

Evolution of Racing Video Games

by

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DECLARATION

I declare that the dissertation titled "Evolution of Racing Video Games," submitted for the degree in Computer Games Design at the University of Trinity Saint David, is an original work conducted by me. All utilised resources are properly cited and referenced. It has not been previously submitted for any other degree. I attest that this work complies with the academic integrity standards of the university.

CONTENTS PAGE:

1.0 Introduction	4
2.0 Literature review	4
2.1 The beginning of motor racing	4
2.2 History of F1	7
2.3 History of racing games	9
3.0 Case study	12
3.1 Gran Turismo	12
3.2 F1 Garage	13
4.0 Methodology	14
4.1 Idea	14
4.2 References PureRef	15
4.3 Planning - Gantt Chart	16
4.4 Props list	16
5.0 Project development	17
5.1 Production phase	17
5.2 Issues	26
6.0 Evaluation	27
7.0 Summary	27
8.0 References / Bibliography	28

TABLE OF IMAGES

Figure 1 [Vanderbilt cup race].....	5
Figure 2 [Indianapolis]	7
Figure 3 [Marcel Renault]	8
Figure 4 [Gran trak 10]	10
Figure 5 [F1 2000 EA]	11
Figure 6 [Gran turismo 5]	13
Figure 7 [Formula 1 garage]	14
Figure 8 [References PureRef]	15
Figure 9 [Gantt chart]	16
Figure 10 [Blockout].....	17
Figure 11 [Blockout + props].....	18
Figure 12 [UV's menu].....	19
Figure 13 [UV's example].....	20
Figure 14 [Maps created by baking].....	21
Figure 15 [Substance Painter previs].....	21
Figure 16 [Unreal Engine texture pack].....	22
Figure 17 [Unreal Engine content drawer (Assets and textures)].....	23
Figure 18 [Unreal Engine material editor].....	23
Figure 19 [Unreal Engine previs].....	24
Figure 20 [Main emissive material nodes].....	24
Figure 21 [Emissive instances].....	25
Figure 22 [Detail lighting].....	25
Figure 23 [First version of the dimensions].....	26
Figure 24 [Difference of the ventilation system with “two sided”].....	27

1.0 Introduction

This dissertation will cover the evolution of racing games and the significance of the subgenre of the driving simulation. Racing games have long been a staple of the gaming industry, captivating players with adrenaline-pumping experiences and competitive thrills. However, it is within the realm of driving simulators that the convergence of cutting-edge technology and meticulous attention to detail truly shines. From the early days of arcade classics like "Pole Position" to the sophisticated realism of modern titles such as "Gran Turismo", the journey of racing games has been a testament to the relentless pursuit of authenticity and immersion.

As advancements in hardware capabilities and software development techniques continue to push the boundaries of realism, driving simulators have emerged as a distinct subset within the racing genre, offering players unparalleled experiences that blur the line between virtual and reality.

This dissertation seeks to explore the evolution of racing games within the broader context of video game history, with a particular focus on the evolution of driving simulators and their impact on gaming culture and industry. Through an examination of key technological advancements, design philosophies, and cultural influences, the aim is to shed light on the intricate evolution of this genre and its significance in shaping the gaming landscape of today and tomorrow.

Chapter 2 will look at the beginnings of motorsport, a history of Formula 1 and the evolution of racing video games in order to provide useful context to the study being presented.

Chapter 3 will consist of a case study on Gran Turismo and its impact, along with an explanation of what constitutes a Formula 1 garage.

Chapter 4 will outline the methodology required to initiate a 3D project, focusing on four key phases: Idea, Reference Gathering, Gantt Chart Creation, and Props List Compilation.

Chapter 5 will focus on the production phase, encompassing modelling, UV mapping, texturing, and the utilisation of Unreal Engine for lighting and rendering. Additionally, it will address the challenges encountered throughout the process.

Finally, results of the practical project will be evaluated and summarised.

2.0 Literature Review

2.1 The Beginning of Motor Racing:

First, we must delve into the inception and evolution of motor implementation in vehicles. The emergence of the first motor vehicles marked a significant milestone in the history of

transportation and mobility. In the late 19th and early 20th centuries, visionaries and inventors contributed groundbreaking innovations to the development of these revolutionary devices. The creation of the first automobiles was intricately linked to technological advancements in internal combustion engines and the design of vehicles powered by such engines.

Prominent figures like Karl Benz and Nikolaus Otto played pivotal roles in refining internal combustion engines, thereby laying the foundation for the production of practical automobiles. In 1885, Karl Benz introduced the Motorwagen, widely recognized as the first automobile with an internal combustion engine. This vehicle, powered by a gasoline engine, set the stage for further advancements in the automotive industry.

A decade later, in 1894, according to Britannica, the world witnessed the inaugural organised automobile competition, spanning from Paris to Rouen, France [1]. Covering a distance of 50 km, the winning vehicle achieved an average speed of 16.4 kph. The following year, another historic race occurred, this time from Paris to Bordeaux, France, covering an extensive distance of 1,178 km [1], with the victor maintaining an average speed of 24.15 kph. Remarkable progress was evident within a mere year.



Figure 1: Vanderbilt cup race

Organised motor racing found its roots in the United States with an 87 km race from Chicago to Evanston. Britannica specifies that in Europe, city-to-city races within France or extending to other nations became commonplace until 1903 [1], when authorities halted the Paris to Madrid race in Bordeaux due to a surge in accidents. It further notes that the inaugural closed-circuit race, the Course de Périgueux, occurred in 1898, covering a 145 km distance in one lap. Such races, overseen by the Automobile Club de France (established in 1895), posed risks to spectators, drivers, and roads ill-equipped for automobiles, ultimately leading to a decline in road races. An exception was the Mille Miglia, which persisted until 1957.

Modern international motor competitions originated after James Gordon Bennett, owner of The New York Herald, proposed a prize for which national automobile clubs would vie annually, utilising three vehicles each constructed with parts manufactured in their respective countries. Britannica highlights that the first iterations of the Bennett Trophy Races were organised by the Automobile Club de France in 1901, 1902, and 1903. Subsequently, the event relocated to the Ireland Circuit (1903), the Taunus Rundstrecke in Germany (1904), and the Auvergne Circuit (1905). French manufacturers' refusal to adhere to the three-vehicle limit led to the boycott of the Bennett Trophy race in 1906, precipitating the inception of the first French Grand Prix race in Le Mans that same year, with cars competing as manufacturer teams.

Furthermore, Britannica explains that in the early stages of racing events, both in Europe and the United States, racing vehicles often served as precursors to models slated for launch the following year. Post-World War I, competitions became too specialised to employ production cars, although occasionally, high-performance cars intended for road use underwent modifications, including stripping of bodies and equipping with racing seats, fuel tanks, and special tires.

The first track specifically designed for automobile racing was constructed in 1906 at Brooklands, near Weybridge, Surrey, England, as highlighted by Britannica. This track comprised a 4.45 km long and 30 m (100 ft) wide circuit, featuring two banked curves reaching a height of 8.5 m. At Brooklands, a variety of competitions were held, including speed, relay, endurance, and handicap races, alongside long-distance events like the 1,600 km race in 1932. The circuit also hosted twenty-four-hour races between 1929 and 1931 before closing its doors in 1939.

