Improving Video Games Replayability with Reactive AI

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Abstract

In this dissertation I will be exploring the AI behavior in the current popular video games available on the market and look into the most popular available types of advanced AI behavior and collect data to determine what the players would prefer to play against with option A being a basic, repetitive and constraint enemy, and option B being a reactive AI that can surprise the player and adapt independently of any constraints. To further explore the public opinion, I have prepared an artifact that was sent out to multiple gaming hubs and asked the users to play it and fill in a questionnaire that will be used to determine what the common preference is. I will also investigate all the external data I can collect about the popular games mentioned above and try to determine if a game can be successful based on the type of AI it employs.

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1. Introduction

With the technological advancement that pushed all tech industries forward, so is the video games industry rapidly advancing and with the introduction of newer and faster hardware and software. As per Statista, the video games market is projected to reach a revenue of £217.10bn by the end of the year 2024 and continue to grow by 6.18% in the following 3 years (Statista, n.d.) while a recent article on Helplama stated that the gaming industry revenue was projected to be at $365.6 billion globally, generating more revenue than both the film and music industries combined (Helplama, 2024).

As the industry keeps growing, so are the user's expectations, with many recently launched games being met with negative reviews on the gaming platform Steam. One example would be “The Lord of the Rings: Gollum” that despite being set in the award-winning Lord of the Rings lore, with over 60% of the reviews being negative out of 420 current reviews as of April 2024. Another massive disappointment was Overwatch II, the second instalment of the hit game Overwatch made and published by Blizzard Entertainment, that currently has a whooping 83% overwhelmingly negative reviews out of 259k reviews, that is here to show that the players have much higher expectations when it comes to quality of game play, with users submitting over 60,000 negative reviews withing the first 48h after its launch in August last year.

On the other hand, a quick example of some of the recent well received games like “Elden Ring” have a massive 92% positive reviews out of close to 600k reviews, or “Dragon’s Dogma 2” with over 60% positive reviews from 58k submissions on Steam. There are many reasons that can be listed as reasons to why these games are such a success, a long compelling story, great fluent mechanics that allow for a high skill cap, but one outstanding thing is the AI these games are using. The after is a RTS (real time strategy) combat game that gives the player and the AI time to think before committing to an action while the prior stated game is an action combat game that requires quick reflexes, but both have highly intelligent AI models that I will list and expand upon later.

To see how much of a factor the AI behavior is in the success of a game, I have prepared a test in which the subjects will encounter a basic AI that has access to a couple of moves and is constrained by hard coded behavior such as “if the player is close do a weapon swing attack” or “if the player is far shoot your bow”, and a more reactive AI that has a list of skills and an algorithm will pick an action based on multiple world variables such as distance, current life of the AI and the player, and will be able to react to what the player is doing against him instead of having a “script” that it uses for all encounters.

Alongside the combat part of the test, there will also be a town setting that will display the current trend in NPC (non-player controlled, also AI) characters and the more realistic approach some renewed games have taken to make their settlements feel alive.

2. Background, Context & Literature Review

Since the invention of the very first video game and every other game that followed, the player required something or someone to play against. While the multiplayer games are now extremely popular and even story driven single player games now come with some sort of CO-OP option (cooperative) in which 2-4 players can get together and play on the same side, the is always a need for an enemy, and unless you are playing a PVP (player versus player) game, that enemy will be driven by some sort of AI. Through

history, multiple types of AI have been invented, and huge advancements were made from the simplistic 2d movement of the ghost in “Pac-Man” that is simply fallowing the player through a pre-defined path.

To better explain what reactive AI is, you can think of an enemy character that will only do a certain action depending on the action you take first, such as it might decide to dodge back if you do an overhead swing against it, or to jump if you do a low sweep attack meant to take it down, instead of always dodging every type of attack you throw at it. Another example would be that it would use an AOE (area of effect) attack when there are multiple players (in case of a multiplayer game) clumped in a tight space and attack that area based on the current location of said players, instead of picking a random location or having a preset area that the AI would deploy that AOE attack every time is programmed to use it.

