Dealing with the emotions of Non Player Characters

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ABSTRACT

Usually in games, the interaction between player and NPCs are very limited and does not allow the spontaneous creation of long-term relationships. The NPCs are cold, direct and faithfully follow his instructions while keeping a well-defined pattern of behavior. The present paper proposes a model to ease the way NPCs act and react, based on human psychology and simulation of emotions. Therefore, the emotions are used to modify the mental state of the NPC, enabling decisions for different reactions and the same event. Each NPC has a personality described using the OCEAN model that is commonly used by psychologists to determine an individual personality. The personality description of a NPC determines how the emotional stimuli are interpreted differently and its current emotions are calculated based on the influential emotion generated by an event and its personality. Finally, state machines are used taking into account human emotions and the individual personality of each NPC, allowing the player to be friend or foe of NPCs depending on their actions with each NPC. This model has been used to develop an experimental game has shown excellent results. In this game, the player plays the role of an adventurer who explores exotic lands and meet creatures (NPCs) that at first may not react to their presence. If the player decides to attack the NPCs, will react by attacking, evading, or becoming friends depending on their personality modeled through a Big Five test.

Keywords: Emotions, Game AI, state machines, big-five, emotional agents.

1 INTRODUCTION

Diverse areas have long argued the importance of characters and proper character development to stories [3, 9, 36]. In the universe of digital games, characters are not always necessary (i.e. Tetris [29]), however the possibilities in engaging character designing has surfaced in diverse successful commercial games since the 1990s [22].

Non-Player Characters (NPCs) is the generic term used to define computer controlled character in a game computer game. Their importance goes from peripheral/decorative (i.e. Crocodiles on Pitfall [1]) to central in the game play (i.e. Ghosts in Pac-Man [15]) depending on the design decisions. Recently, a new wave of story-driven games has gathered a lot of attention. The Last of Us [6] is at the core of this group of successful games, as it is one of the most beloved games of all time, gathering a huge amount of awards since it has been released with a highly awaited sequel planned to be released. The main focus of the game is the relation between the leading characters and its major achievement was engaging the player into their relation through a well written development for the characters and the story.

In some games there are NPCs that help the Player Character (PC), giving game objects to aid the player, and others that act as a helper working side by side with the PC. For instance, the game Ico used the cooperation between the player and a NPC as core feature of its gameplay [38]. Ico received numerous awards and gained a large fan base, being critically acclaimed and well commended for its design decisions. There are various others prosperous games that invested in character designing as well as elevating the participation of non-player characters in the gameplay, improving the interactions between player and Artificial Intelligence (AI) characters, showing the potential of developing rich and engaging character relations in the universe of a game.

But fewer games makes the NPCs AI dynamic enough to change behaviours in relation to the player character, fluctuating between friendly and harmful interactions. On top of that, the effort into creating an interesting and rich interaction with a NPC is usually focused on leading characters only, which is the case for the famous games cited above. To design an individual personality NPC that relates in a specific way to the player is time consuming, and to implement it individually to each NPC of a game is not feasible if we consider that there are limited resources.

Our goal in this paper it to present an AI model that mimics human emotions and personalities that was used in our game prototype in all game NPCs. Each NPC of the game has its own personality and emotional bias with behaviours that are shaped on actual events that affect them, creating a rich ambient of unique individuals that the player can interact with. The proposed model is based on the OCEAN personality model that is commonly used by psychologists to determine an individual personality [37, 34] and also revolves around the emotion model proposed by Robert Plutchik for contrasting and categorization of emotions [33, 31, 32].

2 RELATED WORKS

In order to understand the emotional notation, some psychological papers were consulted and used to define the aspects initially proposed by Plutchik. He proposed the wheel of emotions model in his works [33, 31, 32], based on psychoevolutionary theories and the idea of complex emotions through a combination of basic emotions. The combination enables the emotions to describe a wider variety of emotional aspects. These ideas are used in several studies in Computer Science to set numerical ranges to represent the relationship between emotions and their intensities.

The personality model adopted is based on the Big-Five inventory described by John and Srivastava in [16]. His work describes the five personality traits and also features a big-five inventory that is used to describe the personalities of real individuals. The John and Srivastava's inventory was used to create individual instances during the experiments. In [18], Kallias debate on the relationship between personality traits and preferences for film genres, arguing that there is a correlation between the personalities and genre biases.

The personality aspects obtained by the big-five inventory can be classified through MBTI and Keirsey temperaments. McCrae and P. Costa present in [26] a way to convert the 5 personality traits and classify them into one of 16 personality types of the Myers-Briggs indicator described in [13, 21, 23]. Personality types are used to trace the personality profile of an individual and tend to group similar individuals in the audience. There is also a user sorting through stereotypes and behaviors proposed by Rich in [34].

In [17], Jones *et al.* argues that may be differences in the evaluation of a particular object or action by different individuals. This

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divergence can be classified as the difference between the expected value and the perceived value by individuals. The relationship between personality traits and emotional factors are described by Tupes *et al.* in [37].

In another direction, some papers related to recognition and simulation of emotions were consulted. The dynamic models of emotions are presented by [7, 8, 5]. These work proposes a dynamic model of emotions based on Plutchik's model and Big-five personality traits to simulate the progression of emotions of an individual or virtual agent after stimuli. In [4], the author presents another dynamic model of emotions to define facial expressions of virtual conversational agents. This technique is used to humanize the agents, producing a better quality communication. Also in [30] similar techniques are used in artificial generation of emotions based on personality, mood and emotions in order to simulate facial expressions in robots.

In [19, 20], the state-of-the-art of emotions and personalities simulations are described. The authors propose an approach for the development of virtual agents with emotional memory for objects, people, and certain issues.

The recognition and classification of emotions is covered by [27]. In his work, emotions are analyzed using the text of stories and fairy tales. The author presents an approach to classify the stories in literary genres.

In [14], the author presents a review of the literature regarding the emotional classification based on facial recognition, voice, eyes, gestures, brain waves, heart beats, muscle contractions and other information and achieved by sensors. Techniques for the recognition of emotions in continuous time by monitoring of individuals are presented by [12].

