【Research Note】ストレスでAIエージェントの行動を駆りたてることのプロトタイピング

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Research Note

Prototyping Results of Driving the Behavior of AI Agents

ストレスでAIエージェントの行動を駆りたてることのプロトタイピング

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AI in games has come a long way since its inception, but is still woefully lacking when it comes to more emotive AI agents. In this paper, we describe a system that will serve as the base for more emotive AI, by using stress response to drive agent behavior. By using stressors to initiate agent behavior, we not only enable anything to become a driver for behavior, but we create a more natural approach to AI, which will allow for emotions to be designed as well. However, prototyping has shown that our initial use of behavior trees was lacking. Behavior trees did not allow us the dynamic behavior we required and were hard to maintain as well. Therefore, further development of our system is required.

Keywords: Game Design, Interaction Design, Artificial Intelligence

1. Introduction

Development of AI for games is often limited to improving ways in which AI can attack the player in a believable way, such as path finding or making an AI agent fumble aggressive behavior in a natural manner to give players more of a chance to retaliate effectively. Unfortunately, approaches that would give the AI agent a more emotional behavior are relatively non-existent and as a result, the manners in which AI agents can show emotion to the player have been limited to rather rudimentary methods of interaction. For instance, in the game Persona 5 [1], interaction between the player and the AI agent is done through scripted text sequences, where the player is given a number of choices of which only a few will improve the relationship between the player and the AI agent. As such, the building of relationships is a linear progress, where a particular variable just needs to reach a specific value for the relationship to improve. Persona 5 is hardly alone in this, with many other games following similar tendencies in not allowing an AI agent a more dynamic emotional response.

In this paper, we aim to create a basis for more dynamic emotional interactions between player and NPC. For this, we propose a system based on the human stress response, using stress as a means of driving agent behavior. In particular, we will be using acute stress, which is not necessarily detrimental to mental health [2]. As such, our implementation only deals with (almost) instantaneous reactions and won' t deal with long term concepts such as chronic stress.

1.1 Emotional AI and machine learning

Machine learning has already given us a number of applications for emotional AI. However, while machine learning has its merits, our focus is on creating a solution that is usable by game designers. Machine learning however requires that designers train an AI agent, which takes time and resources. In the case an AI agent does not exhibit the desired traits the designers are aiming for, retraining becomes necessary. Furthermore, once an AI agent has been trained, making the AI agent react very specifically in certain situations is impossible and would require a specifically trained AI agent for that very situation. As such, machine learning is at present not suited for game development, where oftentimes AI needs to behave according to the wishes of the designer. We wish to focus on a solution that can be used in the average game development process, and as such, machine learning is not an option for this research.

2. Approach

2.1 Behavior Tree

In order to develop our AI agent, we decided to use the Unreal 4 engine. The benefits of using Unreal 4 is that it is easy to quickly set up a game project, which allowed us to focus our resources on developing the AI agent. Furthermore, Unreal 4 uses an event based behavior tree for its AI, which initially showed compatibility for our stress response system.

2.2 Stressors

Our system consists out of two elements:
(1) Stressors.
(2) Stress response.

Stressors are events that cause stress to the agent and have two properties.
(1) They have varying levels of intensity.
(2) Due to the human body trying to maintain homeostasis, stressors degrade over time.

To calculate degradation, we use a basic half-life formula.

Equation: $N(t) = N_0 e^{-\lambda t}$

Where N_0 is the initial quantity of stress that will decay, $N(t)$ is the stress that has not yet decayed after time t , and λ is the decay constant of the decaying stress. We identify two types of intensity; eustress (positive stress) and distress (negative stress). To mimic the human fast and slow response to stress [3], we divide stressors into two types; instant stressors and stressors with an effect over a period of time. All stressors are added to a single pool of stress. Initially, we used the average of all stressors in this pool as the output stress level, but in our initial prototyping we found that this made AI agent response time unnaturally fast, to the point of it being instant. To solve this problem, we instead used the average of this pool as the target stress level, and interpolated from the current level of stress to the target level of stress using interpolation functions found within the Unreal 4 engine. This gave us a slight delay in stress activation, eliminating the instant reactions and giving the AI something resembling human reaction time.

