GAMES AND ARTIFICAL LIFE

Artificial Intelligence has been a crucial component in video games throughout its history. The use of logical agents to provide a challenging and engaging experience is a key factor that separates the design of video games from traditional games. AI controlled opponents and virtual environments allow for the competitive aspect of game play to transfer over to a single player experience that would otherwise not be possible.

Early games could not afford to implement sophisticated AI. Limited processing power left little room for complex decision algorithms and improved graphics were seen as a better investment. As technology improved, more powerful gaming systems allowed for much more complex non-player character behavior. Designers began to experiment with more complex logical agents, focusing on creating improved pathfinding, combat tactics, learning agents, and other improvements. Attempts to create realistic AI behavior, however, have fallen short. Bethesda is one of the more notable examples of a company attempting this undertaking through its Radiant AI system, first demonstrated in The Elder Scrolls IV: Oblivion.

Oblivion and its Radiant AI were set to revolutionize the games industry and the way players view game AI. The Radiant AI "imitates the impact of resource pressure, individual needs, and player interaction on a non-player character (NPC), resulting in a dynamic, procedural reaction" (Griffin, 2010, para 2). Non-player characters possessed their own personalities and goals, and could interact with the environment to satisfy their needs. Previews of the game excited players over the prospect of such a rich and dynamic world to interact with. When the game shipped, many were disappointed to find that

many of the advanced features of the Radiant AI were not present. It turned out that the

full AI system ended up causing unexpected behavior, as elaborated on by Sanjeev(2006):

> 1. One character was given a rake and the goal "rake leaves"; another was given a broom and the goal "sweep paths," and this worked smoothly. Then they swapped the items, so that the raker was   given a broom and the sweeper was given the rake. In the end, one of them killed the other so he could get the proper item.
> ...3. In one Dark Brotherhood quest, the player can meet up with a shady merchant who sells skooma, an in-game drug. During testing, the NPC would be dead when the player got to him. The reason was that NPCs from the local skooma den were trying to get their fix, did not have any money, and so were killing the merchant to get it.
> ...5. In one test, after a guard became hungry and left his post in search of food, the other guards followed to arrest him. The town people looted the town shops, due to lack of guards.
>
> Bethesda worked to fix these issues, balancing an NPC's needs against his penchant for destruction so that the game world still functions in a usable fashion. In-game there are over 1,000 different NPCs, not including randomly spawned monsters and bandits. The result is that the AI in the release version is much reduced, only featuring NPC schedules.

The behavior described above is impressive in terms of emergent game

experiences, but its flaws are readily apparent. The responses of the agents are very

erratic and exaggerated compared to normal human behavior (such as in case 1 and 5),

and these responses in turn have negative impacts on elements of story and gameplay

(case 3). While it appears that Bethesda considered all the elements necessary for proper

human agents, the Radiant AI lacked in making natural choices to a human observer. The

functionality is there but the psychology is not. This paper will attempt to address the

issue of making human-like decisions by applying psychological principals to AI design.

To create a more believable human AI in games, there must be a fundamental shift

in the perception of the AI and its place in the game world. If an agent is to be as human-

like as possible, their behavior should be able to exist independent of the game itself. By

separating game mechanics from the high level decisions of game entities, the design not only retains more lifelike decisions but also becomes a more flexible design that can be reused in other games. Thus, the goal of this approach is to first make an AI system that replicates human behavior at a high level, then as the high level decisions are made, lower level game specific tasks can be implemented on a game-by-game basis. The purpose of this paper is to implement and evaluate this approach based on its feasibility, performance, and effectiveness.

Human behavior is an incredibly complex thing. A proper understanding of human thought processes and the logic behind a person's behavior can take years of study, and even then research is still ongoing. Creating a perfect model of human behavior is more likely to come from a fully synthetic brain than a clever AI programmer. Luckily, a perfect representation is not needed to be a believable representation. Applying a well-researched model of human behavior to a game AI provides a base to work off to create believable AI.