Finally, Orellana-Rodriguez *et al.* [28] tries to sort the emotions from short YouTube movies by analyzing users comments.

3 Model of Emotions

During film screening, the audience gets emotionally involved with the story. Individuals in the audience reacts according to their preferences. When an individual enjoys what is staged, he/she tends to reflect the same emotions that are proposed by the story. The greater the identification between the individual and the story, the greater are the emotions experienced.

As an audience can be composed of individuals who have very different preferences, it is important that the storyteller identifies a middle ground to please as many as possible. Knowing some personality traits of each individual helps to get the story closer to the audience.

3.1 Model of Emotions

The emotional notation used to describe the scenes of a story is based on the model of "basic emotions" proposed by Robert Plutchik [31, 32]. Plutchik's model is based on Psychoevolutionary theory. It assumes that emotions are biologically primitive and that they evolved in order to improve animal reproductive capacity. Each of the basic emotions demonstrates a high survival behavior, such as the fear that inspires the fight-or-flight. In Plutchik's approach, the basic emotions are represented by a three-dimensional circumplex model where emotional words were plotted based on similarity (Figure 1)[33]. Plutchik's model is often used in computer science in different versions, for tasks such as affective human-computer interaction or sentiment analysis. It is one of the most influential approaches for classifying emotional responses in general[10].

Each sector of the circle represents an intensity level for each basic emotion: the first intensity is low, the second is normal and the third intensity is high. In each level, there are specific names according to the intensity of the emotion, for example: serenity at

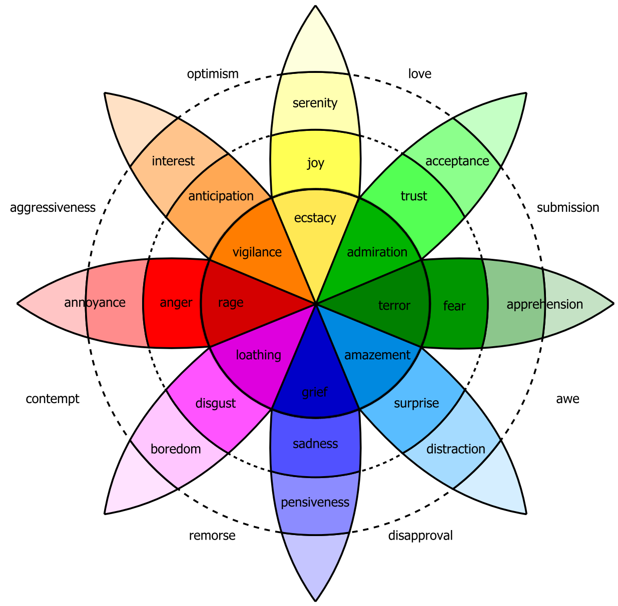

Figure 1: Plutchik's wheel of emotions

low intensity is similar to joy and ecstasy in a higher intensity of the instance.

Plutchik defines that basic emotions can be combined in pairs to produce complex emotions. These combinations are classified in four groups: Primary Dyads (experienced often), Secondary Dyads (sometimes perceived), Tertiary Dyads (rare) and opposite Dyads (cannot be combined).

Primary Dyads are obtained by combining adjacent emotions, e.g., Joy + Trust = Love. The Secondary Dyads are obtained by combining emotions that are two axes distant, for example, Joy + Fear = Excitement. The Tertiary Dyads are obtained by combining emotions that are three axes distant, for example, Joy + Surprise = Delight. The opposite Dyads are on the same axis but on opposite sides, for example, Joy and Sorrow cannot be combined, or cannot occur simultaneously [33]. Complex Emotions - Primaries Dyads:

- anticipation + joy = optimism
- joy + trust = love
- trust + fear = submission
- fear + surprise = awe
- surprise + sadness = disappointment
- sadness + disgust = remorse
- disgust + anger = contempt
- anger + anticipation = aggression

This model assumes that there are eight primary emotions: Joy, Anticipation, Trust, Fear, Disgust, Anger, Surprise and Sadness. It is possible to adapt the Plutchik's model within a structure of 4-axis of emotions [35, 2] as shown in Figure 2.

The Plutchik's model describes a punctual emotion and it is used to represent an individual or a scene in a specific moment. In order to describe the emotions of a scene, the Plutchik's model is converted to a time series of emotions called "dramatic curve". The dramatic curve describes the sequence of emotions in a scene in an

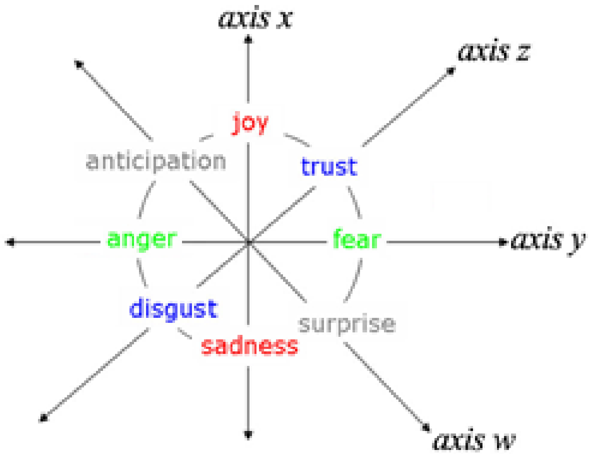

Figure 2: Simplified 4-axis structure - families of emotions

interval of one second per point. It follows the structure of 4-axis based on Plutchik's wheel and maps the variation of events in a story.