2.1 Known types of Reactive AI:

- Behavior Tree

This is the most used AI behavior in games and this type of AI behavior uses a hierarchical structure to determine the action the AI driven character should take. While this can give the impression of being reactive, in the end it is still “hard coded” and it will only take actions under specific situations, without living any room of improvisations or surprises but still much better than the normal FSM (finite state machine) that is the lowest type of AI behavior pattern because it is easier to scale up. A better explanation on how BT works as well as FSM and why these are getting outshined by other patterns ca be found in the paper released by Jakob Rasmussen in the “Game Developer” web page. [Link]

The Ubisoft “Assassin's Creed” series is the most well-known game that uses behavior trees, and while the game is a massive success, it is not due to the difficulty, or it is interaction with the AI.

- GOAP (Goal oriented action planning)

This advanced AI pattern was invented by Jeff Orkin at MIT and, as per his own words, it is a planning architecture designed for real time control of AI controlled characters. This was first implemented by him in the game “F.E.A.R” and then further developed and implemented by others in renowned games like “Fallout 3”, “Just Cause” or “Deus Ex”. (*Goal-Oriented Action Planning (GOAP)*, n.d.)

In my own description, the AI in this case has a list of goals/desires, a list of actions he can take and a bunch of pre-conditions and post-conditions an action requires before it can be used and what is caused after, as well as a cost. The algorithm, usually A Star pathfinding in this case, will then assign a cost for each action available to achieve the current goal and select the best one for the current situation the AI is in. This allows the AI to be highly reactive if he is aware of the state of the world, for example the location of the player, the health, stamina, the type of weapon or any other information it might need to be able to use a better suitable action. This AI behavior is better used when the AI requires to chain multiple actions to achieve a goal and tends to be slower the more actions it has available which makes it less used in fast paced games but well desired in RTS type of games or simulations.

- ## Utility AI

As stated in the previously mentioned paper by Jakob, Utility AI is one of the reactive patterns used by newer games to allow NPC characters to have a reactive and more realistic behavior. This, just like the GOAP behavior, can make decisions on its own depending on what the player does and can exceed or create situations that even the designer could not think of.

The Utility AI also uses goals, actions and world conditions and picks the current action based on a score that each action received depending on what is happening in the world, but usually uses curves over A Star algorithm to decide, and it's not designed to chain multiple actions but instead it will pick one and execute it then recalculate, which makes it a better use if you want your AI to react faster in a combat situation for example. "The Sims" is the game that everyone thinks of when talking about Utility AI.

- ## Hierarchical Task Networks (HTN)

This is the AI pattern deployed by the "StarCraft II" game, also developed by Blizzard released in 2010 which has outstanding positive reviews from the specialized gaming magazines like PC Gamer with 93%, Eurogamer with 9/10 and Metacritic with 93%.

- ## Neural Networks

This is a machine learning technique that is not only used in games but has many other applications such as speech recognition and automatic translator created by Google. The most well-known application in a game comes from "Forza Motorsport" series that uses it in its AI driven cars to make them feel like they are driven by other real players. Dan Greenawalt, the director of Forza games goes into explaining the difficulty and the need of improving the AI in games as they evolved, and how the neural network works and learn from the data collected from the player's behavior and applying it to the AI behavior itself (Ars Technica, 2020). He explains why machine learning is such an amazing tool to apply to your AI behavior to improve the users experience inside the game.

Machine learning is not yet extremely popular, and many developers are staying away from using it, due to how heavy it can hit performance or how much it could increase difficulty if not applied right and hurt the user experience, but from my personal interactions with gamers through time, a general desire is that machine learning will find its way into more games with the increasing popularity of Esports and competitive games.

