



Visual Effects in Hollywood Productions

written by

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Abstract

The research paper starts with a short introduction in Visual Effects and when they come to fore. Then the paper deals with the history of Visual effects starting from the first in-camera effect to today's digital age, including groundbreaking inventions and examples.

The next chapter deals with California and globalization, in which I discuss why VFX became a global industry and why it is hard for California to keep up with other countries.

The main part of this research paper then, deals with the implementation of an effect shot with low budget. This includes a research part, in which a comparison between the different ways of the realization of a defined effect shot will be made, and a practical part, in which the ways will be executed.

It includes a storyboard, the definition of this certain effect shot and it's assembly. In this chapter the different ways of the implementation will be compared. The elements in the scene will be gone through one by one and the best way to implement them in the final scene will be figured out. The different techniques are, for example, crowd simulation, 3D modeling, particle effects, matte paintings, etc.



Table of contents

| | |
|--|-----------|
| 1. INTRODUCTION | 4 |
| 1.1. INTRODUCTION INTO VISUAL EFFECTS | 4 |
| 1.2. HISTORY OF VISUAL EFFECTS..... | 4 |
| 1.3. CALIFORNIA AND GLOBALIZATION: | 8 |
| 2. IMPLEMENTATION OF A LOW BUDGET EFFECT SHOT | 9 |
| 2.1. PRODUCTION PHASES | 9 |
| 2.1.1 <i>Pre-Production</i> | 9 |
| 2.1.2 <i>Production</i> | 9 |
| 2.1.3 <i>Post-Production</i> | 10 |
| 2.2. DESCRIPTION OF THE SCENE..... | 10 |
| 2.2.1 <i>What is Important for Describing the Scene</i> | 10 |
| 2.2.2 <i>Characteristics of the Scene</i> | 10 |
| 2.2.3 <i>The Scene</i> | 10 |
| 2.2.4 <i>Storyboard</i> | 11 |
| 2.3. THE ASSEMBLY OF THE ELEMENTS IN THE SHOT | 13 |
| 2.3.1 <i>The Landscape</i> | 13 |
| 2.3.1.1 <i>Find the Location</i> | 13 |
| 2.3.1.2 <i>Matte Paintings</i> | 13 |
| 2.3.1.3 <i>Rotoscoping</i> | 14 |
| 2.3.1.4 <i>Compositing</i> | 14 |
| 2.3.1.5 <i>Summary for the Specific Task</i> | 14 |
| 2.3.1.6 <i>Implementation</i> | 15 |
| 2.3.1.7 <i>Comparison with Roland Emmerichs „The Patriot“</i> | 16 |
| 2.3.2 <i>The House and the Boats</i> | 17 |
| 2.3.2.1 <i>Progress of Making a 3D Object</i> | 18 |
| 2.3.2.2 <i>Summary for the Specific Task</i> | 19 |
| 2.3.2.3 <i>Implementation</i> | 19 |
| 2.3.3 <i>The Soldiers</i> | 19 |
| 2.3.3.1 <i>Provide Enough Actors</i> | 19 |
| 2.3.3.2 <i>2D Crowd Replication</i> | 20 |
| 2.3.3.3 <i>3D Crowd Simulation – Digital Crowds</i> | 20 |
| 2.3.3.4 <i>Summary for the Specific Task</i> | 21 |
| 2.3.3.5 <i>Implementation</i> | 22 |
| 2.3.3.6 <i>Comparison with Peter Jackson’s „Lord of the Rings“</i> | 22 |
| 2.3.4 <i>Explosions</i> | 23 |
| 2.3.4.1 <i>Real Explosions</i> | 23 |
| 2.3.4.2 <i>Miniatures</i> | 24 |
| 2.3.4.3 <i>Particle Effects</i> | 24 |
| 2.3.4.4 <i>Summary for the Specific Task</i> | 25 |
| 2.3.4.5 <i>Implementation</i> | 25 |
| 3. CONCLUSION | 26 |
| REFERENCES | 27 |



1. Introduction

1.1. Introduction into Visual Effects

VFX are used in animated films as well as in live-action films. “Visual effects is the term used to describe any imagery created altered, or enhanced for a film or other moving media that cannot be accomplished during live-action shooting.” (Fink / Morie 2010, p. 2)

There are a lot of different types of VFX, for example: Matte paintings, 2D, 3D animation, particle effects, crowd simulation and many more. Visual Effects should not attract someone’s attention, because of the effect by itself. VFX should get an integrated part of the film.

“At their best, they work to further the story being told, becoming an integral part of what makes us willing to suspend disbelief.” (Fink / Morie 2010, p. 3)

There are three reasons why VFX are used in a film:

- When there is no practical way to film the scene in reality, for example a starship in space. It does not exist in reality so it is made with VFX.
- When the scene is simply too dangerous and you would risk someone’s life. For instance a scene where someone should be set on fire or close to a heavy explosion.
- When it is more cost effective or practical to utilize a visual effect than to film a scene for real in terms of scale or location, for example, when simulating a huge crowd. In that case, it would need a lot of actors and a lot of space, which may be too expensive. (Fink / Morie 2010, p. 2-3)

1.2. History of Visual Effects

Fink and Morie (2010) have said: “The art of visual effects (VFX) involves nothing less than making words into pictures, technology into art, and magic into reality.” (Fink / Morie 2010, p. 1)

You could write 20 pages, just about the history of visual effects, so this is just a part of it. From the earliest days films have used visual magic to produce illusions. In the beginning of commercial filmmaking, effects were produced within the camera. In these so-called in-camera effects, the effect was achieved before the film left the camera for processing. One of these effects is called stop-trick which appears in the first widely acknowledged Visual Effect shot. It was an 18 second clip made in 1895 called, “The Execution of Mary Stuart” produced by Thomas Edison, which depicts an execution of a woman. The camera was stopped just before the axe hits its mark, the actors froze in place, and the actress who should get executed, was replaced



with a dummy. The camera re-started and the final shot looked like an actual beheading.