3.2 Model of Personality

In Psychology, there are many models to map and define an individual's personality traits. One of the most used is called Big Five or Five Factor Model, developed by Ernest Tupes and Raymond Christal in 1961 [37]. This model was forgotten until achieving notoriety in the early 1980s [34]. This model defines a personality through the five factors based on a linguistic analysis. It is also known by the acronym O.C.E.A.N. that refers to the five personality traits:

1. Openness to experience; $\mathcal{O} \in [0, 1]$
2. Conscientiousness (Scrupulosity); $\mathcal{C} \in [0, 1]$
3. Extraversion; $\mathcal{E} \in [0, 1]$
4. Agreeableness (Sociability); $\mathcal{A} \in [0, 1]$
5. Neuroticism (emotional instability); $\mathcal{N} \in [0, 1]$

The personality of an individual is analyzed and defined throughout answers to a questionnaire that must be completed and verified by factor analysis. Responses are converted to values that define one of the factors on a scale from 0 to 100. Each personality trait is described as follows:

3.2.1 Openness to experience

The openness reflects how much an individual likes and seeks for new experiences. Individuals high in openness are motivated to seek new experiences and to engage in self-examination. In a different way, closed individuals are more comfortable with familiar and traditional experiences. They generally do not depart from the comfort zone [16].

3.2.2 Conscientiousness (Scrupulosity)

Conscientiousness reflects how much careful and organized is an individual. Individuals high on conscientiousness are generally hard working and reliable. When taken to the extreme, they can demonstrate "workaholic", compulsive or perfectionist behaviors. Individuals low on conscientiousness are unable to motivate themselves to perform a task that they would like to accomplish. They tend to be more relaxed, less oriented to fulfill or achieve goals and less driven by success [16].

Table 1: Correlation between Big Five and MBTI factors [26]

	O	C	E	A	N
E-I	0.03	0.08	-0.74	-0.03	0.16
S-N	0.72	-0.15	0.10	0.04	-0.06
T-F	0.02	-0.15	0.19	0.44	0.06
J-P	0.30	-0.49	0.15	-0.06	0.11

3.2.3 Extraversion

Extraversion reflects how an individual is oriented to the external world and get satisfaction from interacting with other people. Individuals high on extraversion tend to enjoy human interactions, are assertive and energized when around other people. Introverts tend to feel worn by socialization and spent more time alone. Because of this behavior, extroverts are generally good at social interactions due to the large amount of experience, while introverts tend to be socially awkward [16].

3.2.4 Agreeableness (Sociability)

Agreeableness reflects how much an individual like and try to please others. Individuals high on agreeableness are perceived as kind, warm and cooperative. They tend to demonstrate higher empathy levels and believe that most people are decent, honest and reliable. On the other hand, individuals low on agreeableness are generally less concerned with others' well-being and demonstrate less empathy. They tend to be manipulative in their social relationships and more likely to compete than to cooperate [16].

3.2.5 Neuroticism (emotional instability)

Neuroticism is the tendency to experience negative emotions. Individuals high on neuroticism generally experience feelings such as anxiety, anger, jealousy, guilt or depression. They have difficulty dealing with stressful events and overreact in ordinary situations. Generally, higher scores on neuroticism indicates problems to control impulses and delay rewards [16].

4 MBTI and Keirsey Temperament Sorter

Another model for typological classification of personality was proposed by Katharine Cook Briggs and her daughter Isabel Briggs Myers. Called Myers-Briggs Type Indicator (MBTI), was used during World War II to identify personal characteristics and preferences[13]. It is based on the theories of Carl Gustav Jung's Psychological Types and widely used in the areas of career counseling, pedagogy, group dynamics, career guidance, leadership training, marriage counseling and personal development[23]. The theory defines 16 psychological types that can be divided into 4 groups according to David Keirsey temperament sorter.

Keirsey expanded the MBTI by studying the ideas of temperament proposed by Hippocrates and Plato in ancient Greece. His work used the names suggested by Plato: Artisan (iconic), Guardian (pistic), Idealist (noetic) and Rational (dianoetic)[21]. Keirsey divided the four groups of temperament into two categories (roles), each one with two types (roles variant). The resulting 16 psychological types are correlated with the 16 types of personality described by Myers and Briggs.

There is a technique used to convert the results of the Big Five to MBTI proposed by Robert R. McCrae and Paul T. Costa[26]. McCrae and Costa defined correlations between the MBTI scales and the five construction factors of the Big Five personality, as demonstrated in Table 1. Thus, it was possible to use the full set of basic domains of personality proposed by the MBTI on a Big Five form.

According to Keirsey[21] each personality group has remarkable characteristics as shown on table 2. These characteristics are very similar to the 4-axis definition of emotions proposed by Plutchik. It is possible to correlate each personality group to an axis of emotions just following the textual descriptions proposed by Keirsley. Table 2 also shows the relation with ancient Greece temperament theory (Humor) that also relates the four classic elements (Element), and were later renamed after the bodily humors (Classic Name).

5 Dynamics of emotions

The following model of dynamics of emotions is based on Newton law's of motion proposed by Lungu et al. [25, 24] and by Egges et al.[7] to simulate emotions and personality for conversational virtual agents. Our model extends the original ideas and is used to predict the audience emotional and mood states based on each individual personality traits. Our objective is to simulate the emotional behavior of entire audiences and result in a approximation of audience ratings. In addition, it is possible to detect problematic individuals in the audience and suggest the formation of groups with similarities and detect the ones who lead the group as opinion-makers.

Given an emotional stimulus, each individual reacts differently, in accordance with your personality. In next paragraphs, we describe a mathematical model to simulate the emotional and mood state of an individual and derive what would be his new emotional state given an external stimulus.

As definition, the emotional state is an emotional manifestation of medium to long term that can last days or weeks. Meanwhile, the mood of an individual is an emotional manifestation of short-medium term that can last minutes or a few days.

5.1 Personality of an individual (p)

The personality model of an individual follows the 5 factor model described on section 3.2.

$p^T = [\alpha_1, ..., \alpha_n], \forall i \in [1, ..., n] \ : \ \alpha_i \in [0, 1]$

$\alpha =$ number of personality traits - OCEAN Model = 5

5.2 Emotional State of an individual (e_t)

The emotional state is a long term condition.

$$e_t^T = \begin{cases} [\beta_1, ..., \beta_m], \forall i \in [1, ..., m] \ : \ \beta_i \in [-1, 1] & \text{if } t > 0 \\ 0 & \text{if } t = 0 \end{cases}$$

where ...
$e_t =$ emotional state at time t
$m =$ emotion m (based on 4-axis Plutchik's model)

5.3 Emotional time series w_t

Describes all emotional states from beginning until time t

$w_t =< e_0, ..., e_t >$

5.4 Influential Emotion a

Emotion that influences an individual is defined as

$a^T = [\delta_1, ..., \delta_m], \forall i \in [1, ..., m] \ : \ \delta_i \in [-1, 1]$

5.5 Function for updating the emotional state ψ_e

Adjusts the emotional state by a influential emotion stimulus.[1]

$\psi_e(p, w_t, a)$
Where ...
$p =$ Personality
$w_t =$ Emotional State in time t
$a =$ Influential Emotion

[1] It is similar to Newtonian force.

