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CGI and Cinematography

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Abstract

The introduction of computer-generated imagery within film and cinema has provided a new dynamic element to the process of filmmaking. This has been accelerated by the huge advancement and growth of modern technology in recent years. As with any element relevant to how a film is created, it must have certain principles and techniques to rely on, to be suitable for film. These principles and techniques are what makes the filmmaking process such an important factor when filming or editing. This process and the principles and techniques involved are all based within the art form that is cinematography. Cinematography represents over a century of the evolution of filming visual and emotional aspects that provide a more engaging experience for the viewer. So far, these elements of cinematography have been applied within the field of computer-generated imagery and it's creation, but not applied in as much depth and attention that could possibly be. In this thesis we examine how both processes have been integrated together and the impact this resulting integration has had on specific areas and aspects of filmmaking. In preparation for these questions, I have researched the principles, techniques and histories of both cinematography and computer-generated imagery and formalised specific areas of study to base my findings. I also provide some conclusions based on the research carried out and the findings from the resulting research.

Acknowledgements

I would first like to thank my supervisor Hugh McCabe for his overall guidance and instruction throughout this process. Also, I wish to acknowledge the support and motivation I received from my family and friends, who helped me through the various stages involved. Finally I wish to thank the Institute of Technology Blanchardstown and my fellow graduates for their assistance in allowing me to achieve my goal.

Declaration

The work submitted in this thesis report is the results of the candidate's own investigations and has not been submitted for any other award. Where use has been made of the work of other people it has been fully acknowledged and referenced.

Gary Burke

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Table of contents

Table of Figures

1 Introduction

In this chapter we introduce the topic of research for this thesis and provide an overview outlining the areas involved. We then provide a breakdown of each chapter within the contents of this study.

1.1 Overview

The research and analysis carried out within this document, concerns itself with the interaction between cinematography and computer-generated imagery. Specifically with the effect of computer-generated virtual cameras and their uses and application through the fundamental techniques and practices of cinematography that is used within the process of filmmaking. Within this area we focus on how both can be integrated together and then applied as one final piece of work. Following research in both areas, we can see that a relationship between both disciplines can be formed. We'll go on to discuss this in further detail at a later stage and provide insights into how the relationship between both comes into effect.

1.2 Cinematography and Computer-generated Imagery

We now outline some fundamental aspects of how both these areas of study have similar and relating theories and techniques. (Mascelli 1965) describes cinematography as a set of principles and techniques pertaining to the effective use of cameras to film live action. The correct application of these principles and techniques allows for the production of a final piece of work that is both aesthetically pleasing and which is also more absorbing, engaging and emotional to an audience. This is in terms of how the final product produced has been created using the specific technical aspects that are associated with the art form that is cinematography. On the other hand we have computer-generated imagery. Computer-

generated imagery also includes a set of principles and techniques, but are associated with the creation and development of simulated imagery and objects. These images and objects are produced within a virtual 3D world. Within this world, there are an unlimited amount of creations that can be made and controlled, based on original virtual objects, or based on objects within the real world in which we live. Regardless of what the final product is based on, it still produces a piece of work that can be applied to live film footage. As these virtual or simulated objects are used alongside real life objects, the techniques in which we incorporate both, must still be based on technical aspects used within the process of filmmaking. This then refers us back to the techniques and principles of cinematography. Whether the final piece of work is real or simulated, it still must be shot in a particular way in order to keep in line with the previous fundamental techniques of filmmaking, which is exactly what the art of cinematography is.

The basis of research is from both areas of study. By understanding the fundamentals of each we can see how both have similar techniques that are relevant and which can be applied to each other, to produce a final piece that has similar outcomes. As these areas can be implemented together and overlap, can then find a whole new area of study from the resulting outcomes? This is where our research begins. The integration of both cinematography principles and techniques and computer-generated imagery principles and techniques, allows for a new set of results which can then be seen as a whole new area of study. In terms of filmmaking, will the integration of both provide directors and producers with a new set of tools, techniques and outcomes? All of which can be used and applied within the creation of film? As this integration has grown over time, the implementation in films has increased largely. As technology continues to grow then so will virtual and simulated technology, eventually resulting in the growth of application to this area in the process of filmmaking. This is why we have chosen to focus specifically within this area, as it has become a major aspect within the film industry and will continue to do so over the coming years.

