

BIG DATA IN SINGLE PLAYER GAMES

by

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Abstract

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Improving video games can be exponentially more efficient by utilizing big data. Big data plays a big part in modern gaming, especially for multiplayer games like poker, first person shooter games. Utilizing the data gathered from video games can be used in ways that will improve the player experience massively and can be eye-opening to find issues, player pattern, and improve the game in ways that will be hard to pin point without gathering data of how the players are playing the game. However, while big data is being utilized in multiplayer games, it's not utilized as much in single player games where the story or action is the main focus of the game. This thesis proposes ways of using big data in single-player story-driven games. There is a lot of potential in taking advantage of the data gathered by players in single player games to improve future single player games. The thesis will cover multiple topics regarding how to improve single player games step by step, starting with what type of video games will be using as an example for the hypothesis, what type of information will be extracted, how to use the data gathered to improve the game, and tools used to develop the game and gather data.

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Chapter 1

Introduction

A lot of businesses now put high emphasis on gathering and making use of data as it gives them better insight into their business by looking into consumer interaction. Similarly, in gaming industry, it is increasingly being recognized that collecting and analyzing data about how various players play the game can improve a video game over the course of time [3]. Data analysis and collection has been utilized more in multiplayer games than in single player games. The goal of this thesis is to be able to simulate data from games and show that by using these data, the games can be improved dramatically. There are many different types of data that can be gathered, which would give good insight on how exactly each player is playing a video game, the data analysis can indicate if everything is working as intended as well as show if all the parts in the game are being utilized. This way, how the player is interacting with specific parts of the game can be analyzed which will play a big role in improving single player games.

To be able to demonstrate how to extract data from video games, A zombie shooting game is made where the player fights for their survival to escape the room and while the player is trying to survive, data is being collected of almost everything that is going on in the game. When the player finishes their run, a file is generated of all the data gathered for that specific run. The main goal is to simulate data that can be relatable to real world games and how these data can give us insight of our own game. The data collected can be utilized and used to demonstrate how using big data can improve single player games. This paper also goes over how to tackle different type of data collection and how to use them.

1.1 Background & Motivation

The reason behind writing this thesis is because of my own interest and passion of playing video games. As a long time, consume I have played over thousands of single player games, witnessed a lot of games that lack both quality and engagement throughout the years. The main motivation for pursuing Computer Science degree has been to learn the process of creating video games behind the scenes and to be able to make my own game one day. In terms of quantity a lot of games get released in a monthly basis, however, a lot of these games lack quality wise. Implementing big data would help gaming industry massively by giving the designers insight of their own game, by having good understanding of how players are playing their games [1].

1.2 Types of Video Games

This thesis discusses how multiplayer games been utilizing big data, however, the focus will be on single-player games. When it comes to single-player games, it is very diverse. There are adventure and exploring games like Skyrim, story-driven games like Assassin's Creed or the Last of Us, and hack and slash games like the Devil May Cry series. While all these games are single-player games, they function and work very differently from one another, so the method extracting data from these games will vary from one another. For example, extracting information from an open free world is different than a hack slash game where the main objective and satisfaction comes from performing combos and defeating their opponent. Adventure games on the other hand, focus on how the player will experience the story and how to keep the player engaged throughout the playthrough [2]. Some games give the player the complete freedom to do whatever they please and approach the game in their own unique way and Skyrim is good example for this [4]. All these examples show how the main theme and objective from each game differ from one another. Therefore, the collecting data process is different from one game to another.

1.3 Big Data in Video Games

In game design, big data highlights what is important for the user's and show trends and patterns in players by keeping track of their behavioral data to update the game accordingly. The goal to increase the game longevity, remove frustrating elements, and to make sure the players are having fun. Using big data is important nowadays because, among other variables, we must understand players likes, dislikes, what puts them off, and what makes them excited to be able to deliver the best possible gameplay. By keeping track of player behavior in the game, we can use those insights to tweak and improve the gameplay [1].

While Big Data is being utilized in the gaming industry, it is mostly used in multiplayer games, such as League of Legends and Dota [3] where extracting information from the players helps the company to balance their games. For example, League of Legends releases patches every two weeks for balance purposes which is determined from the data collected from the player base. These data include information such as what champions they play, what items they buy for that champion, their movement around the map, their creep score, damage score, and a lot more statistical data that helps them determine what champions are over powered and need nerfs and what champions are underpowered and need some help, Dota is very similar as well.

Collecting data, observing it and improving the game because of it increased those games longevity and allowed them to naturally improve over the course of time. However, unfortunately Big Data is not being implemented in Single player games, which is the focus of this paper. By, observing how big data affects the multiplayer scene, it can be shown that there is a lot of potential for it to be implemented in single player games as well.

We need to note that there is big difference between using big data for multiplayers and single players, in the multiplayer games big data is mainly used for balance purposes to keep the

competition scene fair and balanced so the type of data collected is based around information that can be used to know if the game is balanced or not and what needs adjustment. Using Big Data on single player games is for completely different purpose, and that is to make the game more fun for the player and allow the designers to put their focus on something that the player are engaging in and improve on things that are not being interacted by the players.

Different data is collected based on the genre of the game. For example, games like Skyrim where exploring the world and adventure is the focus of the game, collecting information on which NPC the player interacted with in their game play, tracking player location throughout the vast world of Skyrim. While in games like Devil May Cry 5 collecting the sequence of combo moves is more important because Skyrim and Devil May Cry 5 are fundamentally different game wise, so type of data collected should be based off the genre of the game and the objective or goal the game is trying to accomplish.

1.4 Previous Work

In previous paper, we discussed how spatial data is used for the purpose of video games, how terrain models are created for video games using technologies such as GIS (Geographic Information System) , SFK (Software Development Kit), and how to implement them in order to achieve realistic representation of the real world in virtual reality [5]. We discussed the importance of spatial data in future of video games and how it can be implemented to improve video games in general.

A dodging game was made were the main goal is for the player to avoid all enemies while collecting all the coins in the map to proceed into the next level. This is more of a strategic type of game that can give us a lot of input behind the way players approach such game and keep track of player behavior.

1.5 My Contributions

We have developed a first-person shooting game where we will be extracting players behavior throughout their game run. After extracting the data, we will be using it to simulate real world games situations, show that by using big data, the data can be used to improve the game in many ways depending on the data being collected. We will be bringing those data into visualization and explain how useful they are in the world of gaming.

By allowing multiple people to play the game, we will gather enough data to be able to give solid reads that will hopefully prove the point we are trying to make about how big data can be a big change in single player games. Keeping that in mind it is important to note that player privacy is incredibly important and we will try and preserve it as much as possible. More details regarding privacy will be mentioned later in section 4.6.

1.6 Tools and Technology

For tools and technology there are two main tools we will be using for this thesis. First one is Godot, an open-source free engine that was used to build the first-person shooter 3D game from the ground up [6]. The main language Godot uses is GDScript which is based on Python, Godot is a relatively easy engine to use and there are many resources out there to help people get started in their project. Second tool we will be using is called Gimp, which is a tool like photoshop but free to use. So, we can customize and edit any images we want to implement in the game [7].

Blender is the third tool we will be using. It is a free open source 3D computer graphics software toolset that is used for creating visual effects, art, 3D printed models, and interactive 3D applications and video games. Blender will be generally used to create any assist we need for the game [8].

Chapter 2

Data Collection and Use to Improve the Game

This chapter will be divided into multiple sections to describe different types of data that can be extracted from single player games. Skyrim will be the primary example to demonstrate different type of information that can be extracted. Before going into details, talking about the game Skyrim is important.

Skyrim is the fifth installment of the Elder Scrolls franchise published by Bethesda. It is an open-world game where the player is thrown into this massive world and it's up to the player to carve their path in the game. Skyrim is huge and diverse, and the player can approach this game in many ways, such as by becoming a powerful mage, a warrior, a deadly assassin, a swift archer and many more.

Skyrim was designed in mind that the player can do whatever they feel like doing. The game never forces the player any certain build path or following specific quest lines, which makes Skyrim a perfect candidate example for this paper.

2.1 Player Location



Figure 2-1 Skyrim map [15]

Skyrim world is very large as shown in figure 2-1 and it is very common for players to not explore a lot of locations in the map, which is why collecting players coordinates while they are playing the game helps the designers to see the main routes people use in the game and how the players are interacting with the world of Skyrim. This type of data sheds light on the places that get little to no attention from the players.

It allows the designers to adjust and update these areas in the game to encourage the players to take these specific routes and explore those unvisited places. It also, gives designers better understanding on how their game is being approached by millions of players all around the world.

How player location can be tracked is by collecting the coordinates of the player whenever they move around the map, importing the coordinates into visualization tool allow for better understanding of the player behavior while navigating the game. Players coordinates is not the only thing that can be collected, keeping track of specific enemies movement is also useful as it allow to see if the AI is working as intended.

By using the data gathered by player movement, it can be utilized to improve the game depending on the information gathered. If there is a lack of interaction in certain areas, then there are multiple ways to improve the game. Adding some exciting missions that will attract more players to those unexplored locations could be one way since interesting and engaging missions are always a huge drive factor to bring life into those unexplored areas.

Another way is by adding specific NPC's that are only available in areas that are receiving little interaction from the players. By making the loot that gets dropped from the NPC'S to be valuable for the players, they will be motivated to get out of their way and visit those places. Adding specific crops that can only be found in those location where players can collect can be an alternative way. Doing these changes to the game can make it very rewarding to explore those places that players usually tend to ignore.

Keeping track of player location as they play the game can be game changing because the designers can use it to make the game much more intelligent. Having huge sums of data about how the player approaches the game, it can be used to predict their next action and counter it by placing obstacles that will catch the player off guard. This will make the game much more challenging, more intelligent, more realistic, and give the vibe that anything is possible.

2.2 Character Stats



Figure 2-2: Destruction skill tree [16]

In Skyrim every time the players level up, they will gain some points which they can use to build up their characters in different ways. For example, the players can use the points to increase their stamina, mana, health, endurance, strength.

Skyrim has 18 skill trees in total, each 6 skill trees fall under a specific playstyle. There is The Warrior, The Mage, and The Thief, each of those playstyles bring completely different approach and feel into the game. Warriors are straight forward and are always in the front-line during battle, Mages are in the back line usually and perform strong spells to damage their foes and Thief's usually remain unseen and go on with their business quietly. Furthermore, there are the unorthodox builds players go for and it works for them, by gathering these type of data designers will get a lot of insight on what build path players go for, and based on the data collected discover new ideas to improve their game in the following installation of the game.