Figure 3: Experimental game Mice Challenge

5.6 Exchange function of internal decay Ω_e

Adjusts the emotional state returning to the personality emotional bias after the end of the influential emotion result.[2]

$\Omega_e(p, w_t)$
Where ...
$p =$ personality of an individual
$w_t =$ Emotional State in time t

5.7 New Emotional State e_{t+1}

$e_{t+1} = e_t + \psi_e(p, w_t, a) + \Omega_e(p, w_t)$

6 Experiments in Mice Challenge

The proposed model was tested through an experimental game developed by undergraduation students, shown in Figure 3. Note that all arts displayed in this paper are placeholders and will be substituted in official releases of the game.

Mice Challenge is a 2D RPG game influenced by the roguelike genre, a subgenre of computer role-playing games characterized by randomly generated content and permanent death that flourished in the 1980s [11] and still has a large number of new entries as of today.

Following the manners of the cited genre, the experimental game created is centered around procedural content generation. Game maps are fully generated in a programmatic way, as well as all content belonging in the map. Thus, fully levels of the game are procedurally generated, including NPCs associated with the level. The game generation is capable of producing complete and singular levels for dungeon-like game maps, using seeds as a way of controlling the generation. It also has the capacity of applying a difficulty factor to the generation in a way that expands the possible outcomes of the generation.

A level in the experimental game begins with our main character, Fabian, being spawned at the start location of the map. The map is populated by different entities ranging from collectibles to NPCs. Tokens are one of the collectible types and is presented in three different grades: gold, silver and bronze. These grades represents the value and the difficult of obtaining the token, and there are only one of each per level. Fabian must find at least one token of any grade and take it to the level Totem, an entity that represents the final location of the map.

As the player ventures through the generated levels, the hardship increases. The player must interact with the level entities in order to become stronger and be able to endure the adversities encountered in further generated levels. The evolution of the player character is a very important trait and one of the main motivators of the RPG

[2] Force against the force generate by Ω_e, similar to gravity of friction.

Table 2: Relation between Keirsey x MBTI x Characteristics [21]

Humor	Element	Classic Name	Keirsey	MBTI	Characteristics
Blood	Air	Sanguine	Artisan	SP (Improviser)	Cheerful, helpful, loving
Yellow Bile	Fire	Choleric	Rational	NT (Theorist)	Irritable, aggressive, bold
Black Bile	Earth	Melancholic	Idealistic	NF (Catalyst)	Discouraged, restless, complex
Phlegm	Water	Phlegmatic	Guardian	SJ (Stabilizer)	Moderate, cold, diplomatic

genre. One type of entity that the player must interact with are NPCs of each level, and that is where the proposed model fits into the experimental game described.

The interaction with NPCs is one of the most important dynamic present in the game, as it is the fastest way for progressing in the game and to become stronger. Through a number of different possible interactions, players must find out how to deal with NPC emotions in order to receive better gains from NPCs and evolve the main character.

7 Model Implementation and Tuning

Along with the model implementation in the experimental game, a simulation for tuning the model was also implemented. Its purpose is to facilitate the calibration of the model by allowing direct tests on different NPC subjects through different available events to be triggered, collecting the results for further analysis. To clarify the dynamics for the proposed model implementation, the simulation is used to detail the algorithm implementation in this section. It is vital to highlight that by tuning the model using the simulation, the game implementation mirrors the changes.

The simulation program starts by asking for a specific NPC to apply the tests on. Once the NPC subject of the tests is provided, events can be triggered by the simulator to analyze the NPC reactions. Those events are related to emotions and vary from love events to rage events, with the goal of simulating a large variety of reactions. The results are then logged for further analysis.

Under the table, the emotion model is implemented in the simulator to generate the dynamic and credible variation of emotions desired. When a NPC is selected as test subject, the algorithm creates a NPC object with the respective personality, stored as float values that ranges in [0f,1f] for each OCEAN attribute. To be able to work with the emotion model described in this paper, they are mapped to the algorithm as well, where each axis of the model is represented in a array of float values that considers positive values as one side of the axis and negative values as the other side of the axis. Logically, as the model proposed has four axis, the array contains four float values that can vary from negative to positive values. More specifically, those values ranges in [-1f,1f]. The intensity of the emotion is represented by the module of the value stored. To clarify, Table 3 shows how the rage emotions are stored:

Emotion	A-F	D-T	S-J	A-S
Rage	-1.0f	0	0	0
Anger	-0.5f	0	0	0
Annoyance	-0.2f	0	0	0

Table 3: Rage emotion respective modules

It is possible to see in Table 3 that the Rage emotion has the biggest module whereas Annoyance has the smallest, which means that Rage is a stronger emotion and should have a bigger impact in NPC reactions, for instance. We can also extract from the example that the first value in the array represents the Anger x Fear axis, and negative values represents the Anger direction of the axis. Naturally, positive values represents the Fear direction of the axis. This dynamic is the same for the other axis.

A NPC has an emotion in a given time that can vary depending on events that affects the NPC. The current emotion of the NPC is stored with the same logic just described, although a little more reasoning is needed to infer the current emotion of a NPC. Since events can be of distinct emotion axis, the current emotion values of a NPC can contain values in all axis. To extract the current emotion of a NPC, the approach taken was to consider the most influential emotion only i.e. a NPC that has values indicating a terror state of emotion that also has values indicating annoyance is considered to have a terror current emotion.

Once the emotion structure is mapped to the algorithm, associating emotions with different events is trivial in terms of implementation, but semantically associating them with emotions must be done with caution, avoiding the creation of relations that are not credible i.e. attacking NPC event related to love emotion.