1.3 Contents of Thesis

This introduction has outlined the background of our research and the basis of this work. It has presented our reasons for choosing both cinematography and computer-generated imagery as our sources of research, and outlines why this topic is both relevant and current in the industry today.

In Chapter 2 we discuss the features of cinematography, theoretical and practical, that form the basis of this study. Chapter 3 covers the area of computer-generated imagery. We provide a clear insight into each element of computer images and graphics that applies to our research. In Chapter 4 we outline the impact of computer-generated imagery, that we consider suitable for application to the features and theories of cinematography. Finally, in Chapter 5 we present our conclusions and findings of the research and analysis carried out.

2 Cinematography Fundamentals

In this chapter we outline the fundamental elements of cinematography. We discuss the principles and techniques involved and provide a description of each element and their purposes.

2.1 Introduction

In this chapter we introduce the principles, terminology, guidelines and techniques from cinematography that we believe are suitable for application within computer-generated imagery. The process of determining whether theses principles can be enhanced, improved and expanded upon by the involvement and integration of computer-generated imagery, can only be questioned by first looking at cinematography separately, as its own separate field of study.

2.2 Description

Cinematography is the discipline of making lighting and camera choices when recording photographic images for the cinema. It is central to the art of film making (Kneafsy. J 2006). It is the process of taking ideas, actions, emotional subtext, tone and all other forms of non-verbal communication and rendering them in visual terms (Brown 2002). As an art form, it has evolved over a period of time and concerns itself with a set of principles and techniques that are applied within the creation of live action and motion pictures. These aspects are the fundamentals of how filmmaking decisions are decided upon and captured through the cameras, and how the specific features within each aspect of a film is positioned, lighted, framed, angled and focused before the shooting of any shot through a camera. Within cinematography itself, there are sets of features that each refer to, and can be applied to different aspects of filmmaking. These features consist of a combination of different

techniques that must be considered when filming. By looking at each feature separately, we can get a better understanding of what makes cinematography an art form and what steps and processes are involved in considering cinematic decisions for filming.

2.3 Features

The following features are all fundamental elements within cinematography. Each involves a specific aspect that when brought together, make cinematography the art form that it is today (Brown 2002):

Visual Language: The principles that work interactively in various combinations to add depth, movement and visual force to the elements within a frame, within a scene. Principles such as composition, depth perception and visual perspectives are all important visual elements that must be considered when filming a scene. Composition, depth and visual perspectives all refer to how a scene is set-up. This includes all elements within that scene such as props, cameras and actors. According to (Mascelli 1965) the manner in which scenes are composed, staged, lighted, photographed and edited should motivate audience reaction, according to the script's intent.

All of these elements are planned, created and organised in a specific way, to provide the viewer with some sense of what is trying to be achieved within the scene. The viewer is constantly being fed information through the interaction of these elements, to ensure some form of understanding to what they are viewing. This information along with these elements, then form each visual aspect that is displayed. These visual aspects then, depict what is perceived by the viewer and how it is perceived. Through these aspects we can tell the audience where to look, what to look at and in what order to do so. In order to achieve the passing of information to the viewer successfully, we need to control how the viewer will see things, and the sequence they will see things in. It's about guiding the eye and directing the viewers attention to a specific object or place, in an organised and subtle manner. If this is achieved then the information can be conveyed and taken in by the viewer, in turn providing a meaning and understanding to what they are being told to look at.

Lens Language: The methods and practices used to add layers of meaning and emotion to shots. Methods such as framing types, frame rates, focus and filtration all add to the effect and experience for the audience. These methods are created specifically to impact the connection and emotions of the audience by placing the focus within a scene on a specific element or on multiple elements. It also concerns where how the scene is shot by the camera and where the camera is placed within the scene itself to capture everything.

