Video Game Graphics and Players' Perception of Subjective Realism

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Copyright Statement

Abstract

Note to the reader: Throughout the text there are words and phrases which are followed by superscript numbers. These refer to the glossary in Appendix A which explain the terms.

This work explores how people who play and develop video games perceive realism[38]. 'Realism' is a very broad term and has different meanings for different people, therefore in this project the terms 'realism' and 'visual fidelity' are used to refer to the visuals and their appearance in video games. This helps define what is perceived as believable and close to real-life by consumers as well as developers. Realism can clearly be noticed in the artistic aspect of games; accordingly, this project focuses on this side of the subject.

In order to understand why visual fidelity is an important factor in game development, this work provides a brief summary of the history of video games. As Physically Based Rendering[39] is commonly used nowadays, the project aims to understand the contribution of PBR[31] to achieving realism.

The project aims to investigate how game developers achieve visual fidelity and realistic environments. It will consider what is needed to create visuals that are perceived as realistic and what distinguishes the realistic aesthetic from other art styles in video games. Lighting, texture maps[46], workflows[53] and other terms are discussed, in conjunction with exploring consumer opinion on the subject.

The project employs a qualitative research method through asking game developers and gamers[14] for their opinions on themes regarding the subject to help establish whether there is a different understanding of the term in the different groups.

To understand better why visuals are sometimes perceived as 'creepy' and as part of the 'uncanny valley', related psychological aspects and influences are taken into account. This work also investigates how other aspects of the development process (design, animation, narrative, sound, etc.) assist the visual art with conveying realism to the customers. This also aids the formation of a hypothesis of whether true realism in video games will ever be accomplished.

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While this project has felt like both the longest and shortest experience by far, this thesis would not have been written without the help and support of several individuals. I would first like to thank my family, who throughout the length of this project have given me immeasurable amounts support and have always managed to be there for me, even from 3.000 kilometres away.

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Declaration of Authorship

I, Viktoria Nestorova, declare that the material contained in this thesis is my own work.

Chapter One

Introduction

"The video game industry currently makes more revenue than the film and music industry combined, and then doubled" (Parsons 2019).

Video games are a phenomenon of interactive media that are becoming increasingly prevalent in many different aspects of everyday life. In his work the Phaedrus (370 BC), Plato states that if anyone were to try to interact with a painting, they would inevitably get no response. And while this is true for painted artwork, it is certainly not the case for video game art. In fact, for a player[14] to be able to play a game it is necessary for them to interact with it. While the player may not always get a vocal response from a game (even though this may be possible with some games), a game can still provide a response to the player in different ways. In the case of turn-based games, feedback from the game is more obvious. There, in each round, players get responses from the game's Artificial Intelligence (AI)[6], which is an example of how interaction takes place between players and the game itself.

To clarify the size of the game industry, currently the number of gamers (consumers and users of computer and video games) around the world takes a third of the overall population with over 2.5 billion gamers (Narula 2019; Wijman 2020). Moreover, the BBC claim that during lockdown and the COVID-19 pandemic in 2020, video games have become even more popular and companies like EA's net income and player numbers have doubled compared to the previous year (BBC 2020). According to Parsons (2019), the video game industry currently makes more revenue than the film and music industry combined, and then doubled. With net revenue for 2020 "$159.3 billion" according to Wijman (2020) it is easy to consider video games as a big industry, and to appreciate that there would be different types of studios and developers.

Although much of the industry is dominated by huge companies such as Microsoft, Sony and EA, is it still a highly competitive industry, and an important contribution is made by the independent studios (which will be referred to as 'indie'[20] in this project) (Wayne 2013; Parker 2011). Indies are developers and studios that have not received financial support and have not signed contracts with publishers. Often such studios will have a small number of

developers working on a single game. Another type are AAA[4] studios, which are usually larger studios, with publishers who create larger scale games with more content. And lastly there is the newly introduced term AAAA[5] studio, whose initiative according to Grubb (2020), is to develop games "so expensive that their scope may reach beyond the blockbusters we have had up to this point". (see Fig.1.1)

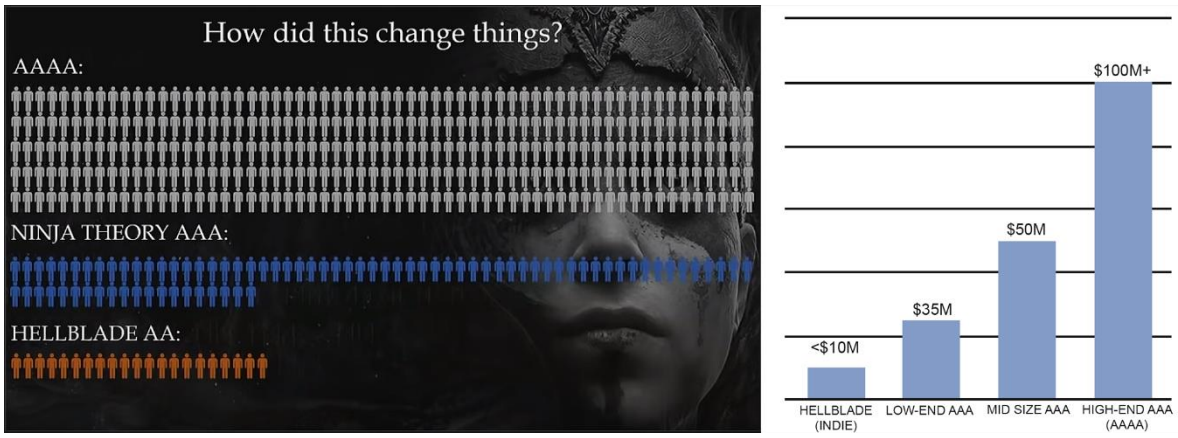

Fig.1.1 shows an adapted image of the figurative representation of AAAA teams compared to high-end[18] indie studios as well as statistics. Both shown at a GDC (2018) talk with Ninja Theory's Matthews and Antoniades.

While there are games which are released for free, in a competitive environment such as the games industry, developers must be able to capture consumer interest. Therefore, video games have to be able to offer authentic responses, and present a believable world, in which the player can feel as if they belong. Moreover, to offer visual believability, developers must consider other aspects of the game, such as correct sound representation aligned to the visual movements and animation and a captivating storyline.

The term 'perception' in this study is used to describe the way in which consumers, be it gamers or game developers understand and comprehend realism in video game worlds.

'Realism' is a term with broad meaning, involving different interpretations for different individuals. Consequently, 'realism' is referred to as subjective in this research, as different individuals may appear to have different views and opinions on the subject matter. As such the terms 'realism' and 'visual fidelity' will be used with regard to the visuals and appearance in video games. Visual fidelity specifically refers to the quality of the graphics a game has, meaning that the higher the quality of the graphics are, the higher the visual fidelity of the game will be. This will assist in defining what is perceived as believable and close to real life by gamers and game developers. The project focuses on the artistic side of the topic as there is a constant expectation for improvement and change in the sector.

It follows that the advancement of technology, and the desire to make game worlds bigger, more visually impressive and more immersive[19], has increased significantly, both for developers and users. This advance in technology has encouraged both gamers' demand for more realistic gaming, and, in return has generated a response from studios and developers to push the boundaries and achieve even higher levels of realism. At the same time, visual realism has increasingly become more achievable by both indie and big budget companies thanks to ever improving pipelines[53] and workflows, which utilise techniques like photogrammetry[33] and motion capture and the construction of the hardware[16] which allows machines to handle the complexity of modern games and the development process. Even considering this, increasing the levels of visual detail and complexity in games and the requirement for real time representation on screen still causes problems with performance[32].

This research will consider the issues faced by the ever-increasing appetite for greater realism, and more expansive game worlds, and environments by examining workflows, and discussing the ways in which realism in video games is possible, through both technological and human input.

1.1 Aim, Questions and Objectives of this Research

The aim of this work is to understand how the development of art within games design has evolved. To do this, the research will consider how far games have progressed in the last few decades, largely focusing on the artistic side of the development pipeline. This will demonstrate how game developers tackle the complexity of realism in video games, and how technology assists them along the way.

Although realism is a broad term, this study will explore the possibility of full gamer immersion. Immersion is intended to be understood as an engagement or involvement that a gamer feels when playing a video game. Successful immersion is when the consumers feel as if they are in the game or part of it in video games (Jennett et al. 2008). The past and future of gaming consoles and VR[52] systems like Oculus will be discussed to help understand if full immersion is possible and when gamers will be able to experience this will be examined.

To assist the aim of this work, the following research questions have been identified:

1. How can realism be enhanced within a video game environment?
2. Does the automation of video game art pose a threat to creatives' job security?
3. Is achieving realism the future of video game art?

The research questions were carefully chosen based on research conducted in the subject area. Question 1. was chosen based on the ever-growing interest in creating better sense of

realism within video game worlds. By sense, this thesis refers to the feeling, perceiving, or understanding of realism and the ability to believe something or someone is actually in a virtual environment. The main discussion of the question can be found in Chapter Two.

Automation in any industry creates reasons for concern and the possibility of employees being replaced by AI or technology, therefore exploring this issue proved to be essential. Automation refers to the creation and use of machines and AI to replace human invention. Once again, the main discussion of this can be found in Chapter Two, but especially in Section 2.13 of the chapter as well as Chapter Five of the thesis which provides a related survey data analysis.

With recent AAA games clearly focussing on realism within their game world, it is easy to assume that the interest of game developers and gamers is to push the technology to its limits and show how far video games can progress realism. The third question ensures that the project reviews relevant opinions and views of gamers and game developers from smaller, indie studios. This issue is introduced in chapter Two and then mainly discussed in Chapter Five.

These research questions provided a guide for the questions included in the surveys detailed in Chapter Five.

The following research objectives have been developed to support the research questions:

1. Understand what realism means for video games.
2. Understand how games, and game art, have evolved over time.
3. Evaluate the impact of changes in video game art with particular emphasis on physically based rendering, photogrammetry, lighting, procedural generation, and level design.
4. Explore the differences to gamers between indie games, AAA and AAAA games in terms of visual realism.

1.2 Thesis Overview

In this chapter, the rationale and context for this research study have been presented. This has included the presentation of visual art within games as an evolving discipline which links to both technological advancement and gamer demands. This is a timely topic which presents an opportunity for detailed investigation. To achieve this, the thesis consists of six Chapters.

Chapter Two acknowledges the evolution of art in video games by paying attention to the origin of video games and video game systems. It provides a brief timeline to explain the

context of the games industry and discusses some of the growth and pitfalls of large video game companies. It also identifies different art styles and discusses the evolution from two-dimensional imagery (2D) into three dimensional visuals (3D) within game worlds.

The chapter also provides a review of the relevant literature, examining different aspects of realism in video games in the context of visual reality. It discusses the reasoning behind the need to play games and why gamers may require those different aspects in different games by exploring some of the relevant functions of the brain. By understanding how the brain responds to certain stimuli, the project will then be able to examine why believability and immersion are so important in conveying realism for games.

This chapter will also discuss the hardware limitations of current generation consoles and PC components in conjunction with the abilities of various 3D modelling and texturing software packages. The use of Photogrammetry and the concept of Procedural Generation will be discussed to allow us to understand why some artists may feel that automation of art may pose a threat to artist jobs. Consideration will be given to discovering what makes environments and characters realistic by understanding what it takes to make them. Looking into the concepts of lighting and shading will help explain how models for games are created following certain workflows and pipelines. From that, it will be possible to derive how light interacts with surfaces and why artists need to understand the basics of the physics happening behind material or texture creation.

Chapter Three discusses the methodology that has been chosen in order to undertake this research and explains why such methodology was considered appropriate. The details of the qualitative methodology used are explained. The research will utilise the philosophy of interpretivism as it “integrates human interest into the study” (Dudovskiy 2019). Accordingly, a combination of qualitative questionnaires and a focus group were used to gather the views and opinions required for this study. The overall approach, strategy and data collection method are all described, as well as the method for analysing the data and the time horizon for the study.

Chapter Four describes the data collection process itself, followed by analysis of the data. In order to explore the perspective of the games industry professionals themselves, a qualitative questionnaire of industry-based game developers was undertaken. This included game artists, game designers and technical artists. The questions used were informed by the literature review. To identify the extent to which gamers and game developers agree on the subject matter, a focus group was organised, with questions derived from the questionnaire with the

industry employees. In the focus group, four games were streamed to the participants to capture their thoughts and views. To help confirm that the data found in the focus group was accurate a second qualitative questionnaire was undertaken, using the questions formed in the previous questionnaire and the focus group. Data analysis was undertaken using the recursive abstraction technique to identify patterns and trends in the participants' responses.

Chapter Five considers the meanings and values that can be abstracted from the data collected and considers any trends that surfaced during the data analysis stage.

Chapter Six draws conclusions from this study and relates them back to the original research questions and research objectives. The limitations of the research and the potential for future work are presented.

Chapter Two

Literature Review

"Creativity is human, and it is social. And, not to forget, creativity is based on vision, connection and empathy" (Pfeiffer 2018, p.22).

2.1 Introduction to the Evolution of Video Games

With the growth of the games industry and its prevalence in society across all generations and socio-economic groups, gamers now constitute more than half of the UK population, according to Newzoo (2018) (see Fig.2.1). Games range from apps available on mobile phones to sophisticated consoles. In terms of video games' aesthetic, genre and platform[34], nowadays players are presented with plenty of options. To have a greater understanding of how game genres and art styles evolved over time, it is important to acknowledge how the history of video games developed. In this thesis, the term 'art style' is referred to as the manner in which game developers express their artistic vision in their games.

Fig.2.1 A summary of the video game market for 2018 by Newzoo.

2.1.1 The Importance of Gaming Hardware

Hardware refers to the physical component parts that a computer system or games console require to function, and it is also what allows game developers to create games. As Chuah et al. (2014) clarify, "high-end[18] video games often require advanced computer graphics and enormous computational power to render realistic and interactive gaming scenes" (p.78). Consequently, to be able to run complicated models, textures and applications containing a

lot of information, one needs to have a powerful machine to operate the on-screen visualisation. They explain that “new video games with better graphics demand higher hardware capability” (Chuah et al. 2014, p.78). Generally, video gaming and video game development machines consist of memory[25], storage[44], a heavy-duty[17] Graphics Processor Unit (GPU[15]), a Central Processing Unit (CPU[10]), a motherboard, a cooling system (be it several internal fans or a water-cooling system) and a power supply.

The Central Processing Unit (CPU) or ‘processor’ is the part which acts like the brain of the computer or console, and according to Dobbin (2019) it “carries out and controls the computer program’s instructions by performing input/output (I/O) operations, basic arithmetic, and logic”. In simple terms, when speaking about games, the CPU handles each process, be it visual, audio or other, making sure that the response between the game and the players are authentic. Pharr (2016, p.38) states that “the computer systems of today and of the future will increasingly feature multiple processing cores”. A computer with a multi core Central Processing Unit is one where the CPU itself is made of two or more central processing units - cores. Dobbin elaborates that “historically, processors had only one core that would focus on one single task”, but nowadays processors can “have between [two and twenty-eight] cores, each of which focuses on a unique task” to “increase performance” (Hoffman, 2018).

As mentioned, the CPU is not the only powerful unit needed to play video games. A GPU or a graphics card ‘is a specialized electronic circuit that accelerates the creation and rendering of images, video, and animations’ says Dobbin (2019). Because video games are very visually dependent, video cards play a big part in the computer system’s ability to run games, and Dobbin (2019) even argues that GPUs can be “even more crucial than the CPU when it comes to playing certain types of games”. Chuah et al. (2014, p.80) say that “as graphics rendering involves the processing of a large block of parallel data, graphics processing units […] are often deployed instead of conventional central processing units”.

Here are examples of why some games depend more on the strength of some PC or console components over others. Video games that require real time calculation of information and games which contain a lot of assets, characters and systems are heavily reliant on CPU power. This does not mean that a graphics card is not necessary, though. Video cards are essential when rendering visual data. Moreover, Dobbin (2019) says that the GPU takes care of processing the 2D and 3D graphics, rendering polygons[35] and mapping textures. She says that the faster the graphics card can process the information, the more frames[12] the player will observe per second. In games where a lot of functions and information needs to be processed, the CPU takes care of the ones which the GPU cannot perform well with. Functions and tasks

such as non-player characters (NPCs) and artificial intelligence (AI) are performed by the processor.

Memory and storage work hand in hand with the processor. The difference between the two is that memory stores short-term information. It helps with momentary tasks and loading applications, and overall, the computer system will perform better if there is more memory installed. Storage on the other hand is where files, programs and the operating system are kept. The processor is the component which accesses the storage and runs the long-term data through the memory. It is correspondingly dependent on how fast the memory is, which is what allows it to quickly run and close applications.

2.1.1.1 Performance Optimisation[29]

Having discussed some of the key hardware parts that make up a computer or a console, it is important to mention that it is these that ensure a game runs smoothly. Even though nowadays technology is significantly better than it was in the first days of game development, optimisation is still necessary.

Optimisation of games according to Preisz and Garney (2010) “describes [the] process for increasing the performance of a video game for better gameplay and visual experience”. Moreover, Dickinson (2017, p.1) elaborates that “even small, intermittent hiccups and [slow] performance can pull the player out of the experience, breaking [the sense of] immersion”. By optimising their games, developers also ensure that players with older technological devices can play their games, resulting in better sales numbers for them.

2.1.2 Video Game Categorisation

So, how does one identify the category of a video game? Games come in single player or multiplayer mode. ‘Player’ in these situations refers to the human participants in the game, and AI[5] and other systems are considered part of the game. Lou (2017) confirms that “if [a person] has ever played a video game, [they] have interacted with artificial intelligence”. Oosterhuis (2006, p.108) clarifies that single player mode is one “where the gamer plays solo against computer-controlled components”. This means that if a game includes fighting or any kind of interaction, the player will fight against an AI instead of real people. With multiplayer mode, the player is faced against other players. Often “two teams are pitted against each other” (Oosterhuis 2006, p.108), although more than two teams can be presented. For example, in Massively Multiplayer Online[26] games the players can collaborate against computer enemies or fight against each other in a player versus player (PvP[36]) manner. Furthermore, there are different perspectives through which the player can experience a

game. Commonly games will be described as first-person player (FPP[13]) or third person player (TPP[48]), although top-down[47], isometric[22] (forty-five-degree angle of view) and side view[42] are popular as well. (see Fig.2.2) Often during cutscenes the perspective may change, and some games allow for the player to change the point of view.

There are several choices of camera perspective that a game developer can make. Those choices can be made based on how much vision the payer will require.

As seen in Fig.2.2 (top), FPP games allow the player to view the game world through the character's eyes. According to Hall (2019), Momot (CD Projekt Red) insists that the Cyberpunk 2077 team decided to change the perspective of the game to be "100% first person" (rather than a mixture of first and third person) as they wanted to achieve "full immersion" (Hall 2019). The player in this perspective only sees the hands of the character or no character at all, which allows them to feel like it is them playing the game.

Third person games give the player a better field of view (see Fig.2.2) and the player can also see the character they are playing. The camera is usually focused on the character and as they move the player can rotate the camera around (which usually is attached to the character) and not only see their character from different angles, but also the game world.

Top-down perspective is the one which shows a large area looking down at the character and the camera moves with them. Another variation of top down is isometric, where the camera looks at the environment and character from a 45° angle.

Side view is the perspective in which the player only sees what is in front, behind, on top and under them, without the ability to see anything in the Z axis. (See page 18)

Fig.2.2 Adapted in game screenshots display the different game perspectives. Top row from left to right; First Person: Apex Legends (Respawn 2019), Third Person: God of War (SIE Santa Monica 2018), Top-Down: Hyper Light Drifter (Heart Machine 2016), Bottom row; Isometric: Diablo lll (Blizzard Entertainment 2012), Side view: Ori and the Blind Forest

2.1.3 Timeline of Video Game Evolution

While it is outside the scope of the present study to draw a timeline of every existing game up to the present day, it is important for the purposes of this research to consider the highlights in video game evolution. Starting with Steve Russell and SpaceWar in 1962 and then Alan Alcorn and the innovative Pong (Fig.2.3 and Fig.2.4) in 1972 (itself based on previous work like William Higinbotham's 1958 Tennis for Two), one can appreciate the importance of simplicity within the gameplay of the classics. Both these games use a very clean environment where the player is represented by simple shapes.

Fig.2.3 SpaceWar running on a PDP-1. Photo courtesy of Kenneth Lu.

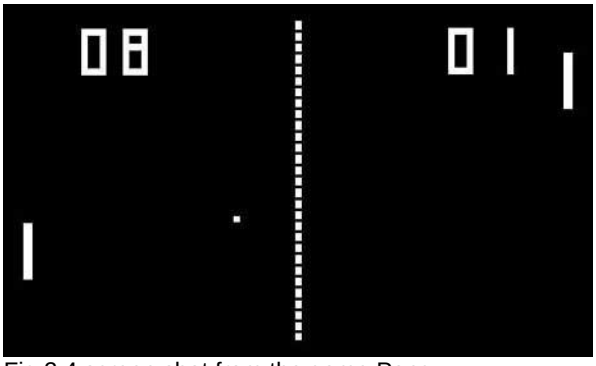

Fig.2.4 screen shot from the game Pong.
Image courtesy of Laura Parker and Darryn King (2008).

In 1969, two colleagues Nolan Bushnell and Ted Dabney created Computer Space, which was a clone of the previously mentioned SpaceWar (Edwards 2017). Their thinking was that the game would be great for bars and might even replace the pinball machines. They founded the company Syzygy, so they can distribute the game, but not much success followed. Later, Bushnell and his trainee Alcorn developed Pong, which was an absolute hit. According to

Sawyer, after the success from Pong, Bushnell renamed Syzygy to Atari, and the new company was a massive success from then on (Sawyer 1996, p.28).

According to Nintendo's official web page, several decades before this, in Kyoto, Japan (1933), an entrepreneur called Fusajiro Yamauchi founded a company called Yamauchi Nintendo & Co. which manufactured 'Hanafuda' Japanese playing cards. They have released multiple successful consoles and video games since 1933, however it was not until 1975 that they began developing electronic video game systems and in "1978, they produced a computer game version of the board game Othello" (BBC Editors 2019). Similarly, to SpaceWar and Pong, Othello had a very simple interface as well.

Fig.2.5 Shows Computer Othello from a leaflet.

Sawyer (1996, p.29) explains that Nintendo and another Japanese company, Namco "dominated the arcades" which was where most people played these games. While at the same time Atari had begun to build a small empire making products for people's homes, or as known nowadays; home consoles (Sawyer 2996, p.29). During that time pixel art was what the hardware could run, and it is important to note that art was not the focus of development. Sawyer adds that Bushnell's company, Atari, which was based in the United States had made billions of dollars by 1980 (Sawyer 1996, p.29). It is easy to conclude that even in their early days, games were in high demand. As the games industry grew and developers strived to deliver better visuals and larger scale games in general, it became apparent that the most successful games were developed by teams which used a range of different specialties and diverse skills.

With the success of these companies came rivalry and developers were striving to achieve better gameplay as well as graphics. In 1985, the Sega Master system was released, and it reassured Sega as Nintendo's competitor on the market (Sawyer 1996, p.36). It suffered in sales, yet it was graphically a superior product, which allowed Sega to survive the hit in sales and begin "to build a brand image as [a] top-quality game machine and software maker" (Sawyer 1996, p.36).

In 1985, the Sega Master System came out and established Sega (founded in 1954 by David Rosen as Service Games Co.) as Nintendo's competitor on the market (Yoshimura 2013). Even though it suffered in sales, the Sega Master System was a graphically superior product, which allowed Sega to survive the competition it offered, and they began "to build a brand image as a top-quality game machine and software maker" (Sawyer 1996, p.36). Some companies of that time, like "the first third-party video game publisher'" (History 2017) Activision, found it difficult to keep up with the rivalry between Sega and Nintendo and found themselves suffering from bankruptcy.

The games industry was composed of several different types of developers. While the games developers were concentrating on how to make their games more exciting with better game play, another market had sprung up around the manufacture of games consoles. Until then, game consoles had been too expensive for individuals to afford (hence the popularity of arcades). New developments in the technology were making it ever more possible for players to own the consoles themselves (Chikhani 2015). Other companies like Electronic Arts (EA) and Sierra On-Line, found that their revenues rising as Personal Computer systems (PCs) were on the winning side as of the beginning of the 1990s (Sawyer 1996). As computers became more sophisticated and more powerful, so too did video games. Sawyer (1996) explains that EA adopted a new strategy by building bigger teams comprised of individuals with specific skills in order to be able to manage and develop better games for the new powerful machines. These new teams had designated specialties like artists, programmers, designers, writers, musicians etc. to be able to cope with the incoming deadlines.16-bit graphics were the innovation and Sega had the lead over Nintendo with their new Genesis machine around 1988-1990. Sawyer (1996) claims that the 1990s were the transitional period from bitmap imagery to 3D graphics, making handheld and home consoles more popular and arcade machines less so.

With the utilisation of polygons in games, console manufacturers started orienting their systems towards being able to handle the complexity of such games. During a conference event in Tokyo (2012), Sony developers spoke about how Sega's Virtua Fighter was the reason for the PlayStation to be developed as a 3D platform. According to Feit (2012), Akakawa elaborates that without "Virtua Fighter, the PlayStation probably would have had a completely different hardware concept".

PC gaming continued to grow in popularity in the 1990s and this was assisted by the fact that Intel's processors became cheaper in price but more powerful in performance.

This encouraged the creation of 3D graphics for games in 32-bit systems (Sawyer 1996, p.49).

After the successful release of the first Sony PlayStation console in 1994, they followed up with the PlayStation 2 (2001), which was "the first console to use DVDs" (History 2017). According to Sirani (2020), it still until this day "the best-selling game console of all time" (Fig.2.6). History.com (2017) claim that "the established video game companies could not compete with Sony's strong third-party support, which helped the PlayStation secure numerous exclusive titles".

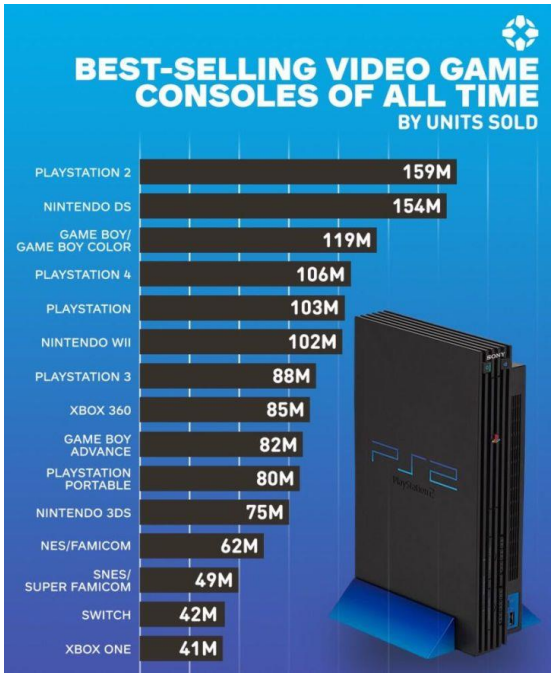

Fig.2.6 IGN displaying the statistics of units sold by August 2020

Since then, consoles have become increasingly more popular, and at the turn of the century there was a further development in portable consoles when Nintendo's DS was released in 2004 and Wii in 2006, these being very successful releases for the company. Around that time, in 2004 the PlayStation Portable (PSP) was released to compete with the DS. The difference between the two handheld consoles was that Nintendo's version had two screens, hence the name Dual Screen (DS). The PSP on the other hand had a powerful GPU (Graphics Processing Unit), allowing for high-end graphics for a handheld machine.

Two years later, both companies joined Microsoft's Xbox 360 in the release of consoles. Sony's PS3 focusing on graphics, was "the first console to have a Blu-ray drive" (Thang 2020). The Xbox 360 had more success than its predecessor by selling "over 85 million units worldwide", compared to the "24 million units" (Thang 2017) in 2001. Over time the 360 "became a popular living room entertainment center" (Thang 2017) by offering streaming services like Netflix and media streaming from local PCs. The Wii, alongside the DS, broke the single-month United States sales records, as Elliott (2009) confirms.

The last ten years of video game history presented the players with consoles like the Nintendo 3DS and PlayStation Vita in 2011, the PlayStation 4 and Xbox One (2013), and Nintendo's switch in 2017. As can be seen in Fig.2.6, during the sales of the eight generation consoles, PlayStation 4 outsold the rest of the released consoles. Sirani (2020) and Ramsey (2020)

clarify that the PS4 sold around 50 million units more than the Xbox One, but still could not outsell its predecessor the PS2.

To date, the PlayStation 5 and Xbox Series X have joined the console market offering powerful processors, memory and graphics cards to run new and future games. Nowadays console manufacturers focus not only on graphics and performance but are also looking into new ways to immerse their players. The new PS5 offers the DualSense controllers which adapt to pressure and “heighten that feeling of immersion” (Nishino 2020) whilst gaming.

Companies like AMD and Nvidia are developing GPUs which support new ways of rendering graphics that allow for better on-screen imagery. This helps newer gaming platforms (PC and consoles) to render even better visuals than the previous generations, but as Thomas (2020) suggests, both companies offer hardware which is “similar in performance”.

Regarding processors, Alcorn (2020) says “there are only two choices to pick from: AMD and Intel”. While both companies produce powerful processor units which allow machines to handle multiple complex tasks at the same time with no difficulty, Alcorn claims that at this point, overall, AMD are producing more powerful units.

In addition, hardware is being developed all the time to help ensure a better sense of realism and believability in video games. With that, Virtual Reality systems have become a popular new way to immerse the player into the game.

2.1.4 Increasing the Sense of Immersion with VR

Early forms of Virtual Reality (VR) have been around since the late 1950s, when the cinematographer Morton Heiling introduced the theatre cabinet: Sensorama (Fig.2.8). (Brockwell 2016) Its purpose was to provide an immersive experience for film with the use of smell emitters which were spread around by fans, audio speakers and also tilted the body of the user. A decade after that a military engineer sparked the interest of the use of VR for training purposes by creating a flight simulator and a professor from Harvard, Ivan Sutherland developed “the Sword of Damocles”, which is considered to be the first VR head-mounted Display.

Fig.2.8 Sensorama. Image provided by Turi, 2014.

In the 1980s the idea to use VR for games was popularised by Tron (Steven Lisberger 1982) and Sayre gloves were invented. The Sayre gloves are the first wired gloves which monitor the movements of the user with the use of “light emitters and photocells in the gloves’ fingers” (Barnard 2019).

In the period of 1986 to the early 1990s, VR was mostly used to develop training programs for NASA and the military (Barnard 2019). In 1991 Virtuality was released. The arcade machines’ purpose was to allow gamers to experience a 3D world through a headset and allowing for multiplayer gaming (see Fig.2.9). In the mid-1990s multiple companies released consoles, headsets and arcade machines that could play VR games.

Fig.2.9 Shows Virtuality arcade machines. Photograph taken from Ota.

In the new century, Google’s Street View was released and later in 2010, Palmer Luckey prototyped the first Oculus Rift headset, which was later bought by Facebook (Barnard 2019). Sony, Google and Samsung also joined the race to develop headsets along with multiple individuals who explored the possibilities of VR, according to Barnard (2019).

Bickmann et al. (2019) argue that “in order to increase the usability and immersion in the VR world the user should not have to hold a conventional controller” and they therefore “propose a glove controller so that it is not necessary for the user to hold an additional divide” in their hands. The difference between these two methods of control is in the player’s experience of the environment; the hand-held controller, for so long an essential part of the gamer’s equipment, becomes an unwelcome obstacle in the way of creating a convincing virtual reality.

This section has briefly provided an overview discussing some of the key milestones in the development of video games and the industry. As examined, the focus was initially on the quality of the game play, and later on the interactivity with the AI that gamers could experience. As games evolved, the attention increasingly turned to the environment in which games were set and the quality of the artwork which was displayed.

2.2 Video Game Art Evolution

Evidently, nowadays an important part of the game development process is played by the artists, who help to create immersive and aesthetic worlds. The role of artists however was not always a distinct specialty in the process of creating games. In the early period of game development there was no requirement for artists to only focus on art - each developer was a

generalist. According to Bethke (2003, p.45) “In the earliest days the programmer, designer, and artist were one and the same person” and after the mid-1980s “small teams of artists […] would work on a project”.

