Perceiving Attributes of Game AI Using Fuzzy Logic

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Abstract. This paper introduces the concept of the SEA Model: "Skill, Experience, and Aggression" – a novel way of representing the behavior of Video Game AI in a linguistic or graphical manner. The SEA Model takes inspiration from the "Big Five Factors of Psychology" – an apparatus used to describe the personalities of different human beings. In the SEA Model, the ideas from the Big Five Factors are modified and applied to Video Game AI, processed through the "Fuzzy Inference System", and presented in a manner that is easily perceivable by humans.

Keywords: Fuzzy Logic; Video Game AI; OCEAN Model; Big Five Factors of Psychology; SEA Model; Perception of Personality; AI Behavior; Fuzzy Inference System.

1 Introduction

The mark of a good video game is transparency: designers need to provide as much information as they can to the players – about the environments and adversaries present in the game world. This is especially true for sports games, competitive games, and strategy games – where players require very detailed information about every aspect of the game.

Unfortunately, describing each of these aspects is not an easy task, as there may be over a thousand of them (depending on the complexity of the game). The sheer number of variables that influence the actions of video game AI would be overwhelming to human players. With that in mind, the primary goal of this paper is to introduce a process that provides designers the ability to convey information about the game AI to the human players in a concise, understandable, and useful way. We have named this process the "SEA Model".

We have developed a game of air hockey to illustrate the use of the SEA model. This game involves two players with "paddles", trying to hit a "puck" into each other's goals. This game comes with different versions of difficulty levels. We have created these difficulty levels using the SEA model. A player who is less skilled, less experienced and less aggressive will come across as easy opponent to a person in comparison to a player who has high skill, experience and aggression. The SEA model provides the "fuzzy" representation of these two AI players' skills.

The purpose of fuzzy logic is to generalize the crisp sets and control the degree of membership of an element of that set, e.g. how strongly does the element belong in that set? The membership of the elements of a set is described by a membership function. Values of the membership function are fuzzy, meaning they can have any value between 0 and 1. 0 being – does not belong at all, and 1 being – fully belongs in the set.

This paper is structured so that readers would be systematically introduced to the concepts that shape the SEA Model. In (II) Background, we define the Big Five Factors of Psychology and its fuzzy interpretation: OCEAN Model. In (III) Methodologies describe the SEA Model, and our application of it in the air-hockey game - this section contains the bulk of our work. The (IV) Findings section contains the results of a survey we have conducted to evaluate the effectiveness of the SEA Model. We concluded the paper and provided an outline for future works on this topic in section (V).

2 Background

Human beings, like Game AI, have innumerable variables contributing to their personality. In 1961, Tupes and Christal[4], noticed similarities in the behavior of different people and identified "five key factors" that could be used to describe an individual's personality [3] – these became known as the Big Five Factors of Psychology, and each of the 5 factors describes a separate aspect of a character's personality [5]. The factors being: Openness (Creativity), Conscientiousness (Dedication), Extraversion (Sociability), Agreeableness (Niceness), Neuroticism (Emotional stability) [5]. These factors are arranged in the acronym – OCEAN. Each of the 5 factors in the OCEAN Model is a spectrum

from “very low” to “very high” (consider as 0 to 1 in fuzzy terms); For example, an extroverted person would have “very high extraversion”, whereas an introvert would have “very low extraversion”.
Oren and Aghaee describe in [2] that each of the 5 “Factors” in the OCEAN model can be broken down into multiple sub-factors, called “Facets” – these sub-factors are also in a spectrum from “very low” to “very high” – and the combinations of the sub-factors give us a more meaningful representation of the parent factors [2][6]. The SEA Model relies on the concept of using multiple sub-factors to define a few main-factors.

3 Methodology

Let us begin by creating a distinction between the “Player Agents” and the “AI Agents”. In video games, the “Player Agent” is any entity that represents the human player in the game world, e.g. in role-playing-games: the game’s protagonist is the player agent – as the human player has full control of the protagonist’s actions and motives. The human player basically puts himself/herself in the shoes of the Player Agent.

