An Adaptive Agent Approach Using Personality and Emotions

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***Abstract*—This paper presents an adaptive model based on emotions and personality, and inspired by human behavior, where the agent emotions and personality vary according to the time and with the interactions. The decision-making actions occur into the environment and with other agents. In this model, the agent personality will be directly related to its own decision making, and the emotions will indirectly influence these decisions. From agent perception, emotions are felt, and from the emotions felt the agent personality changes. In order to study agent behavior, several multi-agent simulations were executed, in different scenarios, to better understand who and why agents exchange resources and consume them to survive. Afterwards, the personality of the other agents was defined, the agent studied modifies their own personality and behavior according to the others. From the results, we identified the adaptability of the agent to the environment in which it lived. This social adaptation was determined by the community in which it was inserted and/or by the environmental factors that it was subject.**

***Index Terms*—Multi-Agent Systems, Personality Simulation, Emotion Simulation**

I. Introduction

Emotions and behavior of an individual are subject to long-standing studies [1]. As the understanding of human behavior has grown, tactics have been created for simulating emotions or personality in agents. Many of these techniques are used in multi-agent systems. However, in most of these systems, agents receive a predefined personality [2]. In this model, we proposed an integration between the personality and the emotion, basing on human behavior features [3], where the personality of an agent can interfere in the decision-making and interfering in the way in which the emotions are generated.

The human personality is influenced, mainly, by two factors: the biological [4] and the sociological [5]. The biological factor indicates that each individual is already born with a genetic predisposition, to have a type of behavior and personality. The sociological factor indicates that the personality and behavior of a person can be determined and influenced in accordance with the society in which it is inserted.

This paper proposes a model capable of simulating variation, and formation, of an agent personality over time and in different social and environmental conditions. The model deals, in a simplified way, with the biological issues. It used an emotional model that allows different responses to the same stimulus (emotions) felt, according to the different personality traits. The psychological models used as the basis are the OCEAN model [6] of personalities and the OCC model of emotions [7].

Our ideas start from the empirical premise that, by making the cognitive behavior of the agent more similar to human concepts, it is possible to bring the behavior of the agent closer to reality, and consequently, it is easier to make its adaptation to an environment.

The paper is divided into 5 sections. Section II presents the theoretical concepts involved in this work. Section III presents the proposed models and its components. The results obtained, the behavior of the model and its analysis are in section IV. Finally, section IV presents the conclusions and future works.

II. Theoretical Background

In this section we present a short introduction to the three main related work themes: multi-agent systems, personality model and emotions model.

A. Multi-agent Systems

As the proposed model aims to determine the emotions to be felt and the individual formation of the personality, it is interesting to simulate it in a Multi-Agent System (MAS). The MAS is a subarea of Distributed Artificial Intelligence, which, unlike the classic Artificial Intelligence that simulates behavior in a single individual, it is able to simulate behavior among various individuals, their social behavior, understanding their interactions [8].

In a MAS, each agent can have its beliefs and desires, thus enabling each individual to 'think' and act differently.

According to [9], an agent is an encapsulated entity capable of solving problems that have autonomy, reactivity, proactivity and social ability. An agent is defined as a conscious cognitive entity, capable of expressing feelings, perceptions and emotions, as well as human beings. These agents have specific characteristics such as benevolence, mobility, knowledge, belief, intentions and rationality.

Since each agent has its own personality, there may be behavioral variations between them, as well as in a society, where each individual, undergoing the same action, may have completely different reactions, according to their thoughts and ideology.

B. Personality Model

Seeking to understand human behavior and its adverse reactions to the same situation, researchers and philosophers have tried to define how human personality works. During research, independent groups of researchers [10] [6] [11] [12] have defined, empirically, human personality as the set of five major factors, which became known as "Big Five" or OCEAN.

These five factors are Openness (O), Conscientiousness (C), Extraversion (E), Agreeableness (A) and Neuroticism (N). Each person has a different weight for each of these factors, always having all the factors represented by some value.

Each factor has a significance and can be influenced in different ways. In a simplified way, an individual with a high value in Openness is more willing to have new experiences, usually has tendencies to be original, curious, creative and seeking new experiences and experiences.

An individual with high value in Conscientiousness is an individual who has more focus on their goals, is usually more systematic and has the discipline to achieve desires.

The Extraversion factor, as can be deduced, is related to the extraversion that the individual has, the ease of being very sociable and communicative.

Agreeableness is the factor that can measures how altruistic the individual is. When an agent has a high value of altruism, it is more friendly and it is more willing to help.

Finally, an individual with a high value in Neuroticism is a very neurotic individual who is afraid that things will go wrong. Such an individual can become a more anxious, irritable or moody.