As already mentioned, in the early days of video game development, games used simplistic art styles. Artists have always faced restrictions when it comes to creativity, and with video games being limited by hardware and software availability as well as experience in the area, artists in the 1970s had to experiment and use simple objects and shapes to represent on screen imagery.

According to Griffiths (2018) the time period between 1983 to 1987 was the era of 8-bit pixel art. He claims that although “still decently limited in a technological sense, it was clear that developers had grown more ambitious in their attempts at engaging their audience” (Griffiths 2018). Clearly improving graphics has always been artists’ priority and on this Towell (2015) claims that in 1982, vector graphics[51] were first used with the home console Vectrex.

In 1984, Elite (Acornsoft) began a whole new era of video game art with breaking boundaries by introducing 3D space to the scene. Elite was the first game to use polygons in six degrees of freedom (6DOF)[3]. Six degrees of freedom is any setting that allows complete freedom of movement within a 3-Dimensional space. (Fig.2.7) Moreover, Nitsche (2008, p.28) adds that 3D space implies the option of a different turn at any moment, a new choice, or a different perspective that outweighs traditional nodes and links.

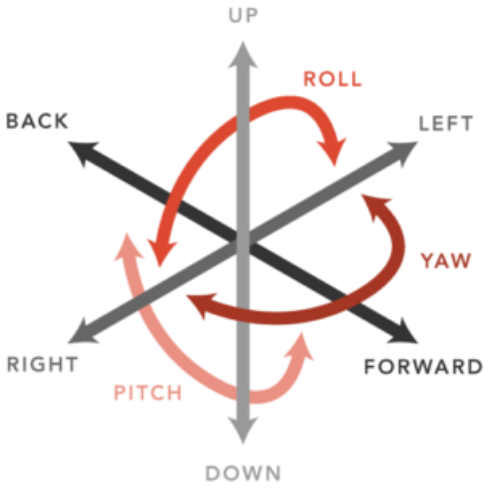

Fig.2.7 6DOF directions of movement. Image by Kilograph, 2017.

Bethke (2003) explains that it was not until around 1994 that the role of the 3D artist became apparent and even “the highlight of the show” (p.47). He claims that those individuals were 2D artists who wanted to translate their vision onto a 3D space and needed the help of “programmer-artists” (nowadays technical artists) to operate the early 3D software packages.

Marriott states that “graphics became even more innovative in the 21st century” (2020) and developers are still looking for ways to bring a better sense of immersion to the consumers of

their games. One of those ways are VR systems, which nowadays are just yet means through which one can experience games.

2.2.1 Video Game Visual Art Styles

Having discussed video game genres, the hardware that is necessary to handle the processes behind playing games and the evolution of game art it is important to note that games can come with different visual characteristics.

There are many different art styles to choose from when developers must make the decision for their games. Factors such as budget, timescale, target audience and preferences may however affect this decision. As there are no pre-set limitations as to what the art style should be, studios may often choose to develop games with distinctive and innovative art styles and abstract visuals.

One such art style is stylised[45]. The approach for this art style can be undertaken when the developers intend for their game to appear more hyperbolic and exaggerated. In such cases the textures can use colours which are referenced from the actual world but are often amplified with the saturation and contrast properties adjusted according to the preferences of the art team. Shapes and forms also appear distorted as the style focuses on emphasizing different parts of the silhouette to achieve an ambiguous aesthetic.

By contrast, a realistic art style approach may be considered when the desired effect is for a game to appear as close, visually, to real life as possible. Today, technology allows for artists to achieve very close resemblance to life. In the early days of game development, high polygon counts on models and high resolution[40] on texture maps were difficult for machines to process. Consequently, achieving an accurate representation of the complexity of real life may prove to be difficult. The development of technology has overcome such barriers, making it possible for art to closely mimic life.

On game art, the artist Brody Condon states that "any software limits your production to the periphery of what was intended by the developer" says Clarke (2006, p.45). The development teams of software packages used in the games industry, update and add new features to deliver the tools that artists need to create better visuals, edit their materials and textures and create visual effects. These features like shader graphs, visual scripting for artists, terrain creation tools etc. make it easier for the artists to work directly in-engine. Anderson et al. (2008) raise the question of whether the toolset must accompany a modern engine. They go on to clarify how content creation packages like 3D Studio Max and Maya (Autodesk) were

not designed for the task of creating game assets but have now become the preferred industry standard for artists.

In summary, game developers are not limited to use software packages made specifically just for game development. Often, they would experiment with software packages meant for other disciplines, so that they can achieve the best results possible when focussing on high fidelity graphics.

2.2.2 Video Game Visual Realism

Graphical or visual fidelity refers to the detail that can be seen on screen, and in this case, the levels of realism and believability perceived in video games. Roza et al. (1999, p.1) elaborate that “fidelity requirements represent the level of realism the simulation must display in order to fulfil the user’s needs and objectives”. In addition, it is “the degree to which a model or simulation reproduces the state and behaviour of a real-world object or perception of a real-world object, feature, condition or standard in a measurable or perceivable manner” (Roza et al.1999, p.1). In other words, visual fidelity in games has different degrees to which it can recreate the actual world; and the gap between the two is constantly getting narrower.

In games, it can be more complicated because realism can be separated into multiple different groups. For example, realism can be identified in gameplay, the narrative, the aesthetic or visuals and even in the stylistic choices in sound design. In terms of art, realistic visuals can be referred to as ‘photorealism’, meaning that the imagery provided by the game for the consumer, will have graphics close to that of a photograph or be as close to life as possible. Mackinlay et al. (1988, p.1) elaborate on this by stating that “photorealism is, by definition, the technique of choice when it is important to present the exact appearance of the world”.

There are pipelines and workflows that artists follow and experiment with daily, to achieve realism and push the norm. Realism often translates to complexity, as a reflection of how complicated the real world is, and therefore how much work and development is required to accurately represent it. Chalmers and Ferko (2008, p.21) claim that “a real environment is seldom pristine and includes accumulated stains, dust, and scratches from every-day use”. In other words, it would be a misrepresentation of a realistic world if it were presented as too immaculate. Regarding complexity, it is also important to consider Mackinlay et al. (1988) who comment that “effects such as refractive transparency, shadows, detailed object geometry, and precise perspective” can make a scene appear cluttered and hard to understand. In terms of realism, too many effects and too much detail can distract the player from the goals of the

game. In order to combat this, game artists and designers therefore pay attention precisely to what needs to be highlighted to guide the player in the right direction.

Mackinlay et al. adopt a different approach, however, when they assert that “effective pictures often contain both photo realistic and stylised aspects” (1988, p.1). Their argument is that the artist need not necessarily have to choose between photorealism or a stylised approach, and that the two can co-exist.

2.3 Video Game – Gamer Relationship

Following what the previous section discussed, McMahan (2003, p.75) explains that in her considered opinion, there are two types of realism in games. Social realism, which she believes is “the extent to which the social interactions in the VRE “Virtual Reality Environment] match [...] interactions in the real world”. It portrays the accuracy of historical events and real-life occurrences in video games, but also the way in which players interact with each other in multiplayer games.

Perceptual realism on the other hand is one which represents “how closely [...] the objects, environments, and events depicted [in game] match those that [...] exist [in real life]” (McMahan 2003, p.75). Once again, rather than focussing on perceptual studies, this section examines the meaning of perception as the gamers’ attitude towards realism. In games which aim to represent historically accurate locations and interactions, these two types of realism play an essential influence.

2.3.1 Gaming Needs and Brain Chemicals

Some knowledge of the responses of the brain is important for game developers to appreciate. The brain commands the entire nervous system in living creatures known to humans. Zuckerman (2009) claims that “the human brain is more complex than any other known structure in the universe”. Humans find different experiences enjoyable and amusing, but it is chemicals that are released in our brains that fuel these emotions and feelings.

For example, dopamine stimulates the need to continue playing games. Pietrangelo (2019) elaborates that dopamine is a neurotransmitter, meaning that it is produced by our bodies and is then sent through the nervous system into the brain. He believes that it is the chemical which makes humans feel motivated, rewarded and reinforced (2019). Moreover, experiments have shown that in video games, the stimulation of dopamine release can be easily detected through accomplishments like defeating an enemy, collecting in game content, completing the game and so on. From this, it is easy to extrapolate that games provide a sensation of

accomplishment which encourages players to feel as if they have achieved something important. In addition, these actions induce the feeling that the player is in control of the game, which can make gamers feel motivated. Newton (2009) believes that “dopamine neurons become activated when something good happens unexpectedly”. He expands on this to say that “relief from an aversive event can be considered as a reward”. Furthermore, defeating a difficult or frightening enemy and receiving an achievement for the work done can create a strong feeling of joy encouraging the player to continue playing.

Serotonin on the other hand, “is considered a natural mood stabili[s]er” (Scaccia 2020), helping us feel happier, calmer, or more focused. Serotonin’s main function is to stabilise the mood and make humans feel happiness, or continue to feel happy, thus after the rush of dopamine, serotonin is activated. To expand on the example given, the player will continue getting satisfaction even after defeating the enemy as serotonin will stimulate memories of the event, thus increasing the desire to play games.

2.3.2 The Physiology of the Perception of Realism

Researchers like Deleuze et al. (2018) consider that gamers play video games as a form of escapism, which they argue can be both “problematic and non-problematic” (Deleuze et al. 2018, p.1028) type of in-game engagement. In order for games to be perceived as realistic, there are multiple functions within the brain that need to be fulfilled.

The Sensory Functions are the means by which the brain picks up information through the five senses of touch, sight, smell, hearing and taste. Cherry (2020) explains that “perception is the sensory experience of the world. It involves both recognizing environmental stimuli and actions in response to these stimuli”. It is through different sensors that people experience the world, and, on the subject of realism and believability, one must consider that at least some of those senses must be entertained in order for them to perceive their surroundings as real. At their current state, video games can entertain the concepts of visual and audio functions, with certain elements of touch.

Perceptual Functions are the brain’s interpretation of “behavio[u]rally relevant information from the environment, but also to the conscious perception or awareness of visual information” (Saalmann and Kastner 2011, p.221). In short, these functions help us identify and organise the information received from the sensory functions mentioned above, ensuring that the sensations experienced are experienced accordingly.

Lastly, Cognitive Functions heed the aspects of attention, memory and perception. Spence and Feng (2010) exemplify that “although the cognitive demands in puzzle and maze games can be considerable, they rarely require such rapid action or reaction” (p.93). From this example it can be derived that different game genres stimulate different spatial skills in the players, hence why some gamers may enjoy certain types of games. Fig.2.10, by Spence and Feng shows the functions that gamers need to input in different video games.

Table 1
Sensory, Perceptual, and Cognitive Functions Exercised by Different Genres of Video Games

Function	Game characteristic	Action	Driving	Maze/puzzle
Sensory				
Detection	Complex 3-D setting, targets in clutter	■■■■■	■■■■	■■
Attention				
Capture	Abrupt-onset events	■■■■■	■■■■	■■
Select	Discriminate/select significant objects	■■■■■	■■	■
Switch	Task switching, multitasking	■■■■■	■■■■	■
Divide	Multiple foci, track multiple objects	■■■■■	■■■■	■■
Distribute	Peripheral events	■■■■■	■■■	■
Visuomotor				
Coordination	Aiming, shooting, operating hardware	■■■■■	■■■	■
Speed	Rapid action/reaction	■■■■■	■■■■■	■
Memory				
Working	Allocate resources, make decisions	■■■■■	■■■■	■■
Long term	Integrate knowledge	■■	■	■■■
Cognition				
Spatial	Mental rotation, wayfinding, navigation	■■■■■	■■	■■■
Analytical	Solve puzzles, devise strategies	■■	■■	■■■■
Auditory	Speech, game sounds, music	■■■	■■	■
Emotional	Arousal (threat)	■■■■■	■■■■	■

Note. Importance: ■■■■■ = very high; ■■■■ = high; ■■■ = medium; ■■ = low; ■ = very low.

Fig.2.10 Image illustrating the spatial, perceptual and cognitive functions depending on different genres of video games by Spence and Feng, 2010.

Different video games challenge the players in different ways. Depending on the genre of the game, there will be different requirements or tasks for the player to complete. Often gamers will have to work together in groups or against each other to achieve the different goals and objectives which the video game presents to them.

2.3.3 Perceptual Opportunities for a Sense of Realism

Fencott (2003) considers presence to be a mental state, it is therefore a direct result of perception rather than sensation. He researches the area of perceptual realism, or gamers’ attitude towards realism, for which he developed with the model of ‘Perceptual Opportunities’ (PO). In this model he looks at the concepts Sureties, Shocks and Surprises, which are essential to gameplay. He describes the concept of sureties as highly predictable, mundane details. Their attraction in a video game is their predictability. Examples of such are lampposts, incidental furniture or architectural detail that can help indicate distance.

Shocks are described as the poor design elements, which make visibly no sense to the user. Examples are the environment in the Virtual Environment (VE) suddenly ending, badly snapped to each other in game models creating a crack that the player can see through, latency problems (the quality of online connection) and others. Fencott (2003) says that surprises are the non-predictable mundane details that arise from the logic of the consciously accepted space. He divides the PO of surprises into attractors, connectors and retainers:

a) Attractors are perceptual opportunities from which the user's attention is drawn from afar, and also rely on people's natural curiosity. Attractors are designed to draw users to areas of conscious activity.

b) Connectors are the perceptual opportunities that help users follow a particular course or convince them to change course because the limits of the virtual space are close.

c) Retainers are local and peripatetic. They seek to keep the user in a particular space in the virtual environment. The purpose is to solely deliver memorable experiences of the environment. An example of that would be birds flying away once the user gets close to them.

When combining or avoiding these perceptual opportunities, designers of video game worlds are able to produce a more realistic environment, where the player does not feel like things are out of place.

In comparison, films have ways of immersing the viewer with the help of big monitors with "LED screens[23] on the sides of the theatre" and lights that "change along with the mood of the movie" (Montemarano 2019). Video games on the other hand convey immersion in different ways, tackling the idea by providing the player with feedback from the input of the mouse and keyboard or controller, and by allowing the player to decide where their character goes and what decisions the character makes. Game consoles like PlayStation (PS) (Sony) are going to great lengths to try and simulate a feeling of the controller in the player's hands. The PS4 Dualshock controllers vibrate in some situations, alerting the player that something is about to happen. The player may also get feedback from the game they are playing with the controller's audio output. The new PS5 DualSense controllers have a built-in microphone and a speaker as well as a resistance mechanism in the triggers (called adaptive or haptic triggers) on the back of the body of the controller. Nishino (2020) claims that using the DualSense controller, players are able to feel powerful sensations when they play, such as

the slow grittiness of driving a car through mud. Furthermore, Lynch et al. (2020) say that "these adaptive triggers [...] allow developers to program the resistance of the triggers to simulate actions more accurately". These innovations are important tools in the developers' hands to make their games feel ever more immersive.

2.3.4 Fracturing the Sense of Realism

While there is research done regarding the enhancement of immersion in video games, it is still possible for developers to fall victim to a phenomenon which fractures the sense of realism and believability in visual media which snaps the consumer out of the established immersion. Following that, the phenomenon may be infamously known in the film industry, but as video games evolve it is quickly becoming a problem for developers as well.

In 1970, Masahiro Mori first coined the term 'uncanny valley'. His hypothesis claims that the more human-like a robot's appearance becomes, the easier humans find it to relate to it positively. However, if it becomes too close to humans, while clearly not being human, it suddenly becomes repulsive and we perceive it as 'creepy'. Below is Mori's (1970) graph of the uncanny valley, simplified and translated by MacDorman (2005). (Fig.2.11)

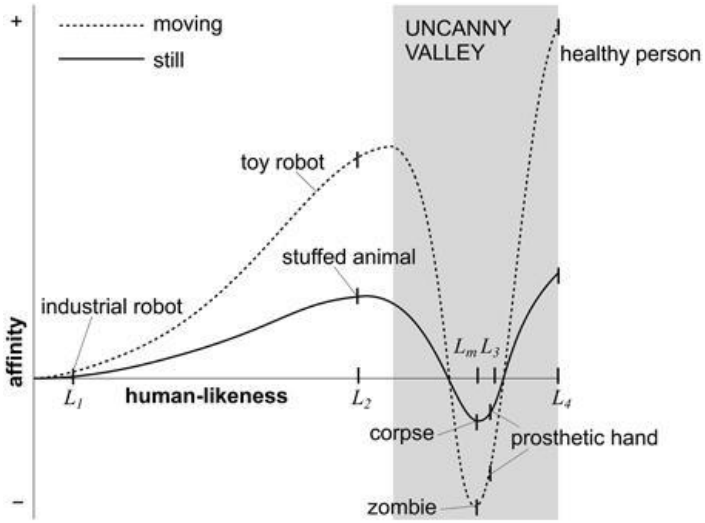

Fig.2.11 Mori's (1927) adapted graph of the uncanny valley

Nowadays this is applied to more organic shapes as well as robots and the 'uncanny valley' phenomenon can be particularly problematic in films when the filmmakers try to portray realism with computer graphics. As game studios are now also developing games that are trying to appear more realistic for audiences, it has become a problem for the game industry as well and particularly the animation aspect of it.

Facial expressions can give away a lot of information, and humans, and even some animals can recognise intentions based on the facial expression. For that reason, masks can be perceived as 'creepy' if worn by a human, as they de-face an individual, and part of our mechanisms for communicating is to seek for facial cues in order to judge what the other person's intentions are. Tinwell (2014, p.150) supports this idea by clarifying that humans tend to seek similarities rather than differences in other humans and that this helps us understand

and validate others. Furthermore, Tinwell (2014, p.150) continues that people constantly look at other humans and see ourselves in reflections, spending our lives observing human and even animal behaviour and movements and accordingly humans are able to recognise movements that are not familiar or feel ‘off’.

If one is to compare still environments to the animation of characters in terms of the ‘uncanny valley’, we can imagine that textures and shapes could also be considered as something that can appear uncanny or out of place. Environments tell stories, and to do so, artists must think about what happened in the place they are creating. Fig.2.12 shows artwork for Metro: Exodus (4A Games, 2019) and, while each piece works well with the rest of the environment, if, for example the table on the left was replaced with something more ornate that looking, as if it came from the Victorian era, the scene would look odd as this table would not fit into the post-apocalyptic world of Metro.

Fig.2.12. Fire Department location for DLC Sam by Novokhatnii, 2020

Moreover, in film, it is accepted that exploration is limited-in the sense that the audience does not decide where the main character, or characters, will go and what they will do. Video games, on the other hand, do potentially offer this freedom. The environment and characters that one can interact with compel the player to explore more. As an example, one can compare video games to a real-life walk: imagine going to the mountains and being able to collect different herbs and flowers. While not everyone will be interested, some would be fascinated to do this. Game designers have to consider such scenarios when they create their games. Considerations such as who will play the game, what the player might need to see or go to are some of the aspects developers need to tackle.

This leads to another problem with realism in games is allowing players to roam at will. A lot of games include the ‘invisible wall’[21] which stops the player from going to different places and Breda (2008) says that they are “sometimes considered errors of level design”. Realistically,

an invisible wall would not be necessary if the players were not curious about exploring places that they are not meant to go, requiring game developers to take this ability away and create a controlled environment. The problem with controlled environments however is that they can detract from the sense of believability within a game environment. For example, if one is to imagine a scenario where the player is in a room on top of a tower, and there is a hole in the wall for story telling purposes. If there is nothing to stop the player from jumping off the tower, inevitably a proportion of gamers might feel tempted to jump, just to see what will happen. Placing an invisible wall stops the player from doing that, assuming the intention is for the player to stay in the room.

Another common way to deal with forcing the player to stay in the room would be to allow the player to jump off but design it so that they fall to their death, then respawning[41] the player back into the room. The issue with this is that the player will have to be respawned, and this might make an impact on the immersion factor as waiting for the level to load might take time, depending on the power of the gaming equipment.

The last and most effective way to combat the player jumping off is to give them the freedom to do so, but program and animate the player character to be resistant to jumping off even if the player inputs their desire for the character to jump off. By doing this the player stays linked to the character and feels more connected to them, knowing that the character themselves did not want to go that way.

Overall, the invisible wall problem can be solved through various design techniques by either making sure that the player does not feel tempted to continue past the wall or making the player realise it is a mistake to go past the point.

2.4 Aesthetics Within Video Game Worlds

The discussed themes in sections 2.3.3 and 2.3.4 may also affect other elements of the art in visual media – the aesthetics of a game world. Dubey et al. (2018) exclaim that visual consistency in a game world is ‘critical’, therefore the art style and game design must be persistent and make sense, as it can otherwise fall into the ‘uncanny valley’ category.

Solarski (2016, p.3) insists that primary shapes correspond to sets of emotional themes, see Fig.2.13 for reference. Shapes (circle, square, triangle) are primitive forms of and in games they can be used in level[24] design as well as art.

Associated Themes

Irrespective of an object's symbolic value, aligning its broader shape concept to the circle, square, or triangle will consequently align it to one of the following themes:

Circle: innocence, youth, energy, movement, positivity, freedom, relaxation
Square: maturity, balance, stubbornness, strength, rest, restraint, rational, conservative, calm
Triangle: aggression, force, instability, pain, sorrow, tension

Fig.2.13 Shows Solarski's (2016) idea of shapes and their corresponding emotional representation

Solarski (2016) elaborates that in order to portray a character's intentions and personality, video game developers can take advantage of shapes. Following his idea of the properties of shapes, developers can also utilise the use of shapes combined with colours to set the mood of an entire level. As seen in Fig.2.14 the characters and environments illustrated clearly portray different meanings and moods. According to Hunicke et al. (2004) the aesthetic is what "describes the desirable emotional responses evoked in the player, when [they] interact with the game system". It is easy to assume from this statement that it is aesthetics that help promote the desire to replay a game.

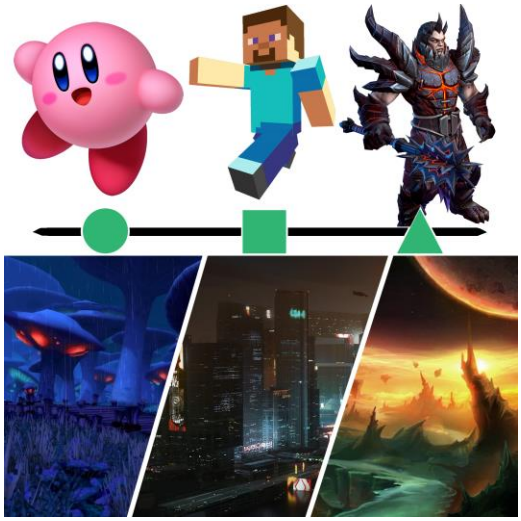

Fig.2.14 Adapted images illustrating the use of shapes to set the mood of characters and scenes. Nestorova 2020.

According to Solarski (2016) composition and colour are important in determining the mood for a game and help convey and support the story or narrative. Some ways to convey otherworldly setting or familiarity in the game world would include manipulating the colours and contrast or by combining familiar objects to create new ones.

The Last of Us 2 (Naughty Dog 2020) for example utilises environmental storytelling to guide the player through the levels, helping them focus on more important tasks finding their way through the game. As seen in Fig.2.15, the character is led through the level to reach a point of interest.

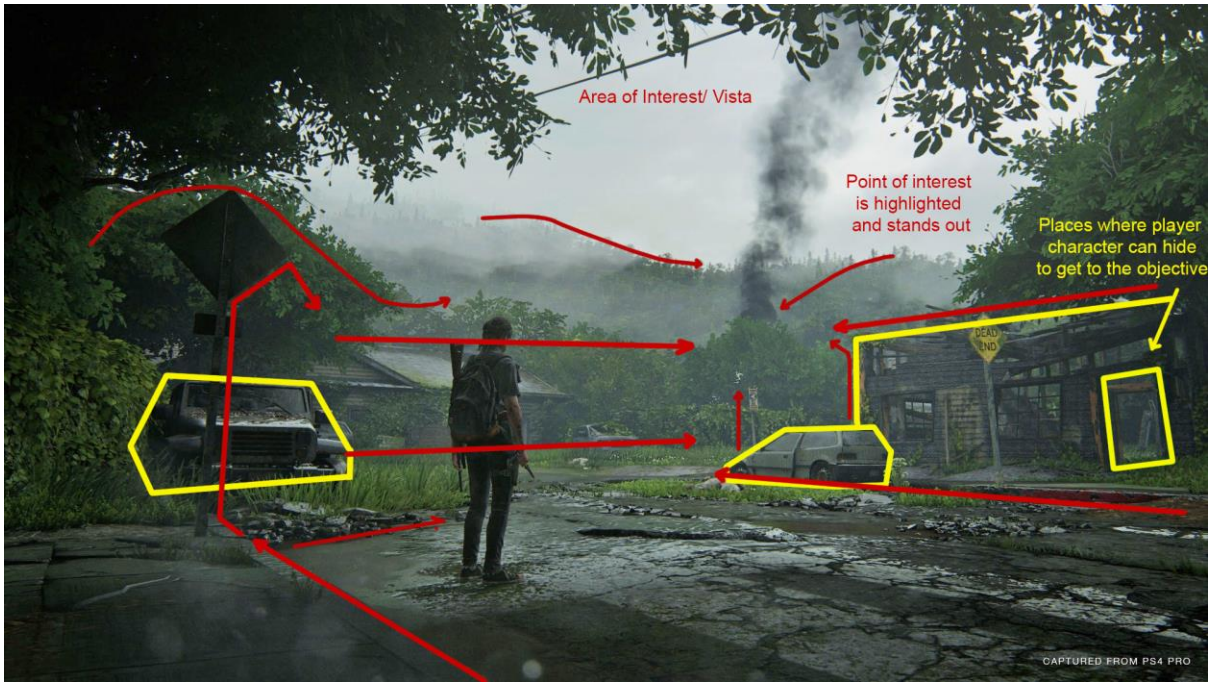

Fig.2.15 Adapted image from The Last of Us 2 to depict the importance of environmental storytelling. Nestorova 2020.

2.5 Video Game Believability and Immersion

As an aspect of realism, believability helps games become more authentic despite the art style or aims of the game. As Pacheco et al. (2018) note, it "is a hard concept to define" as "it depends on what one considers to be 'believable'". It is, however, a pivotal point in convincing the player how and why things in the game world exist, without causing unnecessary questioning. In the establishment of immersive game worlds, believability is a key factor in assuring that the players feel as part of the world. The inclusion of aesthetically pleasing imagery is a supportive aspect of the creation process as it can make the player feel emotions based on the set mood of the game.

Rogier (2020) claims that "science fiction and fantasy genres are especially heavy into fantasy worldbuilding, providing complex, layered settings populated with diverse forms of life". Environments of fantasy games take a lot of real-world inspiration, combining existing parts of nature to create new looking objects. Believability does not depend on familiarity; one can believe in things that one does not necessarily recognise as long as the environment is created in a compelling way.

God of War (Santa Monica Studio, 2018) is a good example of how studios manage to use real world reference, to create a fantasy world. Taraky (2018) (senior concept artist for the game) considers that "there are not as many visual references to draw from" with regard to Norse mythology. Throughout the game, the characters meet mythological creatures and

figures that the Santa Monica studio managed to represent in a way that never suggested to the player that they were not real or that they did not fit within the game world. In the game, one of the maps that the player can explore is Alfheim, a realm of the elves. Although elves are a race that is often depicted in fictional narratives, they are still a fabrication, and there is no basis or proof to suggest that they really existed, in spite of the frequency with which they are referenced in mythology and legends. Taraky (2018) elaborates that "to compensate [for] this, the team had to utilise the limited reference [they] had, [...] use [creativity] to translate the Norse aesthetic into the world and characters" of the game, and "pay attention to the nuances that made the Norse mythology feel real". Moreover, Taraky (2018) describes how, to make the trees in the Alfheim realm, they focussed on real life trees "that have […] grown for a really long time and have an interesting form to them" to emphasise how old the realm is and to break the linear feel that trees can sometimes represent. He also mentions the attention paid to colour values, to help ground the player to the world, he says, as "leaves that are too red or too white may throw off the other level elements" (2018). In other words, extreme differences in colour values for the leaves can take the attention from the other important level design parts.

Overall, the team looked at real world reference, combining different art theories and rules to achieve something that was ultimately neither completely imagined nor based on the real world, but a blend of both. It is easy to assume from these points that to make something otherworldly feel familiar, there needs to be recognisable shapes and colours combined in creative and unusual ways, to help the viewer feel at home. God of War manages to combine characters and locations in ways that provide a feeling of familiarity, and levels that are very linear feel full of atmosphere due to the consistency of the story telling.

Rules are an important part of world building as they help ground ideas and creativity and often limitations help promote more polished ideas. Moreover, Rogier (2020) states that "The purpose of worldbuilding for writers is to give their story structure" and that "even if the world you're building is exactly like our world, it is going to have rules". From geographic location, to deciding whether the world will exist within the bounds of magic, for example, it is crucial to decide these aspects in the beginning of the development process. Recalling Masahiro Mori's (1970) explanation of the discomfort felt when something is too close to reality without being exact, worlds that have not been thought through, and rules have not been set coherently appear uncanny in a way that is disturbing to the player.

To be able to achieve total realism[11] game developers need to consider what makes a game close enough to life but entertaining enough to keep the player captivated by the gameplay.

This thesis defines ‘total realism’ as the recreation of events, worlds and characters in ways which make them indistinguishable from real life, while also allowing the player to feel fully immersed within the game world. The player must feel as if they are being offered something which cannot be found in life, as generally, this is an important part of the attraction. If one is to imagine a scenario in which the player has to take care of their character the way they take care of themselves and do everyday tasks which they have to perform in the real world, this scenario is likely to bring little enjoyment. Even real-world simulation games must be careful to ensure that the player is not stuck doing tedious tasks for a long time.

Movements or environments must make sense and should not offer unnecessary confusion to the player as this can detract from the immersion offered by the game. Even stylised games like World of Warcraft (Blizzard Entertainment 2004) and Wildstar (Carbine Studios 2014) ensure that while the art style, animation and sound appear exaggerated, everything in the game stays consistent.

Chuah et al. consider that “Realistic and smooth game graphics are essential for a good gaming experience” (2014, p.80). Meaning that, in order for the player to be able to become immersed into the world, it should function smoothly, just like the real world. To talk about games as a realistic and believable media, it is important for this research to investigate how much a player can immerse themselves into the world that is created in a video game.

In a qualitative study led by Brown and Cairns (2004), they found that players were able to distinguish different levels of immersion in games and these corresponded to their sense of engagement and involvement in the game. They divide the immersion levels into three different types.

a) Engagement is the most basic level of immersion. Brown and Cairns (2004) state that this level is where the players invest time and effort to play the game.

b) Engrossment is the type of immersion where the players are dedicating a lot of attention and emotional involvement into the game.

c) The third level and highest level of immersion is total immersion, which they identified with presence. Total immersion was seen as the idea of complete involvement with the game where nothing else matters and the player feels “in the game” (Cairns et al. 2014).

In personal communications with George Lucas, Catmull (2020) discussed motion blur[28], and how they used “hand in traditional animation” (Marsh 2012) effects to create motion blur in the first Star Wars trilogy (Lucasfilm 1977). Later, Catmull and his team went on to further develop motion blur, so that it can be used on computer generated images. As Catmull explains “The blur keeps our brains from noticing the sharp edges, and our brains regard this blur as natural” (Catmull 2014, p.24). Motion blur on its own is a very important part of rendering graphics for realistic games nowadays. It helps consumers perceive movement as more believable in games and movies.

Following that, like movies with Computer Graphics (CG), video games use characters and environments made from polygons[35]. In the 1970s, Catmull and his team decided they wanted to force themselves to think differently by giving themselves the task to increase the polygon count of characters in movies from 40,000 to 80,000,000 (Catmull 2020), which even in current generation games is way too big of a number. The reason this was a challenge to them back then is that technology was not as advanced as it is now. Later George Lucas said that in his opinion “technology is what advanced graphics” (Catmull 2020).

Cairns et al. (2014, p.3) explain that immersion does not necessarily need to be reserved for digital games. Moreover, they consider that “the level of immersion experienced correlates with the personality trait of absorption”. By that they mean that if a player is able to become lost in their thoughts, they will be even more able to become immersed in the media experience. They go on to elaborate that there are differences in immersion between video games, and films and books. Cairns et al. (2014) claim that in video games the player is provided with a world that mediates and generates the player experience as opposed to unfolding a scripted narrative to consume, which is what books and film provide.