Another technique would be simple frame splits. In this technique, mattes are used in front of the lens to not expose a certain part of the film. These mattes were slipped into the light path before the film plane. Then the film was rewound to the starting point of the scene and the second element was then exposed onto the film in the area that had no exposure from the matte, so you were able to combine two shots in one scene. (Fink / Morie 2010, p. 4)

Another technique used around this time was “Pepper’s Ghost” named after John Henry Pepper. In this effect, somebody turned into a skeleton and back. This was done by placing a large glass sheet in a 45-degree angle between the audience and the stage. By adjusting the lighting the audience would either see through the glass to the person or the reflection in the glass of a skeleton off stage. This technique was adopted for the camera and a lot of ghost movies that were made around this time.

One of the earliest movies including VFX is called “The Great Train Robbery”. It was a 12 minute long film of Edwin S. Porter and was considered a breakthrough piece. In one scene, he combined footage of a robbery inside an office with a separate shot of a moving train. In this frame split, he used a matte for the window in the office, in which the train in the final projection appears.

In the 1920’s matte paintings, used for backgrounds, became increasingly sophisticated. Artists like Norman Dawn (California), known for “California Missions” in 1907, or Percy Day (England), known for “Thief of Baghdad” in 1940, invented and refined matte painting techniques that were used until the development of digital tools. (Fink / Morie 2010, p. 5)

Another useful invention these days was the optical printer. It made it possible to combine different shots together without having to risk the original negative. The first commercial printer was sold by the Dupue Company in Chicago. Years later Linwood Dunn, who was working for the U.S. military during World War II, is widely acknowledged to have built the first modern Optical Printer called the Acme-Dunn Special Effects Optical Printer. Directors like Orson Welles, Fritz Lang or Alfred Hitchcock worked with it. An example for the use of this printer would be Orson Welles’s “Citizen Cane” in 1941. (Fink / Morie 2010, p. 7-8)

In the 1940’s and early 50’s synchronous motors helped to control pans, tilts, and dolly moves. This predecessor of motion control systems helped visual effects artists to create more innovative shots. For example, to provide identical camera moves like it was used in “Samson and Delilah” in 1949, or to combine

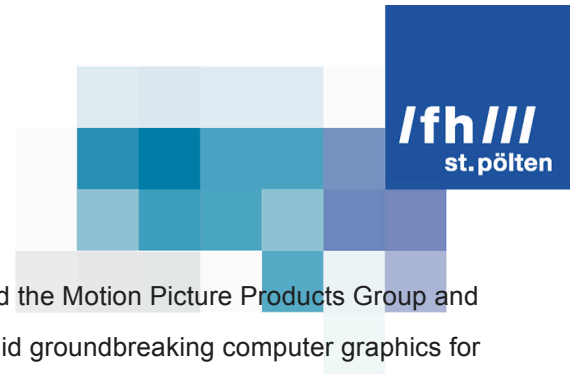
on location shots with matte paintings and stage photography like it is in “An American in Paris” in 1951. The use of these motors continued into the 60’s. “A Space Odyssey” by Stanley Kubrick was an outstanding movie using a lot of this technique. In the 1970’s, improvements made the control of motion of cameras and miniatures in multiple axes to an indispensable tool for Visual and Special Effects. Films like “Star Wars Episode IV, A new hope” used this technique and thrilled the audience with its effects. Motion control systems are a powerful tool and are still in use. For example, James Cameron used a system for his movie “Avatar” with virtual cameras on visualizing virtual sets. (Fink / Morie 2010, p. 8-10)

“Cameron and his Visual Effects team could plan and execute fully digital shots that achieved all the look and feel of physically photography, seamlessly integrating the language of live action camera work into fully digital scenes.” (Fink / Morie 2010, p. 10)

The process photography, the rephotographing of previously shot footage in combination with live action scene became a powerful tool. This allowed the director to place actors into an environment, which was shot somewhere else. It also allowed live-action images to be projected onto tiny screens placed in miniature sets, as you can see in the movie “King Kong” in which the 18-inch King Kong appears like a huge creature. The conflation of synchronous motors to make the same exact camera movement and fine grain film stock was necessary for this technique. This was commonly used until the development of bluescreen and greenscreen and digital compositing. (Fink / Morie 2010, p. 5-7)

Another very successful technique in the 1950’s to 1970’s was the “sodium vapor” process. It is a photochemical technique for combining actors and background. The actors were performing in front of these sodium vapor lights. Two separate films were exposed with the use of a beam splitter prism. The main film was a color negative film that was not sensitive to the sodium light and a second fine grain black and white film, which was highly sensitive to the sodium light. This film, which was only exposed by the yellow sodium light created a matte as well as a counter matte, for use during compositing on an optical printer. Because of this, filmmakers were able to create mattes better than the mattes of the blue screen process these days. Walt Disney used this technique a lot, for instance in “Mary Poppins” in 1964 and “Bedknobs and Broomsticks” in 1971. (Fink / Morie 2010, p. 7)

