

Behavior Tree of Agents in Multi-Agent System on Action Video Game

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Abstract- Video game has its uniqueness as escapism because it have the capabilities to pull player's focus to theirs by utilizing many factors or could be called immersive. One of the factors is the behavior of Non-Player Character (NPC) or agents in multi-agent system. Programming behavior of agents could be a daunting and difficult task, especially when the behavior of agents is too complex and it could take too much time. That is why faster alternative but also capable to done the same task or even better were needed. And that is one of the reason behavior tree is popular, because it is easy to use and visually appealing, but how about its capability? In this study we will assess how well behavior tree convey immersive in an action video game. Action video game in this study serves as multi-agent system. We hope this study could lead as foundation to more studies about behavior of agents that is not only advance and complex, but also visually appealing, easy and ready to use for people in industry.

Keywords— Multi-Agent System, Video Game, Behavior, Behavior Tree, Immersive

I. INTRODUCTION

Video game is one of many form of entertainment human created to escape from daily hectic routine or what people usually called escapism. Eventhough escapism used to be a brief way out when under stressed, people who use escapism especially if not under moderation are people not happy with their condition and looking to run away from reality, but if under moderation video game could bring many positives [1].

Video game have its uniqueness because the capability to make gamer totally focused on the game and feel as if they are in the game, or what people usually called immersivity. Challenges, difficulty and story are usually things that make player feel immersed, and the reason why player feel they truly in the videogame themselves [2].

Multi-agent system heavily used by video game because said system allowed video games to feel more immersive to the player. With multi-agent system, video game would be able to have agents to collaborate or act as enemy to the player, filled the city with people where each

one of them have different roles to make the feel of bustling and crowded feel of the city in real life to virtual environment.

Eventhough multi-agent system brings endless possibility to video games, designing the behavior of each agents could be a daunting task. When the behavior of agents is too complex and unpredictable, the behavior will be manually coded, hard to customize, reuse and possibly took much time. Therefore another alternative were needed and Behavior Tree is suitable, because it is easy to use, visually appealing and capable to accomplish same task [3].

In this paper we will explore implementation of behavior tree on agents or Non-Player Character (NPC) in a multi-agent system. We will later conduct a preliminary experiment to test whether Agents or NPC exhibit characteristics of immersive.

II. LITERATURE REVIEWS

A. Multi-Agent System in Video Game

High emphasis on agent and its roles makes multi-agent system became a mandatory for video game nowadays. Many of its usage in video game is to make the virtual world more believable by assigning different roles to each Non-Player Characters (NPCs), but some researcher have found another way to implement multi-agent system. Kruse in their study [4] found a way to make procedural generated map more advanced and have more quality by employing agents to make the map and each agents have different role.

Although the possibility of multi-agent system in video game is endless, it is not without limitation and challenge. Some of the proposed solution by researcher were not used by practitioner [5][6], the main reason being is academic solution tend to be either hard to implement in industry or time consuming. This has caused behavior tree a popular choice because assigning a task is only a mere drag and drop makes it easy to use and navigate [3].

B. Behavior Tree

Behavior tree represent task as a node. Nodes in behavior tree have parent and children, where parent nodes always play first then followed by children nodes.

Behavior tree always start with a root node and then generating signal to its children and so on. Meanwhile behavior tree executes the logic, behaviour tree will draw

information from its companion called blackboard. Blackboard is vital because it store necessary information for behavior tree.

Behavior tree widely used in video game industry and have been used in major video games such as Halo, Starcraft [7] to name a few.

Eventhough behavior tree came with its simplicity, the hierarchical model of behavior tree usually lead to rigidness of NPC's behavior. Illusion of reactive NPC's behavior also possible by employing a lot of state nodes but at the cost of complex hierarchical model, which killed the very essence of behavior tree.[8]

The problem about the flexibility of behavior tree has researchers put their attention into core problem of behavior tree and some has addressed the problem by making improvement to behavior tree e.g., established interaction between NPC [3], adept and learn human actions [7]

C. Immersive

Various improvement made to behavior tree will lead to increase of immersivity on video game. Immersive is a vital part to video game because it was the reason player kept playing the game and possibly looking for more video game, thus help the sustainability of whole industry.

