A PROCESS OF SEAMLESSLY REPLACING CG ELEMENTS INTO LIVE-ACTION FOOTAGE

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Abstract:

This research focused on inserting a computer-generated element into live-action footage and replacing unwanted existing objects in the footage. In addition, creating a realistic and seamless visual representation in the field of digital compositing. The purpose of this paper is to cover a detailed working process of digital compositing in order to clarify the production process and provide a clear idea for those entry-level artists to improve an overall understanding of the digital compositing and visual effects and hopefully inspire further collaboration and participants particularly between academia and industry.

Key Words: Digital compositing, CG elements, Realistic, Visual effects

Introduction

Along with the increase of digital compositing in feature films, the role of digital compositors has become of unprecedented importance. Compositors thus sit at the core of most image manipulation pipelines. In order to meet the needs of the visual effects industry, universities, art and film schools have established relevant professional courses in recent years. Nevertheless, current educational concepts still need to promote a sound scientific understanding in order to steer entry-level visual effects artists in the right direction.

This study has addressed several main factors from the perspective of theory and practice. As a general discussion, the research briefly outlines the historical perspectives of digital compositing, and continues to investigate the current situation of the digital compositing and visual effects industry. Subsequently as an experiment, a vintage film clip with complicated character movement was utilized. In the section concerning footage analysis, the research explores all possible working difficulties. In order to clarify this production process, a vintage film – *The Lavendar Hill mob* (1951) has been chosen for this experimental project, the researcher intends to integrate a CGI element into the film footage seamlessly. Through a series of practical aspects, the study covered analyses and discussions on analyzing footage, rotoscoping, producing clean plates, 3D camera tracking, creating CGI models, setting virtual lights, animating, rendering and final compositing, etc, and furthermore, the quality of the final project is intended not only for the purpose of demonstration, but also to reach a level of professionalism in line with current industry standards.

Definition Of Digital Compositing

Digital compositing is closely related to photomontage and the digital manipulation of multiple images (moving sequences or still images) into an integrated and seamless whole.

Photomontage is the process of cutting and joining photographic sources in order to recreate a series of photographic prints. The most famous photomontage *The Two Ways of Life* was created in 1857 [1]. Followed shortly by a photograph called “Fading Away” (H.P. Robinson) [2] that was produced by a photographer Henry Peach Robinson in 1858. These series of works actively set out to challenge the then-dominant medium of paint and other forms of photography. In today’s digital world, the traditional method of photomontage is realized through image editing software employed to reproduce a photo- realistic image. Instead of relying solely on a specific effect, a successful digital composite is able to make a particular shot look real. In other words, the goal of compositing is making all the elements (background plate, CGI elements, matte paintings, etc.) look like they were shot by the same camera under the same lighting conditions and existing in a same real world location.

Color images represent the full range of colors with red, green and blue components. A full range of the visible spectrum can be represented by using a combination of these three primary colors at different intensities, and moreover every single channel contains black and white data information [3]. Thus these channels can be thought of as monochrome images in their own channel. In digital images, every single pixel of each channel can be represented by an arbitrary number of bits. Typically each of these channels has 8 bits. The fourth channel, an additional channel which stores opacity of the color can be used as a matte (an alternative name for the matte is the 'alpha channel')[4]. The concept of the alpha channel was introduced by A.R.Smith in the late 1970s (Wikipedia, 2010) [5] and subsequently fully developed by Thomas Porter and Tom Duff in 1984 [6]. They used RGBA to indicate these four channels. Alpha has a value be- tween 0 and 1. A value of 0 means that the pixel is transparent, but on the other hand, a value of 1 means that the pixel is 100 percent opaque. In mathematics, any number times 0 equals to zero and conversely, 1 multi- plies any number will remain the result unchanged. In computer-generated images (CGI), if an image contains an alpha channel, it is usually referred to as a pre-multiplied image. For instance, if an image has value at 0.0,0.5,0.0,0.5 (R,G,B and Alpha), it implies a half green image with a 50% transparent alpha channel on it. If the color were fully green, its RGB channels would be (0.0,1,0.0) [7]. A pre-multiplied image is one where the RGB channels have been multiplied by the alpha channel. This means it is a four-channel image in which the red, green and blue channels have already been multi-plied by the integrated matte (alpha) channel. The R.G.B channels of a pre-multiplied image will never have a higher value than its alpha channel.

