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Abstract
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Keywords
crowd simulation, OCEAN personality model, autonomous agents

Disciplines
Computer Sciences | Engineering | Graphics and Human Computer Interfaces

Creating Crowd Variation with the OCEAN Personality Model (Short Paper)

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ABSTRACT
Most current crowd simulators animate homogeneous crowds, but include underlying parameters that can be tuned to create variations within the crowd. These parameters, however, are specific to the crowd models and may be difficult for an animator or naïve user to use. We propose mapping these parameters to personality traits. In this paper, we extend the HiDAC (High-Density Autonomous Crowds) system by providing each agent with a personality model in order to examine how the emergent behavior of the crowd is affected. We use the OCEAN personality model as a basis for agent psychology. To each personality trait we associate nominal behaviors; thus, specifying personality for an agent leads to an automation of the low-level parameter tuning process. We describe a plausible mapping from personality traits to existing behavior types and analyze the overall emergent crowd behaviors.

Categories and Subject Descriptors
I.3.7 [**Computer Graphics**]: Three-Dimensional Graphics and Realism – Animation; I.6.8 [Simulation and Modeling]: Types of Simulation –Animation

General Terms
Design, Experimentation, Human Factors.

Keywords
Crowd simulation, OCEAN personality model, autonomous agents

1. INTRODUCTION
Simulating the behavior of animated virtual crowds has been a challenging goal for the computer graphics community. The semantics underlying the motion of real crowds should be studied extensively in order to achieve realistic behavior in virtual ones. Psychology studies human nature so that salient behavior characteristics may be captured. There has been extensive research on incorporating psychological models into the simulation of autonomous agents. In the present study, however, we are not interested in the personality of an individual *per se* but the incorporation of a personality model into large groups of people. We thus examine, by changing the parameters, how subgroups of people with different personality traits interact with each other and accordingly, how the global crowd behavior is influenced. It is up to the user to decide the percentage and the distribution of the specific personality traits in the crowd.

Personality is a pattern of behavioral, temperamental, emotional, and mental traits for an individual. There is still considerable controversy in personality research over how many personality traits there are, but the Five Factor or OCEAN model is popular; it is the one we have chosen for this study [4]. The five factors, which are orthogonal dimensions of the personality space, are *openness*, *conscientiousness*, *extroversion*, *agreeableness* and *neuroticism*. Openness describes a dimension of personality that portrays the imaginative, creative aspect of human character. Conscientiousness determines how much an individual is organized and careful. Extroversion is related to how outgoing and sociable a person is. Agreeableness is friendliness, generosity and the tendency to get along with other people Finally, neuroticism refers to emotional instability and the tendency to experience negative emotions. Each factor is bipolar and composed of several traits, which are essentially the adjectives that are used to describe people [1]. Some of the relevant adjectives describing each of the personality factors for each pole are given in Table 1. We have mapped these trait terms to the set of behaviors in an existing crowd simulation system, HiDAC (High-Density Autonomous Crowds) [3].

HiDAC models individual differences by assigning each individual different psychological traits such as impatience, panic, and leadership behaviors and physiological traits such as energy level, speed, etc. The user normally sets these parameters to model the non-uniformity and diversity of the crowd. In this extended work, we free the user of the tedious task of low-level parameter tuning, and combine all these behaviors in distinct personality factors. Here we combine a *standard* personality model with a high-density crowd simulation to create plausible variations in the crowd and permit a novice user to dictate these variations. Furthermore, we examine how these parameters affect the global behavior of a crowd. We will show that novel, emergent formations are realized and behavior timings are also affected.

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The organization of the rest of the paper is as follows: Section 2 gives a review of the related work; Section 3 explains the HiDAC system and the methods used to implement the personality model; Section 4 presents the experiments and results. Finally, Section 5 presents the conclusions.