C. Emotions Model

Emotions are considered one of the main factors that influence our lives, our way of acting and thinking. For that, there are many research in this area and many different definitions for it [13]. Among these definitions, some are more appropriate for computational modeling than others. In computational area, the OCC (acronym of its creators Ortony, Clore and Collins) model [7] is that one of more used. The OCC model divides emotions into three main categories, called event-based emotions, agent-based emotions, and object-based emotions.

Event-based emotions can be defined as emotions that result from the consequence of events that occur with other individuals or with the individual itself. Within these emotions for the individual are: Joy, Distress, Satisfaction, Fears-Confirmed, Relief and Desapointment; And the emotions for others are: Happy-For, Pity, Gloating and Resentment.

Agent-based emotions are emotions felt in relation to some action, both of other individuals and of itself. These emotions are: Pride and Shame for itself, and Admiration and Reproach from other individuals.

Object-Based Emotion are emotions directed at objects. Two emotions are defined: Love and Hate.

D. Emotions and personality in Mult-agent Systems

Social simulations with agents can be executed in many purposes like agents in a game [14], crowd simulations [15] [16], simulation of conversational agents [2] or even to security in network sensors [17]. And can focus in some strategies to make decisions and interact with environment.

In [18] is combined Emotion, personality and physiology functions to create Beliefs, Desires and Intention functions to an agent, with the purpose of creating simulations to inspect security in crisis situations. Other work created agents using different specialized modules for certain tasks, such as biology concepts (physiology agent concepts), personality, culture and emotion, social and decision make, with the aim of simulating human behavior [14]. In [19] was used emotions to influence the actions, belief and desires of combatant agents.

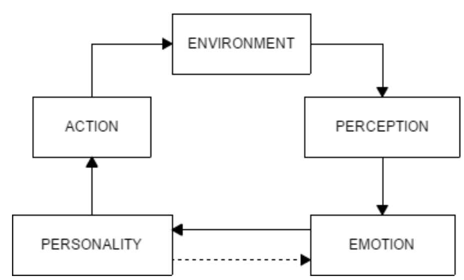
And, in [20], the authors proposed the integration of personality, emotion and mood aspects in decisin-making, in a way that tries to identify similar agents through their pernonality.

Differently of all previously mentioned works, the work of [14] has static personality weights and does not change during simulation.

III. Proposed Model

The proposed model is divided in three parts: the emotion generation part, influenced by personality and environment, which was based on the Egges Model [2]; the personality update part, influenced by emotional state; and the action choice part, influenced by personality status. A flowchat that represents the general idea of proposed model is presented in Figure 1.

Fig. 1: Model behavior flowchart.



The model rules and action choice are explained together, since the action choice depends on the rules model.

A. Emotion Generation

Basing on Figure 1, to an emotion could be generated, an environment perception is necessary. After an environment perception occurs, the agent will have a $Desire\ Emotion$ (DE), that represents the emotions that the agents desires to feel. In section III-C, we will explain how DE is generated.

The emotion felt is called by $Emotional\ State\ (ES)$, and it is calculated using the DE information (Equation 1).

$$ES_t = ES_{t-1} + (DE \times (MEP \times P_{t-1})) - d \qquad (1)$$

MEP is a matrix that represents the influence of each personality attribute to each emotion attribute (Table I).

This matrix has dimensions nE x nP. Where nE is the number of emotions and nP is the number of Personality

TABLE I: Values set to represent how much each emotion felt influences each weight of personality, where 1 would be maximum influence and 0 no influence. O represents Openness; C represents Conscientiousnes; E, Extraversion; A, Agreebleness; and N Neuroticism.

	O	C	E	A	N
Joy	0.4	0.4	0.4	0.4	0.8
Distress	0.6	0.6	0.6	0.6	0.2
Happy-For	0.4	0.4	0.4	0.2	0.8
Pity	0.6	0.6	0.6	0.8	0.2
Gloating	0.4	0.4	0.4	0.2	0.8
Resentment	0.6	0.6	0.6	0.8	0.2
Hope	0.2	0.2	0.4	0.4	0.8
Fear	0.8	0.8	0.6	0.6	0.2
Satisfaction	0.2	0.2	0.4	0.4	0.8
Fears-Confirmed	0.8	0.8	0.6	0.6	0.2
Relief	0.2	0.2	0.4	0.4	0.8
Disapointment	0.8	0.8	0.6	0.6	0.2
Pride	0.4	0.2	0.2	0.4	0.8
Shame	0.6	0.8	0.8	0.6	0.2
Admiration	0.2	0.2	0.2	0.2	0.8
Reproach	0.8	0.8	0.8	0.8	0.2
Gratification	0.4	0.2	0.2	0.4	0.8
Remorse	0.6	0.8	0.8	0.6	0.2
Gratitude	0.4	0.2	0.2	0.2	0.8
Anger	0.6	0.8	0.8	0.8	0.2
Love	0.2	0.4	0.2	0.2	0.8
Hate	0.8	0.6	0.8	0.8	0.2

attributes. These values have been defined to an OCC/OCEAN integration, this model supports different personality and emotions model but is necessary a different matrix. P represents the agent social personality, and it is a vector of nP length, that represents the OCEAN attributes in that instant. The product of MEP and P indicates how much the current agent personality will be influence the emotion that will be felt. This result is multiplied by DE (DE and ES have nE length), which generates a value that represents what felt emotions may be considered in the agent perception and its personality.

