The Techniques of Visual Effects Applied in Captain America: The First Avenger (2011)

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ABSTRACT

Visual effects (VFX) are used extensively in modern entertainment, including films, television shows, ads, and digital media. This research investigates the different types and techniques in visual effects used in animated films. Previous studies have identified a need for more information explicitly focusing on applying some techniques within visual effects. The study intends to fill a knowledge gap by emphasizing strategies in visual effects kinds, particularly in the animated film area. The research objectives are to identify the types and techniques of visual effects and their application in an animated film. Thus, the discussion and findings will be established at the end to conclude the research questions and objectives. This research uses qualitative methods by gathering and analysing data from various sources. The findings show that multiple techniques have been utilized in any animated film to achieve the desired visualization. The research provides important insights into VFX techniques and their application through case studies and references to earlier scholarly works, catering to animation practitioners and students seeking an understanding of VFX workflows.

Keywords: Visual Effects, Techniques, Types, Animated film

INTRODUCTION

Visual effects, or VFX, is a common term that most people are familiar with when it comes to entertainment and media, and it is widely used in movies, films, series, advertisements, and on all digital platforms. The visual effect refers to the imagery that is made, altered, or improved for any film or other moving medium and does not occur during live-action filming. According to Dinur (2017), digital enhancements and video manipulations, primarily in post-production, are visual effects. VFX is the manipulation of moving images using digital or photographic techniques to produce a photorealistic cinematic illusion that is impossible to achieve (Finance et al., 2010).

This research aims to investigate the types and techniques of visual effects used in animated films. In visual effects, storytelling and technique are crucial, as VFX not only impacts numerous film elements but is also essential for giving characters their unique personalities (Lorenzo, 2016). However, based on previous studies, it is found that there needs to be a more information-focused focus on some application of visual effects techniques in film. Digital beauty VFX is rarely discussed, and in a lot of cases, it is utterly denied in the traditional sense (Jon Gress, 2021). According to Cohen (2016), far more digital enhancement is occurring than the public knows, as the visual effects companies responsible for this work are bound by strict confidentiality. The statement supports that there is a knowledge gap regarding the information on specific visual effects techniques in animated films, and there are questions among the audience voicing out their curiosity on how it is done. Based on a market researcher, Hancock (2022) claims that while prominent Hollywood studios have embraced virtual production, which merges live-action and CGI, its full potential will be realized when more companies adopt this technique. Virtual de-aging in film is reshaping CGI and creating digital beauty effects, with companies like Lola Visual Effects, Vitality VFX, and Wētā FX at the forefront of this transformation (Holliday,2021). The introduction of the topic of the technique of visual effects is stated to provide an overview of the study. This will be followed by a problem statement, research objectives, research questions, the

significance of the study, and the research's scope and limitations. This research will study the film Captain America: The First Avenger (2011) as a case study, and the details will be discussed further in chapter 4 of this research.

The objectives of this study are threefold: first, to examine and categorize the various types and techniques of visual effects as identified in the existing body of literature; second, to critically analyse the application of these visual effects techniques within *Captain America: The First Avenger* (2011); and third, to determine the most dominant types and techniques employed in the film, thereby highlighting their significance in shaping its overall visual narrative and cinematic impact.

LITERATURE REVIEW

Visual Effects Definition

According to Jon Gress (2015), VFX involves incorporating or eliminating elements from the original image. VFX in films involves computer-generated special effects, blending live-action footage with enhanced visuals to achieve realism and believability (Majikes, 2022).