2.3 Stress Response

Out of available stress response models, we found that the cognitive-mediational theory [4] was the most effective to use for our own proposed model. According to this theory, the subject uses a two-step appraisal process to analyze stress and determine a manner of coping based on the type of stress. The first step is to determine whether there is a perceived threat or not. When a threat has been perceived, a secondary appraisal is done to determine how to cope with the threat. We based coping mechanisms on the four fear responses; freeze, flight, fight and fright [5], though we decided not to incorporate fright (referred to as "playing dead" in early literature). In our implementation, we found that fright is better suited as an extension to the freeze mechanism rather than a separate coping mechanism.

Freeze, also known as hyper vigilance, is used by the AI agent to gather information. Flight is then used to escape from the stressor. If while fleeing there is no escape path, the fight mechanism will be used to engage the stressor until escape options can be confirmed.

Initially, the AI agent' s reaction time due to stress level interpolation still caused a few unnatural moments, where agents seemed to not react to new stressors in time. To remedy this, we introduced an "instinctual reaction" to the process, where designers can potentially add quick and simple actions, such as rotating to face the new stressor (Figure 1). What separates our model from more classical approaches to game AI is that our model assumes that flight is the end goal due to fleeing giving organisms a better chance at survival rather than simply fighting the stressor. Furthermore, since our system assumes that anything can become a stressor, plenty of behavior patterns become possible.

2.4 System Simplicity

Since we developed this system specifically for use in games, we tried to keep it as simple as possible. The reasoning for this is threefold.

(1) Performance is important. Since the system is meant for in-game use, we cannot put too much strain on the system, especially since this model will serve as the basis for much more complicated systems.

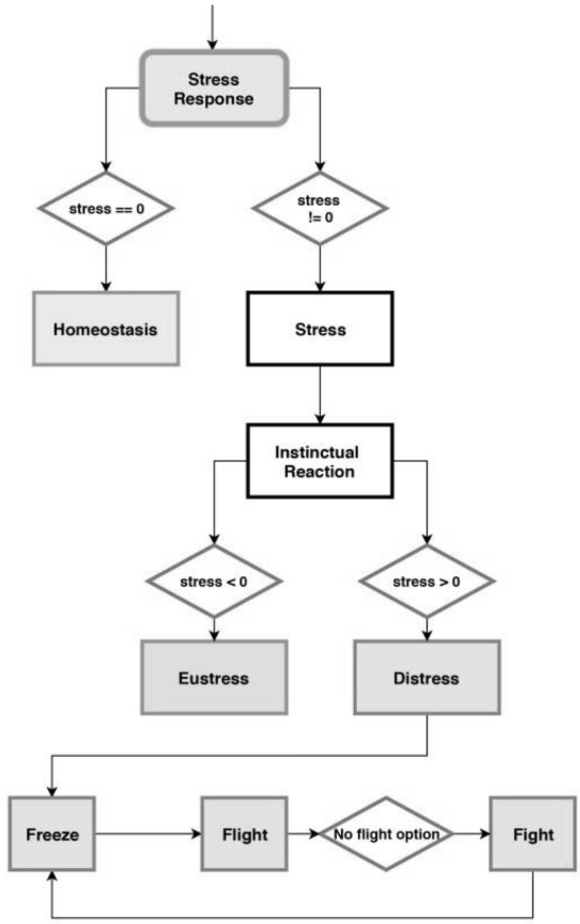

Figure 1: Stress response system

(2) A simple system reduces the chance of bugs appearing that could hinder our AI agent' s credibility, especially considering this system is meant as a base.

(3) Ease of integration is important. Since our system has been developed as a tool for game designers, having too many options may make it hard to integrate into (existing) game projects. Introducing too many variables at this stage would only make it harder and more time consuming to integrate.

3. Prototype

3.1 Prototype Development

The prototype environment was developed in Unreal 4. To speed up development, we opted to use functions and assets already present in the engine wherever possible.

Due to the default character in Unreal 4 not having any ability to exhibit facial expressions, nor having any option to add those, we instead opted to show the AI agent' s mental state through the use of icons in text balloons (Figure 3).