According to Britannica, the most renowned circuit is the 4 km track at the Indianapolis Motor Speedway [1], situated in Speedway, near Indianapolis. Initially inaugurated as an unpaved track in 1909, it was later paved with bricks for the inaugural Indianapolis 500 in 1911. Since then, the race has continued uninterrupted, except during periods of wartime conflict.



Figure 2: Indianapolis

2.2 History of Formula 1

Formula 1 represents the pinnacle of global motorsport. In this category, single-seater, highly specialised vehicles designed to achieve extreme speeds compete. F1 is known for its focus on advanced technology, the presence of highly specialised teams, and the participation of elite drivers.

Its origin dates back to 1950 [2], when the International Automobile Federation (FIA) announced the union of several national Grand Prix races based in Paris (France) to create a World Championship for Drivers. A scoring system was established, and seven races were agreed upon as part of the celebration. The first of these races took place on May 13 at the Silverstone circuit [3], in the United Kingdom.

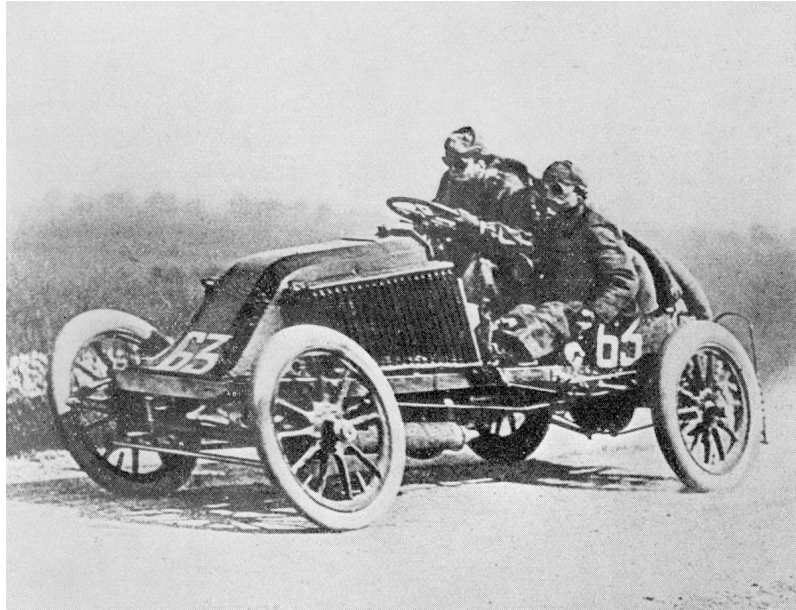


Figure 3: Marcel Renault

In the early competitions of the World Championship, both Italian brands and drivers played leading roles. Giuseppe Farina [3] became the first world champion by driving an Alfa Romeo. Ferrari made its appearance in the second race, in Monaco, and holds the honour of being the only manufacturer to have participated throughout the history of this sport. The period was dominated by teams run by automobile manufacturers Alfa Romeo, Ferrari, Maserati, and Mercedes-Benz, which had competed before the war. In the early seasons, pre-World War II cars like the Alfa Romeo 159 were used. When the Formula 1 World Championship was reinstated, engines were limited to 2.5 litres; in 1954 [4], Mercedes introduced the advanced W196, which included innovations such as desmodromic distribution and fuel injection, as well as a streamlined body. Mercedes won the drivers' championship two consecutive years (1954 and 1955) before retiring from all motor racing competitions following the 1955 Le Mans disaster [4].

In the 1970s, Bernie Ecclestone [4] carried out a restructuring in the management of Formula 1's commercial rights. His contribution is notable for having turned this sport into a multibillion-dollar industry. Previously, circuit owners had control over team revenues and conducted individual negotiations with each. However, Ecclestone persuaded teams to coordinate their negotiations through the Formula 1 Constructors' Association (FOCA).

During the 1980s, the development of electronic aids for drivers began. Lotus pioneered this field by creating an active suspension system that made its debut in 1982 [4]. In 1987, this system was perfected and driven to victory by Ayrton Senna in that year's Monaco Grand Prix. In the early 1990s, other teams followed Lotus's example and began developing similar technologies. This included the creation of semi-automatic gearboxes and traction control systems. Due to complaints that technology determined race results more than driver skill, the FIA banned many of these aids by 1994.

In the 2000s, the FIA regularly modified championship regulations to improve race excitement and reduce costs. Team orders, which had been legal since the championship's inception in 1950, were banned in 2002 [4] after several incidents where teams openly manipulated race results. By the late 2000s, due to the economic crisis, several Formula 1 teams withdrew from competition. Honda and Super Aguri withdrew in late 2008 [4], while BMW and Toyota did the same in late 2009 [4].

Currently, the championship consists of a series of Grand Prix races where 10 teams compete on different circuits around the world, from Australia to Abu Dhabi, including European, Asian, and American countries. Formula 1 is much more than just a sport; it is a high-tech spectacle of strategy and driving skills that captivates millions of fans worldwide and continues to evolve over time.

2.3 History of Racing Games

Racing video games have been a fundamental part of the digital entertainment world since the industry's early days. Their significance has been reflected not only in the technological advancements they've driven but also in the fun and excitement they've offered players of all ages over the years. They have served as a refuge for pure enjoyment and friendly competition. From the thrill of crossing the finish line first to the satisfaction of overcoming the toughest challenges, these games have provided players with the opportunity to immerse themselves in exciting virtual worlds where they can experience speed and adrenaline.

Many racing video games have been developed, but it's impossible to name them all; some have had a greater impact than others, both on society and on technology.

The beginnings were electro-mechanical driving games, entertainment devices that combine electrical and mechanical components to create an interactive experience for the player [5]. But attention shifted to digital video games, both 2D and 3D.

The first 2D racing video game released for arcades was "Gran Trak 10" (1974) [6]. The player races against the clock to accumulate points for the distance travelled on a track [6]. If they touch the edges, the car will brake and get stuck for a while until it's repositioned.



Figure 4: Gran trak 10

From 1976, pseudo 3D video games began, which simulate a three-dimensional experience using techniques and visual effects to give the illusion of depth and perspective in a two-dimensional environment.

In 1982 [7], "Pole Position" was developed. It is possibly considered the most important racing game ever created, evolving from previous electromechanical racing games. This game marked a milestone by being the pioneer in recreating a real racing circuit and introducing the novelty of a qualifying lap. Before competing in Grand Prix races, players had to complete a time trial. Although it wasn't the first third-person racing game (as it was preceded by Sega's "Turbo"), "Pole Position" laid the groundwork for the genre, and its success inspired numerous games that followed [7].

In 1988, advancements were made with the arrival of 3D video games, which use three-dimensional models, textures, and lighting effects to create a detailed and realistic visual representation of the game environment. From here, video games about Formula 1 began to stand out.

"Super Monaco GP," set in the world of Formula 1, offers players the experience of competing on the Monaco circuit and other famous racing circuits. Players take on the role of a racing driver and compete in a series of races to win the world championship [8]. It's worth noting that it contained parodies of real brands and drivers to which they gave similar names.

