total of 52 participants. Since none of the data sets were normally distributed, we used non-parametric tests on our data. Giving that the participant was asked about the same statement for the three videos, we started by doing a Friedman test, verifying if the answers to the different videos were statistically significantly different. To truly understand the relations between the answers, we used a Wilcoxon signed rank test, which allowed us to compare how the answers to a video relate the answers to another video.

The analysis of the collected data led us to conclude that the Anticipation video ranked higher in almost every statement, meaning that participants perceived this video to contain the most believable scene.

The statements regarding the participant's perception of the agents was were we expected to see more similarities between the Anticipation and the No Anticipation videos. The expectations were confirmed and statements as "I could predict the agents' actions." were similar in values between these two videos. A broken expectation was that

of the statement “I could predict the agents’ feelings.”, where we hoped the new information given by the anticipation module would allow participants to more easily predict the agent’s emotions.

A weird phenomenon happen in the statement “I understood the agents’ intentions.” where the three videos were not statically significantly different. One can suppose that the intentions of the agents are easy to perceive in any of the videos or even that after watching the video the intentions were made clear. Other possible supposition is that what the participants meant was that their capability to perceive the intentions had not changed.

The statements regarding the agent’s perception of other agents and their actions, feelings and intentions gave results that always favored the Anticipation video, indicating that in fact the correct usage of the model improves believability.

Although the Anticipation video’s scene is favored, we were expecting the No Anticipation video’s scene to be statistically significantly different from the Random video, which was not the case, probably the addition of new information in the Random video still made participants consider the agent’s aware of each other and therefore similar to the No Anticipation video.

Conclusions

We started by saying that although there are models to create believable characters, interactions with or between characters are generally not the focus of such works. With this we wanted to create a model that focused on interactions and that could possibly leave the Academia and be used in commercial products.

The model we created uses decision making and emotional modules, but the main focus was the subdivision of an action and non-verbal communication.

The subdivision of actions takes inspiration from the principles of traditional animation, where an action can be divided into stages such as the anticipation stage and the follow through. With the usage of these new stages we hoped to increase believability in characters and in scenes.

These stages also allow for the transmission of non-verbal communication, by which we mean, the expression of emotions as a way of communicate.

Having these features we needed to implement them. By using a text and progress bar based Graphical User Interface (GUI), we created a visual guideline that users could watch to see actions take place. The text offered the information about what an agent was doing and feeling and the progress bars offered the notion of how the action stage was developing.

To test this model and to see if it really helped to create more believable characters, we created questionnaires where we asked participants to answer some questions regarding three videos containing different agents in the same scene.

In one version they used the model with correct timed anticipation and expressing the correct emotions.

In the second version the agents did not use anticipation and ignored all the emotional feedback from other agents, this version simulated what most model work (with no anticipation and no non-verbal communication).

Last but no least, the third version presented agents using the model incorrectly, which means that the anticipation responses were ill timed and the emotions sent were erroneous, this version helped prove that to make a more believable character or scene one can not simply adding more information.

After the analysis of the questionnaires we concluded that this model helps create more believable characters that a model that does not consider the subdivision of an action and non-verbal communication.

With this model we hope to be able to bring to commercial products and to other developers an easy way of creating more believable and detailed interactions.

References

[1] J. Bates. The nature of characters in interactive worlds and the oz project. Technical report, Carnegie Mellon University, 1992.

[2] N. Costa. Believable interactions between synthetic characters. Master’s thesis, Instituto Superior Técnico, 2015.

[3] M. Costello. Situatedness. In T. Teo, editor, *Encyclopedia of Critical Psychology*, pages 1757–1762. Springer New York, 2014.

[4] P. Gomes, A. Paiva, C. Martinho, and A. Jhala. Metrics for character believability in interactive narrative. In *Proceedings on the International Conference on Interactive Digital Storytelling*, 2013.

[5] O. Johnston and F. Thomas. *Disney Animation: The Illusion of Life*. Disney Editions; Rev Sub edition, 1995.

[6] P. R. Kleinginna and A. M. Kleinginna. A categorized list of emotion definitions, with suggestions for a consensual definition. *Motivation and Emotion*, 5(4):345–379, Dec. 1981.

[7] J. Lasseter. Principles of traditional animation applied to 3d computer animation. *Computer Graphics*, 21(4):35–44, 1987.

[8] C. Martinho. *Emotivector - Mecanismo Afectivo e Anticipatório para Personagens Sintéticas*. PhD thesis, Instituto Superior Técnico, 2007.

[9] V. Nowlis and H. H. Nowlis. The description and analysis of mood. *Annals of the New York Academy of Sciences*, 65(4):345–355, 1956.

[10] A. Ortony. *On Making Believable Emotional Agents Believable*. MIT, 2002.

[11] P. Pimentel. Gameplay aware expression for virtual characters in video games. Master's thesis, Instituto Superior Técnico, 2015.

[12] K. R. Scherer, T. Banziger, and E. Roesch. *A Blueprint for Affective Computing: A Sourcebook and Manual*. Oxford University Press, Inc., New York, NY, USA, 1st edition, 2010.

[13] H. Schlosberg. Three dimensions of emotion. *Psychological Review*, 61:81–88, 1954.

[14] J. Togelius, G. Yannakakis, S. Karakovskiy, and N. Shaker. Assessing believability. In P. Hingston, editor, *Believable Bots*, pages 215–230. Springer Berlin Heidelberg, 2012.