It is hard to ignore that games are evolving hand in hand with film in a way. De Joya et al. (2015) describe how “film and game production have historically been on parallel yet distinct development tracks”. Although the focus of these projects is video games, it is beneficial to look at and compare them to movies, as the production process can sometimes be similar. Eden (2020) comments that artists in the Computer-Generated Imagery (CGI) sector of film and video game artists have similar roles. The pipeline would often consist of steps like modelling, texturing, rigging, animation, rendering (including lighting and Visual Effects) and post-processing (compositing) (Dreamworks and CGMeetup 2016). From the differences between the two industries which Eden comments on, two are noteworthy for this research-script and budget:

a) Script can refer to two things: narrative (story line) and the actual code behind the visuals. Video games can sometimes have the butterfly effect. Meaning that “the plot of the game constantly changes depending on the player’s actions”, while movies on the other hand have “a fixed script” (Eden 2020). With the changes of narrative, models in game may need to change as well which would therefore require that each character or environmental piece must change in real time, without delays for every single player playing the game. A change of models will need to happen through a code which manages when the changes happen.

b) Budget wise both video games and film have their expenses, from paying wages to release costs. In video games unlike film, budget is also referred to when speaking of polygon count on a model or in some cases visual effects. Eden (2020) believes that the requirement to have smaller polygon numbers on models is what affects time as well, as due to that, artists in games must go through the baking[9] process, however there are also other factors that affect time.

On the topic of film and video game technology’s convergence, the film industry has begun using video game engines and development techniques to achieve realism in their renders, as well as to reduce the costs of sets and speed up the production process. Farris (2020) states that the team behind Disney’s The Mandalorian (Favreau 2019) used a game engine to create the environments for the series. He explains that the team used the Unreal Engine to create backdrops on big screens which showed the rendered scene. (Fig.2.16) According to Epic Games’ Libreri (2020) it was “transformative” to be able to use the power of the engine on set. Knoll (2020) states that shots of a character in a vehicle, travelling through a complex environment is always very difficult to do believably and on stage. However, with the help of engine rendered environments, they could do this more easily and more convincingly and make it a lot easier for the actors to look at the actual object or place in the scene when acting out their parts. Using UE4 also allowed them to change and adjust fragments they did not like in real time. For example, if the team decided they wanted to move a mountain, they can do it instantly (Liberi 2020).

Fig.2.16 A photo of The Mandalorian Film set showing the big screen. Farris 2020.

2.6 Bringing Reality into Virtual Space with Photogrammetry

The previous section discussed the possibilities of creating game worlds which are indistinguishable from the real world. To be able to really represent or copy the real world in games however, one must be able to somehow translate it into a virtual space. Photogrammetry has been a photographic technique that has been in use since the 1850s, when it was first used for the creation of “topographic and elevation drawings” (Albertz and Wiedemann 1996). The technique uses real-world photos of objects or areas to create 3D models. The photos are taken from every possible side and angle and are then imported into a photogrammetry software package to compile them into a 3D model.

Often models derived from photogrammetry come in higher polygon counts than game engines can cope with and they may also contain artefacts[8] - the faults in a 3D model. For this and for easier UV[49] unwrapping, texturing and other types of object manipulation, artists often use retopology - the process “of recreating an existing surface with more optimal geometry” (CGCookie, 2018). Luhmann et al. (2014, p.2) clarify that “the primary purpose of photogrammetric measurement is the three-dimensional reconstruction of an object in digital form”, however often the colour information from the scan may also be used for projects.

Fig.2.17 Shows a screenshot from a real time gameplay of Book of the Dead, by the Unity Demo Team. The team used photogrammetry to scan “geometry and unique texture[s]”

(Pavlov 2018), so that they can achieve highly realistic visual imagery, along with an accurate representation of lighting and materials.

Fig.2.17 In-game screenshot of Book of the dead environment, Unity Demo 2018.

Swearingen and Swearingen (2016, p.1) claim that photogrammetry has “nowadays become part of our common vernacular in the creation of 3D virtual environments”. Consequently, it is easy to assume that more AAA and even indie studios will use the technique in the future. On the possibilities of photogrammetry, Hamilton (2016) notes that they tried hard surface photogrammetry but were quick to realise that it only worked well for organic surfaces and that they did not use the technique for hard-surface models in the end. The problem with hard surfaces is that very often they have high reflectivity properties. Maximov (2017) feels that a big concern for photogrammetry is not being able to capture reflective surfaces, and he goes on to elaborate that the industry is already trying to figure out ways of combating this. He says that in the industry “either you’re using a cross-polarized dark room set up or you’re using a matte spray” when scanning assets. As the industry moves towards more computer-generated techniques, hard surface artists may find that some of the tasks they perform may be overtaken by technology.

As well as objects with high reflectivity surfaces, photogrammetry is not a good process to use when there are small holes in objects, or very defined sharp transitions, like for example the areas between the petals in a rose plant. Fig.2.18 shows a photogrammetry test by Piercy (2018) on matterandform.net, supporting this claim. With complicated shapes like the one showed below, the artists would have to scan leaves from the plant, then use that scan to create texture maps and model each sheet to then combine them to form the plant.

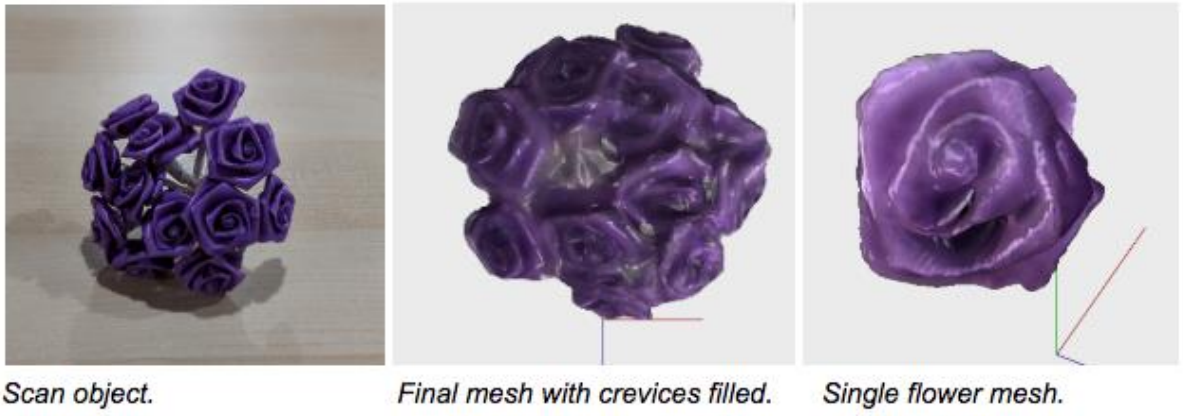

Fig.2.18 Shows a photogrammetry test of complex shapes, Piercy 2018.

Since photogrammetry is used to capture real world data, using it for stylised artwork may be more complicated and may not provide the desired results. Stylised art's sole purpose is to appear exaggerated compared to real life references. Although it may not seem as if photogrammetry is the correct technique to use in more abstract visuals, Statham (2018, p.292) describes how the team behind The Vanishing of Ethan Carter (The Astronauts 2014) "enhanced the photogrammetry assets with stylised handmade details to achieve the artistic and fictional darker tone of the game". It is easy to derive from this statement that developers can partially use the technique for achieving emphasis on certain parts of models. It may also be used to highlight areas and guide the player through the levels.

2.7 Physically Based Rendering

While photogrammetry helps developers create objects which have a close resemblance to real life objects, Physically Based Rendering (PBR) is used to portray realistic materials and light and shadow information onto the surfaces these objects. Chalmers and Debattista (2009) believe that "high-fidelity, physically based rendering has the potential to deliver the same perceptual quality of an image as if you were 'there' in the real-world scene being portrayed". While there is not a specific known date of when Physically Based Rendering (PBR) was invented, the creation of the approach appears to be a long process starting in the 1980s and being popularized by Pharr et al. (2004) with their book on PBR. The trend is a way to render characters, props and environments in real time in "a more detailed reasoning about the behaviour of light and surfaces" (Russell 2015). McDemott (2016) comments that PBR removes the guesswork of authoring surface attributes since the methodology and algorithms of PBR are based on physically accurate formulas. This allows assets and environments to look visibly "accurate" in different lighting situations. Materials can be reused and tweaked at any point, which gives the artists more freedom when deciding what their assets will look like.

2.8 Procedural Generation

The real world consists of randomness and complexity, and while people are capable of capturing that randomness, it can often be time consuming. Procedural Content Generation (PCG) in Video Games is “the creation of game content automatically using algorithms” (Togelius et al. 2011, p.1). Smelik et al. (2011) elaborate that it is “a promising alternative to classical manual modelling approaches, which usually require a large amount of effort and expertise”. It helps create uniqueness in games, levels, scenes, assets and in game behaviours. PCG can be used to create and randomise vegetation, characters, buildings, cities or even entire worlds, with the input premade from the artists' models.

Chiu and Shirley (1995, p.4) note that “procedural models can also communicate with each other”. The creation of a large environment with a variety of vegetation and animals, interacting with each other, just as they do in real life, is not impossible work for developers, however it does take time to model, texture and randomise each model in engine. If the job of an artist consists of only modelling and texturing their model, so that the generator can work on randomisation and placement in the world, it allows for artists to focus on other tasks.

One of the disadvantages of procedural generation is that the “method is highly unpredictable” and it may “lack [...] user control over the generation process and its outcome" (Smelik et al. 2011). This can cause artefacts, unwanted interaction between the properties of objects, in game physics and even code. “Computers know only what you tell them” says Compton (2016), therefore developers must teach or programme the computer to think like humans or even how to “solve problems like a human” (Compton 2016). Even recognising that however, procedural generation is becoming more popular as it assists in the creation of vaster, more impressive worlds for the players in a shorter time scale.

2.9 Creation of 3D Visuals for Games

Having discussed some topics which surround the area of believability and immersion in realism in video games, it is necessary to understand how 3D art for games is made. Marriott (2020) claims:

> *“As virtual reality and machine learning technologies provide even more options for game developers, you can expect to see game graphics transform even more so over the next couple of decades. Indeed, it may get to a point where the graphics are so realistic that they almost resemble the real world” (Marriott 2020).*

To be able to achieve graphics which are so close to the real world however, game developers must understand how objects and materials interact with light and shadows in real life and apply this in engines and various software packages.

2.9.1 Lighting Within Virtual Environments

In a similar manner to real life, in video games, without lighting players will not be able to see what is in the levels presented to them.

The visual receptors in modern digital media, be it film, or video games are visual representations of the human eye, or in other words, a form of camera. Jackman (2010, p.11) comments that “the camera perceives light differently from your eye and in a much more restricted range”. He claims that “the brain uses a huge variety of very subtle details and cues to interpret and understand what the eyes are registering” (Jackman 2010, p.12). In games, therefore, developers must simulate those details and cues in ways which make sense to the human viewer.

Light and dark adaptation are processes by which the human eye adjusts from dark to light environments and *vice versa*. In games, this is used to create a more realistic feeling when transitioning between lighter and darker environments. Ferwerda et al. (1996, p.249) say that “to produce realistic images we need to model not only the physical behaviour of light propagation, but also the parameters of perceptual response”. Lighting is crucial in recognising shapes and movement in games, and it is therefore necessary in the creation of realistic worlds. Moreover, El-Nasr et al. (2005, p.1141) highlight that lighting can be used in environments to establish perceptual goals like “necessary visibility, directing player’s attention to important scene elements, and evoking moods”.

Real life has a level of complexity to it, and therefore to represent realistic lighting, artists have to address this complexity. Akenine-Möller et al. (2018, p.106-107) say that developers use “multiple light sources each with its own size, shape, colo[u]r and intensity” in their games, and also claim that “indirect lighting adds even more variation” to a scene. Lighting can prove to be very processor and graphics intensive, though and for that reason different options for lights in game engines have been invented.

With static lights for example, their sole purpose is to be easy to process and render. Setting a light to static in engine may not allow for physics events to be added to it (like the shadows of moving clouds on surfaces), however stationary lights do allow for this. This type allows for more freedom, while keeping rendering times optimal. Manning (2019) explains that this type

of light is cheaper (more optimised) than movable lights, but still displays dynamic shadows. Stationary lights cast shadows and bounce off lighting from static geometry. If an object moves through a scene, some shadows will be cast onto the environment, however since this type of light forces the engine to remember the non-dynamic shadow information, it creates less work for the engine in general. The most dynamic option for developers is to set a light source to movable, allowing them full freedom. Often, in order to simulate realistic lighting, artists would need to place lighting under objects to simulate more realistic shadows and study real life reference.

2.9.2 Ray Tracing[37]

When discussing lighting, the term 'ray tracing' is an important aspect to uncover. According to Hofmann (1990), ray tracing has existed ever since the 16th century, when Albrecht Dürer attempted to describe it in 1532. In modern times, ray tracing is an algorithm that traces the rays of light coming from a light source and simulates the interaction of the light with the virtual objects (Thomas and Hayward 2019). It is therefore a method of rendering "light and shadows [information] in a scene" (Thomas and Hayward 2019). It can, however, be difficult for some computer systems to process which is why ray tracing has not been introduced to games until recently. Even nowadays, developers still have to consider optimisation when working with ray tracing and Thomas and Hayward (2019) say that "we still [have not] seen a fully ray-traced game".

The film industry has been using ray tracing for a while; animated movies such as Monsters University (Dan Scanlon 2013) used real time ray tracing. The team behind the film was the first to use ray tracing in the film industry, allowing them to create lighting and post processing which appeared more realistic than before.

2.9.3 Shaders Within Virtual Environments

Another aspect of video games that helps manipulate and edit lighting and shadowing are shaders. Shaders are a customisable element of the rendering process in game development. As suggested by Unity Technologies, they are "scripts that contain the mathematical algorithms for calculating the colour of each pixel" (Unity Documentation 2017) on screen. In simpler words, a shader is responsible for taking each pixel and changing its properties as set by the developer. Shaders can also manipulate geometry and change the properties of 2D images in 3D space.

While they are responsible for shading objects, they also change other properties like vertex colour, blur or sharpen on screen information as well as change the geometry of objects

(Randima 2007). There are variations of the shaders which can be: 3D shaders[54], Vertex Shaders[55], Tessellation Shaders[56], Pixel Shaders[57], Geometry Shaders[58], Compute Shaders[59], etc. (See Appendix A)

In summary, visually, shaders help to make games appear more polished and help manipulate properties of pre-made game objects.

2.9.4 Accurate Representation of Game World Surfaces and Materials.

As discussed, surfaces and materials are what gives 3D objects a realistic appearance. This section reviews these properties by examining them through a more technical standpoint and exploring how light and shadows affect the surfaces of objects, as well as how texture types work in general. Within the context of this section the terms 'light ray' and 'ray' define how the light interacting with a surface affects different substances and materials within game environments and characters.

A ray of light "has the trajectory of a straight line in a homogeneous transparent medium such as air" (McDermott 2018, p.18). If one is to picture a ray of light as a straight line, this helps us visualise how a light shining onto a surface changes direction after bouncing off of it. Depending on the material properties of the surface that the ray hits, i.e. whether it is rough, transparent, glossy etc., the outcome will be different.

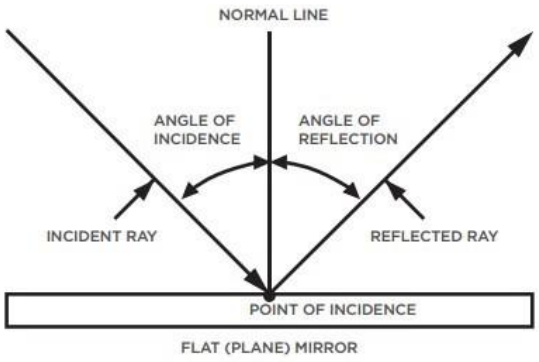

Fig.2.19 A visualisation of a light ray hitting a surface (image from ScienceWorld)

It is important to understand how light reacts with different surfaces when discussing texturing and materials for games, as materials are digital substances that reflect light. Software such as Substance Painter and Designer by Adobe uses 3D viewports to simulate approximately how the materials will look in the engine. The ray which hits the surface is called *Incident ray* (Fig.2.19) and the angle at which it falls is called an *angle of incidence*, also explained in McDermott (McDermott 2018, p.19).

So how do 3D materials work and how does the software define where the reflected ray bounces off to? Materials are a representation of the surfaces of substances and objects from real life in 3D space. Each material can consist of multiple texture types (which determine the bumpiness, reflection and other properties). However, it does not have to include these textures.

When an incident ray interacts with a surface it can either be reflected or refracted. An example of a reflected light ray would behave like the one seen in Fig.19 The reflected ray would mirror the motion of the incident ray bouncing off the point of incidence and get redirected in the opposite direction following the Greek mathematician Euclid's Law of Reflection. The Law states that no matter at what angle the incident ray hits the surface, the angle of incidence will always mirror its motion, as explained in Houstoun (1922). If multiple light rays interact with a surface, and the surface has a different composition than a flat plane, the light will be refracted in different directions.

In 2CE, the Roman astronomer Ptolemy tried to determine the Law of Refraction and over the years Snell and Descartes tried to perfect that Law. The idea was to represent how the light ray travels through different media or materials. Fig.2.20 represents Descartes' formula which helps find the different angles at which the light falls and gets refracted.

In games art, understanding these laws can help artists visualise how different surfaces will affect the light coming from the engine or renderer light source. Understanding these laws also helps artists to interpret the roughness and glossiness of the surface of their models, resulting in a more authentic presence of the model on screen and in game.

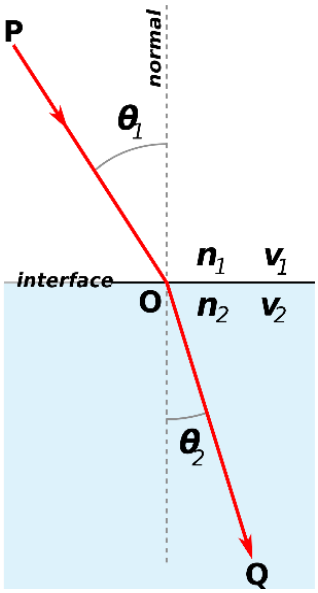

Fig.2.20 Descartes' formula
(image from Wikiwand)

2.9.4.1Complications of Reflection and Refraction

Through reflection and refraction, certain events may occur when light travels from one surface to another.

Fresnel Effect is a phenomenon which depicts how the perception of light changes based on the angle of reflection. To be able to represent the attributes of materials in real life, material artists must reference and understand the real-world physics that give those materials their properties. The Fresnel effect describes that at shallower angles, 'the increase in reflectance is primarily seen at the edges of objects" (Akenine-Möller et al. 2018, p.319). Akenine-Möller et al. explain that if the surfaces are at a glancing angle to the incoming light with the values of θ*i* (≈90◦), they are also at a glancing angle to the eye. They claim that it is for this reason that an increase in reflectance is seen mostly at the edges of objects.

In Fig.2.21 it can be seen that $n_1 < n_2$, where n1 is the “refractive index of the surface ‘above’” and n2 is the “refractive index of the substance ‘below’” (Akenine-Möller et al., 2018, p.317).

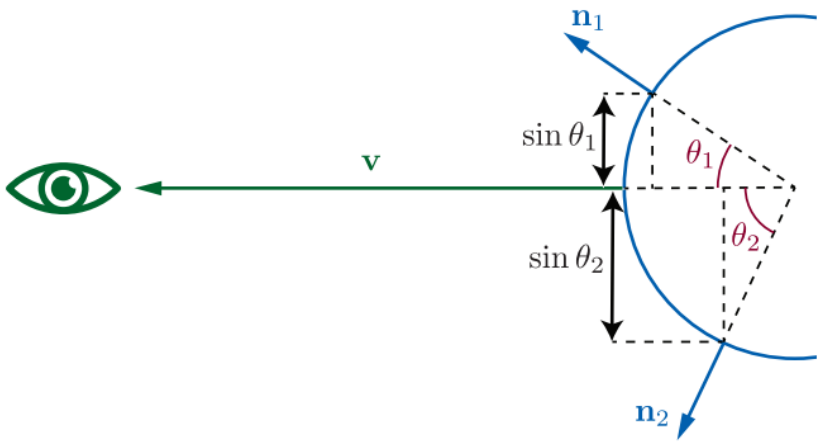

Fig.2.21 Shows the Fresnel Effect described by Tomas Akenine-Möller et al.

Transparent and translucent materials and textures are another pivotal part of creating more believable worlds. When using translucency and transparency maps in conjunction with diffusion maps, complications can arise when more of the light rays get trapped within a surface.

In cases such as these, the artist needs to take into consideration the thickness and shape of the object or model. Depending on the material that the artist is aiming for, if the light scatters after hitting a surface, the light ray direction will change randomly, not changing the intensity of light coming through in the first place. This can be viewed in areas like ears or between the fingers that are exposed to light, as seen in Fig.2.22

Fig.2.22 Showing subsurface scattering in Uncharted 4, Nathan Drake’s ear. In game screenshot

On the other hand, with glass and clear water, most of the light will go through the object and there will be no scattering of the light in view. However, if we go back to looking at the light ray and the way it travels within the material, it can be understood that more light is being absorbed or scattered. McDermott (2018, p.20) observes that “object thickness plays a large role in how much the light is absorbed or scattered”.

2.10 Baking[9] 3D Objects

Hajioannou (2013) says that “A 2D texture map is an image added to a 3D model that provides a higher level of detail, wrapping around whatever 3D art you have to apply or modify certain attributes like colour, transparency, shininess, reflection, and higher detail”. To help reduce the polygon count, but still have complicated-looking models, developers use a technique known as baking. Baking is the act of transferring data from one model to another. Most commonly artists will use the technique to transfer geometry information from high polygon 3D object to a lower polygon 3D object.

To aid with memory conservation and better frame rates, developers limit themselves to a polygon ‘budget’, meaning that a specific model should only consist of the minimal number of polygons that it can be used in game. Wilson (2017) notes that “baking is commonly used to capture detailed surfaces from objects that are otherwise too dense or resource heavy”. Developers have to think about optimisation with any game project they work on, and even though technology is getting better at being able to handle more information, optimisation is a guarantee that gamers with current and previous generation PCs can run newly released games.

In 3D art for games, developers have the option to model or sculpt their models. Sculpting in a 3D software package like ZBrush for example, includes increasing the polygon count of an object, so that the artist can sculpt the information and detail that they have in mind. Polygons, in the case of sculpting, work in a similar way to pixels, in that, the more polygons one has to work with, the more defined the object will look and the final result will not have any hard edges spoiling the otherwise well-defined shapes. Lastly, having a lot of high-definition models creates a lot more information for the engine to render additionally, hence the popularity of the technique.

2.11 Texture Map Types

Baking objects then introduces texture maps which can be applied to the model in engine or a renderer. Texturing for games, like other aspects of development, has evolved over the years, as developers are constantly looking to improve the visual fidelity of their games. There are two industry accepted workflows when working with Physically Based Rendering, and they each come with their own methods of approaching texture maps. Before these workflows are discussed, this study needs to examine some of the general texture maps that are used within workflows.

To begin with, Diffuse and Albedo maps are RGBa (Red, Green, Blue colour and an alpha channel) texture images that show the colour of an object. They both represent the colour of models, hence why they are often referred to as Base Colour maps. Those maps “lack [...] directional light [and] ambient occlusion” (Wilson 2017) stored in the image and have information about “the shadows and highlights [...] removed” (Garlington 2020). When working on realistic environments, it is beneficial for artists to be in control of everything that interacts with their model, and a good way to ensure this is to separate maps so that they can be manipulated individually.

In 1978, Blinn (p.286) described how a flat surface can appear as if it has bumps and details on it. He says that surfaces can be “defined by the values of three bivariate functions”. In Fig.2.23 can be seen the values X, Y, Z which represent the 3D space and RGB (red, green, blue) responding to each value. Normal maps are RGBa maps used to simulate detail on the surface of the model that is not technically there.

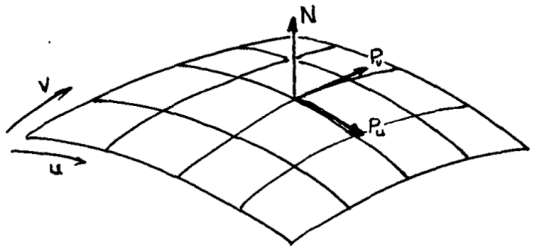

Fig.2.23 Shows Blinn’s definition of normal vector

Normal maps store the projected information of the high poly model, so that it can be used on the low poly model. Both Bump and Normal maps help define detail on the surface of a model, without the detail being sculpted or modelled on it. The difference between the two is that bump maps are grey scale images and normal maps “can be referred to as a newer, better type of bump map” (Pluralsight 2014). Often for optimisation purposes, normal maps are exported as mixed textures, and can include ambient occlusion, roughness or height information in the alpha channel of the image. Fig.2.24 shows the difference a normal map makes.

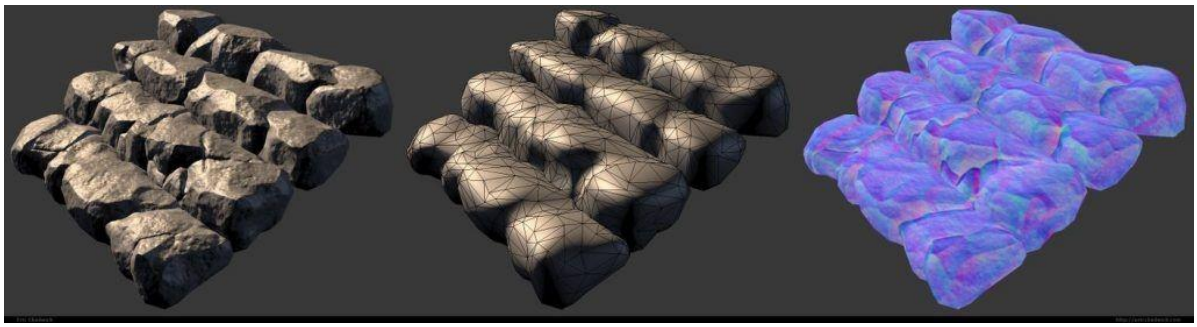

Fig.2.24 Shows the information added from the bake. Left to right are the final model with albedo and normal map, middle: the model with just albedo applied to it and right is the model’s normal map visualisation. The Scout, 2018

To include shading information in a model, so that it looks as if it has ambient shadows cast from a light source, developers use Ambient Occlusion maps (AO). Often used in terrain and landscape creation, height maps are grey scale images where white values represent high points and black represent the lowest points

Height maps are grey scale maps that can be used in conjunction with normal maps to create additional detail. The white values on the map signify higher points on the model and darker values represent low points. The difference is that while “normal mapping modifies the lighting across the surface of the texture, [height mapping] shifts the areas of the visible surface texture” (Unity Documentation, 2020). McDermott (2018) claims that they “add more apparent depth and thus greater realism to normal and bump mapping”. Height simulates the depth of a surface but the “effect is drawn onto the surface of the model and does not modify the actual geometry” (Unity Documentation, 2020).

2.11.1 Textures and Materials

Textures are usually the images that artists or other game developers use with their models. A single texture however would not provide a lot of detail to a model and for that reason there are different types of texture maps that can be used for more detail and definition, such as normal, albedo, ambient occlusion etc. These help with lighting and the model’s authentic appearance in the game world. Textures can be both hand-painted or procedurally / computer generated. Hand painted textures are ones that the artist painted themselves in software packages like Photoshop and MARI and usually appear a lot more stylised, as mentioned previously. Fig.2.25 shows two environments, one done using hand painted, stylised workflows, and the other one using texturing software and realistic workflows.

Fig.2.25 shows two personal projects ‘Fantasy diorama’ and ‘The Office‘. Left is a hand painted stylised diorama and on the right is a realistic piece textured using Substance Painter. Nestorova 2020.

For a more realistic appearance of a texture, often the artist would take photographs of real-life surfaces as reference and later create different texture map types (the mentioned normal, height, ambient occlusion etc.) of the original photographs.

The combination of texture maps that are applied onto geometry or models is often referred to as ‘material’. A material is created so that the engine can recognise how to render the image of the combined textures, however, it does not necessarily consist of multiple texture maps. The material in Fig.2.26 was created in Substance Designer through a node like the one referenced above and applied to a sphere. The addition of normal, height, albedo, roughness and ambient occlusion maps make it appear more defined (left), than the stripped-down version on the right, including just the albedo map.

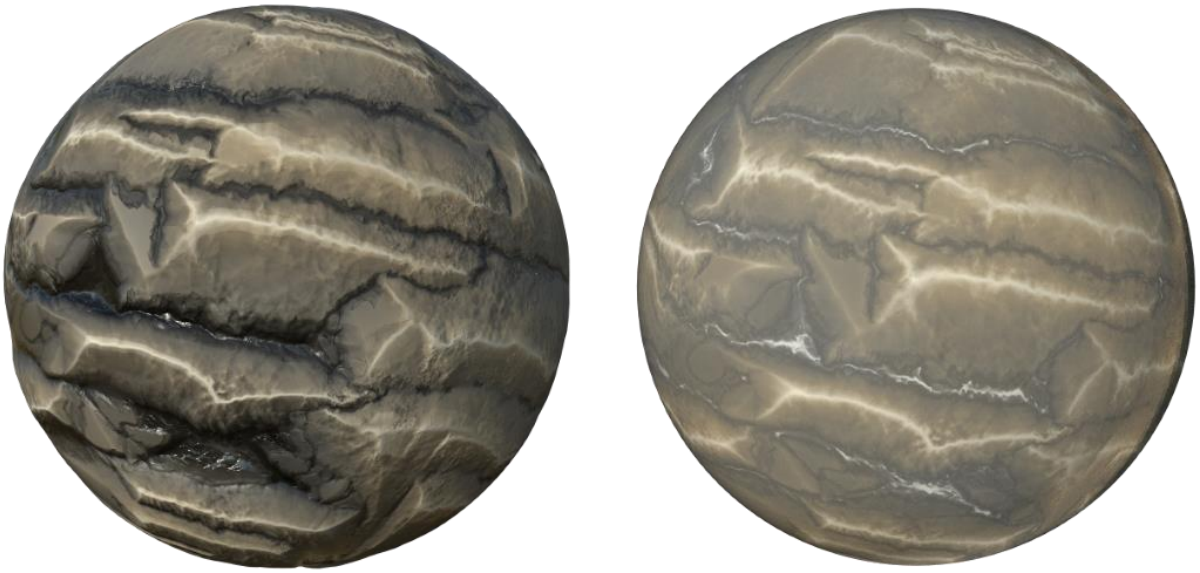

Fig.2.26 The difference between Left a material with base colour, normal, roughness and ambient occlusion textures formed into a material and Right-base colour texture. Both rendered in Substance Designer. Unpublished personal work, 2020.

2.11.2 Texture Map Workflows

Artists "need to think […] about the maps that describe the attributes of a surface" (McDermott 2018, p.46). In order to represent material properties of surfaces accurately, artists need to decide whether their object will have a metallic or non-metallic surface or whether it will have transparent features or not.

When working with PBR there are two workflows to consider: Metal and Specular. Both workflows are defined by feeding a texture image to a material, consequently creating the appearance of the material in-engine or in the selected renderer.

Garlington (2020) mentions that metal / roughness workflow "is more appropriate for real-time PBR renderers as the Unreal Engine, Unity, Quixel etc". He goes on to explain that since PBR is increasingly popular, many traditional renderers are making sure they support both workflows, allowing artists to choose which one they prefer to use (see Fig.2.27).

WORKFLOW COMPATIBILITY CHART

3D APPLICATION	SPECULAR	METALNESS
3dsmax – Art Renderer (Physical Material)	✓	✓
Cinema 4D – Standard & Physical Renderers	✓	✗
Blender – Cycles Renderer (Principled BSDF Shader)	✓	✓
Modo – Standard Renderer	✓	✗
Marmoset Toolbag	✓	✓
Keyshot	✓	✗
Vray (Plugin)	✓	✗
Corona (Plugin)	✓	✗
Arnold (Plugin)	✓	✓
Octane Standalone	✓	✓ Only with a special PBR Shader Impor
Octane (Plugin)	✓	✗
Redshift (Plugin)	✓	✓
Mental Ray (Plugin)	✓	✗

Fig.2.27 Shows compatibility of renderers and workflows (Garlington 2020)

Metal and roughness maps are both grayscale images, but with different properties. Metal maps function similarly to a mask by telling the renderer to mask out the areas in the base colour which should have metallic properties. Black defines which parts of the albedo map will have metallic properties, and white represents non-metalness of a surface. Roughness maps in conjunction with metal maps help define how rough or smooth surfaces will look.

