Creating Individual Agents through Personality Traits

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Abstract. In the era of globalization, concepts such as individualization and personalization become more and more important in virtual systems. With the goal of creating a more familiar interaction between human and machines, it makes sense to create a consistent and believable model of personality. This paper presents an explicit model of personality, based in the Five Factor Model, which aims at the creation of distinguishable personalities by using the personality traits to automatically influence cognitive processes: appraisal, planning,coping, and bodily expression.

Key words: Agent Architectures, Personality

1 Introduction

In the era of globalization, where the number of different individuals with distinct characteristics that come in contact with us in everyday life has increased enormously, more and more aspects such as personalization and individuality become relevant in human-machine interaction. In order to create virtual environments that try to portray the same richness and interaction as the real-world, one needs to address the creation of unique virtual characters with distinct, believable personalities. Many definitions of personality in autonomous agents use traits to define individual characteristics of agents, however, the set of traits used is sometimes ad hoc, which can lead to combination of traits that produce personalities that are not coherent [4]. This may be a small issue when using personality as a exploratory tool in multi-agent systems, but may become a major problem if the goal is to create agents that show believable personalities.

These more ad hoc approaches can be effective, however, they usually lead to more effort in the crafting of each individuality to avoid producing personalities that are not coherent. We defend that using an explicit personality model, based on well established trait theories, such as the Five Factor Model (FFM) of personality [11], provides a better tool to easily create coherent and different personalities. With this in mind, this paper addresses the problem of how to create agents with different distinguishable personalities, just by changing the values of a set of predefined personality traits. Given the definition of Personality as an organized set of characteristics that uniquely influence the processes of cognition, motivation and behaviour [28], we depart from the hiphotesis that

if we use the personality traits to automatically influence emotional, cognitive and behavioural processes, these will then influence the overall behaviour of the agent, thus portraying the defined personality.

This paper is then structured as follows: we start by describing the theories that support the model presented and additional related work. Afterwards, we present the proposed model, and its implementation in a concrete agent architecture. Finally we depict a case study used to evaluate the model, present the results obtained and draw some conclusions.

2 Background and Related Work

A very important psychology work in the area of personality is the work of Gordon Allport who considers traits as being predispositions to act in a certain way [1]. Although there were many studies regarding traits, they never seemed to agree in the number of basic traits until the five-factor model started to emerge [11]. This model proposed five traits as the basic units of personality[21, 11, 10, 16, 17]: Neuroticism, Extroversion, Openness to experience, Agreeableness and Conscientiousness.

There are a few studies who support the validity of the five-factor model and among them there is one that found correlations between traits, emotions and interpersonal behaviour [21]. Thus we need an emotion model that can easily represent emotions in a systematic way. Among the wide variety of emotion theories, the OCC [19] seems like the most suited due to its simplicity and due to the fact that is used in the architecture FAtiMA, which we will extend with our model. OCC theory proposes 22 basic emotion types (e.g. Joy, Distress, Hope) with thresholds and decay rates. The thresholds define the intensity an emotion has to have in order to be felt by an individual, and the decay rate defines the rate at which the intensity of the emotion decays.

Regarding agents with personality, there is a wide variety of approaches, whether in terms of personality theories or in architectural strategies. The works of Rousseau and Hayes-Roth [25, 8, 24, 26, 27], are particularly important in the sense that they provide a nice example of how traits can be implemented in agents. By defining a character's personality and the actions he can perform with values for each trait dimension, they provided a simple way to represent different personalities through different behaviour.

A different approach to personality in synthetic agents is explored in the work of Rizzo et al. [23]. It proves that goals and plans can be used to represent a character's personality in an efficient way, by attributing specific behaviour (personality) to the pursuit of each goal. The work of Malatesta et al. [14] shows how personality can be used to create different expressions of behaviour. A personality trait is linked to mood/emotions and behaviours and these behaviours are expressed through the use of certain expressivity parameters. The works of Kshirsagar et al. [12] and Reichardt[22] show how the Big Five personality theory can be linked with the OCC model of emotions by mapping the five dimensions of personality into specific moods, which in turn influence the agent's emotions.

3 Personality Model in an Agent Architecture

We identified four cognitive/behavioural processes that are strongly influenced by personality: emotions, coping behaviour, means-ends reasoning and bodily expression.