The camera lens is a powerful tool in terms of filming. It determines what the viewer will and will not see within a frame. This is an area in filming, that the director will be heavily involved in. If the camera settings including lens language, are not setup correctly, then the camera will not be able to capture footage that is suitable and of a high enough standard to be shown within film. The lens itself refers to framing, frame rates and focus as outlined previously. All of these elements must be considered to ensure that the field of vision and movement in the scene is visibly clear and in enough focus to be viewed. These elements are then considered in relation to where the camera has been placed. There are many places for a camera to be positioned, to allow for different types of camera shots and angles to be used. Angles above and below the scene, in front or behind specific scene elements or any other possible camera angles, allow for a wide range of possible ways to shoot a scene. After all of this has been considered, and setup correctly, only then can the filming of a scene start.

Camera Dynamics: The techniques and technology of moving the camera to determine what the audience sees, and from what perspective they see it from. Techniques such as camera movement, camera mounting and motion control. The ability to move the camera is the most fundamental aspect, which distinguishes film and video from photography and other visual arts.

The ability to move a camera around, manipulate and control it in any way possible is a fundamental aspect of filming. It allows for an exciting way of filming a scene. With the addition of camera props and such as dollies, cranes and platforms, there is an unlimited set of possibilities for the camera. Dollies, cranes and platforms allow for moving scenes to be captured as well as allowing for a camera to move freely around a scene to capture all elements from different angles and positions. According to (Kipper 1986) these props produce a continually changing visual perspective that allows the viewer to experience better the spatial relationships between objects. Controlling a camera however, is much more than just

moving it around from one place to another, it involves the consideration of much more. To film a scene the camera must first be placed and setup correctly (*lens language*), and then moved in a way that it relates to the all other elements that contribute to the scene itself, such as the style, action, mood and timing. If these elements are captured in sync with the camera, then the attention and emotion of the viewer to what they are viewing will be achieved.

Cinematic Continuity: Continuity applies to everything visible within a scene and ensuring that all items match from shot to shot. Items such as movement, position, time, direction and cutting.

The continuity of camera shots and the way in which they are captured, determine how the final product will turn out. The final product being the completed piece of work, must serve the purpose of achieving it's goal by having an end product that makes sense to both the creator and more importantly, the viewer. If this is not achieved however, then the viewer will have no physical or emotional connection with what they are seeing. This then refers back to continuity. After all shots are filmed, you are left with a sequence of shots that then have to be edited and pieced together to form a final product. As one shot leads into the next, the viewer must see a continuous sequence of events, that include all elements within those events, that then make it believable. These elements consist of the continuity of content: what and how everything is made visible within a scene, the continuity of movement: the movement of objects from one scene to another and the seamless combination of how this is achieved, the continuity of position: the positioning of all elements within scenes must be consistent, and the continuity of time: the flow of time in terms of moving from one scene to another. These all add to the visual consistency and style of scenes.

Exposure: The methods of lighting a scene and all elements within that scene, for visibility correction. Elements such as brightness, contrast, the gray scale and colour all add to the visual element that are lit within the scene.

Controlling the amount of light in a scene is important, as it contributes greatly to what is visibly clear and what can be seen by the camera and the viewer. It can be controlled by the camera itself and by real world environments. Through the camera, the amount of light used for a scene can be adjusted by the cameras lens and aperture. Aperture refers to the size of the lens that allows light to travel into the camera. Within the camera itself, it can determine how

much light is used and where it wants to use it. Being able to control light through the camera, allows the director to adjust the amounts of brightness, contrast and colour within a scene. On the other hand, some scenes make use of real world environment light from the sun and sky. This is used mostly for outdoor scenes and involves setting up a scene using the surrounding world as the source of light. This type of light is known as 'real' light as it comes from the sun. It provides an advantage to filmmakers as it does not require any lighting or light sources to be set-up in order to film.

3 Computer-generated Imagery

In this chapter we outline the key areas and elements relevant to computer-generated imagery (CGI). We provide a description of the techniques involved and discuss key aspects of CGI such as the integration with live action and the use of CGI cameras.

3.1 Introduction

In this chapter we will look at computer-generated imagery, CGI for abbreviation, and the principles and techniques that are involved in creating and simulating imagery, that can then be inserted and blended together with live action footage for the process of filmmaking. CGI is an integral part of creating an unlimited, new set of effects in a range of areas within film, such as animation, special effects, editing and rendering.