As mentioned, PBR focuses on representing surfaces and materials in a more precise manner, to help developers achieve better results when working on authentic worlds. PBR introduced new map types like metal and roughness, which help with defining more precise material surfaces. Both Metallic and Roughness maps are images with grayscale properties. McDermott (2018, p.53) clarifies that the metallic map "operates in a manner similar to a mask" where it tells the renderer to mask out the areas in the base colour which should appear more reflective, like metals do. Masking is the process of dividing sections of an image using black

and white values, which within the context of this map type helps the engine or software decide which parts of the model will have the metallic or other properties.

Roughness is another grayscale texture map. In this texture, the value of 0 or black represents smooth properties and 1 - white represents roughness. Roughness maps help add more definition on objects in games, aiding artists in representing the condition of the objects in a more precise manner. McDermott (2018) suggests that the normal map already holds the guidelines needed when choosing how to use roughness maps. Normal maps hint which parts of the surface would have the properties that would need to be highlighted by the roughness map.

As well as this, Specular/ Glossiness is another workflow used by artists. With Specular maps, the light ray will reflect or bounce off the surface, just like a “ball thrown at a wall” (Russell 2015), creating a mirror-like effect (see Fig.2.28). In this case, the LR “follows the law of reflection, which states that on a perfectly planar surface, the angle of reflection is equal to the angle of incidence” (McDermott 2018, p.19). It is important to note that a lot of materials are not planar and have an irregular surface, which can make light bounce off in different directions, but still not change the intensity.

As McDermott explains, when some of the light gets absorbed and then “makes its way back out of the surface” it becomes Diffuse Light. Understanding that rougher surfaces will have highlights that are larger, and that appear dimmer can be beneficial to artists (McDermott 2018, p.22) (see Fig.2.28).

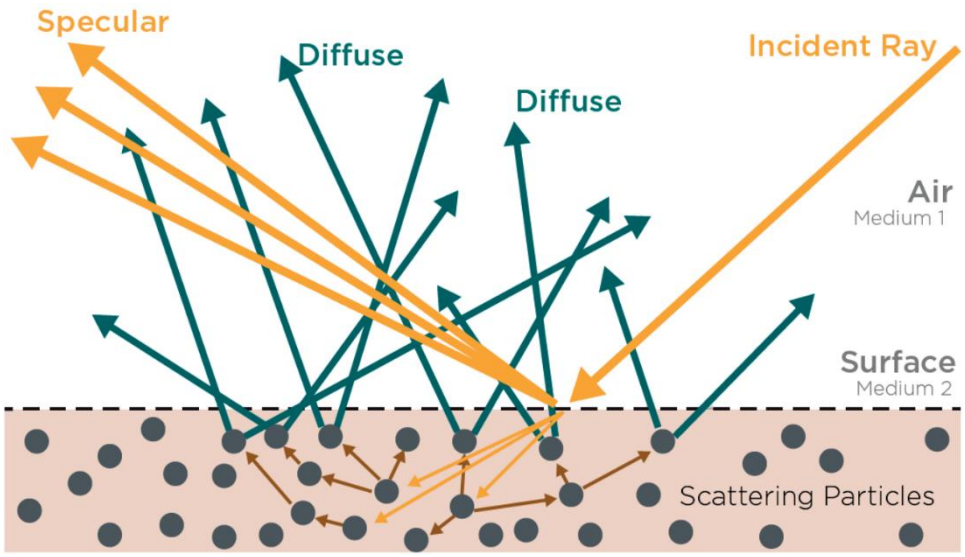

Fig. 2.28 Visualisation of specular and diffuse reflectance (McDermott 2018).

To summarise, Wilson (2015) claims that “there is little difference between these two [texture map] types”. In practice roughness maps use bright values to tell the software which parts of the map should appear as a matte surface, while glossiness maps use the bright values for the opposite-smooth and glossy surfaces. In short, it is important to consider what kind of material will be needed to represent the right surface of a model. McDermott (2018) has provided Fig.2.29 in his PBR Guide 2018, outlining what an artist needs to consider when working with materials.

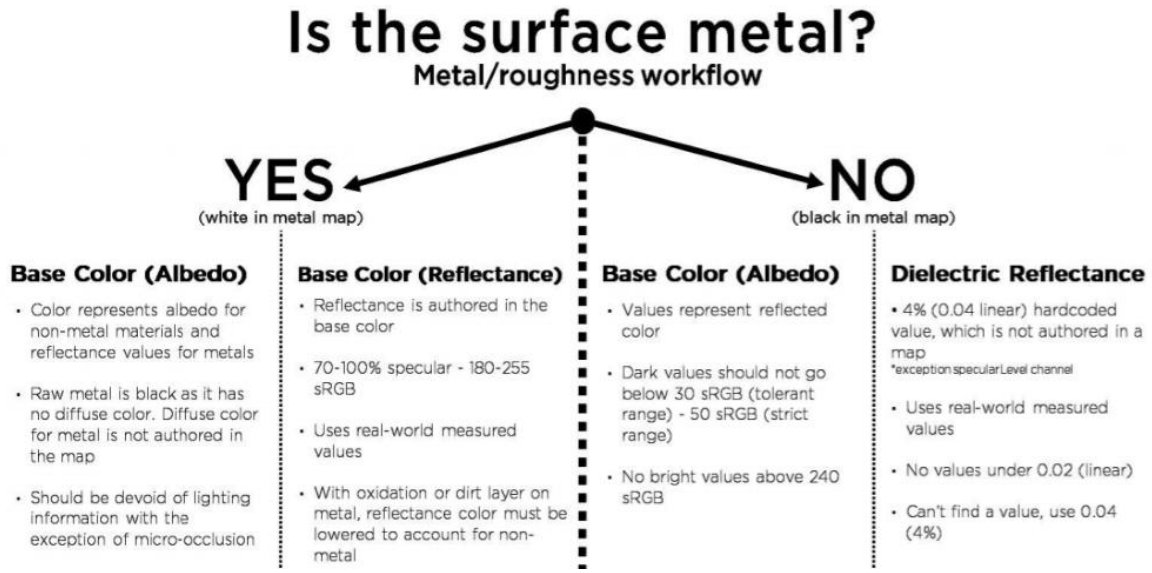

Fig. 2.29 A summary of some key points to make a material appear correctly in your preferred renderer by McDermott 2018.

2.12 3D Object Modelling

As part of the contribution that artists make to video games, they need to be able to create 3D objects, models or sculptures for games. To be able to achieve this, as well as practice and skill, artists need 3D content creating software packages like Autodesk Maya, 3Ds Max or ZBrush to allow them to transfer the concept given to them, or the image in their mind, onto a 3D space. These software packages allow the artist to manipulate shapes in many ways. In video games artists must consider the polygon count and the size of the texture. Bigger texture size often may mean that the developers need to decrease the number of polygons as, having a lot of information for the engine to process may (and most likely will) cause performance issues.

Dietrich et al. (2002, p.12) clarify that “3-D models are made up of geometric points within a coordinate system consisting of an X, Y and Z axis, these axes correspond to width, height, and depth respectively”.

3D models for games are represented by a boundary shaping method. Boundary representation or B-rep, “defines solids by providing explicit information of solid boundaries” (Patrikalakis and Sakkalis 2000, p.389). Solids are represented by topology and geometry. Geometry utilises primitive objects (cubes, spheres, planes, cones etc) and the options that can modify the properties of objects.

Topology, on the other hand, is represented by elements like faces, edges and vertices. Each model consists of several faces or also referred to as polygons (b), which form the shape. A polygon itself, is a plane formed from a loop of 3 or more co-planar line segments (edges), several of which can be combined to create the surface (shell) of a 3D model (if this is defined using boundary-representation) (see Fig.2.30).

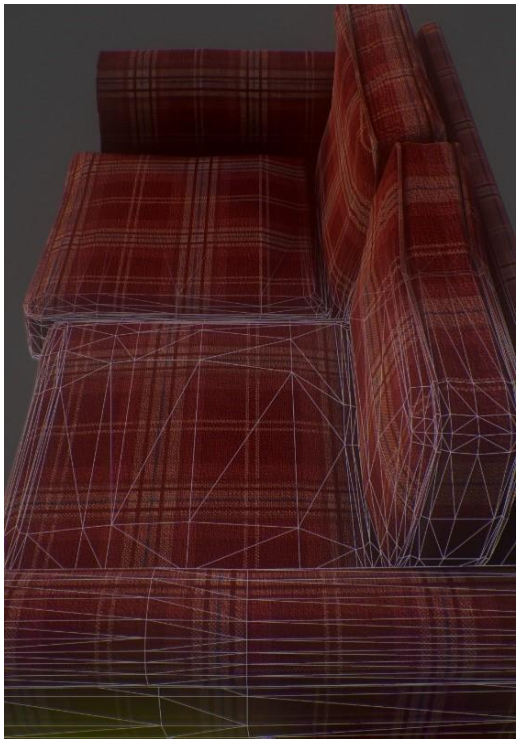

Fig.2.30 Personal project “The Cat Sofa”, showing a wireframe of the polygons and triangles making up the model. (Nestorova 2020)

In 3-Dimensional art, polygons can consist of 3 or 4 sides. The 3 planar edges forming polygons are called: Triangles or Trigs, for short (c). Quadrangles or quads are the 4 planar edges forming a polygon. Each polygon is connected to the adjacent one to it with edges (d) and the edges are connected to each other with vertices, or verts(e). All these concepts combined, form the wireframe of a model, which can be seen in Fig.2.30 as part of a rendered model, and in Fig.2.31 on a primitive shape.

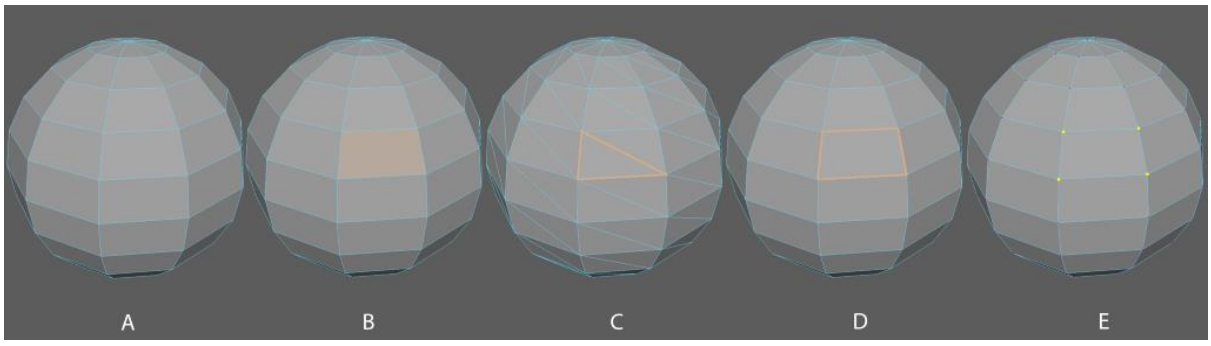

Fig.2.31 Shows A: the wireframe of the model, B: a highlighted Polygon, C: a Triangle, that forms a polygon, D: the edges of a Polygon, E: the vertices that hold the edges. Personal creation, using Autodesk Maya.

2.12.1 Texturing

In the real world one can find countless different surfaces, and in games, artists must replicate these in authentic ways. Artists often have to consider whether their model will have reflective or non-reflective properties, or if they will be metals or not. 3D texturing is the process undertaken to add colour and depth to 3 dimensional models. As technology grows, so does the need to push art and make it more convincing, no matter what the art style. Texturing and landscape creating software nowadays allow for a quick creation of the desired outcome. Companies like Adobe's Substance Designer develop software that allows artists to quickly create and manipulate materials on a node-based system (see Fig.2.32).

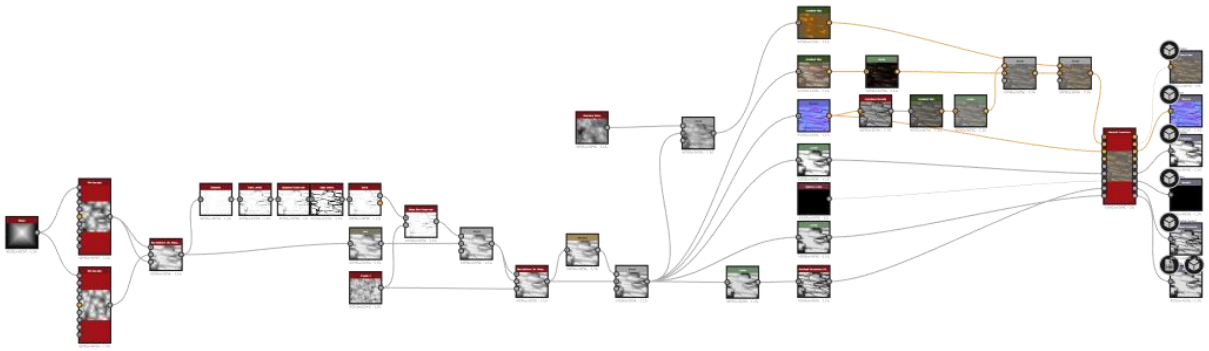

Fig.2.32 Personal unpublished work 'Stylized Rock'. Shows a Substance Designer Node.

In terms of textures, texturing and modelling software packages use the coordinates of a model or more precisely the position of its vertices (Fig. 2.31, image E). Each 3D model is located somewhere in a 3D space, and artists can manipulate where their model will be situated by either manually moving and rotating it or by entering numbers in the 3D modelling software. 3D models are really just empty shells, which artists must construct in ways that make them appear more organic and believable. In the industry, the shell of a model is referred to as its surface mesh, and its organisation is referred to as topology. Clean topology, with polygons of similar size and shape make it not only easy for the game engine, to compute, but also for texturing. Gonzalez poetically states that "improper topology sticks out under the unforgiving lights and shines brightly on all the imperfections" of the model (2019). Meaning that a silhouette of a model should look tidy, instead of having bumpy areas, which can cause unwanted lighting artefacts, similar to the one in Fig.2.33 Gonzalez (2019) clarifies that "clean topology is essential for animation and game asset creation". When animating, if the model has an unstable looking structure, all the imperfections become increasingly noticeable, creating rather unappealing results.

Fig.2.33 Shows lighting artefacts from bad topology (B) after a bake. Personal work ‘Oni Mask’

To be able to texture a model with clean topology, UV unwrapping is a necessary two-dimensional procedure. It is the act of stripping the model of its outside skin, like peeling an orange. The UV maps created from that unwrapping process are what the texture artists use as canvas, so they can transfer imagery onto their models. In a 3D space, software packages usually use X, Y and Z to signify the 3 dimensions. When unwrapped, a screenshot of the wireframe can be taken, so that the artist can use it as a guideline and paint over it (left of Fig.2.34), or the whole model, with unwrapped topology can be imported into software like Substance Painter and 3DCoat (right of Fig.2.34) and in there, the artist can see a real time representation of what they are painting on the model.

Fig.2.34 A personal project ‘Game ready Sci Fi Flood Light’. As presented: A Maya 2020 UV unwrap/ an untextured 3D model/ a textured model/ the UV texture from Substance Painter

Moreover, in the industry it is essential that an artist learns how to unwrap their models tidily. As often nowadays artists can paint on the model in real time with texturing software packages like Substance Painter or Quixel, straight lines and clear shapes in the UV set make texturing easier and faster. Simply put, the artist will not have to attempt to paint accurate shapes by hand, but instead will easily be able to follow the wireframe of the UV island as a guidance.

Moreover, Paulino (2016) says that “if the UVs are not organized, that task might take a long time to complete, and we’ll end up wasting the company money”. Games take a long time to make, and having the process slowed down by a texture artist who has to unwrap a model, which should have already been unwrapped, increases the work and therefore time spent on a model. As many artists agree that this task can be time consuming, developers have created multiple scripts and stand-alone software to combat this. Additionally, it can be as simple as copying and pasting lines of code into the software’s preferences and setting hot keys, to really speed up the process.

However, even following all the steps mentioned above, there is a certain aspect that needs to be considered. Texel Density is crucial when working on environments for games, as it helps maintain the same texture resolution in the entire scene. In the real world, everything looks as if it shares the same level of visual detail, consequently in a game, if objects represent different levels of visual clarity, it can appear peculiar. Moreover, if the player is able to see two objects in the game that clearly have textures with different quality and resolution, it can break the illusion of real-world representation. Fig.2.35 shows the same texture checker applied to two scenes, however the differences can be seen between the well compiled Texel density for the scene compared to badly assembled one.

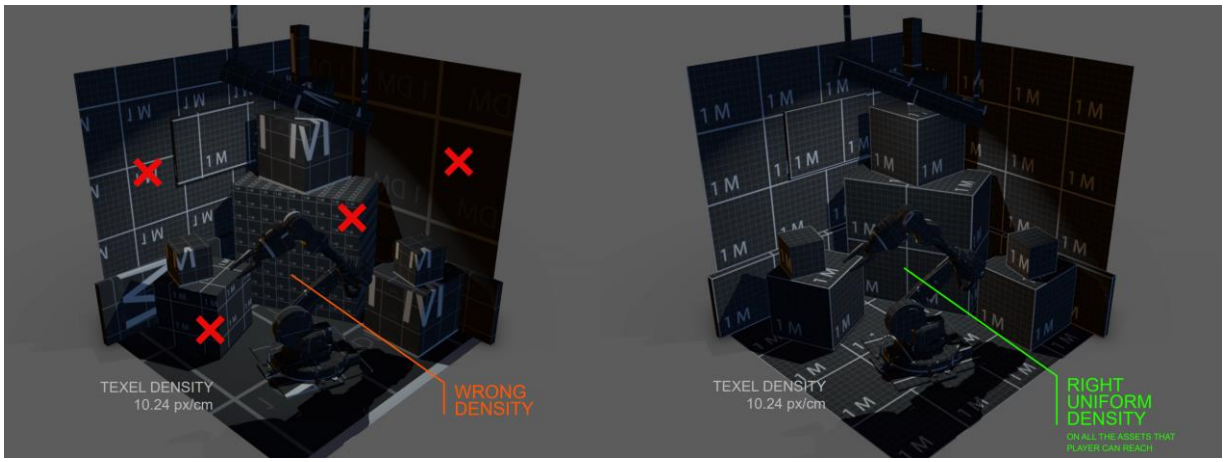

Fig.2.35 Leonardo Iezzi's (2016) visualisation of a checker image with correct and incorrect texel density

2.13 Do PBR and Photogrammetry Endanger Artists?

It is easy to assume that the automation of prop, environment or character creation in 3D games causes panic to employees in the games industry. Like automation in any industry, the thought of being replaced by a machine might scare the employees of companies. The reduced amounts of time and money needed for the creation of game ready models can easily be a reason for the change of artistic pipelines, reducing the number of artists in a team needed to work on a game.

In the games industry, however, photogrammetry is a relatively new technique that has been adopted in order to speed up the development process. In 2015, Star Wars: Battlefront was released, and it was revealed that for some scenes the game art team created 8 different looking planets using the technique. Photogrammetry can save money for publishers by cutting down development time as the process relies on less artistic effort. This in turn allows artists to focus on other tasks, increasing the overall production of art assets (Hall, 2016).

DICE held a poll within the environment team of Star Wars: Battlefront asking about the average number of days spent on the creation of an asset (see Fig.2.36). At a GDC talk in 2016 about photogrammetry, Kenneth Brown stated that using photogrammetry was faster for them and that they felt that as they go along and become more experienced at it, they develop better techniques. He expects that going forward, the team's use of photogrammetry will be even more efficient. As seen from the illustration below, by introducing photogrammetry the time taken for the team to create high poly models and re-topologize them was reduced from eight days to three.

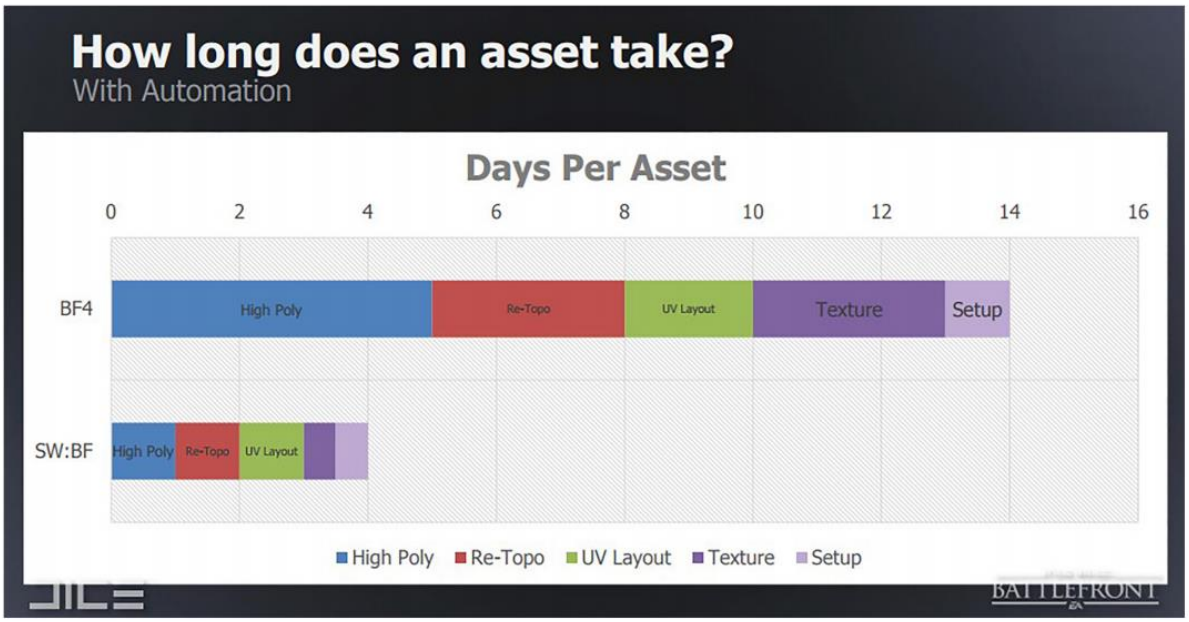

Fig.2.36 Showing the statistics from DICE's GDC talk. Hamilton and Brown 2016.

Pfeiffer interviewed creative professionals for Adobe to help understand the role of technology in those professionals' lives. Pfeiffer's report states that "Creativity is human, and it is social. And, not to forget, creativity is based on vision, connection and empathy" (2018, p.22). He goes on to explain how he believes that those aspects are the reason AI will not be able to replace human work.

The future of AI and creatives could look more like a collaboration where creatives use the help of AI and technology to mitigate tedious tasks and encourage creativity by stimulating ideas. Living in a world where people use AI to perform mundane tasks is not too far-fetched an idea, with all the work that is being put into making technology ‘smarter’. It is normal for developers to like some tasks more than others, just like with any job. As discussed, with photogrammetry, even though a software and a camera are used for the creation of assets, human input is still necessary. With the need for better and bigger video games, larger teams and more work will be needed, therefore companies might find themselves struggling to pay everyone. With automation, more jobs will be available, and creatives can focus on putting more detail into other parts of their games.

Moreover, while the development processes of games and film may differ, the role of the artist is similar in the processes. The convergence of the industries in terms of art, as well as the shrinking limitations of polygon budget in games and texture resolution size may encourage better work opportunities for 3D artists in both sectors.

2.14 Multimodal Contributions to Realism

So far some of the disciplines within game development have been considered, however the term ‘multimodal’ still needs to be discussed. Darzentas et al. (2015) describe how achieving higher levels of immersion and engagement within a game world is possible through multimodal interfaces. These multimodal interfaces aim to satisfy multiple sensory functions, audio, and touch for example rather than just the visual.

Games are not made by just artists and there are other sectors which play a crucial role in portraying realism within the gameplay such as design, sound, animation and writing, as well as others.

Video game designers, according to Baldwin (2006) focus on “creat[ing] a universe, and the items in it with which the game player will interact to create interesting entertainment and story”. He therefore claims that the designers in games create the layout of levels, focusing on how the game world operates, and develop mechanics and systems which make the gameplay more entertaining. Designers must have an understanding of what will be beneficial for the game they are making. The game world and the way everything works within it must make sense to the player and be entertaining at the same time. Along with artists, they make sure that the scale and nature of objects in the world are represented correctly and create obstacles which feel natural for the environment. Often teams would go to real life locations to photoscan objects which can be used in their games as mentioned in the Hellblade

Development Diaries (2014). This allows for the designers and environment artists to consider possible variations of the game world and together plan the game world interactions.

Hearing is one of the perceptual functions that humans need to experience to find their surroundings more believable, therefore making sound designers crucial in the creation of realistic video games. Antoniades (2016) describes how in order to achieve realistic water dripping sounds as well as authentic echo in a cave environment for Hellblade: Senua's Sacrifice, the team went to real life locations to record sound from caves.

Recalling the 'uncanny valley' phenomenon, movements must appear right and possible to the gamer, to ensure the consumer of a game is not taken away from the immersion and believability. This is why motion capture has been heavily popularised in games, not only in those which attempt to achieve realism, but also in stylised ones as well.

Last but not least is the narrative proposed to the player. It is necessary for the player to feel connected so thate they can relate to the character. Foltz (2019) suggests that people find it easier to care about things that we can relate to, therefore, to have a believable experience where the player can connect to the player character, they must feel relatable.

Fast paced games, which do not allow for the player to get attached to their character, can offer a story which is shared with the player throughout gameplay. Game studios find a way to immerse players into their game by offering out of the game experience like comics, short story related video, etc.

2.14.1 Total realism[11]

This study has so far discussed realism, the different types of art styles, and what helps to make games appear realistic overall. Humans however, inherently like to push at the boundaries of their discoveries to see what more can be achieved. So, what would that mean for video games?

Total realism is a term with many potential interpretations. The data found with the focus group and qualitative questionnaires (see Chapter Five) proved that the participants have different opinions on the matter, meaning that different players have different beliefs and understanding of realism. Some believed that games would need to satisfy all the senses that humans can experience to be able to achieve it. Chalmers and Debattista (2009) support this opinion. They believe that "our perception of an environment is not only what we see, but may be significantly influenced by other sensory input, including sound, smell, touch, and even taste". They go on

to elaborate that “results from preliminary studies have shown [...] the introduction of smell does indeed increase the user’s sense of ‘presence’ in the virtual environment” (2009). They also explain that “to achieve true physical accuracy for each of the senses individually for any complex scene in real-time is simply beyond the ability of current standard desktop computers”.

2.15 Summary

In summary, this literature review examined milestones in the history of video games to help understand their evolution. The timeline provided in Section 2.1.3 set a base for understanding the evolution of games and why the discussed topics in Sections 2.7 to 2.13 are important. Some neurological reasons behind gamers’ subconscious needs to play games were also discussed in the sections from 2.3 through 2.5. A discussion about the threat which automation of the industry may pose to game developer jobs was also included.

While the literature review merged these topics to help create a thesis which examines why a level of realism may be an important ingredient for every game regardless of the art style or genre, the next stage of this work is just as important. The methodology and data collection will further examine the issues by providing gamer and developer opinions on the subject matter. This will enrichen the existing literature by supporting or refuting the information established so far.

Chapter Three

Methodology

3.1 Introduction

This chapter explores the methodological strategies undertaken to ensure that the project meets the stated aims and objectives as defined in Chapter One. As a reminder, the research questions are:

1. How can realism be enhanced within a video game environment?
2. Does the automation of video game art creation pose a threat to creatives?
3. Is achieving realism the future of video game art?

This research addresses the issue of the perception of subjective realism in video games. This will be delivered by considering a series of projects that include the making of texture maps and materials to clarify their importance in one of the discussed topics, Physically Based Rendering (PBR).

Whereas **Chapter Two** examined ways in which realism can be enhanced in video games in this context of the objectives of the research, this chapter lays out the structure of the applied methodology and considers how the primary data collection will be undertaken. The different sections of this chapter now present the methods and procedures used in this project, and the rationale behind the methodological choices made by the researcher.

3.2 Focus of the Research

The purpose of this research project is to explore how people who play video games and individuals working in the games industry perceive realism in video games. By aiming to understand how the evolution of game art in game development, and how far games have come in terms of achieving realism, the project mainly focuses on the artistic side of the subject matter. Following this, the research also will explore in greater depth the requirement for believable visuals. This will be achieved by presenting personal projects in the form of examples, academics' research, and professionals' experience, in the area of 3D game art as an example.

As discussed previously in the research, realism in video games is a subjective term, which different people perceive differently. Chapter One therefore sets the aims and objectives of this research study and proposes the structure of the project.

In terms of technology and industry standard pipelines and workflows, the literature review in Chapter Two has discussed whether automation in the industry poses a threat to creative professionals and to future job positions and roles within the industry. This project consequently needs to investigate what helps visuals to appear realistic, and how much further, in terms of believability and realism, video games can be pushed to achieve “full immersion” (Hall 2019).

In conjunction with this, this research observes the effects total realism (a resemblance so close to the real world that makes games hard to distinguish from reality) has had on gamers, and the games industry. The future of gaming consoles and VR systems like Oculus will be discussed with game industry professionals, to help understand if further immersion is possible, and how long it might be until hardware manufacturers start developing such systems.

3.3 Summary of Primary Research

The primary research of this project takes into consideration game developers’ opinions on the subject matter of 3D art in games. This enriches the academically available literature by providing additional data relating to the topic. The primary research undertaken will examine the following overarching themes:

1. What game developers and gamers consider to be realistic in video games.
2. Whether game developers and gamers believe realistic visuals are enough, or if more is necessary to achieve success.
3. Whether game developers and gamers believe it is possible for games to achieve total realism.
4. Whether game developers and gamers believe that they each perceive realism in games in different ways.

3.4 Philosophical Basis

Identifying the perceived future of video game art and understanding why realism in gaming is favoured by gamers and developers, requires understanding their thought processes, opinions and beliefs which is achievable through employing a qualitative form of research.

Interpretivism can provide a philosophical basis to help form theories from the collected data. As Saunders et al. (2016, p.140) clarify, interpretivism in research projects helps create meanings by identifying subjective perspectives and emphasising on human participants. Realism in games, as a term, shapes a highly subjective concept, therefore allowing for different opinions to be formed depending on the individuals' understanding of the concept.

Moreover, this project will benefit from finding "new, richer understandings and interpretations of social worlds and contexts" (Saunders et al. 2016, p.140) by conferring with individuals from different social and cultural backgrounds who have different experiences with the subject matter. There will be two main groups which this research will investigate: the first one consisting of video game developers and the second one of gamers.

3.5 Research Approach

The research project focuses on finding data through the use of qualitative questionnaires and a supporting focus group discussion. The collected data is analysed through an inductive approach for theorising and conceptualising possible outcomes and understanding the nature of the subject matter. As Saunders et al. (2016) confirm, in an inductive inference process, known premises can be used to generate untested conclusions to form a conceptual framework which will be the output of this study.

3.6 Research Design

Both developers and gamers are important drivers of the games industry, consequently the study focuses on how both game developers and gamers perceive realism in video games, with emphasis on visual perception.

Finding out how gamers from various generations perceive visual fidelity within games will help to identify whether the age of gamer participants determines any particular opinions in the subject area of 3D game art. As well as this, a comparison will be drawn to understand if there are differences in the views between game developers and gamers themselves.

3.7 Research Method and Strategy

The project uses a multi-method qualitative approach to collect the data. The two questionnaire methods being used are the qualitative questionnaires and the focus group (Fig.3.1). The first qualitative questionnaire surveyed game developers to determine their thoughts and views on realism in 3D game art and will be undertaken using the JISC online questionnaire service. An online conference call-based focus group discussion was then undertaken with gamers to identify their thoughts and views on the topic. Having established two sets of potentially different views from game developers and gamers, a further qualitative questionnaire was provided to the gamers to validate the focus group findings, and to extend understanding to a deeper level.