The Digital age changed the Visual Effect quite a bit. For example, John Whitney, Sr., who began photographing moving patterns of light and light objects moved by analog computers. The Stargate scene in “2001” in 1968 was inspired by this technique. He was also responsible for the animated graphics on the opening scene of Hitchcock’s “Vertigo” in 1961. Later in the early 1970’s John Whitney, Jr. and Gary Demos,



who were working for Triple-I (Information International Inc.), formed the Motion Picture Products Group and started creating computer graphic images for the industry. Triple-I did groundbreaking computer graphics for “Westworld” in 1973 and “Futureworld” in 1976. Triple I was responsible for the first shaded 3D object (a hand and Peter Fonda’s head in “Futureworld”), and for the first digital full 3D body for Michael Crichton’s “Looker” in 1981. Triple-I together with the companies MAGI, Robert Abel & Associates and Digital Effects made the outstanding computer graphics for Steven Linsberger’s film “Tron” in 1982. (Fink / Morie 2010, p. 10-11)

It followed the first particle effect, used in 1982 made by Pixar, in “Star Trek: The Wrath of Khan”. The first animated character in 1985 in motion picture in the “Young Sherlock Holmes” and a lot of other first seen effects. (Fink / Morie 2010, p. 12)

In 1984, the visual effects work for the movie “The Last Starfighter” were at a far higher level than seen before and from this point on computer graphics became a massive tool, not just seen on displays, but as a real image of the story. (Fink / Morie 2010, p. 11)

Kodak in collaboration with ILM (a Lucasfilm division) invented the first practical film resolution scanner together with the Cineon digital film format, which became standard across the world. In this time people got amazed by fully CG leading characters, digital “morphs” animated creatures in such a convincing way they have never seen before. “Jurassic Park” in 1993 for example showed the power of VFX. (Fink / Morie 2010, p. 12-13)

“Since 1993 it can be argued, included as much innovation as the previous 100 years of visual effects” (Fink / Morie 2010, p. 13). Computers were getting faster and better, 2D compositing software comes to fore as well as developments in 3D camera and object tracking.

“Improvements in animation, modeling, and rigging; the application of physiological attributes to characters; improved motion capture; physical simulation; and- absolutely essential to our current state of accomplishment- huge advances in lightning and rendering.” (Fink / Morie 2010, p. 13)

This can be seen in the previous blockbusters such as “Avatar”, “Lord of the Rings”, “Pirates of the Caribbean” or “Transformers”. Today, what can be imagined is possible to be created.



1.3. California and Globalization:

In the golden age of movie making, the majority of Hollywood films were produced in Los Angeles. The big advantage of Hollywood is that they have a lot of studios setup as a film factory ready to shoot a film. There are a lot of different stages and film settings which allow a wide range of genres to shoot. The distance between the studios is not far and it is also enough space to construct special settings. So it was pretty comfortable to shoot in Hollywood.

This time the majority of VFX for Hollywood productions, such as “Star Wars” were done in California. That state dominated the Visual Effects industry with their techniques and tools along with the artists that used them. The major VFX companies were on a relatively level playing field. The companies got their jobs based on abilities, quality, and costs.

The digital age changed the world of visual effects. Advances in technology, standardization of techniques, cheaper and more available hard- and software, has spread VFX industry. You can take your computer and software and can set it up anywhere in the world. Since some countries and states offered tax incentives including VFX, it made sense to produce somewhere else where it was cheaper. Visual effects used to be created by physical props such as animatronics and models. Today they frequently are created by digital artists trained in 3-D modeling, computer animation and computer graphics, with the aid of 3D software. The Internet made it possible to send data very fast so it could be edited anywhere else, so VFX became a commodity that can be done anywhere all over the world.

Even though more and more visual effects are required, California’s VFX companies try to survive, because they have to compete with the other countries that offer less production costs. Filmmakers are taking advantage of tax incentives of Vancouver or London or of the low-cost labor in India, China or Singapore where artists get 10% of the salary of an American artist. With a 20% or more savings via the government, it’s difficult for VFX companies in California to compete directly.

Hollywood productions began outsourcing special effects and CG, mainly because it is just too expensive to produce it in California. For example Special Effects and CG for Avatar, Spiderman 3, Immortals or Planet of the Apes has been outsourced to India.

So the VFX industry is not only a Californian thing anymore. It has become an industry, with businesses all over the world and this business is thriving. Every current movie in the cinemas contains VFX. According to Rebecca Keegan, “Nine of ten highest-grossing movies worldwide in 2009 relied heavily on special effects



and as much as a third of the budget of the \$200 million to \$300 million movies that are devoted to special effects.”

Which brings me to the question if it is also possible to implement such a Hollywood effect shot without hundreds of people and millions of dollars, since the hardware and software for creating such effect shots has become more accessible and also become easier to use. Does this mean that everyone with according knowledge can create such effect shots, or is it only possible with a lot of manpower and big budget? To find it out I will implement such an effect shot, which is documented in the next chapters.