Classification of visual effects

1. CGI means creating images entirely within computers, and various visual effects utilize this technology to enhance or blend with live-action footage (Maio, 2021). The term CGI refers to visual effects produced digitally for use in movies and television shows, be it 2D or 3D, although mostly involving 3D (Masterclass, 2021). According to Marshall (2023), any visual effect produced with computer software is known as CGI.
2. Based on Jessica Marshall (2023), compositing is mixing two or more images to give the illusion of a single shot, with chroma key compositing, sometimes known as a "green screen," being the most used approach in cinema. According to Dinur (2017), compositing is the last and critical step in creating a final image by assembling all the components. Compositing is the final stage in creating visual effects shots, combining the various layers artists developed into a cohesive image (Finance et al., 2010).
3. Motion capture refers to recording whole-body motions, such as those performed by stunt performers (Finance et al., 2010). According to Masterclass (2021), motion capture is digitally capturing an actor's motions and using that data to create a three-dimensional computer model. Similar to the old method of rotoscoping, modern visual effects artists can use live-action references to increase the realism of CGI through motion capture (Maio, 2021).
4. As Jessica Marshall (2023) said, matte painting was originally a unique effect technique where actors were filmed against painted backdrops on glass panels, creating the illusion of a more extensive set. To produce the intended atmosphere or set extension, matte painters mostly use computers to source, cut, manipulate, and assemble several pieces of images (Dinur, 2017). According to Finance et al. (2010), this method comprises setting up and filming various moving mattes, such as green or blue screens, where appropriate setup and lighting are essential to provide compositors with clear and compelling mattes.
5. Animation, with a rich history and various techniques, differs between 2D hand-drawn characters and 3D computer-generated images, whereas the term "animation" typically refers to fully animated feature films (Dinur, 2017). According to Finance et.al (2010), animation is the art of representing motion. He also said that visual effects artists use animation to describe the movement and evolution of elements inside a scene over time, giving objects and characters more life and expression.

Visual Effects Techniques

Doubling includes the projection of twins or clones, so a performer who does not have a twin is videotaped separately in several locations, and the resulting material is blended to project twins or clones (Nashville Film

Institute, 2022). Body doubles are frequently used to help actors execute daring or seductive actions during the transition from natural to computer-generated scenes (Hill, 2016). An unknown body duplicate is frequently seen wearing a custom 3D digital prosthesis with the star's facial features (Holliday, 2021).

More straightforward face replacements involve having the actor duplicate the stunt performer's performance in set lighting, with their face relative to the camera, but without making the body move (Walker, 2016). One helpful technique for more straightforward face replacements is to have the actor mimic the stunt performer's pose in the set lighting, putting their face about the camera but omitting the body movement (Hill,2020). Face projection is a technique often employed in the VFX business that includes replacing a body double's face with a computer-generated one by projecting a captured performance onto a digital depiction of the actor's head. (William, 2020).

According to Hill (2016), digital cosmetic enhancement includes a wide range of techniques such as face proportion adjustments, eye enhancements, and body shaping like changing the body's proportions or shape by altering and slimming the waist, emphasizing the body's contours, reducing body height, or adding definition to the muscles. Hill also stated that they can digitally remove an actor's head, shoot him reciting better lines against a green screen, and then replace the old head with the new footage. This approach is now being utilized more regularly to enhance the appearance of attractive individuals, allowing them to depict younger versions of themselves (Robinson, 2016).

As William (2016) stated, the actors' features were removed, shrunk by ten percent, and then re-tracked onto their faces. Lola VFX employed de-aging compositing techniques to modify each performer's facial features (Failes, 2016). This entailed modifying lighting and bone structure by removing original lighting and shadows and reconstructing lighting to effectively erase wrinkles (Armstrong, 2016).

In a broader sense, motion capture refers to capturing entire body motions, such as those performed by stunt performers (Finance et al., 2010). According to Sharma et al. (2013), these systems are composed of potentiometers and sliders in the appropriate articulations to display the position. Liverman (2004) stated that optical mocap's are several digital cameras that monitor the position of reflecting markers in space, and in the case of human and animal captures, markers are frequently placed near the joints. According to Menache (2011), electromagnetic motion capture involves a network of receivers measuring their spatial relationship to a nearby emitter, typically attached to the body through an electronic control unit or separate cords, with origins in technologies like helmet-mounted displays used in military aircraft. Liverman (2004) states that transmitters emitting sound are affixed to a subject. Audio receivers surrounding the individual measure the time it takes for the emitted sound to reach them, and a person's joints are equipped with transmitters to capture movement.

A chroma-critical effect removes a specific colour from the background of a shot, and by identifying and removing the colour values of the green screen background, colour sections are eliminated, allowing the underlying video layer to be visible (Aronson, 2006). Any editing or compositing program you use will include a basic chroma keyer (Jackman, 2007). vii. A mask defines which areas of a frame will be prominent and which will be transparent, allowing for a sharp and well-defined blend (Aronson, 2006). As stated by Kuperberg (2002), rotoscoping is the process of digitizing a series of still photographs from an original video, and these still photographs can be used to generate an animation or film after being edited in some way with paint, two distinct keyframes, or other software. Originally, live-action movie scenes were projected onto glass panels and traced using a rotoscope, but nowadays, computers are employed for rotoscoping to create precise and highly detailed composite images (Woltmann, 2023).