Fig.3.1 Personal creation: data collection plan

3.8 Question Development

The qualitative questionnaire for game developers were informed by themes and trends that were revealed by the literature review and correspond to the overarching themes identified in Section 3.3.

The questions asked during the subsequent online conference focus group discussion were derived from the industry employee questionnaire. To provide a point of reference, the participants were also asked to watch a short YouTube video, displaying four different pre-recorded games (two indie games and two AAA games). The games chosen were the following:

- Marvel's Spider-Man (Insomniac Games 2018)
- God of War (SIE Santa Monica 2018)
- A Plague Tale: Innocence (Asobo Studio 2019)
- Everybody's Gone to the Rapture (The Chinese Room 2015)

These games were selected based on availability as well as on online reviews from video game and entertainment media websites such as Gamespot, IGN and Steam and YouTube

video game news channels like ‘gameranx’ and ‘PlayStation Access’. The games for this study had to provide a realistic visual setting and make it difficult to point out immediately whether they were developed using a high or a low budget.

The qualitative questionnaire for gamers included questions informed by the results of the earlier game developers’ qualitative questionnaire, integrated with the focus group findings.

3.8.1 Participant Recruitment

The game developers were recruited through personal and professional contacts, supported by advertising using social media. A total of 8 game developers were recruited for the qualitative questionnaire. A similar method for recruiting the gamers was employed and a further 8 gamers were recruited of which 2 participated in the focus group, and 6 participated in the qualitative questionnaire.

3.8.2 Sampling

Each of the participants chosen to partake in the qualitative games developer questionnaire was picked out with the requirement that their personal specialty in the industry is either in the area of art, animation or design and that they currently work in the video game industry. This ensured that the participants have a good understanding of how the visual side of video games works, thus being able to provide more in-depth answers. This is therefore a non-probability purposive (judgemental) sampling method based upon a largely homogenous population.

Participants both for the focus group and qualitative gamer questionnaire were also selected using a non-probability purposive (judgemental) sampling method based upon a largely heterogeneous population. In this case the population had clear definitions based upon age, and level of game playing. The age groups were defined based upon eighteen to thirty-five years of age, or above thirty-five years of age.

3.8.3 Ethical Considerations

The sample of participants taking part in this project are considered not to be vulnerable and of no risk because of the project’s requirements (even taking into account data collection was undertaken during the COVID-19 pandemic). This includes:

- No face-to-face communication, for health and safety reasons due to COVID-19.
- No video recording or photos of the participants, to protect their identity.
- Option for anonymity or pseudonymization of the participants’ names.
- No sensitive information for the participants was required or included (sexual activity, drug use, criminal activity).

- No administration of drugs or other substances for the success of the data collection.
- No harmful, invasive or intrusive procedures throughout the process.
- Only audio recording and written opinions and views of focus group participants required and only during the event.
- Only written opinions and views from the qualitative questionnaires were requested.
- The participants could withdraw at any point without giving a reason.
- The participants were asked to join the project without any pressure or inducement.
- Participants had to be over the age of 18 to be included in the study.
-

Undertaking the data collection was possible due to receiving ethical permission for Bournemouth University Ethics Committee[1].

3.9 Time-Horizon

A cross-sectional time-horizon was chosen for this research project as there is no necessity to observe the development of theories and ideas of the participants over time. The reason for this is that opinions and views of the participants may change or develop over time, and this research focuses on finding their initial thoughts on the subject matter. The qualitative questionnaires, along with the focus group, were chosen to collect data which will represent a snapshot in time regarding the views and opinions of the participants, and the questions were asked in a manner that they do not encourage the need to revisit responses in the future.

3.10 Data Analysis Approach

This project will employ the approach of Recursive Abstraction for the data analysis from both qualitative questionnaires, and also from the focus groups (Polkinghorne and Arnold 2014). The Recursive Abstraction method will enable the research to identify patterns and trends within the qualitative data.

3.10.1 Ensuring Validity and Reliability

To remove researcher bias, open ended questions have been used in both the qualitative questionnaires and also in the focus group. Participants have been able to complete the qualitative questionnaires at their leisure, from within their home environment, and without any pressure or influence from the researcher. The focus group was recorded to ensure that all

[1] under ethics ID: 33373 and 31769.

relevant comments were captured which has further reduced researcher bias and influence (Saunders et al. 2016).

Questions within both qualitative questionnaires were independently reviewed in a pseudo pilot exercise, before release to participants, to ensure that each question was understandable and unambiguous.

Chapter Four

Data Collection and Analysis

This Chapter presents and discusses the data collection and analysis process.

4.1 Data Collection

As previously detailed in Fig 3.1, data collection was performed in three phases conducted in a serial manner. This serial approach allowed for the second and third stages to include ideas derived from the first phase. In each case, overall descriptive data was collected based on the occupation of the participant (plus age in the second phase).

To anonymise the identity of the individual participants, each one had a random number assigned to their answers, irrespective of when they completed the qualitative questionnaire. As well as this, for the combined gamer data from the focus group and gamer qualitative questionnaire, each participant was also given the numbers 18 or 35 depending on their age group, (i.e 1235 or 1218).

4.1.1 Phase One

During Phase 1, a qualitative questionnaire was used for the data collection process. The eight chosen participants were video game developers working in different game development roles in their studios (art, animation, and design). The participants were asked questions regarding their views and opinions on the overarching themes of this research project (defined in section 3.3). Data collection started in May 2020 and ended in August 2020. The following questions were included:

1. How would you define realism in video games?
2. Do you think realistic visuals, sound and animation contribute to a game's success and if so, why?
3. Do you believe games can reach total realism? And what would that mean:
4. Do you think developers and gamers perceive realism in video games in different ways and if so, why?
5. Has there ever been a game released that impressed you with how close to life it looked? If so, what game was it and what year did it release? (If you are not sure about the release date, just state the name of the game)
6. In your opinion, what drives and impacts the decision to choose either hand painted or computer-generated materials in games?

7. A lot of games that release nowadays strive to appear as visually realistic as possible. Do you believe there is a reason for this?
8. Do you think that realism in games is achievable through art alone or do you feel that games require more than just visuals to be realistic?
9. How would you say the role of the animator/artist/designer as a developer has evolved with the evolution of games?
10. What would you say defines ‘good’ environment art in a game?
11. Do you believe that visual realism is what the future of video games holds? If yes, then why / If no, then why? (This question is a follow up to 7.)
12. Is it important for environment artists to work closely with and learn from designers and animators? What can they learn from them?
13. Tell us about a realistic piece you have worked on. What techniques did you use to achieve it?

4.1.2 Phase Two

Phase 1 required that gamers watch an online video of video games that were pre-recorded and streamed during the event. The event was held using online video conferencing software (Zoom) on 29th August 2020 and the pre-recorded video was linked through YouTube: (https://www.youtube.com/watch?v=eGzMzLp2xgk). Additionally, the two participants taking part, one from the 18-35 and the other from the 35+ age group were asked a set of questions regarding the video:

1. What are the first differences between the AAA games and indie games that you noticed?
2. How would you compare the indie games to the AAA ones?
3. Do you think any of these games are more believable than the others?
4. What are the first differences between the indie games that you saw?
5. Which game/s did you think looked most convincing, believable and close to life?
6. Do you think an art piece on its own can be considered realistic? (for example, a prop or a single model) Why?

In addition, questions about their opinions, beliefs, and views on realism in video games were asked:

7. How would you define realism in video games?
8. Do you think realistic visuals, sound and animation contribute to a game's success and if so, why?
9. Do you believe games can reach total realism? And what would that mean?

10. Do you think developers and gamers perceive realism in video games in different ways and if so, why?
11. Has there ever been a game released that impressed you with how close to life it looked? If so, what game was it and what year did it release? (If you are not sure about the release date, just state the name of the game).
12. A lot of games that release nowadays strive to appear as visually realistic as possible. Do you believe there is a reason for this?
13. Do you think that realism in games is achievable through art alone or do you feel that games require more than just visuals to be realistic?
14. What would you say defines 'good' environment art in a game?
15. Do you believe that visual realism is what the future of video games holds? If yes, then why / If no, then why?

4.1.3 Phase Three

Phase 3 was the confirmation phase of Phase two. Individuals who were not able to take part in the focus group agreed to state their opinions and views on the same questions as the focus group participants to add to the data collected from the participants in the focus group. The six participants chosen for this phase were chosen based on their age resulting in an equal number of participants representing each previously identified age group, i.e. 18-35 and 35+.

At the end of this Phase, all the acquired data derived from the collection process in Phases 1, 2 and 3 were reviewed, and compared, regarding the game developer and gamer opinions.

4.2 Data Analysis Process

This data analysis process section considered the steps that need to be undertaken to identify the patterns and trends within the qualitative data collected.

The process used for this data analysis is Recursive Abstraction which (see Fig 4.1) is undertaken in six defined steps (Polkinghorne and Arnold 2014). It can then be repeated to collapse the data to identify emerging patterns and trends. To achieve this, that data is collected, paraphrased, and then coded within emergent themes.

Recursive Abstraction is particularly applicable to analysing the data from qualitative questionnaires and from focus groups (Polkinghorne and Taylor 2019).

Through this method it was anticipated that the opinions of game developers and gamers would become apparent. Differences in opinion may also become obvious, and the opinions and views of game developers regarding their perception of realism in video games, and what might the future of video games look like, will be considered. Furthermore, the responses from gamers will be used to validate the outcomes from the focus group.

The six-step recursive abstraction process has then been separately applied to the data collected in Phases 1, 2 and 3 of this research study.

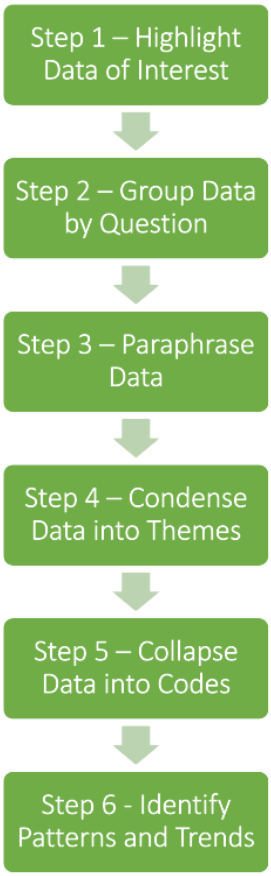

Fig 4.1 Six Step Process

4.3 Analysis: Game Developer Qualitative Questionnaire

Details of the six-step recursive abstraction process being applied can be located in Appendix C.

In Steps One and Two the relevant data was extracted from the qualitative questionnaire and grouped into questions. Examples of the types of data being extracted in Step One are detailed below:

- Games are approaching visuals that are hard to distinguish from reality as perceived by a camera or human senses
- People like to do what they cannot do in real life
- Technology is going to keep evolving to allow for more visually realistic games
- Games could be made to be 100% realistic, but would limit themselves in terms of gameplay
- The art of a game should help to ground the player in the world that the game presents

- People are attracted to shiny things, and to complexity

In Step Three of the process, data was paraphrased based upon the output of Steps One and Two. Examples of the types of data being extracted in Step Three are detailed below:

- Visually true to life art style
- Games are escapism and fantasy fulfilment
- Limitations are slowly shrinking
- Game must be fun, otherwise it will not be successful
- Harmonised visual and gameplay design
- People are attracted to complexity

In Step Four of the process, data is grouped into initial themes. Examples of the themes being applied in Step Four are detailed below:

- Total Realism
- Visuals Success Factor
- Detail
- Drive for Realism
- Realism/ Believability
- Detail (environment art)
- Techniques for realism

In Step Five, the data is collapsed into codes. Examples of this are detailed below:

- Visually true to life art style → Mimicking Life
- Games are escapism and fantasy fulfilment → Escapism / Fantasy fulfilment
- Limitations are slowly shrinking → Limitations are shrinking
- Game must be fun, otherwise it will not be successful → Require more than visuals
- Harmonised visual and gameplay design → Harmonised visual / gameplay design
- People are attracted to complexity → Complexity / detail excites

The final Step 6 of the process brings the data together, along with the codes and the themes, into a single combined (Table 4.1) from which apparent patterns and trends can be identified.

Developer Questionnaire Data									
Themes	Code	Participants							
		1	2	3	4	5	6	7	8
Realism/ believability	Immersion	x	x	x				x	
	Mimicking real life			x	x	x	x		x
	Harmonised visual and gameplay design	x	x	x	x				
	Photo-realistic visuals					x	x		x
Total realism	All senses must be considered	x	x	x		x			
	Close to but not 100%	x	x	x			x	x	x
	Limitations are shrinking			x		x		x	x
	Visual realism will remain highly used					x	x		
	Games are escape from reality		x		x		x		x
Visuals success factor	Visuals contribute to success	x	x			x	x		x
	Require more than visuals	x	x	x	x	x	x	x	
	Need of alternatives to similar looking games	x		x	x				
	To appear cinematic						x	x	
Detail	Complexity/detail excites		x		x	x			x
	Devs spot subtle flaws because they work with detail	x		x	x		x		x
	What is achievable from the developers	x	x						
	Gamers presume realism		x	x	x			x	
Detail (environment art)	Focus on storytelling and mood	x	x		x	x	x	x	
	Consistent style (matches/ heightens the game vision)	x		x	x	x	x	x	x
	No unwanted confusion	x		x	x	x	x	x	x
“Wow” factor of realism (year)	2020 (Last of us/ Flight Simulator)	x	x	x	x		x	x	x
	2019 (COD Modern Warfare/ Death Stranding)						x	x	
	2018 (Red Dead Redemption 2/ FIFA)				x		x		
	2013 (Last of us/Tomb raider)						x	x	
Drive for realism	Budget	x	x	x		x			x
	Benchmark	x	x	x	x		x	x	x
	Technical limitations	x		x			x	x	x
	Down to the developer				x	x	x		x
	Games: complicated/ require more from developers		x		x		x	x	x
Techniques for realism	Real world reference	x		x	x		x		
	Documentation with key information about the subject	x		x					
	Simulation of realistic physics				x			x	x
	Utilisation of PBR						x	x	
	Photogrammetry			x				x	

Table 4.1 Game developer data collected and analysed.

4.4 Analysis: Gamer Focus Group

The data analysis process for the Gamer Focus Group followed the same overall steps, even though there a different data collection procedure had been employed. The full breakdown of the process can be seen in Appendix D.

During Step One, it was ensured that all essential data was highlighted in the transcript and extracted. Illustrative examples of this extraction process are provided below:

- "Partly, something you want our game to do, is to do things that you can't do in the real world, because you can't afford to do that sort of thing, because of the laws and morals that we set and that sort of thing."
- "One of the things I picked up on was possibly the difference between light and dark. The darker scenes, It was kind of less that I felt there was less difference. The lighter scenes, like he said, reflections."
- "It's great to have gameplay systems or mechanics in the environment."
- "It still looks realistic just because all the buildings look like they could really exist, they could really be built."
- "Maybe semantics but realistic and believable are different. I don't think I'm bothered about realistic and what is believable."
- "I think it's possible today to become fully immersed in a game."

In Step Two, the data was grouped into questions which acted as pseudo initial themes:

- Games are played to escape, and fulfil fantasies
- Difference between light and dark were noticeable in terms of reflections
- Mechanics within the environment, gameplay systems
- It looks like it can exist
- Believable is more important than realistic
- Can be fully immersed in a game today

In Step Three, the data was paraphrased. Examples of this paraphrasing can be seen below:

- Games are escapism / fantasy fulfilment
- Differences in reflections
- Mechanics within the environment
- Real life equivalent
- Believability is of high importance
- Immersion fully possible today

In Step Four, the different themes were formed by collating together paraphrases on connected topics. Examples of these themes are provided below:

- Contrast
- Reflections
- Believability / Realism
- 100% realistic
- Detail
- Immersion
- Success Factor
- Devs versus gamers (on perception)

Step Five ensured repeating data codes were eliminated, and the data was condensed into the themes. Examples can be seen below:

- Games are escapism/ fantasy fulfilment → Escapism / Fantasy fulfllment
- Differences in reflections → Reflections
- Mechanics within the environment → Environmental interactivity
- Real life equivalent → Mimicking life
- Believability is of high importance → Believability over realism
- Immersion fully possible today → Full immersion presently

As seen in Table 4.2 the data analysed through the six-step Recursive Abstraction process.

Focus Group Data			
Themes	**Code**	Participants	
		9618	1735
Contrast	Differences in contrast		x
	Dark scenes had less detail		x
	Believability of light scenes		x
Believability/ Realism	Mimicking life	x	x
	Believability is related to animation, sound, level design		x
	Depth of field not actually realistic (Rapture)	x	x
	Graphically it must be believable	x	x
	Easier to relate to the characters	x	x
	Believability over realism		x
	Not as detailed as real life	x	
	Reflections	x	x
Total realism	Environmental interactivity	x	x
	Consumers and developers will keep pushing for more	x	
	100% realism will never be possible	x	x
	Escapism/ Fantasy Fulfilment		x
	Depends on supply and demand		x
	Consider all senses		x
Detail	No difference in foliage	x	
	Attention to detail in buildings and clouds	x	
	Freedom to go anywhere	x	
	Studios showing off how much they can do	x	
	Aesthetically pleasing	x	
	Automation makes it easier to create bigger worlds	x	x
	Graphics will not get much better for a while	x	
	Smooth feel of the game		x
	Expectations rise over time		x
Immersion	Fully possible presently	x	
	Indication of where the player should go and do	x	
	Visuals, sound and feel		x
Success Factor	Art is the driving factor	x	x
	Games become more cinematic	x	x
	Devs should focus on mechanics		x
Perception of games	Developing is different than playing	x	x
	Yes, especially artists	x	

Table 4.2 Gamer data collected and analysed.

4.5 Analysis: Gamer Qualitative Questionnaire

Similarly, to the previous two processes, this Gamer Qualitative Questionnaire was analysed using the six-step process which is detailed in Appendix E.

Steps One and Two were undertaken together, ensuring that the relevant data was extracted and grouped. Examples of the extracted data can be seen below:

- While all games look amazing there seems to be just a little bit more polish to the AAA games
- Any 3D rendered object can be imbued with a realistic life
- Gamers want games to be more realistic visually
- The drive for realism is to push new hardware to its limits
- There will always be demand for different styles
- If it is not fun to play it does not matter what it looks like

In Step Three the relevant data was paraphrased. Examples of the types of data being paraphrased in Step Three are detailed below:

- AAA have better visual fidelity
- A single prop can be made realistic
- Gamers require realism
- To push hardware to its limits
- There will be demand for different styles
- Gamers seek a reaction/enjoyment

Step Four helped to group the data into initial themes as seen below:

- Detail
- Believability / Level of immersion (Games)
- Drive for Realism
- Realism
- 100% Realism
- Visual Success Factor
- Wow Factor of realism (year)

In Step Five the data was collapsed into codes:

- AAA have better visual fidelity → AAA more polished
- A single prop can be made realistic → Single prop can be realistic
- Gamers require realism → Gamers require realism
- To push hardware to its limits → Benchmark
- There will be demand for different styles → Demand for different styles
- Gamers seek a reaction/enjoyment → Gameplay over graphics

In Step Six, all the data was combined and organised into Table 4.3 to reveal any apparently patterns and trends:

Gamer Questionnaire Data								
Themes	**Code**	Participant #						
		8518	5135	7235	6118	4235	1918	
Detail	AAA more polished	x	x	x	x	x	x	
	Attention to detail in AAA was apparent	x			x	x	x	
	Plague Tale has more detail than Rapture		x		x		x	
Believability/ level of immersion (Games)	Marvel's Spider Man	x	x			x	x	
	God of War				x	x		
	A Plague Tale: Innocence		x					
	Everybody's Gone to the Rapture	x		x			x	
Drive for realism	Devs believe realism will sell	x		x		x	x	
	Budget	x	x		x			
	Benchmark/ push technology to its limits	x	x	x	x			
	Further immersion		x	x	x			
	Gamers require realism	x		x			x	
Realism	Mimic real life	x		x	x	x	x	
	Immersion	x		x			x	
	Narrative/ story	x	x				x	
	Single prop can be realistic	x	x	x			x	
Total realism	Likelike physics	x	x	x		x		
	Games are escape from reality	x		x				
	Too much realism can be fun killing	x		x		x		
Visuals success factor	Realism is more than visuals	x	x	x	x	x	x	
	Demand for different styles	x			x	x	x	
'Wow' factor of realism (year)	2020 (Ghost of Tsushima)				x			
	2018 (Spiderman/ Far Cry 5/ Red Dead 2)	x	x					
	2016 (Uncharted 4)					x		
	2011 (Skyrim)				x			
	2007 (Uncharted)						x	
	2004 (Half Life 2)			x				

Table 4.3 Gamer qualitative questionnaire data collected and analysed.

Chapter Five

Findings

This chapter will consider the data collected and analysed in Chapter Four, to establish what patterns and trends have been revealed, and to interpret what these factors may indicate, which will enhance our understanding of the perception of realism in video game art.

The chapter will explore the data collected from the qualitative questionnaire undertaken with games developers, the focus groups undertaken with gamers, and then the qualitative questionnaires undertaken with gamers. Finally, the chapter will integrate these results together to reveal an overall picture of understanding which will contribute towards answering the research questions of this study.

5.1 Findings from the Game Developer Qualitative Questionnaire

The first experiment in this research study consulted game developers with different development specialisations. Overall, the responses from the game developers demonstrated a wide range of different perspectives with only approximately 50.0% agreeing on any one individual topic.

Table 5.1 shows the data derived from the developer questionnaire for the theme of Realism and Believability. From this data it is possible to identify that five out of eight game developers interviewed believe realism in video games can be achieved through mimicking real life. As stated in the Literature Review (Chapter Two), to be able to relate to a specific phenomenon, one must be able to understand it, and to understand it one needs to have experience of it. Real life, however, can be very complicated, and technology may pose restrictions on the developers which limits their ability to achieve this complexity.

Half of the participants also commented on the way they perceive realism and how immersion is crucial when trying to represent believable worlds. Naturally, immersion makes people feel more connected to different concepts, other people and phenomena. As discussed in Chapter Two, being able to encapture the player into the game is necessary for all types of games, regardless of their style, genre or type.

As well as immersion, half of the game developers commented that for a game to feel believable and realistic, the mechanics and overall design should be harmonised with the

visual design of the game. In sections 2.14 the importance of development roles within the creation of games were discussed and these findings support this.

In this case, the collected data could point us to the assumption that no single developer role, or concept of games, is more significant than others in the making of games and it is only through the combined efforts of all specialists that realism in games is achievable. Subsequently, in support of this assumption, only three of the game developers believed that photo-realistic visuals are crucial for a game to be perceived as realistic and believable.

Overall, participants 1, 2 and 3 all agreed that immersion, and harmonised visuals and gameplay are crucial when trying to convey realism to the player. Conversely, participants 5,6 and 8 believe that to represent realism in video games, developers must focus on creating game worlds which mimic real life and have photo-realistic visuals. This dichotomy suggests that either immersion and harmonised visuals are considered as important by the game developers or mimicking of real life and photo-realistic visuals are important, but not a combination of all of them.

Developer Questionnaire Data									
Themes	Code	Participants							
		1	2	3	4	5	6	7	8
Realism/ believability	Immersion	x	x	x				x	
	Mimicking real life			x	x	x	x		x
	Harmonised visual and gameplay design	x	x	x	x				
	Photo-realistic visuals					x	x		x

Table 5.1 Developer qualitative questionnaire data. Full table can be found in Appendix C.

Considering the limitations of technology, as described in Table 5.2, half of the participants have mentioned that they believe the restrictions which technology imposes on game development are diminishing with the rapid advancement of both the software and the hardware available to game developers and game players' technology. As mentioned in the literature findings throughout this study, game companies aim to produce powerful computer and technological components which focus on processing the overall complexity and sophistication of current generation video games. Consequently, believing that visually and technically games will keep progressing until they reach realism indistinguishable from reality is not too improbable a belief. With the advancement of technology, it is also possible that in the near future gamers will be able to experience video games through other senses than just sight, touch and sound (hearing). As discussed, video games acknowledge and learn from the film industry, which has already experimented with concepts like smell, taste and better sense

of touch. Although games are not streamed in theatres, seats which allow players to feel as if they are in a car already exist.

Currently, as discussed in Chapter Two, PS5 DualSense controllers utilise adaptive or haptic triggers, which enable players to feel the resistance of weapons and other gameplay features during play. Gamers are yet to experience full body sense of touch; however, this may be possible in the future with the attention that is being paid to immersion. Companies which specialise in delivering games with a more complete sense of immersion for players are constantly looking into new and better ways to bring improved technology to help with that.

Furthermore, half of the participants believe that to achieve total realism in games, all senses that humans experience must be considered as satisfied in some way. As discussed in the literature review, games are only able to currently satisfy a few senses, but it seems very likely that more will follow as technology develops.

On the subject of the possibility in which video games become fully realistic (Table 5.2), six out of eight of the participants said that they do not believe games will ever, or at least not in the near future, reach full realism. It is one thing to consider realism in games in the sense of motion and graphics, sound and narrative, however, to be fully realistic, games must evolve into a new medium. As discussed in the literature review, games present the players with the opportunity to experience new concepts, worlds and interactions. If games were able to reach a level of realism where the player would no longer be able to distinguish reality from gameplay, this could potentially result in monotonous player experience as games are commonly used as an escape.

In Section 2.13 it was discussed that automation of game developer pipelines and workflows, poses a risk to job opportunities especially for artists if the situation does develop where machines and AI begin to replace artists. In this section it was also discussed that photogrammetry and PBR are some of the main approaches which concern artists worried about their future role. The data detailed in Table 5.2 shows that only two of the developer participants in the qualitative questionnaire believe that visual realism will continue to be highly used. Since the approaches are currently used mainly in the creation of realistic graphics for games, this could mean that job opportunities for artists will still be available in the future. Automation in the industry could suggest that the approaches used to create realistic visuals could be made faster and easier with the help of AI, while on the other hand, abstract and stylised approaches might witness an increase in popularity from the player base.

Also, in Table 5.3, it is revealed that participants 1, 2 and 3 seem to agree on the topic that games will never reach a level of realism which is indistinguishable from reality unless they manage to satisfy all senses that humans can experience, as discussed in Chapter Two. Participants 2 and 6 stated that games will not reach full realism and moreover they should not make the attempt, as they are made to be experienced as an escape from reality. On the other hand, developers 7 and 8 believe that while games may not reach full realism in the near future, the limitations imposed on game developers are diminishing, which could imply that they believe full realism is possible in the far future, although there was no confirmation for that claim. The overall sentiment in table 5.2 appears to be that while we are not able to achieve full realism in the current state of technology, there might be a way to achieve a greater proximity to it in the future.

An interesting further observation is that participants considering that limitations are shrinking, do not agree that games are an escape from reality and *vice versa*. This could possibly be because, to them, games have already achieved what they need to, in being a form of escapism and limitations in terms of software and hardware are not taking away from that.

Developer Questionnaire Data									
Themes	Code	Participants							
		1	2	3	4	5	6	7	8
Total realism	All senses must be considered	x	x	x		x			
	Close to but not 100%	x	x	x			x	x	x
	Limitations are shrinking			x		x		x	x
	Visual realism will remain highly used					x	x		
	Games are escape from reality		x		x		x		x

Table 5.2 Developer qualitative questionnaire data. Full table can be found in Appendix C.

Table 5.3 presents the theme of the success that visuals bring to video game sales. Here, five of the participants agree that visuals for games contribute to the overall success of a game, however seven of the eight developers agree that, for the success of a game, more than visuals are necessary. Furthermore, they require more than graphics to be considered successful and, as discussed in Chapter Two, it is necessary for games to have engaging gameplay mechanics and captivating narrative, combined with fitting sound design and a well programmed game is consequential.

Only three of the game developers stated that they believe gamers will need alternatives to games which try to represent the real world visually. Perhaps this suggests that the other five developers believe there are already enough alternatives to realistic looking games. As

discussed in Section 2.1, the video games market is already presenting gamers with multiple genres and art styles. It is possible that the developers believe there are already many viable options which gamers can choose from and that realism in games is something that can be studied further. As seen in Table 5.4, four of the game developers believe that the complexity of realism in games is still fascinating to gamers and that they are still intrigued by how far games can push realism.

Participants 1, 2, 5 and 6 agree that while visuals contribute to the success of video games, they require more for what is considered as successful sales. As examined in Chapter Two, and confirmed in Table 5.1, games require compelling narrative and authentic in-game interactions.

Participants 6 and 7 believe that while video games require more than visuals for them to be successful, cinematic environments in games help gamers relate to in-game interactions and gameplay in general. The reasoning behind this could be that cinematic visuals are familiar to film enthusiasts, allowing for them to become easily accustomed to video games.

It should also be noted that the participants who consider that visuals are the driving factor for success, do not consider that there is a need for alternatives for similar looking games and *vice versa*. The possibility in this case could be that they believe visuals are what distinguishes some games from others. Moreover, they could be implying that there will always be developers working on different art styles and genres, and therefore gamers would not need to worry about being able to find different games in terms of visuals.

Developer Questionnaire Data									
Themes	Code	**Participants**							
		1	2	3	4	5	6	7	8
Visuals success factor	Visuals contribute to success	x	x			x	x		x
	Require more than visual	x	x	x	x	x	x	x	
	Need of alternatives to similar looking games	x		x	x				
	To appear cinematic						x	x	

Table 5.3 Developer qualitative questionnaire data. Full table can be found in Appendix C.

Table 5.4 highlights that the developers consider themselves to be more critical when it comes to attention to detail within game environments. They believe that gamers are more focused on a single task at a time throughout their play through. Furthermore, without generalising, they believe a large number of gamers do not pay attention to the models in game as much as a game artist might do. The developers shared that they believe artists tend to focus on

achieving accurate representations of concepts given to them (or based on real life references) which was also discussed throughout the literature review. This does not mean that gamers do not appreciate the visuals of a game, in fact the developers taking part in the research shared that they believe gamers perceive games on a different, if not, higher level. Meaning that gamers have a lot more than just the in-game models to focus on during play and often, the objective of gameplay would take them away from characters, environments and props. In addition to that, as can be seen in Table 5.4, half of the developers believe that there is a natural trend towards complexity, be it visual or gameplay related.

As for visual fidelity, the game developers believe that for them, it is fascinating to study how realism would be represented in a video game. They believe that while visuals are not the most important part of video games, experiencing higher forms of reality through them must feel significant for the gamers and it is why developers focus on representing reality with precision.

Only two of the game developers stated that they believe the amount of detail put into a game is highly dependent on what is achievable by the developers. From this data, and from the literature findings in Chapter One it is possible to derive that detail takes memory and graphics power from a console or a PC in order for it to be displayed on screen. It is probable that developers believe it is not only dependent on their own abilities to depict complexity, but also on whether current generation technology can cope with it.

As seen in Table 5.4, developers 3 and 4 believe that overall developers and gamers perceive games differently, as gamers presume realism rather than having to create it. Developers 3 and 4 said they think developers focus on representing the complexity and the detail which realism presents and gamers simply presume. This adds to the statements and ideas presented in Sections 2.3.4 through to 2.8, by supporting the claims that developers must pay attention to detail in the creation of models for games.

Developer Questionnaire Data									
Themes	Code	Participants							
		1	2	3	4	5	6	7	8
Detail	Complexity/detail excites		x		x	x			x
	Developers spot flaws	x		x	x		x		x
	What is achievable from the developers	x	x						
	Gamers presume realism		x	x	x			x	

Table 5.4 Developer qualitative questionnaire data. Full table can be found in Appendix C.

The developers were also asked about their opinions on what makes 'good' environment art in a game. Overall, six out of eight participants agreed that an environment in a game, no matter the art style, should focus on telling a story and set the mood, preparing the player for what is to come. They commented that 'good' environment art establishes the story of the game by supporting the narrative, which was also discussed in Section 2.4 and Section 2.5. Moreover, seven agreed that the art style of a video game must highlight the game's vision by staying consistent. 6 out of 7 developers also said that it is important for the environment and art style of games not to cause unwanted confusion to the player. The player must know where to go next during gameplay through not only on-screen UI tips, but also environmental storytelling and pointers.