The ES_{t-1} value represents Emotional State in previous time, when $t = 0$, ES is a zeros vector. And d represents a decay constant, set as 0.1 in our experiments [1]. Finally, the ES highest values will generate emotions.

B. Personality Update

To understand how personality update works, firstly, it is important to understand how personality variation works. Each OCEAN weight can be represented by the interval $[0, 1]$, where 0 means abstinence from a given weight and 1 means total presence. For example, if an agent has a value of 0 in Agreeableness ($A = 0$), that can means a very selfish agent; in opposite, if this value is 1 ($A = 1$), it can means that the agent is very altruistic.

When an agent has an OCEAN weight close to the limits (0 or 1), the variation of its personality is smaller than when its weight is intermediate, i.e., an agent with $A = 0.1$ has less positive variation in its OCEAN weight than an agent with $A = 0.6$, when exposed to the same event of altruism. This feature was based on the concept of confirmatory bias [21].

For this variation behavior to be possible, the OCEAN values were represented by a sigmoidal function, which makes possible greater variations when its weight is medium, and smaller variations at when its weights are in the limits (minimum and maximum).

The function representing the OCEAN weights is given by Equation 2.

$$f(x_i) = \frac{1}{1 + e^{-kx_i}} \tag{2}$$

To update the personality weights, we work with the values of x. As each agent can be initialized with different personality values, it is necessary to find each initial value of x. Applying basic mathematical rules and logarithmic properties, in Eq. 2 we have the equation 3.

$$x_i = -\frac{1}{k} \times \ln \frac{1 - f(x_i)}{f(x_i)} \tag{3}$$

Two equations were defined to perform the OCEAN weight update: one will set the climbing behavior and the other the descent behavior for each OCEAN attribute, eg., when the agent feels a "good" emotion, it will raises the OCEA weights and down the value of N or, when feels a "bad" emotion, it will lowers the OCEA weights and increases the weight N.

In these equations, two types of personality factors are used, the social personality, which we have called as $f(x)$, and the biological personality ($PBio$) (mentioned in introduction).

Unlike the social personality, the biological personality never changes, it is constant throughout the agent's life. $PBio$ is responsible for influence the agent's final personality. In this way, an agent who has its $pBio$ defined as very selfish, however it has altruistic iterations, it is an agent that will throughout life, it will never be completely unselfish.

Therefore, the equation responsible for climbing the personality value is presented in Equation 4.

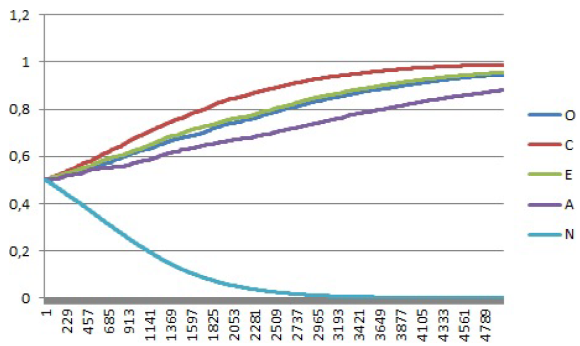
$$x_{i(t+1)} = x_i + \frac{f(x_i) + C \times (pBio_i - f(x_i))}{fD + fT} \tag{4}$$

And the equation responsible for descent OCEAN values is presented in Equation 5.

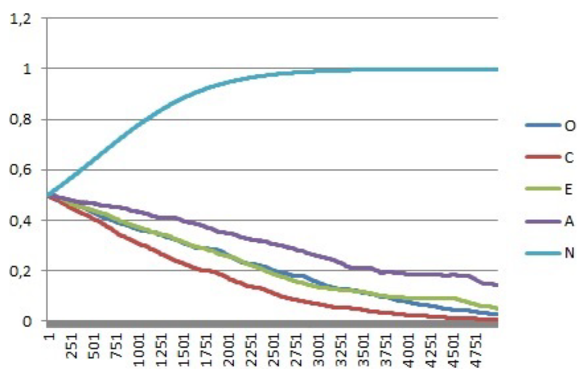
$$x_{i(t+1)} = x_i - \frac{1 - f(x_i) + C \times (pBio_i - f(x_i))}{fD + fT} \tag{5}$$

Where, fD is a division constant that changes the x value smoothly. fT is the time factor of the equation. At each iteration, this factor increases, decreasing more the variation suffered by x. It is responsible for giving weight to the emotions occurred earlier, so that an emotion that was felt at some point continue having its weight, even if small, in the current personality of the agent, or emotion previously felt by the agent, will leave its mark for the rest of the iterations it suffers. Thus, it is possible that the emotions felt have a weight in the final formation of the agent's personality.