Application of Visual Effects Techniques in Animated Film

According to the journal The Evolution of Animation to CGI (Computer-Generated Imagery) and the Impact of James Cameron's Avatar (2014), CGI has helped open a universe of possibilities that were previously only imagined by filmmakers and animators.

Figure 1. Head replacement of Brad Pitt with the body double's head

(Source: Mike Seymour, 2009)

"The Curious Case of Benjamin Button" is a pioneering film in a reverse aging story examining themes of adulthood and mortality, heavily utilizing Lola Visual Effects' de-aging technology (Holliday, 2021). Giardina (2009) stated the technique breakdown where the body actor performed from the neck down, and a computer-generated head based on Pitt's performance was used to replace the body actor's head. According to William (2016), for the initial part of the film, Digital Domain used a wholly synthetic computer-generated head, with Pitt's face covered in tracking dots; they used facial performance capture to power the animation. According to Russell (2018), David Fincher later applied this continuity technique to the Winklevoss twins in *The Social Network*. Desowitz (2010) advocated using a "hockey mask" face projection technique to visually construct the Winklevoss twins (both played by Armie Hammer).

Figure 2. Face projection technique on Josh's face

(Source: Desowitz, 2010)

With Lola VFX "youthening" stars Patrick Stewart and Ian McKellen by a substantial margin of at least a quarter of a century, the movie shows off the astounding benefits of digital cosmetic enhancement (Cohen, 2006). According to Shreya (2023), Lola VFX worked with plastic surgeons and creatively used digital skin grafts to successfully tackle the problem of de-aging actors Patrick Stewart and Ian McKellen. She also stated that producers were provided with a de-aging solution by Lola VFX that did not interfere with filming by avoiding tracking dots, motion capture, or MOVA dust.

Figure 3. Patrick Stewart and Ian McKellen after being de-aged by Lola VFX

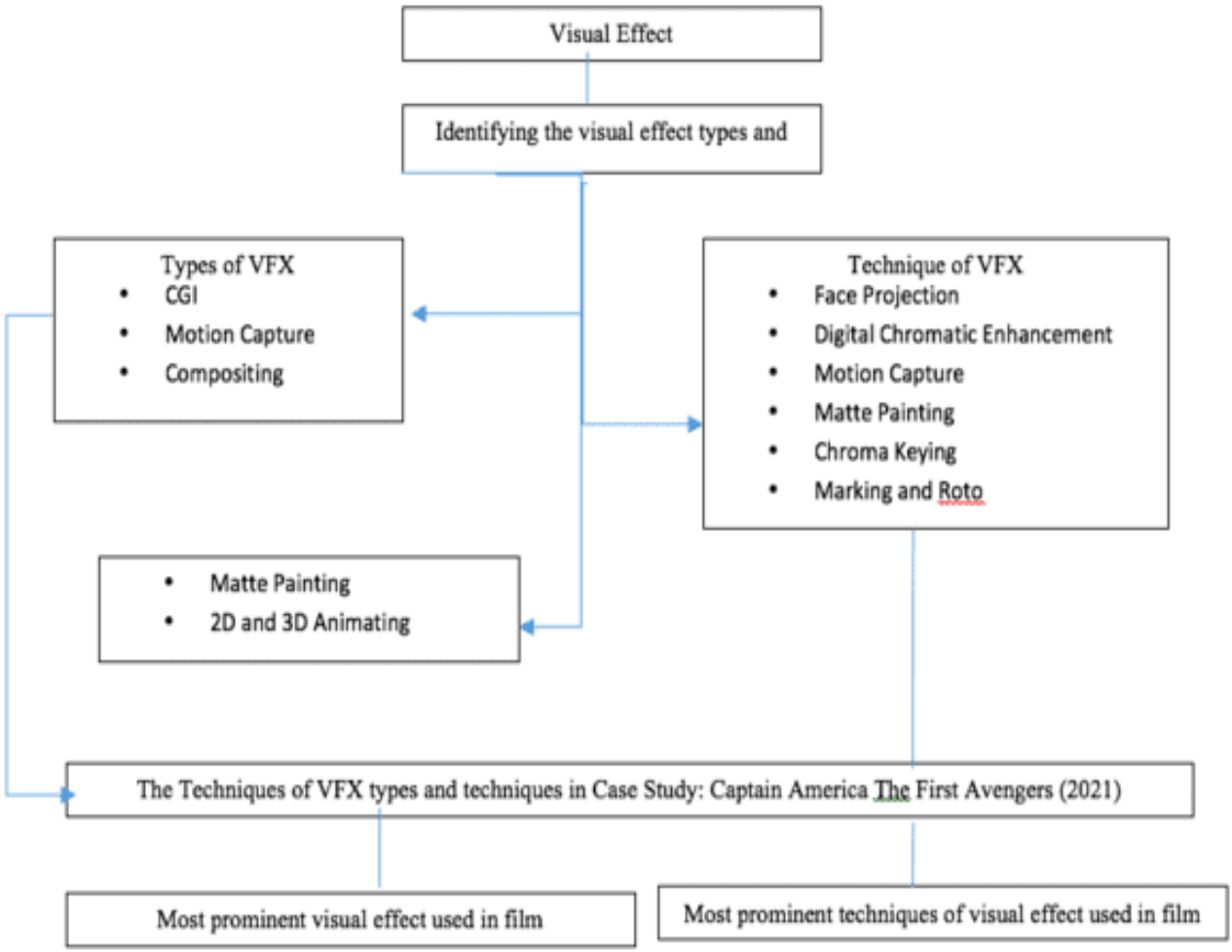
(Source: Shreya 2023)