The first games to truly simulate Formula One races were Chequered Flag (1983) and Geoff Crammond's Formula One Grand Prix (F1GP) in 1991. Chequered Flag included features

such as fuel depletion and car damage, along with a selection of real circuits. Before this, most racing games representing Formula One, such as Accolade's Grand Prix Circuit and Electronic Arts' Ferrari Formula One, focused on a more arcade style. However, F1GP paid greater attention to car physics, as well as innovative graphics and accurate representation of real racing circuits.

During the first half of the 1990s, Formula One games experienced a surge in popularity, with many software companies obtaining licences to include real names and cars. A notable example was Domark's "Formula One" [9], which offered a wide range of authentic tracks, drivers, and teams.

The first 3D games to feature a full licence were F1 Challenge (1995) for Sega Saturn, and Formula 1 (1996) developed by Bizarre Creations for PlayStation (SONY) [9].

The Formula 1 licence rotated through various companies such as SONY, Ubisoft, Electronic Arts, Codemasters, until Electronic Arts acquired it in 2021 [9]. Some had exclusivity, such as SONY, and the video game was only available for PlayStation.



Figure 5: F1 2000 EA

Furthermore, the evolution of racing video games has not only mirrored advancements in technology but also contributed to shaping consumer preferences and expectations in the gaming industry. As hardware capabilities expanded and developers pushed the boundaries of what was possible, racing games evolved from simple pixelated experiences to immersive simulations that rival real-world driving experiences. This evolution has been driven by a combination of factors, including improvements in graphics, physics engines, and online multiplayer capabilities. Racing games have become more than just entertainment—they

have become a platform for innovation and creativity, inspiring players and developers alike to push the boundaries of what is possible in the virtual world.

3.0 Case study

3.1 The Impact of Gran Turismo

Gran Turismo, commonly known as GT, is a Japanese-origin racing simulation video game series created by Polyphony Digital. Designed for PlayStation platforms, these games aim to faithfully reproduce the appearance and behaviour of a wide range of vehicles, many of which are licensed recreations of real cars. Since its debut in 1997, the franchise has sold over 90 million [10] copies worldwide, establishing itself as the most successful video game series associated with the PlayStation brand.

The influences of Gran Turismo in the gaming industry remain prominent to this day. From introducing cutting-edge graphics in modern racing games to implementing precise and realistic physics, many titles have taken note of its success. When the series made its initial debut, innovative gameplay was a rarity in racing games. At that time, there were good racing video games, but Gran Turismo pushed the boundaries and popularised the racing genre on a large scale.

The impact of Gran Turismo was the catalyst for numerous racing games, including Forza [11], exclusive to Microsoft's consoles and PC, which has established itself as a formidable competitor in the genre. More realistic simulation racers such as Assetto Corsa, iRacing, and rFactor also began to understand the concept of racing and automotive culture.

Each of these games features unique characteristics that set them apart, especially in terms of physics, gameplay, and overall experience. Although some have gained considerable popularity, it is undeniable that Gran Turismo served as a fundamental starting point for their development. Essentially, the series laid the groundwork for these future games and inspired innovation in the racing genre in a unique and distinctive way.

The influence of Gran Turismo is not only within the racing game genre itself but also contributed to Sony and PlayStation's extraordinary success in the mid-2000s [11].

In addition to offering players the opportunity to experience virtual driving, Gran Turismo also opened doors for real-world competition through the GT Academy [11]. This initiative was conceived to provide talented Gran Turismo players the chance to become professional racing drivers. The legacy in the video game industry, as well as in the world of motorsports and the automotive industry as a whole, is truly monumental and represents an unparalleled success story.



Figure 6: Gran turismo 5

Gran Turismo raised the level of detail in racing video games considerably over the years, forcing its competitors to try to match or exceed the features it provided in each game of the series. It's worth noting the use of real brands and physics, which significantly increased its popularity and customer base.

Moreover, the impact of Gran Turismo extends beyond the gaming industry, influencing popular culture and even inspiring a generation of automotive enthusiasts. Its meticulous attention to detail and dedication to realism have set a standard that continues to shape the development of racing games and simulation experiences.

3.2 F1 Garage

A Formula 1 garage is a specially designed area within the paddock of a racing circuit where Formula 1 teams operate and maintain their cars during an event. These garages are essential as they are equipped with all kinds of tools and technologies capable of preparing and maintaining the cars.

In addition to serving as the operational centre during practice, qualifying, and race sessions, garages are also where pit stops take place during races, where tire changes, setup adjustments, and other quick maintenance tasks are performed. In this sport, every second counts, so the importance of having a good garage to improve in every possible aspect is essential.

In this case, a 3D environment has been developed for a garage belonging to the Ferrari team, aiming to achieve maximum realism by modelling tools, technologies, and parts of the cars. The garage is located in the pit lane, serving as the interior part where everything is prepared

before the race. On the outside would be the actual pit boxes, situated directly in the pit lane, where work is carried out during the race.

The International Automobile Federation (FIA) establishes a minimum width for garages, although this requirement is sometimes overlooked. However, there is no defined maximum limit. In modern and spacious pit buildings, there is room to expand the sides and have more space. Conversely, some older pit buildings, dating back to the 1980s [12] or earlier, are often narrower and more intimate. Therefore, the team layout is designed flexibly to adapt to different situations. This can involve creating a wider entrance at the rear of the garage or using a modular portal system where overhead panels containing lighting, air ducts, the driver's monitor, and electrical connection points are installed. This versatility allows teams to adjust the space according to their specific needs during a Formula 1 event.



Figure 7: Formula 1 garage

Additionally, garages are not only functional spaces but also serve as a showcase for sponsors and team branding. From logos plastered on walls to strategically placed banners and signage, teams use the garage environment as an opportunity to promote their partners and enhance their brand visibility. This dual purpose of functionality and marketing underscores the importance of the garage as a central hub of activity and engagement during Formula 1 events.

4.0 Methodology

4.1 Idea

The practical part of this independent project consists of creating a 3D Environment focused on video games or 3D animation films. The entire pipeline will be explained chronologically, understanding the why and the importance of each phase to reach the final objective.

The project idea revolves around a 3D environment of a Formula 1 garage, a highly specialised space where adjustments, maintenance, and preparation of race cars are carried out, equipped with cutting-edge technology and a team of world-class mechanics and engineers. Formula 1 is the most popular automotive sport in the world, hence the reason for developing the project in it, aiming to focus on the development of props and environments.

4.2 References PureRef

Once the concept is firmly grasped, the meticulous process of gathering reference images commences. This entails conducting a comprehensive exploration of the internet to locate images that align with the envisioned idea. To streamline this task, PureRef software proves invaluable, facilitating the organisation of all gathered references into a cohesive and easily accessible single file. Within this file, images are systematically arranged into sections, ensuring clarity and efficiency in the creative process.