[1]This value was chosen that the decay did not occur very quickly, after some tests with several values.



(a) OCEAN variation when 75% of emotions was "good"



(b) OCEAN variation when 75% of emotions was "bad"

Fig. 2: OCEAN variation over time.

C is a multiplication constant responsible for defining how much the personality will influence the agent's final personality.

The personality update depends of the $Emotional\ State$ (ES), where each felt emotion modifies certain attributes of the personality. In this way, after the agent felt an emotion, the OCEAN weights suffer different modifications. The figure 2(a) demonstrate the OCEAN changing over time when an agent feel 75% of "good" emotions, and figure 2(b) when an agent feel 75% of "bad" emotions.

This figure also illustrates the behavior of Equations 4 and 5, where in the Figure 2(a) the OCEA values were updated 75% of the time with the Equation 4 and in Figure 2(b) these weights were updated 75% of the times using the Equation 5. Its enable to verify that these equations work in the opposite way.

C. Action Choice and Environment Model

To describe how action choices is chosen, it is necessary to explain which actions the model have and what these actions represent. For this, it was necessary create an environment model where the agents were inserted to create a multi-agent simulation.

This model was developed to simplify actions as much as possible, and to demonstrate in a clear and simple way how the personality can influence the actions of an agent. Therefore, a model based on the exchange of resources between agents was developed.

The model follows the following context: Each agent produces a certain type of resource. This agent can consume the resource that it produces, however to survive, it must consume a different type of resource at a determined amount of time (iterations). Each agent can produce only one type of resource (force the interaction). In this way, it must perform exchanges with other agents. There are some rules in this environment: If an agent does not consume a different resource within a N number of days, it dies; After consuming a different resource, the agent has N days more to consume another different resource again; An agent can only do an exchange request for day, however it can receive more than one request; There must be a M value, which defines the maximum amount of stock for each resource.

Basically, the agent's goal is to do trade-offs to survive. This scenario was created with the intention of performing a simulation between very simple agents and that was able to validate and demonstrate the behavior of the model.

After described the environment model, it is possible to explain how occurs the action choice. Each agent has, in its beliefs, the amount of each its resource and the amount of iterations that need to consume a new resource. The action choices are based on these two beliefs and its personality weights. An exchange request is done when the agent has a desire to exchange. The exchange desire is defined by the agent's need to obtain a new resource, what varies according to the amount of different resources it has and two OCEAN attributes in its beliefs (Conscientiousness and Extrovert). It means that the change desire varies, depends on how much the agent is focused to reach the goal and how easy to it to communicate with other agents.

If there is a desire for exchange, it will be necessary to choose the agent for exchange, and after define how much resources will be offer.

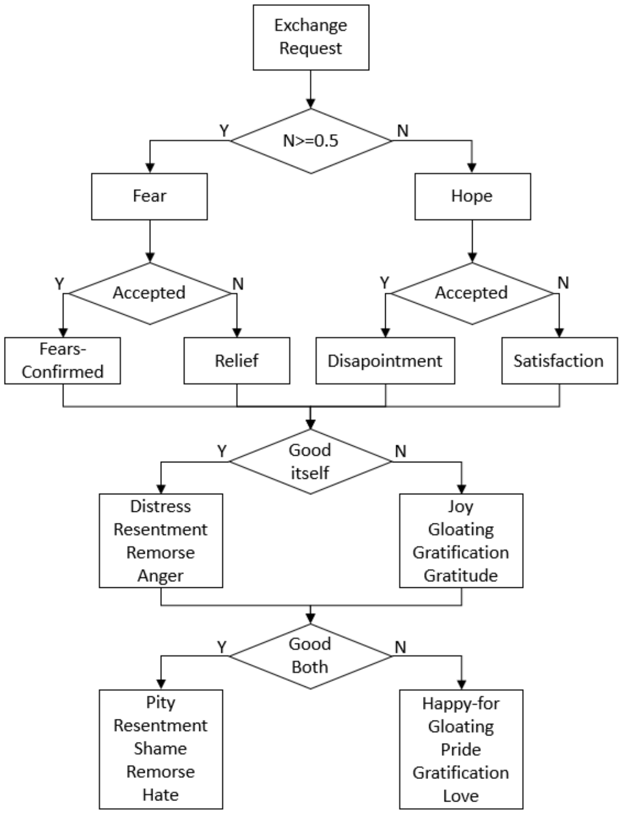
The agent choice is defined by three factors: the Openness, which represents how the agent is open to do an exchange with other agent; the Neuroticism, that verifies if the agent has fear to miss the exchange; and the last exchange result (if the last exchange was good, then it will have more chance to request the exchange to the same last agent).