According to Holliday (2021), in *Central Intelligence*, Weta FX used motion capture, computer animation, 3D facial scans, and face replacement technologies to seamlessly superimpose a virtual prosthesis of Dwayne's face onto the body double actor at the shoulder blades. It was a synthesis of various digital effects techniques (Cohen, 2011).

RESEARCH METHODOLOGY

This study uses a qualitative method by gathering and analysing data from various articles, journals, books, and interview videos taken from YouTube and other sources. Content analysis has been used to collect and analyse information to guide the researcher in finding the answer to the research objectives in data collection.

Conceptual Framework



This study aims to identify the types and techniques of visual effects through a comprehensive literature review, providing a foundation for analysing their application in the case study. Ultimately, this framework is designed to guide the researcher in identifying and understanding the types and techniques of visual effects in the case study, leveraging data collection and discussion in the findings section.

Data Collections

This research will explore the technique of visual effects in Captain America: The First Avenger, known as 'Skinny Steve' scenes. Throughout the film, there are scenes where Steve Rogers, a scrappy and underfed 98-pound guy who enlisted in the military, participates in an experimental program that turns him into a super soldier after being injected with the super soldier serum, which is then known as Captain America. The 'Skinny Steve' scene has become the film's highlight as it clearly shows the use of the visual effects technique, one of the most demanding techniques in the film industry.

Data Analysis

Types of VFX	Description	Characteristic
Computer-Generated Imagery (CGI)	CGI is a type of digitally produced visual effect frequently used in films and television. It involves creating 3D models with computer graphics. Originally developed for 2D visuals, it now includes fully computer-generated features.	- Visual Effects, Special Effects - Computer-Generated Elements - 2D & 3D Computer Graphics Software - Visual Enhancement, Digital Characters, and Environments - Animated Films - Virtual Characters, Objects, Settings
Compositing	Compositing blends several visual elements into one seamless image. It often uses green screen, blue screen, or chroma key techniques.	- Visual Effects - Chroma Keying - Green/Blue Screen - Integrating Visual Elements - Mixing Two Images - Final Process, Post-Production - Composite Pictures, Double Exposure, Matte Painting
Motion Capture	Motion capture (mo-cap) digitally records an actor's movements for use in creating 3D models. It captures gestures, facial expressions, and body motion to improve realism.	- Computer-Generated 3D Model - Visual Effects - Body Movement, Body Motion - Live-Action Reference - Rotoscoping - Facial Expressions

Figure 4. Table refers to types of visual effects (by keywords)

After a thorough analysis and compilation of descriptions relevant to various sorts of visual effects, the researcher notices contradictions and inconsistencies in the classification of visual effects. While some sources claim there are five varieties, some claim there are three, and yet another group claims there are four. This variation shows a need for more consistency and standardization in visual effects.

