Case Study:
AI Companions in *Bioshock Infinite* and *The Last of Us*

{ Rohan Deuskar EC22054 }

Introduction
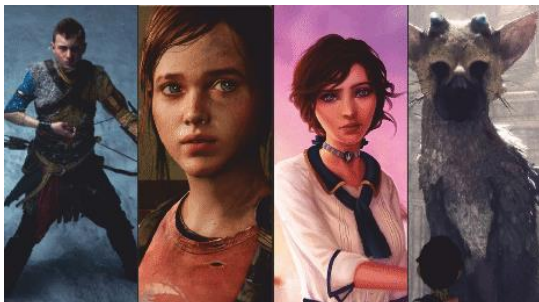
NPC and companions

What is a common theme between the characters like Dr Watson from Sherlock Holmes, Donkey from Shrek? It would be the fact that these characters are companions who accompany the main character through their journeys and complement the persona of the main character as well as creating an emotional connection between them. Along with pop culture movies and stories, games have also adapted the concept of companions for similar reasons. Be it in the form of a dog or a human, the concept of buddy AI has been adapted in the industry in many ways.

Conventionally the concept of NPC (Non-Player Characters) was used sparsely and didn't use to be characters who would stay with the player for a long time, an example of this would be Cortana in the Halo series where she wouldn't necessarily stay with the player but would show up in cutscenes and other instances to interact with the player usually by audio cues. Some instances of AI companions for a good chunk of the game would be done through audio only, for example the narrator in Stanley's Parable. In some cases, the AI companions are non-humans like Dogmeat in Fallout.

AI companions could be player controlled like Trico from The Last Guardian where the player has to give him callouts to move or depend on some follow along mechanisms, companions could be part-autonomous like Atreus from God of War where the player has the ability to instruct Atreus on what to do but otherwise is independent, or sometimes AI companions can be completely autonomous like Ellie and Elizabeth from Last of Us and Bioshock Infinite.

Last of Us and Bioshock Infinite

The Last of Us is a post-apocalyptic action-adventure game developed by Naughty Dog. The world in the game has a fungal infection which wipes out most of humanity. The gameplay revolves around stealth, exploration, and combat, as the player plays as Joel, a smuggler who is tasked with escorting a young girl named Ellie who is our AI companion across the country to a resistance group. Along the way, the player must scavenge for supplies, craft weapons and items, and avoid or confront both infected and hostile human

enemies. The Last of Us has a very emotional story, well-developed characters, and intense gameplay.

Bioshock Infinite is a first-person shooter game developed by Irrational Games. The world in the game is a floating city called Columbia, which was built by the United States government to showcase American exceptionalism. The player plays the role of Booker DeWitt, a former Pinkerton detective who is tasked with rescuing a young woman named Elizabeth – our AI companion – from the city. The gameplay revolves around shooting, exploration, and puzzle-solving, as the player navigates through the city and its various factions. The game also has supernatural powers known as Vigors, which allow the player to manipulate elements such as fire and electricity. Bioshock Infinite also follows a very intricate storyline revealing mysteries through the game.

Ellie and Elizabeth both serve unique mechanics. Ellie assists the player in combat and puzzle-solving by providing support, such as throwing bricks or bottles at enemies, sometimes helping the player get out of a headlock and shoot enemies as well. Elizabeth, on the other hand, can toss the player ammunition, health, or weapons during combat. These unique mechanics add an extra layer of strategy to the gameplay, allowing the player to approach combat in a variety of ways.

Companion Mechanics

Elizabeth's Movement

The aim behind Elizabeth's movement was to keep her in front of the player, the developers used theatre techniques implemented using some clever algorithms to keep her in front and in view of the character. After several prototypes to make her follow the player, then a prototype to predict the player's movement and let her move in front in that direction, the programmers settled on a final method of using their concept of 'golden path' technique.