Finally, the offer will be calculated based on the agent Agreeableness and in it necessity of a exchange. If the agent has few resources, this need is greater, than the agent offer a 'bad' change for itself. If the Agreeableness agent weight is high, the same occurs.

Exchange requested, the receiving agent will evaluate the offer. This evaluate is do through the Agreeableness (if the receiver is altruist, it has more chances to accepted the offer) and an analysis of how good the offer is.

The results of this exchange will be responsible for the agent's emotional desire (DE). The flowchart in Figure 3 demonstrates how these result actuation in (DE). If an emotion is activated by flow chart, the agent receive a stimulus to this emotion.

Fig. 3: Desire emotion flowchart.



IV. Model Behavior

One of the main behavioral characteristics of the model is the agent adaptation in the environment in which it is inserted. This adaptation can suffer influences from other agents or to the environment. In this way, the agent adaptation type can be occur through two different factors.

The first factor is the environment. If the agents are inserted in an environment that tends to be hostile, i.e., there is a low production of resources and there is a high need to resources consumption, the agents tend to become more hostile, and their altruism and opennesses values lower and neuroticism value higher. Otherwise, when the environment is more friendly, there is great production of resources and small need for consumption, their altruism and opennesses values are higher and neuroticism value is lower.

Another factor that modifies the agent behavior is the other agents into environment. If an agent is inserted into a community with only hostile agents, it tends to be more hostile; otherwise, if it is inserted in an environment with more friendly agents, it tends to become more friendly.

In the following subsections we will discuss about experiments performed to demonstrate such behavior. Also explain and demonstrate some results.

A. Simulation Parameters

In order to demonstrate the two factors mentioned previously, 30 different scenarios types were performed (see Table II). For each scenario, the same simulation was repeated 100 times in order to obtain the average values[2]. In this table, the colunm "Dev.OCEAN Values" present the standard deviation of the values of OCEAN weights in each scenario and these values are near to zero, and we can conclude that the OCEAN values converge to specific values (there are a stabilization of the emotions, and consequently, a stabilization of the personalities.

Each simulation was performed with 500 agents, where only one was studied in relation to the others. Each simulation had a maximum value of 10.000 iterations, in cases where the studied agent died before the simulation ended, simulation stopped and a new one started.

To define the 30 different scenarios, other aspects were analyzed, as the amount of resources generated in each iteration and the number of iterations that an agent could be without consuming any resources.

The Table III represents the variations defined for the amount of resources generated per day. The Table IV demonstrates the variations of the number of days that an agent survives without consume different resources, and the Table V represents the variations of studied agents.

In Table III, AR (Amount of Resources) means quantity of resources generated at each time; QP (Quantity of Products) means quantity of days for the next production of these resources; and type demonstrates the expected behavior that this generates for the simulation.

In the Table IV, NI represents the number of iterations required to produce new features and type also demonstrates the expected behavior for the simulation.

In Table V it is shown the value set as biological personality of agents inserted in the environment, excluded the studied agent, which had neutral biological personality, i.e., with all OCEAN weights equal to 0.5.

Besides these parameters, we defined some constants that are included in the formulas of the model. In this way, the personality variation was not abrupt and a smoothed curve was obtained, the constant k of Equation 2 was defined as $k = 8$. The constant of multiplication of the Biological factor C of Equations 4 and 5 was defined as $C = 2.5$. The division constant fD was defined as $fD = 100$. And, the decay constant d of Equation 1 was defined as $d = 0.1$.

B. Model Evaluation

The proposed model works as follows: when the environment is hostile, the agents tend to have their personality weights low, with exception of Neuroticism which works contrary to the other weights. Also, when the agents are inserted in a more friendly environment, their OCEAN attributes tend to higher, with the exception of Neuroticism, that tends to lower.

[2]The source code of this work can be found in https://github.com/gersonUrban/Personality_And_Emotion_Model, as well as more information about it. The model was implemented in Java and the NetBeans was used to run the simulations.

TABLE II: Results of the set of experiments. The column Ex. is the experiment's number; Ag0 type is the studied agents type; Ags Type is the type of other agents in simulation; Env. is the type of environment; Rec/Day is the resources quantity that is produced per day; Cons. is the days number that an agent can survive without consume a resource; Av. SI is the average of iterations that an agent survived; Min. SI is the minimal iterations that an agent survived; Max. SI is the maximal iterations that an agent survived; Dev. is the standard deviation; Av. OCEAN are the values of OCEAN weigths; Dev. OCEAN are the standard deviation values of OCEAN weights; and Sum. Dev. is the sum of agent weight standard deviation.