Eventhough vital to the video game, there is still so many studies and research on meaning of immersive and how a virtual world convey immersive to human. One of the studies found that immersive, or can also perceived as presence is a state of mind when player felt as if they are in the virtual world and to truly achieve it, the design of virtual world have to be able to simulate a real life [9]. There is one particular video game successfully simulate real life, the game called Red Dead Redemption 2.

One of the game regarded by many as immersive is Red Dead Redemption 2 because behavior of NPCs in the game imitating real life society where each NPC have their own schedule, work, could interact with their surrounding not limited to other NPC, but also environment. If player by any chance wreck or vandalize a building, NPC in Red Dead Redemption 2 will make comments about it and could possibly despise player because NPCs programmed to have their own memory and affinity toward other people whether it is player or other NPC [10].

Even with various of cutting-edge technology used in a game, some people might find it not as immersive as the others because apparently immersive is a combination between technical aspect and profiles or preferences of the users.

Some user likes to explore, whether exploring environment or create and build something new. The others prefer to sympathetic with the virtual environment as if they are in the game themselves. Thus important for practitioner to consider not only technical aspect of video game but also profiles of player that potentially will playing the game [11].

III. METHODS

In this study we will implement interaction between NPC using behavior tree. NPC have role as enemies and will notify other NPC whenever they encounter player.

A. Game Prototype

For this study we will build the game in Unreal Engine 5. Unreal Engine is one of the popular game engine and widely used in video game industry.

The reason we choose action video game as our case studies because it is easier to monitor NPC's behavior, NPC will react everytime they encounter player and interaction between NPC will noticeable because NPC will call nearby NPC to team up and attack enemy.

B. Enemy Behavior

Behavior for NPC use behavior tree. We use interaction between NPC to convey immersivity.

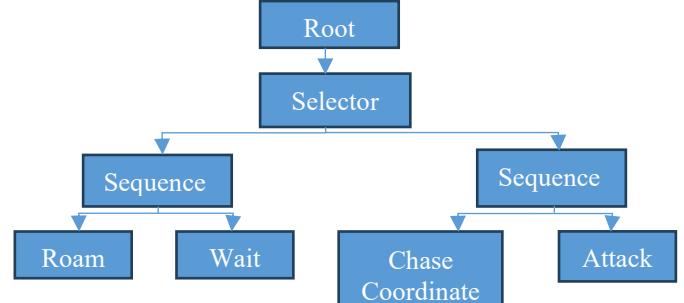


Fig. 1. Behavior tree for enemy NPC used in our game

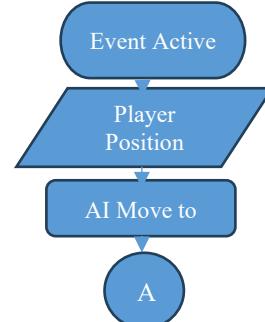
From behavior tree shown in Fig.2, there is 4 states, roam, wait, chase and coordinate, and attack. Roam nodes is on the far left side of the tree followed by wait nodes, and then chase coordinate and attack on the right side of the behavior tree.

Roam state function to command NPC to go to random coordinate within perimeter. Meanwhile wait node works when roam state finish and function as intermediary, either make a loop to roam state again or continue to chase and coordinate state.

Chase coordinate state will only work when player were within NPC's boundary and will chase and send player's location to other NPCs. Meanwhile attack state works as a way to give challenge to player by making NPC able to decrease player's health point.

Our behavior tree works by fire left side of the sequence first (roam and wait sequence). Roam nodes work by programmed enemy NPC to go to a random place within perimeters. And everytime NPC reach the destination, wait node will works and set to 5 seconds and then continue wandering until they encounter player.

If player were within NPC's collision boundary while they wandering and within NPC's line of sight, right side of the sequence (chase coordinate and attack sequence) NPC will chase player along with other NPC.