Table 1. Trait-descriptive adjectives

O+	Curious, alert, informed, perceptive
O-	Simple, narrow, ignorant
C+	Persistent, orderly, predictable, dependable, prompt
C-	Messy, careless, rude, changeable
E+	Social, active, assertive, dominant, energetic
E-	Distant, unsocial, lethargic, vigorless, shy
A+	Cooperative, tolerant, patient, kind
A-	Bossy, negative, contrary, stubborn, harsh
N+	Oversensitive, fearful, dependent, submissive, unconfident
N-	Calm, independent, confident

2. SYSTEM

2.1 HiDAC

HiDAC [3] is a high density crowd simulation system, which addresses the simulation of local behaviors and global way-finding of crowds in a dynamically changing environment. The behaviors of autonomous agents in HIDAC are governed by the combination of geometrical and psychological rules. Psychological attributes include impatience, panic, and leadership behaviors. Physiological attributes are determined by traits such as locomotion, energy levels, maximum speed, etc. Agents are provided with skills such as navigation in complex environments, communication, learning and certain kinds of decision-making. Furthermore, they have perception so that they can react to obstacles, other agents, and dynamic changes in the environment.

In order to achieve realistic behavior, collisions are handled both by avoidance and response forces. Over long distances, collision avoidance is applied so that agents can steer around obstacles. On the other hand, collision response is utilized over shorter distances to prevent overlapping of agents with each other and with the environment.

In addition to usual crowd behavior, agents might show pushing behavior or can wait for other agents to pass first depending on their politeness and patience. Pushing behavior arises from varying the personal space threshold of each individual. Impatient agents do not respect others' personal space and they appear to push their way through the crowd. In addition, relaxed agents temporarily stop when another agent moves into their path, while impatient agents do not respond to this feedback and tend to 'push'.

2.2 Integrating the OCEAN Model into HiDAC

The crowd is composed of subgroups with different personalities. Variations in the characteristics of the subgroups influence the emergent crowd behavior. The user can add any number of groups with shared personality traits and can edit these characteristics during the course of the animation. An agent's personality π is a five-dimensional vector, where each dimension is represented by a personality factor, Ψ_i. The distribution of the personality factors in a group of individuals is modeled by a Gaussian distribution function N with mean μ_i and standard deviation σ_i:

$\pi = <\Psi_O, \Psi_C, \Psi_E, \Psi_A, \Psi_N>$,

$\Psi_i = N(\mu_i, \sigma_i^2)$, for $i \in \{O, C, E, A, N\}$

where $\mu \in [0\ 1]$, $\sigma \in [-0.1\ 0.1]$

The overall behavior β for an individual is a combination of different behaviors. Each behavior is a function of personality as:

$\beta = (\beta_1, \beta_2, ..., \beta_n)$

$\beta_j = f(\pi)$, for j = 1…n

Since each factor is bipolar, Ψ can take both positive and negative values.

2.3 Personality to Behavior Mapping

The agents' personality factors (adjectives) are mapped into low-level parameters and some of the built-in behaviors in the HiDAC model are shown in Table 2. A positive factor takes values in the range [0.5 1], whereas a negative factor takes values in the range [0 0.5). A factor given without any sign indicates that both poles apply to that behavior. For instance E+ for a behavior means that only extroversion is related to that behavior; introversion is not applicable. As indicated in Table 2, a behavior can be defined by more than one personality dimension. The more adjectives of a certain factor define a behavior, the stronger is the impact of that factor on that behavior. Thus, we assign a weight to the factor's impact on a specific behavior. For instance, ω_{EL} is the weight of extroversion on leadership and it takes a value in the range [0 1]. The sum of the weights for a specific type of behavior is 1. Now we can see how the mapping from a personality dimension to a specific type of behavior for an agent *i* is performed on two examples:

