Simulating Emotional Behaviors in a Strategy Video Game Artificial Player
An Emotional Artificial Intelligent Player for Starcraft II

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Abstract: The Artificial Intelligence sub area of Affective Computing is a subject of great interest, as it can be shown by the intense research and development over the last years. The incorporation of emotional models into computational systems has proven to have many applications in different domains like Robotics, Human-Robot Interactions, Social Simulations and Entertainment. In the entertainment industry, designers start to include emotional models into games and game characters, in order to increase the player’s game experience through believability. In the case of RTS Games, the game AI is deprived of emotions, and is usually very mechanical and predictable. In this thesis, we developed a trigger based architecture that simulates emotional behavior in the AI of the RTS Game Starcraft II in order in improve its believability and to identify some possible advantages (or disadvantages) of this new kind of Emotional Intelligent Artificial Player (EAI). Our evaluation based on a survey containing game footage from this new type of AI showed that, in 36% of the cases, its behavior is considered to be more believable than the original AI, which also contributed to identify some interesting conclusions for the field of Affective Computing and RTS Games in general.

Keywords: Artificial Intelligence, Affective Computing, Emotional Agents, Emotional Behaviors, Agent Believability, RTS Games.

1. Introduction

A video game’s success can come from many factors like how fun it is to play, how it looks or how original it is. However, in the current days, one factor that is drastically increasing in importance is how the game moves the players emotionally [1, 2].

1.1 Motivation

Games that move a player emotionally increase player’s engagement with the game and transform the whole gaming experience into an experience to remember and tell others about, just because of the emotions that were felt during play, thus improving the overall gaming experience and game success. One important source of emotions is the ability to play the game with or against other human players.

When in shortage of human players, many games offer the chance to play with or against an Artificial Intelligence. However, game AI behavior is still easily indentified when compared to a human player, which decreases the player’s emotional experience.

1.2 Problem Description

In order to address that lack of believability, and following the recent advances in the field of Affective Computing, we present in this thesis an attempt to simulate human emotional behavior in an artificial game player. This was achieved by modifying the existing AI of the RTS game Starcraft II™ [3] from Blizzard Entertainment® [4].

1.3 Main Objectives

The objective of this thesis is to create an Emotional Artificial Intelligent Player for the RTS game Starcraft II, and then to evaluate its resulting behavior. We want to show that we can increase believability in an AI player by simulating emotional behaviors in it. Our working hypothesis is then as follows:

“By simulating Emotional Behaviors in an Artificial Player for an RTS Game we can achieve a higher degree of believability.”

It is important to refer that we are not trying to improve the existing AI, such as making it more efficient or increasing its performance. The evaluation will, instead, be focused on two topics:

Believability. To what extent can we say that the new agent is believable? How will the imposition of emotions influence the behavior of the artificial agent and whether these influences will make it more or less similar to the behavior of a human player? This evaluation concerns one of the goals of the Affective Computing area, which is creating synthetic characters that can emulate humans.
Advantages and Disadvantages. Considering Affective Computing, game performance, and RTS games, we want to answer questions like: Which conclusions can we bring to the Affective Computing area? Which are the main consequences of implementing an Artificial Emotional RTS Player? Can this Emotional Agent achieve better results than the original one? In this perspective, we can say that this evaluation concerns one of the goals of Affecting Computing, which is improving machine intelligence.

2. Background

2.1 Emotions and Affective Computing

This work’s subject falls within the field of Artificial Intelligence, in the area of Affective Computing. This modern branch of Computer Science originated with Rosalind Picard’s research [6, 7, 8], where she defines Affective Computing as being “computing that relates to, arises from, or influences emotions”.

An emotion is, according to Damásio, a conscious experience characterized by a “collection of changes occurring in both brain and body, usually prompted by a particular mental content” [9, p. 270], that makes us inclined to act in some way (“states of action readiness” [10, p. 469]). The mental content, also known as appraisal, is a result of confronting a given situation to the individual’s concerns. The collection of physiological changes, also known as arousal, has the purpose to alert the brain for the situation and prepare the body for a responsive action. An emotion has a valence (positive or negative), intensity (its strength), an arousal (readiness to respond), and a category (which are still not consensual).

2.2 Emotional Agents and Appraisal Theories

Affecting Computing seeks to create Emotional Agents through the modeling of emotions in an artificial fashion. An Emotional Agent is an Agent whose deliberative process and interactions with the environment are affected by emotions. Emotional Agents generate emotions by the appraisal of a subjectively experienced event. The result of this appraisal is the input to Appraisal Theories that determine which emotion or emotions should be generated by the agent [12]. There are many different Appraisal Theories, where some of the most important are as follows:

Lazarus’ Cognitive-Motivational-Relational Theory. [13, 14] It considers two kinds of appraising: Primary Appraising, comprising three main components: Goal Relevance, Goal Congruence and type of Ego-Involvement; and Secondary Appraising, which comprises three basic judgments: blame or credit for an outcome, Coping Potential and Future Expectations towards the person-environment relationship.

Goal Relevance is essential to all emotions. An emotion will be only be generated if a goal is at stake during an encounter [13, p.149-150, p.222]. Goal congruence leads to positive emotions and goal incongruence leads to negative ones [13, p.150]. Ego-Involvement refers to diverse aspects of ego-identity, moral values, ego-ideals or life goals.

The main characteristics of this theory are that it emphasizes the importance of Coping Potential to the emotion process and that it defines emotions according to “core relational themes”. For instance, Sadness’s appraisals include low coping potential [13, p.249], contrary to Anger which includes high coping potential [13, p.225-226]. Coping Potential also influences the generated emotion’s intensities in the case of the Fear emotion. Lazarus says that if one “could avoid or escape the sudden danger, fright would be aborted or rapidly mitigated” [13, p.237].

Future Expectancy has to do with whether, in the future, things are likely to change psychologically for the better or for the worse [13, p.150]. Future Expectations also influence the generated emotion’s intensities (with the exception of Fear). For example, with Happiness, if future expectations are guarded or unfavourable, then happiness can be miter or undermined [13, p.268] (or increased, otherwise).