Research Methods And Findings

The goal of this project is to explore a systematic process of inserting CGI elements into digital moving images, with the aim of producing a seamless and photo- realistic composite.

Project Concept

The project will explore and examine issues from erasing unwanted parts from the footage and making clean plates, to the entire complex process of 2d tracking, 3d camera match moving, building 3d models, multi-pass rendering and integrating CGI elements into the original footage in order to seamlessly replace one existing object in the footage. As an example, one object on the original footage will be completely removed and replaced with a CG coke glass bottle by the end of this project. Through a detailed discussion and demonstration, the study will clearly reveal a series of processes undertaken to replace objects and insert CG elements in feature films.

Footage Analysis

The overall length of this project is approximately in 16 seconds (00:00:16:00) and it was captured as a PAL TV broadcast format. The following image (Fig 1.) shows one frame of the entire clip. The object - toy Eiffel Tower in the man's hand will be replaced by a CG coke bottle.

Figure 1. One snapped image at frame 150.

Working range of this project is 55 frames long (frame 130 – frame 185), however, the difficulties on this part are fairly challenging. Fig 2. Indicates a number of unwanted objects, which have been marked at frame 165. Creating a clean plate for the luggage case (inside part). This is because the character grabs one toy from the opened brief case. A clean empty space is needed after erasing the toy from its original position. In addition, several places also need clean plates, such as shadow of the toy on the wall and the man's chest when he was passing the toys from one person to another. Fig 3. Shows these unwanted objects in three different frames.

Figure 2. Shows a series of key frames between frame 130 and 185.

Figure 3. Shows a number of unwanted objects, which need to be removed in order of create a clean plate.

Creating Mattes and Clean Plates

Creating mattes and clean plates is a tedious process, however, mattes and clean plates are essential elements in digital compositing, especially for producing a photo- realistic composite. Rotoscoping [8] is one of the main tasks in this project, which will directly determine the success of the final result. Rotoscoping started from frame 130 and finished at 185 frames for most objects in the scene. The compositor had to repeatedly roto every object, which overlapped with the target frame by frame within frame 130 to 185. Because the position of the target is in a medium shot, it therefore required highly accurate mattes, otherwise the final composite would reveal the edges of the original background around the mattes. Fig 4. Shows a pair of finished mattes.

Figure 4. Shows two finished mattes, which are used for bringing objects back to their original position after compositing.

The clean plates were created using a "Time Offset" method. The concept of this method is to take advantage of the time offset between each movement of the objects. For instance, if an object moves from position A to B from frame 100 to 150, it means the position of frame 100 is empty and clean when the object has moved to frame 150. Fig 5. Shows the result of creating clean patches (Left) and a completed clean plate (Right)

Figure 5. Shows the result of creating clean patches (Left) and a completed clean plate (Right) at frame 150.

3D Camera Tracking

3D camera tracking is an important section. CG elements need to have the same camera lens distortion when composite with live-action footage in order to look as they were shot by the exactly the same camera at the same time [9]. In 3D tracking section, the original plate needs to be undistorted before the 3D matching tasks. See Fig 6.

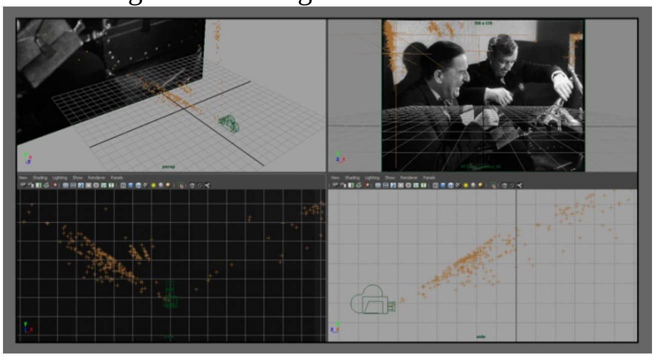

Figure 6. Shows a match moving scene with 3D tracking data.

Creating CG Elements

The footage - *The Lavender Hill Mob* was filmed in 1951. If a CG coke bottle is replaced into the scene, we need to ensure that the shape of CG glass bottle matches the style of the coke bottle in 1951. Such details are fairly important in compositing. In some cases a small detail can bring an entire scene back to life. The name of coke bottle from 1951 to 1958 was called 'Hobbleskirt Coke, 6 FL OZ' [10], it was embossed with the Coca-Cola logo and capped with a white and red cap. See Fig 7.