2. Implementation of a Low Budget Effect Shot

2.1. Production Phases

2.1.1 Pre-Production

At first it is important that the task of the work is defined carefully. The next step is to paint a storyboard to create a picture of the scene. This is a very important step especially if you work together in a team, because VFX cannot be defined exactly as a written task. When you paint a storyboard you see the proportions roughly, the allocation and the distances of all the elements in the shot, and so you avoid misunderstandings and unpredicted surprises. It has been stated: “A picture says more than thousand words” meaning especially for the VFX, it is important to picture the scene in order to let everyone who is working on the project know how the scene should look like.

When the storyboard is painted, all the elements that occur in the scene will be gone through one by one and the best way to implement them in the final scene will be figured out. In most cases, there are more ways to implement something into the effect shot; the decisive factor is to find out the best and most cost-effective way. In brief, in this step the different possibilities of implementing something into the scene will be compared and the advantages and disadvantages will be examined. Finally, the best way for this specific effect shot will be chosen.

2.1.2. Production

At first, the scene has to be split up into what can be shot with the camera (live-action shooting) and what has to be added in the post-production. After that, the scenes, which were needed, have to be shot. Most elements will be implemented in post-production and thus, the production phase will be not very long.



2.1.3. Post-Production

The post-production is the most time-consuming phase, because most of the elements have to be created and inserted into the scene, and composed to a whole shot. Largely, this will be done with the aid of the compositing software “Adobe After Effects CS5”.

2.2. Description of the Scene

2.2.1. What is Important for Describing the Scene

VFX are often very difficult to explain, because everyone perceives the same written task differently. When you show some people a picture and they have to describe it, no description would be the same. Adjectives such as “far” or “dramatic” or “bright” create subjective images.

As Sacha Bertram (2005) stated, it is very important to describe things as exactly and visually as possible, like a description for a blind person. Which form do things have (organic or technical)?, where and how does choreography go?, how does it look?, how does the surface look?, how big is it?, is it matt or brilliant?, how does the background look like?, etc. It is also important to describe the interactions as clearly as possible, especially if computer animated objects interact with real things. Finally, the points, which should not be forgotten, are the shot type and the distance: Is it a close-up or a long shot?, how far are things away? etc. (Bertram 2005, p. 16-17)

2.2.2. Characteristics of the Scene

This is a scene how it appears in Hollywood war-movies such as Steven Spielberg’s “Saving Private Ryan”. The scene should look as realistic as possible. Therefore it is important for the effect shot that no effect is clearly recognizable. Such effects based on Sacha Bertram (2005) are called “invisible effects”. These effects are applied, for example, to change the location, to remove or add something such as a house or a street, to change the weather or the season. They are very helpful, and you save a lot of money in matters of travel costs and building sets, but they are very difficult to make, because the human eye is very sensitive to such realistic things that are around daily.

(Bertram 2005, p. 176).

2.2.3. The Scene

It is afternoon, the sky is slightly cloudy, and it is a murky day. The perspective is a long shot from a bunker on the top of a hill which is about 25 meters high and it is about 50 meters away from the oncoming soldiers.

A squad of soldiers tries to charge the base where the bunker is. They get bombarded from the base, so there are a lot of explosions of the order of a grenade on the battlefield. Therefore, there is a little bit of smoke and fog.

A bomb hits three of the soldiers. Six of the soldiers try to hide behind a house in the middle of the battlefield. It is a small blue house with a window. A rocket strikes this house, and it explodes. The rest of the advancing soldiers get shot on their way to the base.

With regard to the landscape, there more levels, on the top level there is the bunker and it is on the opposite side of the sea. On the sea there are four boats, and two of them get hit by rockets as well and explode.

2.2.4. Storyboard

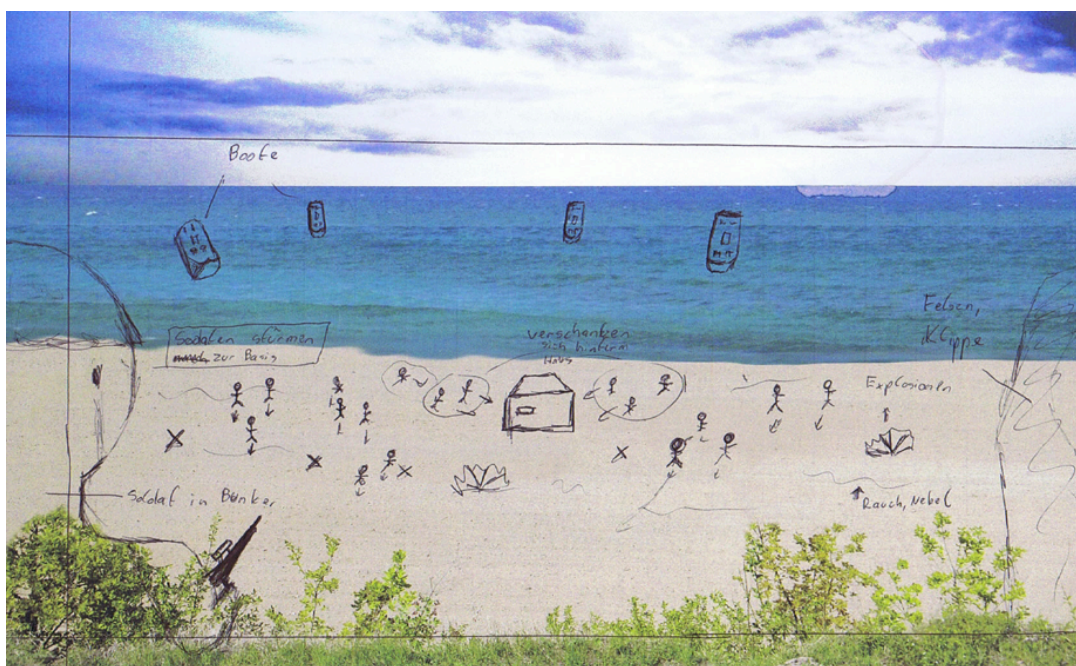


Figure 1: First picture of the storyboard



Figure 2: Second picture of the storyboard



Figure 3: Third picture of the storyboard



2.3. The Assembly of the Elements in the Shot

2.3.1 The Landscape

There are different ways to find the appropriate landscape for this shot. In the next chapters the different ways and important steps are outlined to get the landscape for this task.