In contrast, the “AI Agent” are entities that seem intelligent from a human player’s perspective, but are not under the control of the human player, e.g. in role-playing-games: individual villagers, animals, soldiers, villains, etc. are AI Agents. The human player can interact with them, talk to them, and at best influence their actions, but ultimately, the AI Agent’s actions are controlled by the algorithm in the game. Note: It is important that the human player “perceives” the AI Agent as intelligent – this improves the game world’s realism.

For the purpose of this paper, the Player Agent in the air-hockey game is the “bottom paddle” controlled by the player, while the AI Agent is the “top paddle” controlled by the Artificial Intelligence of the game; and the main focus of this paper is on the AI Agent – specifically on how the human player perceives the “personality” of the AI Agent.

Reasoning – Summary

The AI Agent – being only a paddle – cannot talk, cannot make facial expressions, and cannot display emotions. Attempting to linguistically describe such an agent’s personality using the OCEAN model would be futile. However, we can identify other aspects of the AI Agent: the way it moves, the speed at which it reacts, the type of shots it plays, etc. We will call these observable aspects the “Facets” of the AI Agent. They are: “Accuracy”, “Reaction”, “Position”, “Cunning”, “Speed”, and “Power”.

These Facets are also the core functionality of the air-hockey game’s AI Agent: they have values, are programmable and are chosen by the game’s developers. This paper has 6 facets for the AI Agent in an air-hockey game (this game is simple – more complex games would require more facets). All of these facets are observable by the human player through the actions of the AI Agent.

Furthermore, these 6 Facets can be grouped into 3 clusters – we will call these three groups the “Factors”. They are: “Skill”, “Experience”, and “Aggression”. Inspired from the OCEAN model, we call this the “SEA model”. The 3 Factors are fuzzy functions of the values of the 6 Facets, such that:

Skill ← S (Accuracy , Reaction)
Experience ← E (Positioning , Cunning)
Aggression ← A (Speed , Power)

Just like the OCEAN model’s factors, the SEA Model Factors are abstract in nature – the values they hold do not make sense to the game’s programming. However, they serve an important role in conveying a concise “message” to the human players: How “skilled” is the AI Agent? How “experienced” is the AI agent? And how “aggressive” is the AI Agent?

Here in, lies the fundamental concept of this paper: human beings easily understand behavior of agents in terms of few, linguistic, abstract terms (the Factors); and are confused by multiple, specific, values (the Facets). The SEA model provides a way to convert the developer’s input values that the game utilizes, into linguistic terms that the game’s consumer can easily understand.

Inputs - Explanation

When developing the air-hockey game, we included the 6 Facets in the game’s programing. Each Facet has a specific value and control / limit / influence the AI Agent’s behavior. They are: “Accuracy”, “Reaction”, “Position”, “Cunning”, “Speed”, and “Power”.

Accuracy: The AI Agent is programmed to target the opponent’s goal. So by default, the AI Agent always hits the puck in such a way that it is shot at the center of the opponent’s goal. The Accuracy modifier is a probability that the default action is performed; i.e. if set to 100% Accuracy (MAX), the AI Agent performs the default action 100% of the time; and when set to 50% Accuracy (MIN), the AI Agent performs the default operation 50% of the time and intentionally misses (it targets the bars of the goal) 50% of the time. An AI agent with “perfect aim” has Accuracy set to 100% , and one with “terrible aim” Accuracy set to 50%.

Reaction: To make the game easier to play, the AI Agent has a time delay (delay in reaction) which it must suffer before reacting to a shot from the Player Agent. Reaction is a value from -1.5sec to 0sec: describing how long the AI Agent waits before making a move against the Player Agent’s attack. An AI Agent with “lazy reaction” has the variable set to -1.5sec (MIN), and one with “instant reaction” has the variable set to 0sec.

Positioning: Is a discreet input for (1 to 6) that defines the AI Agent’s knowledge of positioning in the playing field. An agent with Positioning set to 1 (MIN) is thought to be “reactionary”: it has no understanding of positioning and only runs after the puck (i.e. reacting to the opponents shots). An agent with positioning set to 2-5 shows varying levels of position adjustments, e.g. an AI Agent with rating of 3 "mimics" the Player Agent after hitting the puck. An agent with positioning set to 6 (MAX) is said to be "predictive", based on the player's movements, it calculates where the Player Agent is going to shoot the puck and readies itself in that position.