Leadership*:* Leaders tend to have more confidence in themselves and they help others find their way through a building. Each agent has a leadership percentage determined by its extroversion, disagreeableness, conscientiousness and stability. The leadership behavior is computed by:

$$\beta_i^{Leadership} = \omega_{EL}\psi_i^E + \omega_{AL} f(\psi_i^A) + \omega_{CL} g(\psi_i^C) + \omega_{NL}(1-\psi_i^N)$$

$$f(\psi_i^A) = \begin{cases} 2\psi_i^A & : \psi_i^A < 0 \\ 0 & : otherwise \end{cases}$$

$$g(\psi_i^C) = \begin{cases} 2\psi_i^C - 1 & : \psi_i^C \geq 0 \\ 0 & : otherwise \end{cases}$$

where $\beta_i^{Leadership} \propto$ E, A-, C+, $\beta_i^{Leadership} \propto^{-1}$ N and $\beta_i^{Leadership} \in [0\ 1]$.

Right preference: When the crowd is dispersed, individuals tend to look for avoidance from far away and they prefer to move towards the right hand side of the obstacle they are about to face. This behavior shows the individual's level of conformity to the rules. The right preference behavior is a probability function. If an agent is disagreeable or non-conscientious, then that agent can make right or left preference with equal probability. On the other hand, an agent prefers the right side by increasing probability proportional to its agreeableness and conscientiousness values if these are positive.

$$P(Right) = \begin{cases} 0.5 & : \psi_i^A < 0 \ \ or \ \ \psi_i^C < 0 \\ \omega_{AR}\psi_i^A + \omega_{CR}\psi_i^C & : otherwise \end{cases}$$

where $\beta_i^{Right} \propto$ A, C , and $\beta_i^{Right} \in \{0, 1\}$.

Table 2. Low-level parameters vs. trait-descriptive adjectives

Leadership	Dominant, assertive, bossy, dependable, confident, unconfident, submissive, dependent, social, unsocial	E, A-, C+, N
Trained/not trained	Informed, ignorant	O
Communication	Social, unsocial	E
Panic	Oversensitive, fearful, calm, orderly, predictable	N, C+
Impatience	Rude, assertive, patient, stubborn, tolerant, orderly	E+, C, A
Pushing	Rude, kind, harsh, assertive, shy	A, E
Right preference	Cooperative, predictable, negative, contrary, changeable	A, C
Avoidance /personal space	Social, distant	E
Waiting radius	Tolerant, patient, negative	A
Waiting timer	Kind, patient, negative	A
Exploring environment	Curious, narrow	O
Walking speed	Energetic, lethargic, vigorless	E

3. RESULTS AND ANALYSIS

We have run several tests to see how the global crowd behavior is affected by modifying the personality parameters of the subgroups. We ran our first experiment to see how the extroverts and introverts are distributed around a point of attraction. The results can be seen in Figure 1, where the agents in blue suits are extroverted with $\mu = 0.9$ and $\sigma = 0.1$ and the agents in grey suits are introverted with $\mu = 0.1$ and $\sigma = 0.1$ for the 'extroversion' factor. The ratio of introverts to extroverts in a society is found to be 25% [2], according to which we assigned the initial number of agents. The results show that introverts are left out of the ring structure around the object of attraction. As extroverts are faster, they approach the attraction point in a shorter time. In addition, when there are other agents blocking their way, they tend to push them to reach their goal. The figure also shows the difference between the personal spaces of individuals with introverted and extroverted personality.

The second experiment is to test the impact of openness. We included 10 agents for each of the 20 openness groups with openness values ranging from 0 to 1 in steps of 0.05. Each agent is assigned actions in accordance with their openness level. We recorded the average time they spent in the building. The results can be seen in Figure 2. As openness increases, the number of places they explore increases and thus, they leave the building later.

We computed the time two groups spend moving through each other depending on the conscientiousness and agreeableness as a third experiment. Groups of ten people each having a combination of conscientiousness and agreeableness values of 0, 0.5 and 1 are sampled. The results are shown in Figure 3. The shortest time is achieved when conscientiousness and agreeableness are highest. The result is expected as agreeable and conscientious individuals are more patient, they don't push each other and are always predictable as they prefer the right side to move on. Also, the longest time is obtained when both values are minimal.