Furthermore, emotions are also characterized according to Action Tendencies and Pathology. For instance, the Action Tendencies for the Fear, Sadness and Anger emotions are, respectively, avoid or to flee from conflict [13, p.238], inaction and withdrawal into oneself [13, p.251] and attack on the agent held to be blameworthy of the offense [13, p.226]. The Pathologies are, for both Anger and Fear, dysfunction and distress [13, p.233, p.239] and depression for Sadness [13, p.253].

Frijda’s Theory. [15] Frijda’s Theory describes emotions as changes in action readiness characterized by “activation” and “action tendency”. When the “activation” is present, the “action tendency” may be translated in behavior. Both “activation” and “action tendency” are altered by regulatory processes. In this process, Frijda identifies two important evaluations: Relevance evaluation and Context evaluation, which is an obvious influence from Lazarus’ theory, when we compare to the notion of primary and secondary appraising. To complement his theory, Frijda also postulated the Laws of Emotions [16, 17], which are rules that govern emotional processes and contain a great deal of essential information concerning the cognitive nature of emotions.

The OCC Model. [18] According to this theory, emotions are a valenced affective reaction to one of three kinds of concerns, depending on whether their eliciting appraisals are focused on: the consequences of an event, the actions of an agent or the aspects of an object. It is widely used in the design of emotional agents due to its simplicity and implementability. It has a simple but exhaustive tree structure, using well-studied concepts in logic such as beliefs, desires and
standards and a combination of finite set of appraisal variables which suffices for current applications [19].

**Roseman's Theory.** [20, 21, 22] This theory’s structure is represented by a grid accounting for 16 different emotions. The structure can be quickly translated into computable rules that define which emotions are generated by each appraisal. The emotions are differentiated through a process of event assessments, where events are categorized according to five variables: *Situation*, *Time*, *Place*, *Person*, *Person*. This differentiation is based on the probability of events occurring, the person they affect, and the emotional response they elicit.  

Emotions are categorized according to *Strength*, *Value*, *Time*, *Place*, *Person*. The strength of an emotion is determined by the extent to which it is felt by the individual. The value of an emotion is determined by the extent to which it is desired by the individual. The time of an emotion is determined by the extent to which it is expected to last. The place of an emotion is determined by the extent to which it is felt in a specific location. The person of an emotion is determined by the extent to which it is felt by another person.

Roseman’s theory makes several important contributions to our understanding of emotion. First, it accounts for the idea that emotions are not just subjective experiences but also have real-world effects. Second, it provides a framework for understanding how emotions are generated and how they can be influenced. Third, it highlights the importance of considering the context in which emotions occur.

When designing games with Affective Computing, the use of computational agents has been a major focus. By incorporating emotion models into the game mechanics, players can experience a more realistic and engaging experience. However, in order to improve the realism of games, it is necessary to implement a comprehensive emotion model that can accurately reflect the emotional state of the player.

**2.4 Emotions in Video Games**

**2.4.1 Affective Gaming**

The combination of Affective Computing, Human-Computer Interaction and video games gave birth to the recent field of Affective Gaming. In games based on Affective Gaming, not only the player’s traditional input controllers enable the player to play the game, but also the player’s emotional state. To read the player’s affective state in real-time, Affective Gaming uses a series of non-intrusive sensors, like biofeedback devices and motion sensor devices.

**2.4.2 Emotion Models**

The player’s emotional experience can also be increased with the inclusion of emotional models in the games themselves [44] which can be relevant for two reasons: they can facilitate the creation of more detailed affective models of the players and they can also enable the game and game characters to dynamically generate affective behavior in real time, in response to situations within the game, and to player behavior. Such adaptive behavior is more believable than 'scripted' behavior, and the resulting realism contributes to an increased sense of engagement by the player.

**2.5 RTS Games’ AI Players**

When playing against the RTS games’ AI players, we can still recognize we are not playing against a human player, and that is what can be improved by incorporating emotion models into the AI. With an emotional model, the AI can exhibit more human behaviors, appear more believable and less mechanical, which offers a much more rewarding experience to the player.

In the context of RTS games, AI has undergone major advances, not only with the advances in the processing power of computers, but also in the quality of the artificial agents created. There has been an effort to reduce cheats, to simulate intelligence and create genuinely smarter agents, but maintaining the strength similar to the strength of a human being.
Game AI is closely related to adversarial real-time planning, decision making under uncertainty, opponent modeling, spatial and temporal reasoning, resource management, and path finding [45]. The current state of RTS game AI lacks planning and learning, which are areas in which humans are currently much better than machines. Therefore, RTS games make an ideal test-bed for real-time AI research.

2.6 The Starcraft II AI

Starcraft II is a RTS game whose story is based on the war between three races: the Terrans, futuristic humans; the Zerg, dangerous insectoids; and the Protoss, technologically advanced aliens. In Starcraft II, players take command over these races and, like any other traditional RTS, gather resources in order to build structures, train units and develop technologies so they can destroy their opponents.

Besides from playing against other human players, we can also play versus the game’s AI. The Starcraft II developers have put a lot of effort in creating the AI player. For instance, the AI has no access to cheats or information about the opposing players, that is, it only knows what it have seen, as if it were a human player.

However, even with these advances there are still large gaps in the behavior of AI players, making them easily identifiable when compared with human players [46] (e.g. parallel processing of the units, regular gameplay over the game, same responses to the same situations). By incorporating human emotions into the AI, we will try to reduce that gap and increase the believability of the AI player. As many researchers have used the game’s editor tool from the Starcraft II predecessor: Starcraft I, to modify the game AI and study the implementation of some AI and Agent techniques, we will use the Starcraft II editor to implement our emotional artificial player.

3. Proposed Solution

3.1 Solution Models

3.1.1 The chosen Influences of Emotions

We have chosen four aspects of the EAIP’s gameplay to be influenced by emotions:

- 1) **Fight / Retreat**: Deciding if it is better to keep fighting or retreat during a battle.
- 2) **Passive / Aggressive**: Adopting a more passive and defensive position or a more aggressive one.
- 3) **Miss clicks / Miss Targeting**: The precision from which the EAIP targets its unit abilities.
- 4) **Rage Quit**: Surrender and leaving the game prematurely.