Cunning: There are 3 trick-shots in air-hockey, and the discreet input, Cunning, unlocks these. A rating of 1 (MIN) mean the AI Agent cannot perform any trick-shots and must resort to making only "direct" shots towards the goal. A rating of 2, means the AI can perform angled shots, a rating of 3 "tricky" unlocks the ability to perform bank shots, and a rating of 4 (MAX) "deceiving" unlocks the ability to perform double-bank shots.

Speed: The game has a top speed, T, at which any object in the game is allowed to move at. AI Agents move always move at the highest speed they are allowed to. The Speed modifier is a percentage input that acts as a limit to that top speed. An input of 100% (MAX) means the AI Agent can move at T*100% speed – the agent is "explosive" in nature. Where as, an agent with 30% (MIN) is able to move at T*30% - making it "sluggish" in nature.

Power: The Power modifier is a percentage that describes the strength with which the AI Agent hits the puck. We have developed the game to calculate momentum when making shots. To make the game playable we have made the AI Agent "defy the laws of physics" by reducing momentum in an instant. Consider the transfer of momentum to the puck from the AI Agent to be, M. With 100% (MAX), the puck retains M*100% of it momentum; and with 30% (MIN), the puck retains M*30% of its momentum.

Reasoning - Explanation

Skill: From the perspective of a human being, Skill is a trait that describes someone's latent abilities. Linguistically speaking, a "talented" player has: "quick" Reaction and "perfect" accuracy; where as an "inept" player has: "lazy" Reaction and "terrible" accuracy. For our AI Agent, Skill can be defined as a function of Accuracy and Reaction.

Skill ← S (Accuracy , Reaction)

Furthermore, the relationship between the Facets: ("Accuracy","Reaction") and the Factor: ("Skill") can be represented in a table:

Table I

	Reaction	Lazy	Attentive	Instant
Accuracy	**Skill**			
Terrible		Inept	Inept	Average
Precise		Inept	Average	Talented
Perfect		Average	Talented	Talented

However, the problem in this table is that it shows relationship between "linguistic" variables – whereas, the inputs we have used in the game are both floating numbers.

The "linguistic values" of Accuracy: Terrible, Precise, and Perfect. The "linguistic values" of Reaction: Sluggish, Attentive, and Instant. Whereas, in the game, the input range for Accuracy: [50 , 100] %, and the input range for Reaction: [-1.5 , 0] sec.

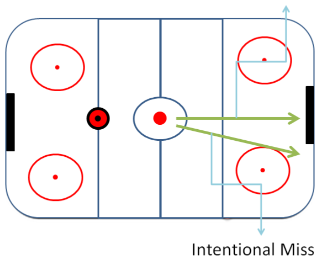


Fig 1. Air Hockey Game

In order for us to represent the relationship between Accuracy and Reaction as Skill, we will have to find a way of representing the floating number inputs in the form of linguistic variables. This is where the Fuzzy Inference System (FIS) plays an important role. The FIS allows us to represent the "linguistic values" of Accuracy and Reaction in the form of membership functions:

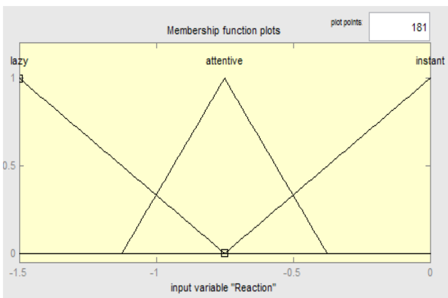


Fig 2(a). Reaction

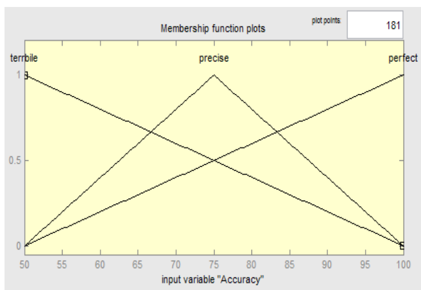


Fig 2(b) Accuracy

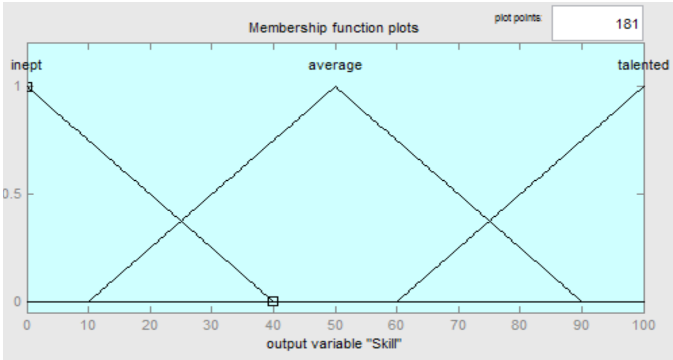


Fig 3. Skill Membership

The input values for Reaction and Accuracy provide a fuzzy membership value (between 0 and 1) for each linguistic value (depending on the membership function of each linguistic value). The membership values are compared with the Relationship Rules in the FIS (which is the Table 1). Finally, depending on the membership functions of the linguistic values of Skill, the results is a value [1 , 100] for Skill, This is simply a generalization of how the FIS works. A full explanation of the membership functions and FIS is beyond the scope of this paper.

Experience: From the perspective of a human being, Experience can only be gained over time and through practice – individuals may learn from through trial and error on where to “position” themselves given the situation, and by observing more experienced players, individuals may pick up knowledge on how to play “cunning” shots. For this reason, the AI Agent’s Experience factor can be represented in the form of a function of Positioning and Cunning.

$$\text{Experience} \leftarrow E(\text{Positioning}, \text{Cunning})$$

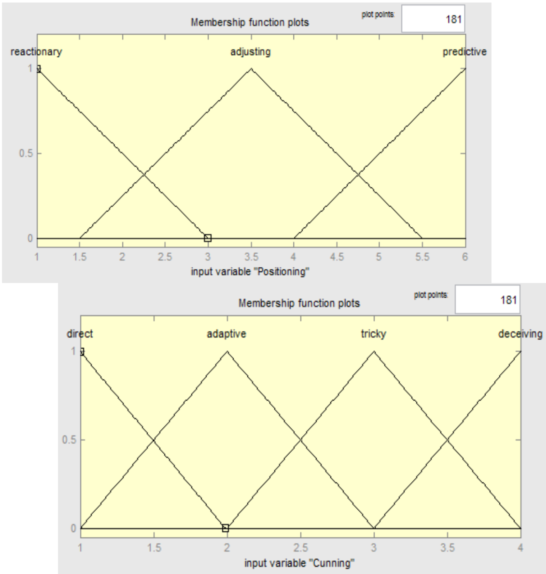


Fig.4 Positioiniong and Cunning Membership

The relationship can be represented in terms of linguistic values in the form of a table:

Table II

Cunning	**Positioning** / **Experience**	Reactionary	Adjusting	Predictive
Direct		newbie	amateur	Moderate
Adaptive		amateur	moderate	Moderate
Tricky		moderate	Profession al	Professional
Deceiving		moderate	legendary	Legendary

Aggression: Unlike experience and skill, aggression is dependent on a person's mentality. An aggressive individual moves around the board quickly and plays powerful shots as a display of intimidation. For this reason, the Aggression factor of our AI Agent is a function of Speed and Power.

$$\text{Aggression} \leftarrow A(\text{Speed}, \text{Power})$$

Similarly, the relationship can be represented in terms of linguistic values in the form of a table:

Table III

	Power	Weak	Medium	Strong

Speed	Aggression			
Sluggish		Pacifist	Pacifist	Neutral
Normal		Neutral	Neutral	Brutal
Explosive		Neutral	Neutral	Brutal

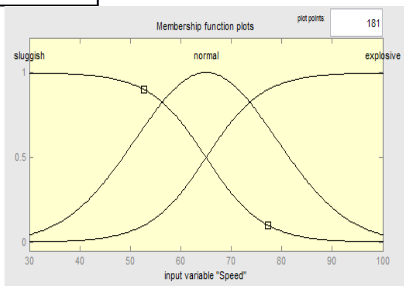
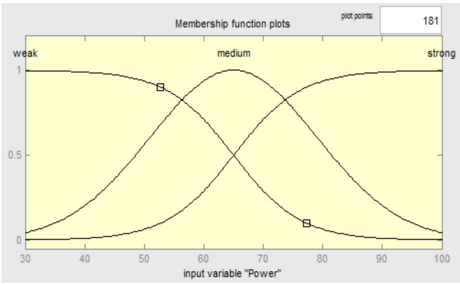


Fig.5 Speed Membership Function.