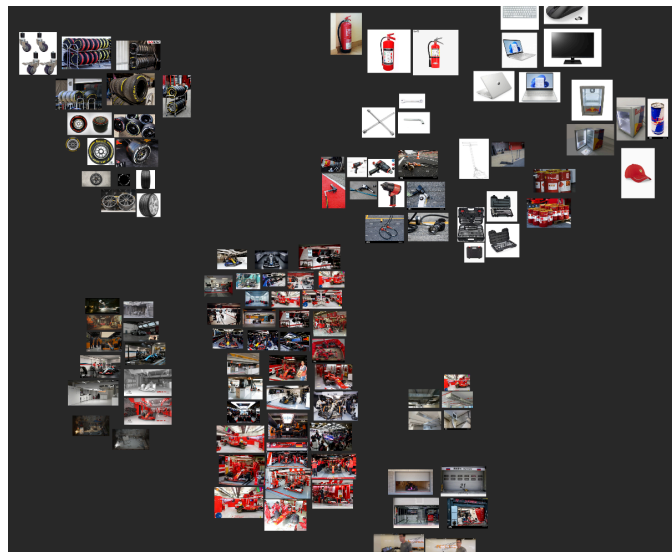


Figure 8: References PureRef

References on garages from different teams of the championship to choose a specific structure from the beginning, others on similar 3D projects about sports garages, plus references from the official F1 video game. Later on, references of all individual props are added. Here it is decided that the visual aspect of the garage will be based on the Scuderia Ferrari.

4.3 Planning / Gantt chart

In the progression of a long-term project, organisation becomes paramount. One effective tool for such organisation is the creation of a Gantt Chart. This strategic visual divides the project into distinct phases, offering a clear roadmap for execution. These phases typically include fundamental stages such as research and practical implementation.

Once the project's delivery dates are established, the next crucial step involves estimating the time required to complete each phase. This estimation process is essential for effective time management and resource allocation throughout the project lifecycle. By accurately gauging the time needed for each phase, project managers can better anticipate potential delays, allocate resources efficiently, and maintain overall project momentum.

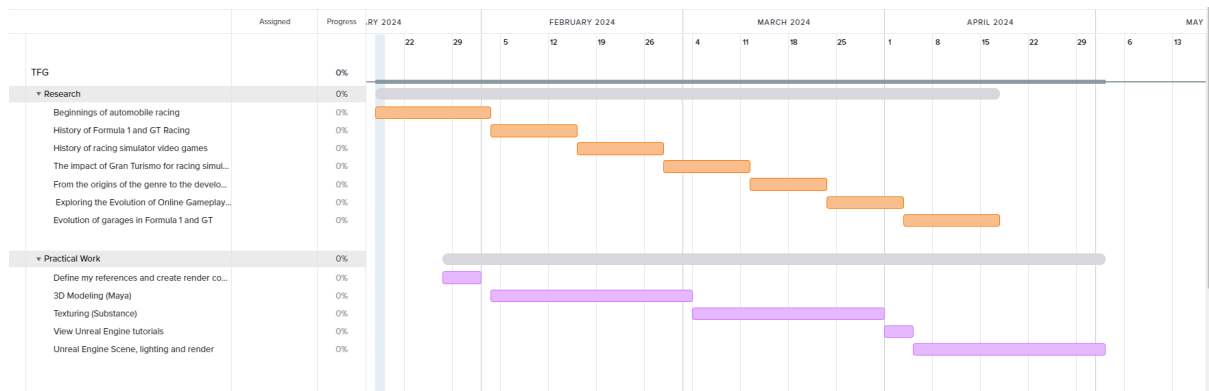


Figure 9: Gantt chart

4.4 Props list

Next, it is crucial to determine which props will be modelled. This involves creating a comprehensive list of props, which are then categorised into main and secondary ones. The prioritisation strategy focuses on identifying and modelling the fundamental pieces typically found in a Formula 1 garage first, followed by the secondary ones.

By establishing this clear hierarchy, the workflow becomes more efficient as it provides a roadmap for the modelling process. This approach significantly speeds up the work by ensuring that there is a clear understanding of what needs to be done from the outset, minimising deviations and potential time wastage.

Moreover, prioritising the modelling of the most essential elements ensures that even if there are delays in the project schedule, the core components necessary for functionality and realism have already been addressed. This proactive approach ultimately results in a better

outcome, as it mitigates the risk of critical items being left unfinished or rushed due to time constraints.

5.0 Project Development

5.1 Production phase

Once the conceptual groundwork is laid out, the production phase of the pipeline kicks off, initiating with the intricate art of 3D modelling. Here, the primary objective pivots around crafting a virtual environment tailored for video game integration, necessitating a delicate equilibrium between visual fidelity and operational efficiency. Central to this endeavour is the meticulous crafting of low-polygon models, optimising performance without compromising on quality. In this endeavour, the indispensable tool of choice is Autodesk Maya 2024, harnessed under the canopy of a student licence, empowering creators to sculpt digital landscapes with precision and finesse.

The inception of the modelling process unfolds with a strategic blockout phase, where the skeletal framework of the virtual garage begins to take shape. Every aspect of the garage's infrastructure, from cabinets to tables, ventilation systems to beams, undergoes meticulous scrutiny and formulation. These foundational elements, while not necessarily classified as props, form the very backbone of the garage's structural integrity, laying the groundwork for the immersive experience that awaits players within the digital realm.

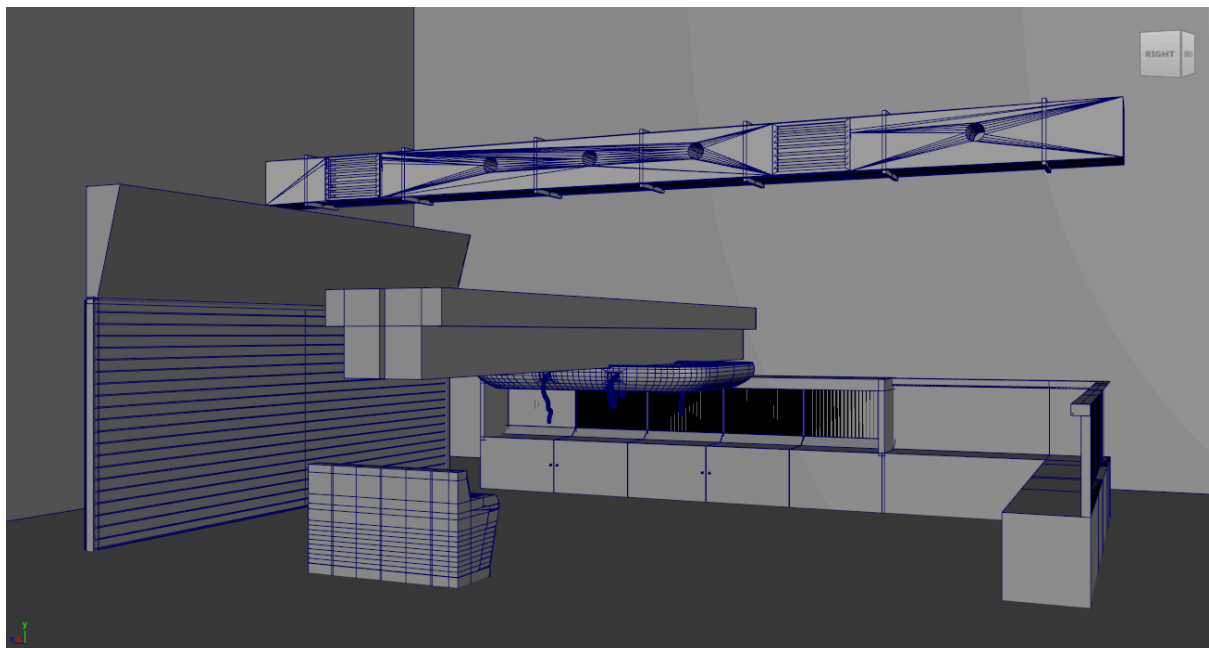


Figure 10: Blockout

Then, the development process kicks off with the meticulous modelling of a diverse range of assets crucial for the smooth functioning and safety of a competition garage. These assets encompass a plethora of items, including computers, monitors, wheels, tools, impact guns, barrels, chairs, fire extinguishers, and more.

