Matchmoved Architectural Visualization

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Abstract:

This project is concerning matchmoving and architectural visualizations. It attempts to determine how matchmoving can be presented to the architectural visualization industry, as an addition to contemporary industry visualization methods of 3D still images and 3D animations. Through analysis of the history and technique of matchmoving, the purpose and history of architectural visualizations in the industry, the concept of Faction, film techniques and interviews with architectural visualization companies, a design was constructed to test the use of matchmoving as an architectural visualization for sales purposes. The product was a short film that matchmoved a 3D building onto real footage, attempting to convey as realistic a mood as possible, through aiming for a high degree of verisimilitude. The test showed, from expert respondents, that the current architectural visualization industry is not yet ready to accept the project film as a valid addition to contemporary visualization methods for the purpose of sales. But the test also strongly indicated that matchmoving could instead be used to convey a sense of the building's physical presence in the scene, rather than a realistic mood, or attempt to convey a redefined and more visually pleasing version of a realistic mood.

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Preface

This project was developed as a Master thesis, during the 10th and final semester of Medialogy at Aalborg University Copenhagen, in the period from the 1st of February to the 27th of May. Being a master thesis, no specific theme directed the project.

The product of the project is an architectural visualization video, which uses matchmoving to combine a building created in Autodesk Maya with footage recorded from the real world, with a small handheld camera. It is used to test how matchmoving can been presented to the architectural visualization industry as an addition to contemporary visualization methods. The report covers relevant topics, such as the history and technique of matchmoving, the concept of Faction, film techniques, an investigation of the history of architectural visualization aesthetics, as well as several interviews with architectural visualization companies.

Reader's guide

This report is organized to follow the structure of the actual work progress of the project. Beginning with the motivation for the project, the Introduction and Pre-analysis chapters will explain the investigations, considerations and visualization industry collaborations done by the group in order to achieve the final problem formulation, which is the base of the entire project. Chapter 3 *Analysis* investigates all important areas of the final problem formulation to determine how to construct the design for a product, which should be able to test the final problem formulation. Chapter 4 *Design* and chapter 5 *Implementation* will describe the creation of the product itself, before the chapter 6 *Test* describes the design of the test of the product in relation to the final problem formulation, as well as presenting and analyzing the test results. In the end, the final conclusion is presented.

The information contained in the header of each page will be the name of the group members, the year of production for the project, the title of the report and the logo of the university.

When referring to most sources in the report, the APA Quotation standard is used. "To be or not to be, that is the question. (Shakespeare, 1603)."

However, a different style of quotation is used, when referring to interviews and correspondence with professionals from the architectural visualization industry. References to quotes or information gained via e-mail, will be references as such: "Eugen Olsen, 3D Tree – Appendix 9.2" Written first is name and company of employment. The e-mails to which we reference can be found in the appendix of the report, and "Appendix 9.2" thus means, that the mail from Eugen Olsen, 3D Tree can be found in the Appendix, chapter 9.2.

References to recorded interviews with the industry will be done in a similar fashion to references to e-mails: "Lars Hilfling Nielsen, Cenario – **I2 3:55**". Once again, name and company is written first. But subsequently, the reference will list, in bold, the number of the interview, which is defined in the report, as well as the specific time of the quoted reference in the interview. In case the specific time cannot be determined, e.g. if a reference is pieced together from several responses appearing at different times during the interview, the specific time will be omitted from the reference.

A full list of all references can be found in chapter 8 *Bibliography*. When referencing to a chapter or image in the report, the text will be in italic. Images will be referenced *Illustration* X.Y, where X is the current chapter and Y is the image number in that chapter. Both chapter and image references will be in the Calibri font, whereas the text of the report is in the Times New Roman font.

Any image found in the report will be listed with proper copyright underneath, as such: “Archivisuals, “Image name” © 2010”, where the company Archivisuals is the copyright holder and image name will be provided if it is available. Copyright will be credited specifically for each image, also when several images appear side by side. If only one mention of copyright is given under several images, all images have the same copyright holder.

Chapter 9 *Appendix*, contains all relevant e-mail correspondence with visualization companies. The full Dogme WoW of Chastity can be found there. Every test answer can be found in written form. Fully detailed affinity diagrams, organizing all test answers into categories analyzed in the main test of the report, can also be found in this chapter.

Table of content

1 Introduction

This project focuses on matchmoving and architectural visualizations. This introductory chapter will explain the motivation for the project, along with an investigation of the state of the art within the industry of architectural visualizations. In conclusion it will establish an initial problem formulation, which will be expanded in chapter 2 *Pre-analysis*.

1.1 Motivation

Visualizing buildings has long been a stable part of the industry of architecture. There are many ways of approaching an architectural visualization, be it a black/white drawing, a colored painting, a watercolor image or, as recent trends seem to follow, a 3D image. The purpose of architectural visualizations varies, whether it is to merely demonstrate the form of the building or express it with the hopes of evoking a deeper response from the viewer. Whatever the form and purpose, architectural visualizations are so important, they have grown into an industry of their own.

Examining current trends amongst visualizations firms world-wide – specifically firms working with 3D images, since the hand-drawn visualizations are currently a minority - a pattern presents itself: Architectural visualizations hardly ever merely serve the purpose of demonstrating the building itself - its shape, lines or size compared to the surrounding environment. Typical visualizations will attempt to induce an emotional response from the viewer or to convey a specific mood. The conveyed mood can e.g. be the perfect, blue-skied summer day or maybe a calm, cozy, sunset evening. The images might be aided by the inclusion of additional vegetation or by the enhancement of color in the sky and the light. While images might seek to achieve various moods, they all share a common characteristic: The buildings are often presented in such perfect conditions that they ultimately exhibit a virtual quality. Buildings tend to be visualized in a virtual reality more visually gratifying than the actual reality in which they are to be built. We are very interested in examining the results of an architectural visualization exhibiting a more realistic mood. When displaying an architectural project, it seems that a realistic representation should have clear benefits, since the client can better evaluate what he purchases.

Another trend amongst visualization firms is that they all generally create only two types of visualizations:

- A 3D image
- A 3D animation

In rare cases, a visualization firm will utilize e.g. an interactive walkthrough of a building. But 3D images and animations are what drive the industry, with the amount of 3D images holding a significant dominance over the amount of animations. The industry at large seems to be reluctant to embrace other technologies and as Medialogy students, for whom the inclusion of new technologies to aid our projects is commonplace, it became intriguing for us to examine why the industry seems to favor a few possibilities so heavily, as well as explore what the introduction of a new technology could contribute to the architectural visualization industry.