Developer Questionnaire Data									
Themes	Code	Participants							
		1	2	3	4	5	6	7	8
Detail (environment art)	Focus on storytelling and mood	x	x		x	x	x	x	
	Consistent style highlighting the game vision	x		x	x	x	x	x	x
	No unwanted confusion	x		x	x	x	x	x	x

Table 5.5 Developer qualitative questionnaire data. Full table can be found in Appendix C.

When asked about their opinions on what makes studios develop visually realistic games, five of the developers stated that they believe budget is the biggest drive. The games industry, as stated in the beginning of the project, is one of the fastest growing industries, therefore, understandably, budgeting would be one of the core drivers that help it to flourish.
Budgeting in the industry can be reviewed from two perspectives: sales and development time. Sales-wise, would mean that the studio or company focuses on developing a game which they know will sell well. Often well-established franchises like, for example, Call of Duty (Activision), which has been around since 2003 may find that they can afford to develop hyper-realistic graphics as they have the comfort both from previous sales, but also the knowledge that they have already collected a fanbase over the years. Moreover, with photogrammetry and PBR in the picture, and powerful computer components, companies like Activision can cut down on development time, which can cut down on costs.

Development time budgeting covers the costs during development. Developing realistic games often means hiring motion capture gear and space, photogrammetry gear as well as software and possibly actors, etc. Finding all of these can take time for some studios and often the team members may need to be introduced to the technology, all of which takes time and development budget.

Nowadays hiring all this technical kit can be affordable, however paying wages and considering in-house costs (software, hardware and also consumables) are another part of budgeting to consider for video game studios.

Seven out of the eight developers stated that they believe a major driver for realistic visuals in video games is an opportunity for developers to showcase their artistic abilities and push technology to its limits. 5 of those 7 also stated that it is currently the power of publicly available technology which stops developers from showcasing their full ability.

When asked about their opinion on what decides in which art style games are going to be developed, half of the developers stated that it is the creative team's decision what art style the game will have. It is possible that the rest of the developers believe that gamers demand realistic visuals but also that publishers have identified that realistic art styles are more profitable and therefore they encourage developers to work on visual realism.

As discussed in the literature review, nowadays game developers are presented with not only new tools and software packages but also the ability to run those on improved hardware. five of the developers mentioned in their answers that they believe that games have become more sophisticated and complicated, making the job of the artist more demanding. This means that while there are new workflows and pipelines to help artists create artwork, overall, ever more is being required from them.

Developer Questionnaire Data									
Theme	Code	Participants							
		1	2	3	4	5	6	7	8
Drive for realism	Budget	x	x	x		x			x
	Benchmark	x	x	x	x		x	x	x
	Technical limitations	x		x			x	x	x
	Down to the developer				x	x	x		x
	Games are more complicated now/ require more		x		x		x	x	x

Table 5.6 Developer qualitative questionnaire data. Full table can be found in Appendix C.

Lastly, Table 5.7 depicts the opinions in response to the developers being asked to share techniques and methods they used in their projects for the creation of realistic and believable graphics. Taking the real world as reference, seemed to be their preferred way to achieve the closest resemblance to real world objects and organic shapes. Those who had worked on

realistic games recently shared that photogrammetry (discussed in Section 2.6) was a technique used to represent objects as close to real life as possible.

Developer Questionnaire Data									
Themes	Code	Participants							
		1	2	3	4	5	6	7	8
Techniques for realism	Real world reference	x		x	x		x		
	Documentation with key information about the subject	x		x					
	Simulation of realistic physics				x			x	x
	Utilisation of PBR						x	x	
	Photogrammetry			x				x	

Table 5.7 Developer qualitative questionnaire data. Full table can be found in Appendix C.

5.2 Findings from the Gamer Focus Group

This phase was undertaken to discover any possible ideas and trends which can later be confirmed by a bigger group of gamers. During the focus group, the participants were asked to watch a video consisting of gameplay of four games and, in addition, were asked some general questions. As seen in Table 5.8 there was no consensus between the participants on all of the codes identified through the data analysis. This could be due to personal preferences of gameplay and visuals of the participants.

Focus Group Data			
Themes	**Code**	Participants	
		9618	1735
Contrast	Differences in contrast		x
	Dark scenes had less detail		x
	Believability of light scenes		x

Table 5.8 Gamer data analysed through recursive abstraction. Full table can be found in Appendix D.

In Table 5.9 it can be seen that both the participants stated that to achieve believable realism in games the developers must focus on mimicking real life, as that is the best reference we can get for visuals. This supports the answers given from the developers in Table 5.1. As well as that, both the participants elaborated that reflections are crucial when trying to represent realism in video games. As discussed in Section 2.9.3, in real life, the surfaces of our surroundings can have many different properties. Here the focus group participants may be suggesting that the developers can capture this detail through studying real life.

Both the participants also agree that it is easier to relate to realistic looking characters in games than stylised characters. This could have something to do with the previously

discussed ‘uncanny valley’ (Section 2.3.4) and the ways in which people perceive and understand facial expressions and movements.

It is interesting that only participant 1735 mentioned that, in their opinion, believability is more important than realism and that it is through different concepts like animation, sound design and level design that developers can convey this. The reason for this could be because participant 1735 is the older one from the two and that, possibly, they have grown up with games which the other participant has not played, making participant 1735’s views more critical.

On the other hand, participant 9618 stated that they think the games shown were not as detailed as real life yet, which corroborates the concepts discussed throughout the project. There are a lot of factors which play important roles in conveying believability and realism in games and, in their current state, games can not satisfy all the sensors of perception, as discussed in Section 2.3.

Focus Group Data			
Themes	**Code**	Participants	
		9618	1735
Believability/ Realism	Mimicking life	x	x
	Believability is related to animation, sound, level design		x
	Depth of field not actually realistic (Rapture)	x	x
	Easier to relate to the characters	x	x
	Believability over realism		x
	Not as detailed as real life	x	
	Reflections	x	x

Table 5.9 Gamer data analysed through recursive abstraction. Full table can be found in Appendix D.

Table 5.10 shows that overall, the two participants are in disagreement here except for one concept, that video games will never achieve total realism. In Sections 2.3.2 and 2.3.3 of this study, the types of presence were discussed, which considered that to be able to achieve full realism, video games will have to make sure their players can be fully immersed in the game through the concept of total immersion, suggested by Cairns et al. (2014) as mentioned in Section 2.5. The participants elaborate on that by introducing the concept of environmental interactivity, meaning that players must be able to communicate and interact with their environment, just like it is possible to do so in real life.

Focus Group Data			
Themes	**Code**	Participants	
		9618	1735
Total Realism	Environmental interactivity	x	x
	Consumers and developers will keep pushing for more	x	
	Total realism will never be possible	x	x
	Escapism/ fantasy fulfilment		x
	Depends on supply and demand		x
	Consider all senses		x

Table 5.10 Gamer data analysed through recursive abstraction. Full table can be found in Appendix D.

Similar to Table 5.10, Table 5.11 illustrates another overall disagreement of the participants except for one concept. They believe that automation of the industry's workflows and pipelines would mean that bigger worlds will be easier to create. While this was discussed in Section 2.13, the gamers taking part in the focus group agree that even though automation of the industry might take on some of the existing tasks for developers, it will also make it easier for them to focus on other, more important tasks which may result in saving development time.

Participant 9618 noted that for them, attention to detail includes the freedom for the player to go anywhere in the world. The age gap in this case could mean that the younger participant is more accustomed to seeing elaborate and sophisticated mechanics in game systems, while the older participant has had the chance to view the evolution of video games form a different perspective. This is also supported by their views about the expectations of gamers on games. To interpret this, gamer 1735 could be implying that as new generations of gamers are born, so are new generations of games and consoles. Therefore, the younger gamers grow up with their generation of video games, which are inevitably improved, compared to the previous generation. This can then point to the assumption that younger generations experience games through a different perspective and their expectations are greater compared to older generations of gamers.

Focus Group Data			
Themes	**Code**	Participants	
		9618	1735
Detail	No difference in foliage (in the displayed games)	x	
	Attention to detail in buildings and clouds	x	
	Freedom to go anywhere	x	
	Studios showing off how much they can do	x	
	Aesthetically pleasing	x	
	Automation makes it easier to create bigger worlds	x	x
	Graphics will not get much better for a while	x	
	Smooth feel of the game		x
	Expectations rise over time		x

Table 5.11 Gamer data analysed through recursive abstraction. Full table can be found in Appendix D.

While Cairns et al. (2014) suggest that full realism is only possible through total immersion, they do not specify that the concept is applicable both ways, that is to say that immersion always equates to the representation of full realism. Moreover, in Table 5.12, gamer 9618 claims that currently it is possible to be fully immersed in a game. Both participants claimed that a fully immersive game leads the player through the levels by indicating subtly where they should go and what their next objective is. This agrees with the opinions of the game developers in Table 5.1 and Table 5.5. Participant 1735 added that, to be fully immersive, games must focus on the visuals and sound which should enhance the vision of the game; this is what the game developers insisted on as well, in Table 5.5.

Focus Group Data			
Themes	**Code**	Participants	
		9618	1735
Immersion	Fully possible presently	x	
	Indication of where the player should go and do	x	x
	Visuals, sound and feel		x

Table 5.12 Gamer data analysed through recursive abstraction. Full table can be found in Appendix D.

Table 5.13 indicates that both the participants of the focus group believe art is the priority in recently released games because game developers are trying to make them appear more cinematic. It is interesting to note that while both of the participants showed their agreement, only participant 1735 stated that, for them, mechanics are more important than visuals when playing games.

Focus Group Data			
Themes	**Code**	Participants	
		9618	1735
Success Factor	Art is the driving factor	x	x
	Games become more cinematic	x	x
	Developers should focus on mechanics		x

Table 5.13 Gamer data analysed through recursive abstraction. Full table can be found in Appendix D.

When asked about their views on whether they believe themselves and game developers perceive games in different ways, both participants stated that developing games is different from playing them, which supported the developer views in Table 5.4.

Focus Group Data			
Themes	**Code**	Participants	
		9618	1735
Perception of games	Developing is different than playing	x	x
	Yes, especially artists	x	

Table 5.14 Gamer data analysed through recursive abstraction. Full table can be found in Appendix D.

5.3 Findings from the Gamer Qualitative Questionnaire

To ensure the data collected during the focus group was indicative of a wider set of views, a qualitative questionnaire was also undertaken. The participants for the qualitative questionnaire were asked the same sets of questions and were provided with the same video as the focus group participants had seen previously.

Table 5.15 shows the participants of the qualitative questionnaire strongly agreeing that, from the games displayed to them, the AAA titles have more polished visuals, with 4 out of the 6 noting that they thought the attention to detail put into the AAA titles was apparent. This could be due to the fact that AAA titles have larger budgets as discussed throughout Chapter Two, meaning that they can afford more time or more development tools and developers to work on the games.

On the other hand, half of the participants also stated that they believe A Plague Tale: Innocence (2019) looked more detailed than Everybody's Gone to the Rapture (2015). It is important to note that A Plague Tale: Innocence was released more recently than Everybody's Gone to the Rapture. This information could create the impression that the team behind A Plague Tale: Innocence had better tools and technology than the team working on Everybody's gone to the Rapture.

All the participants in the age group of eighteen to thirty-five have said that, for them, AAA games look more polished and the attention to detail is apparent in them unlike in the indie games. Moreover, participants 6118 and 1918 appear to share the same views.

Gamer Questionnaire Data								
Themes	**Code**	Participant #						
		8518	5135	7235	6118	4235	1918
Detail	AAA more polished	X	X	X	X	X	X
	Attention to detail in AAA was apparent	X			X	X	X
	A Plague Tale has more detail than Rapture		X		X		X

Table 5.15 Gamer qualitative questionnaire data analysed through recursive abstraction. Full table can be found in Appendix E.

When asked which games from the four displayed to them were most immersive and believable, four out of six gamers said they thought Marvel's Spider Man (2018) was the one that stood out the most. The participants noted that the reflections and overall physics of the game felt most believable to them.

Interestingly, in Table 5.16, half of the participants said that Everybody's gone to the Rapture was another one of the games which they thought had a high level of believability to it, making it the second most preferred game, in terms of believability and level of immersion. It is possible that the gamers taking part in the study thought this game was believable, as it represents an English town which might have felt familiar. As mentioned in Section 5.1, it is easier to relate to something which we understand.

Participants 8518 and 1918, both aged eighteen to thirty-five seem to have similar views on the levels of believability and selected the same games as their preferred choice.

Gamer Questionnaire Data							
Themes	**Code**	Participant #					
		8518	5135	7235	6118	4235	1918
Believability/ level of immersion (Games)	Marvel's Spider Man	X	X			X	X
	God of War				X	X	
	A Plague Tale: Innocence		X				
	Everybody's Gone to the Rapture	X		X			X

Table 5.16 Gamer qualitative questionnaire data analysed through recursive abstraction. Full table can be found in Appendix E.

The gamers were then asked general questions, which the game developers were asked as well. Table 5.17 illustrates that four of the gamers believe that it is developers who think realistic visuals will sell well. 3 out of those 4 participants agreed that it is in fact gamers who require realism and therefore developers try to deliver to their requirements.

Gamers 8518, 5135 and 6118 agreed that developers create realistic visuals to push technology to its limits, while also focusing on realism, because they know that it will help to boost game sales because it is impressive to the consumers. This supports the findings from Section 5.1, Table 5.4 where half of the developers said they believe complexity excites the players of their games.

Participants 5135, 7235 and 6118 agree that, in their opinion, while developers focus on creating realistic games so that they can see how far they can push technology, they also do it because they are striving to reach a point of an ever-better sense of immersion in their games. It was seen in Table 5.1 that half of the game developers believe immersion is crucial in the representation of realism in games. From this one can derive that both developers and games think immersion is an important concept to consider when advertising realistic visuals.

Gamer Questionnaire Data								
Themes	**Code**	Participant #						
		8518	5135	7235	6118	4235	1918	
Drive for realism	Developers believe realism will sell	X		X		X	X	
	Budget	X	X		X			
	Benchmark/ push technology to its limits	X	X	X	X			
	Further immersion		X	X	X			
	Gamers require realism	X		X			X	

Table 5.17 Gamer qualitative questionnaire data analysed through recursive abstraction. Full table can be found in Appendix E.

Table 5.18 illustrates that five of the gamers taking part in the qualitative survey think that in order to achieve realism in their games, developers must focus on graphics which mimic real life.

It should also be noted that participants 8518, 5135 and 1918 have shared their beliefs that while a prop can look realistic on its own, in a game it has to fit into the narrative and support the story. As the developers mentioned in Table 5.5, in a scene, every single 3D model should be placed in ways in which they heighten the vision of the art style and keep it consistent. What the gamers may mean in this case is that, when multiple artists with different skill levels work on the same scene, this consistency can be broken. Consequently, a single prop placed in a scene has nothing to distract from its consistency and vision.

Gamer Questionnaire Data								
Themes	**Code**	Participant #						
		8518	5135	7235	6118	4235	1918	
Realism	Mimic real life	X		X	X	X	X	
	Immersion	X		X			X	
	Narrative/ story	X	X				X	
	Single prop can be realistic	X	X	X			X	

Table 5.18 Gamer qualitative questionnaire data analysed through recursive abstraction. Full table can be found in Appendix E.

When the gamers were asked about their opinions on the meaning of full realism[11] four of them said that for games to appear 100% real, developers and technology manufacturers would have to focus on being able to simulate real life physics. 3 out of the 4 participants agreeing on this, also agreed that if games were made to be fully realistic, then the enjoyment of video games might be lost. This was already discussed in Section 5.1 and supports the opinions given by the game developers.

Participants 8518 and 7235 agreed that games are played as an escape from reality, this consequently supports the 50.0% of game developers who consider games as escapism.

Gamer Questionnaire Data								
Themes	**Code**	Participant #						
		8518	5135	7235	6118	4235	1918	
Total realism	Likelike physics	x	x	x		x		
	Games are escape from reality	x		x				
	Too much realism can be fun killing	x		x		x		

Table 5.19 Gamer qualitative questionnaire data analysed through recursive abstraction. Full table can be found in Appendix E.

Similar to the game developers, the gamers were asked about their views on whether excellent visuals automatically mean success for games. All the gamers agreed that for games to be successful, developers must focus on more than just the visuals. Four of the six participants, in support of the game developers in Section 5.1, also said that they believe in the near future there will be a demand for games which look more abstract than realistic games can look like.

Gamer Questionnaire Data								
Themes	**Code**	Participant #						
		8518	5135	7235	6118	4235	1918	
Visuals Success Factor	Realism is more than visuals	x	x	x	x	x	x	
	Demand for different styles	x			x	x	x	

Table 5.20 Gamer qualitative questionnaire data analysed through recursive abstraction. Full table can be found in Appendix E.

Lastly, the gamers were asked to share in which year games were released that impressed them most with how realistic graphically and gameplaywise they looked. The year with the most mentions was 2018. If one is to assume games released in 2020 were not chosen because, at the time of data collection, the new console generation had not yet been released a clear pattern can be identified. It seems that the games chosen are two years apart in release, which is exactly what Moore's Law[27] states, that every two years the technology that is developed is more sophisticated.

Gamer Questionnaire Data							
Themes	**Code**	Participant #					
		8518	5135	7235	6118	4235	1918
'Wow' factor of realism (year)	2020 (Ghost of Tsushima)				X		
	2018 (Spiderman/ Far Cry 5/ Red Dead 2)	X	X				
	2016 (Uncharted 4)					X	
	2011 (Skyrim)				X		
	2007 (Uncharted)						X
	2004 (Half Life 2)			X			

Table 5.21 Gamer qualitative questionnaire data analysed through recursive abstraction. Full table can be found in Appendix E.

5.4 Integrated Findings from Gamers

This phase consisted of combining the analysed data and finding whether any of the identified codes and themes corresponded. As well as this, the transcript from the focus group and the qualitative questionnaire were consulted to ensure all data is represented correctly. To enable faster reading of the tables, the participant's name codes were replaced with a single number and according to their age 18 (for under 35) or 35 (for over 35) after the number (i.e. 118 and 235). The full table can be found in Appendix F.

As can be seen in Table 5.22, all six of the participants agree that the AAA games presented to them were visually more polished. 5 out of the 8 participants also agreed that the detail put into the AAA games was clear, even at first glance. The difference here is that group 18 in this study seemed to pay more attention to the visuals of the games.

Overall, combining the data did not reveal any new trends other than confirming the findings in Sections 5.2 and 5.3. Thus, in its essence, integrating the two data findings has confirmed that realism is a broad term, the meaning of which may differ depending on the individual's own interpretation. In other words, the findings of this aspect of the research indicate that realism is actually a highly subjective concept.

Table 5.22 shows which games were found most believable and immersive according to the gamers. Overall, the participants found AAA games to be more believable by the fact that they were chosen 7 times, as opposed to 5 votes being given for the indie games. Group 35 gave the most votes to the AAA games, while group 18 voted most for the indie games. Interestingly, the younger group found that the AAA games, which they said were more polished, were less immersive and believable.

As can be seen in Table 5.22, the majority of the participants in the questionnaire considered Marvel's Spider Man to be the game with the highest believability factor from the 4 games played to them. The importance of reflections was the most commonly stated view in the answers, and arguably, reflection is what gives substances and overall objects, a more familiar and easier to understand appearance. The other game with highest preference was Everybody's Gone to the Rapture. If one is to compare the two games and try to find similarities, they would be that:

a) Both games have a similar overall idea, that is to say being able to move around the environment, making the environment itself very important. This makes the environment depend on the buildings as sureties (Section 2.3.3) to be highlighted by the connectors (trees, land posts etc)
b) That both the games are set in a town or city, heavily focussed on depicting current world representation.

It is also interesting to note that all of the participants believed that realism in video games means more than just the visuals, with seven suggesting that the developers of realistic games must try to mimic real life.

Lastly, exactly half of both age groups believed that while realism will continue to evolve as a style and genre, different art styles and gameplay mechanics will be necessary to keep gamers invested in the game worlds presented to them.

Integrated Gamer Data									
Themes	Code	Questionnaire						FG	
		118	235	335	418	535	618	718	835
Detail	AAA more polished	X	X	X	X	X	X	X	X
	Attention to detail in AAA was apparent	X			X	X	X		X
Believability/ level of immersion	Marvel's Spider Man	X	X			X	X		X
	God of War				X	X			
	A Plague Tale: Innocence		X						
	Everybody's Gone to the Rapture	X		X			X	X	
Realism	Mimic real life	X		X	X	X	X	X	X
Total Realism	Lifelike physics	X	X	X		X	X	X	X
Visuals Success Factor	Realism is more than visuals	X	X	X	X	X	X	X	X
	There will be demand for different styles	X			X	X			X

Table 5.22 Combined data from the gamer focus group and qualitative questionnaire. Full table can be found in Appendix F.

5.5 Overall Integrated Findings from Game Developers and Gamers

This phase consisted of combining all participant data found throughout the data collection process. When combining the data at the end, to form a Table of comparisons which consists of game developers and gamers, it was necessary to revisit the existing qualitative questionnaires data and the focus group transcript and audio recording. This ensured that no essential information was accidentally excluded during the process, as well as ensuring that there were no views and opinions which were presented incorrectly.

Table 5.23 shows highlights of trends which surfaced when the data was integrated. The full table can be found in Appendix G.

The first obvious trend that surfaced after combining the data was the difference in opinions of developers and gamers on their ideas of realism. Four of the developers stated that they believed a game must have harmonised visual and gameplay design, while six of the gamers stated the same.

On the subject of what makes developers create realistic visuals, none of the participants suggested that the reason they develop such games is that gamers demand it. Moreover, from the information provided from them, it is easy to assume that instead, their focus was to push technology to its limits and display to enthusiasts what current technology is capable of. It is of interest to note that, according to the data, the developers and gamers were in disagreement here. The gamers stated that, for them the driver to create more realistic visuals is in order to cater for gamers' demands as opposed to benchmarking current technology. Clearly, there are different sets of priorities in each of the groups, as the gamers taking part in this study have stated that, for them, it is more important to have harmonised visual and gameplay design than for developers to focus on visuals.

Another significant difference that can be seen is that all of the developers believe a game must be consistent and seamless in all aspects for it to be perceived as totally realistic, while only three of the gamers agree. This is interesting, as only half, or four of the developers have said that lifelike physics and photo-realistic visuals should be focussed on, compared to seven of the gamers. The reason could be connected to the next trend which surfaced from combining the data that more game developers (six compared to three of the gamers) think that games will never reach total realism, hence why they believe games must be entirely seamless for that to be achieved.

While four of the developers have said that they believe the limitations which stop them from developing high fidelity games are shrinking, only 1 of the gamers agreed with this. One can assume that developers understand the technology behind the creation of games better than gamers do, thus they are more confident in making this claim.

The developers and gamers were all asked whether they think the two groups perceive games differently. five of the developers said that, as gamers expect realism in their games, they must become more critical, so that they can these expectations. Only two of the gamers seem to agree with this though. The reason for this could be that to them, game developers must play games as well to ensure that they can view their games through the same lens as the gamers. This in return will allow the developers to understand what gamers need from their games.

The discussed previously, in Section 2.4, the importance of environmental storytelling emerged when the data was combined. five of the gamers stated that, to be immersed in a game, they need to be able to interact with the environment, while only two said that the environment in a game should guide the player without causing confusion. Interestingly only one of the developers claimed that it is important to have in-game environmental interactivity and seven said that it is more important for the environment to subtly guide the players through the levels. One can assume that, as games become more complex due to the inevitable evolution of games and games technology, gamers are expecting more from them, while game developers focus on providing an experience which targets functionality over eccentricity.

Last but not least is the principle discussed in Section 5.3, which, after the data was combined, became even more apparent: Moore's Law. As can be seen in Table 5.23, seven out of the eight developers have stated that they were impressed with games which came out during the year of 2020. To create games which will sell well, game developers must understand what is preferred by the market and possibly compare new releases and learn from them. This can therefore imply that game developers are better informed on new releases, or at least more aware of them, than the gamers. It is also apparent in Table 2.23 that 2018 and 2016 were highlighted as years in which games with high visual fidelity were released. Moore's Law, as discussed, predicts that every two years technology becomes better, which, in the case of video games, allows for better graphics and faster performance.

Integrated Data with Developers and Gamers																		
THEMES	CODE	Participants																
		Developers									Gamers							
		1	2	3	4	5	6	7	8		1	2	3	4	5	6	7	8
Realism	Harmonised visual and gameplay design	■	■	■	■					■	■		■	■	■	■		■
Success	Visuals are advertised first	■					■		■	■								
Drive for realism	Gamers demand realism									■	■					■	■	
	Budget	■	■	■		■			■	■	■		■	■	■	■	■	■
	Benchmark/ to push technology to its limits	■	■	■	■		■	■	■	■		■	■					
Total Realism	Lifelike Physics and photorealistic visuals				■	■	■		■	■	■	■	■		■	■	■	■
	Consistent and seamless in all aspects	■	■	■	■	■	■	■	■	■		■		■		■		
	Limitations are shrinking			■		■		■	■	■		■						
	Games will never reach total realism	■	■	■			■	■	■	■	■	■						■
Detail	Developers: more critical/ gamers: presume	■		■	■		■		■	■			■				■	
	Complexity attracts attention		■		■	■			■	■		■						
Immersion	Interactivity in an environment	■								■			■	■		■	■	■
	Environments guide the player	■		■	■	■	■	■	■	■							■	■
	Elicits emotions and provoke response	■	■		■	■	■			■			■					■
Realistic games (year)	2020	■	■	■	■		■	■	■	■		■						
	2018				■		■			■	■							
	2016							■		■					■			

Table 5.23 Integrated data with gamers and Developers. Full table can be found in Appendix G.

Overall, the game developers and gamers agreed on multiple subjects, but new trends surfaced once the data was combined. These new trends were discussed in this section to provide a clearer image of the areas in which they disagree.

5.6 Summary

In summary, the data found predominantly supports the available literature. Different views and opinions were examined, mostly based on the participants' age, gaming experience and occupation (if they are gamers or game developers). The first phase which discussed the data collected with game developers largely supported the literature provided in Chapter Two.

The second stage of the gamer data collection helped confirm that overall, the views and opinions of individuals may vary based on their age. This was anticipated to be the case, due to the evolution of video games and the difference in video game availability between the two generations aged eighteen to thirty-five and over thirty-five.

Integrating the available data proved that while the gamers and the developers may agree on some concepts, they also disagree on others. This was demonstrated especially in areas which addressed the properties of video games such as: in-game environmental interactivity, the possibility of video games achieving total realism and the ways in which the groups view games overall.

Chapter Six

Conclusions

6.1 Summary

The aim of this work was to understand how the development of art within games has evolved. To do this, the research has considered how far games have progressed over the last few decades and has largely focussed on the artistic side of the development pipeline. This has demonstrated how game developers tackle the complexity of realism in video games, and how technology assists them along the way.

An overview of the ways in which realism can be perceived has been discussed throughout this study. The literature examined in Chapter Two helped to provide an understanding of how it is perceived and created in video games. This was possible as a result of acknowledging the milestones in video games history and video game art evolution, as well as investigating some of the functions of the brain which are responsible for our perception of realism. This then helped the research to interpret concepts like the types of presence in an artificial world as well as the 'uncanny valley' phenomenon.

It was also discussed that, in order to create realistic and believable worlds, game developers need to consider the level of immersion which their video games provide to the players. Additionally, hardware components that are necessary to operate and develop video games were examined and different software packages that can aid the creation of more authentic and natural looking surfaces for 3D objects were discussed.

Lastly, some of the key 3D game object creation practices were discussed with an emphasis on how they help a game world to appear more life-like. Particularly techniques like photogrammetry and the PBR approach were considered to help understand the logic behind the creation of authentic materials.

To help confirm or refute the ideas and statements presented in the literature review, two qualitative questionnaires and a focus group were undertaken, in which the views and opinions of both gamers and game developers were sought, and then analysed.

6.2 Research Question 1

In Section 1.1, the ways in which realism can be enhanced within video games was identified as a research question to direct the investigation. Overall, a general theme was identified throughout the findings which led to the assumption that both game developers and gamers perceive realism in games differently. This confirmed the definition of realism provided in Chapter One.

6.2.1 Game Developers

Initially, the data found in the opinions of the game developers showed that half of them thought, to create realistic game worlds, developers must focus on mimicking the real world which then helps promote a higher sense of immersion in their games. This also supports the ideas discussed in Section 2.5. In addition to this, four also said that while it is important to focus on visual design, developers should not neglect the importance of gameplay mechanics. Moreover, seven of the developers stated that it is more than just the visuals that contribute to the success of games.

The game developers also acknowledged the necessity of employing different art styles in games. Five described the current video game market as having a sufficient amount of diversity already. Interestingly, the participants who stated that there is no need for more diversity in art styles in games, also claimed that it is art that pushes the need to create games which aim to replicate real life.

6.2.2 Gamers

The study undertaken with the gamers showed that, overall, gamers have similar opinions on the questions presented to them. It was, however, observable that a difference in age sometimes provided separation in the generations' points of view.

A number of answers referring to the questions regarding the games displayed to the participants included mentions of the importance of reflections and shadows. This confirmed the statements made in Section 2.9.4, on the importance of simulating surfaces with natural properties in games.

Table 5.22 suggested results which showed that overall, the gamers preferred AAA games to indie games, in terms of realism and believability. They did also clarify that it is due to budget and time that the teams behind the indie games could not possibly achieve the pristine renders of the AAA games and it was not due to a lack of skill on behalf of the developers and artists.

6.2.3 Integrated Findings with Gamers and Game Developers

While very close statistically, the developers and gamers did show a difference in their views. A trend that appeared after combining the gamer and developer data was that half of the developers thought games must have harmonised visuals and gameplay design, while six of the gamers claimed the same. Moreover, while five of the game developers believed that game environments should help guide the player through the levels, only two of the gamers agreed. This was interesting to observe as a large proportion (seven) of the gamers said that they required interactivity in game environments while only one of the developers agreed. It can be concluded that this is due to the critical nature of game developers, making their focus on the functionality of a game, rather than the level of novelty included in their games.

6.2.4 Research Question Summary

Based on the findings of this research, game art realism can be enhanced in some of the following ways, according to the game developers and gamers. A sense of believability must be considered in the creation of video games, so that they can be perceived by the players as more realistic. This believability can also be enhanced by producing natural reflections of surfaces and providing authentic material properties.

Additionally, as important as visuals can be for the perception of game realism, they must support the gameplay mechanics. It is also crucial for developers to establish stable gameplay mechanics and systems, as this makes the game environment feel richer and more interactive.

6.3 Research Question 2

‘Does the automation of video game art pose a threat to creatives’ job security?’ was the second chosen research question for this project. This issue was discussed briefly in Section 2.13 and introduced the concept to which the game developers and gamers were encouraged to discuss and state their opinions on.

6.3.1 Game Developers

The game developers discussed that they believe the restrictions which technology currently poses on development are slowly receding. This could mean that the developers do not necessarily feel threatened by the advancement of technology and AI replacing some of the tasks they currently have to manage. They stated that complexity attracts gamer attention, which could mean that the developers are, in fact, excited that some of the tedious tasks they have to currently perform will be overtaken by technological sophistication. Moreover, an assumption was made that the developers could feel that automation in the industry could

suggest that some approaches and pipelines may become faster to perform, allowing the creatives in the industry to focus more on details and the creation of more sophisticated worlds.

Furthermore, only two of the game developers said that, the amount of detail included in games is highly dependent on what is achievable by them. This makes it easy to assume that the developers believe that they are still constricted by technology and time, and automation of certain tasks within the industry will allow them to spend more time on putting detail into their games.

6.3.2 Gamers

The gamers said that in their opinion, in support of the views of the game developers and the ideas discussed in Section 2.13, the automation of the industry will make it easier for the developers to focus on more important tasks.

Three of the participants in the qualitative questionnaire also stated that, in their opinion, the developers are focussing on creating realistic visuals to push technology and showcase their skills, in order, most importantly, so that they can reach a point of better immersion for the players.

6.3.3 Integrated Findings with Gamers and Game Developers

In general, the game developers agreed that the more sophisticated technology becomes, and the more powerful hardware components are, the better developers can showcase their capability in the creation of realism in game worlds. Four of the game developers also said that the limitations of technology are slowly diminishing, which will allow them to keep expanding their knowledge of the development process and be able to meet gamers' expectations. The gamers, on the other hand, indicated that they believe game developers try to benchmark current technology to meet their demands for improved realism in games.