We chose these four aspects because we believe they can contribute to the believability of the EAIP as they are consequences in key game moments which can also be perceived and visualized by a human player. Furthermore, they were also chosen based on the possible influences of emotions, as described in Section 2.3. The first and second aspects are related to the influence of emotions in Reasoning, Decision Making, Risk Perception and Risk Taking. The third aspect is related to the influence of emotions in Action Execution and Control, and the fourth aspect is related to the influence of emotions in Reasoning, Decision Making and Motivation.

3.1.2 The EAIP’s Emotional Behaviors

In order to influence the chosen four aspects, we need to simulate the corresponding emotions which can have as consequences influences on the aspects that we chose so that we can generate the desired Emotional Behaviors, i.e. the consequences of emotions (that we shall name, for now on, the effects).

Starting with the first effect - “Fight / Retreat” -, we can say that deciding to retreat from a fight or keep fighting is a decision related to Risk Perception and Risk Taking. As described in Section 2.3, “where-as fearful people expressed pessimistic risk estimates and risk-averse choices, angry people expressed optimistic risk estimates and risk-seeking choices” [39]. Additionally, people who are angry or happy make more optimistic risk estimates than people who are sad [40], and fearful people are more risk-averse, contrary to angry people, who are more risk seekers [41]. Taking those studies into account, for this effect, we need to simulate the emotions of Happiness, Anger, Fear and Sadness. Anger and Happiness will influence the EAIP’s risk perception during battles on an optimistic way (e.g. the battle will appear to be more easy to win than it actually is), opposed to Fear and Sadness. In addition, Anger will facilitate risk seeking choices (e.g. fighting even with low chances of winning), contrary to Fear, which will facilitate risk aversion (e.g. retreating even with high chances of winning). Furthermore, as described in Section 2.2, Fear’s Action Tendency is to avoid or to flee [13, p.238] and Fear’s Emotivational Goal and Response Strategy are getting to safety and moving away, respectively [21]. This means, as in concordance with the effects of Fear on risk estimation and choice, Fear must influence the EAIP’s decision of retreating from a fight in a positive way.

Considering the second effect - “Passive / Aggressive “ - , as mentioned in Section 2.2, Sadness’ Action Tendency is characterized by inaction and withdrawal into oneself [13, p.251], and Fear’s Action Tendency is characterized by avoidance and escape to conflict [21, p.238]. On the other hand, Anger’s Action Tendency is characterized by the attack on the agent held to be blameworthy of the offense [21, p.226]. Like-
wise, Sadness and Fear have Behavioral Emotional Components of inaction and inhibition, respectively, and belong to the Distancing Family of appraisals [21]. Anger belongs to the Attack Family of appraisals and with an Emotivational Goal Emotional Component of hurting, getting revenge, and a strategy which involves “moving against other”. Taken this into account, this second effect needs the emotions of Sadness, Fear and Anger, which were already needed due to the first effect.

For the third effect - “Miss clicks / Miss Targeting” -, we know that it is related to the influence of emotions in Action Execution and Control. In RTS games, this can manifest as giving a wrong unit command or missing a targeting unit ability. As stated in Section 2.3, research in neuroscience concludes that emotions significantly influences action generation, execution and control, as “the pathways of emotional responses mediated by the amygdala descend to the brain stem, which organizes and coordinates most relatively simple, stereotypic motor responses and facial expressions” [43, p.14]. “It is hard to put a thread through the eye of a needle when you are in a state of rage or anxiety, simply because you cannot accurately control your hands in such a mood.” [43, p.13]. As described in Section 2.2, one of the Anger’s Pathology is dysfunction [13, p.233]. That being said, this third effect needs the emotion of Anger, which is already needed due to the first two effects.

For the fourth and last effect - “Rage Quit” -, we know that, as described in Section 2.2, Anger and Frustration are closely related [23]. Frustration can be defined as the blockage of goal attainment [24], i.e. victory, in RTS games. Several responses to frustration can include loss self-confidence, stress and quitting, moving away or giving up [28, 29]. These latests can be related to video games, in the form of “rage-quitting”. This often happens when a player feels a large amount of anger or frustration in a short period of time, i.e. an anger spike [29]. In Starcraft II, players sometimes rage quit when they lose a big advantage for nothing and fell anger or frustrated about what happened. That being said, and since Anger is already needed for the other three effects, we will use Anger in order to influence this fourth effect.

To summarize, we then have four emotions that we have to simulate in the EAIP: Happiness, Anger, Fear and Sadness.

3.1.3 The Emotional Appraisal Theory

We need to use an Appraisal Theory in order to know for each of the game’s events which emotion should be generated by the EAIP.

As described in Section 2.2, it appears that the OCC Theory is a good candidate, as it is widely used in the design of emotional agents due to its simplicity and implementability. However, it does not deal with coping potential which is an essential to determine the generated emotion as well as its intensity in a game of Starcraft II. On the other hand, as mentioned in Section 2.2, Lazarus’ Theory includes an evaluation of coping potential. Nevertheless, Lazarus’ Theory isn’t particularly adequate to be implemented because it includes no explicit single appraisal process which aggregates all the emotions. Now considering Roseman’s theory [21], as described in Section 2.2, it shares some similarities with Lazarus’ theory (e.g. coping potential, directed blame) and has a simple table structure which can be quickly translated into computable rules. Taking this into account, we have chosen the Roseman’s Theory as our main Appraisal Theory for our EAIP, as long with some influences from the Lazarus’ Theory and Frijda’s Theory (this can be easily done as some of the cognitive dimensions tend to overlap [13, p.149]).