What is left to do is producing the NPC reactions based on their personalities and the events triggered. If were to disregard the NPC personalities, event emotions would directly affect the NPCs current emotion, in a very simple manner. The use of personalities requires a little more effort to create the NPC reactions, as each OCEAN personality trait should affect their reactions in a credible way.

In order to control the relation between each OCEAN attribute and emotions from the model of emotions described in this paper, the weights of each personality trait on each emotion is stored on factor matrices, illustrated in Table 4 and Table 5. Aiming to better structure the data, two matrices are used: Table 4 stores factors f_{ij} for emotions in the positive direction of axis from the emotion model, and Table 5 stores factors f_{ij} for the emotions in the negative direction.

Fear	Trust	Joy	Surprise	
f_{11}	f_{12}	f_{13}	f_{14}	O
f_{21}	f_{22}	f_{23}	f_{24}	C
f_{31}	f_{32}	f_{33}	f_{34}	E
f_{41}	f_{42}	f_{43}	f_{44}	A
f_{51}	f_{52}	f_{53}	f_{54}	N

Table 4: Positive emotion axis factor matrix

Anger	Disgust	Sadness	Anticipation	
f_{11}	f_{12}	f_{13}	f_{14}	O
f_{21}	f_{22}	f_{23}	f_{24}	C
f_{31}	f_{32}	f_{33}	f_{34}	E
f_{41}	f_{42}	f_{43}	f_{44}	A
f_{51}	f_{52}	f_{53}	f_{54}	N

Table 5: Negative emotion axis factor matrix

The values stored in the matrices represents how a personality trait affects the reactions to a specific emotion axis from the model. In the implementation, values stored in the matrices are unitary. They can be either positive or negative. The notion implied in the signal of the value is that a trait can influence in a emotional reaction in both directions depending on their relation. This enriches

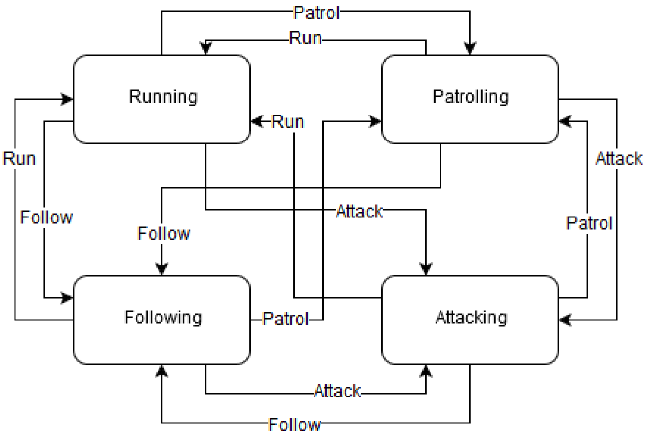

Figure 4: NPC behaviour state machine

the NPCs reaction as it allows more accurracy in their reactions. As an example, imagine a NPC that has a high neuroticism rate. Neuroticism should influence negatively in the reaction of various events i.e. trust event. In that case, the NPC could react oppositely to the event emotion of trust tending to a disgust reaction.

After producing the NPC reactions, taking into account their personalities and the event emotion that triggered the reaction, they are applied to the NPC current emotion, resulting in a new current emotional state for the NPC.

To translate the NPC emotional state into NPC actions in the experimental game, our approach took a rather simple route. A state machine that is represented in Figure 4 was implemented to control NPC behaviours. Once a NPC enters in an emotional state, a command is dispatched to the state machine, changing the current state if necessary. In the experimental game, there is no distinction of actions between NPCs in a emotional state, meaning that every NPC in a specific emotional state proceeds to execute the same action. To personalize the actions in an emotional state of each NPC or to different groups of NPCs is trivial and very interesting, since it would give a new layer of variation to the NPCs interaction.

In Figure 4, it is possible to see the core NPC behaviour state machine of the experimental game. Observe that the states contained in the state machine are evident, but for clarification it is beneficial to detail a little more. While Running, Patrolling and Attacking states converts only into actions of the same semantics, the Following state also represents that the NPC has become friends with player and can aid him in numerous ways through his journey, but at any moment, depending on events that occur, this friendly relation may succumb, showing the aliveness and volatile characteristic of the proposed model.

At last, it is necessary to bring to discussion an important trait of the model that is not present in the simulation but is present in the experimental game, which is the NPC tendency to stay at its emotional bias. As time goes by, emotional states of NPCs gravitate towards their bias in a individual rate to simulate human emotional bias, and it is directly implemented through a decaying method that applies to each NPC their bias rate into their emotional state.

8 Results

To test the concept in a game environment, the experimental game Mice Challenge was used to examine the outcomes of the model in practice. As stated before, the experimental game used is heavily based on procedural generation, and NPCs are one of its generated content. This trait was combined with our model by attaching each generated NPC a randomized personality, creating a vast range of test objects. It is necessary to mention that some fixed personality NPCs are present in the game accordingly to the intended game design. With the implementation of the model, NPCs in the experimental game showed an interesting variation of emotions on occurrence of distinct events, allowing a custom and diverse behaviour based on its current emotional state. Fig. 5a and Fig. 5b illustrate how dynamic the interactions with NPCs are in the experimental game, as a result of the implemented model. Both figures display NPCs reactions to an attack received from the player. While in Fig.5a the NPC reacted to the attack becoming angry and proceeding to attack the player, in Fig.5b the NPC reacted distinctly, entering in a scared state and fleeing from p layer. The NPCs reacted in different manners due to their different personalities. Images contained in Figure 5 were adjusted to better the visualization, although zooming in is still recommended.