To conclude this list, there are many ways of having reactive AI in a game, and all these options are better or worse depending on the type of game you are creating, but there seems to be a pattern between the reactive AI and the games that have managed to sell well and receive a majority of good reviews.

3. Case Study

As mentioned in the introduction of this dissertation paper, I have created a prototype which will highlight the more common type of AI, the FSM (Finite State Machine), and a more advanced AI that will take into consideration multiple factors before deciding and acting. Now keep in mind that due to time constraints and the small scope of this prototype, where my AI enemy character only has available a small number of actions such as move, attack, and defend, using something like GOAP or even Utility AI would not be quite possible as there would not be enough variety to make the cost of those action to fluctuate enough that would change the behavior enough, so I did a work around which will simulate reactiveness but it's more of dynamic and somewhat randomized FSM. This could be one of the negative points of complex AI patterns, they are meant to be used on games with bigger scope that have many diverse types of characters in place with multiple actions that could be deployed any given time depending on the world state. There is also a text-based reaction in the town simulation of the prototype which is meant to emphasize that the AI can also improve other areas of gameplay such as user experience and improve realism in some cases, allowing the player to sink in the environment.

The testing prototype has been created in a way that the subjects are not directed into liking one or the other, with no specific names given to any of the AI characters, and the only differentiation given is red or blue, where red is the reactive AI and blue is the basic FSM. Each part of the test is also randomized in such a way that each user will have a different timeline of encountering these characters. For example, one user might have to fight the red enemy first with a bow and then the blue enemy with a sword second and third the blue enemy with a bow and so on, while another one will meet these enemies arranged in a unique way, to remove any possibility of guiding the testers to a certain outcome.

3.1 Aims and Objectives

The goal of the prototype is finding the user's opinions on how the AI feels while encountering it and if they can tell the difference between the two cases, to find out what would they prefer when given the two options when it comes to combat and what would they prefer when it comes to non-combatant NPCs such as townsfolks encountered in most story driven games. The collected data will then be analyzed along with the data collected on the active player base of current games and the reviews to form a conclusion on if games can be improved by reactive AI.

3.2 Pre-Assumptions & Expectations

Now in my opinion, and I did my best to not influence in any way the outcome of the test, I do believe that using reactive AI in games is the way to go forward. I mostly play online competitive games like "World of Warcraft" which created a fan base and a whole movement in Esports for those who like to compete against each other and against harder, smarter AI.

I also play single player games (that might have a COOP mode in some cases), such "Elden Ring" or "Dark Souls" that even though they are not having players compete against each other, they have extremely hard to defeat "boss fights" and the entire player base of this game praises the game for is willing to try out other games from this development and future DLCs of the games.

Now as my background is quite heavily leaning onto competitive combat games and most of the people, I know that play games for a sizable chunk of their free time, my assumption would be that the winner of debate would be the reactive AI. I can see the benefits of more basic AI, one of them is that it caters better to small simplistic games that do not require the AI to be very smart, or to games that heavily focus on storytelling and want their user to have a relaxed time cruising through it.

3.3 Methodology

The questionnaire is designed to make use of the Likert scale (Likert, 1932), described as a measurement method used to evaluate opinions. Most of the questions are designed to be answered on a quantifiable basis from 1 to 5.

The questionnaire is also designed to not guide the participants in any way with the questions being between blue and red, and the answers are either A or B, or in other cases and to allow me to quantify and analyze the answers, from 1 to 5 on both cases. Control questions such as age, sex and how much time the person spends playing video games or what type of video games they are playing are also asked to further determine the validity of the answers given different criteria of research.

The questionnaire is presented to the tester after completing the prototype but also a link is provided in the prototype in case any errors occur during the test, but the testers are asked to only fill it in after fully completing everything.