2.3.1.1. Find the Location

Usually a location scout travels around the world until he finds the right place for the shot. After he found the place and the director is satisfied with the place, the whole team and equipment is going to this place. This is always combined with a lot of traveling costs and often the location is not the same as it is in your imagination. Big Hollywood productions spend a lot of money in finding or creating the right location, but in my specific effect shot I couldn't find a perfect location so I decided to create it digitally.

2.3.1.2. Matte Paintings

Matte painting is one of the oldest visual effect techniques in film. With matte paintings you can add something to your scene, change something, expand your set or build complete environments.

“Very early on, matte painting became an important tool to create settings in a cost-effective and efficient manner. Matte paintings help tell stories that would be impossible without them for technical, logistical, and budgetary reasons.”

(Barron et al. 2010, p. 575)

In the past those paintings were painted behind glass. Today matte paintings are created digitally on the computer. This has a lot of advantages such as removing something from the real material, adding something from a real photo, and things can be changed very fast if they do not fit into the scene.

Matte paintings are applied to reach a realistic look and they are often much easier and faster to create than a computer animated 3D Model.

The advantages of matte paintings are:

- They are and easier to create compared to a real set or a 3D model.
- They are often much cheaper than a real set or a 3D model.
- They look very realistic.
- You can create any environment, in a cost effective way.



But matte paintings also have a few disadvantages:

- Speaking of the interaction between the environment and the performers on the set, it is often a better choice to build a real set than add it in the post. It depends on the complexity, with which the actors and the environment interact, with regards to lighting as well as physical interaction. (Barron et al. 2010, p. 579).
- The next problem is camera movement. Matte Paintings are flat, 2D, and they have only one fixed perspective. So if a shot requires a lot of camera movement or bigger perspective changes the matte painting is useless. A little pan or tilt of the camera is often no problem when the painting is in the background. If more camera movement is necessary a motion tracking has to be done so that the matte goes with the shot. However, this also has its limits.

2.3.1.3. Rotoscoping

“Rotoscoping is the process of outlining and ‘lifting’ elements of a filmed scene off the frame so that other elements can be added to the frame either in front of or behind the rotoscoped elements.”

(Brain 2011, no page)

„In today’s visual effects rotoscoping process, digital footage is loaded into a rotoscoping software package and the artists use splines to trace the required articulated mattes.“(Krasser 2010, p. 570) Splines are a series of points connected by a line or curve.

With those mattes you cut out the part you want and rotoscoped images could be processed in the compositing software.

2.3.1.4. Compositing

In the Compositing part you put all the different elements together into a final scene, for example, rotoscoped images, matte paintings, particular effects etc.

Compositing is a very important part, because if the compositing is bad, you see it immediately and the scene loses a lot of quality.

2.3.1.5. Summary for the Specific Task

For a low-budget production it is not possible to travel around the world for the perfect location that will be too expensive. Therefore a mixture of both ways will be done. Consequently, because of matte paintings the camera movement suffers, although budget will be reduced.

- The ground, which the soldiers are running on, has to be shot on location because of the interaction. So I found a place how it is described in the scene.
- The sky and the ocean have no interaction with anything, so I decided to film it separately and composite all together. The sky and the ocean was also no problem to film in California.

Concerning compositing, it is important, that everything is consistent. So adaptations have to be made, in order to the consistency, for example, color correction and scaling.

In brief, getting the appropriate landscape is possible with low budget. A high budget Hollywood production will create a much better landscape in a shorter time, but also with low budget it is possible to create an appropriate landscape.

2.3.1.6. Implementation

- At first the original location has to be shot.