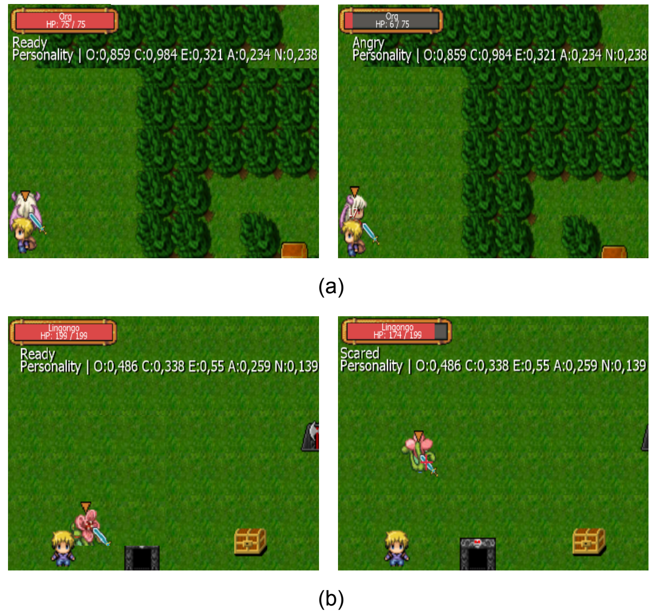

Figure 5: (a) NPC reacting to an attack into an Angry state. (b) A different NPC from (a) reacting to an attack into a Scared state.

Since the suggested model is based on actual human psychology and emotions, a calibration of the implementation is very important to create credible NPC interactions. This fine tuning was done using fixed personalities planned for characters of the Mice Challenge Game: Fabian, Nemesis, Giovanna and Dr. Ruddyard. Their personalities are displayed in Table 6, where values ranges in the interval [0,1].

Character	O	C	E	A	N
Fabian	0,40	0,64	0,73	0,56	0,83
Nemesis	0,70	1,00	0,45	0,31	0,35
Giovanna	0,30	0,29	0,93	0,49	0,68
Dr. Ruddyard	0,64	1,00	0,43	0,27	0,83

Table 6: Fixed NPCs personalities

Those characters and their personalities were submitted to numerous tests. Tests were realized by dispatching events on the test objects and collecting their reactions to further analyze the results. Events triggered in the experiment are associated to different emotions, acting as influential e motions o f t he p roposed m odel, thus updating the emotional state of the subject. It is important to elucidate that emotional states of NPCs gravitate towards their bias as time goes by and that the current emotional state is affected by all emotion axis, even though the calibration tests described in this section does not illustrate those traits. Tables 7, 8, 9 and 10 shows some of the outcomes in the later set of tests effectuated, as they are analyzed and detailed.

Character	A-F	D-T	S-J	A-S	Inclination
Fabian	-0,038	0,000	0,000	0,000	Anger
Nemesis	0,130	0,000	0,000	0,000	Fear
Giovanna	-0,078	0,000	0,000	0,000	Anger
Dr. Ruddyard	0,034	0,000	0,000	0,000	Fear

Table 7: Rage event results (attacking NPCs)

In Table 7, NPCs were submitted to rage events as they were attacked by an external entity. From the results, it is possible to see how they react distinctively to the stimulus that they are given. Depending on their personalities, NPCs can interpret the stimulus given in different manners, leaning to a positive or a negative direction of the emotion axis in question. In this case, Fabian and Giovanna reacted to the event emotion with anger impulses, while Nemesis and Dr. Ruddyard reacted with fear impulses. What we can extract from this data is that, if we were to attack NPCs Fabian and Giovanna, both would tend to a angry emotional state, and with we were to attack Nemesis and Dr. Ruddyard, they would steer to a fearful emotional state. This variation of the reactions produced by the NPCs is the key dynamic of the model proposed, and it enriches the NPCs behaviour greatly.

Their reactions are a product of their personalities and, considering that the model is based on human psychology, it is important that they are credible. The way that we wired their personalities to rage events has given satisfactory results. By inspecting the NPCs personalities and the results produced in Table 7, it is possible to see the connections between them. The factors applied to achieve the results exposed relates neuroticism and conscientiousness with influential emotions of rage. High neuroticism values represents emotional instability and tendency to get easily angered, while high conscientiousness indicates tendency of being more controlled and of being a planner. With this in mind, we can see why Fabian and Giovanna leaned to an anger state, as they both have more neuroticism than conscientiousness. For the opposite reason, Nemesis and Dr. Ruddyard leaned to a fearful state. It is also possible how the magnitude of each attribute in their personalities affects the weight on the resulting reaction. In this case, the bigger the difference between neuroticism and conscientiousness, the bigger the module of the resulting reaction.

Character	A-F	D-T	S-J	A-S	Inclination
Fabian	0,086	0,000	0,000	0,000	Fear
Nemesis	-0,070	0,000	0,000	0,000	Anger
Giovanna	0,076	0,000	0,000	0,000	Fear
Dr. Ruddyard	0,038	0,000	0,000	0,000	Fear

Table 8: Terror event results (lowering NPCs life to the minimum)

It may appear logical that terror events would generate opposite reactions if compared to rage events, since they both share and axis and are from opposite extremes, but Table 8 tells another story. The way we implemented the proposed model allows us to define different factors for influential emotions on the same axis, giving more flexibility to adjustments and increasing independence of the reactions. The personalities connection with the terror event was made taking into account that high openness indicates and inclination to be more daring and curious and, similar to the rage event, neuroticism represents emotional instability and tendency to fearful states.

What the results shows in Table 8 is that Nemesis is the only NPC that has a personality that is more open than neurotic, thus is the only one not being scared by the terror event.

Character	A-F	D-T	S-J	A-S	Inclination
Fabian	0,000	0,172	0,000	0,000	Trust
Nemesis	0,000	0,222	0,000	0,000	Trust
Giovanna	0,000	0,208	0,000	0,000	Trust
Dr. Ruddyard	0,000	0,102	0,000	0,000	Trust

Table 9: Trust event results (offering equipment to NPCs)

Table 9 is the only one that shows the same reaction inclination for all NPCs, but it is still interesting to understand how the results were produced, even because a different personality could have produced a different inclination. A combination of personality attributes were used to produce the reactions from trust events. Openness, extroversion and agreeableness were elected to positively influence on trust events, as they are related to trusting (agreeableness), sociability (extroversion) and openness to experiences (openness). The only personality trait related negatively to trust events is neuroticism as it relates to pessimism, anxiety, insecurity and other attributes that can steer away from trusting. This results in the data shown in table 9, as neuroticism from all NPCs was not enough to prevent them from leaning to a trusting state on events of trust. It is interesting to notice that, if we were to remove openness from the equation, Dr. Ruddyard would lean to the opposite direction and would not trust and event of trust. That is the dynamic of the model calibration, to adjust factors and fine tune results accordingly to the game design and reality.