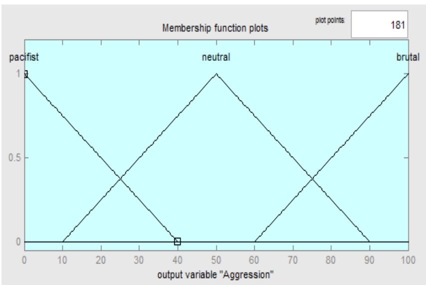


Fig.6 Power Membership Function. **Fig.7** Aggresion Membership Function Ouput.

By itself the values [0 , 100] for the Factors: Skill, Experience, and Aggression is enough to give human players a good understanding of what the "play-style" and in-turn the "personality" of different AI Agents are like. However, we can make it even easier for the human players by displaying the Factors in the form of a 3-armed Kiviat Chart (or RADAR Chart).

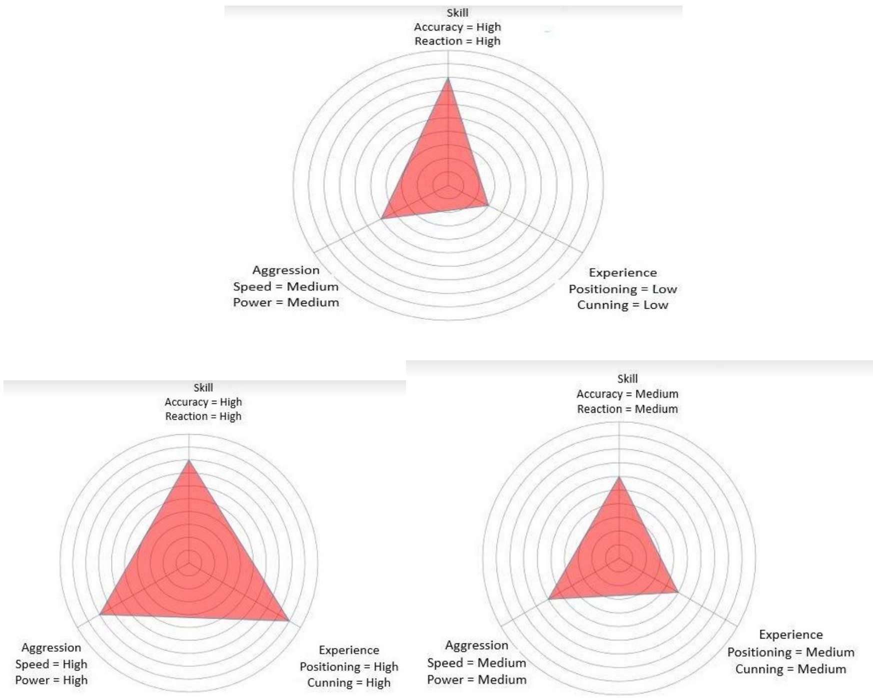


Fig.8 Radar charts with varying parameters

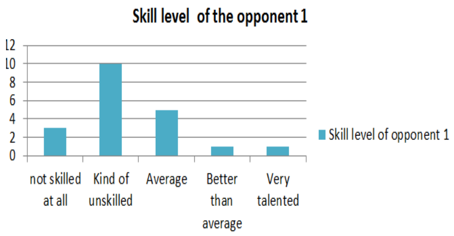
4 Findings

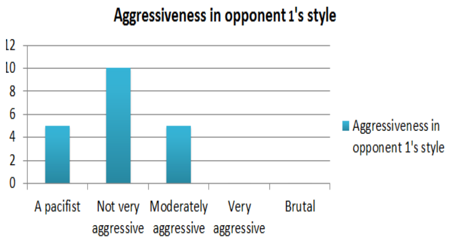
We conduct a survey over 20 people in a gamer community and also non-gamer. 12 males and 8 are females are part of these surveys. We created 2 opponents and named them, opponent 1 and opponent 2.