Ex.	Ag0 Type	Ags Typ	Env.	Rec/Day	Cons.	AV. SI	Min. SI	Max. SI	Dev. SI	Av. OCEAN Values	Dev. OCEAN Values	Sum. Dev.
1	Neutral	Good	Bad	2/2	5	10000	10000	10000	0	0,60 0,60 0,60 0,59 0,19	0,00 0,00 1,28E-5 1,28E-5 0,01	0,01990
2	Neutral	Good	Bad	5/4	2	761	3	10000	1.967	0,47 0,47 0,50 0,50 0,51	0,02 0,0271 0,0161 0,0161 0,0137	0,100323
3	Neutral	Good	Good	5/4	20	10000	10000	10000	0	0.60 0.60 0.60 0.59 0.19	0.00 0.0040 1.3797E-5 1.3697E-5 0.0151	0,023317
4	Neutral	Good	Good	20/2	5	9900	10000	6	999	0.60 0.60 0.59 0.59 0.19	0.01 0.0116 0.0100 0.0099 0.0337	0,076974
5	Neutral	Good	Too Bad	2/2	2	8317	10000	3	3.736	0.54 0.54 0.57 0.57 0.39	0.02 0.0290 0.0370 0.0370 0.0664	0,198693
6	Neutral	Good	Very Good	20/2	20	10000	10000	10000	0	0.60 0.60 0.60 0.59 0.19	0.00 0.0037 1.2665E-5 1.2685E-5 0.0154	0,023002
7	Neutral	Bad	Bad	2/2	5	141	6	660	149	0.48 0.48 0.49 0.49 0.51	0.01 0.0160 0.0016 0.0016 0.0114	0,046750
8	Neutral	Bad	Bad	5/4	2	7	3	39	7	0.49 0.49 0.49 0.49 0.50	0.00 0.0014 2.2293E-4 2.2284E-4 0.0010	0,004280
9	Neutral	Bad	Good	5/4	20	10000	10000	10000	0	0.54 0.54 0.58 0.58 0.42	0.01 0.0110 0.0023 0.0023 0.01465	0,041578
10	Neutral	Bad	Good	20/2	5	104	6	522	109	0.49 0.49 0.49 0.49 0.50	0.00 0.0068 8.0887E-4 8.0879E-4 0.0056	0,020979
11	Neutral	Bad	Too Bad	2/2	2	7	3	36	6	0.49 0.49 0.49 0.49 0.50	0.00 0.0014 2.5040E-4 2.5031E-4 0.0011	0,004607
12	Neutral	Bad	Very Good	20/2	20	10000	10000	10000	0	0.52 0.52 0.58 0.58 0.43	0.00 0.0061 0.0024 0.0024 0.0179	0,035332
13	Neutral	Random	Bad	2/2	5	10000	10000	10000	0	0.56 0.56 0.59 0.59 0.33	0.00 0.0063 0.0023 0.0023 0.02057	0,038011
14	Neutral	Random	Bad	5/4	2	126	3	447	109	0.48 0.48 0.49 0.49 0.51	0.00 0.0088 0.0032 0.0032 0.0070	0,031170
15	Neutral	Random	Good	5/4	20	10000	10000	10000	0	0.57 0.57 0.59 0.59 0.30	0.00 0.0052 0.0017 0.0017 0.0187	0,032677
16	Neutral	Random	Good	20/2	5	9800	6	10000	1.406	0.56 0.56 0.59 0.59 0.33	0.01 0.0111 0.0136 0.0136 0.0306	0,08012
17	Neutral	Random	Too Bad	2/2	2	288	3	1380	281	0.48 0.48 0.49 0.49 0.51	0.01 0.0121 0.0060 0.0060 0.0090	0,045423
18	Neutral	Random	Very Good	20/2	20	10000	10000	10000	0	0.57 0.57 0.59 0.59 0.30	0.00 0.0047 0.0014 0.0014 0.0160	0,028488
19	Good	Good	Very Good	20/2	20	10000	10000	10000	0	0.98 0.98 0.72 0.72 0.34	3.18E-4 3.1869E-4 0.0014 0.0014 0.0038	7,34E-03
20	Good	Good	Too Bad	2/2	2	8802	3	10000	3.259	0.92 0.92 0.67 0.67 0.34	0.15 0.1513 0.0639 0.0639 0.0570	0,48755
21	Good	Bad	Very Good	20/2	20	10000	10000	10000	0	0.97 0.97 0.68 0.68 0.30	4.18E-4 4.1822E-4 0.0018 0.0018 0.0036	8,08E-03
22	Good	Bad	Too Bad	2/2	2	8	3	33	7	0.50 0.50 0.50 0.50 0.49	0.00 0.0052 3.9605E-4 3.9589E-4 0.0018	0,013229
23	Good	Random	Very Good	20/2	20	10000	10000	10000	0	0.98 0.98 0.70 0.70 0.32	3.89E-4 3.8947E-4 0.0014 0.0014 0.0036	7,40E-03
24	Good	Random	Too Bad	2/2	2	447	3	10000	1.047	0.64 0.64 0.52 0.52 0.46	0.09 0.0972 0.0230 0.0230 0.0276	0,26841
25	Bad	Good	Very Good	20/2	20	10000	10000	10000	0	0.38 0.38 0.34 0.34 0.87	0.02 0.0238 0.0014 0.0014 0.0032	0,053871
26	Bad	Good	Too Bad	2/2	2	8901	3	10000	3.139	0.49 0.49 0.38 0.38 0.85	0.00 0.0078 0.0413 0.0413 0.1223	0,2207
27	Bad	Bad	Very Good	20/2	20	10000	10000	10000	0	0.49 0.49 0.38 0.38 0.90	1.08E-4 1.0896E-4 0.0023 0.0023 0.0019	6,98E-03
28	Bad	Bad	Too Bad	2/2	2	7	3	33	6	0.49 0.49 0.49 0.49 0.50	4.36E-4 4.3639E-4 5.0103E-4 5.0083E-4 0.0038	5,74E-03
29	Bad	Random	Very Good	20/2	20	10000	10000	10000	0	0.49 0.49 0.36 0.36 0.89	0.01 0.0103 0.0020 0.0020 0.0023	0,02714
30	Bad	Random	Too Bad	2/2	2	258	3	1119	229	0.49 0.49 0.49 0.49 0.59	3.67E-4 3.6785E-4 0.0048 0.0048 0.0623	7,27E-02