Overall, the project motivation is to address two aspects of contemporary visualizations:

- The virtual aesthetic should become more realistic
- The reluctance to make use of new technological possibilities should be reversed

A technology that we have previous working experience with, and which is suitable to address the two aspects, is matchmoving. Not only is its use in architectural visualization significantly rare; it also relies

heavily on the use of video footage take from reality, giving it a suitable starting point for addressing the virtual aspect. Furthermore, matchmoving primarily produces a result similar to regular architectural visualizations – an image or a movie – making it a comparable technique in the basic aspects of the field.

This chapter will therefore proceed to more closely examine state of the art in architectural visualization, to provide a more detailed examination of the virtual aspect that this project seeks to address. It will then formulate the initial problem, providing an early overview of the basis for the entire project.

1.2 State of the art

Establishing current trends within the field of digital visualization of architecture becomes paramount in understanding the potential role of matchmoving in the field. Not only to dissolve doubts about the popularity of the technique and avoid potential issues of this project merely imitating existing visualization methods, but also to ascertain the rationale behind the current state of digital architecture visualization and – if suitable to the project – build upon current trends in the industry and expand them further.

Digitally visualizing architecture primarily comes about in two ways:

- Creating a 3D image
- Creating a 3D animation

Looking at visualization companies in Denmark or abroad, the 3D image dominates the market, with animations taking a distant second. In Denmark, such companies include Archivisuals and 3d-Empire and examples of their work can be seen in *Illustration* 1.1.

Illustration 1.1 - Danish company Archivisuals create their visualizations similar to many other companies. Archivisuals © 2011

Both companies, and many similar Danish companies strive to achieve a certain mood to be perceived by the viewer from their images. Buildings become placed in ever-present, unnaturally visually pleasing scenery; the sun perpetually shining to create clear skies and cause shadows to fall in such a way, that they always accentuate the shapes and features of the buildings.

Looking outside Danish borders, the trend is strikingly similar. French 3D Fabrique or American DoHere, present their own 3D images with a familiar focus on showing their buildings in as pleasant and inviting a locale as possible, as seen in *Illustration* 1.2.

Illustration 1.2 - Similar to e.g. Danish Archivisuals, French 3D Fabrique also focus heavily on creating an inviting mood in their still images
3D Fabrique © 2010

Another element utilized for establishing a given disposition is the inclusion of real humans. These are predominantly pictures of people taken from external sources and included to induce a sensation of life that potential clients can hope to experience, if living in the buildings being visualized. Close observations of these people reveal that they may be lit very differently (e.g. from different directions), they are missing proper cast shadows on the environment, as well as companies perhaps opting to re-use some people in several images. Most revealing however, is when people are transparent, such as seen in *Illustration* 1.3.

Illustration 1.3 - People are not always realistically represented in architectural visualizations
3D Fabrique © 2010

It presents a somewhat odd contrast to the rendering of the buildings. While maybe not presented to the point of extreme photorealism, the buildings often come across as fairly realistic. Juxtaposing them with transparent people without cast shadows might seem peculiar, however it is present in the images from many different companies and appears used quite deliberately, most likely as a tool to aid the creation of a desired mood in the image.

Apart from pictures of people, it is not unlikely to see other elements of these still images, such as lamps, posters, roads etc. being incorporated from other pictures and included to help set the mood of the picture and institute coherence in the surroundings.

Significantly less common is the use of animations to visualize buildings virtually, not in terms of the amount of companies creating animations, but in percentage of each company's portfolio. These animations, such as seen from Australian firm Preconstruct, while being capable of serving as an alternative way of conveying the sense of the building within its' intended surroundings, can have other purposes, E.g. for competitions, where architectural firms vie for the rights to construct a building, an animation can help convey the creation of a firm's idea, from basic sketch to complete 3D model and ascertain a more detailed expression of the thoughts and considerations behind the idea.

These animations need not consist solely of 3D elements. As with images, some companies insert footage of real people into their animations, such as Austrian firm Tangram 3DS. They show a woman and her family as they live their normal lives in the virtual buildings, illustrating how she functions within all rooms of the build, as well as the adjacent environment, as seen in *Illustration* 1.4.

Illustration 1.4 - In this shot from a Tangram 3DS visualization animation, only the man and woman are real - the remainder of the scene is virtual
Tangram 3DS © 2010

From investigations into current trends in digital visualization of architecture, very few companies divert from the traditional 3D image and animation. Some firms apply their own spins to these, but the format remains the same overall. However, certain companies do perform similar service to the goal of this report – visualizing architecture digitally via matchmoving. Internationally, companies such as English Cityscape Digital and South African 3DTree have performed a certain amount work with matchmoving, although with rather limited frequency – their portfolio remains dominated by traditional 3D images and animations. Both companies approach the technique in a similar fashion and attempt to create a video that provides a good overview of the building in its surrounding. The videos are shot from a helicopter, after which the 3D buildings are matchmoved into the footage as seen in *Illustration* 1.5.

Illustration 1.5 - The three buildings in the foreground (denoted by red arrows) are virtual; the rest of the scene is real
Cityscape Digital © 2010

Even though the buildings match the footage quite well, both companies ensure that the viewer knows exactly what is virtual and what is real through the editing of the movies.

In Denmark, very few visualization companies work with matchmoving. One of the few is Moose-studio. They list matchmoving as part of their services, but they have yet to utilize the technology in architectural visualization. Its use is very limited internationally, but especially domestically, and the few companies who do include it in their services, approach it very differently from what this project aims to explore. Based on this, the idea of this project is deemed sufficiently unique so as to progress it further.

1.3 Initial problem formulation

When examining how architectural visualizations are created for sales, they are primarily created either as 3D still images or 3D animations and the industry seems reluctant to explore new opportunities. They furthermore all share an expression of a stylized and virtual mood, regardless of whether a still image or an animation is created. Therefore, this project is motivated to take architectural visualizations in a different direction.

This project regards realism as an appealing direction to explore regarding architectural visualizations. Contemporary visualizations methods for sales often produce visually impressive results, but the connection to the actual reality of the buildings tends to be overshadowed. However the fact that the client can use the visualization to get an impression of the architectural project, as it will look in reality, when finished, is sufficiently interesting for us to explore it in this project. Therefore the initial problem formulation is:

"How can we present a realistic addition to contemporary stylized architectural visualization methods?"

2 Pre-analysis

In this chapter, key aspects from the initial problem formulation will be explored further, in order to narrow down the scope of the project and reach a final problem formulation. Matchmoving in relation to this project will be investigated in detail, along with the purpose of architectural visualizations in relation to this project. Before the final problem formulation can be specified, the target group will be described.