The modelling approach adheres to traditional techniques, predominantly relying on vertex, face, and edge extrusions. This method ensures precision and control over the geometry of each asset, facilitating a comprehensive understanding of its dimensions and characteristics within the virtual environment.

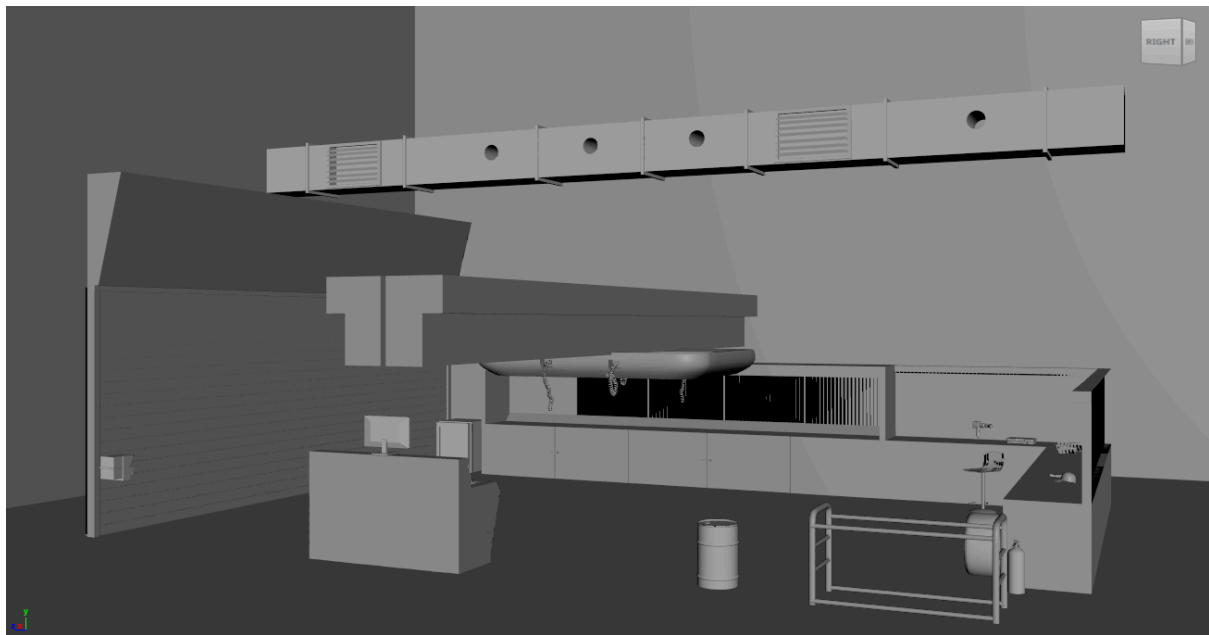


Figure 11: Blockout + props

The goal has been to achieve the highest realism possible through details and proportions. An attempt has been made to separate all possible pieces to have the least amount of edges in the objects and thus greatly facilitate the UV mapping process. 28 different assets have been modelled.

With all the modelling completed, the next step is to create the UVs for all the models for texturing. UV mapping is done by unfolding the geometry of the model onto a two-dimensional plane, so that each point of the 3D model corresponds to a point on the 2D plane. Without UVs, the texture cannot be projected onto the geometry, making it indispensable for the texturing process.

Using Maya's "UV Editing" panel, a 3D view of the model and its conversion into 2D (UV) are accessed.

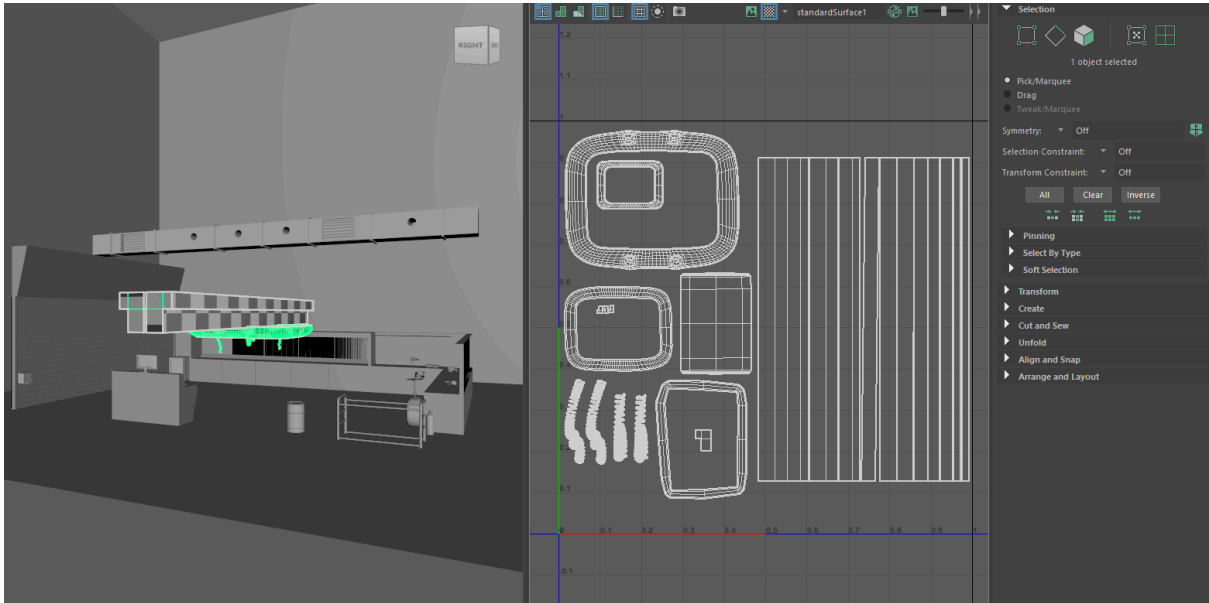


Figure 12: UV's menu

The development process for these models has been meticulous, with each model receiving individual attention. Tools like "create camera based" have been instrumental in crafting precise 2D model projections, ensuring accuracy and detail in their representation. Beyond that, a suite of tools including "cut," "sew," "unfold," "layout," and "orient shells" have been crucial in the refinement process.