As the player levels up, they get specific set of points they can distribute among the 16 skill trees. The more points the player invest in a specific skill tree the more techniques they can unlock based on that skill tree. For example, in figure 2-2 the more points placed in the Destruction skill tree the more techniques and skills the player unlock that would help their destructive abilities. One way to make use of the data gathered is to check if the techniques gained from investing into these skill trees are being utilized or not. If not, then do the appropriate changes to allow players use them, this will help massively in keeping the game skill system being improved over time based on the data gathered. Information on what build path is strong and what is not can be used to balance things up, to make all build paths fun and desirable and most importantly reach its intended strength. Keeping track of all this information is important in order to not overwhelm the players by skill trees that no one ever picks or use and give more attention to skill trees that are being utilized and used.

2.3 Weapons, Armory, and Crafting

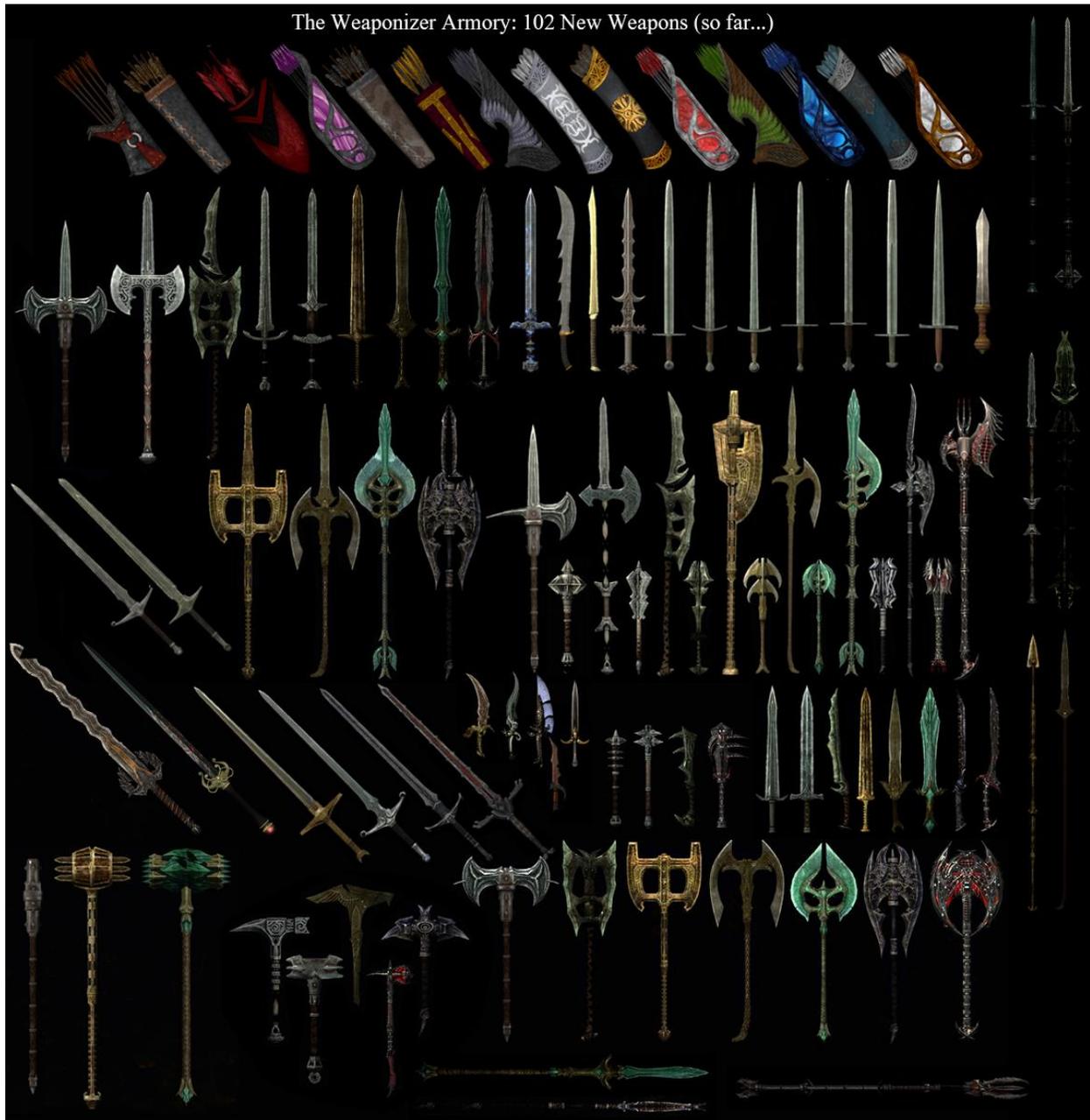


Figure 2-3: Skyrim weapons [13]

While analyzing the way players build their characters via stats is useful, it does not give a clear view of how the players are playing the game. By gathering information about what type of weapons the player uses during their long journey in the world of Skyrim and how they engage with the weapon system in general, it will give complete understanding of how the players are

interacting with the combat system. This will be massively helpful data because it gives statistic of every weapon of the game and how much it is being used for its respective level. Since some weapons are early levels while some are mid-level and end game weapons.

Leaving the level required to use a weapon out of the equation, Skyrim offers variety of different weapons that are under three categories- One handed weapon, Two Handed weapon, and Archery. Each Category offers different play style the player can experience. The One-handed weapon include weapons such as Daggers, Maces, Swords and War Axes- each of these weapon choices have their positives and negatives. A Dagger for example, is the fastest but deals the least damage unlike the Maces which are the slowest and deal the most damage. The same thing applies for the weapons under the Two-Handed Weapons category. Every weapon in this game offers something different.

Archery on the other hand is limited to bows and crossbows but there are many different types of arrows that can gathered. Each offers unique trait or spell that boost the way it damages enemies. Some arrows offer high damage output while some other arrows increase the chances to stun, paralyze, or weaken the enemy for a specific amount of time.

Armory in Skyrim is unique and diverse, it is also divided into two categories, Heavy armor, and Light Armor. Heavy armor allows the player to survive long enough to deal enough damage to finish the enemy off, but restricts the player movement speed while Light armory grants utility to the player but lacks the defensive attribute Heavy armor has. Under these two categories there are hundreds of different armories, each is unique from the other by having different stats, attribute, and magic.

Gathering these types of data will tell the designers a lot about their player base playstyle and how using such data appropriately will improve the game based on what players like to use and what they do not like to use. In the end, all this information extracted will be used to cater to all playstyles and help the less-used weapons, armories, and broaden it up.

Crafting in Skyrim is very well done. The player can craft all sort of stuff as long they gain the ingredients, or the items required for whatever they are trying to craft. The player can craft potions that can give the player power boost or other attributes for a brief amount of time usually 30 seconds when consuming them, poison that can be mixed with arrows, Smiting armors, Mining weapons, Cooking, and Enchanting. While all of these are self-explanatory, Enchanting is little bit more complex than the rest; a player can enchant their weapon or armor granting them special effects that would benefit them greatly in battle. There are all sort of special effects from absorbing health from the enemies such as absorbing magic, stamina and some effects that fear the enemy away [11]. There is a lot of potential for improvement for Enchantment. By keeping track of what type of enchantments player use can be used as the backbone to further work on the Enchantments in Skyrim, by knowing which spell effects are most favorable, it can give ideas to what type of special effects player look for when enchanting their weapon or armory.

2.4 Classes

When a player makes a new character in Skyrim, they must choose a class and every class is different than the other. Collecting this information can help to see what players use the most and can adjust the underused classes to make it more appealing for the players. This can help massively in future games or future patches where balancing the classes are based on statistics and information gathered from millions of players around the world.

2.5 NPC Interaction

In every game, there is always a couple of interesting important NPC's that can get a player into an awesome mission, but sometimes the players can miss it because they simply did not find it or just did not interact with it. By collecting data regarding NPC interaction with the player, pinpointing which NPC's get interacted with the most and which do not, the designers can improve the NPC accordingly. For example, making some NPC more accessible and easier to find, updating the NPC routing path would make the chances of encountering them while exploring the wide massive world higher. Making use of these types of data, allow to make the NPC's feel more alive in the game because they can be adjusted them to make them smarter at predicting the player's movements.

2.6 Items

In games like Skyrim there are thousands of items a player can collect/gather which is why it is important to keep track of what items get picked the most and what gets picked the least. When looking at these types of statistics gathered, to tackle around items that are not being used we either create some new useful items that need multiple items from the underused ones to make, or straight up buff the items, this will make underused items more valuable and will encourage people to find them. Also, gathering information about what players use their items for, how they get their items, will give the designer a detailed view of the itemization use in the game and if it is being used for what it was intended for. This can help for balancing purposes and produce accurate data of the market itemization in the game.

2.7 Enemies

Monsters, in games such as Skyrim the number of monsters is extremely diverse. Here we can collect multiple data on player interactions with monsters such as how often do they fight the players; how much the players struggle with specific monsters? Gathering these types of data is

important for balancing purposes and making sure the monster is not more difficult than what they are intended to be. Also, use this type of information can be used to make the monsters NPC smarter by being able to predict player's actions, which can lead to much more intense exciting gameplay that challenges the player.

By collecting data of how the enemies are being damaged by the players. Based on the data, the enemies can be improved to be much more intelligent. For example, if the player is using a two-handed weapon the enemies would attack and back off, to minimize the amount of damage the player can deal to them. If the player is using magic or is attacking the player from afar then they will do whatever it takes to be in close range within the player and give the player as much room as possible to move around. Considering that not all enemies are designed to be intelligent, but how players approach different type of enemies gives ideas on how to design much more interesting enemies for the players to face.

2.8 Dungeons

There are many dungeons in Skyrim the player can explore. Keeping track of how many dungeons get explored, which dungeons get the most attention and which dungeons the players do not get to interact with. Collecting these types of data can help to see underused dungeon and possibly patterns on why some certain dungeons are not being explored as often. This is very useful to know because this information can be used to update the dungeons accordingly which in return will increase the longevity of the game.

For the dungeons that do get cleared, it is usually just the player making it all the way to the boss of the dungeon and defeating the boss, this label the dungeon as cleared. However, that does not mean that the dungeon has been cleared 100%; there might be some enemies, un looted items and treasures left behind. Moreover, it will give the designers insight on what really the

players care about when doing the dungeons, collecting all the treasures in the dungeons, killing every single enemy, killing the boss monsters mainly, stepping into every single pixel in the dungeon and exploring it completely which is why collecting percentage wise on how much the dungeons been cleared by players would give the designers a better understanding on the average clearance of the dungeons overall.