From Lazarus’ Theory, we are going to use the appraisal components of Ego-Involvement and Future Expectancy, as described in Section 2.2. From Frijda’s Theory we are going to use some of his postulated Laws of Emotions [16, 17], as described in Section 2.1.2, such as [17, p.4-19]:

- **Law of Concern:** If the meaning of a situation is irrelevant to an individual’s concerns, no emotion is generated. This overlaps with the Lazarus’ Theory appraisal component of Goal Relevance.
- **Law of Change:** Emotions are elicited by events with respect to a measure of desirability that is not absolute but rather relative to some referential, which then determines the emotion’s intensity.
- **Law of Comparative Feeling:** For emotion elicitation, what matters is the referential to which the new event is compared. This referential may be the current state of affairs, one’s idea of normality or justice, among others.
- **Law of Habituation:** Repeated experiences of the same situation result in emotions which gradually become weaker. This law, as long with the laws of Change and Comparative Feeling, are then in concordance with the Lazarus’ Secondary Appraisal component of Future Expectancy.

Taking these theories into account, we then have an appraisal flowchart to be implemented in the EAIP’s Appraisal System, as presented in Annex A. Keep in mind that we only generate four emotions, which allows us to simplify the appraisal tree. As explained, we have four appraisal components: Goal Relevance, Motive Consistency, Certainty and Coping Potential, which were taken from the Lazarus’, Frijda’s (Law of Concern) and Roseman’s theories. Only events or player actions which have goal relevance (i.e. achieving victory in the game) will be able to generate emotions. Motive Consistency allows us to distinguish between goal congruent and goal incongruent events. Goal congruent events (i.e. they facilitate victory) can only generate Happiness. If the event is motive inconsistent, then the Event’s Uncertainty
allows us to distinguish Fear from the other motive inconsistent emotions. The EAIP’s Coping Potential against the event can be high or low, which allows us to distinguish between Anger and Sadness, respectively.

As described in Section 2.2, the generated emotion’s intensities are also influenced by several aspects like Ego-Involvement, Future Expectations and Coping Potential.

Much as a human player, the EAIP’s Ego-Involvement (i.e. “life goal” or “ego-ideal”) is to win the game. This means that the more (less) an event contributes to the EAIP’s goal of winning the game, the bigger (lower) should be the intensity of the generated emotion.

As for Future Expectations, when the EAIP experiences a favourable (or unfavourable) situation, the generated emotion’s intensity must be amplified (or reduced) accordingly to the future expectations, i.e. a referential, as it is described in Frijda’s laws. The referential can vary for each situation (e.g. when building a base, the referential is the number of bases each player has) or, in a more general case, the referential can be a general sense of who is at a better position in the game. The Law of Habituation is also implicitly used because, if some favourable (or unfavourable) event repeats itself, the future expectations will increase (or decrease) with each repetition (as long with the referential), and the generated emotion intensities will, by the same process, start to mitigate.

Coping Potential also influences the generated emotion’s intensities in the case of the Fear emotion. According to Lazarus and Roseman, Fear has an uncertain and low coping potential, respectively [13, p.236][21]. If one “could avoid or escape the sudden danger, fright would be aborted or rapidly mitigated” [13, p.237]. This means that if a situation which generates Fear, the Fear’s intensity is mitigated if we have the coping potential to deal with the threat.

3.1.4 The EAIP’s Architectural Model

Using the ideas described in previous sections, we have a complete architectural model for our EAIP, as it is presented in Anex B.

The EAIP’s Architectural Model consists in three main components: The Appraisal System, the State Variables and the Emotional Behaviours. When a percept (i.e. a game event) comes from the game environment it is evaluated by the Appraisal System to determine which emotion is generated, if any, as it was described in Anex A from Section 3.1.3. When an emotion is generated, its intensity is influenced by the Coping Potential (only for the Fear emotion), Ego-Involvement and Future Expectations (which by themselves depend on the Game’s State and the Frijda’s Laws of Change, Habituation and Comparative Feeling). The EAIP’s current emotions’ intensities are then updated accordingly. Then, as described in Section 3.1.2, the emotions’ intensities will influence the original AI’s components of Reasoning, Motivation, Action Execution and Control, Decision Making, Risk Perception and Risk Taking in order to achieve the desired Emotional Behaviours by modifying the AI’s actions. Keep in mind that the AI’s actions are only influenced by the emotions went their intensities are at specific states, which means that, when the emotions’ intensities aren’t sufficient enough to generate an Emotional Behaviour, the EAIP will behave as the original AI.

3.2 Solution Implementation

3.2.1 The EAIP’s Base Variables

The EAIP’s four emotions are represented by a set of four variables, each of them holding the corresponding emotion’s actual intensity. As most emotions’ intensities decay as the time passes [6], each emotion’s intensity decreases each game second.

One important variable is the General Game State (GGS). The GGS is a rational number (from 0 to 1) and it is an indicator of the game state for the EAIP, i.e. how well the game is going for it. It is a weighted sum of the EAIP’s performance in several Game Aspects (GA) (e.g. Income, Army Strength). Each GAs can also be evaluated separately, and the EAIP’s performance in each of them is ranked using a Level System (LOW, NORMAL and HIGH). The purpose of the GGS, as well as each of the GAs evaluators, is to influence emotion’s intensities during the EAIP’s appraisal process, as we describe in the next section.

3.2.2 The EAIP’s Appraisal System

The EAIP’s Appraisal System is mainly based on triggers. When a specific game event or agent action (that we shall name, for now on, the sources) arises, a trigger is fired in order to evaluate which emotion, if any, is generated, as well as its intensity, i.e. the appraisal process. These are called the Appraisal Triggers (AT). Each source has its own AT. Not all ATs function in the same way, but they have similar structures, as is described as follows.

Most ATs have pre-determined intensities which are generated according to each source. However, the generated intensities are always attenuated according to what we call Intensity Factors, which represent the Future Expectations of the EAIP as long with any influences of the Frijda’s Laws of Emotion that might modify the generated emotion’s intensity, as described in Section 3.1.3. For instance, when the EAIP builds a new base the Future Expectations are based on the number of bases comparing with the opponent and on the income Level, which is a GA. If the EAIP has now 2 or more (or less) bases than its opponent, then the intensity factor is set at 1 (or 0.2).
If the difference in bases is now of 1 or less, the \textit{intensity factor} is set at 0.4, 0.6 or 0.8. This means we have the following graphic (ignoring the influence of the income Level), as presented in Figure 1:

![Base Build Intensity Factor Graph](image)

\textbf{Figure 1} – “Base Build” Intensity Factor Graph.