3.4 Prototype Walkthrough

As mentioned before, the order in which the levels are presented will differ from tester to tester, is randomized with each level having a 25% chance to be first, second and so on. In this case I have started in the “Melee Easy Town,” the one that has basic AI, and you play as a sword user. As seen in the video, you can navigate through town and try to interact with the NPCs, but you would get a basic answer from them, to showcase what usually happens in most games where there is a town that you can visit but most of the NPCs are there to make it seem busy but not actually make the town feel real. After finding the mayor, a quest giver, you get teleported to fight a monster, the easy monster. This uses the basic FSM pattern and can walk, attack from close and attack from range depending on the distance to player. His attack pattern is basic and follows a simple 1-1-2 repeat attack pattern. This is quite easy to defeat as it is simple to understand what he will do next and dodge it. Next is the “Ranged Hard Town” and here you can see that the NPC will give you a different text based on what you would have equipped on yourself and understand that you are looking for the mayor and help you find it easier. Fighting the hard NPC after leaving the down is also proving more difficult as it does not use a certain attack pattern, but instead will pick its action based on multiple factors such as his own stamina, health, distance to player and in order to simulate Utility AI or GOAP, it will do different random animations for each time he wants to attack. The rest of the walkthrough is the previous 2 encounters but inversed, you will go against the “Ranged Easy” and “Melee Hard” enemies. In the “Melee Hard Town” you can also see the townsfolk, NPCs, talking to each other about the player as you walk through town. This small thing will make the environment feel much more real while allowing the player to be part of it as the NPCs will talk about what weapon he has equipped or what title the player has.

4. Results

Unfortunately, I could not get enough people to test the prototype and I only collected answers from 9 participants over a week. I had the prototype out on multiple locations filled with gamers, but people are unwilling to download something and try it out from a stranger online even if it is for research purposes. All 9 participants were male, mostly in the mid-twenties that spend over 10 hours playing videogames. Judging from the control questions, all participants are familiar with action combat and MMOs (massive multiplayer online games). Overall, the results are in favor of the red, the more reactive AI, though not as much as I would have expected prior to seeing these results. Most of the combat related questions are in the middle while the ones related to the town environment and on the lower side on both red and blue interaction.

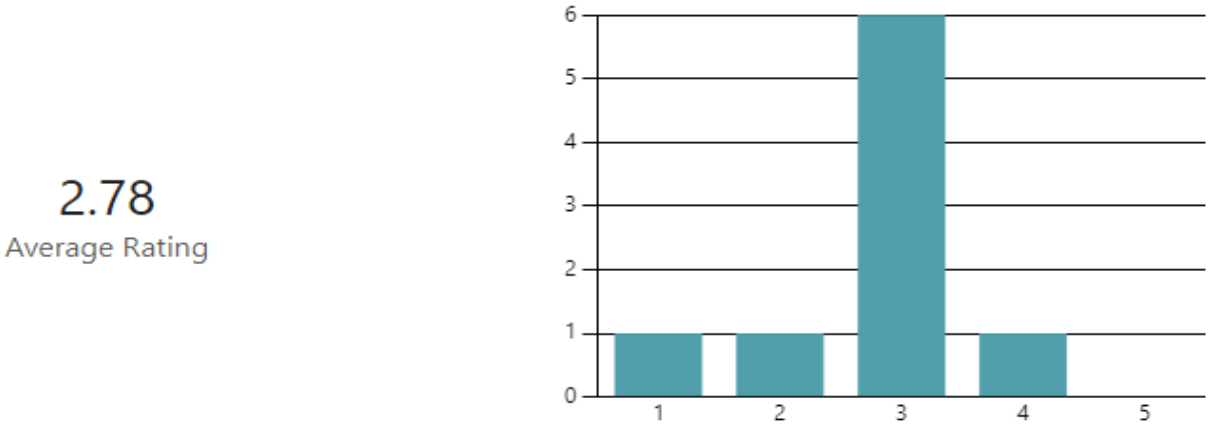
I will do my best to further analyze these numbers and break them down individually to see what the subjects of the test feel about the AI presented in the prototype.