Figure 7. Shows the style of the coke bottle in 1951, and a CG coke bottle model (Right) based on this bottle.

Multi-pass Rendering

Caustics

Caustics occur on transparent objects. When light rays pass through a transparent object, due to the principle of physical optics, light rays will be enveloped by the curvature of the surface of this object and projected onto another surface [11]. In computer graphics, caustics effect is accomplished by ray- tracing attributes through Mental Ray rendering engine of 3D applications, such as Maya. See Fig 8.

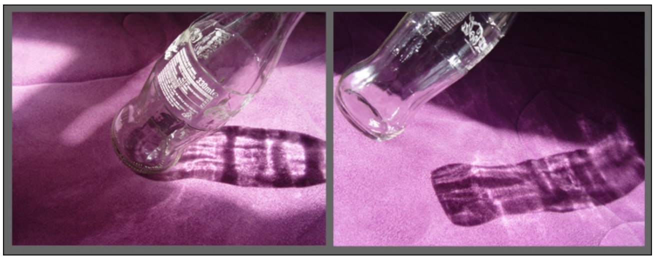

Figure 8. Shows a comparison of examining caustics from a real glass coke bottle.

In 3D software, caustics rendering is based on the luminance value (luminance value must be higher than 0) of the shader attributes of the dummy CG object, these receive caustics from transparent objects. The issue is that if the caustics are to be received by CG surfaces, the luminance value of the CG surface must be 0. In compositing, 0 means completely transparent, any value above 0 means semi-transparent and 1 means 100% opaque, so if the value is 0 the rendered caustics can be composited with live-action footage in digital compositing. However, there is a known issue with Maya the mental ray engine, which is not fully compatible with Maya nodes.

Test one: Test one was performed by applying a “Surface Shader” (the “Surface Shader” uses Maya default shading algorithms which black the object with a zero value) to the surface of a test CG object, then position this object behind a transparent character, the result of rendering was a fully black image without caustics cast on it.

Test two: In test two, a “Background Shader” was applied to the same surface of this testing CG objects (Background is a Maya shader, it leaves a transparent area around the outside of the test objects). It was assumed that this method would provide a result, which only rendered the caustics area and rest of the parts with a value of 0, so it could be used for compositing purposes. However, the result was not successful and good enough for digital compositing.

Solution: The solution for rendering an image with successful caustics on was to change the “Color” and “Weight” attributes of the shader, which is used for receiving caustic objects. In addition, the value of caustic Phones was increased to 3000000, photon intensity was increased to 800000 and the photon exponent value to was reduced to 0.01. The following image Fig 9. Shows a comparison result of creating caustics. Fig 10. Indicates an acceptable value of “Color” and “Weight” in Maya render attributes.

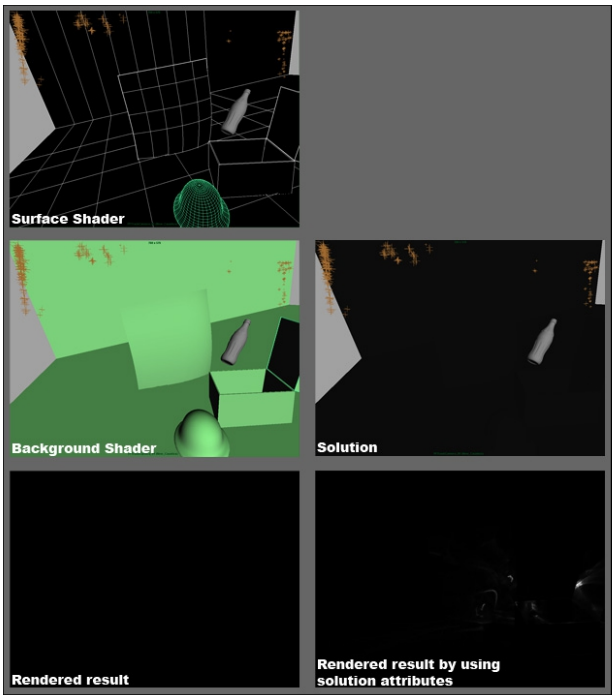

Figure 9. Shows a comparison result of creating caustics.