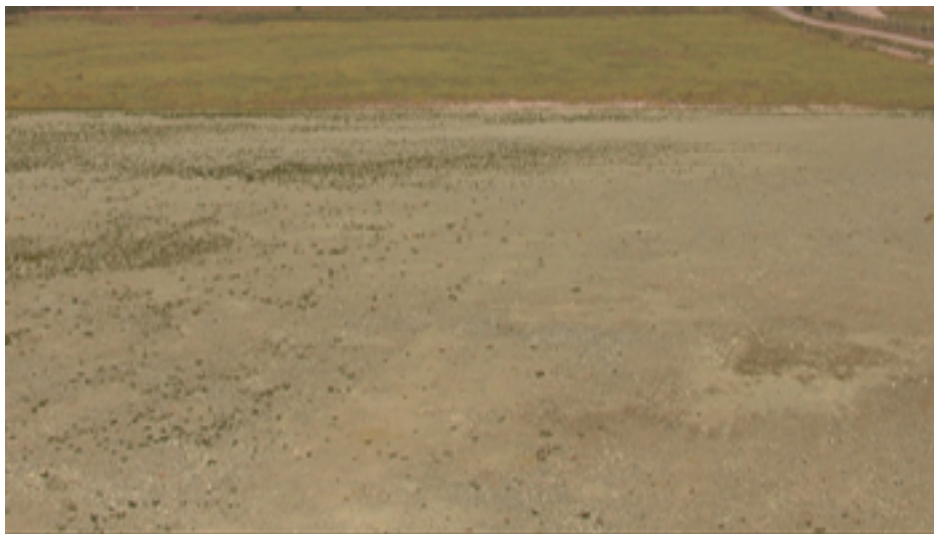


Figure 4: Original landscape



- After that the footage of the sea and the sky has to be rotoscoped and inserted into the scene.
- At last, everything has to be adapted to get the final landscape



Figure 5: Final landscape

2.3.1.7. Comparison with Roland Emmerichs „*The Patriot*“

Director: Roland Emmerich

VFX supervisor: Frank Wegerhoff

As Marshall Brain 2011 showed on the website <http://entertainment.howstuffworks.com>, “*The Patriot*” also uses a lot of these techniques.

First they looked for a big field and shot soldiers running on that field, so this is real footage.



Figure 6: Original shot
(Brain 2011, no page)

The breastworks that you see in Figure 6 on the sides of the pictures were built for the scene.

Later they rotoscoped everything they want to add to the final shot, for example, the field of the original footage, the ocean from another shot, and the sky from a photo.



An artist created a matte painting from of the town.



Figure 7: Matte painting of the town
(Brain 2011, no page)

Then they created computer generated boats and smoke and finally composite all together in a final shot.
(Brain 2011, no page)



Figure 8: Final Shot
(Brain 2011, no page)

2.3.2. The House and the Boats

To get the house and the boats into the scene matte paintings like it is described in the chapter before is a possible way. But these elements should explode in the scene, and so using matte paintings is not preferred if a realistic explosion is depicted. When it is done with matte paintings you could put a keyed explosion in a layer over the house (or boats), but this looks not very realistic because the house (or boats) and the explosion are two separate elements, which are not well matched.

The boats would work with matte paintings, because they are far in the back, but the house would not look realistic.

A better solution for this situation is to build a 3D object of the house and the boats. The costs are not much higher, but it is more time consuming. Additionally a 3D Software as Autodesk *Maya* or Maxon *Cinema 4D* is needed to the compositing software.



2.3.2.1. Progress of Making a 3D Object

Regardless which 3D objects are created, the working steps and the process of making them are mostly the same.

Modeling→Surfacing→Animation→Lightning→Rendering

In the modeling part you create the shape of the object. The most common ways of modeling are:

- Modeling with polygons
- Primitive forms
- “Nurbs”
- Subdivision Surfaces (Flückiger 2008, p. 56)

With these techniques, objects can be created in your own imagination without any physical limits. (Flückiger 2008, p. 56)

In the surfacing part you create the surface of the object.

- Assign a material (effects on the reflection of the light)
 - Assign a shader (a mathematical description of the surface, for example hair or wood)
 - Assign textures (flat pictures projected onto the surface)
 - Assign Bump or Displacement maps (to create little levies or an abrasive surface)
- (Bertram 2005, p. 35-36)

The surfacing part is often combined with the lighting part, because only then you can judge about the quality of the shading and the textures. (Bertram 2005, p. 36) In this part a virtual light source is created, which lights the objects and creates shades.

In the animation part the behavior of the object is assigned. There are a lot of different animation types, for example, keyframe animation, particle animation etc. In this task the animated explosion belongs to the animation part.

The last step is the rendering part. This part is largely an automatic process. With the aid of the computer the sequence with the given parameters will be calculated, and added together, picture per picture, to a final scene. The parameters come from the animation, textures, light, and surface.



2.3.2.2. Summary for the Specific Task

Creating 3D models of the house and the boats is not much more expensive, but much more realistic compared to matte paintings. What is needed is a 3D software to build the models.

All in all creating a 3D object is more work and time consuming steps than doing it with matte paintings, but not much more expensive. The object is created together with the explosion in the 3D software, as a result it is adapted for the house and the boats and they look like one piece and much more realistic.

To sum it up, it is possible to get the house and the boats into the scene with low budget also, but not in the same quality, not in the same time and not as professional as a big budget Hollywood production, but with knowledge in 3D in a trustworthy form.

2.3.2.3. Implementation

The house and the boats are built in the 3D software and get inserted into the compositing software. There the objects and the other elements get composite together into a final shot (Figure 9).

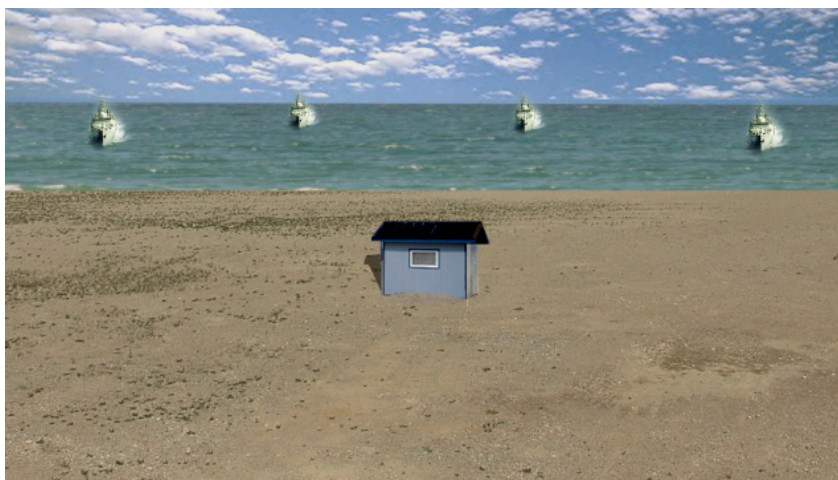


Figure 9: House and boats

2.3.3 The Soldiers

There are many ways to get the soldiers for the scene.