4.1 Data Analysis

- How difficult was the fight?

There seems to be a mutual perception for this question, with a huge incline towards the extremely easy for the basic AI, averaging a 1.89/5 for the 9 people that answered this question.

On the reactive side of the fight, the average is at 2.78/5, people finding it adequately hard to fight against. In this case I would think a median answer is the desired answer as nobody wants to go against an enemy that feels impossible to defeat.



To further dive into this rating, the ones that have marked the reactive AI as average difficulty are 4 out of the 5 subjects that stated they play video games for over 30 hours a week.

- Have you noticed a change in attack patterns during the fights?

For the blue enemy, the basic one, the stats are overwhelmingly in the “No” camp. This was very predictable, and it is indeed quite easy to tell what attack this AI will do next as it is chained to repeat the same actions one after another with no variation depending on world conditions. On the other side

for the red, more reactive, enemy, the opinions are mixed, slightly in the favor of “Yes” a change in pattern have been noticed with a 5/9 rating.

8. Have you noticed a change in attack patterns in the fight against the blue enemy throu fights?

More Details

Yes	1
No	8

9. Have you noticed a change in attack patterns in the fight against the red enemy throug

More Details

Yes	5
No	4

Interestingly, all the 5 people that have noticed a change in patterns have stated in the control questions that they mostly spend their time playing MMO games, games that tend to have many enemies with different attack patterns. I would like to assume that these types of players are the ones with the highest expectations when it comes to the difficulty and variety of an enemy's attack patterns.

- If a game you like has fights like the one against the blue/red enemy only, will you complete that game?

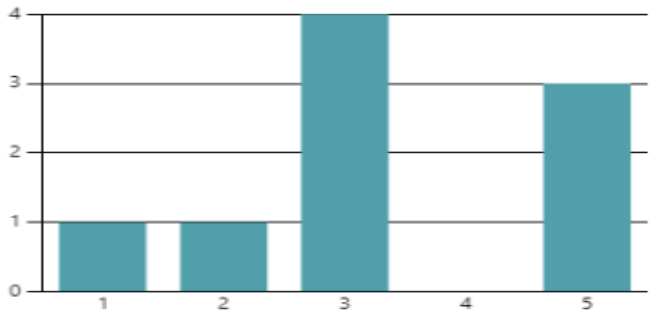
This is one of the core questions I could produce, it is important to find the desire of people to complete the game that you have started as that would reflect how entertaining the game is. The answers in both cases are close to the average, both in this case tilted on the unlikely side. The average for the basic AI is at 3.22/5, unlikely to complete the game while the one for the more reactive AI sitting at 2.56/5. This could be caused by the way I formulated the question though as I asked if they would be willing to finish the game if it “Only” had fights like those, which would be against the point I made prior to this talking about the desire of variety in attack patterns and types of enemies, so I won’t go too deep into analyzing this one.

There are 4 people that voted “extremely likely” in favor of the reactive AI while only one of them also voted the same for the blue one, and these are ones more the same that stated they tend to mostly play MMO games most of their time.

- How likely is it for you to play a game that has fights like the one against the blue/red enemy multiple times?

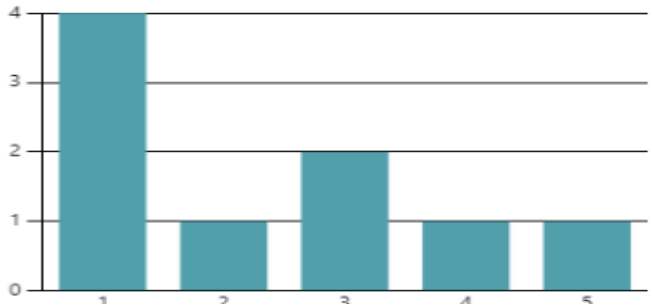
Here we can see better the public opinion being split between the blue and red, as the average of the easy one is 3.33 being unlikely to desire to play the same game multiple times if the AI is basic like that. The reactive AI has an average rating of 2.33 on this question, with people being slightly more inclined to play the same game multiple times if the AI present in that game is reactive and can bring a different type of difficulty depending on what the player does against it.