These tools serve varied purposes, collectively contributing to the intricate construction of the models. "Cut" facilitates the division of complex shapes into manageable sections, allowing for easier manipulation and refinement. "Sew" then seamlessly merges these sections, ensuring continuity and cohesion in the final model. "Unfold" plays a pivotal role in transforming three-dimensional shapes into flat patterns, a necessary step in the transition from digital design to physical realisation.

Moreover, "layout" aids in the strategic arrangement of these flattened shapes, optimising space utilisation and minimising waste. This meticulous arrangement ensures efficiency in subsequent stages of production. Finally, "orient shells" fine-tunes the positioning of these components, aligning them in a manner conducive to efficient texture mapping.

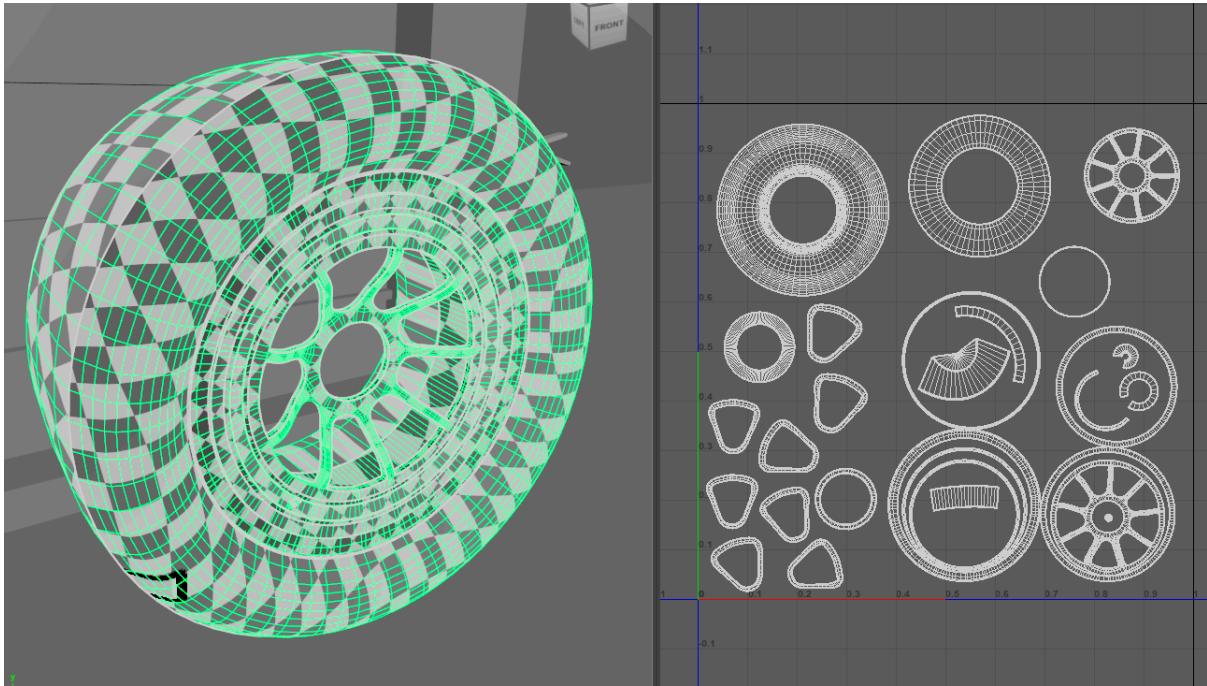


Figure 13: UV's example

After completing the UV mapping process for all the models, the next step involves exporting them as .fbx files. This export format ensures compatibility across different software platforms commonly used in the production pipeline. However, before exporting, it's crucial to clear the history and freeze parameters. Clearing the history helps reduce file size and prevents any unnecessary data from being carried over. Freezing parameters ensures that the models retain their intended shape and attributes without being affected by any subsequent modifications. Once these preparations are done, the models are ready to transition smoothly into the next phase of production.

The next phase is texturing, which refers to the process of applying textures to three-dimensional objects. Textures are two-dimensional images applied to the surface (UV) of a 3D model to add visual details such as colour, patterns, roughness, glossiness, and other attributes that make the object appear more realistic or stylized.

For this entire process, Adobe Substance Painter software has been used. A separate SP file has been created for each asset.

The initial phase involves setting up the scene and importing the .fbx file. A resolution of 4096 and OpenGL settings are applied. Following this, a baking process is executed on the model, utilising the LowPoly version as the HighPoly reference. This step generates various maps including Normal, Ambient Occlusion, Curvature, among others.

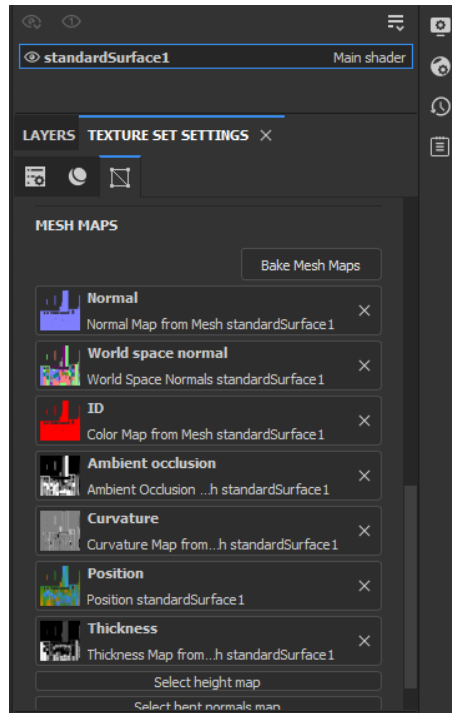


Figure 14: Maps created by baking

After enabling Anti-Aliasing and ramping up the quality to 128 samples per pixel (spp) for a smoother and more detailed preview, the painting process commences, meticulously building up layers one by one. This methodical approach often involves utilising fill layers for broad strokes of colour and drawing layers for precise detailing. Additionally, black and white masks are employed strategically to control the visibility and opacity of various elements within the artwork, allowing for greater control and finesse in the creation process.



Figure 15: Substance Painter previs

The next step is exporting them using the Unreal Engine template. This template optimises texture quality by exporting them at a resolution of 4096, ensuring high fidelity in the final product. Unreal's packaging process consolidates textures into three distinct images. BaseColor and Normal maps are separated, preserving their individual characteristics.

Meanwhile, Occlusion, Roughness, and Metallic properties are combined into a single map, streamlining the texture workflow and enhancing efficiency during development. This meticulous approach ensures that textures are optimised for Unreal Engine, facilitating immersive and visually stunning experiences for users.

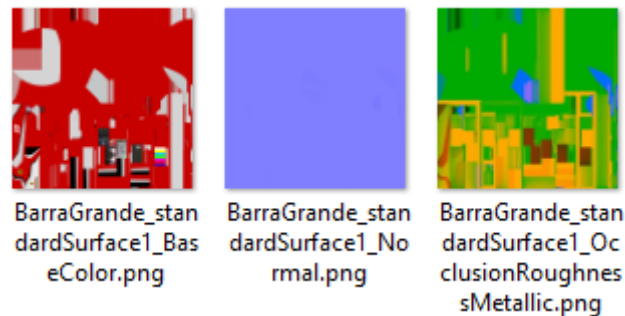


Figure 16: Unreal Engine texture pack

The next step in production is Unreal Engine, a game engine developed by Epic Games. It's a powerful and versatile platform used to create games with stunning graphics, realistic physics, and a wide range of development features. Its real-time rendering stands out, allowing developers to see changes in the appearance and lighting of their game immediately as they develop it. This means they can adjust and refine the game's visual appearance on the fly, speeding up the development process and enabling faster and more efficient iteration.