Figure 4 shows how congestion occurs due to low conscientiousness and agreeableness values. People are stuck at the center, and they refuse to let other people move. Finally, Figure 5 illustrates the effect of neuroticism and non-conscientiousness on panic behavior. A total of 100 agents are simulated. 25% of the agents have neuroticism values of $\mu = 0.9$ and $\sigma = 0.1$ and conscientiousness values of $\mu = 0.1$ and $\sigma = 0.1$. The remaining agents, which are stable, have neuroticism values of $\mu = 0.1$ and $\sigma = 0.1$ and conscientiousness values of $\mu = 0.9$ and $\sigma = 0.1$. The agents in black suits are neurotic and less conscientiousness. It can be seen in the figure that these agents tend to panic more, pushing other agents, forcing their way through the crowd and rushing to the door.

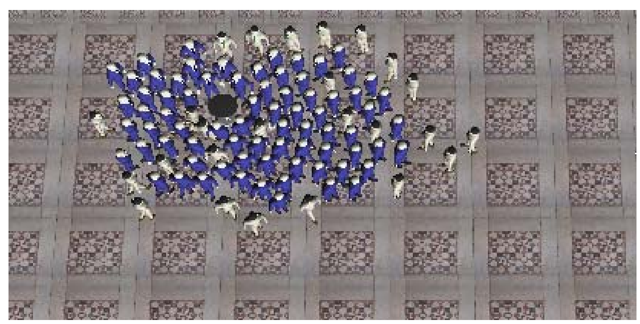

Figure 1. Ring formation where extroverts (blue suits) are inside and introverts are outside.

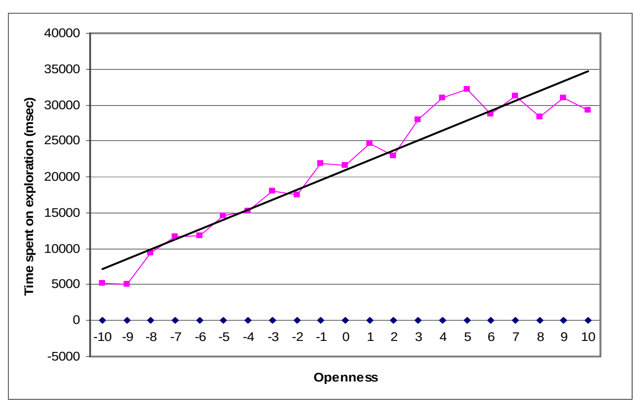

Figure 2. Openness vs. the time spent in the environment in milliseconds.

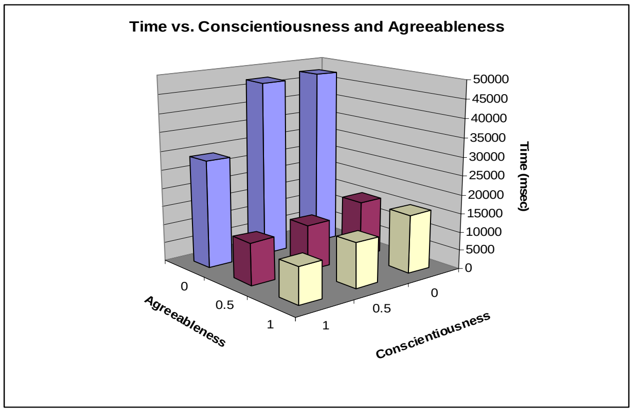

Figure 3. Conscientiousness and agreeableness vs. the time spent for two groups to move across each other in milliseconds.