Chapter 3

Hack and Slash: Data Collection and Improvement

For this chapter, the focus will be on breaking down a lot of aspects of the game Devil May Cry 5 and what data can be collected from the game, and how to use those data to improve the game. Devil May Cry 5 was chosen because out of all the Hack and Slash games out there, it's considered by many to be the best current Hack and Slash game. The game was released in 2019 so it is new, and it also got the best action game for 2019, making it a perfect game candidate to look at in details and use it as example on how big data can be implemented in those type of game genre. The term Hack and Slash refers to a type of gameplay that emphasizes combat

3.1 Hack and Slash: Weapons

Weapons in Devil May Cry 5 are very diverse, deep, and complex that gives the player the opportunity to approach the game in the style of their choosing. There are 3 main characters the player can choose from in the game and each character have their own unique set of weapons that become accessible throughout the story as the player progresses [10]. The moment the player acquires the weapon they can use it immediately. During combat the player can switch between weapons almost immediately and each weapon gives the player a unique take into fighting that develop excitement. Mixing all the weapons together while in combat can make to one great experience.

With having such diversity and control of what weapon the player can use at any given time, one would think that there is no room for improvement; but if we implement collecting data from players while they are going through the game we can extract so many information that would

help giving a much depth insight on when the weapons are used, against which enemies, how often they are used, the time frame using the weapon before switching to another, and a lot of other in depth discoveries that would be almost impossible to discover without the use of big data.

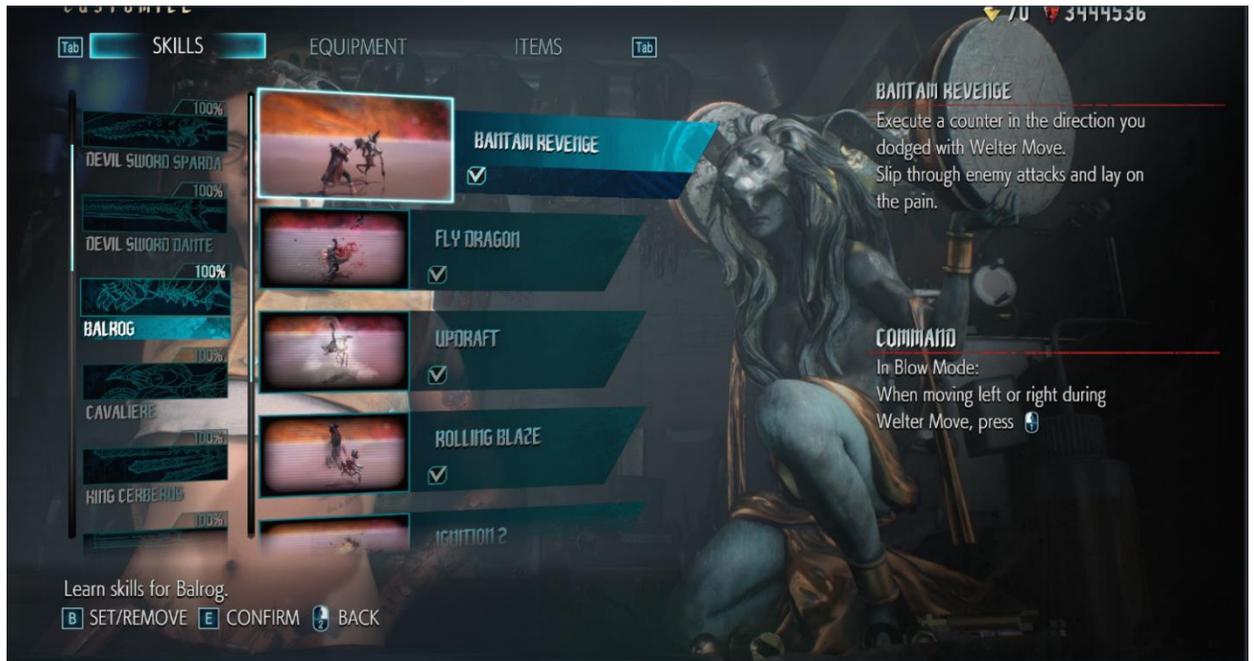


Figure 3-1: Weapon move sets

Weapons in Devil May Cry are designed for a specific purpose, some weapons are light weapons while other are heavy slow weapons that do a lot of damage, each weapon is designed to counter a specific situation. One of the main characters in the game Dante, has 6 melee weapons and 4 range weapons. The 6 melee weapons are Rebellion, Balrog, Cavaliere, Devil Sword Sparda, Devil Sword Dante, and King Cerberus [10]. Each of these weapons have different set of moves. Some of the weapons have 6-7 moves while some has 11 moves, and one weapon specifically Balrog weapon has 19 moves the player can use in combat. Similarly, the range weapons have set of move-set the player can unlock as well. Some moves are cheap while others are expensive but each move serves a purpose. Collecting how players invest their red orbs on what move sets they get after acquiring the weapon is useful. Information on which weapons move sets are used the

most and which move sets are used less and if they are used what moves are followed will allow the designer to tell which move sets work the best with one another as well as how frequently the move set is used during the battle. Questions such as Do players use the same weapons and move sets for all kinds of enemies, or do they switch weapons can be answered [10].

3.2 Hack and slash: Combat

The combat system in Devil May Cry 5 is one of the most complex and deep combat systems in the current Hack and Slash genre by far. Allowing the player to perform actions in the game that people usually only see in a cut scene or in a movie and they always wish they could do that in a game and that is what Devil May Cry 5 does. It gives the player all the tools they need for them to fight their enemies with extreme style.

Combat in Devil May Cry 5 provides the player with unique style of approaching the game depending on the character they choose. We have three different characters in the game and each one provides a completely new experience in the game, and they stand out on their own. Each character will be described in detail to give an idea on how many sequences of moves and techniques can be executed, and how by collecting these types of data the designer can improve the combat system, starting by the first character Dante.

Dante is fan favorite due to his playstyle, and for a good reason. Dante has 4 different styles Trickster, Gunslinger, Royal Guard, and Sword master as shown in figure 3-2.



Figure 3-2: Styles [12]

These 4 styles change the way the player fights in the game [9]. Trickster allows dodging the enemies much more easier, by giving the player access to a lot of mobility in the game which makes the moves and the combat the player pulls much more smoother, allowing for air-dodge, teleportation, and overall gives the player extreme mobility either it be in ground or in air [9].

The second style option is Gunslinger, this style focuses on the use of guns in the game, by giving each gun weapon a unique attack for flashy combat. It allows dealing with long range enemies easier. It also has other uses like keeping enemies at bay and slowing their movement as they approach the plater, temporarily stun or paralyze the enemy while mid combat to make kill

the enemies in more style. Overall, gunslinger is fan favorite if they enjoy shooting their way out of a situation.

Third style is the Sword master, similar to gunslinger, this style amplifies all Dante's melee weapon by granting special ability that is only available when this style is on. It massively improves closed combat and is essential style to use to keep the combos following one another smoothly.

Fourth style option is Royal Guard. It is debatably the hardest style to use out of the 4 styles as it requires precision timing to pull it off. Royal Guard is a defensive style that allows the player to guard against enemies' attacks. If timed properly Dante will not suffer any damage and after each successful defense, the Royal Guard meter fills up which allows a strike back with energy stored up from any successful block. While this style does not possess the number of new moves or options other style do, but it compensates by allowing the player to parry almost any attack in the game if timed correctly.

Not only does each style offer a new approach to the game, the player can also switch between any style almost immediately in the middle of the combat which adds another layer of depth and complexity to the combat system of Devil May Cry 5.

Outside of the 4 styles option Dante can use it, the player has access to Devil Trigger which is ultimately Dante demon form. Whenever the Devil Trigger gauge is filled up from fighting enemies, the player has the option to activate the Devil Trigger, when activated the character changes into his Demon form which gives the player boost of power while fighting enemies. When the devil trigger is on the health bar will slowly regenerate, the attacks gain damage boost, and the player no longer get stunned or paralyzed while taking attacks from enemies which reinforce the

aggressive style this form is aiming for. But that is not the only form player can transform into, there is another more powerful form called the Sin Devil Trigger Form and to activate this form the player need to fill up the Sin Devil Trigger gauge by transferring the accumulated DT gauge. However, this form is extremely powerful as it allows the players to perform some seriously overpowered move and makes the player feel like they are the boss in the game. It is usually used to take out enemies or bosses quickly.

Second character in the game is a character called Nero. Nero, like Dante has deep and complex combat mechanics but in a different way. Nero uses primarily one gun and one sword throughout the game. Both weapons have lengthy moves player can unlock throughout the game. But what makes Nero stand out is the devil breakers he gains throughout the game as shown in figure 3-4.