3.2 Description

CGI is the application of the field of computer graphics, (or more specifically, 3D computer graphics) to special effects (ScienceDaily.com 2010). A definition of computer graphics are 2D and 3D images that are used to create pieces of work that look and feel as close to real life objects as possible. If more than one of these images are blended together in a sequence, then this forms a continuous chain of images that when viewed, look like a piece of video, and this is why filmmakers use this method to implement into film to enhance real footage. This method is then created specifically for film, for the purpose of integration and simulation, to expand the capabilities of filmmaking itself. This is then why it is referred to as computer-generated imagery or CGI.

CGI footage itself is footage that has been created in a 3D world within a piece of graphics software. The footage is not real and has not been captured in real life by a film camera, it has been produced separately, to be integrated later with real footage. The development of CGI has been constant and ever present within film today. It enhances real live footage by allowing for endless possibilities of filmmaking. It can be applied to all aspects such as cameras, lights, scenes and characters. The 3D graphics software that produces this imagery is based within an imaginary 3D world where there are no limits to creating pieces of work. There are no constraints in movement or positioning, there is just an empty space that can be filled and manipulated in any way, unlike in real film where there are constraints within the real world to what you can do. This is where CGI becomes essential. It can create endless objects and images that can be integrated in real film, look exactly like real world objects and can create effects that would be impossible to create using a film camera. With CGI, you can create flying cars, cameras that can spin, turn and squeeze in the smallest of spaces or create cartoon characters that can walk and talk as if they were real people.

3.3 Techniques

CGI techniques and principles are similar to the techniques and principles of filmmaking, except for the fact that CGI principles are based within a virtual world. The principles remain the same, as they will later be integrated into real footage. The techniques however can be expanded upon within the vast free space that is the three dimensional world they are created in. Within this space, objects can be manipulated in new ways and in a free fluid motion without any constraints. For this space to be created then, we need to refer back to the basics of CGI creation and 3D graphic fundamentals. These must be considered before any virtual pieces of work can be created. Such fundamentals allow for this type of creation to be possible. 3D fundamentals such as modeling, representation and rendering are core elements that allow this to happen. Modeling 3D graphics refers to taking a 2D image or object, taking it into a 3D virtual world and turning it into a 3D object using its physical coordinates and dimensions to then create a physical 3D model. The final 3D model is then a mathematical representation of the three dimensional object is was created from, either real or inanimate (ScienceDaily.com 2010). This model can then be manipulated within the virtual world to move and look as similar to a real life object as possible. This is where camera techniques

such as movement and positioning can be used in new ways to create shots that have never been done before. Characters can be created in three dimensional space and can be created identical to a real life characters. Within the space the 3D character can be manipulated in various ways and then be applied to the real life character when integrating both types of footage together. The real life character now looks as if they are doing extraordinary things in the shot that seems impossible to do physically in real life. In reality it is the 3D character achieving this but when viewed by an audience, gives the impression that the real life character is the one actually achieving this. These are the advantages of using computer-generated imagery.

3.4 Integration with live action

The integration of CGI and live action involves the blending together of 3D footage and real live footage. As we know, 3D footage is reproduced using 3D software while live footage is captured in real life by a camera. The blending of both these types of footage is how 3D animation, computer animation and special effects are created. The integration process itself, involves several stages of production, each with it's own set of elements that when integrated together, produce a final product. Here is an outlined breakdown of each of these stages:

Stage 1 On-set passes: This is the first stage of blending and involves the task of setting up a scene with sufficient and accurate lighting. This needs to be setup first properly so that when the scene is shot for both live and virtual means, it has the necessary light and reflection needed to make the blending look natural and believable. If the lighting of a scene looks unnatural or false, then the virtual footage will look out of place when integrated. Following the successful development of the lighting, the scene can then be shot using the following methods. Firstly, a rehearsal shot is taken to make sure the lighting has been rightly adjusted. Then the scene is shot using an actor standing in for the place where the CGI object will be *(As shown in Fig. 3.4.1)*. The examples shown below, are stills taken from the 2011 film 'Real Steel', which heavily involved the use of CGI integration for the creation of life like robots. These example show the process of how a scene containing a CGI object is created both before and after integration. The next step is to create the CGI object itself, with the same movements, dimensions and style of the actor. Finally after the object has been created,

it is integrated with the live footage in place of where the original actor was placed. Using editing software the two are now manipulated to look as one *(As shown in Fig. 3.4.2).*