This sigmoid type of graph is in direct correspondence with Frijda’s Laws of Change and Comparative Feeling, as described in Section 3.1.3, with the \textit{Referential} being, in this case, the different in bases between the EAIP and its opponent. The more (less) bases the EAIP has over its opponent, the more the Happiness starts to attenuate, as the referential moves up (down) and positively (negatively), i.e. the changes in Future Expectancy are less and less relevant. On the other hand, if the EAIP and its opponent both have one base, and the EAIP manages to build a new one, the \textit{intensity factor} (0.8 in this case) as long with the generate Happiness are big, as the EAIP has now the double of bases over its opponent, i.e. the Future Expectations and change of Referential are now much higher (than, for example, building a sixth base when the opponent only has 2).

Some other ATs use the GGS as the \textit{Intensity Factor}. This happens when the \textit{source} (e.g. researching a new upgrade) has no explicit referential to which we can compare to see if there was any significant improvement on the EAIP’s Future Expectations. The GGS acts as a general indicator of how well is going the game for the EAIP. It functions like an aggregator of all GAs, i.e. all referentials.

ATs related to Anger and Sadness always evaluate the \textit{Coping Potential} of the EAIP in order to recover from the Goal-Incongruent source. For instance, when the EAIP loses a base, we must see if it has the capability to rebuild a new one. If so, Anger will be generated, or Sadness otherwise.

Some ATs also have what we call \textit{Emotion Cooldown Timers}. They prevent the same emotion from specific sources to be generated over and over again. For instance, we the EAIP reaches an high income GA, we want it to generate Happiness. Still, we don’t want it to be constantly generating Happiness when it is in a high income GA state. Thus, and following the ideas behind Frijda’s Law of Habituation, as described in Section 3.1.3, we disable this AT for a certain amount of time each time the source arises, i.e. an \textit{Emotion Cooldown Timer}.

ATs related to the Fear emotion function with two differences. The first one is that, as described in Section 3.1.3, the \textit{Coping Potential} influences the generated Fear’s intensities, i.e. it corresponds to the Fear’s \textit{Intensity Factors}. This means that if a situation generates Fear (e.g. the opponent has harass units), the Fear’s \textit{intensity} is mitigated if the EAIP has the coping potential to deal with the threat (e.g. a good base defences Level). The second difference is that, at any type, Fear’s the corresponding threat does no longer exists, the Fear’s \textit{intensity} is instantly dropped by the same amount it was raised (taking into account the decay rate that already has passed).

### 3.2.3 The EAIP’s Emotional Behaviors

As we have the ATs for dealing with the appraisal process, we also have \textit{Effect Triggers} (ET) to deal with the four effects.

1) **Fight / Retreat.** This effect’s ET is a periodic trigger that repeatedly fires during a battle. At each execution, the EAIP decides if it wants to continue fighting or retreat. That decision is made over several steps and is influenced by the emotions. First, using several GAs, we calculate the chances of the EAIP winning the battle. Then, as described in Section 3.1.2, Anger and Happiness influence the EAIP’s risk perception during battles on an optimistic way, opposed to Fear and Sadness. So, the winning chances are changed accordingly to those emotion’s intensities. Now the EAIP must decide how much risk it wants to take. As described in Section 3.1.2, Anger facilitates risk seeking choices, contrary to Fear, that facilitates risk aversion. The winning chances are then inflated and deflated, respectively, according to those emotions’ intensities. If the final result is greater than 50%, the EAIP decides to continue to fight, otherwise it retreats to the nearest base. A graph version of this process can be found in Anex C.

2) **Passive / Aggressive.** This effect is about adopting a more passive position or a more aggressive one, which we call the \textit{Passive and Aggressive Stances}, respectively. It is implemented using a periodic ET that runs each 2 game seconds. As we saw in Section 3.1.2, the emotions related with the \textit{Passive Stance} are Sadness and Fear, and those related with the \textit{Aggressive Stance} are Anger. So, each time the ET runs, we check if the EAIP’s \textit{Stance} changes according to those emotions’ intensities. This is done using the decision tree presented in Figure 2.

The “Threshold” acts as a minimum \textit{intensity} the emotion must have in order to trigger a \textit{Stance}. In order to enter the \textit{Passive Stance} through the Sadness emotion, we also include the test with Happiness because it wouldn’t make sense to enter a passive state if the Happiness’ \textit{intensity} was bigger than Sadness’. To prevent constant fluctuations among the three Stances as long with strange behaviors, whenever the EAIP changes \textit{Stance} it cannot change again.
until after some time. After determining if the EAIP’s Stance has changed or stays the same, the current Stance takes effect. When in the Passive Stance, the EAIP never attacks its opponent and, when on the Aggressive Stance, the EAIP is constantly “blindly” attacking its opponent. When in none of those Stances there is no additional effect.

Figure 2—“Passive/Aggressive”Stance Decision Tree.

To prevent strange behaviors like staying at base when another base is being destroyed, we disable the Stance’ effects when the EAIP is under attack. At the same time, when on the Aggressive Stance, we prevent the EAIP from attacking with very few units knowing its opponent has a much bigger army.

3) Miss clicks / Miss Targeting. This effect is implemented using an ET which runs every time the EAIP uses units’ abilities (only abilities targeting map points are considered, i.e. “skill-shots”), and Anger’s intensity is above a certain threshold. If so, the ability is instead used targeting a new generated point, just as if the EAIP had its aiming capabilities deteriorated. The new point is generated in the following way: we create a circle with the center being the original point where the ability was being targeted at and with a radius that increases as long with the Anger’s current intensity. Then, we chose a random point inside that circle, which is the new target for the ability. This way, the bigger the Anger’s intensity, the greater the circle and the greater are the chances of having bigger and bigger distances on the miss-click.