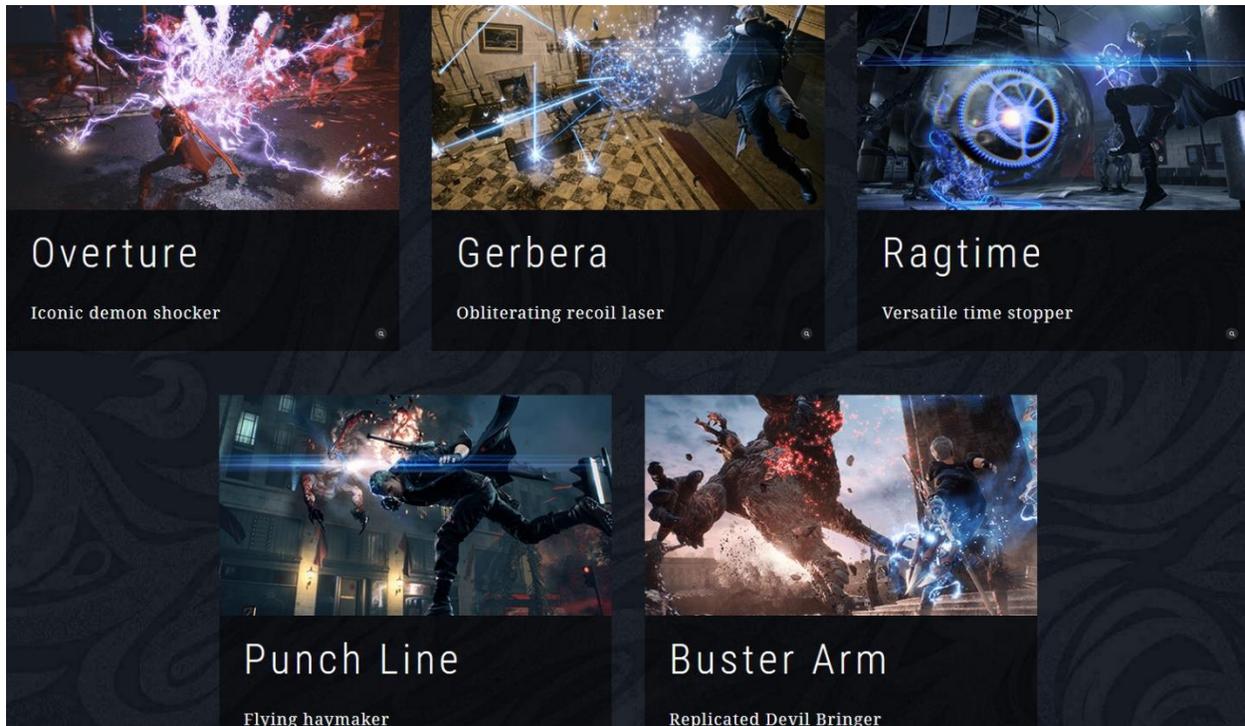


Figure 3-3: Devil breakers

Devil Breaker has 3 main properties. It has a grappling attack that pulls the enemies toward the player to force them get into close range or use it to extend combos. Each unique devil breaker has different attacks and abilities for different situations and each devil breaker has a powerful attack that deals decent damage but at the cost of destroying the devil breaker itself in the process [9]. Taking all those options in mind, there are about 10 devil breakers the player gains throughout the game before the mission starts. If the player is playing Nero then they can buy devil breakers from the shop, some cost 500 red orbs while other devil breakers cost 1000 red orb. After buying the devil breakers the player wants to use for that mission, they can organize the devil breakers they want to use in any order they want for that specific mission as shown in figure 3-5.



Figure 3-4: Devil breaker [14]

When the player destroys the devil breaker, they move into the next devil breaker in the list. This adds a layer of strategy to the combat system. Enemies can also destroy devil breakers forcing the player to move into the next devil breaker in the list. A lot of information can be collected from the use of devil breaker, which one the players are using the most, how are the players moving into the next devil breaker, do they change in a fast pace or they wait until the enemies somehow break the weapon, how are the devil breaker ordered, and do players take advantage of everything the devil breaker has to offer. This information can fundamentally

improve the devil breaker system in future Devil May Cry games. The designers can focus on the things the player is interested in and expand upon it.

Another mechanic that makes Nero special is the Exceed system to his sword. By revving up the sword, the player deals more damage with basic attacks and special moves. The player can upgrade the exceed system up to level three. The more the player revs the sword the higher the exceeds level get. At final level, exceeds attacks will not only grant increased damage to special moves, but they will also hit more enemies with it. The player can get one bar of exceed immediately if they time the attack button and the rev button at the same time. Making combos during mid combat more stylish if the player has mastered the character, which adds another layer of complexity in combat system.

By looking at both characters Dante and Nero we can see they are both extremely different combat and style wise. The combat system boils down to executing sequence of moves almost infinitely until the player defeats all the enemies on the screen. Each character has over 50+ moves they can use, and it can be overwhelming for the player. Although this is intended to give satisfaction for the players who committed their time to learn the moves and master the combat system in Devil May Cry 5. However, due to how complex and diverse different sequence of moves a player can pull off, collecting these sequences of moves from each player can be groundbreaking as it gives the designers deep look into their combat system, which is the most important aspect of the game as it shows how it is being approached by the players and how different playstyles players fight their way through the game.

There are possibly millions of different sequences of moves players can perform in Devil May Cry 5. By figuring out all the sequence of moves players do from all over the world. Designers can massively improve the combat system. They can label down which sequence of moves is most

popular, which sequence of moves is used the least, long sequences of moves, short sequences of moves, how diverse those sequences of moves being switched from weapons, to guns, to devil breaker, to demon transformation etc. This is important, because the intention of the game is to give absolute freedom on how stylish players want to be. Having these kinds of data visualized while the designers are working on their next installment is huge assist on improving the combat system in Devil May Cry 5.

Third character the player can play in Devil May Cry 5 brings completely different approach to the combat system and his name is V. With the other two characters Dante and Nero, the player brings the actions to the enemies and get into close range but with V the player summons two demons to fight the enemies. However, these demons cannot kill the enemies. They damage them enough until a white indicator shows on the enemies and that's when V must get into close range to finish the enemies off. Otherwise, the enemies will regain health and the player must damage them to the point where the white indicator appears again.

V brings the type of playstyle where the player let his summons do the work for them, while they orchestra the way they want to finish off their opponents. However, the downside of this is that V the character himself is weak and vulnerable. Playing this character requires the players to keep their distance, keep an eye on the entire battlefield, and execute the enemies carefully one by one. Otherwise, the player will die quickly.

V has 3 summonses that he can control in the battlefield. Griffon, Shadow, and Nightmare. These summonses have their own health bar. Taking enough damage from the enemies will force the summons to enter a hibernate state where it will take some time for them to rejoin the battlefield again.

Griffon is the first summon the player gets, Griffon is a lightning bird and he attacks whenever the player presses the square button. Griffon is a ranged attack demon. By pressing square, he fires lightning range attacks. The further the player upgrades Griffon, he gains wide variety of new skills and moves. Most of them however focus on area crowd control with laser beams. Slowing multiple enemies down, knocking enemies who get too close to V, allows V to get away from enemies by using griffon to fly the player away, and use his constant range attacks that is used to weaken the enemies.

The second summon players get their hands on is Shadow and is the main source of damage. Shadow attacks whenever the player press the triangle button on the PlayStation. Shadow was designed to take on enemies' head on and deal a lot of damage. The more the player invest in shadow the more abilities they unlock. Shadow gains some very powerful moves the player can utilize; some heavy Area of Effect attacks that deal a lot of damage to his surroundings, knock enemies in the air, and can be used by V to slide quickly to the left or right to avoid attacks.

The third and final summon is Nightmare, and unlike Griffon and Shadow where the player can control simultaneously. The player needs to fill up the Devil Trigger gauge first and after it is filled the player can summon Nightmare. Nightmare is a very powerful summon and can attack all the enemies on screen dealing lots of damage.

By using both Griffon and Shadow the player can pull off some very complex combos in the middle of the battle. Using Shadow to knock the enemies off in the air while using Griffon to juggle enemies in the air and keep the enemies at bay in the air for a while. There is a lot of different combinations and moves the player can pull off using Griffon and Shadows moves. Keeping track of such data will give the designer great length of highlights and in depth information about their very own combat system for example, what type of enemies is being damages, how is the enemy

being damaged, what moves are being used, what order the moves are being used, and how effective it is to kill off the enemies. All these types of data can be visualized in a nice way for the designers to look at, digest, and use to improve the game.

Some examples on improving the combat based on those data can be to make the dynamic between Griffon and Shadow more appealing, by making combos more satisfying to pull off; update some moves that might work well individually but dynamically it's not hitting the mark so the feel of using both Griffon and Shadow for combo purposes is much better; use these patterns between the two summon to create new moves for the character; make the summons more interactive around Nightmare to make more flashy and stylish plays.

Another mechanic the character V can utilize is by holding the R2 button on PlayStation will make V read a book. Now this slows the character down, but as long as the player reads the book the Devil Trigger meter will fill out gradually. This mechanics works very well cause the character V is not in the middle of the battle. So, while the summons is doing damage, the player can use the opportunity to read the book to fill out the Devil Trigger gauge as often as possible which means summoning Nightmare more often. Keeping track of how much usage the player uses this mechanic and how often it is interrupted can be very useful. It can give designers ideas to improve the mechanic for future games. Some examples of improving such mechanism would be- if the players are not using it often then giving traits or effects while reading the book that helps in battle would make it more appealing to use, increasing the speed of the Devil Trigger gauge being filled by the second, or if it's being used too frequently by the players to the point it's getting overpowered then making the enemies target the character V more frequently when they player uses such the technique. There are lots of ways to go around this to improve the game based on the results they get from the players.

Collecting the following data on how Griffon, Shadow, and Nightmare are being utilized. The data can be used to modify and update their play style. Some examples could be if the abilities being used for the purpose it was intended for, balancing purposes, discovering new patterns of using V's summons, how fast does player invest in upgrading the summons throughout the game etc.

These data can be then used to improve the design philosophy for the character V. For example, by collecting all the combination pattern for every player who played V, new combos and ideas could be discovered and figuring out which move is the most popular among each summoning would not be speculation anymore. V movement around the battle field as the player is using the summons to battle enemies off is very useful because this can be used as a backbone to create a much more complex summoner character like V for future Devil May Cry games.

3.3 Hack and Slash: Boss Battles:

Boss battles plays a major part in Hack and Slash games. They are more difficult to defeat than normal enemies. They add another level of excitement for the players to defeat. In Devil May Cry 5 defeating bosses usually grant the players new weapons as reward. Devil May Cry series was always known for it is exciting boss battles because it is the closest thing to a player vs player scenario. Each Boss battle allows the player to think differently on how they approach it. Players usually die couple of times until they figure out a way to defeat the bosses.

Fan favorite boss battle in Devil May Cry 5 is the final boss the player face in the series which is the antagonist character brother Vergil. What makes Vergil as a Boss to stand out differently from other boss battles is the fact that he is the same size as the player character, very versatile and fast, meaning he can keep up with the player speed. Vergil is also very stylish capable of performing combos on the player, taunting the players. He gradually increases in difficulty the

more damage the player deals to him. It gives the players the feel that they are actually fighting a professional player instead of AI where the player has to put all the skills they acquired up until that point into the test and force them to push their limits in order to defeat the final Boss.

However, over time as players figure out the pattern of the boss battle and which way is the most efficient in defeating bosses. Boss battles lose their uniqueness. For example, while Vergil as a boss battle is extremely fun. If players have mastery over Royal Guard style, they can easily defeat Vergil without really doing much.

While learning bosses' patterns and moves is part of the game design so the player can adapt and be able to defeat them later, having a specific difficulty where the Boss AI has patterns based on the data collected from how players all around the world attempted to defeat Vergil would allow the designers to be able to improve the boss AI across the entire game. It would make them much more intelligent, more challenging and very exciting to face. It would also increase the longevity of doing the bosses multiple times because the boss would react differently depending on how the players will be approaching them.