2.3.3.1. Provide Enough Actors

One of these ways is to provide the number of actors that are needed in the scene, give them their choreography and shoot the scene. But as we know actors are expensive and so we try to minimize the people on the set and look for another possibility to have enough soldiers.



2.3.3.2. 2D Crowd Replication

2D crowd replication is one of the simplest ways to create larger crowds. With 2D crowd replication you need much less actors. With the aid of a compositing software, you can transform a small crowd into a larger crowd.

At first a group of people have to build up. With this group of actors multiple passes are shot. In every pass the group is in another place or moves differently compared to the first pass. After that a simple copy/paste function is used with the separate plates. Paint a matte around the groups and add it to the other shots so they all can be combined in one shot. With this procedure the illusion of a larger crowd is created. (Knoll 2010, p. 690)

Nevertheless, there are some facts that you have to be careful about:

- During the shooting there should be no overlapping between the different groups. If there is no possibility that they do not overlap, you have to use a greenscreen during the shooting, or you have to rotoscope it for the frames they overlap.
- The camera movement is limited. If more camera movement is required use motion control systems to repeat the move of the cameras exactly. (Knoll 2010, p. 690)
- The light has to be the same for every plate. This could be difficult if the location is outside and you have to shoot a lot of plates, because the weather could change and the sun is also moving. All this affects the light. And if the light is not the same you see it in the final composition.

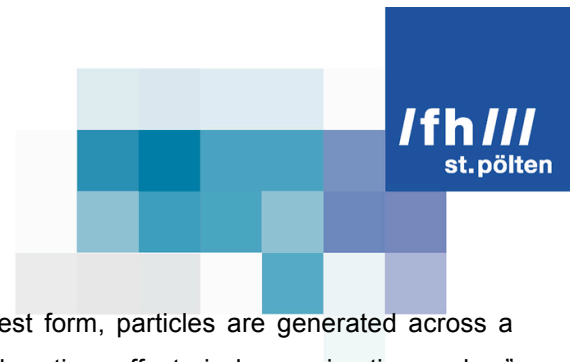
Often it is more reasonable to create a crowd in a completely digital way. For example, if you need millions of people as in Roland Emmerichs "*Lord of the Rings*", a 3D crowd simulation is needed.

2.3.3.3. 3D Crowd Simulation – Digital Crowds

In this case the crowd is created and animated digitally with a crowd simulation software (or Plug-In), such as Massive, on the computer. Massive was developed for the battle scenes in the "*Lord of the Rings*" trilogy. This software works with artificial intelligence, which means diverse parameters are defined, which affects on the behavior of the digital crowd.

"Massive users construct a 'brain'- basically a parametric behavior decision tree that controls how characters respond to their surroundings and other characters." (Knoll 2010, p. 694)

For example, an army A fights against an army B. If the army A is superior to army B a soldier of A kills the soldier of B with a likelihood x , and search for a new enemy. Is he encircled from a number y of enemies he escapes. (Sacha Bertram 2005, p. 164)



A second variant is to treat the crowd like particles. “In its simplest form, particles are generated across a surface and are used to instance model variations driven by random time offsets in long animation cycles.” (Knoll 2010, p. 693)

When building the crowd you do not build each member individually. A small number is built and then generate variations of them. For example, different textures, different body types, different shader parameters, and multiple wardrobe, etc. To create realistic motion, motion capture systems are employed. (Knoll 2010, p. 692)

3D crowd simulation based on John Knoll is applied, to simulate a huge crowd. This offers numerous of advantages compared to 2D replication:

- Unlimited crowd size.
- No shoot of multiple plates.
- More complex behavior.
- Camera motion is not limited.
- Crowd can also be humanoid characters.
- Dangerous events are no problem for the crowd. (John Knoll 2010, p. 692)

2.3.3.4. Summary for the Specific Task

As related to the task, the cheapest and simplest way to get the crowd is 2D crowd Replication because:

- In this task 10 to 15 people are required, so 3D crowd simulation would be too sophisticated and too complicated.
- The camera is fixed, so we have no problem with camera movement.
- It is much faster and cheaper to shoot a few plates, compared to the whole 3D process.

Things you have to keep in mind:

- The light should be the same over the whole day
- The choreography of the actors should be planed well that there is no overlapping between the different plates.

All in all, the soldiers are no problem for our low-budget effect shot. 2D crowd replication is a good method to keep the budget low, and a good way to create a realistic crowd for the scene.



2.3.3.5. Implementation

After building a group of people, the choreography for every plate should be planned. You shoot so much plates that the field is filled. After that, you put the footage into the compositing software, rotoscope the groups of every plate and composite all of it together into a final shot.