This technique allowed Elizabeth to stay true to the character and wander around the map to interact with events which the developers called smart terrain which were pre-placed instances where Elizabeth would interact or talk to other NPCs but at the same time stay in the view of the player. Unlike Ellie, the programmers did use teleportation to move Elizabeth near the goal if the player was using shortcuts which Elizabeth was not capable of taking, for example grappling somewhere. The developers also made sure that Elizabeth was only interacting in the cone of focus of the player, which became smaller and smaller as the player moved closer to the goal. The character was new to the world and from a realistic
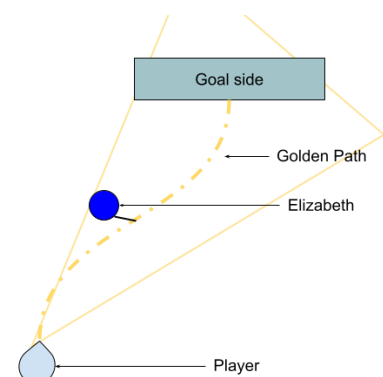
point of view would want to explore the world, but from a programming perspective, having a character who would not only lead the player but also explore the world was a difficult balance.

Elizabeth's Utility and Interactions

The Smart terrain was a trigger system that the AI could activate if the NPC was close to it which would trigger certain animations and voice lines which made the AI feel more natural and human (See figures). However the animation would pause at the first frame if the player wasn't looking and would only play when the player's field of view was on the character which was an efficient system.

Some of these smart terrains were also limited to use, and would keep a variable count of how many times they had been used. Some smart terrains would also trigger eye tracking for the character and would make the character look at the events around her, prioritising higher weighted events like people talking or important objects in the world.

Another good realism included in the AI of Elizabeth was emotion (see figure), depending on the current emotion of the character, she would decide to trigger or not trigger some smart pointers in the environment, which made sense considering no human would want to happily eat cotton candy after watching a live shooting a few minutes before. This system was implemented into the animation system of the character allowing them to be responsive through gameplay and scripted events.
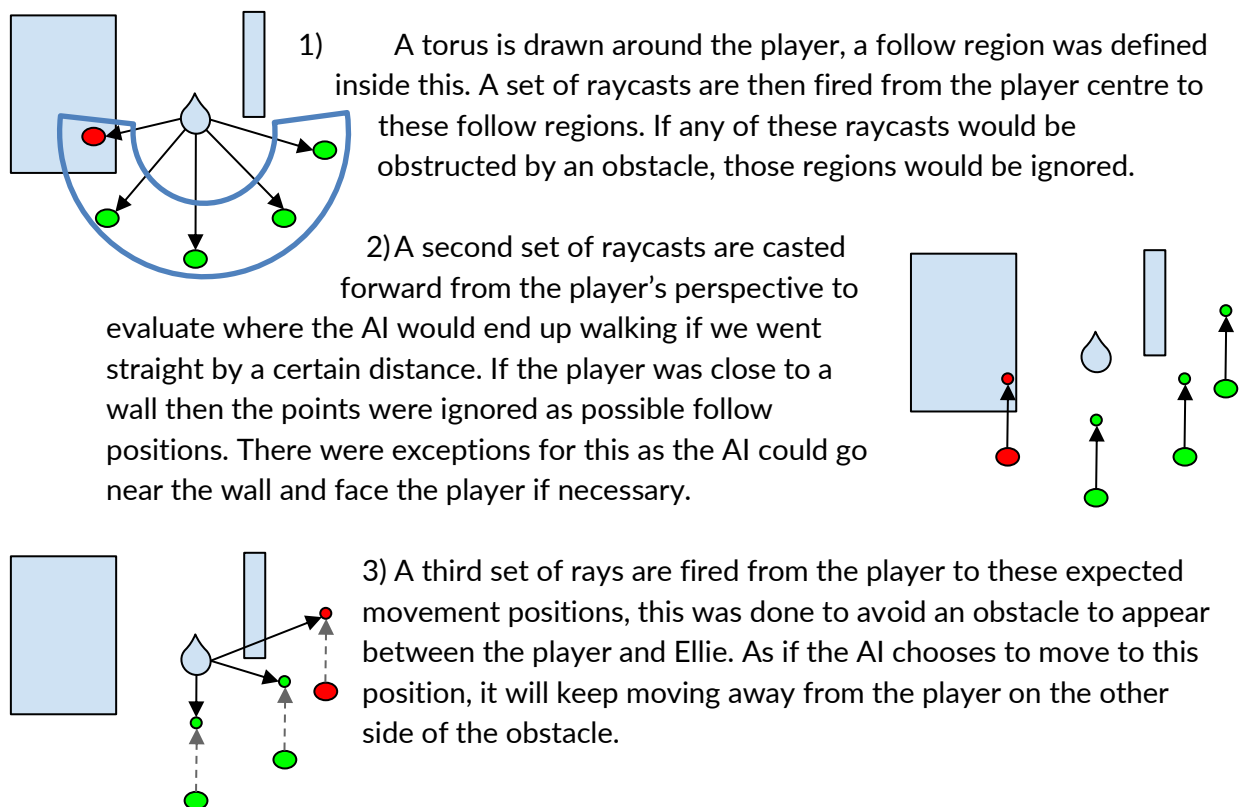