Character	A-F	D-T	S-J	A-S	Inclination
Fabian	0,000	0,000	0,000	0,044	Surprise
Nemesis	0,000	0,000	0,000	0,022	Surprise
Giovanna	0,000	0,000	0,000	0,150	Surprise
Dr. Ruddyard	0,000	0,000	0,000	-0,098	Anticipation

Table 10: Vigilance event results (getting closer to the NPCs)

Finally, in Table 10 the NPCs were submitted to a vigilance event that simulates a player getting closer to the NPCs. Dr. Ruddyard is the only one to react negatively, leaning to a vigilant state. The process of calculating the resulting reaction for vigilance events is the only one, detailed in this paper, that considers all personality attributes. Openness to experience (openness), extroversion (sociability) and agreeableness (trusting) influences positively in the reaction, while neuroticism and conscientiousness (careful and prudent) impact negatively. With this knowledge, it is easy to understand the exposed results in Table 10. Only Dr. Ruddyard has a combination of neuroticism and conscientiousness that is bigger than the sum of all other attributes.

The factor matrices used to produce these results are shown in Table 11 and Table 12 to aid the understanding of the generated data in the tests. As stated before, values in the factor matrices affects how each personality trait affects the reactions to a specific emotion axis from the model.

Fear	Trust	Joy	Surprise	
-1	1	1	-1	O
0	0	0	0	C
0	1	1	1	E
0	1	1	1	A
1	-1	-1	-1	N

Table 11: Values in positive emotion axis factor matrix

Anger	Disgust	Sadness	Anticipation	
0	-1	-1	-1	O
-1	0	1	1	C
0	0	1	-1	E
0	-1	0	-1	A
1	1	1	1	N

Table 12: Values in negative emotion axis factor matrix

9 Conclusions

This paper presents an AI model that mimics human emotions and personalities to be used in game NPCs. The model introduced is based on the OCEAN model that is commonly used by psychologists to determine an individual personality. It also revolves around the emotion model proposed by Robert Plutchik for contrasting and categorization of emotions.

The implementation of the proposed model has shown promising results, enabling a dynamic and rich variation of behaviours and reactions from the NPCs in our experimental game. Player interactions with NPCs produced credible reactions that were very intrinsic to the personalities of each NPC, giving much more life to the AI and increasing the overall experience of the experimental game Mice Challenge.

The distinct reactions of NPCs to the same event on account of differences in their personalities while mirroring human psychology had a very interesting impact on the player reasoning, as dealing with NPCs in the experimental game opposes the more simple and cold more common interactions. Players must deal with individual NPC emotional states that can vary upon new events that affects the NPC, producing variations that depends on NPC personalities and emotional bias. These variations must be treated with caution by the players since NPCs are prone different outcomes that were not predicted i.e. becoming angrier on scary situations.

As stated before, the AI model is based on actual human psychology and emotions, and a calibration of the implementation is very important to create credible NPC interactions. By maintaining matrices of factors we were able to tune the model with ease and set a configuration that meet our expectations as it allowed a plausible relation between the personalities and emotions, but it does not mean that better calibration cannot be done. If more precision over the relation between personalities and emotions is wanted, we suggest a few solutions that may produce the expected outcome. At first, to have a better control over the weight of each OCEAN attribute on emotions axis, an approach that does not use only unitary factors can expand the control of possibilities and is recommended as it is implemented without much effort. Another option is to increase independence between emotions of the same axis in the reactions produced by interactions, which is restricted in the current implementation i.e. if AI does not react getting scarier with a scary event, the only other options is to react neutrally or react getting angrier. An investigation should be headed on the later suggestion to determine if it is beneficial for the AI model.

In a game universe, it is interesting and very common to have categories of NPCs i.e. enemies of specific kinds. In these situations, similar behaviours between NPCs of the same type might be of interest to the designers. To reproduce this outcome using our model, we commend the definition of similar personalities in a range that encapsulates NPCs of specific groups, achieving the desired group behaviour but still keeping the individuality of each entity of the group.

Lastly, although in our experimental game the NPC emotional state is directly translated into actions in a way that all NPCs in the same emotional state performs the same actions, to individualize actions for different NPCs or groups of NPCs can be of advantage and benefit the overall game AI experience. This trait can be easily implemented as it is only a matter of differentiating the actions of an emotional state accordingly to the desired individualization.

In conclusion, the effort into applying the proposed model in our experimental game was worth it and fulfilled our expectations, as it enriched and expanded the AI interactions and behaviours mimicking human psychology in a believable manner, maintaining a sufficient control over the AI actions even with the numerous existent possibilities of emotional variations accordingly to NPC individual personalities.

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References

[1] D. C. Activision. Pitfall (digital game). 1982.

[2] E. T. Araujo and A. E. M. Ciarlini. Verification of temporal constraints in continuous time on nondeterministic stories. In *Proceedings of the 10th International Conference on Entertainment Computing*, 2011.

[3] Aristotle. Poetics. *London: Penguin*, 1996.

[4] C. Becker, S. Kopp, and I. Wachsmuth. Simulating the emotion dynamics of a multimodal conversational agent. In E. André, L. Dybkjær, W. Minker, and P. Heisterkamp, editors, *Affective Dialogue Systems*, volume 3068 of *Lecture Notes in Computer Science*, pages 154–165. Springer Berlin Heidelberg, 2004.

[5] A. Chandra. A computational architecture to model human emotions. In *Intelligent Information Systems, 1997. IIS '97. Proceedings*, pages 86–89, Dec 1997.

[6] N. Dog. The last of us (digital game). *Sony Computer Entertainment*, 2013.

[7] A. Egges, S. Kshirsagar, and N. Magnenat-Thalmann. A model for personality and emotion simulation. In V. Palade, R. J. Howlett, and L. C. Jain, editors, *KES*, volume 2773 of *Lecture Notes in Computer Science*, pages 453–461. Springer, 2003.