Chapter 4

Experimental Game: Data Analysis and Improvements

In this chapter we discuss the game that was developed for the purpose of this thesis. Discussing the data analysis done based of the data collected to demonstrate how useful big data is when implemented in single player games and how we can use the data to improve the game.

4.1 Experimental Game: Description

The main game made for the purpose of this thesis, is a first-person shooter game where the player must fight their way out to escape the room. There are two ways to accomplish this- first one is to kill all the zombies in the map, this gets harder the longer the player waits since zombies will be spawning every couple of seconds, or play around the zombies and find the key to unlock the door to escape the room. Everything the player does in the game is being recorded to be able to simulate data and show how data collection and analysis is beneficial for gaming.

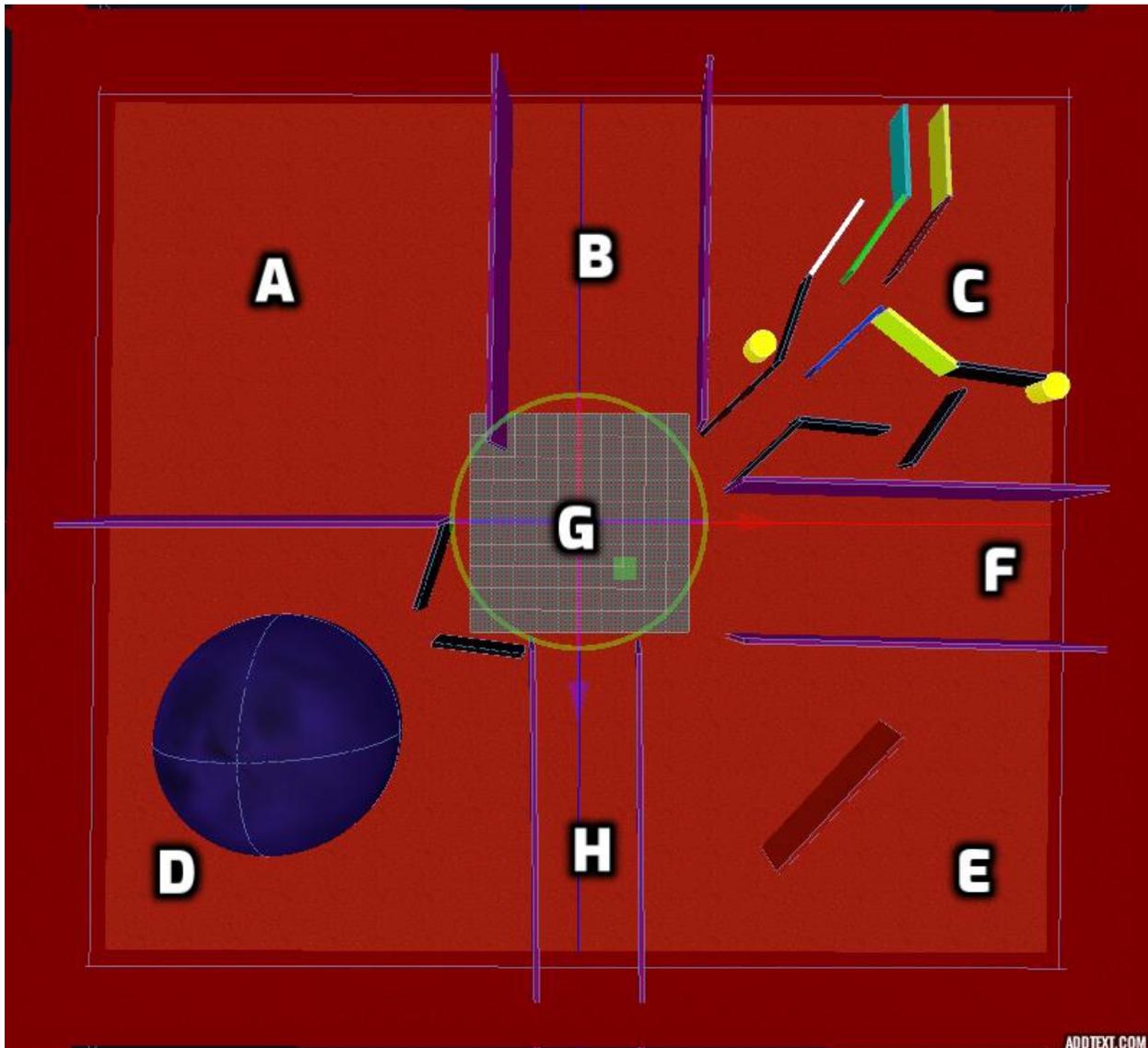


Figure 4-1: Game map

As shown in the figure 4-1, the map is large and is divided into multiple sections. The player starts in section H and must go around the map, find the key and escape the room before the zombies kill the player. There are 5 portals located in section A, B, C, E, and D. Every couple of second a zombie gets spawned from a random portal. Three of these portals spawn normal zombies and the other two spawn unique type of zombies.

The key is hidden in one of the 5 portals and the player can retrieve the key by destroying the correct portal and collecting the key. After obtaining the key the player needs to search for the door to escape the room. The door is hidden in section C and only upon interacting with the door while having the key in their possession, they win the game.

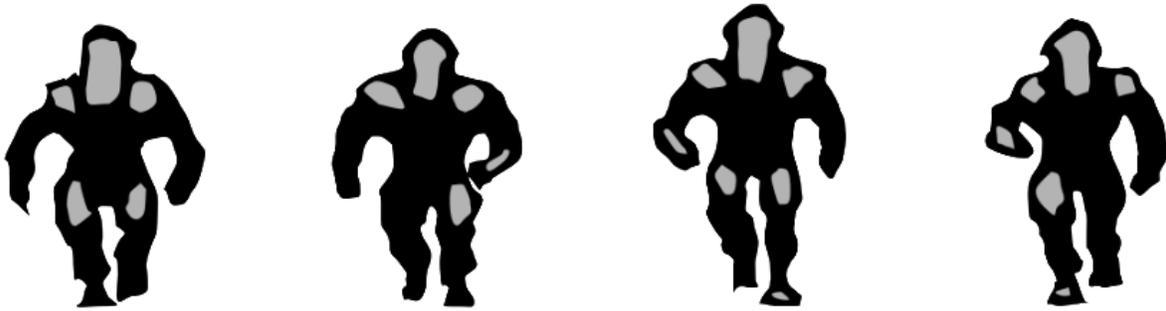


Figure 4-2: Regular zombie

There are also 3 types of enemies in the game called zombies. The first type of zombie is a regular zombie that follows the player around the map and does 1 point of damage every time the zombie interact with the player.

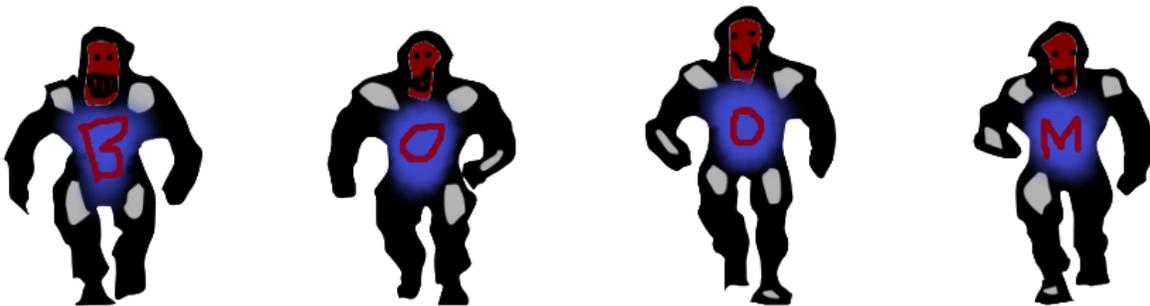


Figure 4-3: Explosive zombie

The second type of zombie is an explosive one; whenever the player kills this type of zombie, it explodes damaging everything around it for 10 points of damage, except the same type of explosive zombies. This was done in purpose to prevent multiple explosive zombies to

explode in one go if a player kills one of them.

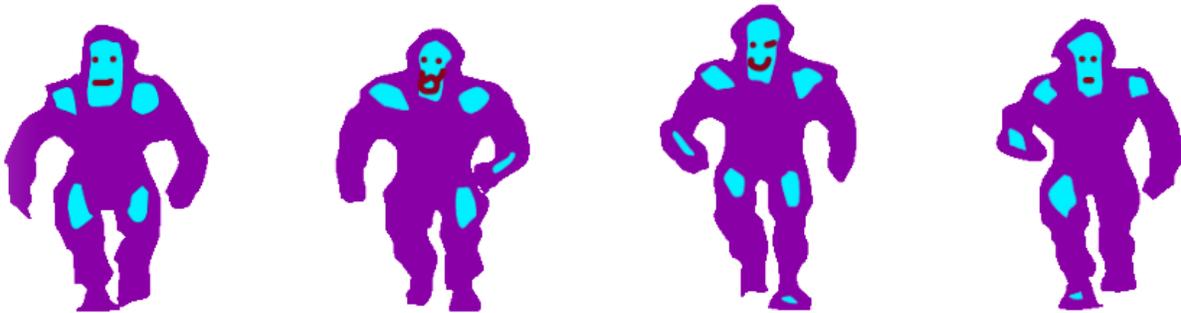


Figure 4-4: Frenzy zombie



Figure 4-5: Frenzy zombie

The third type of zombie is different in color than the other two zombies and power wise is the same level as a regular zombie. However, the moment the player damages the zombie and reduces their health to a certain point, the zombie enters frenzy mode which increase their movement speed, damage, and change their appearance. One hit of this zombie to the player does 5 point of damage and it can be very deadly.



Figure 4-6: ammo



Figure 4-7: health pack

There are four items that the player can collect in the game. At the start of the game the player has 40 ammunition. Since running out of bullets can be a problem for the player, but there is ammo scattered around the map and collecting ammo refills the player ammunition completely. There is also health pack that restores 2 health point whenever the player collects them. The player has 10 health points in total.