4) Rage Quit. As we saw in Section 3.1.2, rage quit happens when a player feels a large amount of Anger in a short period of time, i.e. an Anger spike. As such, this effect is implemented using a periodic ET which runs every game second and checks for Anger Spikes. This is done by storing, for each of the last 15 seconds, how much the Anger’s intensity has fluctuated when comparing to the previous second. Then, if the sum of the fluctuations over those seconds is greater than a threshold, then we consider to have an Anger Spike. When an Anger Spike occurs, we perform additional checks to see if it is acceptable for the EAIP to rage quit the game. Therefore, even if an Anger Spike occurs, the EAIP doesn’t rage quit if Happiness’ intensity is greater than Anger’s intensity or if the Level of the GAs “Number of Bases comparing to the opponent” or “Army Strength” is HIGH.

4. Solution Evaluation

4.1 Evaluation Procedure

4.1.1 Evaluating the EAIP’s Believability

Most of the EAIP’s Emotional Behaviors aren’t always taking effect over the course of a match. Therefore, our evaluation procedure consisted on a survey coupled with video footage from the EAIP’s gameplay (including some comparative cases with the original AI). The survey consisted on a series of questions about small videos each of them showing a specific game situation where the EAIP is influenced by one of the four implemented Emotional Behaviors. This allows us to focus on the game situations where the emotions actually take effect on the EAIP, as well as obtaining answers in a quicker fashion.

For each of the videos, we ask the participants if they are able to identify the identity of a specific player (i.e. the EAIP, in all the cases), to which they can answer: “Human”, “AI” or “No idea”. If they answer “Human” or “No idea”, then we ask why they think that player acted that way, to which they can give a pre-established answer (which includes reasons related to emotions) or they can give an open answer. On the other hand, if they answered “AI”, we then ask for a level of believability (from a scale 1 to 5) of that player’s actions. In either ways, we also ask which of the cases participants think it is more believable: the one from the video, i.e. the EAIP, or a case with the same player having the opposite reaction (e.g. fight instead of retreat), i.e. the AI original reaction. Keep in mind that during the survey we never reveal to the participants the true identities of the players in the videos nor we mention the existence of an EAIP.

4.1.2 Evaluating the EAIP’s Advantages and Disadvantages

Our evaluation procedure to discover the advantages and disadvantages of the EAIP will be done in three ways: by evaluating some of the participant’s answers on the survey, through a personal analysis of the EAIP and by evaluating the EAIP’s performance against the original AI.

4.2 Results Analysis

Our survey was answered by 54 participants. Their average level of knowledge about RTS games and Starcraft II was auto-evaluated in 4.2 and 4.1, respectively (from a 1 to 5 scale).

4.2.1 Believability Analysis

In order to assess the believability of the EAIP we will use the results from the survey questions related
to Player Identification, AI Believability Level and More Believable Case. This will allow us to see if the EAIP is capable of appearing to be a human player (Player Identification), if it can be more believable than the original AI (More Believable Case) and, when seen as an AI, what are its levels of believability (AI Believability Level). Therefore, we present in Table 1 and Table 2 a condensed form of the results related to Player Identification and AI Believability Level and of the results related to More Believable Case, respectively, for each off the effects, as well as their aggregation:

<table>
<thead>
<tr>
<th>EAIP Identification</th>
<th>Al Believability Level (Averages)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effect 1)</td>
<td>45%</td>
</tr>
<tr>
<td>Effect 2)</td>
<td>55%</td>
</tr>
<tr>
<td>Effect 3)</td>
<td>63%</td>
</tr>
<tr>
<td>Effect 4)</td>
<td>75%</td>
</tr>
<tr>
<td>All Effects</td>
<td>55%</td>
</tr>
</tbody>
</table>

Table 1 – EAIP Identification Results.

<table>
<thead>
<tr>
<th>EAIP Case</th>
<th>AI Case</th>
<th>Both Cases</th>
<th>None of the Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effect 1)</td>
<td>32%</td>
<td>31%</td>
<td>37%</td>
</tr>
<tr>
<td>Effect 2)</td>
<td>54%</td>
<td>5%</td>
<td>41%</td>
</tr>
<tr>
<td>Effect 3)</td>
<td>25%</td>
<td>20%</td>
<td>45%</td>
</tr>
<tr>
<td>Effect 4)</td>
<td>23%</td>
<td>5%</td>
<td>71%</td>
</tr>
<tr>
<td>All Effects</td>
<td>36%</td>
<td>19%</td>
<td>45%</td>
</tr>
</tbody>
</table>

Table 2 – More Believable Cases Results.

Starting with the first effect – “Fight / Retreat” - , considering Table 1, we see that it has the lowest percentage of “Human” answers (45%) and the highest percentage of “No idea” answers (35%). Considering Table 2, we can see the results were almost evenly balanced. Even so, this is the effect with the highest percentage of “The AI Case” answers (31%) and the lowest percentage of “Both Cases” answers (37%).

This was the effect which failed the most at convincing the participants the EAIP was a human player (45%) and, on the other hand, it was the effect which led the participants to be more undecided (35%).

The low percentage of “Human” answers coupled with the high percentage of “No idea” make us conclude that, because this effect makes the EAIP fight battles with low chances of winning and retreat from battles in which it had high chances of winning, this effect can lead to many different perceptions about the player. The participants can have considered those decisions to be strange for a human or AI player, as they would normally have dealt with the situation differently. Furthermore, they can have considered that sometimes players (human or AI) can make mistakes or be unskilled in the game. This can be shown as many participants, after answering “No idea”, said as open answers that the reasons behind the player’s decisions were, among others: “unskilled decision”, “strange decision” or “Overconfidence”. This also explains the high percentage of “The AI Case”, as participants were expecting the opposite decision to by the player (between fighting and retreating).

We then conclude that this effect - “Fight / Retreat”, although it doesn’t contribute much for the EAIP to be identified as a human player, it can create some confusion and differentiation from the original AI. Even with the highest percentage of “The AI Case” answers, this effect also has an average percentage of “The EAIP Case” answers, which makes a good contribution for the EAIP’s believability.

For the second effect – “Passive / Aggressive” - , considering Table 1, it has the second highest percentage of “Human” answers (55%) and the highest average of AI Believability Level (3.4). Considering Table 2, it has the highest percentage of “The EAIP case” answers (54%) and one of the lowest percentages of “The AI case” answers (5%).