3.33
Average Rating



ly is it for you to play the game that has fights like the one against the red enemy multiple tir
l is extremely likely and 5 is extremely unlikely)

2.33
Average Rating



- How alive (realistic behavior) did the blue/red town feel?

On this question we once more see the average of the blue, basic AI, recording a low rating of only 1.67 as the NPCs are mostly there to fill in the space and not actually interact with the player in any way. This is quite a common behavior in most games with only the NPCs that quest givers or part of a quest being given more features like talking on a special move set compared to everyone else.

The red town, which has NPCs that will notice the player and talk about him as they pass by, gained an average of 2.89, with people feeling that even though it is not realistic, it can make the town feel more alive and populated by real people instead of NPCs.

5 Conclusion

In conclusion, reactive AI can improve the perception of the quality of a game. Even though the reactive AI did not have an overwhelming win over the basic one in this case, I do believe that games should use more reactive AI in places where it makes sense such as important combat like boss fights or for important NPCs that the player meet often along the journey.

In this test case I have seen the reactive AI having over 10% better approval rating over the basic one, with these numbers likely increasing if the subjects of the test were only MMO players.

As it can be seen on the [mmo-population] website, a website that specifically tracks the player base of MMO games, we can see that the top games ranked by the total player count are “Baldur’s Gate III” a game with RTS combat that uses reactive AI all over the place and has a diverse enemy type that have multiple actions available, we can also see “World of Warcraft” that has maybe the most competitive player base when it comes to combat against AI, and it’s known for its mythic tier difficulty in which the AI is has multiple actions at its disposal.

On the other hand, at the bottom of the list we see games like “Black Desert Online” and “Lost Ark” which both have many types of enemies but the AI driving them is quite basic and they are easy to deal with even multiple at one time.

Another case of complete success is “Elden Ring,” a game that has reached 23 million copies sold in just 2 years since its release and has mostly positive reviews on steam. (Bonelli, 2024)

There are many successes stories along the years where games are highly praised for either the complex combat provided by the AI driving those enemies, or by the narrative the games show which is backed by great NPCs driven by AI that can interact with the player without making every interaction feel the same. Especially with the hardware rapidly evolving, it is now much easier for both developers and players and their computers to run a high number of computations that these types of AIs need to function properly, there is no excuse, in my opinion, not to use reactive AI in the important locations of your game that the player has to face repeatedly.

5.1 Pros and Cons

Quick bullet point recap of the pros and cons of reactive AI in games:

Pros:

- Easy to expand
- Fluidity / Responsiveness
- Can add natural difficulty to games
- Allows AI characters to feel more realistic
- Can execute complex tasks
- Presents intelligent and adaptive behavior

Cons:

- Slightly Unpredictable behavior
- Takes time to properly set up and requires a higher programming knowledge
- Could impact performance if not set up correctly

5.2 Recommendations

I would recommend using reactive AI such as Utility AI or GOAP, only if the agent has a high number of actions available to choose from, and if the game you are working on has a wide scope. There is no need for advanced AI behavior if your agent only needs to see the player, go to the player, and perform 1 or 2 attacks. In this case, a basic FSM will be more than enough as it will save on performance and time consumed.

In the case that you have a boss fight and the game you are working on has fluid combat, then I would highly recommend something like Utility AI that will allow your agent to quickly react the player's actions and create a natural difficulty to the encounter. I would recommend reactive AI or at least some sort of reactive dialogue for NPCs in open world towns, where the AI has at its disposal a few facts about the current state of the world such as characters dead or player's title, reputation, or the NPC can "see" the player and react to its clothes in order to create an organic dialogue between the AI and the player.

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