2.1 Choosing matchmoving

The original idea of the project revolved around architectural and interior 3D visualization, which required examining the current state of the art in this area. It showed that visualizations are almost exclusively still images and 3D animations depicting the design either completely virtually or photomatched into a real scene. Learning this, we contemplated the many possibilities that realism offers through the media of film, how they could be implemented in the architectural visualization industry, what results could be achieved, and most importantly, why this is not already being done? If you are making a 3D model of an architectural design, why is it then only used for 2D purposes in a still image? Why not take advantage of its 3D capabilities? This project will therefore revolve around taking better advantage of the qualities of 3D by creating a video, which can show the building whilst moving around it, rather than being locked to a single viewpoint in a still image.

A contemporary industry visualization method which can accomplish this is the 3D animation. However, this lacks any resemblance to the real world. Everything in the industry 3D animation is virtually created, promoting the idea that the building being visualized has no direct connection to reality. Implementation of the matchmoving technique could offer an alternative way of visualizing this scenario. Through the matchmoving of video recordings of the surrounding environment, the final result would be a video of the actual location with the 3D model inserted in the scene. Thus, matchmoving provides a way of maintaining the realistic quality of photomatching in industry still images, while also utilizing the 3D capabilities of the building, showing the building whilst moving around it, from industry 3D animations.

The motivation however stretches further than merely offering an addition to the existing methods of architectural visualization. The goal is also to establish collaboration with various 3D visualization companies and present this project to them. It is a strong motivational factor to observe something which we believe to largely be an absence in a given industry - in this case the 3D architectural visualization industry - and present our approach to addressing this absence directly to people working in the industry. This project goes beyond merely making a film and testing it against the existing still images and animations: It is an investigation of a technique, its potential in the industry and of the reactions from the professionals.

2.2 History of matchmoving

The matchmoving technique is an essential element of the project, which makes it relevant to include its background history. When we are to work with a technique so extensively, a deeper level of understanding is required, which includes historic information about it and its development. It can also determine, if matchmoving has previously been proven to be effective, or if it is an experimental technology.

Before 3D tracking, or even 2D tracking, was researched and implemented into visual post-production, the only way to manipulate footage or add elements, was to make a locked off camera shot, meaning that the camera does not move at all. For several years this was almost a mandatory requirement for visual effects shots, because it was so difficult to synchronize multiple elements in the same scene, if the camera movements were not exactly the same. The first solution to this issue came in the form of motion controlled cameras. These were capable of performing a camera move and then repeating it, since it was predetermined

and computer controlled. This made it possible to layer the camera shots in editing programs for visual effects work. However, motion control rigs were large and expensive pieces of equipment, and in some cases even too noisy with regards to sound recording requirements. But all cons aside, these motion controlled cameras are still in use today (Guenther, 2010).

The concept of tracking was first developed by the US Defense Department for use in missile guidance systems. The implementation of this technology into the visual effects industry happened in 1985 at the NYIT graphics lab, where it was used for a series of television commercials entitled "The rising coin" (Seymour, 2004). These were commercials for National Geographic in which a gold coin traveled in an arc, as if it was a rising sun. To create this shot, the coin had to stabilized to match the movement and jitter of the background layer. The company ILM had an early 2D tracking software system called MM2, which was first tested on the films *Hook* and *Death becomes her*. MM2 was not an automated tool, as offered by the matchmoving programs of today, and so the artist was forced to keyframe position changes by hand. However, this was used as basis for the development of one of the earliest 3D tracking systems, which was used for *Jurassic Park* (Seymour, 2004). These early developments of 3D tracking are the technological foundation, which makes it possible for us to achieve advanced results with the technique today. Much of the early work on tracking systems evolves around one individual; J.P.Lewis. He developed a Fourier-domain algorithm for normalized cross correlation, which was particularly important for image processing and tracking as the brightness of an image may differ compared to the image(s) in the following frame(s) of the sequence (Guenther, 2010).

The first commercially available tracking system specifically for creating visual effects was Flame, developed by the company Discreet in the early 1990's (Guenther, 2010, p. 20). It was able to track one single point through every frame of an image sequence. The algorithm used in Flame was constantly developed and improved upon. One such development was to process the R, G and B-color channels independently for greater accuracy and speed, and then average it into one point again. However, within a few years this method was discarded, as another method which included merging the color channels had proven superior with a more accurate track, using light and illumination changes as well as faster computation. In the middle of the 1990´s, there was a general shift in the visual effects industry to 3D, which was reflected in the development of tracking software. A key concept for 3D camera tracking is photogrammetry, which is the understanding and calculation of geometric properties for photographs, such as the shape of an object in photo. It has been used for aerial photography, remote sensing for the army and for geographical research. The company Science-D-Vision in Germany became the first software company to release a reliable 3D camera tracking application called 3D-Equalizer. This application has since become one of the key matchmoving systems of choice for the visual effects industry (Seymour, 2004).

Matchmoving has previously been an overlooked craft and the technique did not receive much credit from the visual effects industry, not until 1998 where it started to acknowledged by the industry awards. At the 1998 Oscars, the Scientific and Technical Academy Award went to Gary Tregaskis for the primary design and to Dominique Boisvert, Phillippe Panzini and Andre LeBlanc for the development and implementation of the Flame and Inferno software (Seymour, 2004). As evident by e.g. the modern movie industry, matchmoving is now a vital part of creating visual effects and has long be capable of creating a believably realistic blend between 3D graphics and real footage.

With a historic overview and greater understanding of matchmoving, the investigation of its limited use in the architectural visualization industry can commence. Being more familiar with the technique can aid to understand or even question the reasons for its under-use.

2.3 Why matchmoving is under-used in the industry

This is one of the fundamental questions of the project. Why has this technique, which is used in such a high degree in the film industry, not found a similar popularity in the industry of architectural visualization? As stated in 2.1 *Choosing matchmoving*, a goal of the project was to establish a collaboration with architectural visualization companies. To achieve this, we have visited various 3D visualization companies in Copenhagen, conducted e-mail correspondence with a South African company and visited a traditional architectural company also located in Copenhagen, all for the purpose of obtaining information about the industry from actual professionals and investigate the role of matchmoving in the industry. The arguments presented in this chapter are based on these conversations with industry professionals, whose respective companies are listed below:

Visualization companies:

- Archivisuals, interviewed Peter Krogh-Hansen (interview not recorded)
- Cenario, interviewed Lars Hilfling Nielsen
- Vistec, interviewed Poul Erik Christensen
- Moose Studio, interviewed Peter Krogtoft
- 3DTree (South Africa), interviewed Eugen Olsen

Architectural companies:

- SEA, interviewed Uffe Leth

When combining the information from the company visits and correspondences, some coherence presented itself in the arguments and answers provided. Internationally, matchmoving has actually been used in an architectural visualization context by 3DTree in South Africa, and domestically, Moose Studio includes matchmoving in the services they offer. They confirmed our findings from Digital Cityscape, that the technique being used internationally, which could be explained by the much larger visual effects industry abroad:

"I know it is utilized internationally, specifically in USA and Dubai among other countries."