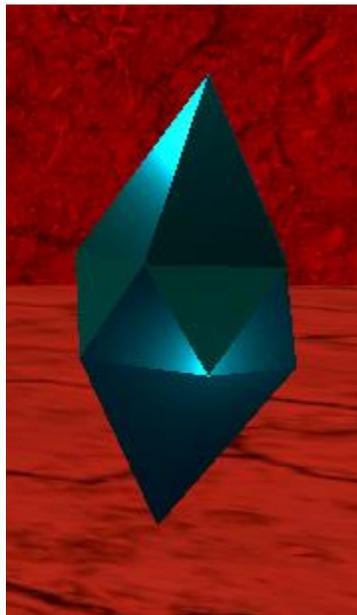


Figure 4-8: Crystal

The last two items are powerups the player can get. The first one is damage boost, the item is located in section D in the bottom left corner of that section. It increases the player weapon damage per shot allowing them to deal 2 points of damage per shot which in turn allows to effectively kill zombies faster.



Figure 4-9: Heart

The last type of item is a heart and when collected, it increases the player max health permanently by 5 points of health. This item is in section E in the bottom right corner of that section. Both items are located in hidden places. The purpose behind this is to reward the players for exploring the map.

Also, there are barrels scattered around the map as well, mainly in section G. Shooting the barrels will force it to explode damaging everything around it, including all type of zombies and the player. The player can also use them to be able to escape the zombies by running around them since the zombies cannot go through objects.

4.2 Experimental game: File Logging

```
21 rounds
Ammo-01 at [-10, 0, -10], 26 rounds.
Ammo-02 at [10, 0, 10], 21 rounds.
Ammo-03 at [-10, 0, 10], 28 rounds.
Ammo-04 at [10, 0, -10], 25 rounds.
Zombie-01 at [-5.71379, 0, -8.25133], 4 hp
Zombie-02 at [11.2862, 0, -8.25133], 2 hp
Zombie-03 at [-6.71379, 0, -9.25133], 3 hp
Zombie-04 at [13.2862, 0, -12.25133], 4 hp
Zombie-05 at [0.172808, 0, -10.721], 4 hp
Zombie-06 at [-9.38564, 0, -14.6541], 3 hp
Zombie-07 at [6.02678, 0, -15.5231], 2 hp
Zombie-08 at [2.09364, 0, -9.39468], 4 hp
Zombie-09 at [-23.0907, 0, 3.65265], 3 hp
Zombie-10 at [-15.2833, 0, 2.5093], 3 hp
Zombie-11 at [-26.7626, 0, -2.75013], 3 hp
Zombie-12 at [-6.09075, 0, 3.65265], 3 hp
Zombie-13 at [-11.3502, 0, -3.61908], 3 hp
Zombie-14 at [-17.2042, 0, 1.18301], 3 hp
Zombie-15 at [-26.2538, 0, 15.2697], 3 hp
Zombie-16 at [-9.25376, 0, 15.2697], 2 hp
Zombie-17 at [-14.5132, 0, 7.99796], 3 hp
Zombie-18 at [-20.3672, 0, 12.8001], 4 hp
Zombie-19 at [-18.4463, 0, 14.1263], 3 hp
Zombie-20 at [-29.9256, 0, 8.86691], 3 hp
obstc-01 at [-20, 0, -30], 4 hp
obstc-02 at [-10, 0, -30], 2 hp
obstc-03 at [0, 0, -30], 3 hp
obstc-04 at [10, 0, -30], 2 hp
obstc-05 at [20, 0, -30], 2 hp
obstc-06 at [-20, 0, -20], 2 hp
obstc-07 at [-20, 0, -10], 2 hp
obstc-08 at [-20, 0, 0], 4 hp
obstc-09 at [-20, 0, 10], 3 hp
```

Figure 4-10: Data

```
Initial health is :9
zombie damaged player.
Zombie-12 wounded by 1, now has 2.
Zombie-12 wounded by 1, now has 1.
Zombie-12 died.
Initial health is :8
zombie damaged player.
Player obtained a healthpack and increased his health by : 2 His health now is : 10
Initial health is :9
zombie damaged player.
Initial health is :8
zombie damaged player.
Initial health is :7
zombie damaged player.
Initial health is :6
zombie damaged player.
Initial health is :5
```

Figure 4-11: Data

While the player is playing the game, everything the player is doing is being recorded in the compiler. Their location is being printed every couple of seconds; if they damage enemies it will specify which enemies they damage and vice versa if the zombie damage the player it will print what type of zombie damaged the player and how much health point the player has left; if the player collects items it will be printed as well. Everything the player does is being collected.

There is a tool in Godot called File Logging where it creates a text file in the directory of that player specific run. Inside the text file everything that was printed in the compiler for that run is available for use. Every time the player starts a new run, a log file is created for that specific play run. The files were imported into excel to visualize the data.

4.3 Data Analysis and Visualization: Player Location

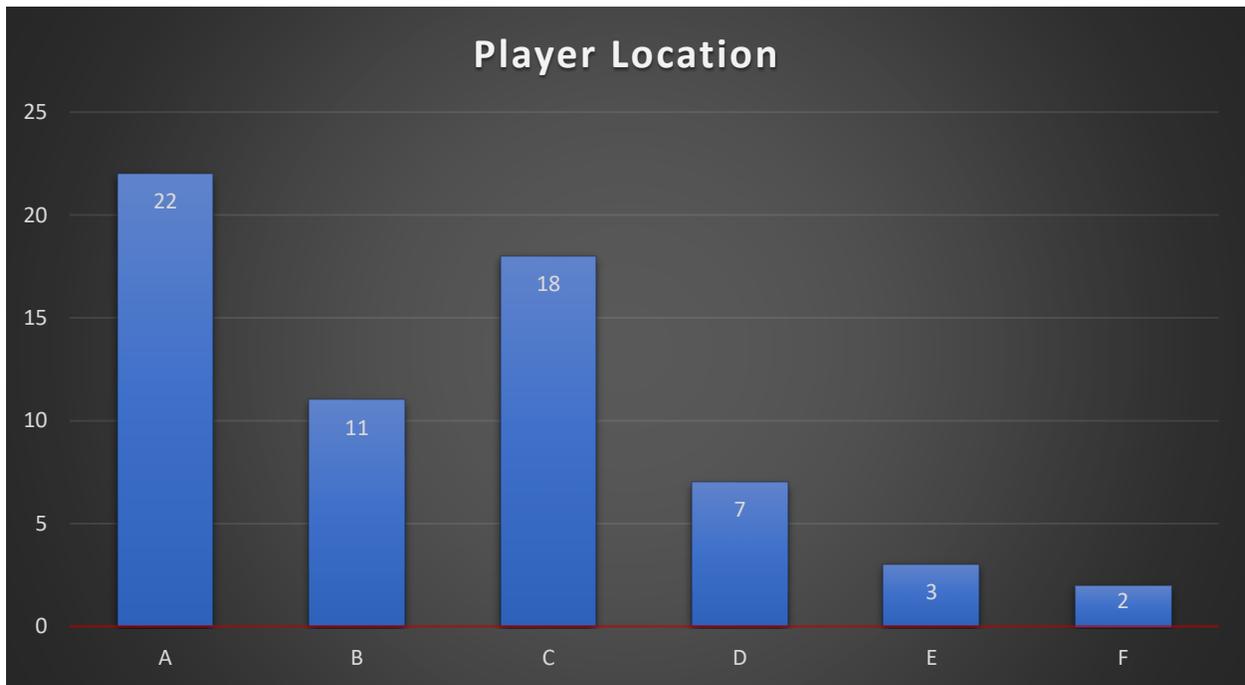


Figure 4-12: Player location

In order to create data to simulate some of the cases stated previously in the paper, the game was played many times, enough to have sufficient data to show example of how collecting

data and visualizing it can be used to give the designer better understanding of the game they created and use these information to improve the game. In figure 4-12, the players location were collected throughout the player run, which made it possible to know how many times the sections in the map were visited by the players. Section H and G were not included since the players always start in section H and everyone has to access section G before going to the other sections.

From the data gathered, section A was visited the most by the players, which makes sense since in order to beat the game the player must destroy the portal in section A and gain the key. Followed closely is section C and B. Section C came second place which seems logical. In order to win the game, the players must go to section C after obtaining the key to be able to escape the room and section C is the most interesting section out of the other sections.

However, we can see that section E and F were the least visited. One of the reasons why section E got visited less could be its uninteresting appearance from the outside. Out of all the sections, it is kind of a blind spot to the player since most players tend to go to the sections in front of them and explore those first. By doing that they managed to finish the game after multiple attempts. Section F was not visited much either because the player can clearly see that it is a dead end and thus there is no point in going there.

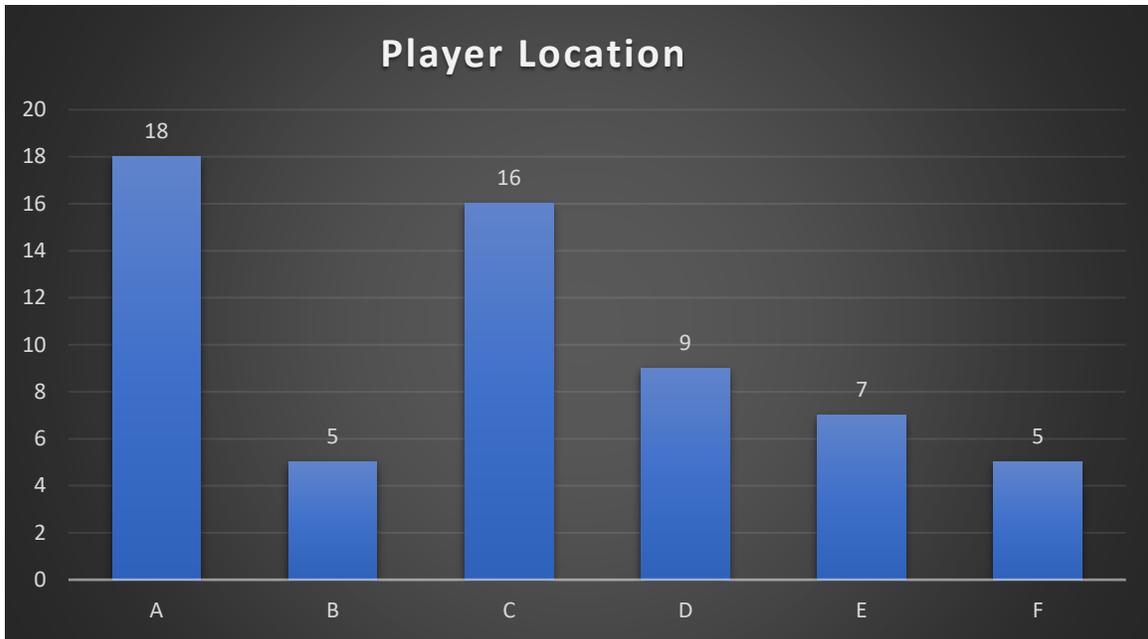


Figure 4-13: Player Location

After observing the data, adjustment was made to the sections that got little interaction from the players. More ammunition and health pack were added in section F to reward the players for going there, since it is a dead-end section. With section E a possible improvement to increase the interaction in that area is to make the door require two keys to win the game, one in section A and one in section C. While making this change is possible, by doing so will be forcing the player to go to a specific location, which is not the intentions. This improvement is definitely an option if it was a massive game like Skyrim. The only improvement that was made in section E was to make it look prettier by adding more colors and random shapes around. After incorporating these changes, the players were allowed to play the game again until enough information was collected. As shown in the figure 4-13 section E and F indeed both received more love than the previous run, which is considered a success and shows that if data were gathered from single player games the designers could use these data to improve the game and make some location more interactable by the players.