Figure 3.4.1 Scene with actor standing in before CGI

Figure 3.4.2 Scene with robot after CGI integration

Stage 2 Complex and Dynamic HDR's: This stage involves using high dynamic range (HDR) maps, for applying environment lighting to CGI objects. HDR is a term taken from the producing of different lighting exposures for film. Within this stage, HDR images are taken of

the CGI object and the surrounding real world environment, as the CGI object moves around within it. In real live footage, lighting and reflections are cast onto all objects within the environment, caused by light and object movement, reflection and absorption. This then needs to be reproduced using the CGI object, to ensure that the light and reflections are cast as normal onto the virtual object, just like they would with a real object. To do this then, HDR image maps are taken of the surrounding environment and mapped onto the CGI object to look as real as possible, as that object moves around. This process is very time consuming and involves much precision and calculation when mapping.

Stage 3 Contacts and Interactions: To allow CGI and live action integration to look natural, the 3D models must be as close to the real characters as possible. As outlined in *Stage 1*, an actor stands in place of the model before it is integrated. This allow developers to mimic the style and movement of the actor to then apply to the model. Props and items can then be added to the actor to make creating the 3D model even easier. The closer the actor is to the 3D model they want to create, the easier it is to make it look as real and life like. In our example, shoulder pads and leg extensions have been added to the actor to make him look more 'robot like' *(As shown in Fig. 3.4.3).* This then makes the creation of the 3D model easier to produce and seem more life like. The final shot including the 3D model shows the similarities between the shape of the actor and the shape of the model after creation *(As shown in Fig. 3.4.4).*

Figure 3.4.3 Scene with actor wearing props

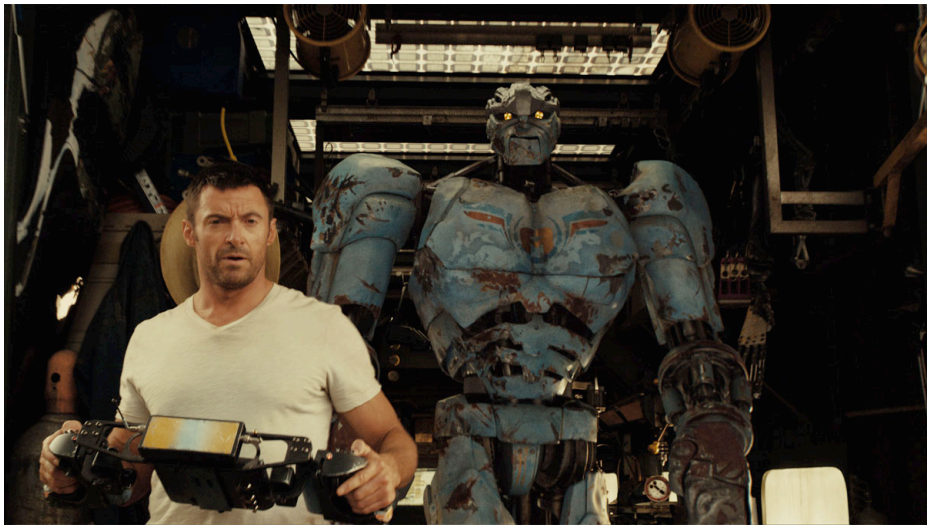

Figure 3.4.4 Scene with robot after CGI integration

Stage 4 Staging and Framing: This stage involves setting up a scene for the purpose of adding CGI footage to it later. Staging and framing of a scene for CGI must consider all of the possible problems that may be encountered. Framing refers to where an object is positioned within a scene. With CGI involvement, capturing footage must have the right framing proportions and planning to capture everything within a scene, including CGI objects, equally and in focus.

Stage 5 A seamless, tight acquisition pipeline: This refers to the workflow of capturing shots in a sequence using high quality camera equipment. All of these shots are captured with the necessary framing and positioning using actors, before any CGI footage is created. The sequence of shots and the workflow and process involved, is also known as a production pipeline. For a successful pipeline, all shots must be captured correctly using the highest quality cameras, and can then only be applied for use with CGI footage.