The process initiates with the creation of the project employing the third-person game template, incorporating a playable character poised to navigate the environment. Subsequently, all assets and their corresponding texture maps are systematically imported in an organised manner, utilising folders allocated for each asset type and its maps.

Upon the project's configuration, assets and textures are imported into separate folders to maintain a structured framework. Assets are stored within individual folders, while associated texture maps are housed within their respective folders. This demarcation ensures a clear and orderly resource management system, thereby facilitating efficient navigation and manipulation throughout the project's development lifecycle.

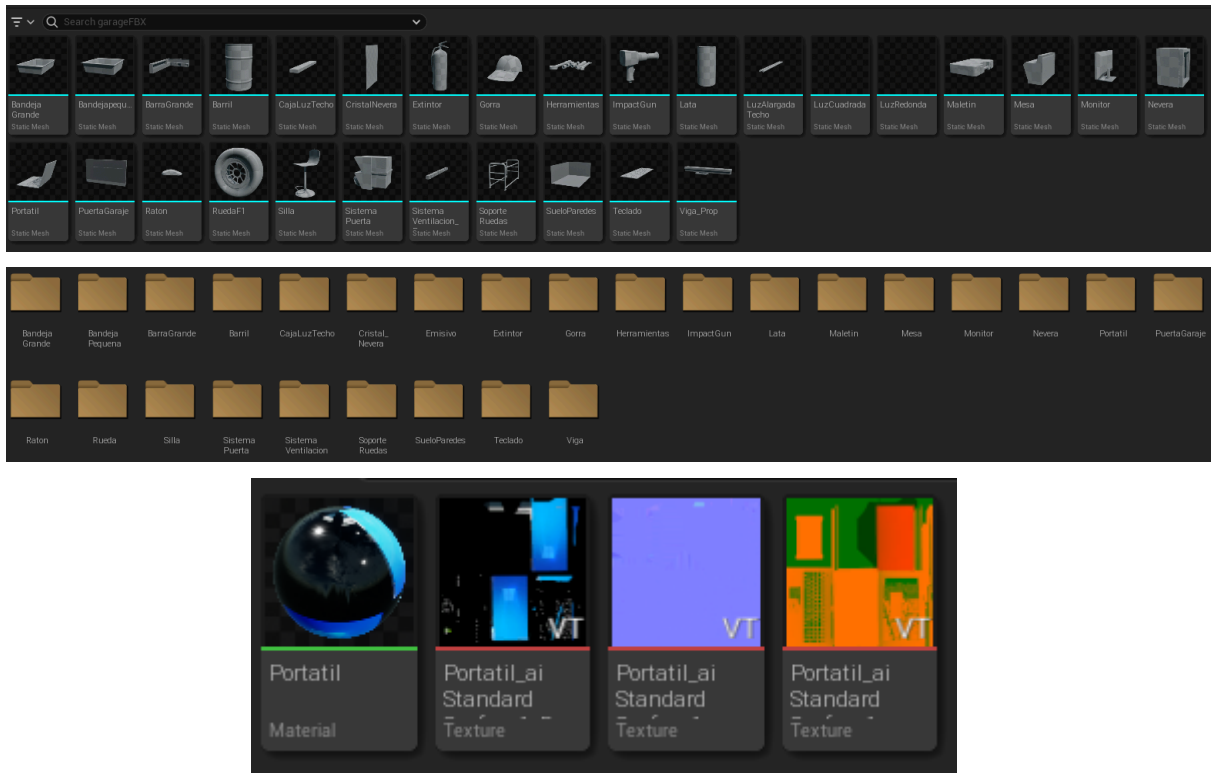


Figure 17: Unreal Engine content drawer (Assets and textures)

A distinct material is generated tailored to each asset, incorporating texture maps through the utilisation of nodes. Subsequently, the final step involves simply dragging and dropping the created material onto the respective asset.

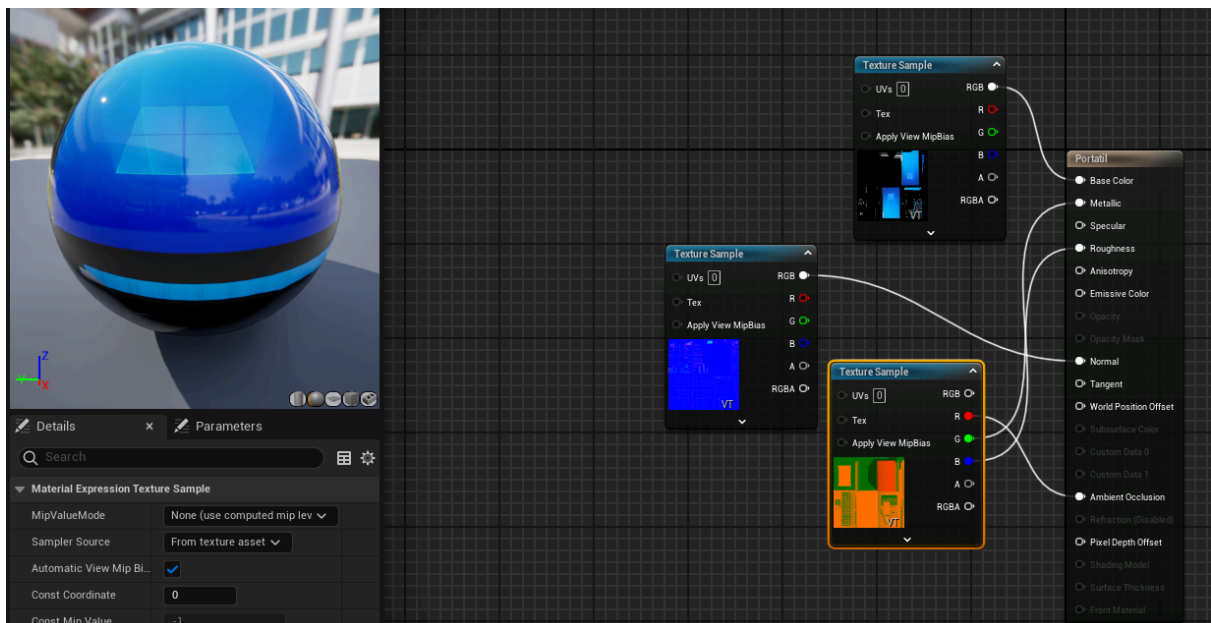


Figure 18: Unreal Engine material editor

With all the assets placed and textured, the scene can be previewed, allowing for consideration of changes and developments within it.



Figure 19: Unreal Engine previs

The next phase involves the implementation of lighting. Given that the environment is enclosed, artificial lighting will be the primary source. Several lighting models incorporating emissive materials have been selected for this purpose. A fundamental material has been crafted utilising a vector (xyz) in conjunction with a parameter to dictate the numerical magnitude of the material's power. This approach enables precise control over the luminosity and distribution of light within the space, ensuring optimal illumination for the intended atmosphere or function.