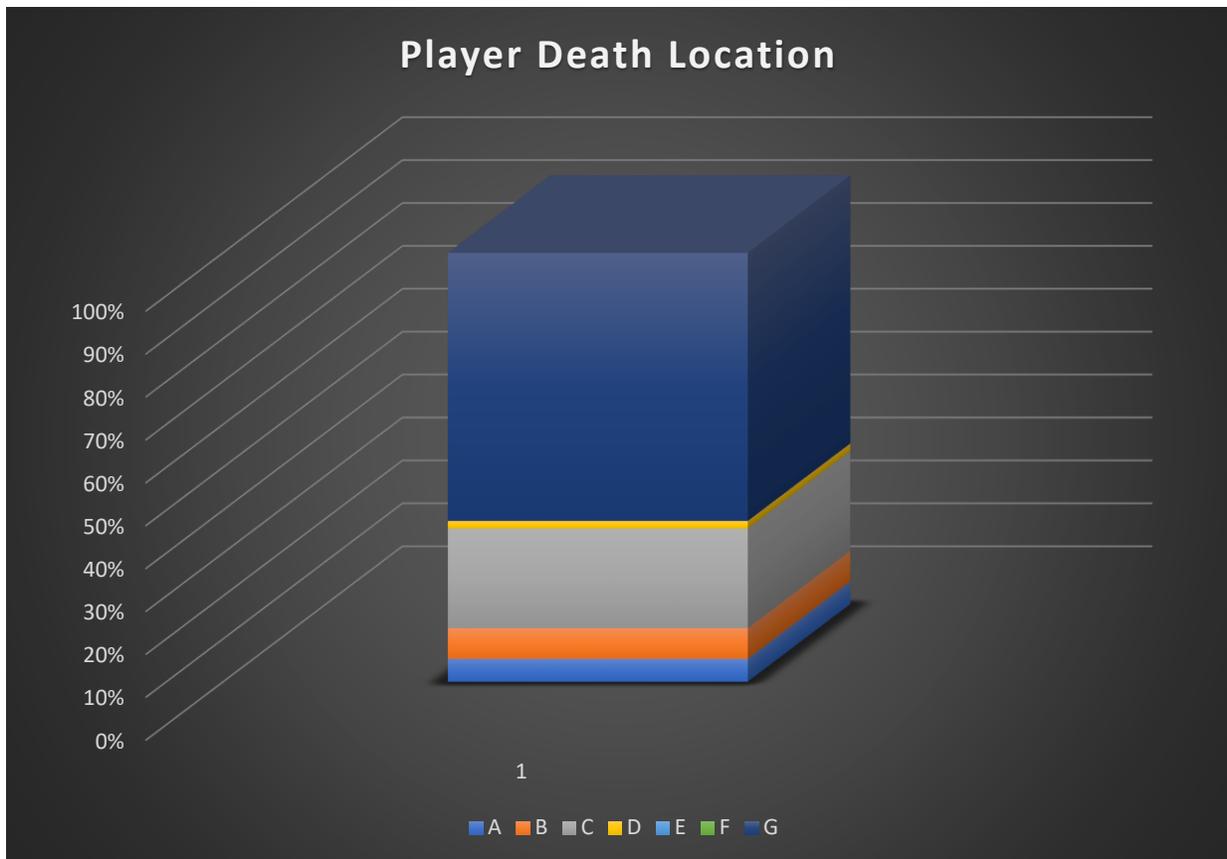


Figure 4-14 : Death location

Another thing that was possible to collect is the player death location as shown in figure 4-14. Players died mostly in section G making up to about 60% of all players death which makes sense since section G is connected to all the other sections and has the greatest number of zombies.

Followed by section C which is a semi maze. A portal is located there as well that produces the frenzy zombie type. That section was made to be the most challenging out of the other sections and the data shown supports that it is indeed is out of all the sections (not taking section G into account). The players died in other sections as well but not as significant as the others. Having an idea of where the players die in single player games is important especially if it is games like Skyrim. It provides the designer with solid answers and not speculation about the difficulty of the areas which can be measured by how many times the players die in that specific area.

4.4 Data Analysis and Visualization : Causes of Death

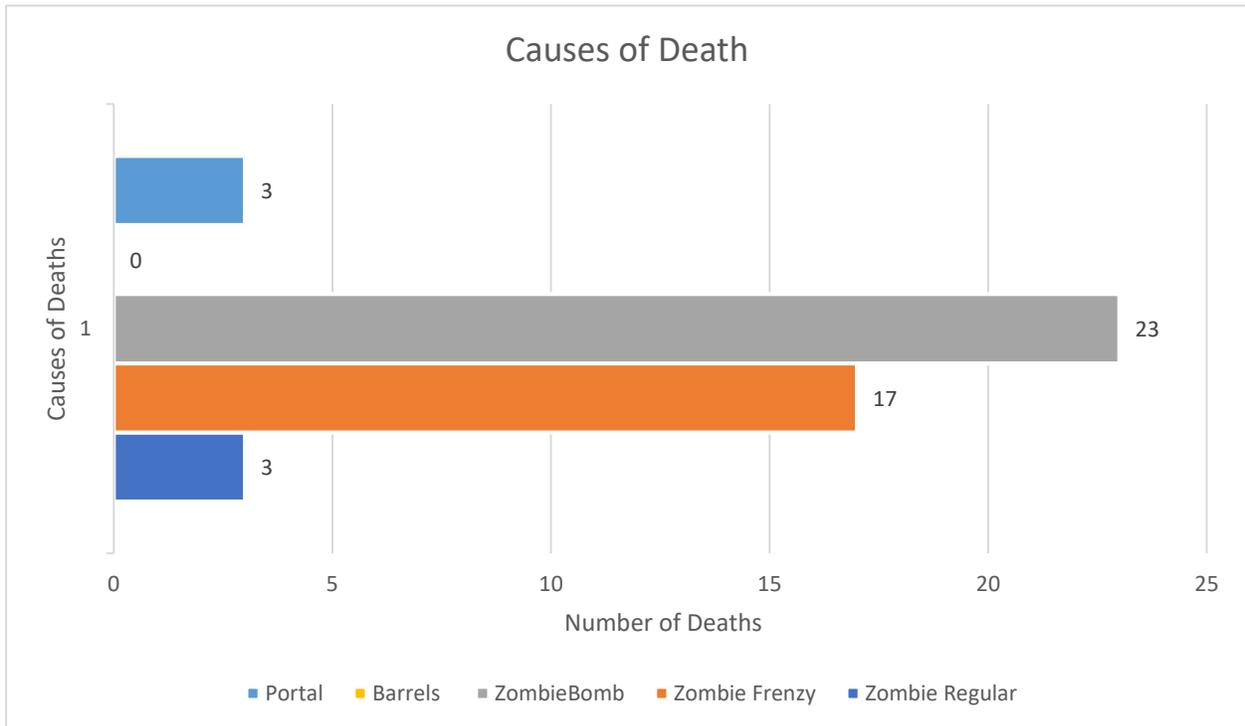


Figure 4-15: Causes of death

There are multiple things that can get the player killed in the game. Knowing what causes the player death the most can give in depth knowledge if some of the enemies need rebalanced or if there are other factors in play here. According to the data in figure 4-15 the number one cause of player death is the explosive zombie. This is because when explosive zombie die, they explode dealing 10 points of damage enough to kill the player instantly. Players often mistake shooting the zombie up close. Following closely is the frenzy zombie; the moment the frenzy zombie is damaged if the players are not paying attention to finish the zombie off, they are most likely dead because of their increased speed that matches the player and strong attacks that damages half of the player health with one attack. Coming off in a tie is both the regular zombies and portals. Common zombies are self-explanatory while the portal deaths are probably because the players did not expect to die when destroying the portals. What is surprising though is that out of the many

game runs that happened, no one died to the barrel a single time. This indicates that better barrels placement around the map is needed so that the barrels are in specific places where if the player is not paying enough attention, it can cause harm rather than good. Data like this can be eye opening because some intentions a designer planned for the game are not happening. While the barrels were made for the purpose to support the player, we also want it to cause death of the player even by little bit. The diagram shows us some holes where improvement can be made.