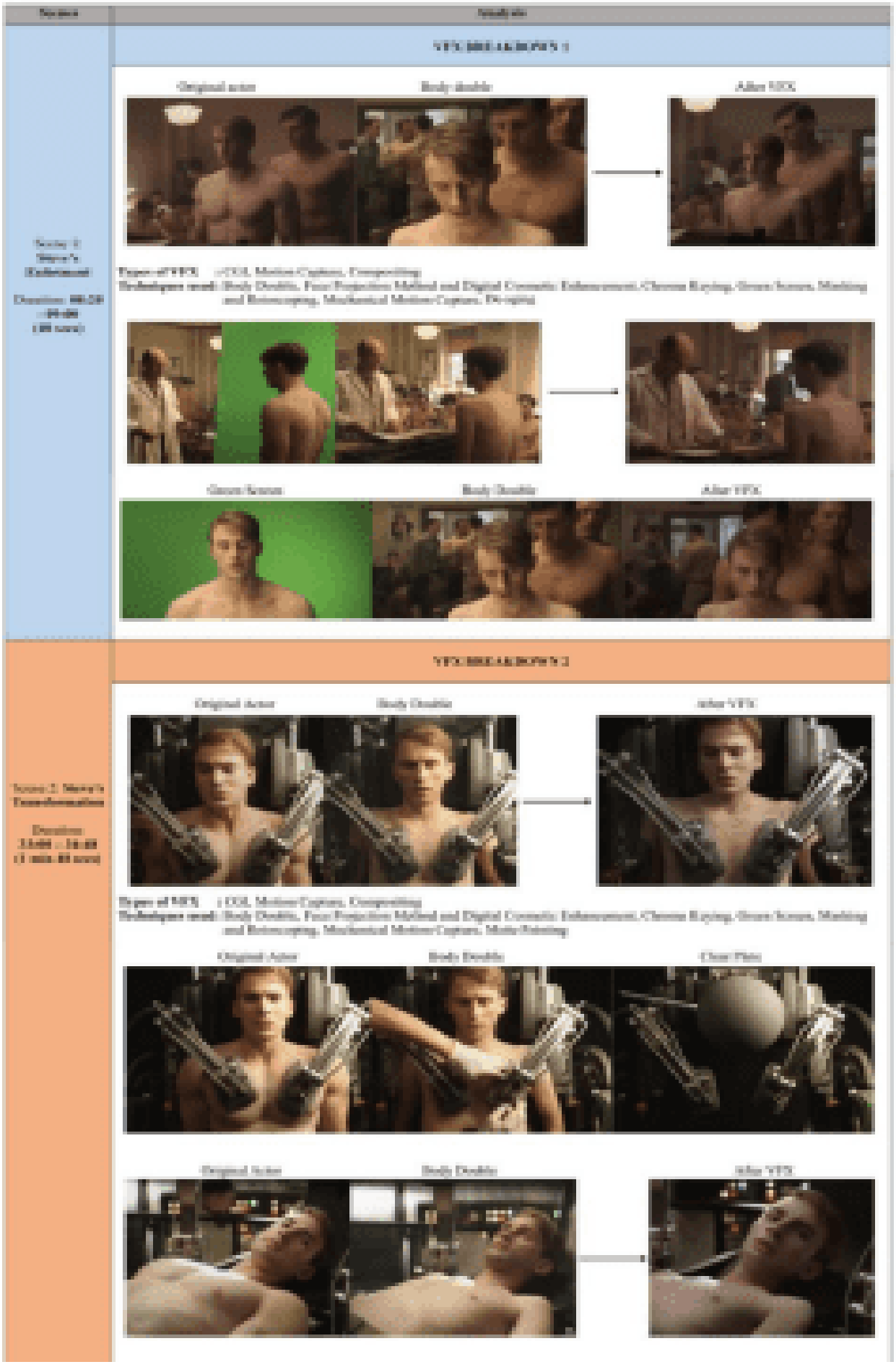
No.	Techniques in VFX	Description	Characteristics
1.	Body Double	Body double involves using stand-ins or body actors to replace the main actor in specific scenes, often for stunts or complex sequences. This practice allows another person to play the role, with the main actor's face later replaced during the compositing process. It is a technique employed to achieve specific shots or scenes while maintaining the visual continuity of the main actor.	• Visual Effects, CGI, Techniques • Body Actors, Body Duplicates, Stunt Doubles, Stand-ins
2.	Face Projection Method (Digital Composite Enhancement)	The face replacement technique digitally replaces the facial appearance of a stand-in actor with that of the main actor, ensuring realism and continuity. This process can include advanced methods, including 3D scanning and digital doubles. Digital enhancement, such as digitally removing age-related blemishes, scars, or imperfections, for improved performance and portrayal of younger versions of actors.	• Face Projection, Split Screen, Green Screen, Performance Capture • Photogrammetry, Facial Scanning, 3D Digital Double
3.	De-aging	The de-aging technique in VFX involves digitally altering the appearance of actors to make them look younger. It removes age-	• De-aging, Youthifying