Figure 10: One plate



Figure 11: All plates together

2.3.3.6. Comparison with Peter Jackson's „Lord of the Rings“

Director: Peter Jackson

VFX supervisor: Jim Rygiel

Figure 12 shows the battles of lord of the rings there were millions of people on the battlefield.



**Figure 12: Digital crowd from “Lord of the Rings”
(Jackson et al. 2001, no page)**

This is only possible with a crowd simulation software. “*Lord of the Rings*” used the software “Massive”. Developer of this software is Stephen Regelous. With this software you can create millions of people with artificial intelligence.

This software makes it possible, that the battle scenes look very realistic. If such a high number of people is required, it is indispensable to use such a software, but compared to our scene with a few people it is not necessary and would be more expensive and time consuming.

2.3.4 Explosions

The explosions are the third big part of the scene, and there are always many ways to get these.

2.3.4.1. Real Explosions

The first way is to make the explosions during the shooting with all the other elements you shoot. Important is, to shoot with a very short shutter time, because then, the explosion is not blurred. No explosion looks more realistic than a real one, but this is very expensive, and often simply not possible, because it is too dangerous for the actors or something else on the set.



2.3.4.2. Miniatures

Explosions are scaled down for example to 1:8 and are filmed in front of a green screen. Then after keying it you can insert it in the compositing software into any footage you want and scale it up to a much bigger explosion. “Explosions, when properly designed, can work in the range of 1:4 to 1:12 scale.”

(James 2010, p. 332)

But all types of pyrotechnics have an influence on the frame rate for the shooting. A miniature explosion happens over a much shorter time, than an explosion in full-size. So you have to shoot with a higher frame rate and make it slower in the post. According to Ian Hunter 2010 this is the formula to determine proper frame rate to the scale being used:

$$(\sqrt{m}) \times (r) = f$$

m=Miniature's scale
r=Base frame rate
f= New frame rate

For example 1:4 scale at 24fps = $(\sqrt{4}) \times (24) = 48$ fps. (Hunter 2010, p. 315)

For a realistic fire propane or naphthalene is usually used. For more visual detail it is substituted with MAPP (methyl acetylene and propadiene). This causes more variation in colors, black smoke and it burns hotter than pure propane. So you get fireballs full of contrasting intricate details. This looks amazing on screen and hides the real scale of the explosion. To add more turbulence or more realistic behavior some light wind sources can be used. (James 2010, p. 329)

2.3.4.3. Particle Effects

In a particle system, a lot of particles are generated from an emitter. These have at least a direction, a speed and a life span. Depending on what effect you want to create you have to adjust a lot of other parameters that are controlling the behavior of the particles such as mass, color, spawning rate, velocity, turbulence, wind and many more. Most of these parameters have no precise numeric value, but rather a random value, and may vary over time.

Under these conditions, particle effects are a good way to animate fire and explosions. For explosions the particles are replaced by a kind of geometry, or just an equation that renders something smoky or flame colored. These replaced particles have a short life span. For a fire simulation the color changes over the particles life. For example it changes from white through red to orange. (Zerouni 2010, p. 644)



2.3.4.4. Summary for the Specific Task

For this task it is a mixture of more ways. Real explosions would probably look most realistic, but for big explosions it would simply be too dangerous and a way too expensive for the low budget. So, for big explosions the best way is to use miniatures. Little explosions, as from guns, could be made while shooting, with firecrackers on the ground. To create dust and smoke to make the shot credible, particle effects are a good solution.

The explosions are also possible with low budget, but they will never look as amazing as the big explosions in the Hollywood productions. But when they are made well, they could be a good and trustworthy effect.

2.3.4.5. Implementation

At first the little real explosions on location have to be shot. After that you plan the explosions for the house, and the grenades as miniature effects. Then you shoot it in the appropriate scale in front of a greenscreen and then it has to be keyed. After that, you make the smoke and dust with particle effects and finally composite all together in a final shot, in the compositing software.



Figure 13 Final shot



3. Conclusion

Since the beginning of commercial filmmaking VFX has changed a lot, beginning from the first illusions and in-camera effects to the digital age. Also that California is the only country producing the big Hollywood effects is past. Since the digital age and since hard and software became more accessible and cheaper and techniques got standardized it became a business all over the globe. So it came up the question for me if I could make one of this effect shots with low budget too.

The answer is yes and no - it is possible to create such an effect shot with low budget, but compared to a big budget Hollywood effect shot the quality and the level of realism is much lower. But often it is not a question of realistic or not, but rather a question of trustworthy or not. When you look on successful science fictions films, the most elements are not real. They are all new invented, but they are suitable for the movie. When you think about George Lucas's "Star Wars", no elements exist in real life, but the effects were trustworthy, so that the movie was a blockbuster. Before "Star Wars", nobody was able to describe a starship, but after the movie everybody has an imagination of how a spaceship may look like.

In brief, the effects for the effect shot have not to be completely realistic, they have to be trustworthy for the audience.

The next thing is, that in Hollywood productions, a lot of people work on such effect shots. Every person has its own section, in which he is an expert. This is why they reach such a high quality level.

You can also do little effect shots on your own if you have the extensive knowledge, but it will be much more time-consuming and will hardly reach the quality of a Hollywood effect shot.

To sum it up, creating a large scale effect shot with low budget is possible. But it is not possible to reach it in such a quality and the same time as in a Hollywood production, but with according knowledge a credible effect shot is achievable.



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