Peter Krogtoft, Moose Studio – Appendix 9.2.

Despite currently being a performed by certain companies, matchmoving is far from an integrated element in the field, as explained by Eugen Olsen from 3DTree.

"I've hardly seen it used in architectural visualization. I think the reason is that the process involves a number of processes that are highly specialized. For example, not only does the model need to have pretty realistic texturing, the scene needs to be matchmoved, and some of the scene needs to be modeled (the buildings or topology that interact, reflect, or cast shadows onto or from the new building) and good lighting and rendering (probably image-based lighting, like HDRI panorama or something similar) followed by good compositing to make sure the 3D blends right with the imagery. So you can see it's not that straightforward (which is probably why it's hardly done)"

Eugen Olsen, 3D Tree – Appendix 9.1

According to 3DTree, who's matchmoved architectural visualization can be seen in *Illustration* 2.1, the number of steps required to achieve a valid matchmoving result might be the reason to the lack of use in the architectural visualization industry.

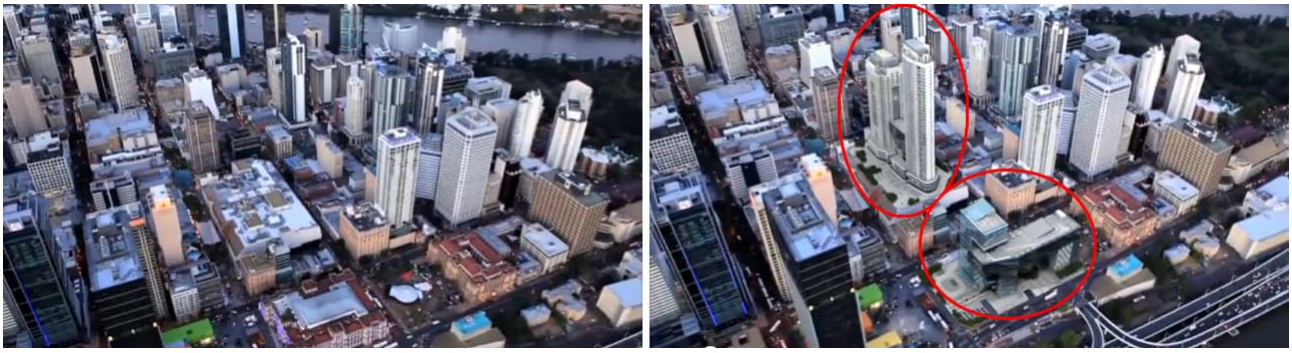

Illustration 2.1 - From 3D Tree's matchmoved architectural visualization. The left picture shows the clean scene. The right picture shows the added 3D buildings, enclosed in red circles.
3D Tree, "Architectural Visualization" © 2010

This answer is very similar to the ones provided by the various Danish companies. In Denmark, matchmoving is hardly used at all for architectural visualizations. Certain companies, such as Moose Studio, write on their website that their services include matchmoving, but this can also refer to what is also known as photo matching, where a 3D model is inserted into an image. Essentially this is matchmoving, although limited to a single frame and therefore falls in the category of still images. All the visited companies were aware of the concept of matchmoving, but mentioned the following issues as reasons for its lack of use:

- Economy
- Length of the process
- Conservative clients prefer still images

Regarding economy, the company Cenario mentioned that they had once hired a film crew for a one-day shooting assignment. This job included matchmoving, but was not for an architectural visualization. The rent for the film crew had cost them approximately 10.000 DKK, but this was not the primary economic issue. Instead the true expense was the man-hours spent on all the processes of tracking, editing, post processing etc. Compared to making still images, the process of matchmoving has higher costs in terms of time and therefore economy.

"The technology and the hardware itself is not the problem at all […] For the station on Frederiksberg, we hired a film company for one day, I think it cost 10.000 […] But it is specifically what comes after that, which is expensive. It's the camera matching, the tracking, the editing."

Lars Hilfling Nielsen, Cenario – **I2 3:55**

Vistec is a Danish company that has performed matchmoving, but never been able to sell it to clients. Again the main reason is the economy, but other issues that might arise with doing matchmoving were also mentioned by the company. The location is important regardless of video or photography, but matchmoving has more requirements that need to be fulfilled. A decent amount of tracking features must be present in the scene, and objects such as trees and other vegetation might be blocking the space where the 3D model should be. Lastly the location must allow for the camera moves needed, where a still image only requires a few static positions. So instead of needing to mask out a tree or other obstacles, which is an arduous process to do acceptably, Vistec recommends doing the whole project in 3D:

"When we arrive at many construction sites, they have started the building process. This means, that when you matchmove a construction site and insert a nice house, you need to retouch the film to the extreme,

leaving almost nothing. If you're lucky, there might be two neighboring buildings, which are somewhat intact, maybe with a fence near the bottom, as a section of road filled with mud below, which you need to create in 3D anyway. There is nothing to retrieve. It is not a good strategy – it's much better to just build it in 3D and create some renders and make movies in pure 3D."

Poul Erik Christensen, Vistec – **I3 5:42**

A final point from the Vistec visit is a simple, yet important one. Matchmoving is widely known and used in the film industry, and people involved in this industry are well aware of what can be achieved with the technique (Poul Erik Christensen, Vistec – **I3 6:45**). Even though people from the architectural visualization industry are familiar with matchmoving, it does not mean that their clients are. If they do not know what matchmoving can offer, it is understandable why they generally prefer still images or 3D animations.

The visit to Moose Studio confirmed what appears to be the general approach towards matchmoving for architectural visualization. It is too expensive and elaborate a process compared to contemporary methods of still images and 3D animations. Furthermore this is a business where time is of the essence, which often argues for the use of still images rather than 3D animations, even though 3D animations are occasionally used (Peter Krogtoft, Moose Studio – Appendix 9.2).

Despite seeing some use internationally, matchmoving has not yet become more than an occasional part of the architectural visualization industry in Denmark. Economy is the biggest obstacle to overcome if this scenario is to be altered. Various architecture projects simply do not budget sufficiently large amounts for visualization, thus leaving little freedom of choice of technology for the companies that create the visualizations. Another point is that clients are generally pleased with still images, which they can show to future tenants of an apartment building or to city officials regarding a new office building. It currently suffices and they see no reason to change it. However, despite their arguments of long processes and economy, all the visited companies were positive about the possibilities of matchmoving.