Elizabeth's Combat Utility

Elizabeth's combat interactions are rather limited however it fits the character well. Elizabeth has 2 main behaviours during combat, the initial being finding cover, Unlike Ellie in 'Last Of Us' who can generate her own points to take cover, as mentioned later, Elizabeth would route to predesigned cover spots. During combat, the player has complete focus on enemy NPCs, hence Elizabeth doesn't follow the golden path rules and strays away to find cover and can also teleport around off screen.

Elizabeth also has the ability to toss guns, ammo or health packs to the player during combat, which was triggered by the player, hence it doesn't take the player out of the play.

To keep Elizabeth engaged in the game play, when throwing the objects the camera faces Elizabeth forcing the player to look at her.

Ellie's Movement

The aim behind Ellie's movement in the game was to keep it realistic and not use any cheats. Conventionally NPCs in games will be teleported to places if deemed necessary during the gameplay as we saw in Elizabeth's movement to keep the character close and in view of the player, however for Last of us, they tried to avoid teleporting Ellie's character and stick to her walking everywhere, this solved the problem for the audio department with footsteps primarily, but also made the character feel more alive. The movement of the character was done using follow-positions. These follow-positions were points around the player where the buddy (companion AI) would place themselves if and when the player was stationary. This was done in 3 steps.

1) A torus is drawn around the player, a follow region was defined inside this. A set of raycasts are then fired from the player centre to these follow regions. If any of these raycasts would be obstructed by an obstacle, those regions would be ignored.

2) A second set of raycasts are casted forward from the player's perspective to evaluate where the AI would end up walking if we went straight by a certain distance. If the player was close to a wall then the points were ignored as possible follow positions. There were exceptions for this as the AI could go near the wall and face the player if necessary.

3) A third set of rays are fired from the player to these expected movement positions, this was done to avoid an obstacle to appear between the player and Ellie. As if the AI chooses to move to this position, it will keep moving away from the player on the other side of the obstacle.

After this, the remaining positions are then ranked on the basis of some considerations and the ranked top position is chosen. This calculation was done every frame to figure out if a new position was needed for the AI. Some smoothing was done to the switch between the movement so that Ellie wouldn't jump back and forth between these points and move unnecessarily.

During non-combat situations, Ellie was programmed to move at different speeds depending on the distance to the player's current position, using walk, run, or sprint animations as needed. These animations were blended together seamlessly to avoid noticeable switches. For follow mechanisms, Ellie would select a follow position and walk to that point as the player travelled.

Ellie's Utility and Interactions

If the player moves towards Ellie, conventionally the NPC would move to let the player go through due to the 'player is the leader' strategy of most games, Ellie however, wouldn't move until the last moment and only at the last moment would play a stumble-like dodge animation with audio cues signifying annoyance to bump into her. This gave the character a more human-like experience as usually a human wouldn't expect someone else to run and bump them either.

The developers wanted Ellie to be able to take cover like the player, but the static Cover Action Packs designed for NPCs were too sparse, so they used Runtime Cover Generation. This program fires 80 raycasts around the player to detect edges and procedurally generate edges around the player every frame, which are then rated based on factors like distance from the player and number of threats nearby. This system was only used by Ellie as it was extremely computationally expensive. A bug in this system led to the implementation of a new feature called Cover Share, where Joel puts his arm over Ellie in the same cover point. This allows Ellie to take cover in a more dynamic and responsive way and adds an extra layer of immersion to the gameplay.