Stage 6 Animation and Texturing: An important factor of any 3D model is it's look and feel. During this stage, the focus is on adding animation and texture to the 3D model. To achieve this the developers must ensure that the movement and actions of the models are exactly the same as the real life actors. This process is known as animating. Texturing must also be applied to make the physical, graphical representation of the model look real. This is achieved by applying various textured images onto the model itself and blending that image into the

curves, shapes and general structure of the model. Both animation and texturing are key elements to the design of any 3D model.

Stage 7 Great Compositors: Finally we will look at compositing the final integrated footage. Compositing refers to the process of taking various visual elements, in our case virtual and live footage, and combining them together to form one image. To composite these two visual forms, all visual elements must be matched up together and blended together to look as one. This involves matching the colour levels and highlights within an image and adjusting various key elements such as motion blur, shadows, lighting and contrast.

Now we will look at the purpose of CGI cameras in the process of both 3D graphics and filmmaking

3.5 CGI Cameras

Computer-generated cameras also known as virtual cameras are one of the main uses for CGI in film and television today. As virtual 3D graphics and technologies have grown, virtual cameras have been an important element considered and used by filmmakers. With this type of camera there is has an unlimited amount of options to control and manipulate it, unlike real world cameras. The difference is that virtual cameras are not real. They only exist within the virtual environment they are created in. An environment where there are no constraints, limits or obstacles. The reason why these cameras are preferred to instead of real cameras in some cases is for this reason. Unlike real cameras, when a camera is created in a virtual world, it can do anything and everything it wishes. Real world cameras on the other hand, can only be used within the real world and therefore has it limits to what it can do and how it can be used. For example, a real world camera has limits in its movement, position and controls whereas a virtual camera does not. A virtual camera can look as if it's flying through the sky, squeezing through the smallest of holes or falling from the highest buildings. This type of cameras provides filmmakers with the opportunity to use cameras in ways the have never done before, and the reason why this method is so popular is that when created and animated, the virtual camera can then be integrated within real film to look as same and have the same effect as a real camera would. This then refers back to the progress of virtual technology and how far it

has come, that we can use virtual objects that will look as real as possible even though created within a virtual world. For these reasons, filmmakers are able to make impossible ideas become possible. Scenes that were impossible to create using a real world camera, simply because of human constraints, can now be achieved through a virtual world.

CGI cameras continue to grow within film and television today and can be used on a small or large-scale basis. For example, the highest grossing film of all time, the 2009 James Cameron science fiction blockbuster 'Avatar', had the majority of its footage created in CGI.

Figure 3.5.1 Screenshot from the film Avatar

4 Impact of CGI on Cinematography

In this chapter we outline our main area of study which discusses how CGI impacts cinematography. We begin by discussing the similarities between both areas, then focus on how the integration between the two have impacted within the proccess and techniques of camera camera, camera footage and rendering footage. We finish by discussing the impact of CGI within motion pictures and special effects.

4.1 Similarities between CGI and Cinematography

To compare these two areas of study, we must consider them in the process they are created. Firstly we'll take CGI, as its creation must first take place in order to then apply cinematic principles and techniques. After CGI models have been created, they can only be used in certain ways in order to be of cinematic quality. As each individual principle of cinematography determines the rules for filmmaking, the CGI model must then be used in accordance with these rules, in order to be of sufficient quality to be applied in film. For the CGI models to be as realistic as possible, they must have all the same attributes as real world objects. To achieve this the filmmaker must control these models in certain ways to make this possible. Cinematic principles such as camera control, continuity and visual language are all vital aspects of filmmaking that must be applied to each individual object within a film scene. This is the same for CGI models. There is no exception regardless of what type of objects are being filmed.

The comparison between CGI and cinematography then, is that both need to be applied in a specific way to be used within film. Without cinematic principles and techniques, CGI would not be enough to be used and considered in film. Without the advent of CGI, filmmaking would not have access to the wealth of techniques that this technology has made possible and therefore the art of cinematography needs to be expanded in order to take into account the new parameters of what is now possible within filmmaking.

4.2 Camera Control

The camera is the one constant element within every scene that captures everything that is happening. Controlling a camera is then an vital task to any filmmaker. For each film scene the camera determines what is being seen and what isn't. In order to capture moving objects within a scene, the camera must move around to accommodate this. This is why camera control is so important. The ability to move a camera around, manipulate and control it in any way possible is a fundamental aspect of filming (Brown 2002).