"Matchmoving is definitely an awesome way to do visualization. Not only does it put the illustration into a real and tangible environment (with the feel of the real world) but it is in the organic and natural movement of the camera that shot the original footage (most 3D animation suffers from the very lifeless and mechanical camera moves that are mathematically precise and therefore unnatural)" (Eugen Olsen, 3D Tree – Appendix 9.1).

This quote by Eugen Olsen from 3DTree describes very well how matchmoving differs from conventional still images and animations. However, at this point the cons seem to outweigh the pros regarding the implementation of this technique in the Danish and international architectural visualization industry.

An important early development of the project, as a result of interviewing the companies, was the decision to present our project to these industry professionals and get their feedback. It was their experience with matchmoving in the industry, which ultimately confirmed for us that matchmoving was the chosen addition to contemporary visualization methods. We therefore deemed it prudent to present the project film to them when testing if it could indeed satisfy our final problem formulation.

2.4 The purpose of architectural visualizations

As briefly introduced in chapter1.1 *Motivation*, architectural visualization can serve varying purposes. Whether it revolves around marketing, internal demonstration or aiding in planning for construction, the role will often vary from project to project. This furthermore reflects on the applications used to create visualizations. Uffe Leth, of Danish architecture firm Special Edition Architecture, states reasons for why a program such as Rhino is suited for production stages of an architecture project:

"We generally work in Rhino. […] Many people use it. My experience with Rhino began when I participated in projecting the concert hall of Danmark's Radio, which was made in Rhino, and one of the reasons is that it is a very precise program to work in, and a very easy program to model in. And since then, Rhino has also improved for making simple visualizations with, via the VRay plugin. That's what we use."

Uffe Leth Special Edition Architecture, ***I1 – 01:40***

He furthermore relays, that, while 3D production in Rhino is an integrated part of their production, they limit it to very simple productions, as seen in *Illustration* 2.1, which they control themselves, only outsourcing 3D production to external companies for visualization very rarely (**I1 – 2:54**).

Illustration 2.2 - Simple visualizations, focusing more on the form and perspective of the building can be the focus for certain architectural visualizations
Watertower Copyright: Special Edition Architecture, 2009

This method of architectural visualization certainly has its uses, but what this project aims to challenge is the type of visualization created for marketing purposes. Lars Hifling Nielsen, of Danish visualization firm Cenario, explains the purpose of the marketing focused visualizations:

"If a studio has an idea for a concept, they must communicate their vision. They should not communicate if it is granite floors or marble floors […] it is too concrete. So it is a lot about making it so that people can hop in on a dream and put into it what they want to. […] It is the vision, it is to pull the green stroke into a house through an intern garden, it is seldom about materials. And that becomes the lighting and the mood."

Lars Hilfling Nielsen, Cenario. ***I2 – 30:44***

Mood and the visual appeal of the visualization takes clear priority over precision of the image, adversely to the more production supportive visualizations of e.g. Special Edition Architecture. Precisely how big the building is in relation to its surroundings, the specific material of each section of the building etc. is not as important as making the building feel nice on a picture. This focus on mood is supported by Peter Krogtoft, of Danish visualization firm Moose Studio:

"[…]to hit what strikes into the heart […] It can be mood, an evening mood. Coffee can stand smoking on the table and it can look cozy and inviting etc. Those things can be part of selling."

Peter Krogtoft, Moose Studio, ***I4 – 05:34***

When creating visualizations that suit this purpose of mood over precision, several elements go towards establishing the mood. Possibly the most important aspect is the light in the picture. The choice of lighting can direct the eye, it can determine the time of day and it can dictate the color of the image. Lighting and its effect are promoted by Cenario, Moose Studio and VTI Vistec as well (**I3 – 19:56**), a company that also emphasizes the quality of utilized textures and important for the quality of the picture. As suggested by Moose Studio, the composition and all the elements that make up the image also of significant importance (**I4 – 06:07**), furthermore supported by Cenario in their notion to bring in the green stroke (vegetation) to a visualization. A visualization can often consist of elements, such as the trees, bushes, pavements, billboards etc., being imported from external sources, to aid the creation of a desired mood. Also important for composition is the chosen camera angle. What you specifically choose to show and not to show plays a major part in presenting the building as best as possible (**I2 – 23:55**), as does how the image is constructed to guide the focus of the eye of the viewer (**I4 – 06:12**). A full-blown example of all elements creating an architectural visualization focusing on a mood can be seen in *Illustration* 2.2.

Illustration 2.3 - While light can be the dominating element in establishing mood (picture 1), the manipulation of color and inclusion of vegetation and people (sometimes transparent) are also major contributing factors, as is chosen camera angles Picture 1 Skanske Oeresund Copyright: Moose Studio, 2010. Picture 2 Deichmanske Library Copyright: Cenario, 2011

This purpose of visualizing a mood and the techniques used to build these visualizations is not a practice that is prone to involve innovation or experimentation (**I4 – 12:00**). The aim has for years been to show the idyllic (**I4 – 25:30**) and even though it is possible to do visualizations for other purposes, the aim of creating a mood is the dominant for most visualization firms and the one that this project seeks to create an addition to.

2.5 Target group

The target group for this project is people working in the architectural visualization industry, the very people we have been visiting and e-mailing with regards to the investigation describes in chapter 2.3 *Why matchmoving is under-used in the industry*. To some extent, the target group also covers architectural companies, as some of them do their visualization in-house. The common denominator of people fitting the target group is professional experience with architectural visualizations – still images or animations, whether it entails creating or knowledge of utilizing the visualizations sales. They can provide usable answers and feedback to the project's production pipeline and to the project film, as well as sharing their knowledge of the visualization industry from the inside, such as what customers require and how to meet these requirements. During the individual company visits, we managed to arrange a second meeting near the end of the project period with each company, allowing us to return and demonstrate for them the product of the project. Their responses in the test of the project film will provide the data foundation on which a conclusion will be formed about whether or not the final problem formulation for the project has been satisfied. To account for any bias that might exist in the target group, the test should also include a control group of equal size, consisting of respondents not employed in the industry.

2.6 Delimitation (including introducing the idea of a production pipeline)

In chapter 2.1 *Choosing matchmoving* the technique of matchmoving was selected as the desired addition to contemporary visualization methods, as it offers the opportunity to take advantage of the 3D capabilities of the building, while maintaining a realistic quality. The choice of matchmoving was further solidified by its general underuse in the industry, while our investigation of the history of matchmoving showed that it has long been capable of creating a believably realistic blend between 3D graphics of real footage, thereby proving the potential of the technique. Our examination of the purpose or architectural visualizations determined that the creation of a mood was essential, not a precise representation of a building.