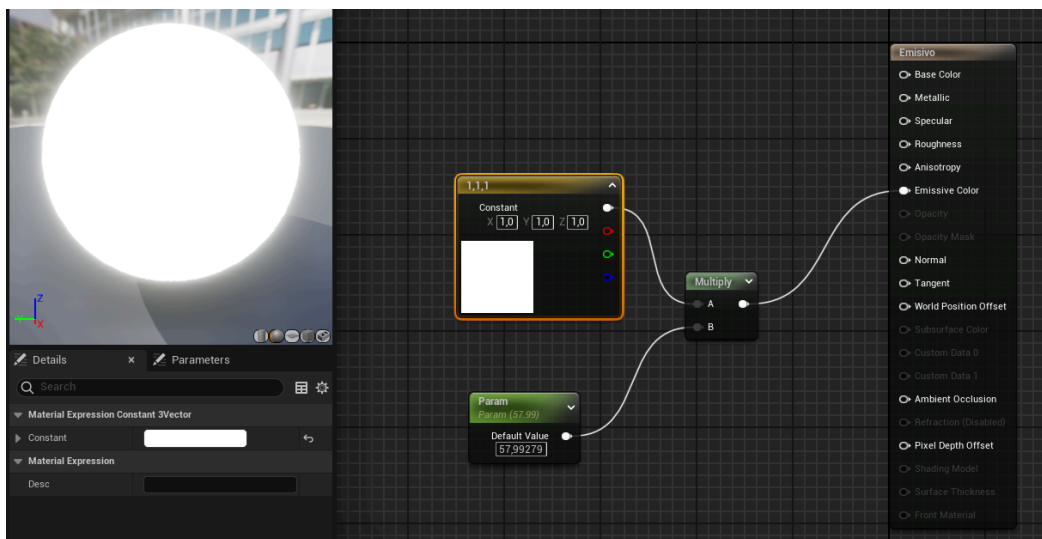


Figure 20: Main emissive material nodes

Following this, to expand the repertoire of emissive lighting options, the foundational material has been instantiated, resulting in multiple instances with distinct values assigned to each depending on the specific type of light they represent (ceiling lights, fridge lights, etc.) This approach facilitates the customization and fine-tuning of lighting characteristics tailored to the requirements of various areas or objects within the enclosed space. By individually adjusting the parameters of each instance, such as intensity and colour temperature, a diverse and dynamic lighting environment can be achieved, enhancing both the aesthetic appeal and functional efficacy of the overall design.



Figure 21: Emissive instances

To optimise illumination within the space, a system of ceiling lamps has been strategically deployed. Additionally, supplementary lights have been strategically placed in designated work areas to ensure adequate brightness and functionality. Notably, a prominent feature is the ring light positioned centrally above the area where the single-seater would be situated, serving to accentuate this focal point and provide enhanced visibility.

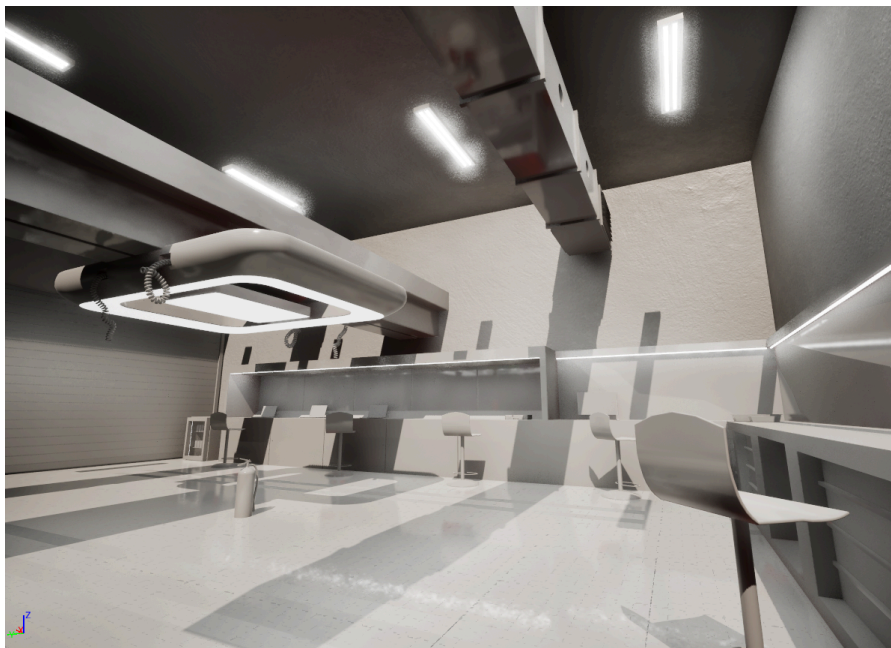


Figure 22: Detail lighting

5.2 Issues

Throughout the process, various unexpected problems have arisen that require finding solutions.

Firstly, upon importing all textured assets into UE, the dimensions of the ceiling were too large in relation to the rest. This created a very large and empty space above the character. It was necessary to lower the ceiling and adjust the orientation of the ventilation ducts to avoid collision with the garage door.



Figure 23: First version of the dimensions

Secondly, there were more technical issues. In the ventilation systems, there was geometry that disappeared from certain angles of observation. The solution was to enable "two-sided" in the material editor for this object. This issue occurred due to the object's normals; UE interpreted that the object was facing inward, causing it to disappear from the outside. Enabling "two-sided" allows both sides of the object to be rendered independently of their normals.



Figure 24: Difference of the ventilation system with “two sided”

Addressing another concern, there was an opacity mapping issue encountered with the refrigerator asset, particularly in the glass section. Upon texture application, the glass component failed to recognize the opacity section of the maps, leading to visual discrepancies. To resolve this issue, a solution was implemented by isolating the glass portion and exporting it as a separate .fbx file distinct from the main refrigerator model. Subsequently, the glass component underwent retexturing, and this targeted approach rectified the opacity mapping problem, ensuring seamless integration and visual consistency within the asset.

6.0 Evaluation

In this process, the evaluation would be on a large scale positive, as significant improvement has been achieved by completing the entire pipeline of creating 3D environments, and enhancements have been made in the Unreal Engine software, as it is the first project in which it has been used for this type of work. Several aspects could have been improved, notably the decision not to rely on a single concept or reference for the composition (where props are placed), but instead, multiple references and ideas were utilised. This approach could have resulted in a much better and more realistic composition, minimising potential gaps.

Highlighting the fact that the entire process was carried out by a single individual, thus enabling learning at each stage and constantly acquiring a wealth of knowledge, which is crucial for a 3D modeller in the creation of any project.

7.0 Summary

In summary, this dissertation traces the development of racing video games from the origins of automobile racing to the creation of ultra-realistic simulators. It highlights the industry's

continuous efforts to replicate the excitement of real-life racing experiences. By exploring technological advancements and gameplay innovations, it becomes evident that racing games have evolved into immersive simulations, promising even more engaging experiences in the future.

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