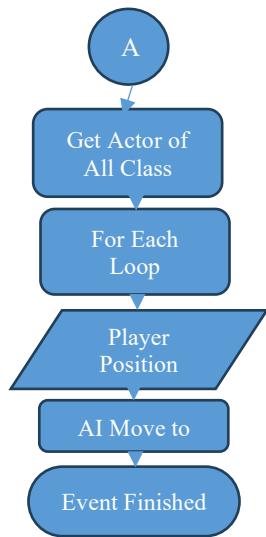


Fig. 2. Flowchart of chase and coordinate node



Fig. 3. The perimeters for our enemy NPC (coloured green) and collision of NPC (coloured red)

The perimeters were set to make our study easier and to increase the encounter between NPC and NPC or NPC and player.

C. NPC

In this studies we set our NPC to have 2 sensor, collision boundary and vision. Vision works like eyes for the NPC and will only detect player or NPC if they are on vision's line of sight, if player happen to be behind of NPC, it will not chasing player. Meanwhile collision is necessary to send signal to run the behavior tree

D. Measurement

In this study we will use likert scale as our initial measurements for NPCs behavior. We will later use more robust questionnaire for our measurements because we plan to survey our game to several player and ask for their feedback.

But for now we will start our preliminary experiment with likert scale.

IV. RESULTS

The results below are preliminary results from our studies about interaction between NPC using behavior tree.



Fig. 4. Main Menu Screen of Our Game.



Fig. 5. Scene when NPC still wandering and has not detect player

As we can see from fig.5, it is our main menu when the game load up. Our main menu screen made up from main map used in our game. And from fig.6, player spawning near the NPC but not near enough to trigger their chase and coordinate state, and NPC still in wandering state.



Fig. 6. Scene when player was attack by NPC

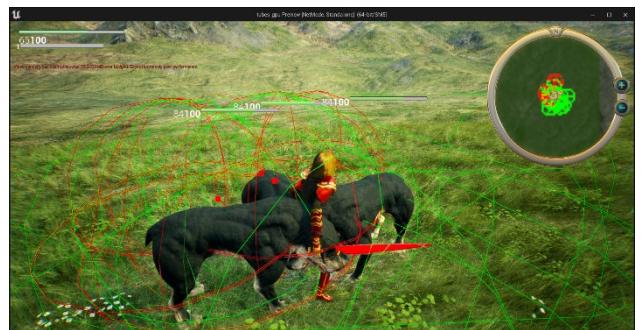


Fig. 7. Scene when player attacked by nearby NPC

From fig.7 we can see player were spotted by NPC and attacked, and all NPC were notified and attack player by fig.8



Fig. 8 Scene when player health ran out

TABLE I. Likert Scale Table for Our Studies

Scale	1	2	3	4	5
NPC's Interaction	Very Rigid	Rigid	Normal	Fluid	Very Fluid
Pattern	Very Limited	Limited	Normal	Plenty	Various
Unpredictability	Very Predictable	Predictable	Normal	Unpredictable	Very Unpredictable
Context Awareness	Not Aware	Not Aware in some aspect	Normal	Aware to some extend	Aware

As we can see in table I. we have identified 4 parameter we will use after our initial observation on our NPCs: NPC's interaction, pattern, unpredictability, context awareness.

After we identified our parameters we then move to likert scale. We use scale from 1 – 5.

After the experiment concluded, we notice a few things about our preliminary experiment.

TABLE II. Likert Scale Table for Our Studies

Parameter	Our Game
NPC's Interaction	Rigid
Pattern	Limited
Unpredictability	Predictable
Context Awareness	Not Aware in some aspect

V. CONCLUSION

Our studies start with how important immersive in video game is and how to improve it. As we study more literature we found that even though many methods and technology has been invented, not many were actually used in industry because of the complexity and not practical, therefore behavior tree seen as ideal alternative because of its hierarchical model.

After we decided to use behavior tree, we conducted a preliminary experiment about NPC's behavior, and interaction between NPC were seen as vital to make the game felt immersive, and thus we decided to test NPC's interaction as the first parameter of immersive to test.

Testing NPCs interaction were seen as partially success. NPCs could interact with others perfectly, but the interaction still need more variation and were seen as stiff or rigid. Another studies to test more immersive parameter were needed, and also studies about whether genre of video game affect what kind of immersive parameter to use.

Before we present our results, we would like to show likert scale and parameter we use in our studies.

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