PICKING THE MODEL: MASLOW'S HIERARCHY

The psychological model chosen for this project is Maslow's Heirarchy of Needs. In his A Theory of Human Motivation, Abraham Maslow detailed his numerous findings on what drives human motivation. Of note is one of his more interesting propositions, that "human needs arrange themselves in hierachies of pre-potency...the appearance of

one need usually rests on the prior satisfaction of another"(Maslow, 1943, p. 370). This concept gave birth to the Maslow Hierachy, a tiered organization of human needs that demonstrate which human needs are dependent on others before they become motivational factors. The Hierarchy itself consists of five levels of human needs arranged in a pyramid. At the bottom of pyramid are Physiological needs, the most basic requirements of life such as food, water, and sleep. The next layer is Safety, ensuring that one possesses enough resources and stability in the near future to be confident of his or her future. The following three levels are, respectively, Love/Belonging, Esteem, and Self-actualization. As the bottommost needs are satisfied, higher level needs then appear to motivate the decision process. For example, someone "lacking food, safety, love, and esteem would most probably hunger for food more strongly than anything else"(Maslow, 1943, p. 373).

Maslow's Hierarchy is an excellent model for simulating human behavior in games. The model is simple enough for anyone to understand but its simplicity also makes it flexible. It already provides the conditions of high level decision making, and defines those conditions in a general enough manner to be applied to a wide variety of game types. The bottom two layers tie in extremely well with the common gameplay themes of survival against a harsh environment or enemy. Not all layers need to be implemented either, allowing games to select the particular levels their game addresses and dropping the rest without changing the basic decision model.

BUILDING THE HIERARCHY

To test the effectiveness of the Maslow-based model, an experimental game is developed using the principles of the design for the game agents. The game features a player-controlled avatar interacting with a 2D environment populated by various world objects and AI entities representing human farmers. Each agent is given a set of goals to accomplish that correspond to the first two levels of the Maslow Hierarchy, covering the most basic needs of survival and stable health. The game world is populated by houses and farmland that are property of the agents, and can be used to satisfy their needs. Both player and agents are able to alter their surroundings in a positive/constructive way and a negative/destructive way. Positive actions offer a benefit to needs, such as working farmland for food or planting new crops. Negative actions cause harm, such as destroying crops or harming other agents.

The experiment was developed using C# and the XNA 4.0 library. Ease of use and flexibility were the two main considerations when selecting language and library. The game consists of three primary classes: a main class to execute the game and update all the game objects at each frame, a Utility class that stores the condition variables used for evaluating decisions, and an umbrella class called Entity that handles information related to all in game objects. Entity is further broken down into Agent, Player, and WObject subclasses.

Agents are the game's AI entity and contain the implementation of the Maslow AI being evaluated. Each Agent possesses an instance of Utility that is used for tracking their

current state, and its values are used in the logic function to make decisions. The Agent class also includes two arrays of WObjects. The first array holds all of the agent's available knowledge about the world. Whenever a new object is sensed, it is added to the knowledge array. The second array consists of all WObjects that an agent is considered the owner of. Owned property takes precedence over unowned property due to its non-existent risk. While this array is somewhat redundant and could easily be integrated to the knowledge array, separating out the owned property from the total knowledge base improves readability and understanding of the code, however does result in additional memory usage.

The Utility class contains all the important information related to making decisions for the Agents. Utility contains two sets of condition values: an available amount of utility for each condition value (for evaluating the current state of an Agent/WObject) and a return amount for how much utility can be transferred in one game iteration (for evaluating a choice once a goal state has been specified). Whenever an agent uses an object, that object will return the gained utility based on the action taken, and the values are added to the agent's own utility. The values tracked include hunger, sleep, stored food, and threat. These are just the conditions used for this experiment, and an actual game application could have many more depending on the needs of the project and how detailed the decision process should be.

Due to limited resources, the sample game focuses only on the first two levels of Maslow's Hierarchy. The first level, Physiological, uses the hunger and sleep Utility to form its decisions. While the Physiological level covers a larger range of needs, food and

sleep are far more relevant to games than the others listed. The second level, Safety, relies on the food stores condition variable. Safety also covers a large range of needs, many of which could have game applications. The context of the example game made security of resources, in this case food, the best choice for second level decisions.