[8] A. Egges, S. Kshirsagar, and N. Magnenat-Thalmann. Generic personality and emotion simulation for conversational agents: Research articles. *Comput. Animat. Virtual Worlds*, 15(1):1–13, Mar. 2004.

[9] L. Egri. *The Art of Dramatic Writing: Its Basis in the Creative Interpretation of Human Motives. With an Introd. by Gilbert Miller*. Simon and Schuster, 1960.

[10] P. Ellsworth and K. Scherer. Appraisal processes in emotion. *In R. J. Davidson, K. R. Scherer, & H. H. Goldsmith (Eds.), Handbook of affective sciences*, pages 572–595, 2003.

[11] M. B. Garda. Neo-rogue and the essence of roguelikeness. *Homo Ludens*, 1(5):59–72, 2013.

[12] H. Gunes and M. Pantic. Automatic, dimensional and continuous emotion recognition. *Int. J. Synth. Emot.*, 1(1):68–99, Jan. 2010.

[13] A. Hammer and N. Barger. Mbti applications: A decade of research on the myers-briggs type indicator, 1996.

[14] M. Hurst, T. Jackson, and M. Glencross. Emotion recognition: Theory or practicality. In *Automation and Computing (ICAC), 2012 18th International Conference on*, pages 1–6, Sept 2012.

[15] T. Iwatani. Pac-man. *Tokyo: Namco*, 1980.

[16] P. John and S. Srivastava. The big-five trait taxonomy: History, measurement, and theoretical perspectives. *In L. A. Pervin & O. P. John (Eds.), Handbook of personality: Theory and research*, 2:102–138, 1999.

[17] E. Jones and R. Nisbett. The actor and the observer: Divergent perceptions of the causes of behavior, 1971.

[18] A. Kallias. *Individual Differences and the Psychology of Film Preferences*. PhD thesis, University of London, 2012.

[19] Z. Kasap, M. Ben Moussa, P. Chaudhuri, and N. Magnenat-Thalmann. Making them remember: Emotional virtual characters with memory. *Computer Graphics and Applications, IEEE*, 29(2):20–29, March 2009.

[20] Z. Kasap and N. Magnenat-Thalmann. Intelligent virtual humans with autonomy and personality: State-of-the-art. In N. Magnenat-Thalmann, L. Jain, and N. Ichalkaranje, editors, *New Advances in Virtual Humans*, volume 140 of *Studies in Computational Intelligence*, pages 43–84. Springer Berlin Heidelberg, 2008.

[21] D. Keirsey. Please understand me ii: Temperament, character, intelligence, 1978.

[22] P. Lankoski. *Character-driven game design: A design approach and its foundations in character engagement*, volume 101. Taik Books, 2011.

[23] G. Lawrence and C. Martin. Building people, building programs - a practitioner's guide for introducing the mbti to individuals and organizations. *CAPT*, 2001.

[24] V. Lungu. Newtonian emotion system. In G. Fortino, C. Badica, M. Malgeri, and R. Unland, editors, *Intelligent Distributed Computing VI*, volume 446 of *Studies in Computational Intelligence*, pages 307–315. Springer Berlin Heidelberg, 2013.

[25] V. Lungu, A. Baltoiu, and e. Radu. Using emotion as motivation in the newtonian emotion system. In F. Zavoral, J. J. Jung, and C. Badica, editors, *Intelligent Distributed Computing VII*, volume 511 of *Studies in Computational Intelligence*, pages 355–364. Springer International Publishing, 2014.

[26] R. McCrae and P. Costa. Reinterpreting the myers-briggs type indicator from the perspective of the five-factor model of personality. *Journal of Personality*, 1989.

[27] S. Mohammad. From once upon a time to happily ever after: Tracking emotions in novels and fairy tales. In *Proceedings of the 5th ACL-HLT Workshop on Language Technology for Cultural Heritage, Social Sciences, and Humanities*, LaTeCH '11, pages 105–114, Stroudsburg, PA, USA, 2011. Association for Computational Linguistics.

[28] C. Orellana-Rodriguez, E. Diaz-Aviles, and W. Nejdl. Mining emotions in short films: User comments or crowdsourcing? In *Proceedings of the 22Nd International Conference on World Wide Web Companion*, WWW '13 Companion, pages 69–70, Republic and Canton of Geneva, Switzerland, 2013. International World Wide Web Conferences Steering Committee.

[29] A. Pajitnov, D. PAVLOVSKY, and V. GERASIMOV. Tetris. 1984.

[30] J. Park, W. Kim, W. Lee, and M. Chung. Artificial emotion generation based on personality, mood, and emotion for life-like facial expressions of robots. In P. Forbrig, F. Paternó, and A. Mark Pejtersen, editors, *Human-Computer Interaction*, volume 332 of *IFIP Advances in Information and Communication Technology*, pages 223–233. Springer Berlin Heidelberg, 2010.

[31] R. Plutchik. The emotions: Facts, theories, and a new model. New York, Random House, 1962.

[32] R. Plutchik. A general psychoevolutionary theory of emotions. *In: R. Plutchik & H. Kellerman (Eds.), Emotion: Theory, research, and experience*, Theories of emotion, 1980.

[33] R. Plutchik. The nature of emotions. *American Scientist*, 2001.

[34] E. Rich. User modeling via stereotypes. *Cognitive Science 3*, pages 329–354, 1979.

[35] P. Rodrigues. *Um Sistema de Geração de Expressões Faciais Dinâmicas em Animações Faciais 3D com Processamento de Fala*. PhD thesis, Pontifícia Universidade Católica do Rio de Janeiro, 2007.

[36] M. Smith and M. Smith. *Engaging characters: Fiction, emotion, and the cinema*. Clarendon Press Oxford, 1995.

[37] C. Tupes and R. Christal. Recurrent personality factors based on trait ratings. Technical report, Air Force Systems Command, 1961.

[38] F. Ueda and K. Kaido. Game design methods of ico. In *Game Developers Conference*, 2002.