The amount of control we have depends on what type of camera we are using, where we are using it and what are we using it for. This can be explained by taking camera control as two separate parts e.g real world camera control and virtual camera control. Both types have their own specific benefits but depends on what each will be filming. Controlling a real world camera, we position a scene containing multiple objects. The physical camera is then positioned in a particular place to capture the scene as it plays. If the need for a moving camera is required, then various equipment tools such as camera dolly's or cranes will be applied. This is then expanded on and explored further with virtual cameras. This type of camera is not a real physical object. It is created within a 3D virtual world and occupies a physical space within that world. The major difference is that virtual cameras have been created within a world space that is not real and therefore carries no real aspects of the real world such as limits, constraints or rules. This provides an unlimited amount of control over a camera.

There are many advantages for choosing a virtual camera over a real camera. With virtual cameras, the director has an unlimited scale and range to what can be achieved. Using a camera within a virtual world allows for a whole new area of control. With this method, CGI scenes can have multiple moving objects and effects that rapidly move around within the virtual space. The camera can then move around in exactly the same way at the same speed, and capture all these objects as they are moving, in a clear and visual manner. The camera can be controlled and manipulated in ways that are physically impossible for a real camera. With no constraints or obstacles, virtual cameras compensate for all the physical constraints of real cameras. This is why the implementation of virtual cameras are used more commonly in film today. They provide

new options, new means of control and new methods of capturing footage, unlike any real world camera.

As we have outlined the advantages of the virtual camera, we must also concede that these cameras do have their limitations. For one, they can only exist in the virtual world they were created and can only film virtual objects. However, with the giant increases of realism in CGI, those virtual worlds can be almost indistinguishable from the real one and hence an almost seamless integration of these two types of footage can be achieved. For example in the opening scene of the 2002 David Fincher film 'Panic Room', the use of the virtual camera created a shot where the camera that moved through the sky past buildings for the opening credits (*As shown in Fig. 4.2.1*) and moved through the walls and floors of a house in one continuous shot. This was achieved by reconstructing the entire sky, buildings and house using CGI and then using a virtual camera, as it was physically impossible to achieve using a real camera.

Figure 4.2.1 Scene mapped out before CGI

Figure 4.2.2 Scene rebuilt in CGI

4.3 Camera Footage

A vital process of filmmaking is rendering footage, which creates the final piece of work. But what about the individual pieces of camera footage that are rendered. With real footage, the camera captures the scene, imports the footage into a piece of software that can then be edited and rendered for the filmmaking process. For computer-generated footage, the process involves creating the 3D models, rendering the footage, integrating the footage within the film scene and then rendering everything out together as a whole, through the software. Before any render can take place however, the individual pieces of footage being used must first have been edited for the final product. This works fine if all the footage has been edited correctly and all scenes are matching and consistent. If some scenes need to be changed however, then the ease which they can be changed differ greatly.

For both types of footage, the difference between each after it has been created, is how easily changes can be made to it. Each can be re-adjusted and edited, but the way in which this is done is through two different means. For real footage, only a certain amount of changes can be made without the need to re-do the entire scene. With computer-generated footage, there are multiple benefits to a director to what can be changed if required. If something goes wrong in the process, the footage can be changed relatively easier through the 3D software. Through the ease of clicking a mouse, huge changes can be made. The software in which the footage was created, allows for all changes to be possible from the one place. There is no need for re-shooting of a scene, because all elements within that scene are not real. They have been created from nothing in a virtual world. This is why changing virtual footage is easier than changing real footage. There are no real world constraints or physical obstacles to overcome.

Another huge benefit of CGI footage is that it doesn't require any real world objects. There is no need for actors, models, locations or sets. All these elements can be re-created and re-adjusted through the software. With this process, the changing of footage requires no extra input or re-using of film equipment. This then has a positive effect on the filmmaking process itself as it reduces costs and makes the fixing of errors less time consuming and more manageable.