		related features, including wrinkles, lines, and changes in facial shape and texture. This is frequently used in flashback sequences or in films depicting digital rejuvenation	• Digital Rejuvenation, De-aging Process
4.	Mechanical Motion Capture	Mechanical tracking refers to a motion capture system that involves mechanical devices worn by actors to record movement data. This method uses attached physical sensors and exoskeletons on actors, which helps in tracking their motion and translating it to mechanical devices such as goniometers or encoders, to capture the motion in three-dimensional space.	• Mechanical Trackers, Goniometers, Encoders • Exoskeleton Motion Capture, Motion Sensors
5.	Optical Motion Capture	Optical mocap is a widespread mocap system, used in studios and on-location shoots. It employs infrared cameras and special reflective markers attached to track performers' movements in physical space for human and digital characters.	• Optical (CCD/CMOS, Digital Cameras) • Reflective Markers, Passive Markers
6.	Magnetic Motion Capture	This highly accurate method involves a performer wearing a specially designed suit with multiple sensors that employ electromagnetic signals to track movements.	• Electromagnetic Mocap System, Reflective Markers • Sensors, Magnetic Sensors
7.	Acoustic Motion Capture	Sound waves recognize emitted sound from joints or limb movements. Acoustic mocap involves creating an acoustic sound space to track moving performers. These systems place microphones in fixed locations and then capture movement by differentiating the position and timing of the captured signals.	• Acoustic Sensors, Sound Trackers • Performers' Joints, Recorded Space, Actors' Area
8.	Matte Painting	Matte digital climate background replaces film displays of distant landscapes or artificially filmed landscapes, usually painting the backgrounds digitally. This creates an expansive environment that would be too costly or impractical to shoot physically.	• Glass Plate, Black-Painted Matte, Computer-Generated Matte Painting
9.	Chroma Keying (Green Screen)	This technique involves using chroma keying, where green screens are removed from background images to insert new footage. This allows for digitally created or live backgrounds to replace scenes in front of the green screen. Widely used in filmmaking, it blends live-action footage with virtual environments.	• Chroma Key, Green Screen, BlueScreen • Matte, Compositing, Key Effect, Mask
10.	Masking and Rotoscoping	Masking and rotoscoping are techniques for a clean cut. This removes unwanted portions from video footage frame by frame, used for background replacement and composite shots. It allows for detailed compositing processes. Rotoscoping isolates objects, characters, or portions of frames, often incorporating green screen footage for fine-tuned action refinement.	• Mask,Rotoscope • Chroma Keying Regions, Green Screen, Image Compositing

Figure 5. Techniques in VFX that are frequently used in animated films (by keywords)

From the data collected, the researcher can conclude that different studios used different terms for face projection methods, such as face replacement technique, mesh warping, head replacement, digital cosmetic enhancement, facial performance capture, and 3D face projection. Nevertheless, due to their similarities, these terms can be classified as face projection methods. With slight differences, the researchers classified de-aging as a different technique in CGI due to its clear distinction from the face projection method. In Table 4.1.2, the researcher can conclude that most animated films use various VFX techniques in films and more than one technique. This shows that various techniques are needed to achieve a specific visualization in a particular scene. According to Jon Gress (2015), the goal is to combine independently shot CGI elements into accurate background material, allowing for the insertion of new elements, the removal of existing ones, or a combination of the two in the final composition.

Analysing Application of Types and Techniques in Visual Effects in Case Study: Captain America: The First Avenger (2011)



Scene from Film	Process	Types of VFX:
Scene 1: Steve Rogers enters the transformation machine (01:09:55 – 01:10:15)	Original Actor → Body Double → After VFX	• CGI (Computer-Generated Imagery) • Motion Capture • Compositing and Digital Cosmetic Enhancement • Chroma Keying (Green Screen) • Matching Body Proportions and Scale • Replacement of Actor with Body Double
Scene 2: Steve Rogers emerges from the transformation machine (01:10:20 – 01:10:55)	Original Actor → Body Double → After VFX	• CGI (Computer-Generated Imagery) • Motion Capture • Compositing and Digital Cosmetic Enhancement • Chroma Keying (Green Screen) • Matching Body Proportions and Scale • Replacement of Actor with Body Double