3.2 Prototype Game Rules

For the prototype, we made a simple game where the goal is for the player to surprise the AI agent present within the game map. One game map has been constructed, with one AI agent and a number of debris objects on higher elevations the player can push down (Figure 2).

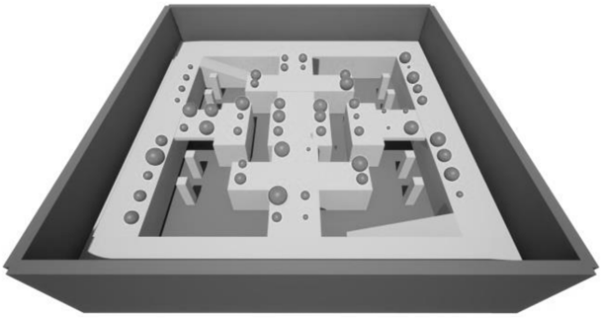

Figure 2: The game map used for the prototype. The spheres function as debris. When the game starts, the player is spawned on the upper level and the AI agent is spawned on the lower level.

If a debris object is dropped near the AI agent, the AI agent will experience an increase in distress. The player has an additional action, in the form of trying to surprise the AI agent, which can have various effects depending on the current stress level of the agent. The agent has roughly four types of behavior;

(1) If too much time passes with nothing happening (i.e. if no debris drops nears the agent or the player doesn' t attempt to surprise the agent), the agent will move to a different random location within a certain radius.

(2) If the AI agent becomes stressed due to falling debris, the agent will first panic and freeze in place (freeze response) and later move to a safe location (flight response).

(3) If the player tries to surprise the AI agent, but the agent is not sufficiently stressed, the agent gets annoyed and moves away from the player.

(4) If the player tries to surprise the AI agent when it has built up a sufficient amount of distress, the AI agent will be surprised and fall over.

Using these four behaviors, the goal for the player is to simply successfully make the AI agent fall over in surprise.

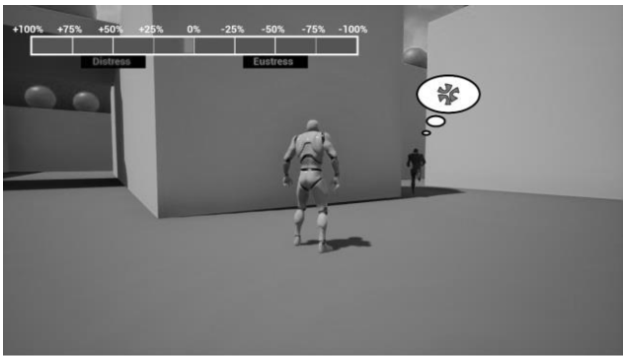

Figure 3: The player tries to surprise the AI agent, but due to lacking distress levels, the agent becomes annoyed instead. Emotion is shown through text balloons.

4. Limitations

4.1 Behavior Tree Limitation

While initially it seemed behavior trees are a good way of implementing our system, we quickly found that our system will create behavior trees that are relatively hard to prototype and maintain, which is something we wish to avoid. Developing the prototype also suggested that behavior trees lack the ability to dynamically react to different kinds of stimuli. For instance, we found that our AI agent tended to react very slowly to the player trying to surprise the agent after the agent had been assailed with falling debris. A potential solution to this problem could be the use of utility AI [6] instead of behavior trees. Using utility AI, the agent is given a number of tasks, which are scored based on an interval. The higher the score, the more likely it is for the AI to start a specific task.

4.2 Emotional Expressions

Due to this research being meant to create the basis of our more emotional approach to AI, we were limited in how complex the behavior of our AI agent could be. As such, for the prototype we could only create very basic implementations of emotions such as surprise, fear and annoyance.

5. Conclusions and Future Work

In this paper, we have presented a system where AI agents base their decisions on the distress and eustress they are experiencing. Using this system, we have found a much more natural way of driving behavior, which has allowed for the creation of a basis that allows for more emotive AI agents. Furthermore, due to anything being able to become a stressor, the system is very versatile in what can cause behaviors to happen.

However, we also found that in conjunction with behavior trees, our system was not able to perform at its full potential and as such, we wish to see whether our system could work better with something based on utility AI instead.

For our future work, we wish to further develop this system, as well as broaden the range of emotions that our system can output.

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