4.4 Rendering Footage

After all footage has been captured or created, it then has to be outputted in a way that it can be used within a film sequence. This output is known as the process of *rendering*. This process is carried out at the final stage of filmmaking, following the capture of all elements with each scene. Elements such as film footage and audio, editing and special effects, are all taken into a piece of software and rendered out to produce a single sequence containing the final piece of work. In terms of computer graphics, a different type of rendering must first be carried out and then integrated with real film footage, before the final render of all film elements can take place. The first rendering of computer graphics is a way of outputting a visualised representation of the 2D or 3D computer generated object created. According to (Lathop 1997), rendering is the "drawing" part of computer graphics. It's the process of converting all the stuff in a scene into that 2D or 3D grid of pixels we call an image. With this in mind, we will now compare the rendering of real footage and computer generated footage, to outline the different methods involved.

With real footage, the process of rendering involves taking all footage from the camera, entering it into a piece of editing software, editing all of the footage together and finally outputting it all as one continuous long clip. This clip is then the final product i.e the film itself. The final rendered clip can be used to display in cinema screens, television, DVD or online, all with the specific settings included for each. With computer-generated footage, the virtual world is created using 3d sofware. The virtual world is created based on the real world objects they are to resemble. After the 3d world is created, a virtual camera is added to capture the footage. The footage is then rendered out of the 3D sofware using the specific settings. Next the rendered footage is inserted into the editing sofware and integrated with real footage. That footage is then rendered out again as decribed in the previous section.

These processes of rendering allow for different types of film footage to be used. For CGI, the process takes longer but the final result provides a new dynamic for creating film. For real footage the process is quicker but involves making sure that the footage captured is exactly the footage required. CGI can be re-edited if required to make any changes, but real footage cannot be re-created after the original footage has been captured. To do this the whole scene must be set-up and captured again. This is why CGI footage is benefitial to filmmakers.

5 Conclusions

In this chapter we summarise our main points, compare our findings within our areas of study, provide a general assessment of our results and conclude on a number of points.

5.1 Summary

We begin this thesis by making the case that computer-generated imagery influences and impacts on the principles and techniques of cinematography. We put this statement in the context that both areas can be integrated together for the purpose of filmmaking. First we discussed cinematography in detail including the principles and techniques involved such as visual language, lens language, camera dynamics, cinematic continuity and exposure, and methods for putting all of these together in the shooting, filming and editing of scenes. We then discussed computer-generated imagery in similar terms, outlining the techniques involved, the six stages of integration with live action and a detailed account of virtual cameras. Following these two areas we then began outlining the key elements relevant to explaining our original statement and our main area of study. This went on to explain how computer-generated imagery and cinematography can be integrated together and what the resulting effects and conclusions were. We discuss the similarities between both, the impact both have on camera control and camera footage, how both footage types are rendered and the impact computer-generated imagery has had on motion pictures and special effects. Finally in the next section we provide our conclusions of the research topic and the resulting findings of this thesis.

5.2 Conclusions

We conclude by noting some important findings regarding this research topic. The goal set out at the beginning of this thesis was to carry out enough research to determine whether cinematography and computer-generated imagery could be brought together and whether both could be used alongside the other to improve specific aspects of filmmaking. Having carried out the research and gathered the findings, we can finally say that the research topic outlined is both a valid and a conclusive one. Both areas can be applied to the other in particular ways to make the shooting of scenes and the filming of footage more visually acceptable and appealing. Within the filmmaking process itself, both areas need each other in some way to be created. For cinematography, the principles and techniques that make it an art form, can only be used and required if they are being applied to elements within film. For computer-generated imagery, the virtual computer animated models can only be created as similar to human or real objects, if they resemble and act like these objects. To do this, the virtual models must be captured in a cinematic way to be suitable for use within film. This is then achieved by applying the principles and techniques of cinematography to them. We also conclude that several outcomes are clear to be seen from the integration of these areas. Some specific impacts have come to effect from this integration. Impacts within camera work, camera footage and the rendering of footage, all of which are vital to the filmmaking process.

Our reasoning behind this topic is that within the constant and ever growing business of filmmaking, these two areas have become increasing more frequent for filmmakers. As technologies, budgets and expectations continue to grow and advance, we will see a continuous growth in the development and research of both these areas. Our study focuses mainly on how these areas can be applied and integrated within one another with the current technology and development in place. But in years to come these areas will grow and become even more interesting and entertaining, and will continue to ensure that filmmaking and the process involved will be a major business worldwide for the foreseeable future.

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