TABLE III: Type of resources production.

Amount of Resources (AR)	Quantity of Products (QP)	Type
2	2	Bad
5	4	Regular
20	2	Good

TABLE IV: Number of iterations to consume a resource.

Number of Iterations (NI)	Type
2	Bad
5	Regular
20	Good

The personality of each agent, through the OCEAN weights, is capable of modify the environment, because, an agent with high level of Altruism, for example, accepts many exchanges and requests many Good exchanges, leaving the environment better and friendlier. Also, the amount of days an agent has to consume a new resource is important because it tells how much the agent can be "stopped" only storing its own resource. If this number of days is very low, the environment will be more hostile, as agents will be constantly exchanging, and with a high consumption of resources, they may not always have enough resources to exchange.

Furthermore, the amount of extra resources that each agent produced per iteration is also essential for making the environment hostile or not, because with this parameter that agents will have resources to request exchanges. If the resources production is low, agents will live in a hostile environment, because they will do few exchanges. In a system where the production of resources is high, agents will have more resources available, than agents will accept more exchange requests.

C. Simulation Analysis

In this section will be discussed the simulations performed, presented the values that best represent the model behavior were summarized through Tables VI and VII .

In Table VI, two characteristics of the model behavior can be extracted: How the environment influences the final agent personality and how other agents influence the final personality of an agent.

In simulations 17 and 18, where the inserted agents have a random personality weights, it is possible to verify that the final result of the personality of the studied agent varies, i.e., the OCEAN values are varying according to the environment in which they were inserted. This behavior can also be observed by making comparisons between simulations 2 and 5 or, simulations 11 and 12. In a more hostile environment (Simulation 17), OCEAN values tend to be smaller, whereas in a not-so-hostile environment (Simulation 18), the agent tends to have higher OCEAN values.

Moreover, with this same table, it is possible to analyze that the behavior of an agent varies according to the agents that it interacts. It is possible to verify this behavior through simulations 5, 11 and 17, where these contain the same parameters for the environment, but the agents contained in the community are different. It is possible to analyze that in an

TABLE V: Agent types in the simulations

Biological Agent Personality					Type
O	C	E	A	N	
0.1	0.1	0.1	0.1	0.9	Bad
Random	Random	Random	Random	Random	Regular
0.9	0.9	0.9	0.9	0.1	Good

environment where there are more hostile agents (Simulation 11), the OCEAN values of the agent studied fell, while in a community with more friendly agents (Simulation 5), it was possible to identify the opposite behavior.

It is possible verify (Table II) the influence that other agents give to the final personality of the studied agent, analyzing and comparing simulations: 1, 7 and 13; 2, 8 and 14; 3, 9 and 15; 4, 10 and 16; 5, 11 and 17; 6, 12 and 18.