4.5 Data Analysis and Visualization : Items

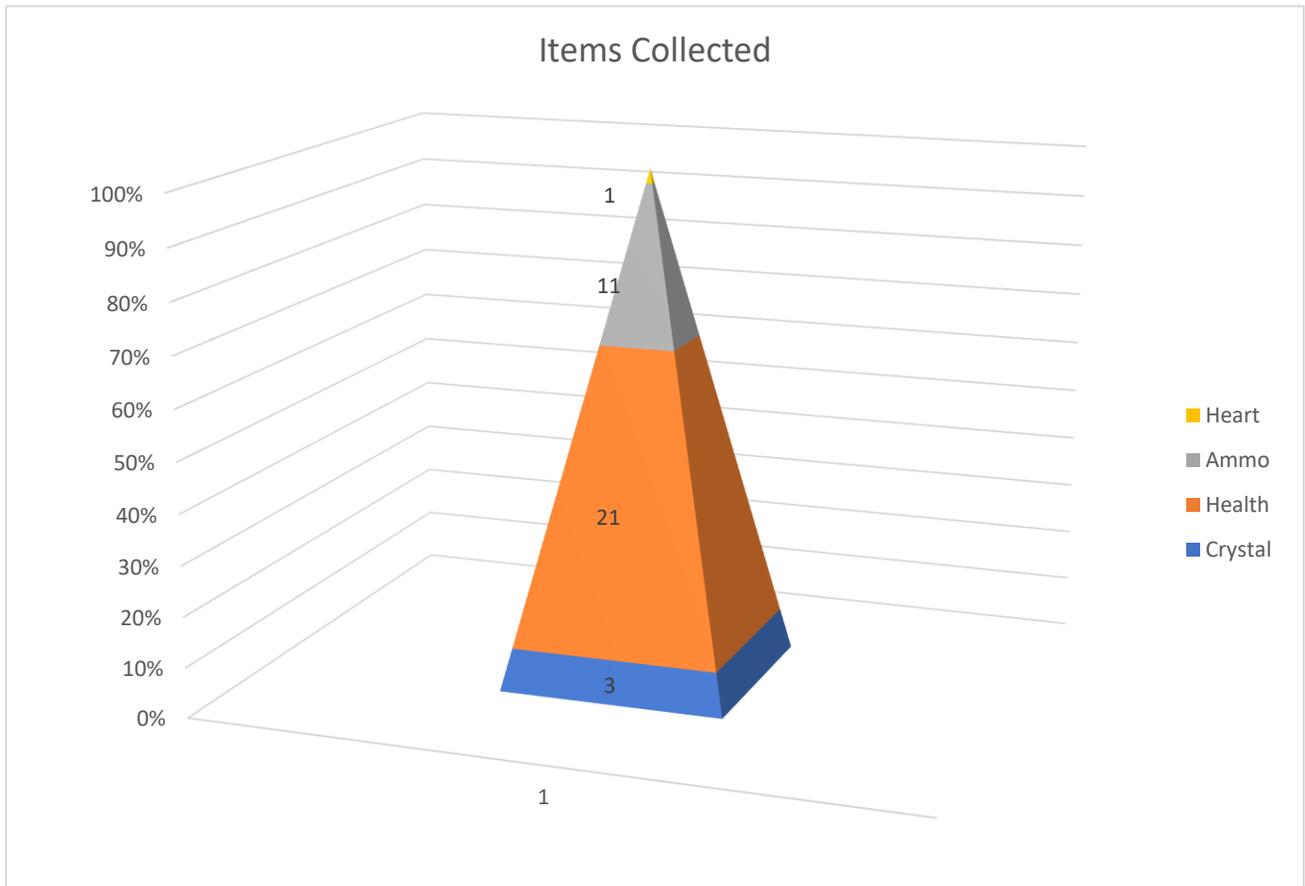


Figure 4-16: Items collected

Having variety of items in single player games is important which raises the question, are these items being picked up by the player? Knowing which items are being used the most and

which are used the least is very important information since there is wide variety of items in single player games like Skyrim. In the experimental game there are 4 items in total excluding the key.

According to the figure 4-16, health is the most picked item in the game. Second most picked item is the ammo, not as much as health pack and the reason is probably since player health is 10 points, players get damaged a lot and often go for health packs to recover some health. If the designer's main objective is to increase the amount of ammo picked by the player, a good start would be to decrease the amount of ammo the player has, forcing them to pick ammo often. One other option could be to make each bullet shot deduct 2 bullets resulting them to run out of ammo faster. On the other hand, if health pack were not being picked up often, which is not the case here but if hypothetically it was a problem a good way to go about this would be to increase the player max health and decrease zombies damage by a bit, allowing the player more time to stay alive in order for them to pick more health packs.

Since the main objective of the game is to kill zombies and escape the room it is well within reason why the health pack and ammo are the top 2 in the list. With the power up items picked up the least; this makes a lot of sense since the items where those two are located were not visited much by the players. Lastly, heart only got picked up one time because players barely visited section E as shown in figure 4-12 and the heart is located in section E. These data are part of the first round of runs before the E section was edited to make player interact more in that area.



Figure 4-17: Items collected

As we can see in the second run data in figure 4-17, the amount of heart and crystals collected is more than the previous collection of game runs. If the designer wanted the item to be easily accessed, moving the heart location somewhere visible in a place where the player interact with a lot like section G could be a viable option. However, since power up items are supposed to be unique their location was not changed but because E section was interacted more often by the players, more hearts were collected in the process. Nothing significant changed among the amount of ammo and health pack collected. Similar philosophy can be applied in games like Skyrim, if an item is not really being used or picked up by the player, ways to make it more attractive is by either

making the item more accessible or make the location where the item is more interactable by the players.

4.6 Data Analysis and Visualization : Win Condition

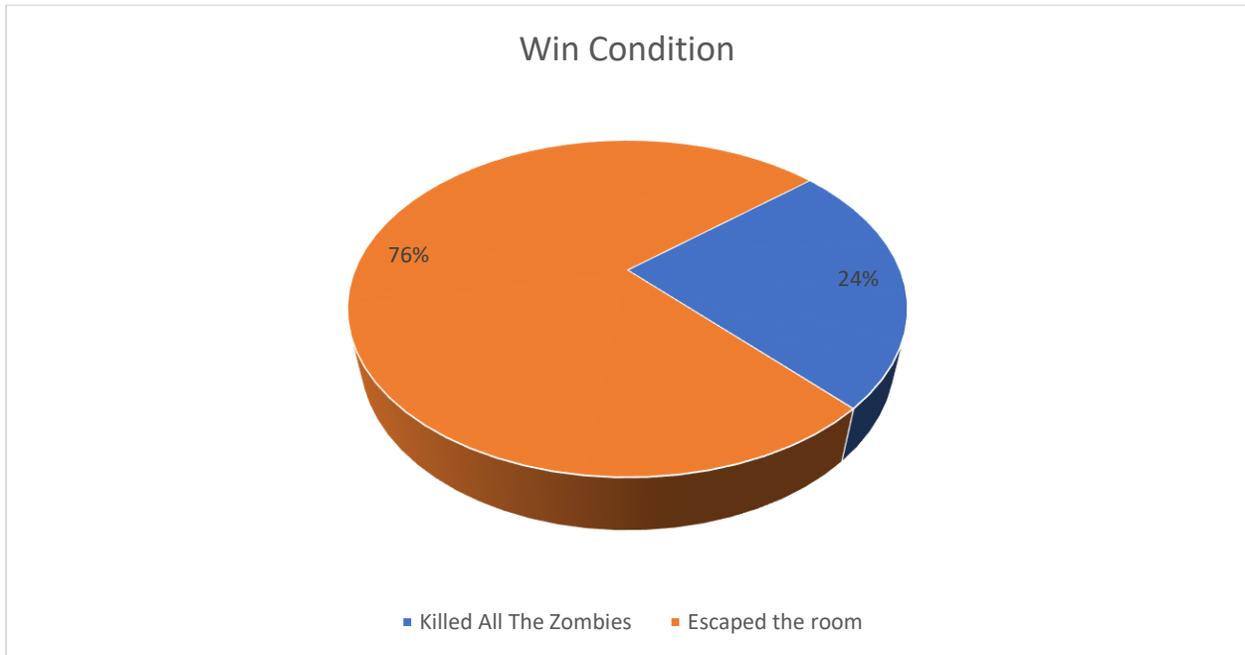


Figure 4-18: Win condition

How did the player beat the game, did they kill all the zombies or escaped the room? Results in figure 4-18 show that most games played were completed by escaping the room. This result is expected since the game was designed for the player to win the game by escaping the room. This gives a purpose for the game and not just mindlessly kill zombies which is why winning by killing all the zombies is made more difficult. This tells us that the game is being approached the way it is intended, while giving the player a choice. The alternative option/strategy is not removed completely but is rather made much more difficult to achieve with the increasing number of zombies over time.

4.7 Privacy

Privacy of the player is extremely important. Tracking what the player do in single player game is not meant to prey on them. In this game every single game run was completely anonymous. Although new file was created every time the player played the game, in triple AAA games like Skyrim or Devil May Cry 5, this method will not work. Solution for this is to create one file for every player who plays the game with online connection, that file is associated with that player only and is saved in the databases as player 1, player 2, player 3 etc [2]. The player's personal information is not being recorded in the file. This file can be imported into visualization tools and only relevant data that will help give insight of the game state is to be collected in the file. Every time the player plays the game their file is updated accordingly while preserving their privacy. If the player decided to play the game offline that is completely fine, the players are not forced to connect online to play the game.

Chapter 5

Conclusion and Future work

5.1 Creativity vs Data Collection

While in this thesis we explain how we can extract information from single player games and how to use the information to improve the game, never in this thesis do we prioritize data collection over creativity, and it should never be the case. Data collection should be used as a support for creativity because creativity is what makes great games like Skyrim and Devil May Cry 5. Using data collection and visualizing should help to improve these games and give more ideas and ways to improve and not vice versa.

5.2 Conclusion

In this thesis, we propose how implementing big data in video games, especially in single player games, can be used to give in depth insight on how the games are being played by the player; how to use the information collected to improve the different aspects of the game, respectively.

The thesis is based on two big single player game from different genre. One is an open world adventure game called Skyrim, and the other is Hack and Slash game called Devil May Cry 5. We break down these two games in order to demonstrate what type of data we can extract from those games and how to use these data to improve both games, respectively.

A first-person shooter game was developed in order to demonstrate how useful big data can be if implemented in single player games. Visualizing the data collected can be used to shed light into different aspects of the game information regarding what can be improved in the game and other useful insight that can be taken into consideration if next installment of the game is to be ever made.

5.3 Future Work

While adequate data was obtained from this research, more research could be done to show the benefits of implementing big data in single player games. Having access to data from both Skyrim and Devil May Cry 5 would be great to demonstrate and visualize how the game is being played.

Future work could focus on creating other type of games and use them as an example to further demonstrate how important big data is and simulate data that is much more complex like in Skyrim and Devil May Cry 5 since, in this paper lot of data that were discussed in for both these games were not possible to simulate or replicate due to their complexity.

Other genre in the single player games like strategy games where big data can be implemented should also be looked at as the might give completely new perspective on analyzing data and ways to improve those type of games.

Glossary

- 1- **Balance:** video game design concept where the strengths of a character or a particular strategy are offset by a proportional drawback in another area to prevent domination of one character or gaming approach.
- 2- **Buff:** is a term used in some video games, especially MMORPGs and MUDs, to describe increases in the power of a game element. There are two main usages. The first describes a permanent (or at least indefinite) increase in power levels as a result of adjustments to game mechanics, usually in pursuit of game balance.
- 3- **Nerf:** in video gaming a nerf is a change to a game that reduces the desirability or effectiveness of a particular game element. The term is also used as a verb for the act of making such a change. The opposite of nerf is buff (in one of that term's two usages).
- 4- **MMORPG:** an online role-playing video game in which a very large number of people participate simultaneously.

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