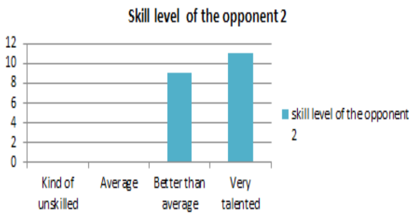
Skill level of opponent 1:
50% of the respondents said that the bot was “kind of unskilled”. 25% replied that the bot was average. 15% replied with the bot “BOT was not skilled at all” 5% saying it’s better than average.5% saying it’s very talented.

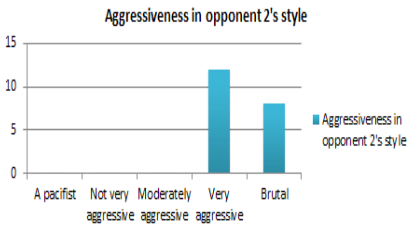
Aggressiveness in opponent 1's style:

50% people replied that the bot was not very aggressive. 25% voted into a pacifist and moderately aggressive. None of them responded found opponent 1 as very aggressive or brutal.









Skill level of opponent 2:
55% very talented. 45% better than average. None of them found kind of unskilled or average.

Aggressiveness in opponent 2's style:
60% people found it very aggressive. 40% people found it brutal. None of them voted the bot a pacifist, not very aggressive or moderately aggressive.

1 Conclusion and Future Work

This paper introduces the concept of the "SEA Model" for describing the behavior of a computer controlled agent in a concise and simple manner. To demonstrate the model, we have developed an Air-Hockey video game with 2 AI-Agents, extracted the SEA Model's interpretations of their behavior, and displayed them in a web-chart. We conducted a survey where we asked respondents to play against the 2 AI-Agents and rate their behavior – the survey resulted in more than half of the respondents agreeing with the output from the SEA Model. This paper fulfills its purpose of introducing this new concept of "perceiving game AI using Fuzzy Logic". However, at its infancy, the SEA Model is still not a completely ground breaking tool. Therefore we have outlined our next path

The application of the SEA Model on a game as simple as Air-Hockey is a bit of an exaggeration. Here, the model converts 6 facets to 3 factors – a ratio of 2. Where the SEA Model would shine are more complex games, where it might be necessary to convert over a thousand facets to a handful of factors – having a conversion ratio of hundreds.
As such, our next path of research would be refine the processes in the SEA Model and apply it to a more complex video game AI – and perform further testing on this concept

References

1. Pirovano,M.(2012). The use of Fuzzy Logic for Artificial Intelligence in games. University of Milano, Milano
2. Oren, T. I., & Ghasem-Aghaee, N. (2003, July). Personality representation processable in fuzzy logic for human behavior simulation. In Summer Computer Simulation Conference (pp. 11-18). Society for Computer Simulation International; 1998
3. McCrae, R. R., & John, O. P. (1992). An introduction to the five-factor model and its applications. Journal of personality, 60(2), 175-215.

4. Tupes, E. C., & Christal, R. E. (1992). Recurrent personality factors based on trait ratings. Journal of personality, 60(2), 225-251

5. Howard, P. J., & Howard, J. M. (1995). The Big Five Quickstart: An Introduction to the Five-Factor Model of Personality for Human Resource Professionals.

6. Ghasem-Aghaee, N., & Oren, T. I. (2003, July). Towards fuzzy agents with dynamic personality for human behavior simulation. In SUMMER COMPUTER SIMULATION CONFERENCE (pp. 3-10). Society for Computer Simulation International; 1998.

7. Ghasem-Aghaee, N., & Oren, T. I. (2004). Effects of cognitive complexity in agent simulation: Basics. Simulation Series, 36(4), 15.

8. Ghasem-Aghae, N., Kaedi, M., & Ören, T. I. (2005). Effects of Cognitive Complexity in Agent Simulation: Fuzzy Rules and an Implementation. In Proceedings of: CM&SC-Conceptual Modeling and Simulation Conference(pp. 20-22).

9. “Air Hockey Trick Shots - Deceptive Shooting Techniques.” Bubble & Air Hockey, www.bubbleairhockey.com/trick-shots.html.