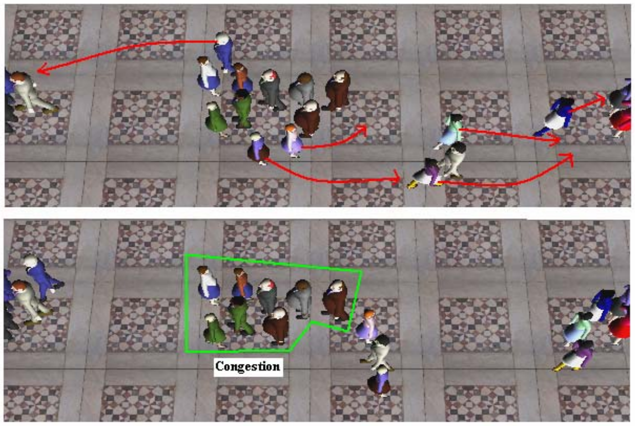

Figure 4. People with low conscientiousness and agreeableness value cause congestion.

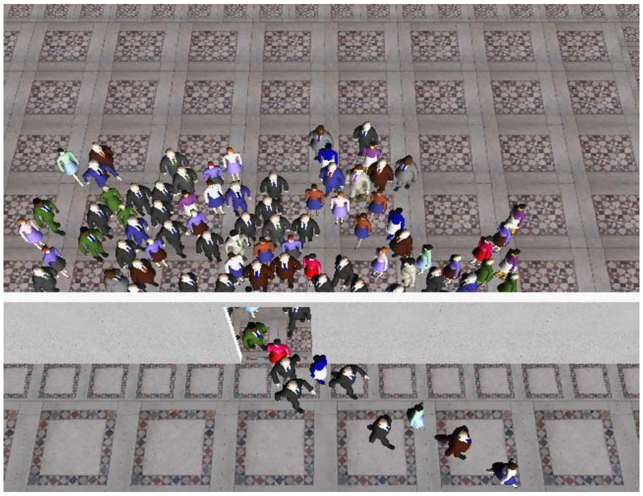

Figure 5. Neurotic and non-conscientious agents (in black suits) show panic behavior.

4. CONCLUSION

In this study, we explain how we have integrated the OCEAN personality model into an existing crowd simulation system, HiDAC. In doing so, we have collected the adjectives identifying each personality factor and defined a direct mapping between the parameters in HiDAC and the personality traits. Our system enables the simulation of heterogeneous crowds, where each subgroup is composed of individuals with similar personality traits. The user can specify the distribution and the values of the five personality factors within the crowd and can examine how the subgroups of people with common characteristics act under particular circumstances. In contrast to the low-level parameter tuning process in previous work, we now let the user choose from higher-level concepts related to human psychology. Thus, the user is freed from understanding the underlying methodologies used in HiDAC. Our mapping also decreases the number of parameters that need to be set from 12 to 5. There are certainly other psychological models that could have been used. Emotion models, for one, have been referenced in autonomous agent research. Future research may include adding emotion to the agents, but while personality is a pattern of behavior (extended through time), emotions change according to the agent state and the situation. Therefore emotions should evolve through the simulation, not be set by the animator. Certainly, personality impacts emotional tendency and hence is a foundation to build on. Furthermore, because personality is a pattern of behavior, it may aid in observers of the characters developing a sense of knowing the character. They may become individuals instead of just another collection of anonymous computer characters.

Our future work also includes extending the investigation of other emergent behaviors and validating our results with psychological experiments in order to see how individuals with different personalities behave in real crowds. We are also interested in determining what differences in behaviors observers can actually perceive when given such agents with personality.

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6. REFERENCES

1. Goldberg, L.R. An Alternative "Description of Personality": The Big-Five Factor Structure. *Journal of Personality and Social Psychology*, *59* (6). 1216-1229, 1990.
2. McLean, K.C., & Pasupathi, M. Collaborative Narration of the Past and Extraversion. *Journal of Research in Personality*, *40*. 1219-1231, 2006.
3. Pelechano, N., Allbeck, J.M. and Badler, N.I. Controlling Individual Agents in High-Density Crowd Simulation *ACM SIGGRAPH / Eurographics Symposium on Computer Animation (SCA)*, ACM Press, San Diego, CA, 2007.
4. Wiggins, J.S. *The Five-Factor Model of Personality: Theoretical Perspectives*. The Guilford Press, New York, 1996.