The threat metric stands separate, as it doesn't particularly fit into a specific level. Rather, it modifies the decision process of the other levels based upon the perceived risk of an action, object, or person. An agent eating its own food carries zero threat: there is no chance of a conflict for this action. However, eating another agent's food carries the risk of being seen, and the other agent retaliating in defense. Thus, unowned property has some level of threat. Threat helps make decisions based on the state of the agent, used to evaluate the risks of one option over another. Agents will not take a risky option unless a no-risk option is not available. This element of risk evaluation helps prevent some of the flaws of the Radiant AI. Violence is much closer to a last resort, and what agent's would be willing to fight for

These components combine together to form the decision logic of the agents. An agent will first check to see if its immediate Physiological needs are met. If the agent determines it is not in a stable state, it will attempt to satisfy its needs. It will look first for sources of food and rest that are owned by the agent. The greater the immediate need, the greater the risk the agent will take to satisfy its need, such as if an owned source of food cannot be reached in time, a nearby unowned source will be picked in order to ensure survival. Agents will first prioritize owned sources and efficient sources (those that give/possess the greatest utility), as long as they are within a reasonable range. Once

Physiological needs are met, the agent attempts to secure long term food sources. This is

achieved through working farmland and planting new crops. The agent will work the

farmland available to it until it runs out of its stored utility. If the amount of farmland is

insufficient for long term stable survival, the agent will being planting new crops that will

turn into farmland to fulfill the needs. When both levels are seen as being in a stable state,

the agent stops acting. In a further experiment, it would be worthwhile to code some third

level Social actions for the agent to perform, such as wandering around the game world

and talking to other agents.

REVIEWING THE THEORY

While the program produced mostly desired results, the experiment as a whole

resulted in some mixed observations as to the benefit of the approach. For the evaluation,

it is important to observe positive and negative aspects from the standpoint of a player

playing the game as well as the programmer involved in its creation. For the Maslow

approach to be valid, it must display the desired effects of a more believable AI while

keeping the additional development time required low enough to be worth the added

benefit.

The additional difficulties in programming the Maslow AI and its needed

components result in a substantial drawback for the flexibility of the model. In order to

even implement the approach, the game's mechanics must necessitate two or more levels

of the hierarchy for the AI to act upon. A game such as a First Person Shooter would have a difficult time integrating more than one level. Even if a shooter could incorporate more than one level, the decisions made between levels would have very little game impact compared to the decisions made within a level, such as combat tactics. The hierarchy also doesn't address any of the inner-level decision making problems, and the inclusion of the condition metrics can complicate the inner workings of the AI more than simplify them. The sample game could have ignored the Maslow approach and simply had the agents move to locations at scripted or semi-random intervals, drastically reducing the development time of the game while arguably not sacrificing much in return.

The Maslow approach is not proven to be without merit, however. The game and the experience it attempts to provide need to suit the design goals of the Maslow AI in order to be used properly. Taking the Maslow Hierarchy approach requires a game that puts realistic human behavior as a key aspect of its design goals. It is not coincidental that the games that inspired the project are also the ones that most benefit. Oblivion, with its focus on breathing world that the player can immerse themselves in, can make excellent use of the Hierarchy for the residents of its world and avoid the self-destructive and irrational habits of the Radiant AI. The experimental game itself functions very much like an simplified version of Radiant, tracking multiple statistics and making choices to improve overall well being and satisfying player goals. Oblivion and games like it focus on interacting with human-like agents on a regular basis as part of its gameplay, justifying the design expense of the Maslow approach.

CONCLUSION

Using Maslow's Hierachy as a design paradigm is still in a very early stage. The experiment acted as an example of how to use the technique and to show that it can be used to design a game AI. However the simplicity of the experiment, both in terms of its use of only the first two levels of Maslow's Hierarchy and with its bare presentation and mechanics as a game itself, does not give sufficient evidence of the effectiveness of this design approach. Implementation difficulties hurt the potential for the Maslow model to be used in simple games and many game genres. It still shows potential for games the take advantage of the psychological influence on its AI design, but there is no evidence yet to support its use in those games.

Discovering the potential of this new AI approach requires a more involved case study. Applying the Maslow design to a professional game that could utilize its advantages would provide the best case to observe the effects on development cost and added player experience. This scenario is nearly impossible to accomplish in an academic setting, so it will likely be up to the games industry itself to experiment with the concepts detailed in this paper. If nothing else, the idea of turning to psychology to improve game AI can be a valuable lesson for the future of innovative game design, even if Maslow's Hierarchy isn't the approach to handle it.

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