Showing the project film to a viewer is the main aspect of presenting the project to the industry, but not the only one. A secondary aspect of presenting the project to the industry is the production pipeline, which has been briefly mentioned in chapter 2.5 *Target group* . This is a secondary goal of the project; to present our production pipeline from the process of creating the film, in order to receive industry feedback for it, as well as for production time of the project film. Hopefully this will work as a strong argument against the industry's common preconception of matchmoving being equal to high financial costs and long working processes, and instead speak for the possibility of implementing this technique in the industry.

With the fundamental elements of the projects determined, the final problem formulation can be defined based of the initial problem formulation and thus provide a distinct direction and goal for the project to fulfill.

2.7 Final problem formulation

How can we, through a short film, present matchmoving to the industry, as a realistic addition to contemporary visualization methods, while maintaining the sales oriented purpose of the visualizations?

3 Analysis

Based on the final problem formulation, the analysis will further investigate the areas of interest, in order to be able to answer the final problem formulation and produce a design. Initially, the analysis will describe the methodology of the project, to give the reader an understanding of its development. Subsequently this chapter will describe in detail the analysis of every important aspect of the final problem formulation. In conclusion, the chapter will present the solution requirements for the project film.

3.1 Methodology – the project structure

An iterative, user-centered development model which loops analysis, design, implementation and test, as shown in *Illustration* 3.1, will be used to structure the project.

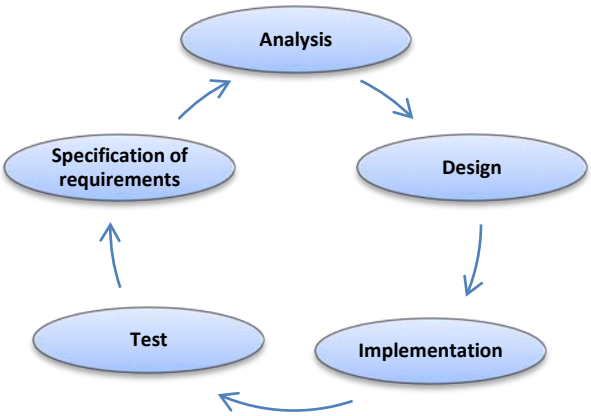

Illustration 3.1 – The project structure runs through the 1st iteration in this report, with a 2nd iteration intended for future works

The testing performed in this project will be used for many purposes. User testing will be used to support design decisions and obtain data which can possibly satisfy the final problem formulation.

Before tests can be performed and the project re-iterated, it must go through its' first iteration. This iteration will introduce various theories through analysis, which is based on the final problem formulation. These theories will then be used for design of the product, followed by the implementation and testing steps, which will determine if the product has satisfied the final problem formulation, or if it needs to undergo a second iteration.

The project will go through a second iteration, which is scheduled for the period between report delivery and the exam. The 2nd iteration product will thus be based on the test data obtained from the 1st iteration.

3.2 Faction – combining the concepts of fact and fiction

Faction is a genre that combines fact and fiction. The difference between these two is their relationship with reality. When dealing with facts, one must seek to speak the truth about the respective subject. With fiction, one does not (Larsen, 1990).

This project combines 3D graphics and real footage, a combination that made it interesting to look into faction, as 3D graphics and real footage can be categorized as fiction and fact respectively. What is particularly interesting are the differences between fact and fiction, because one must assume that these differences are important in terms of how the given film or TV program works in relation to the audience. How does the audience receive the film (reception), what do they get out of watching it (output) and how

does it work (effects)? Investigating these subjects will help explain the concept of faction and how it differentiates from pure fact or fiction (Larsen, 1990).

The reception process and the effects within fact and fiction are very different. This is noticeable e.g. in the reactions typically triggered by a well made factual- or fictional program. With a factual program it is quite common that the viewer actively discusses the subject(s) while watching: "*That is amazing*", "*Outrageous*", "*Hmm, I didn't know that*", "*That's what I thought*" etc. Conversely the viewer is more passive when watching a fictional program and the effects are more in terms of emotional responses like laughing, crying, cheering or turning the head away in fear (Larsen, 1990). A factual program which in our case is the recorded real footage, develops a reality-engagement in the viewer. This is achieved through by exploiting a (possible) lack of knowledge or the existence of prejudices in the viewer, combined with the knowledge and the facts that the program reveals. A fictional program, which in our case is the inserted 3D graphic, activates imaginary-conceptions in the viewer. These are made through the viewer's own experiences, dreams and wishes, and then the more or less imaginary reality the program portrays. The output is equally different in the two genres. Factual programs are in most cases a one time performance, while fiction is more endurable and even something the viewer would want to return to and watch again and again. Once the knowledge communicated in a factual program is understood and accepted/rejected, there is no real cognitive motivation to watch it again. In fiction, the opposite can occur. These differences between fact and fiction reveal the purpose of faction; to simultaneously develop reality-engagement and imaginary-conceptions in the viewer (Larsen, 1990). It could prove very beneficial if the project film could make the viewer develop a reality-engagement for the real environment shown in the film, combined with imaginary-conceptions for the 3D graphics that are placed in the environment as well. According to faction, we could adapt the advantages from both the factual and fictional genre into one entity.

There is much going on with the viewer while he/she watches a certain media production. Three forms of basic mental needs, which can be satisfied through the reception of film, TV programs etc. are listed below:

1. Fascination of images
2. Desire for narrative
3. Desire for knowledge

It can be assumed that when people voluntarily watch TV or other media, their motive is very likely to be the opportunity to satisfy one or more of these needs through reception (Larsen, 1990). The need for images – the fascination of exiting visual impressions, is one of the most fundamental mental forces in us. It is deeply rooted in several areas such as drawing, painting, sculpting, photography, architecture, and when people in vast numbers attend shows and exhibitions, it can be assumed that a strong motivation is the need for fascination of new visual impressions. The term "eyekick" is often used in order to describe this experience. The fascination of images can be related to the stylized images found in industry architectural visualizations, since the purpose of these is to produce a visually pleasing image.

That people have a desire for narrative can be argued in that we generally enjoy both telling and have stories be told to us (Larsen, 1990). This mental need is not important for the project and will not be further elaborated, as we do not expect the short film to contain a narrative.

Lastly there is the desire for knowledge, which is based on the experience of safety and security that can be achieved by gaining knowledge. One gets an overview of the reality because an overview of one's possibilities for actions and limitations is also achieved. Knowledge is in essence a form of freedom for the consciousness, and the desire for knowledge is connected with the fundamental human desire for freedom

(Larsen, 1990). This mental need can be related to our project and the realistic mood we attempt to convey through the short film, since the purpose is to show the 3D building as it would actually look when completed.