Ellie's Combat Utility

For the purpose of combat and utility, Ellie had 4 main behaviours – Throwing, Grapples, Gifting and Shooting. Ellie had a Throwing behaviour where she would grab bottles or bricks and throw them at the enemy whenever they would be close to detecting Joel. She also could stab enemies when the player is stuck in a grapple which helped strengthen the player and Ellie's relationship. Ellie had the ability to throw ammo or health packs to Joel which were generated through the drop system of the game. Ellie also can shoot however this ability was kept inaccurate and importantly infrequent, as realistically Ellie was a young girl who would be hesitant to hold a gun and shoot and be inaccurate in doing so.

Conclusion
Elizabeth's AI design

Overall, the AI system for Elizabeth in the game was well-designed and achieved its goal of creating a realistic and believable companion for the player. The use of the golden path technique to keep Elizabeth in front of the player, as well as the implementation of smart terrain triggers to make her interactions with the environment feel natural, were both successful methods. The inclusion of emotion in Elizabeth's AI also added to the realism of her character.

However, Elizabeth's combat interactions were somewhat limited, and she was restricted to pre-designed cover spots rather than being able to generate her own cover points like Ellie in 'Last of Us.' Additionally, while her ability to toss items to the player during combat was a clever way to keep her engaged in gameplay, the camera forcing the player to

look at her during this interaction could also be seen as somewhat restrictive but necessary to keep her a part of the gameplay as a companion.

Compared to other games, Elizabeth's AI system stands out as a well-crafted and nuanced companion character. The idea of trying to use theatre tricks and football tricks in AI programming helped solidify the need to not invent innovative ideas to problem solve but rather try to convert well-established concepts to solve the problem in hand instead. There is always room for improvement, but overall, the developers' goals for her AI were met to keep her the focus of the player in the game and she remains a memorable part of the game's experience. The notes provided by the developers tells us a lot about how difficult and in turn important it is to debug an AI character and how important it is to prototype-test-discard-retry until we can settle on a final system.

Ellie's AI design

The AI design of Ellie in The Last of Us is a proof of the efforts put in by the developers to make the character feel more lifelike and realistic even while having only a few months for development of the entire system. By avoiding teleportation and instead using follow-positions for movement, Ellie's character appears more human-like and immerses the player in the game. The use of procedural cover generation and the addition of the Cover Share feature for combat and utility further adds to the overall experience of realism and makes you understand how this character would behave in reality.

Overall, the designers' goals of creating a realistic and believable companion AI were well-satisfied. The efforts put in to achieve this are commendable, especially when compared to other games that rely on teleportation and simplistic follow mechanisms.

One area of improvement could be more intractability of the AI with the environment during non-combat, as in most cases Ellie is just following Joel, which makes the player feel isolated even when he has an AI companion.

From a technical point of view, the AI design of Ellie in The Last of Us serves as an excellent example for learning the importance of dynamic systems in the game development industry. It showcases the importance of creating companion AI that is realistic, dynamic, and interactive, and the use of techniques such as the dynamic follow points and procedural cover generation to achieve this. Overall, Ellie's AI design shows that when we have a few resources at disposal when it comes to consoles and high-end systems, one can create a lot of dynamic realism in an AI character by using concepts like raycasts and perception systems.

Learnings and Conclusion

Both Ellie and Elizabeth were developed in a crunch time of a few months, due to several reasons, however have been regarded as some of the best autonomous AI companions built to date. Both characters have autonomy and their behaviours stay true to their systems, Ellie is a scared young girl in a post-apocalyptic world who grows to become more and more independent through the game. Elizabeth is a woman who has been trapped for her entire life and through the game is able to interact with the world and become more worldly. The characters really help understand that technology has reached a point where we don't need to rely on scripted events in games to establish a relationship between the AI and player anymore and now can move forward by creating more realistic AI systems which will be able to develop as companions to the player through gameplay itself.

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