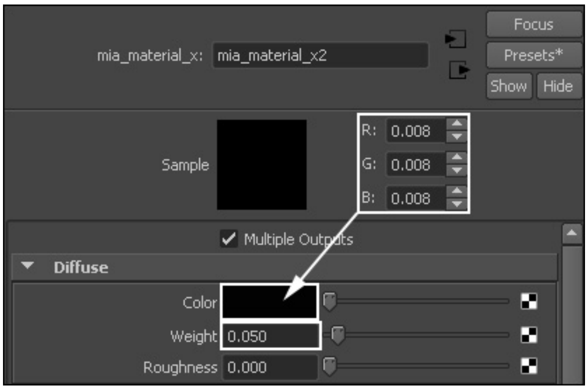

Figure 10. Multi-pass rendering

Multi-pass images give digital compositors a great deal of control over the look of the shot. Compositors can make an overall improvement to each pass as well as adjust the final composite more artistically. In addition, compositors can take advantage of a specific pass by interactively relighting the scene, adding motion blur or even retexturing the CG elements without spending extra time re-rendering them in the 3D software.

The most often used multi-passes are: Beauty pass, diffuse pass, specular pass, reflection, refraction, shadow pass, depth pass, normal pass, ambient occlusion pass, ID pass, motion vector, etc. These separated render passes can be seamlessly combined together later on through the use of mathematic formulas in digital compositing software. See Fig 11.

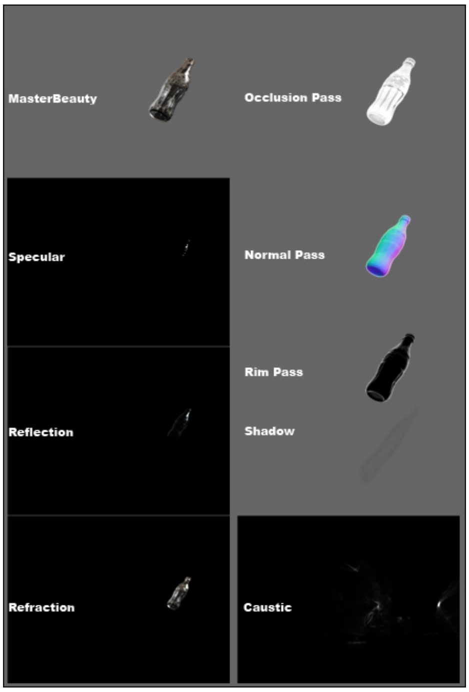

Figure 11. Shows a series of multipass images.

Final Compositing

Once all the multi-pass images have been rendered compositors can make an overall improvement to each pass as well as adjust the final composite more artistically. With a full understanding of mathematical formulas of digital compositing and a strong aesthetic ability, a seamless composite will be created. Advanced compositing effects can be achieved by using an alpha channel with a series of math operations. The most common compositing operation is to combine image A (foreground) and B (Background) through a number of math formulas. However, at this stage of combining multi-passes the main operation formulas are: Over, Plus, Multiply [12].

Over operator

Over = (A x B) + [(1 – M) x B] (1)

Over operator is the most often used formula in digital compositing. It takes image A on top of image B, by using a matte of image A.

First of all, the foreground image A is multiplied by its matte image, this allows the matte of A to cut out image A. As mentioned in previous sections, in digital compositing, black implies 0 and white is represented as 1. This step will produce an image with black areas around it. Once this cutout has been created the result is then added on the top of image B, which is an inverted matte of A multiplies image B (Background image).

Plus operator

Plus = A(r,g,b)) + B(r,g,b) (2)

It simply added two images together. The order in which two images are asymmetrical, and can be switched over. This operator usually uses for adding reflection pass, refraction pass, specular pass, etc. elements together.

Multiply operator Multiply operation will mostly use for Occlusion pass, which multiplied by a combination of other multi-pass images. The result can enrich soft shadow of CG objects and enhance the look of realism.

Multiply = A x B (3)

Figure 12. A comparison of original footage and the final composition.

Conclusion

This experimental project focused on the process of replacing an object with a CG object for feature films. Instead of defining a series of complicated theories the compositor attempted to cover a number of key steps through a piece of challenging vintage film material. The difficulties involved in using this footage are comparable to real VFX industry scenarios.

By translating a series of complex theories into a practical study through one challenging real world example of digital compositing, the basic structure of the operating procedures of digital compositing have been laid out and a series of experimental results have been demonstrated. Although this study is finished, the technique of digital compositing and visual effects is still developing, and more realistic and breathtaking visual effects will be presented in the future in feature films. With the aim of creating ever more lifelike visual effects the field of digital compositing will continually evolve in this way.

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