3.3 The technique of matchmoving

This discipline goes by other names besides matchmoving, such as camera tracking or camera matching. But whatever you are calling it, the essence of matchmoving is the blending of computer graphics and live action footage. More specifically, the matchmover takes information from a real life set and uses it to recreate the camera in a computer graphic (CG) environment. The information from the set includes the focal length of the lens, the height and the tilt of the camera as well as its position and motion (if any) relative to the subject. These data are used to help create the CG elements in the virtual environment so they will have the same perspective, depth and relationship to the recreated virtual camera as the live actors and elements had to the live camera (Hornung, 2010).

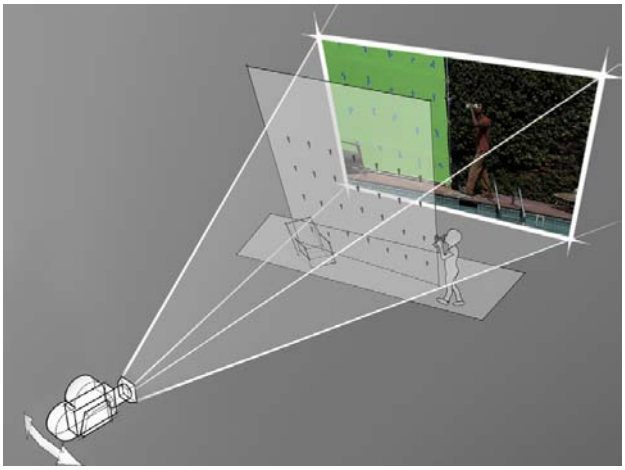

Illustration 3.2 - The virtual camera in the CG environment. It is animated so that its movements are corresponding to the movements of the real life camera.
Erica Hornung © 2010

3.3.1 Camera moves and tracking

How to approach a track of a camera depends on how the camera moved during shooting. There are several ways the camera can move, some of which are displayed in the following list:

- Lockoff
- Pan and tilt
- Truck/dolly
- Crane
- Steadicam
- Handheld

The first type is the lockoff shot, which essentially is a shot where the camera is motionless. It is typically locked on to a tripod or some other form of mounted equipment. This is the easiest type of shot to track because as the camera does not move, it does not need to be animated. Next is the pan and/or tilt shot, which rotates back and forth or up and down its axis, similar to the movement of shaking or nodding your head. A camera pan rotates across the horizon and reveals the width of the scene, while the tilt rotates up and down from the ground to the sky (Hornung, 2010). A truck/dolly shot is one in which the camera is mounted on a

moving platform in order for it to move smoothly toward or away from the scene. This kind of shot involves X and Z translation and almost always Y translation, caused by the fact that it is practically impossible to achieve a perfectly level ground for the dolly to roll over. The camera will therefore have up and down movements, though minor, no matter what. Furthermore it would be considered rare if the camera had no rotation at all, as the camera operator will usually tilt and pan the camera during the move to better follow the action in the scene (Hornung, 2010). In a crane shot, the camera sort of flies up and over the scene, or it can dip down rapidly from up high to reveal the action down below. As the name refers to, the camera is attached to a crane or some other type of arm, which extends it into the sky. Crane shots are very similar to dolly shots, apart from the fact that they move much more in the Y axis than on the ground plane. A steadicam is a special rig that allows the camera operator to carry the camera and achieve movements that are more smooth than handheld, but less smooth than dolly, crane or other types of camera mount. With experience, a steadicam shot can become very smooth and even look much like a dolly shot, while providing the camera operator more freedom of movement. The last type of camera movement is handheld. As the name implies, this type is shot with the operator carrying the camera in his hands. Handheld shots can be very jittery and jumpy which is often caused by sudden movements. Opposite to lockoff, handheld shots can be very challenging to solve. They often have a lot of motion blur, many fields of view, and good 2D track points can be difficult to find. A point to note here is that this kind of shot (can also include steadicam) is likely to contain Z rotation. When a camera is mounted, it is generally restricted from rotating in the Z axis, but when it is being held by a person it is free to move in any direction (Hornung, 2010). An example of Z rotation is shown in *Illustration* 3.3.

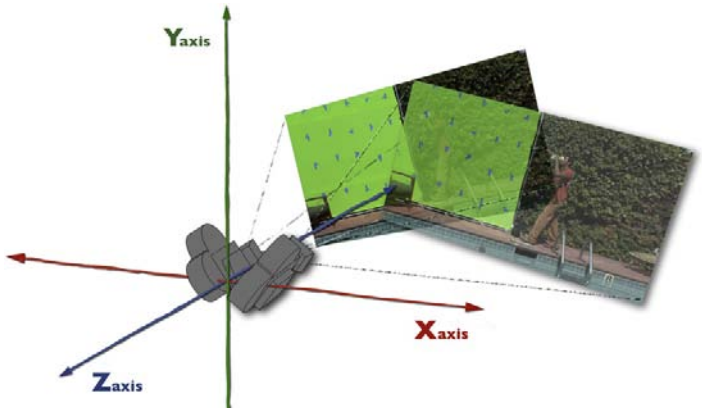

Illustration 3.3- The Z rotation that is likely to occur when shooting with a handheld camera. Erica Hornung © 2010

Knowing how the camera moves increases the possibility for a good matchmove. Before beginning the tracking process, the shot needs to be analyzed in order to determine the best approach. There are two ways in which the tracking can proceed: automatic and manual tracking, each with their own pros and cons. The often tricky handheld shots for example are good candidates for the automatic tracking process to begin with. This method can usually get the matchmover about 80% to 90% of the way there, but sometimes it might not be able to help at all. The software uses mathematical algorithms to pick hundreds of 2D points to track, and then analyzes the motion of those points to create a camera move and a point cloud that approximates the 3D locations of those tracked points. A point cloud is a CG virtual set made up of many 3D locators representing a surface or location, so called because they can be very dense and look like clouds seen from above (Hornung, 2010), as shown in *Illustration* 3.4.