It occurs because if the inserted agents are mostly "Good", there is a greater amount of exchanges accepted, which will give more "Good" emotions to the agents, and increased their OCEAN weights. And similarly, if there is a greater production of resources, there will also be a greater amount of exchanges, with good proposals for exchanges. What will also do the OCEAN weights, in general, to increase.

However, this is a simplified analysis, since the weights are set in a similar way, that is, OCEA are close to 1 and N is close to 0. In a more detailed analysis, the main factor for such behavior is A, since an agent with high value of A make the exchanges easier, than more exchanges occurring and consequently generating more "good" emotions. The second main factor is C, responsible for the agent motivation to fulfill its goal, and making more exchanges.

Besides this type of behavior, it is also possible to identify the behavior of the agent according to its biological personality, which has an influence on the final result of the OCEAN weights. In simulations 19 and 20 (Table VII), it is possible to see that the agents always tends to have high OCEAN values, following their biological personality more than the environment itself. This kind of comparisons can be made through simulations 21 and 22; 23 and 24; 25 and 26; 27 and 28; and 29 and 30.

Simulations 25 and 26 show the same type of behavior, where the agent follows its biological personality factor. It is important to remember that the weight that the biological personality influences the agent can vary only adjusting a constant.

About simulations 25 and 26, where the environment is worse in simulation 26, smaller OCEAN values are found in simulation 25. However, this occurs because simulation 26 is very hostile, causing the agents die in a few iterations, not giving time to change the OCEAN weights. This can be visualized through the average of iterations survived by the agent, as well as by deviation of iterations survived.

This tendency to follow biological weights can be visualized in simulations 19, 21 and 23, where the environment is the same but the agents inserted are different. In these simulations it is also possible to verify the another agents influence in final OCEAN values. It is also possible to verify by comparing the

TABLE VI: Demonstration of the environment has influence over an agent, as well as other agents have influence over an agent.

Ex.	AgsType	Env.	O	C	E	A	N	Sum. Dev
2	Good	Bad	0.4777	0.4777	0.5025	0.5025	0.5138	0.1003230597
5	Good	Too Bad	0.5435	0.5435	0.5742	0.5742	0.3932	0.1986939286
11	Bad	Too Bad	0.4985	0.4985	0.4998	0.4998	0.5013	0.004607608055
12	Bad	Very Good	0.5211	0.5211	0.5834	0.5834	0.4392	0.03533245973
17	Random	Too Bad	0.4812	0.4812	0.4973	0.4973	0.5148	0.04542379084
18	Random	Very Good	0.5722	0.5722	0.5983	0.5983	0.308	0.02848846643

TABLE VII: Demonstration of biological personality modifies an agent.

Ex.	Ag0 Type	Env.	O	C	E	A	N	Sum. Dev.
19	Good	Very Good	0.982	0.982	0.72	0.72	0.348	7.34E-03
20	Good	Too Bad	0.9244	0.9244	0.6737	0.6736	0.3437	0.4875530244
25	Bad	Very Good	0.3866	0.3866	0.3492	0.3492	0.8727	0.05387189391
26	Bad	Too Bad	0.4986	0.4986	0.3836	0.3837	0.8552	0.220730723

simulations 20, 22 and 24; 25, 27 and 29; 26, 28 and 30.

From these simulations it is possible to verify the factors involved in the agent adaptability according to the environment and society which is inserted. They also demonstrate that the methods developed during the proposal of the work performs in a generic and effective way.

V. Conclusion

In this work, we proposed an adapting agent simulation model, using emotions and personality. We have demonstrated how emotions can influence directly the personality changes and indirectly the action choices. Also, we demonstrated how personality influences the action choices and it can indirectly influences the emotions, and how biological personality can influence the final agent personality. Furthermore, our model is generic to emotions and personality models, what do possible to work with other personality and emotions models (unlike OCC and OCEAN).

It is important to note that the model integrates emotions and personality in a way that one influences the other, and both vary over time. Unlike other models like [2], where there is a static model where only emotions are felt.

With the obtained results, it is possible verifies that in a neutral environment, an agent is influenced main by other agents, and then adapting it behavior to survive. It was also possible to verify, through the OCEAN weights, that in simulations where cooperation was greater, agents tended to survive more, and in less hostile environments agents tended to become more cooperative. However, the environment model proposed is very simple and it is necessary test the agent model in other environment types and with other goal types, once the emotions felt depend mainly by the agent environment perception.

As future works, new methods of activating emotions will be evaluated, as well as the MEP matrix, which defines statically as each emotion influences the OCEAN values. The model will also be used in new environments and multi-agent systems in order to verify the model in other environments and with new rules. And the MEP matrix will be modified in order to not be static and may have small variations over time, for this will be used interval matrix and concepts of fuzzy sets.

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