This means that this is the effect which presents the best results in terms of believability. It is the only one where more than half of the cases (54%) the EAIP’s behavior was considered to be more believable than the original AI (which has only 5% answers). Furthermore, in more than half of the cases the EAIP’s behavior is seen as a human one (55%) and when it doesn’t, its AI Believability Level is 3.4, which is also above average.

Despite the also high percentage of “Both cases are believable” (41%) answers, we can then say that the original AI’s decisions about being passive or aggressive have some deficiencies, as they seem not to correspond to the expectations of the players.

We can conclude that this second effect – “Passive / Aggressive” greatly contributes to the believability of the EAIP and, when it doesn’t, its behaviors are at least as good as those from the original AI.

For the third effect – “Miss Targeting” – considering Table 1, it has the highest percentage of “AI” answers (31%) and the lowest average AI Believability Level (2.7). Considering Table 2, it has the lowest percentage of “The EAIP case” answers (25%) and the highest percentage of “The AI case” answers (28%).

Considering the remarks from Table 1, as well as the fairly high percentage of “Human” (53%) and the fairly low percentage of “No idea” answers (16%) this means that, under this effect, the EAIP can be easily identified as a human player (who missed the unit’s abilities) or as an AI player with low believability.

Considering the remarks from Table 2, we can see that this effect is the one that less contributes for the believability of the EAIP. As the percentages of “The EAIP case” “ and “The AI case “ are very similar and, if summed, we have roughly the same percentage of answers as “Both cases “, we can say that, in average, the EAIP’s behavior is at least (45% of the cases) as believable as the original AI. This can be explained by the fact that, in Starcraft II, either missing or hitting the unit’s abilities are always two common outcomes.
This third effect — “Miss clicks / Miss Targeting” — make us conclude that it can have opposing consequences on the identification of the EAIP’s identity: in roughly most of the cases (53%) the EAIP is seen as a human player and then, in almost a third of the cases (31%) it is seen as a poorly built AI. Despite having a contribution of 25% to the EAIP’s believability, almost most of the times (45%) the EAIP’s behavior is as believable as the original AI.

For the fourth effect — “Rage Quit” — considering Table 1, it has the highest percentage of “Human” (76%) answers as long as with the lowest percentage of both “AI” (11%) and “No idea” (13%) answers. Considering Table 2, it has the highest percentage of “Both cases” answers (71%) as long as with the lowest percentages of both “The EAIP case” (23%) and “The AI case” answers (5%).

Therefore it is the effect with the best results in terms of Player Identification, as more than 75% of the cases the EAIP is, under that effect, seen as a human player. This can be explained by the fact that players generally associate rage quitting with a human player. However, considering the remarks from Table 2, we see that this effect has a very small increase in believability because, even if the percentage of “The EAIP case” answers is far more superior than the percentage of “The AI case” answers, 71% of the cases the EAIP’s behavior is as believable as the original AI.

We can then conclude that this effect — “Rage Quit” — despite greatly contributing to the identification of the EAIP as being a human player, the results on increased believability are not very substantial.

When considering all of the effects, we see that, in Table 1, The EAIP can roughly in most of the cases be seen as a human player (55%) and, in some of the cases, it can at least differentiate itself from the original AI (25%). Roughly all of the four effects made the same contribution to this result. Although this doesn’t prove us that the EAIP is more believable than the original AI (because the original AI can also be identified as a human player) we can at least be sure of the existence of cases where the EAIP can be seen as a human player. If not, we could be falling in the error of having more believable behaviors, but still strange and non-human ones.

When analyzing the results from Table 2 we see that, in 36% of the cases, the EAIP’s behavior is considered to be more believable than the original AI. Taking this into account, we can say that the results from our work in terms of improving the original AI’s believability, although they weren’t exceptionally positive or negative, prove to be encouraging. At least in 45% of the cases the EAIP is as believable as the original AI and only in 19% of the cases it is considered less believable.

We can then conclude that, besides the EAIP can be seen as a human player most of the cases, the results in believability from Table 2 are enough to prove our hypothesis that:

“By simulating Emotional Behaviors in an Artificial Player for an RTS Game we can achieve a higher degree of believability.”

Keep in mind that the EAIP’s believability was mainly evaluated by experienced players, and the achieved believability results are only related to the four effects we have implemented, and are not to be viewed in a more general perspective.

4.2.2 Other Relevant Conclusions

As described in Sections 1.3 and 4.1.2, we want to answer the questions of: “Which other conclusions can we bring to the Affective Computing area?”, “Can this Emotional Agent achieve better results than the original one?” and “Which are the main consequences of implementing an Artificial Emotional RTS Player?”.

Concerning the first question, we present in Table 3 a summarized form of the results from the answers related to Behavioral Reasons (i.e. why the participants think the player, in all cases, the EAIP, acted in a certain way):

![Table 3 – EAIP Behavioral Reasons.](image)

By observing Table 3, we see that for both the first and third effects, the participants mostly consider the reasons of the EAIP’s behaviors to be non-emotional. As the first effect is related to fighting and retreat, and the third one is related to hitting unit’s abilities, we can conclude that most players consider those game aspects to be principally determined by strategic decisions and skill, respectively. This can also explain the similar percentages of “The EAIP case” and “The AI case” found in Table 2 from the previous section for these effects. Both behaviors (fighting or retreat and hitting unit’s abilities) and skilled related, and therefore it is always common or believable to see one or another. On the other hand, we see that for both the second and fourth effects, the situation is reversed. For the fourth effect, this was already expected, as the main reason behind rage quit is anger, which is an emotional reason. For the second effect — “Passive / Aggressive”, players mostly considers the reason of the behavior to be emotional, which leads us to conclude that sometimes, the reason that leads a player to be more offensive or defensive is not only perceived to be strategy related, but it can also be perceived to be emotionally related.
When we take all effects into account, we see that, in general, the participants consider most of the times the reasons for the behaviors to be non-emotional. Maybe this happens because we need a higher quality EAIP, or because players aren’t used to the idea of emotional agent players, or because they underestimate the influences of emotions, especially in a RTS game. However, this can prove to be contradictory to the purpose of our work. Why building an emotional artificial intelligent player if, most of the times, the players will consider that the reasons behind its behaviors are non-emotional? Yes, we have improved its believability but, if the reasons for the behaviors are never considered to be emotional, maybe we can just simply incorporate randomly generated behaviors into artificial players and achieve the same level of believability, with less work, complexity and required processing power. The answers to these issues may require further investigation.