Personality and Emotions
Personality is said to influence in a major way, the way one feels [3]. Therefore, we have mapped personality traits into emotions. The personality traits define the predisposition that the agent has to feel certain emotions, as well as their intensity. We can easily make a link between traits and emotions by defining the emotions thresholds and decay rates as being influenced by each trait:

– **Neuroticism -** associated to individuals that often feel anxious and sad[17]. So there is a strong relation between neuroticism and Distress/Joy emotions. Neuroticism is also associated with insecureness and self-punishment [29]. Thus, neurotic agents should feel weaker positive emotions when they accomplish/achieve things and stronger negative emotions when they fail. The OCC emotions related to the success/failure of goals are Satisfaction, Disappointment, Relief, Fears-Confirmed, Gratification and Remorse. Finally, given that the neurotic individual is fearful [11] [21], this trait will be used to influence Hope(negatively) and Fear(positively).
– **Extroversion -** Some studies have said that introverts feel emotions more intensely than extrovert with the same amount of stimuli [21]. For this reason, agents with a high score on Extroversion have this trait influencing negatively all emotions, i. e., extroverted agents will have higher thresholds for every emotion. However, this effect is not as strong as the influence of other traits.
– **Openness to Experience -** Individuals with a high score on Openness are unconventional and do not value norms [15]. Thus, we argue that such individuals attribute less blameworthy and praiseworthy (evaluated from norms and values) to actions and events. Thus, open minded agents will fell with less intensity OCC emotions related to these evaluations: Pride, Shame, Admiration and Reproach. Opposingly, close minded individuals will experience these emotions with greater intensity.
– **Agreeableness -** A high agreeableness implies that the agent feels more intensely emotions which are positive towards others: Love, Happy-For, Pitty, Admiration, Gratitude; and that the agent feels less intensely emotions considered negative towards others: Hate, Resentment, Gloating, Reproach and Anger. A low agreeableness affects the same emotions opposingly.
– **Conscientiousness -** Conscientiousness is associated with assertiveness and research shows that there is a strong relationship between assertiveness and pride [30]. Thus, a high score in this trait imply stronger feelings of pride. Conscientiousness delays gratification, which indicates that noon-conscientious people feel gratification more. As such, a low score in this trait will also make the agent feel more intense Gratification emotions.

Personality and Planning
Deliberative agent architectures usually model the concepts of goals, intentions and plans. Upon the selection of a possible achievable goal, a plan is created, composed by actions, in order to achieve the goal. The point of relevance for personality here, is that the agent has many goals he can pursuit at a given time, and can construct several plans to achieve every single one of them.

Among the five traits, Conscientiousness is the one that was found to be more relevant to this process. Conscientiousness describes several characteristics of the human being that are naturally part of the planning process, such as the degree of organization, persistence and motivation in goal-directed behaviour. People who score high tend to be hard-working and persevering; people who score low are usually undetermined and sloppy [21, 11, 10, 17, 15]. Therefore, an agent with a low level of Conscientiousness will prefer plans with a smaller number of actions and smaller number of open preconditions, while an agent with high Conscientiousness will prefer a plan with better probability of success, not minding a greater number of actions. This is formalized through an heuristic function, where the plan with the lowest value of $h(p)$ will be the one selected by the agent:

$$h(p) = \frac{Steps(p) \times c_{value} + OpenPrecond(p) \times c_{value}}{probability(p) \times (6 - c_{value})}$$

$Steps(p)$ returns the number of steps (actions) in the plan, $OpenPrecond(p)$ the number of open preconditions (conditions that are not yet achieved by the plan and must be planned for) and $probability(p)$ is the plan's probability of success. The constant c_{value} represents the agent's conscientiousness value.

Personality and Coping Behaviour
Research within the big five personality traits theory has shown that these traits can provide information regarding the individual's coping process [6, 18, 31, 9]. However, there is not an agreement on which traits influence coping or how they influence it. Because Neuroticism is the only trait that has enough support by researchers on the matter of influencing coping, we chose to influence coping strategies with Neuroticism wherever it was possible. In our model, denial or wishfull thinking is applied when, for example, there are certain goals that are being threatened by an active plan. In this case, the agent denies those threats, going forward with the plan. To make this dependent on the personality, this strategy is only chosen by the agent, depending on his level of Neuroticism: if it is high, the agent applies denial/wishfull-thinking, if it is low, the agent does not.

Personality and Expressivity
Research shows that one's facial expressions influences the judgement that other people make about one's personality [5]. Regarding other bodily expressions, several studies have shown the relationship between, for example, the arms position, facial expressions, vocal expressions and posture expressions, and personality traits [2].

Personality is then introduced at this level through the expression of emotions and through the diversity of ways that the agent can express the same gesture, by manipulating a set of expressivity parameters: Spacial extent - amount of space required to perform and expression - extroverts use a lot of spacial extent, while introverts use a small space; Temporal extent - amount of time spent to perform an expression - we assigned a short temporal extent to extroverts;

Fluidity - smoothness of movements - agents have a high fluidity if they are not extroverted nor neurotic and a low fluidity otherwise; Power - intensity of an intention - power is directly proportional to extroversion; Repetitivity - repetition of certain movements - a character with high neuroticism will have a high repetitivity.