6.3.4 Research Question Summary

Widely, the participants stated that automation of the industry will not pose a threat to developer positions. The game developers and gamers largely agreed that the automation of development pipelines would take away the need to perform tedious tasks and give them the opportunity to focus on development tasks which require more creativity. Additionally, the gamers believe that automation will allow game developers to focus on creating a better sense of immersion for the players.

Altogether the developers and gamers insisted that, as technology is improving, so will the expectations of gamers and the need for improvement in the skills of game developers.

6.4 Research Question 3

The third question selected to help structure this study was: Is achieving an improved sense of realism the future of video game art? The data found regarding this question proved that the opinions between the developers and gamers may vary in terms of criticism.

6.4.1 Game Developers

Overall, the game developers agreed that to achieve a better sense of realism games must be consistent and seamless in all aspects. Six of the developers stated that they do not believe that total realism will be achieved in the near future, although that will not stop manufacturers and developers from attempting to improve the feeling of immersion in video games. Furthermore, they stated that if video game were to reach total realism in the future, then they would evolve into a new medium.

While half of the game developers seem to believe that there is a natural trend towards complexity (mimicking reality in terms of visuals and gameplay mechanics), only two of the participants claimed that, in their opinion, visual realism will remain highly used. three of the developers explained that different art styles will be preferred to realism in a way to differentiate similar looking games.

6.4.2 Gamers

Half of all the gamer participants said that in their opinion, realism, both in terms of art style and gameplay mechanics, will continue to evolve. Moreover, it was discussed that in order to keep gamers interested, more attention should be paid to the abstract aspects of the visuals in games.

Only three of the gamers said that, from their point of view, games will never achieve total realism, which leads to the assumption that the rest may be consider that it will be possible to achieve it.

6.4.3 Integrated Findings with Gamers and Game Developers

When combined, the data from the participants showed that, overall, the game developers were more sceptical of the possibility of total realism in games than the gamers. A trend was noticed that followed Moore's Law, suggesting that, as technology advances, there might be a possibility for total realism in games in the future.

6.4.4 Research Question Summary

In summary, more than half of all the participants were hesitant to believe that games will ever obtain total realism, although the possibility of an improved experience of it was considered possible. The concept of keeping gamers interested by presenting more abstract games to them was also assumed.

6.5 Limitations: COVID-19

This project was undertaken during the COVID-19 pandemic of 2020 while the lockdowns and country-wide restrictions were enforced as result of the virus outbreak. The project was impacted as a result, since communication with potential participants for data collection was limited, and, as a result the number of participants was lower than originally anticipated. In addition, a number of game developers who had agreed to participate subsequently withdrew, possibly because of the personal and work pressures they were facing resulting from the unprecedented situation

6.6 Future Work and Further Development Opportunities

Whilst not within the scope of this study, there are clear opportunities for taking this research forward.

One can hypothesise the future of video games by observing the fast pace of changes both in the available technology and in what the development industry can deliver and consumers desire. While this study discussed some of the ways in which visual realism can be enhanced. For example, improved ray tracing and the new generation of video games, consoles and computer components present an opportunity to further discuss the evolution of art within games.

In a larger study than the current research project, the research begun here could benefit from refining the questions included in the focus group and qualitative questionnaires and conducting further data collection events with larger groups of participants. This would aid in the establishment of possible new trends and may help update the findings discovered so far. It would be especially constructive in terms of the identified trends which emerged from the participants answers that invoked Moore's Law, which introduced the idea that the participants found games getting more immersive and realistic every two years.

In terms of the findings in the literature, a future development of the project could benefit from discussing the concept of total realism and total immersion in greater depth. This would help

uncover whether video games can achieve a level of realism and in virtual interactions which are indistinguishable from real life.

While VR systems were briefly introduced in this research study, a further development of the project might present the opportunity to discuss the possibility of full body immersion, in the context of the concept of total player immersion.

Lastly, a longer time frame would allow for further creation of examples of 3D work, which illustrate the discovered literature findings and data collected from participants.

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Appendices

Appendix A

Glossary

[2] **3D** – Three Dimensional

[3] **6DOF** – Six Degrees of Freedom. It is a setting which allows the player complete freedom in the 3D space.

[4] **AAA** – Triple A video game development studios and companies are such which have substantial budgets and large development teams. A AAA game would be one which is developed by such a studio.

[5] **AAAA** – Quadruple A is a term which was recently introduced to the games industry. While the term is largely unclear, studios with the title consider themselves to have substantially bigger budgets and team sizes which are beyond the scope of AAA studios.

[6] **AI** – Artificial Intelligence. It is a system which follows programmed behaviours.

[7] **AR** – Augmented Reality

[8] **Artefacts** – fragments on 3D models caused by bad baking, lighting, texel density. They should be avoided in the creation of 3D models for games.

[9] **Baking** – the act of transferring geometry information from one 3D object to another.

[10] **CPU** – the Central Processing Unit of a machine. It is responsible for carrying out the computer program's functions, by handling the different processes and tasks.

[11] **Full Realism, 100% realism or Total Realism** – It is the state of representing the real world in video games, so close to reality that makes games hard to distinguish from it.

[12] **Frame Rate** – the speed at which images or 'frames' on screen are changed. Frame rate is important in video games because it ensures that the player gets the fastest visual feedback from the game, and in fast paced games it is crucial.

[13] **FPP** – First Person Perspective. A point of view in which the player looks through the eyes of their character.

[14] **Gamer, Player** – consumers, users of video games.

[15] **GPU** – Graphics Processing Unit, responsible for representing the visuals on screen and handling the rendering processes.

[16] **Hardware** – the equipment and parts necessary to run games and develop games.

[17] **Heavy-duty (parts)** – parts which are powerful and hardy enough to handle the most complicated processes, software and games.

[18] **High-end** – hardware parts which are newest and most able to handle the most complicated processes, software and games. They can also be expensive due to their properties.

[19] **Immersion** – the level of engagement of the player.

[20] **Indie** – video game studios which are self-funded.

[21] **Invisible wall** – a boundary in games which stops the player to go to certain areas. They are not visible and the player can only find them if they walk into them.

[22] **Isometric** – a perspective where the player camera is set at a 45° angle.

[23] **LED screen** - Flat displays which are made of large numbers of light- emitting diodes acting as pixels.

[24] **Level** – an area of the game world. A level is the space in which the player can move to complete an objective.

[25] **Memory (RAM)** – is responsible for storing necessary variables and content. It stores temporary items and ensures they are run as fast as possible. The more RAM the quicker data is loaded.

[26] **MMO** – Massively Multiplayer Online games. Those are the genre of video game which allow for masses of players to meet and play together in a virtual world.

[27] **Moore's Law** - the Law states that technology is expected to advance every two years (and become less expensive).

[28] **Motion Blur** – is the blur or trail which follows rapidly moving objects.

[29] **Optimisation** – the act of ensuring the best possible performance and graphics. A poorly optimised game requires a powerful PC or Console to run or in some cases may not be able to run at all.

[30] **PCG** – Procedural content generation is the use of algorithms to create content as opposed to doing so manually.

[31] **PBR** – Physically Based Rendering. An approach used to simulate realistic lighting on materials and surfaces.

[32] **Performance** – how smoothly a game runs and how easily it is handled by a PC or console.

[33] **Photogrammetry** – the technique of photo-scanning real-life objects by taking photographs of an object from different positions and angles and then using these images to generate virtual 3D objects.

[34] **Platform or Gaming Platform** – a computer system which handles video games.

[35] **Polygon** – a plane in a 3D space with at least 3 connected sides.

[36] **PvP** – an interactive conflict in which players are matched against other players. It stands for Player versus Player. PvP can include any number of players from 1 versus 1 to a mix of hundreds of different players, to teams fighting against each other.

[37] **Ray Tracing** – an algorithm which allows for more correct lighting and shading in game. It calculates how many times a ray of light bounces off surfaces.

[38] **Realism** – visual fidelity, graphical closeness to the real world.

[39] **Rendering** – is the process of generating the graphics on screen handled by a program and performed by the hardware.

[40] **Resolution** – The size of an image or screen.

[41] **Respawn** - Revived, brought back to life usually at the last saved point.

[42] **Side View/ Side Scroller** – the point of view in which the player views their character and the environment from the side.

[43] **Software/ Software package** – a computer program

[44] **Storage** – is the component of a computer which handles long term data.

[45] **Stylised** – an art style which appears abstract and overly exaggerated.

[46] **Texture maps** – an image that can be applied on 3D objects.

[47] **Top-Down** – a perspective where the camera is set above the environment and player.

[48] **TPP** – Third Person Perspective. A point of view where the player camera is set behind the player character.

[49] **UV** – the flattened skin of a 3D model in the U (0,0) and V (1,1) space.

[50] **VFX -Visual Effects**

[51] **Vector Graphics** - vector graphics use mathematical equations to depict images. Each vector image is made from points which are connected by lines or curves (vector paths). This allows for the image to be scaled in any size without becoming lower quality (which can be viewed in bitmap images).

[52] **VR** – Virtual Reality

[53] **Workflow / Pipeline** – a set of steps which make creating games more organised and easier to follow.

Appendix B

Shaders

[54] **3D Shader** - this type of shader is responsible for accessing the attributes of geometry in 3D space as well as being able to manipulate colours and textures.

[55] **Vertex Shader** - They are responsible for processing the attributes of vertices. They are used to transform vertices and change their position in 3D space. This shader can also in a limited manner manipulate the colour of vertices, as well as control movement, lighting and texture coordinates of 3D objects.

[56] **Tessellation Shader** - tessellation shaders can be used to increase the vertex resolution of 3D objects and are useful for LoD (Level of Detail) computations, where objects close to the camera and such further away will appear as high quality while simultaneously optimising rendering performance.

[57] **Pixel Shader** - a pixel or fragment shader processes the attributes of each raster pixel such as colour, brightness, and textures, facilitating effects such as shadows, transparency, etc. These shaders can also be used to detect the edges of objects or images in 3D space and blur or sharpen them as well as create effects such as cel- shading (see image below for illustration).

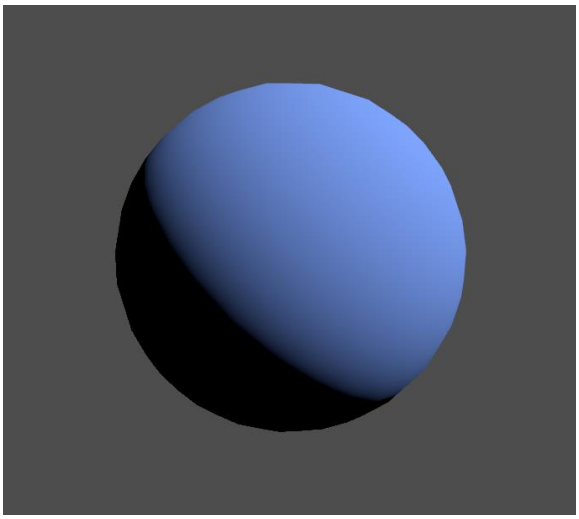

Fig.B.1 Not Cel- Shaded.

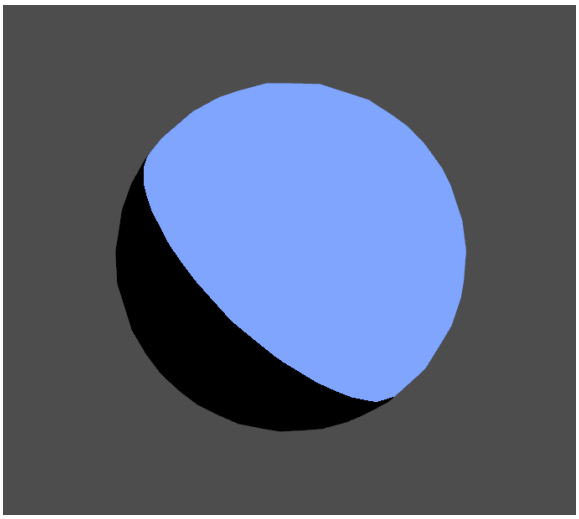

Fig.B.2 Cel- Shaded.

[58] **Geometry Shader** - this type of shader can produce new primitives (triangles, points and lines).

[59] **Compute Shader** - GPGPU (General Purpose GPU) operations are processed using compute shaders, but they can also be used for animation and lighting as well as help with rendering.

Appendix C

Qualitative Questionnaire with Developers

Questions used to form the qualitative questionnaire for game developers:

1. How would you define realism in video games?
2. Do you think realistic visuals, sound and animation contribute to a game's success and if so, why?
3. Do you believe games can be 100% realistic? And what would that mean:
4. Do you think developers and gamers perceive realism in video games in different ways and if so, why?
5. Has there ever been a game released that impressed you with how close to life it looked? If so, what game was it and what year did it release? (If you are not sure about the release date, just state the name of the game)
6. In your opinion, what drives and impacts the decision to choose either hand painted or computer- generated materials in games?
7. A lot of games that release nowadays strive to appear as visually realistic as possible. Do you believe there is a reason for this?
8. Do you think that realism in games is achievable through art alone or do you feel that games require more than just visuals to be realistic?
9. How would you say the role of the animator/artist/designer as a developer has evolved with the evolution of games?
10. What would you say defines ‘good’ environment art in a game?
11. Do you believe that visual realism is what the future of video games holds? If yes, then why/ If no, then why? (This question is a follow up to 7.)
12. Is it important for environment artists to work closely with and learn from designers and animators? What can they learn from them?
13. Tell us about a realistic piece you have worked on. What techniques did you use to achieve it

The following table shows the data analysed from the game developer qualitative questionnaire using the Recursive Abstraction method:

Developer Questionnaire Data									
Themes	Code	Participants							
		1	2	3	4	5	6	7	8
Realism/ believability	Immersion	x	x	x				x	
	Mimicking real life			x	x	x	x		x
	Harmonised visual and gameplay design	x	x	x	x				
	Photo-realistic visuals					x	x		x
100% realism	All senses must be considered	x	x	x		x			
	Close to but not 100%	x	x	x			x	x	x
	Limitations are shrinking			x		x		x	x
	Visual realism will remain highly used					x	x		
	Games are escape from reality		x		x		x		x
Visuals success factor	Visuals contribute to success	x	x			x	x		x
	Require more than visuals	x	x	x	x	x	x	x	
	Need of alternatives to similar looking games	x		x	x				
	To appear cinematic						x	x	
Detail	Complexity/detail excites		x		x	x			x
	Devs spot subtle flaws because they work with detail	x		x	x		x		x
	What is achievable from the developers	x	x						
	Gamers presume realism		x	x	x			x	
Detail (environment art)	Focus on storytelling and mood	x	x		x	x	x	x	
	Consistent style (matches/ heightens the game vision)	x		x	x	x	x	x	x
	No unwanted confusion	x		x	x	x	x	x	x
“Wow” factor of realism (year)	2020 (Last of us/ Flight Simulator)	x	x	x	x		x	x	x
	2019 (COD Modern Warfare/ Death Stranding)						x	x	
	2018 (Red Dead Redemption 2/ FIFA)				x		x		
	2013 (Last of us/Tomb raider)						x	x	
Drive for realism	Budget	x	x	x		x			x
	Benchmark	x	x	x	x		x	x	x
	Technical limitations	x		x			x	x	x
	Down to the developer				x	x	x		x
	Games: complicated/ require more from developers		x		x		x	x	x
Techniques for realism	Real world reference	x		x	x		x		
	Documentation with key information about the subject	x		x					
	Simulation of realistic physics				x			x	x
	Utilisation of PBR						x	x	
	Photogrammetry			x				x	

Below can be found some of the steps undertaken during recursive abstraction. Due to the large amount of data collected the table from step one was separated into two parts.

Part one can be seen below:

Game Developer Qualitative Questionnaire							
61886646	**61892495**	**62059508**	**63066399**	**63079152**	**63148261**	**63209616**	**64049756**
immersion Harmonised visual and gameplay design	immersion supporting gameplay and visuals - not hindering experience (incapacitate)	- visually true to life art style - mimicking real life	- gameplay mechanics real world equivalent - graphics: = simulation of RL materials and objects	indistinguishable from reality photorealism	visuals that are hard to distinguish from common reality	Convincing lighting	Photo-realistic visuals - Putting gamers in situations they would be in RL - Accurate depictions of violence
- Yes - depends on the type of game - game must be fun, otherwise it won't be successful	- Yes - people crave these experiences - games are played for immersive and realistic experience	- no - depends on the type of game - Stigma around AAA: realistic Graphics/sound etc = better game - realism captures audience interest	- No - games - created to be enjoyed - Not everyone wants to simulate real life when trying to escape real life	- Yes - People are attracted to complexity - Realistic games absorb the complexity of life	- Yes - Initial screenshots and footage showing more realism excite gamers - Easier to relate to realistic looking characters	- No - Narrative can feel realistic if the game doesn't look it	- Yes - gamers play to experience a game like another reality - AAA studios have the budget to push the limits of realism - detail impresses gamers
- 100% would mean you can feel the world around - seamless in all aspects - technical limitations bring the uncanny out of immersion	- only when all senses can be considered	- close to but not 100% - game engines and graphic fidelity is growing	- depends on the definition of 'game' - 100% realistic would limit games in terms of gameplay - would satisfy a niche market and may not benefit sales	- can become complex enough to withstand understanding of natural senses	- existing games are hard to tell apart from real life already - Presumably FMV games are 100% realistic	- unsure anything can be 100% realistic without being real - currently characters look more realistic than the rest of their environment	- No - Some games should not be 100% - Simulation games are very close but still not 100%
- Yes - Gamers talk about visuals because visuals are being advertised first - realism for devs is what is achievable and how impactful it will be for players - Players presume realism	Yes. - developers have to adapt realism and consider gameplay mechanics and optimisation - Realism is warped to create a more enjoyable experience	- developers work with high attention to detail and focus on mistakes that can ruin the immersive experience - a lot of players focus on a single task allowing the rest of the scene wash over them	- developers perceive realism based on the part that they intended to simulate - gamers, may not care too much for specific parts of the game and focus on the gameplay presented to them	this is a false dichotomy	Developers may be better at spotting subtle flaws	- different individuals focus on different things- devs see the game constantly, which changes their opinion on their work - gamers will perceive realism on a higher level than devs	- developers are responsible for the depictions and experiences they present to their audience
Flight Simulator - the tech used to create realistic weather conditions and using satellite imagery to populate the world with trees and real buildings	- The Last Of Us 2, 2020	- Project Cars 2 21st Sep 2017 - The Last Of Us 2, 2020	- Red Dead Redemption 2 (2018) - The Last of Us 2 (2020)	- Crysis 3, 2007 - standards change with age and with technology	Yes, The Last of Us 2 (2020) - FIFA 2018 - Call of Duty 4 Modern Warfare - TES 5 Skyrim - Tomb Raider (2013)	- the last of us 2013 - Until dawn 2015 - uncharted 4 2016 - death stranding 2019 the last of us 2020	Microsoft Flight Simulator, August 18th, 2020 - Bing maps and AI to generate the whole world absolutely blew me away
audience, time and money.	- Procedural tools create straightforward production - Hand painted usually works in smaller studios where the team of artists share the same vision	Budget, time, style, game design, subject matter	The goals of the studio/company - some studios test how far they can push graphics on modern hardware	this decision is usually made by an individual: based on an artistic, political or financial reasoning	The lead artist, the capabilities of the team and tools, the marketing department, the studio head	depends on the project and what you want to convey - the capabilities of a team - technical limitations	- personal choice down to the developer. - it's not always down to budget - hand painted or "looks" indie, does not mean that it was any less or more difficult to create
AAA: you are not competing if you fall short of the set bar - announcing games usually means showing pre-rendered footage, not gameplay - gamers first compare how it looks to other games	People like to do what they cannot do in real life	Stigma: the more realistic games are better Stigma: stylized means indie, lower quality, cheaper	- For studios to show how far their technology/ engine has come over the years - showcasing the studio's technical capabilities	- there is a natural trend towards complexity - fascinating to study and experience reality - we have not conquered realism in games yet, the more we push, the more we want	- to make good first impression - to appeal to people who like films - to generate empathy - to imbue more weight in tone and decision making	- immersion	technology is allowing it to happen.

Part two is included below:

Game Developer Qualitative Questionnaire							
Games require more than just visuals - poorly designed gameplay and user experience can ruin the experience of realism - if it was a film it would be okay	Realism falls apart without good writing, dialogue, sound design, animation, AI	every aspect of a game should be pushing for realism	More than art to truly be realistic - a game needs to have a realistic experience and not just realistic look	Realism in games is the sum of all the ways in which humans experience them - Visuals are just one aspect.	Games are artificial systems that will never approach reality, but can certainly look real due to art, sound, animation.	Games require audio, lighting, design and animation as well to be realistic	Realism is achievable through art alone
Not much for designers -artists/ animators: huge advancement in tools and technology - memory allows for larger quantities of complex assets	games are more complicated as a whole and require more.	Games have become more collaborative, and cross over with each other more now	game development overall has become more demanding - developer roles have also become more demanding of the type of skills required	N/A	People tend to spend more time on assets, despite better tools and faster computers - specialisations are developed as team sizes grow	Everyone has to adapt and change to keep up - developers have to perfect their crafts	These roles have become 'easy to learn' but 'hard to master' due to the tools and technology
if the person viewing it feels it has a place within the world it is	Storytelling, detail, mood.	- consistent visual style that matches and heightens the game vision - focus on optimisation and modular design	art that helps to build the 'world' or 'story' of the game - grounds the player in the world that the game presents - not get in the way of or detract from the game itself	achieves the artistic intent does not communicate anything else that the intended ideas	helps the player feel what the game is supposed to be about - guides the player through the space - evokes emotion - not causing unwanted confusion	The environment helps with the story, no matter the art style	High fidelity art that does not break illusions.
eventually people will look for alternatives to playing similar looking games	N/A	there is a place for it - more unique visuals will become more popular	division in developers: gameplay and visual realism focussed - visual realism is a goal to push games further - realism is not the overarching goal	- inevitable part of the future of video games - we will also move beyond realism	visual realism will remain highly used - Virtual reality (VR) games will approach realism as a form of escape and wish fulfilment	Limitations are slowly shrinking - devs are becoming better at their job	Technology evolves to allow more visually realistic games - Visual realism evolving in the form of high fidelity FOIP (face over IP) in stylized games - the fidelity of facial animation
Not so much with animators as with designers	Not so much with animators as with designers - Environment artists work closely with level designers to produce kits and props - animators are tied to character artists	ER can learn ab. Leading the player through space from designers - animators can help ER with understanding movement and how things grow/ are built	Helps ER understand what their art is built for - learn how to help guide players - help with world building	ER can learn from everyone. - animators can teach ER about communication?	discussing requirements and having frequent reviews	It's important for all devs to talk to and learn from each other	animators: how living beings move - Designers: specific look as an expectation for the game Communication between the team makes a much more informed dev process
Animating animals in PlanetZoo: A lot of real-world reference. Documented each animal with key information	N/A	SAI: Design- real life examples and references for forests. Learning how and why certain plants and trees grow	Sniper: Ghost Warrior Contracts. Firing a sniper through implementations such as realistic bullet physics	Museum exhibit: The player flies through virtual landscapes supposed to look like real world locations as they existed 2000 years ago	Star Wars XWing Hardware and time limitations forced the devs to avoid rendering anything but hard surface objects and vfx. Utilised PBR rendering, baked normal map detail and simple environments. - Made people cry because they loved the experience	Using softwares marvelous designer to get the most of realistic cloth folds and experimenting w/ photogrammetry	Car Configurators using Video Game Technology (Unreal Engine 4) Used Ray tracing for more realistic AO and reflections visually impressive techniques from the CGI industry are making their way into the video game world

The next step was adapted to help identify possible repeating themes. Part one can be seen below.

Game Developer Qualitative Questionnaire

Q	Participants							
	61886646	**61892495**	**62059508**	**63066399**	**63079152**	**63148261**	**63209616**	**64049756**
1	- Immersion - gameplay mechanics	- immersion - Strengthen experience	- believable art style - replicates reality	- gameplay mechanics - replicates reality - graphics: = RL simulation	- replicates reality - photorealistic visuals	- replicates reality - photorealistic visuals	Convincing lighting	Photorealistic visuals - RL situations - replicates reality (violence)
2	- Yes - game dependant - game = fun	- Yes - experience craving - immersion - believable experience	- no - game dependant - realistic not better - interest capturer	- No - purpose: enjoyment - escapism	- Yes - complexity impresses - Realistic = complexity	- Yes - interest capturer - relatable	- No - Realistic Narrative	- Yes - believable experience - AAA budgets - complexity impresses
3	- all senses - seamless - technological limitations - not 100%	- all senses - not 100%	- not 100% - technological limitations	- 'game' definition - limiting gameplay - Niche market may hinder sales	- complexity to stay natural - all senses - not 100%	- existing games hard to tell apart from rl - FMV 100%	- only realistic if real - characters realistic> env	- No - not all games should be realistic - simulators close
4	- Yes D: create experience - advertised visuals - P: presume realism	Yes. - D: create experience - Warped realism – enjoyable experience	- Yes D: focus on detail D: spot flaws D: constantly viewing P: Task focused P: overlook details	- Yes D: part dependant D: Simulated intentions P: task focused P: overlook details	false dichotomy	- Yes D: focus on detail D: spot flaws D: constantly viewing	false dichotomy D: spot flaws D: constantly viewing P: presume realism	- Yes D: focus on detail
5	Flight Simulator -Map integration AI world generation	The Last Of Us 2, 2020	Project Cars 2 21st Sep 2017 - The Last Of Us 2, 2020	Red Dead Redemption 2 (2018) - The Last of Us 2 (2020)	Crysis 3, 2007 - standards change	The Last of Us 2 (2020) - FIFA 2018 - Call of Duty 4 Modern Warfare - TES 5 Skyrim - Tomb Raider (2013)	- the last of us from 2013 - Until dawn 2015 - uncharted 4 2016 - death stranding 2019 - the last of us 2020	Microsoft Flight Simulator, August 18th, 2020 Map integration AI world generation
6	- audience - time - budget	Procedural tools - Hand painted textures: (Style) - Small studios - shared vision Project dependant	- Budget - time - style - design - project dependant	- project dependant - hardware benchmark	- personal decision - budget - politics - style	- lead capabilities - team capabilities - tools presented - marketing	project dependant - team capabilities - technical limitations	- personal decision - not budget dependant - style does not define budget
7	AAA: not competing if not standard - visuals seen first - visual comparison	- games are escapism and fantasy fulfilment	Stigma: realistic = better Stigma: stylized = indie - lower quality - cheaper	- showcasing hardware - showcasing technical capabilities	- complexity impresses - experience reality - Understanding reality - more requirements	- first impressions - filmlike/ cinematic - generate empathy	- immersion	technology allows
8	- Realism in every aspect - ruined experience caused by bad game design	- Realism in every aspect	Realism in every aspect every aspect of a game should be pushing for realism	Realism in every aspect - realistic experience	Realism in every aspect	- games can never be real - can certainly look real	require audio, lighting, design and animation	achievable through art alone

Part two is shown below:

Game Developer Qualitative Questionnaire								
Q	Participants							
	61886646	61892495	62059508	63066399	63079152	63148261	63209616	64049756
9	- Not designers -artists/ animators: huge advancement in tools and technology - memory allows for larger quantities assets	Game development is more demanding	Games are more collaborative	Game development is more demanding - developers have to perfect work - roles are more demanding	N/A	- more time spent on assets - Bigger team sizes encourage specialisations	- adaptation and change necessary to keep up - developers have to perfect work - roles are more demanding	'easy to learn' but 'hard to master' - developers have to perfect work - roles are more demanding
10	- feeling of belonging in the world	- Storytelling - detail/mood - visual style heightening the game vision. feeling of belonging in the world	- visual style heightening the game vision - focus on optimisation and modular design	- visual style heightening the game vision - grounds the player in the world - causes no unwanted confusion	- grounds the player in the world - causes no unwanted confusion	- visual style heightening the game vision - guides the player through the space - evokes emotion - causes no unwanted confusion	helps story regardless the art style	- art that does not break illusions visual style heightening the game vision.
	- budget	- Hand painted textures: (Style) - Small studios - shared vision Project dependant	- style - design - project dependant	- hardware benchmark	- politics - style	- tools presented - marketing	- technical limitations	- not budget dependant - style does not define budget
11	Need for alternatives to similar looking games	N/A	- inevitable - unique visuals will become more popular	gameplay focussed - visual realism focussed - goal to push games further - not the overarching goal	- inevitable - we will also move beyond realism	- visual realism will remain - Virtual reality (VR) will serve as escapism	Limitations are slowly shrinking - goal to push games further	Limitations are slowly shrinking - goal to push games further - Visual realism evolving - facial animation
12	- animators no - designers yes	animators no - designers yes - Environment work with designers - animators tied to character artists	- ER to learn from designers -leading through space - animators: understanding movement - help with world building	- ER to learn from designers -leading through space - help with world building	ER can learn from everyone. - Communication is key	- Communication is key	- Communication is key	- animators: understanding movement - ER to learn from designers - Communication is key
13	PlanetZoo: real-world reference. Documented each animal with key information	N/A	SAI: Design- real life examples and references for forests. Learning how and why certain plants and trees grow	Sniper: Ghost Warrior Contracts. Firing a sniper through implementations such as realistic bullet physics	Museum exhibit: The player flies through virtual landscapes supposed to look like real world locations as they existed 2000 years ago	Star Wars XWing PSVR: Hardware and time limitations forced the devs to avoid rendering anything but hard surface objects and vfx. Utilised PBR rendering, baked normal map detail and simple environments. - Made people cry because they loved the experience	Using softwares marvelous designer to get the most of realistic cloth folds and experimenting w/ photogrammetry	Car Configurators using Video Game Technology (Unreal Engine 4) Used Ray tracing for more realistic AO and reflections visually impressive techniques from the CGI industry are making their way into the video game world

Once again adapted to the research, the table below shows the final step of data analysis through recursive abstraction. Part one:

Game Developer Qualitative Questionnaire								
Qs	**Participants**							
	61886646	**61892495**	**62059508**	**63066399**	**63079152**	**63148261**	**63209616**	**64049756**
Realism/ believability	- Immersion - Harmonised visual and gameplay design - realism for devs is what is achievable and how impactful it will be for players	- immersion - Harmonised visual and gameplay design - Realism is warped to create a more enjoyable experience Fantasy fulfilment/ able to do the impossible IRL	- real world equivalent - mimicking real life	- real world equivalent - mimicking real life - Harmonised visual and gameplay design - must have realistic experience not just realistic look - visual realism is a goal to push games further - realism is not the overarching goal	- real world equivalent - Photo-realistic visuals	- real world equivalent - mimicking real life - Easier to relate to realistic looking characters - to generate empathy - can be fully immersed already visual realism will remain highly used - VR will serve as escapism and wish fulfilment	Convincing lighting - immersion	- Photo-realistic visuals - Believable escapism - Accurate depictions of violence - Realism is achievable through art alone - focus on the fidelity of facial animation
100% realism	- 100% would mean you can feel the world around - seamless in all aspects	- all senses to be considered - every aspect of a game should be pushing for realism	- close to but not 100% - game engines and graphic fidelity is growing - every aspect of a game should be pushing for realism	- Not everyone wants to simulate real life when trying to escape real life - 100% realistic would limit games in terms of gameplay - would satisfy a niche market and may not benefit sales - every aspect of a game should be pushing for realism	- complex enough to withstand understanding of natural senses - fascinating to study and experience reality - (realism not conquered) the more we push, the more we want - every aspect of a game should be pushing for realism - inevitable part of the future of video games - game will move beyond realism	- Presumably FMV games are 100% realistic Games are artificial systems that will never approach reality, but can look real	- nothing can be 100% realistic without being real - currently characters look more realistic than the rest of their environment - every aspect of a game should be pushing for realism Limitations are slowly shrinking	- Games serve as escapism - Some games should not be 100% - Simulation games are very close but still not 100%
Visuals success factor	- Yes - game type dependant - game must be fun (success) - advertised first, so gamers talk about them - to make good first impression Games require more than visuals - poorly designed gameplay and user experience can ruin realism - games are not movies - people will look for alternatives to similar looking games	- Yes - played for immersive and realistic experience - poorly designed gameplay and user experience can ruin realism	- no - game type dependant - realism captures audience interest there is a place for it - people will look for alternatives to similar looking games	- No - games must be fun Developers will separate to gameplay and visual realism	- Yes - Visuals are just one aspect.	- Yes - Initial realistic footage excite gamers - to make good first impression - to appeal to people who like films	- No - Narrative can feel realistic if the game visually isn't	- Yes
Detail	- technical limitations bring the uncanny out of immersion	- People are attracted to complexity	Developers are better at spotting subtle flaws - Devs focus on details - gamers focus on the gameplay instead of a specific part		- People are attracted to complexity - Realistic games absorb the complexity of life - natural trend towards complexity	Developers are better at spotting subtle flaws		- detail impresses gamers - developers are better at spotting subtle flaws - Devs focus on details

Part two of the table is below:

Game Developer Qualitative Questionnaire								
Qs	**Participants**							
	61886646	**61892495**	**62059508**	**63066399**	**63079152**	**63148261**	**63209616**	**64049756**
Detail environment art	- Feeling of belonging within the world	- focus on storytelling, detail, mood.	- consistent visual style that matches and heightens the game vision	consistent visual style that matches and heightens the game vision - grounds the player in the world that the game presents - doesn't cause unwanted confusion	- consistent visual style that matches and heightens the game vision - doesn't cause unwanted confusion	- consistent visual style that matches and heightens the game vision - guides the player through the space - evokes emotion - doesn't cause unwanted confusion	- consistent visual style that matches and heightens the game vision Helps with storytelling	High fidelity art that does not break illusions
Indie vs AAA	AAA: you are not competing if you fall short of the set bar		- Stigma: AAA realistic is better - Stigma: AAA realistic is better Stigma: stylized means indie, lower quality, cheaper					- AAA have the budget to push the limits of realism
Gamers vs Devs	- Players presume realism - gamers first compare how it looks to other games	- developers have to adapt realism and consider gameplay mechanics and optimisation		- developers perceive realism based on the part that they intended to simulate - gamers focus on the gameplay instead of a specific part			- different individuals focus on different things - seeing the game constantly changes opinion on work - gamers will perceive realism on a higher level than devs	
Wow factor of realism	2020 Flight Simulator	2020 Last of us	2020 Last of us 2017 Project Cars 2	2020 Last of us 2018 Red Dead Redemption 2	2007 Crysis 3	2020 Last of us 2019 COD Modern Warfare 2018 FIFA 2013 Tomb Raider 2011 TES 5 Skyrim	2020 Last of us 2019 Death Stranding 2016 Uncharted 2 2015 Until Dawn 2013 Last of us	2020 Flight Simulator
Drive for realism	audience time budget - memory allows for larger quantities of complex assets	Procedural tools create straightforward production - Hand painted works in smaller studios where the team of artists share the same vision - games are more complicated as a whole and require more.	Budget, time, style, game design, subject matter - focus on optimisation and modular design	- goals of the studio/company - push technical limitations - showcasing technology/ engine evolution - showcasing a studio's technical capabilities - game development overall has become more demanding - developer roles have become more demanding of skills required	Decision made by an individual Artistic vision audience budget	- the capabilities of the team - technical limitations/tools marketing department studio head Devs spend more time on assets, despite better tools and technology - specialisations are developed as team sizes grow	depends on the project and what you want to convey - the capabilities of a team - technical limitations/tools - game development overall has become more demanding - developer roles have become more demanding of skills required	- down to developers - not always down to budget - hand painted or "looks" indie, does not mean it less or more difficult to create - technology is allowing it to happen game - development overall has become more demanding - Devs spend more time on assets, despite better tools and technology Technology evolves to allow higher visual fidelity
Techniques for realism	- Real world reference - Documentation with key information about the subject	N/A	- Real world reference - Documentation with key information about the subject	- Real world reference - Simulation of realistic physics	N/A	- Rendering of only hard surface objects due to technical limitations - Utilisation of PBR	- Marvelous designer for realistic cloth simulation - Photogrammetry for real world resemblance	- Car Configurators using Video Game Technology (Unreal Engine 4) - Used Ray tracing for more realistic AO and reflections

Appendix D

Focus Group

Questions used during the focus group with gamers and the gamer qualitative questionnaire. Video link is included in text.