In order to answer the second question - “Can this Emotional Agent achieve better results than the original one?” – we need to analyze the results from the performance tests. In those tests, the EAIP won 31% of the games against an AI with the same level of difficulty. In Starcraft II, as with most RTS games, when we face two AI’s with the same level of difficulty, we have win rates close to 50%. Thus, as the EAIP only won 31% of the games, we can conclude that the emotional behaviors have deteriorated the AI’s performance. This can be explained as most of the effects we have implemented have a negative impact on the EAIP’s gameplay. For instance, the first effect – “Fight / Retreat” – can make the EAIP keep fighting during a battle with low chances of winning, or retreat from a battle in which it had high chances of winning, both of which don’t contribute to victory. The third effect – “Miss clicks / Miss Targeting” – only contributes for the EAIP to miss its unit’s abilities. The fourth effect – “Rage Quit” –, can also only contribute to defeat, as it makes the EAIP leave the game, sometimes prematurely, where it still had chances of winning.

Considering the third question - “Which are the main consequences of implementing an Artificial Emotional RTS Player?” - the development of this EAIP can also bring some advantages to RTS games area in general. The trigger-based architecture we implemented, using Appraisal Triggers (AT) and Emotional Triggers (ET) can be used in other RTS games in order to achieve the same or other objectives, like performance. When in shortage of human players, the EAIP can also be used for competitive training, as its behaviors are closer to the human ones when comparing to the traditional AI.

However, the EAIP also has its disadvantages in RTS games. Sometimes players, for training purposes, only want to play against efficient and good players or AI, something that the EAIP fails to offer, as we saw that its performance is worse than the original AI. In addition, during the survey, some participants said in some open answers that they were against the fourth effect – “Rage Quit” –, because no AI should rage quit for the sake of believability, as it takes the pleasure of winning from a human player. This can prove to go against the second goal of Affective Computing – making robots or machines which can emulate humans – as this time, the artificial case is preferred over the believable “human” one. Furthermore, The EAIP also requires more memory and processing power than the original AI, something that, if we want the EAIPs to be more complex and believable, can start to prove as a difficulty.

5. Conclusions

5.1 Final Conclusions

As stated in Section 4.2.1, in 36% of the evaluation cases, the EAIP’s behavior was considered to be more believable than the original AI, which is enough to prove our hypothesis.

The second effect – “Passive / Aggressive” was the one which contributed the most to that increase in believability. It also made us conclude that the original AI may have some imperfections when it takes to deciding whether to be passive or aggressive, as it seems not to corresponding the player’s expectations. The EAIP is also identified as a human player in most of the cases (55%), and it is most due to the fourth effect – “Rage Quit”. Although this doesn’t prove us that the EAIP is more believable than the original AI, these are good indicators to whether we have achieved a human-like behavior with the EAIP.

As described in Section 4.2.2, the reasons behind the EAIP’s behaviors were most of the time considered to be non-emotional (54%). This can prove to be contradictory to the purpose of our work and Affective Computing in general. Why building an emotional artificial intelligent player if, most of the times, the players will consider that the reasons behind its behaviors are non-emotional? Perhaps we can achieve the same level of believability by simply incorporating randomly generated behaviors into artificial players, which requires less work, complexity and processing power. These answers to these conclusions may require further investigation.

The EAIP’s performance was also deteriorated, as its win rate against the original AI is far below the standard 50% (only 31)! This is explained by the fact that most of the effects we have implemented, although they have increased the believability, they have a negative impact on the EAIP’s gameplay.

Nevertheless, the trigger-based architecture we implemented, using Appraisal Triggers (AT) and Emotional Triggers (ET) can be used in other RTS games in order to achieve the same or other objec-
tives, like performance. When in shortage of human players, the EAIP can also be used for competitive training, as its behaviors are closer to the human ones when comparing to the traditional AI.

The EAIP also has its disadvantages in RTS games. Sometimes players, for training purposes, only want to play against efficient and good players or AI, something that the EAIP fails to offer, as we saw with its performance. The issue of rage quitting for the sake of believability also goes against the second goal of Affective Computing – making robots or machines which can emulate humans –, and this may also require further investigation. Furthermore, The EAIP also requires more memory and processing power than the original AI, something that, if we want the EAIPs to be more complex and believable, can start to prove as a difficulty.

To conclude our thesis, our increase in believability is encouraging for the continuation of our work. We hope that the development of this emotional player serves as the first step for creating believable artificial emotional players with which we can play against, as well as contributing to the field of Affective Computing and RTS games in general.

5.2 Future Work

More Sources, Effects and Emotions. The EAIP’s emotional model can be expanded with additional emotions, sources and effects. For instance, we can include emotions like Pride, Relief, Surprise, Shame, Nervousness, Hope or Worry, as long with their own sources. In addition, we can also develop other interesting effects such as: making strategy or tactical mistakes, focusing feared units in battles, changing the APM limit or being bounded to attention focus.

EAIP Personalities. The EAIP can also be parameterized with Personalities. Each personality type differs in the way each of the emotions’ intensities rises (and decays) for each of the possible sources. For instance, a “Nervous” EAIP will see the intensity of the Nervousness emotion quickly rising each time the Nervousness’s sources occurs.

EAIP Communication Module. During a Starcraft II game between human players, the players are allowed to communicate with each other through chat messages. In order to increase the EAIP’s believability, we can also implement a Communication Module that allows the same type of interactions while considering the EAIP’s emotional state. The exchanged messages will belong to a pre-defined set known to the EAIP. This could demonstrate how it would be to simulate chat messages and responses which vary according to the EAIP’s emotional state (as well as affecting it), and can also serve as a starting point for a future work related to a natural language interface.

References


Anex A
The EAIP’s Appraisal Flowchart.

Anex – B
The EAIP’s Architectural Model.
Anex – C
Fight / Retreat” Decision Process
Graph Version.