4 Implementation

Figure 1 shows the integration of the proposed trait-based personality model into an Agent Architecture, which uses FAtiMA [7] as the agent's mind and GRETA [20] as the body. Whenever an event is perceived, it starts by appraising the event according to OCC theory, generating emotions. The event is then sent to the deliberative layer, which updates the memory of the agent and checks whether any goal has become active. If so, the agent creates an intention to achieve the goal. Then, a plan of actions is created for that intention, and coping strategies such as acceptance (giving up a goal) or wishfull thinking (lowering a threat's probability) can be applied as well. Finally, the actions are sent for execution to GRETA, which expresses them through gestures, facial expressions and posture.
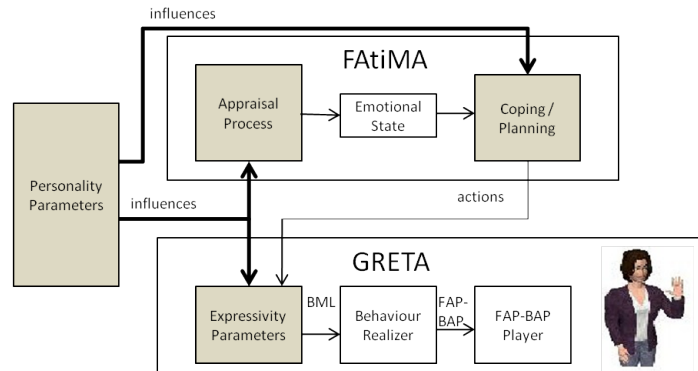

Fig. 1. Agent Architecture using FAtiMA and Greta

5 Evaluation

In order to evaluate the model, we created a very simple case study, with four different basic personality types [13]: sanguine, melancholic, phlegmatic and choleric. The evaluation was then performed by having users watch a video with a performance of an agent with a specific personality (each user saw only one personality) and then fill a personality questionnaire concerning the personality of the agent. Our aim was to determine if the created architecture is able to

convey the different personalities, and if users could identify correctly the traits of the agent. In total we got 46 answered questionnaires (roughly 11 for each personality), ranged from 20 to 30 years old. The Openness to Experience trait was not evaluated since it is more related to actions (painting, reading, etc) than to actual expression of emotions.

The first test consisted in determining whether users could perceive the personalities as distinct. The personality was selected as the control variable (thus creating four control groups), and the user's classification of the agent's traits as the dependent variables. We applied an one-way independent ANOVA statistical test and obtained the following results: Extraversion - $F(3, 42) = 15.95, p < 0.01, r = 0.76$; Agreeableness - $F(3, 42) = 7.91, p < 0.01, r = 0.62$; Conscientiousness - $F(3, 42) = 2.80, p = 0.051, r = 0.37$; Neuroticism - $F(3, 42) = 12.97, p < 0.01, r = 0.72$. In other words, the results show that the defined personality significantly affected the user's perception of agent's extraversion, agreeableness and neuroticism traits. Moreover, the effect was substantial. As for the conscientiousness trait, it is very close to being significant, but only has a moderate effect. Thus, this first test tells us that the architecture was indeed able to create distinguishable personality just by changing its traits.

Our second goal was making users correctly identify the traits defined for each personality. In order to test this, we checked if there was any individual correlation between the defined traits and the traits perceived. After applying a Pearson correlation test, the results obtained were: $C(Def_E, Per_E) = 0.45, p = 0.02; C(Def_A, Per_A) = 0.54, p < 0.01; C(Def_C, Per_C) = 0.09, p = 0.56; C(Def_N, Per_N) = 0.677, p < 0.01$. This means that the neuroticism trait has a positive relation with the perceived neuroticism. The same happens with agreebleness and extraversion (although with a weaker correlation). Unfortunately, there was no correlation found between the conscientiousness value used to define the agent's personality, and the user's perception of the same trait.

6 Conclusions

The work presented in this paper aimed at the creation of an explicit personality model based on trait theories, which would allow the creation of agents with distinguishable personalities, just by changing the values for the traits. In our proposed model, we identified four cognitive/behavioural processes that are strongly influenced by personality: emotions, coping behaviour, planning and bodily expression. We then used the personality traits to influence each of these processes. The model was implemented into FAtiMA, an emotional agent architecture, and integrated with the ECA GRETA. Results have shown that indeed the model is partially successful, since it is able to create perceivably different personalities, and the user's classification is correlated with the original values for extroversion, neuroticism, and agreeableness. The worst results, obtained for conscientiousness, can likely be explained by the fact that it only affects two very particular emotions.

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