1.1. What are the first differences between the AAA games and indie games that you noticed?
1.2. How would you compare the indie games to AAA ones?
1.3. Do you think any of these games are more believable than the others?
1.4. What are the first differences between the indie games that you saw?
1.5. Which game/s did you think looked most convincing, believable and close to life?
1.6. Do you think an art piece on its own can be considered realistic? (for example, a prop or a single model) Why?
2.1. How would you define realism in video games?
2.2. Do you think realistic visuals, sound and animation contribute to a game's success and if so, why?
2.3. Do you believe games can be 100% realistic? And what would that mean:
2.4. Do you think developers and gamers perceive realism in video games in different ways and if so, why?
2.5. Has there ever been a game released that impressed you with how close to life it looked? If so, what game was it and what year did it release? (If you are not sure about the release date, just state the name of the game).
2.6. A lot of games that release nowadays strive to appear as visually realistic as possible. Do you believe there is a reason for this?
2.7. Do you think that realism in games is achievable through art alone or do you feel that games require more than just visuals to be realistic?
2.8. What would you say defines ‘good’ environment art in a game?
2.9. Do you believe that visual realism is what the future of video games holds? If yes, then why/ If no, then why?

The full table of analysed data from the focus group using Recursive Abstraction:

Focus Group Data			
Themes	**Code**	Participants	
		9618	1735
Contrast	Differences in contrast		x
	Dark scenes had less detail		x
	Believability of light scenes		x
Believability/ Realism	Mimicking life	x	x
	Believability is related to animation, sound, level design		x
	Depth of field not actually realistic (Rapture)	x	x
	Graphically it must be believable	x	x
	Easier to relate to the characters	x	x
	Believability over realism		x
	Not as detailed as real life	x	
	Reflections	x	x
100% realistic	Environmental interactivity	x	x
	Consumers and developers will keep pushing for more	x	
	100% realism will never be possible	x	x
	Escapism/ Fantasy Fulfilment		x
	Depends on supply and demand		x
	Consider all senses		x
Detail	No difference in foliage	x	
	Attention to detail in buildings and clouds	x	
	Freedom to go anywhere	x	
	Studios showing off how much they can do	x	
	Aesthetically pleasing	x	
	Automation makes it easier to create bigger worlds	x	x
	Graphics will not get much better for a while	x	
	Smooth feel of the game		x
	Expectations rise over time		x
Immersion	Fully possible presently	x	
	Indication of where the player should go and do	x	
	Visuals, sound and feel		x
Success Factor	Art is the driving factor	x	x
	Games become more cinematic	x	x
	Devs should focus on mechanics		x
Perception of games	Developing is different than playing	x	x
	Yes, especially artists	x	

The extracted data in this table may differ from the combined gamer table due to the importance in which the participants stated their answers.

Some of the steps undertaken during recursive abstraction are detailed below:

Step Two extraction of data from the transcript:

RECURSIVE ABSTRACTION: FOCUS GROUP		
Qs	9618	1735
1.1	• Little Difference • No difference in foliage • Differences in reflections	• Differences in contrast • Differences in reflections • Dark scenes had less detail
1.2		• Dark scenes had less detail
1.3	• Relatable and realistic • Realistic perspective: Spiderman • Not as detailed as real life • Clearly not actually real	• Realistic • Depth of field not actually realistic (Rapture)
1.4	• Reflections	• Reflections • Believability of light scenes
1.5	• AAA better than Indie • Reflections (City)	• All looked good • Believability of light scenes
1.6		• Believability is related to animation, sound, level design
2.1	• It looks like it can exist	• Visuals, sound and feel • Interaction with the game
2.2	• Interaction with the game	• Consider all senses
2.3	• Can be fully immersed in a game today • 100% realism will ever be possible • Can't replicate physics	• Not in the next 60 years • Consider all senses • Believable yes, realism no • Games are escapism, fantasy fulfilment • Depends on supply and demand
2.4	• Yes, especially artists • Developing is different than playing	• Yes • Developing is different than playing
2.5	• 2013 GTA V • Attention to detail in buildings and clouds • Freedom to go anywhere	• 1993 Doom • Smooth feel of the game
2.6	• yes • Games become more cinematic • Easier to relate to the characters	• Games become more cinematic
2.7	• Art is the driving factor • Studios showing off how much they can do	• Art is the driving factor • Devs should focus on mechanics • Expectations rise over time
2.8	• Aesthetically pleasing • graphically it must be believable • Mechanics within the environment • Indication of where the player should go and do	• graphically it must be believable • Player actions to affect dynamic environment
2.9	• It's inevitable • Consumers and developers will keep pushing for more • Automation makes it easier to create bigger worlds • Graphics won't get much better for a while	• Believable is more important than realistic • Automation makes it easier to create bigger worlds

Step Three:

RECURSIVE ABSTRACTION: FOCUS GROUP		
Themes	9618	1735
Contrast		• Differences in contrast • Dark scenes had less detail • Believability of light scenes • Believability of light scenes
Reflections	• Differences in reflections • Reflections • Reflections (City)	• Differences in reflections • Reflections
Believability / Realism	• Relatable and realistic • Not as detailed as real life • Clearly not actually real • Realistic perspective e.g. Spiderman • Real life equivalent • Easier to relate to the characters • It's inevitable	• Realistic • Believability is related to animation, sound, level design • Depth of field not actually realistic (Rapture) • Easier to relate to the characters • Believability is of high importance
100% realistic	• Can't replicate physics • Mechanics within the environment • Consumers and developers will keep pushing for more • 100% realism will ever be possible	• Not in the next 60 years • Consider all senses • Consider all senses • Believable yes, realism no • Games are played to escape, and fulfil fantasies • Depends on supply and demand
Detail	• No difference in foliage • Attention to detail in buildings and clouds • Freedom to go anywhere • Studios showing off how much they can do • Aesthetically pleasing • Graphically it must be believable • Automation makes it easier to create bigger worlds • Graphics won't get much better for a while	• Smooth feel of the game • Expectations rise over time • Graphically it must be believable • Player actions to affect dynamic environment • Automation makes it easier to create bigger worlds
Immersion	• Can be fully immersed in a game today • Interaction with the game • Indication of where the player should go and do	• Interaction with the game • Visuals, sound and feel
Success Factor	• Art is the driving factor • Games become more cinematic	• Art is the driving factor • Devs should focus on mechanics • Games become more cinematic
Devs versus Gamers (on Perception)	• Developing is different than playing • Yes, especially artists	• Developing is different than playing

Step Four:

RECURSIVE ABSTRACTION: FOCUS GROUP		
Themes	9618	1735
Contrast		• Differences in contrast • Dark scenes had less detail • Believability of light scenes
Reflections	• Differences in reflections • Reflections	• Differences in reflections • Reflections
Believability / Realism	• Relatable and realistic • Not as detailed as real life • Realistic perspective e.g. Spiderman • Real life equivalent • Easier to relate to the characters • It's inevitable • Graphically it must be believable	• Realistic • Believability is related to animation, sound, level design • Depth of field not actually realistic • Easier to relate to the characters • Believability is of high importance • Graphically it must be believable
100% realistic	• Mechanics within the environment • Consumers and developers will keep pushing for more • 100% realism will ever be possible	• Not in the next 60 years • Consider all senses • Believable yes, realism no • Games are escapism / fantasy fulfilment • Depends on supply and demand
Detail	• No difference in foliage • Attention to detail in buildings and clouds • Freedom to go anywhere • Studios showing off their abilities • Aesthetically pleasing • Automation makes it easier to create bigger worlds • Graphics won't get much better for a while	• Smooth feel of the game • Expectations rise over time • Player actions to affect dynamic environment • Automation makes it easier to create bigger worlds
Immersion	• Immersion fully possible today • Interaction with the game • Indication of where the player should go and do	• Interaction with the game • Visuals, sound and feel
Success Factor	• Art is the driving factor • Games become more cinematic	• Art is the driving factor • Devs should focus on mechanics • Games become more cinematic
Devs vs Gamers (on Perception)	• Developing is different than playing • Yes, especially artists	• Developing is different than playing

Step Five:

Themes	Code	9618	1735
Contrast	Differences in contrast		*
	Dark scenes had less detail		*
	Believability of light scenes		*
Reflections	Differences in reflections	*	*
	Reflections	*	*
Believability/ Realism	Realistic	*	*
	Believability is related to animation, sound, level design		*
	Depth of field not actually realistic (Rapture)	*	*
	Graphically it must be believable	*	*
	Easier to relate to the characters	*	*
	Believability is of high importance		*
	Not as detailed as real life	*	
	Real life equivalent	*	
	It's inevitable	*	
	Graphically it must be believable	*	
100% realistic	Mechanics within the environment	*	
	Consumers and developers will keep pushing for more	*	
	100% realism will never be possible	*	*
	Games are escapism/ fantasy fulfilment		*
	Depends on supply and demand		*
	Consider all senses		*
Detail	No difference in foliage	*	
	Attention to detail in buildings and clouds	*	
	Freedom to go anywhere	*	
	Studios showing off how much they can do	*	
	Aesthetically pleasing	*	
	Automation makes it easier to create bigger worlds	*	*
	Graphics won't get much better for a while	*	
	Smooth feel of the game		*
	Expectations rise over time		*
	Player actions to affect dynamic environment		*
Immersion	Immersion fully possible today	*	
	Interaction with the game	*	*
	Indication of where the player should go and do	*	
	Visuals, sound and feel		*
Success Factor	Art is the driving factor	*	*
	Games become more cinematic	*	*
	Devs should focus on mechanics		*
Devs vs Gamers (on Perception)	Developing is different than playing	*	*
	Yes, especially artists	*	

Appendix E

Qualitative Questionnaire: Gamers

The iterations of the data analysed using Recursive Abstraction can be found below: (qualitative questionnaire with gamers)

Gamer Questionnaire Data								
Themes	**Code**	Participant #						
		8518	5135	7235	6118	4235	1918	
Detail	AAA more polished	x	x	x	x	x	x	
	Attention to detail in AAA was apparent	x			x	x	x	
	A Plague Tale has more detail than Rapture		x		x		x	
Believability/ level of immersion (Games)	Marvel's Spider Man	x	x			x	x	
	God of War				x	x		
	A Plague Tale: Innocence		x					
	Everybody's Gone to the Rapture	x		x			x	
Drive for realism	Developers believe realism will sell	x		x		x	x	
	Budget	x	x		x			
	Benchmark/ push technology to its limits	x	x	x	x			
	Further immersion		x	x	x			
	Gamers require realism	x		x			x	
Realism	Mimic real life	x		x	x	x	x	
	Immersion	x		x			x	
	Narrative/ story	x	x				x	
	Single prop can be realistic	x	x	x			x	
100% realism	Likelike physics	x	x	x		x		
	Games are escape from reality	x		x				
	Too much realism can be fun killing	x		x		x		
Visuals Success Factor	Realism is more than visuals	x	x	x	x	x	x	
	Demand for different styles	x			x	x	x	
'Wow' factor of realism (year)	2020 (Ghost of Tsushima)				x			
	2018 (Spiderman/ Far Cry 5/ Red Dead 2)	x	x					
	2016 (Uncharted 4)					x		
	2011 (Skyrim)				x			
	2007 (Uncharted)						x	
	2004 (Half Life 2)			x				

Next are the steps undertaken during recursive abstraction:

Gamer Questionnaire Data						
Qs	Participant #					
	8518	5135	7235	6118	4235	1918
1.1	While all games look amazing there seems to be just a little bit more polish to the AAA games - reflections in the buildings in Spiderman	Location	Slight blurring of visuals in Indies - crisp rendering of AAA graphics	difference of fog and depth of field	level of polish applied to the textures - AAA: excellent texture work - jagged edges from the indie games show up	- notices visuals first - AAA better visual fidelity - indie have striking art direction
1.2	all games look visually stunning - to think 2 had been done by very small teams while the others were made by huge studios and probably 100's of people the comparison is amazing in terms of graphics alone.	The level of detail and polish is higher on the AAA games no doubt due to budget and team sizes	Indie has a more "arty" appearance – It feels like you are immersed within a story, rather than having to stay alert to danger in your surroundings	- It's clear that the AAA games have more budget to play with and better engines that allow more polys	It all depends based on graphical quality AAA games definitely have more polish but sometimes games can look mediocre but play brilliantly	- indie can take more risks - clear AAA has more budget - creativity is often born out of limitation - indie game developers face many more limitations than AAA
1.3	Spiderman is most believable - buildings look pretty much real - cars aren't great	PS4 exclusive games will always look better than multiplatform - there are no hardware variables.	Rapture is more immersive - peripheral movement within the scenes	God of war - expert use of colour, temperature and distance fog	AAA have an extra level of polish and immersion	- plague tale is most impressive visually - God of war enviro were weakest/ top notch art dir. - Spider. amazing reflections - spiderm. Gound level models and textures were not impressive
1.4	The setting	Rapture looks more basic compared to A Plague Tale	Rapture: even though abandoned, had the appearance of recently lived in The Plague Tale scenes were more bucolic and only contained old ruins, giving a more desolate impression	one was clearly lower resolution that the second indie game shown. - visible polygons make a huge difference in realism	Level of polish textures	- indies had fussiness/blur - crisp rendering of AAA graphics
1.5	Spiderman Everybody's gone to the rapture	1- A Plague Tale 2- Spider-Man, 3- GOW, 4 - Rapture	rapture	God of War	God of War Spiderman	- Spiderman - Everybody's gone to the rapture
1.6	Prop can look realistic Must be in a scene with realistic properties	in its natural environment - story guides you on a journey to make it believable	Of course any 3D rendered object can be imbued with a realistic life	realism comes from the lighting any object not detailed enough will not look real in any lighting	a character model can be a piece of art	- yes - the object will be realistic, but not it's surrounding
2.1	Visuals, certain gameplay mechanics, setting, story	A game that draws me in to its world.	physics and realistic behaviour in relation to neighbouring objects with refraction, reflection and dispersion of light	The ability to visually recreate lifelike objects/landscapes	As being as close to real life as possible	- possible through graphics alone - narrative, graphics, level design - can become immersed in a world that is not necessarily realistic
2.2	GTAV visuals, sound and animation. Physics are close to life	Visuals are least important being able to enter your favourite characters/hero's world's	If located irl For immersion	combination of all these things that create the realism	Yes, Immersion and emotion Believability	- believes that most played and bought games are realistic visually - people look for familiar experiences
2.3	No It would be boring Would have to look after the character Slow progression Games are about escaping reality	Yes Full immersion via VR	All senses must be stimulated include relative gravity	Yes if indistinguishable from RL	Don't need to be 100% realistic visual language is important	- only if they evolve into more than games - connecting your brain to a simulation like the Matrix
2.4	Yes Gamers want games to be more realistic visually Developers have restraints: technical, time or money	Devs create the visual style first and then create a game around it	Gamers seek a reaction/enjoyment D: realism is a benchmark P: gameplay restraints can kill enjoyment Too much realism can be fun killing	I like to think that most developers were, if not are, gamers themselves.	battle between the two visions.	Yes. Developers are more critical of games as they understand the process behind them better
2.5	PS4 Spiderman Far Cry 5	Red Dead 2 small details that make a big difference	Half Life 2	skyrim (Nov 2011) Ghost of Tsushima	Uncharted 4	Uncharted (2007)
2.6	Gamers expect realism developers think will sell	push new hardware to its limits.	Commercialism Make it better than competitors To sell hardware	Better sense of immersion	It's not about realism but balance	Believes photorealistic graphics are marketed because gamers want it
2.7	More than visuals Animation	Sound feel	Proper physics full environmental modelling, not just visuals	Art is the base of realism More for realism	Needs more than visuals	Needs more than visuals
2.8	Prefers non-realistic graphics	Expansive explorable worlds	Heights that make you stay away from the edge Environment that elicits a response	One that fits the scene properly in all aspects. light, colour, sound, visual effects etc.	models and backdrops Believable assets attention to detail	Consistent seamless
2.9	Next gen is heavily focused on visuals If it's not fun to play it doesn't matter what it looks like	no	By making games resemble real life, the barrier between behaviour in-game and in real-life begins to break down	There will always be demand for different styles	There will be demand for different styles	For now. If devs hit a soft limit more stylised games will arise to distinguish themselves from the norm

	Gamer Questionnaire Data					
Qs	Participant #					
	8518	5135	7235	6118	4235	1918
1.1	AAA more polished - reflections in the buildings in Spiderman	Location	Slight blurring of visuals in Indies - crisp rendering of AAA graphics	difference of fog and depth of field	level of polish applied to the textures - AAA: excellent texture work - jagged edges from the indie games show up	- notices visuals first - AAA better visual fidelity - indie have striking art direction
1.2	all games look visually stunning - the comparison is amazing in terms of graphics alone.	Budget and team size helped AAA games stand out - More polished and detailed	Indie has an "artier" appearance – Immersed, rather than alert of surroundings	- clear AAA has more budget - better engines that allow more polys	AAA has more polish - games can look mediocre but play brilliantly	- indie can take more risks - clear AAA has more budget - -
1.3	Spiderman is most believable - buildings look pretty much real - cars aren't great	PS4 exclusive games will always look better than multiplatform	Rapture is more immersive - movement	God of war - expert use of colour, temperature and distance fog	AAA have an extra level of polish and immersion	- plague tale is most impressive visually - God of war enviro were weakest/ top notch art dir. - Spider. amazing reflections - spiderm. Gound level models and textures were not impressive
1.4	The setting	Rapture looks more basic compared to A Plague Tale	Rapture: even though abandoned, had the appearance of recently lived in The Plague Tale scenes were more bucolic and only contained old ruins, giving a more desolate impression	one was clearly lower resolution that the second indie game shown. - visible polygons make a huge difference in realism	Level of polish textures	- indies had fussiness/blur - crisp rendering of AAA graphics
1.5	Spiderman Everybody's gone to the rapture	1- A Plague Tale 2- Spider-Man, 3- GOW, 4 - Rapture	rapture	God of War	God of War Spiderman	- Spiderman - Everybody's gone to the rapture
1.6	Prop can look realistic Must be in a scene with realistic properties	in its natural environment - story guides you on a journey to make it believable	Of course any 3D rendered object can be imbued with a realistic life	realism comes from the lighting any object not detailed enough will not look real in any lighting	a character model can be a piece of art	- yes - the object will be realistic, but not it's surrounding
2.1	Visuals, certain gameplay mechanics, setting, story	A game that draws me in to its world.	physics and realistic behaviour in relation to neighbouring objects with refraction, reflection and dispersion of light	The ability to visually recreate lifelike objects/landscapes	As being as close to real life as possible	- possible through graphics alone - narrative, graphics, level design - can become immersed in a world that is not necessarily realistic
2.2	GTAV visuals, sound and animation. Physics are close to life	Visuals are least important being able to enter your favourite characters/hero's world's	If located irl For immersion	combination of all these things that create the realism	Yes, Immersion and emotion Believability	- believes that most played and bought games are realistic visually - people look for familiar experiences
2.3	No It would be boring Would have to look after the character Slow progression Games are about escaping reality	Yes Full immersion via VR	All senses must be stimulated include relative gravity	Yes if indistinguishable from RL	Don't need to be 100% realistic visual language is important	- only if they evolve into more than games - connecting your brain to a simulation like the Matrix
2.4	Yes Gamers want games to be more realistic visually Developers have restraints: technical, time or money	Devs create the visual style first and then create a game around it	Gamers seek a reaction/enjoyment D: realism is a benchmark P: gameplay restraints can kill enjoyment Too much realism can be fun killing	I like to think that most developers were, if not are, gamers themselves.	battle between the two visions.	Yes. Developers are more critical of games as they understand the process behind them better
2.5	PS4 Spiderman Far Cry 5	Red Dead 2 small details that make a big difference	Half Life 2	skyrim (Nov 2011) Ghost of Tsushima	Uncharted 4	Uncharted (2007)
2.6	Gamers expect realism developers think will sell	push new hardware to its limits.	Commercialism Make it better than competitors To sell hardware	Better sense of immersion	It's not about realism but balance	Believes photorealistic graphics are marketed because gamers want it
2.7	More than visuals Animation	Sound feel	Proper physics full environmental modelling, not just visuals	Art is the base of realism More for realism	Needs more than visuals	Needs more than visuals
2.8	Prefers non-realistic graphics	Expansive explorable worlds	Heights that make you stay away from the edge Environment that elicits a response	One that fits the scene properly in all aspects. light, colour, sound, visual effects etc.	models and backdrops Believable assets attention to detail	Consistent seamless
2.9	Next gen is heavily focused on visuals If it's not fun to play it doesn't matter what it looks like	no	By making games resemble real life, the barrier between behaviour in-game and in real-life begins to break down	There will always be demand for different styles	There will be demand for different styles	For now. If devs hit a soft limit more stylised games will arise to distinguish themselves from the norm

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Gamer Questionnaire Data						
Qs	Participant #					
	8518	5135	7235	6118	4235	1918
1.1	AAA more polished - reflections in the buildings in Spiderman	Location	Slight blurring of visuals in Indies - AAA more polished	difference of fog and depth of field	AAA have better visual fidelity - jagged edges in Indie	Visuals noticed first AAA have better visual fidelity Indie has striking art direction
1.2	All games look visually stunning	Budget and team size help AAA stand out - AAA have better visual fidelity	Indie has an "artier" appearance – indie feels friendlier	Budget and team size help AAA stand out - better engines that allow more polys	AAA have better visual fidelity - graphics don't define good gameplay	AAA have better visual fidelity
1.3	Spiderman is most believable - buildings look pretty much real - cars aren't that believable	PlayStation exclusives always look better than multiplatform	Rapture is more immersive	God of war is most immersive - expert use of colour, temperature and distance fog	AAA have an extra level of polish and immersion	plague tale is most impressive visually God of war enviro were weakest/ top notch art dir. - buildings look pretty much real - cars aren't that believable
1.4	The setting	Rapture looks more basic compared to A Plague Tale	Rapture: even though abandoned, had the appearance of recently lived in The Plague Tale scenes were more bucolic and only contained old ruins, giving a more desolate impression	Rapture is lower resolution than plague tale - visible polygons make a huge difference in realism	Level of polish Textures in AAA	- indies had fussiness/blur - crisp rendering of AAA graphics
1.5	Spiderman Everybody's gone to the rapture	1- A Plague Tale 2- Spider-Man, 3- GOW, 4 - Rapture	rapture	God of War	God of War Spiderman	Spiderman Everybody's gone to the rapture
1.6	A single prop can be made realistic	A single prop can be made realistic - story guides you on a journey to make it believable	A single prop can be made realistic	realism comes from the lighting	a character model can	the object will be realistic, but not it's surrounding
2.1	Visually lifelike properties gameplay mechanics setting story	An Immersive game	Physics realistic behaviour in relation to neighbouring objects lifelike refraction, reflection	Visually lifelike properties	Visually lifelike properties Physics As being as close to real life as possible	immersed in a world that is not realistic
2.2	Visuals and sound help immerse the player Must have believable sound and animation Physics are close to life	Visuals are least important for relatability	Visuals contribute to success Visuals and sound help immerse the player	Visuals and sound help immerse the player	Visuals and sound help immerse the player	people look for familiar experiences Most Played and bought games are realistic visually
2.3	100% real would be boring Slow progression Games escape from reality	Full immersion via VR	All senses must be considered Physics	Indistinguishable from RL	Games escape from reality	if they evolve into more than games To connect brain to a simulation (Matrix)
2.4	Yes Gamers require realism D: realism is a benchmark Developer restraints: time or money	Devs create the visual style first and then create a game around it	Gamers seek a reaction/enjoyment D: realism is a benchmark P: gameplay restraints can kill enjoyment - Too much realism can be fun killing	I like to think that most developers were. if not are, gamers themselves.	Too much realism can be fun killing	Developers are more critical
2.5	2018 PS4 Spiderman 2018 Far Cry 5	2018 Red Dead 2 small details that make a big difference	2004 Half Life 2	2011 skyrim 2020 Ghost of Tsushima	2016 Uncharted 4	Uncharted (2007)
2.6	Gamers require realism developers think realism will sell	To push hardware to its limits	developers think realism will sell Make it better than competitors To push hardware to its limits	Better sense of immersion	Developers think realism will sell	Gamers require realism developers think realism will sell
2.7	Realism is more than visuals Animation	Realism is more than visuals Sound Lifelike physics push realism further	Realism is more than visuals Lifelike physics push realism further	Realism is more than visuals	Realism is more than visuals	Needs more than visuals
2.8	Prefers non-realistic graphics	Expansive explorable worlds	Highlights all aspects of the game	Highlights all aspects of the game	models and backdrops Attention to detail	Consistent seamless
2.9	First showcases of games are about graphics Next gen is heavily focused on visuals Gameplay over graphics	Realism Is not the future	Games should not be associated with life By making games resemble real life, the barrier between behaviour in-game and in real-life begins to break down	There will be demand for different styles	There will be demand for different styles	There will be demand for different styles

Appendix F

Integrated findings with Gamers

The table shows the combined data from gamers taking part both in the focus group for this project and the confirming qualitative questionnaire. Some new trends emerged after reviewing all 8 participants' data. This data was once again double checked by revisiting the transcript, audio recording from the focus group and answers from the qualitative questionnaire. It was necessary to ensure there were no gaps made throughout the first process and to also ensure no participants were misunderstood.

Integrated Gamer Data									
Themes	Code	Questionnaire						FG	
		118	235	335	418	535	618	718	835
Detail	AAA more polished	x	x	x	x	x	x	x	x
	Attention to detail in AAA was apparent	x			x	x	x		x
	A Plague Tale has more detail than Rapture		x		x		x		
Believability/ level of immersion	Marvel's Spider Man	x	x			x	x		x
	God of War				x	x			
	A Plague Tale: Innocence		x						
	Everybody's Gone to the Rapture	x		x			x		
Drive for realism	Developers believe realism will sell	x		x		x	x		x
	Budget	x	x		x				x
	Benchmark	x	x	x	x			x	
	Further sense of immersion		x	x	x			x	x
	Gamers require more realistic games	x		x			x		
Realism	Mimick real life	x		x	x	x	x	x	x
	Immersion	x		x			x		
	Narrative/ story	x	x				x		x
	Single Prop can be realistic	x	x	x			x		
100% Realism	Lifelike physics	x	x	x		x	x	x	x
	Games as escapism	x		x					x
	Too much realism can be fun killing	x		x		x			
Visuals Success Factor	Realism is more than visuals	x	x	x	x	x	x	x	x
	There will be demand for different styles	x			x	x			x
'Wow' factor of realism (year)	2020 (Ghost of Tsushima)				x				
	2018 (Spiderman/ Far Cry 5/ Red Dead 2)	x	x						
	2016 (Uncharted 4)					x			
	2013 (GTA V)							x	
	2011 (Skyrim)				x				
	2007 (Uncharted)			x			x		

Appendix G

Integrated findings

Analysed data from the game developer qualitative questionnaire and focus group and qualitative questionnaire with gamers using Recursive Abstraction

Gamers and Developers																	
THEMES	**CODE**	**Participants**															
		IE									**Gamers**						
		1	2	3	4	5	6	7	8		1	2	3	4	5	6	7	8
Realism/ believability	Immersion																	
	Mimicking Real Life																	
	Harmonised visual and gameplay design																	
	Attention to detail																	
Drive for Realism	Gamers demand realism																	
	Budget																	
	Benchmark/ to push technology to its limits																	
	To appear cinematic																	
	For a better sense of immersion																	
100% Realism	Lifelike Physics and photorealistic visuals																	
	Must consider all senses																	
	Must be consistent and seamless in all aspects																	
	Games must not be fully realistic																	
	Limitations are shrinking																	
	Games will never be 100% realistic																	
Success factor of visuals	Visuals are a driving factor/ starting point for realism																	
	More than visuals are necessary																	
	There will be a demand for different art styles																	
	Visuals are advertised first																	
Detail	Gamers and developers perceive realism differently																	
	*Devs are more critical/ gamers focus on tasks rather than certain aspects																	
	Complexity attracts attention																	
Immersion	Interactivity in an environment																	
	Environments guide the player / no unwanted confusion																	
	Elicits emotions and provoke response																	
	Escapism and fantasy fulfilment																	
Realistic games (year)	2020																	
	2018																	
	2016																	
	2013																	
	2011																	
	2007																	