Table 6. Scene analysis in Captain America: The First Avenger (2011)

According to Table 6, the VFX breakdown for every scene is shown in detail. In scene 1, where Steve's application to join the army was rejected, the VFX techniques used were body double, face projection method, green screen, motion capture and masking, and rotoscoping. Based on the VFX breakdown, it is seen that the original actor, Evans, acted out the scene first, followed by a body double, Deeny's body, where he observed and then mimicked Evans' movement. With the green dots on Deeny's face as motion trackers, his head was replaced with Evan's head using face projection and digital cosmetic enhancement. The techniques employed in VFX breakdown one has been replicated in scene 2, featuring body doubles, face projection methods, motion tracking, a green screen, and a clean plate. Analysing VFX breakdown 3, the scene did not require a body double as the VFX houses planned to shrink only Evans' face to his lower neck and chest, capturing only the active screen. In scene 4, two shots were taken: one with Evans and one with Deeny. Evans's head was digitally placed onto Deeny's head in the latter.

Based on the analysis in Table 4.2.1, various types and techniques of visual effects have been applied in Captain America: The First Avenger, specifically in the 'Skinny Steve' scenes, which show the face and body transformations of the main character, Captain America. Throughout the scenes, most techniques from CGI, motion capture, and compositing were combined and worked relatively well together.

From the data collected, the researcher can conclude that the technique of body doubles and face projections was extensively used in filmmaking. Face projection covers any head replacement process, making it the most frequently used technique in the film. Like a body double, the use of a double eases the 'Skinny Steve' scene process. Rather than slimming down Evans' bulky figure, which will take up many background clean-up processes, the production slimmed down a small quantity of Deeny's figure and replaced Evans' head with Deeny's. According to Failes (2016), even though effects artists had a variety of methods at their disposal, the solution required hours of painstaking creativity rather than a straightforward, "one-touch" method.

FINDINGS

	SCENE 1	SCENE 2	SCENE 3	SCENE 4
Techniques Applied				
Body Double	/	/		/
Face Projection Method	/	/	/	/
De-aging	/		/	
Motion Capture	/	/		/
Matte Painting	/	/		
Chroma Keying/Green Screen	/	/	/	/
Masking/Rotoscoping	/	/	/	/

Figure 7. Summary of VFX techniques used in Table 6 analysis

The results in Figure 7 indicate that CGI and compositing are the most employed types of VFX classes. Within CGI, the face projection method is the most utilized technique, and chroma keying, masking, and rotoscoping are the most frequently used techniques within compositing.

Based on the findings, the researcher can conclude that the face projection method is the primary visual effects technique used in 'Skinny Steve' scenes in Captain America: The First Avenger. Analysing Figure 7, the researcher believes that it becomes evident that every scene in the film employed this technique, emphasizing its critical role. The consistent and frequent usage of this technique is further highlighted in Figure 6, where all compared films also incorporated it to achieve facial transformations. Contrary to compositing, an essential final step in filmmaking, the reality is that compositing is crucial for any film. It serves as the concluding phase before a film is presented on screen, making most compositing techniques necessary, regardless of their extent of use. Therefore, researcher concludes that compositing is the main type of visual effects, and its techniques are extensively applied in the 'Skinny Steve' scenes. To support the researcher's conclusion statement, a book called *"The Filmmakers Guide to VFX"* written by Dinur (2017), stated that compositing is the process of putting all the parts together and determining the final look, and this is where even the smallest detail can have a significant impact, for better or worse.

CONCLUSION

In conclusion, visual effects are crucial in modern entertainment, encompassing movies, series, advertisements, and digital platforms. Various types and techniques in visual effects are utilized in animated films. In this research, Captain America: The First Avenger extensively explores Steve Rogers' physique transformation using a variety of CGI, motion capture, and compositing techniques. Overall, Captain America: The First Avenger employed a combination of CGI, motion capture, and compositing techniques, with techniques like body double, face projection, and de-aging, and various compositing techniques such as matte painting, chroma-keying, and masking. The researcher hopes this finding fills the knowledge gap by focusing on the techniques within the types of visual effects, particularly in animated films. While the research covers various types and techniques in CGI, motion capture, and compositing, I suggest that future researchers explore different topics and delve deeper into the application and workflow of these techniques in diverse film contexts.

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