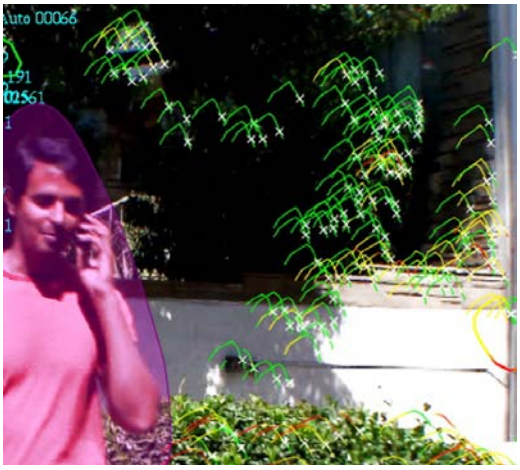

Illustration 3.4 - The white crosses represent the hundreds of generated track points, whose movements are illustrated by the colored lines. The person is masked, making him unable to be tracked, as this would produce false results.
Erica Hornung © 2010

The con however with the automatic tracking is that it often creates track points which last only around five frames. It makes up for the lack of specific data with an overwhelming volume of data. The alternative is the manual tracking, which works with a much smaller amount of track points. For a simple track, the matchmover only needs around six to eight points. This method provides full control of where in the scene to place the track points, and also of how many of them to use. The reason why it can work with so few points is because there is usually data about the scene and the camera, which makes it obsolete to use the automatic tracking to provide estimates for these data. The manual track points can also be inserted into an automatic track. These points have more influence than the automatic points, and can help specify the solution (Digital Tutors, 2010). Being aware of what kind of shot you are dealing with and how to approach it with regards to tracking can prove to be very time and resource saving in the implementation phase of a project.

The rest of this chapter will focus on the technical specifications regarding matchmoving. This includes going into depth with topics such as parallax, cameras, focal length and various tracking issues.

3.3.2 Parallax

Parallax is something which practically all people have experienced, but it is likely that not all people are familiar with the scientific name of the concept. A good illustrative explanation of it is to picture yourself being the passenger of a moving vehicle. Parallax is thus the experience of nearby objects such as fences, trees or utility poles moving by quickly, while distant objects such as mountains or hills seem to be moving very slowly if at all. The change in parallax (movement of objects relative to each other) makes it possible to calculate distances and positions in three dimensional spaces from two or more images (Guenther, 2010).

The process starts with identifying features in one image, which corresponds to features in the real scene. The specific feature in this image is the corner of the piano bench. This mark on the image has only a 2D position (X, Y), but it does correspond to a 3D position somewhere in the scene as well. Only at this point, we do not know where it is. What is known though, is that the point on the piano bench emitted a ray of light that passed through the center of the lens and onto the film. The exact position of the camera is not yet known, because the distance from the camera to the object is unknown. What has been done so far is a constraint of one axis of the camera, however it is still possible to rotate it around this axis and have the feature remain in place (Dobbert, 2005), as seen in *Illustration* 3.5.

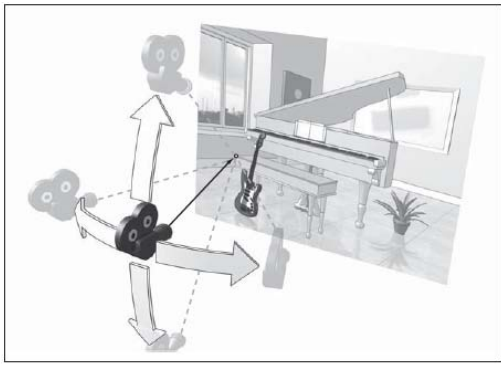

Illustration 3.5 - With only one point selected, the camera can still move in virtually any direction.
Tim Dobbert © 2005

To solve the rotation issue, more features need to be included. Adding a second point in the image provides two anchor points for the rotation, which means that the camera is now only available to rotate around one axis. The left image in *Illustration* 3.6 depicts this scenario as around the x-axis, because the second feature lies on the other side of the piano bench. Continuing this procedure, a third point must be chosen to limit the camera from further rotation.

Illustration 3.6 - With three features, all three rotational axes can be locked.
Tim Dobbert © 2005

The right image in *Illustration* 3.6 shows how three features can lock off the axes and thus prevent more rotation. With the rotational aspects of the camera now established, the only missing information is where the camera is, because it is still unknown exactly where along the projection lines the points lie. The camera can therefore still move by sliding these points along their respective lines. The solution to this comes in the form of another camera(s). A second camera with a different point of view would produce different features, caused by the change in perspective. If both cameras have the same features marked on the images, they both would have their rotational axes locked. The positions of the two cameras can thus be calculated if a position in the scene can be found, which allows the 3D points to intersect with the projection lines of both cameras (Dobbert, 2005), as seen in *Illustration* 3.7.

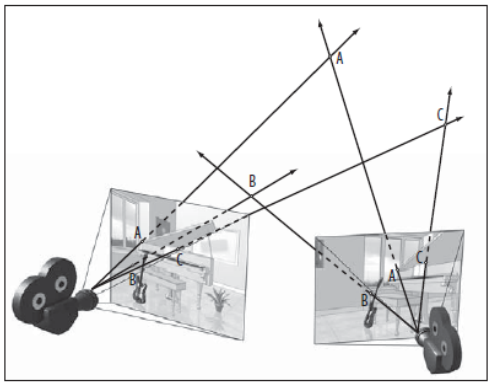

Illustration 3.7 With several features selected, it is possible to calculate the 3D positions of the cameras as well as the features.
Tim Dobbert © 2005

This example involves two separate cameras and not a movie sequence, but the idea is essentially the same for both scenarios. A movie sequence is merely a sequence of images/frames, played back at a certain speed such as 24, 25 or 30 frames per second (fps). The matchmoving program solves the initial image, and then adds the remaining one-by-one, which in the end results in a single camera that moves to each position the program has solved. This camera path is shown in *Illustration* 3.8.

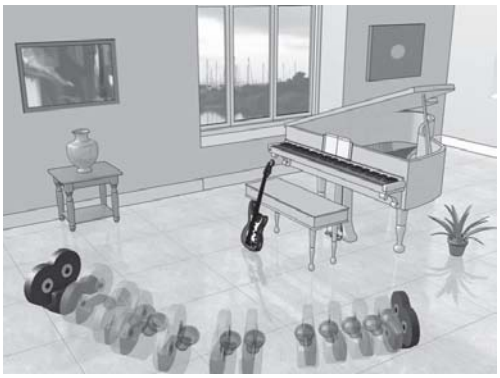

Illustration 3.8 A movie sequence can be thought of as a series of individual images with respective camera positions, which makes up a camera path.
Tim Dobbert © 2005

3.3.3 Camera calibration

Dealing with the camera can be a very straight forward process, or it can be the cause of long hours trying to solve the shot properly. The job of a matchmover is to take an image sequence and create a 3D camera that precisely mimics the camera that originally filmed the sequence. This process is usually a lot easier if the matchmover is provided with notes taken at the shot location or if he himself was present to observe. The notes often include the focal length of the camera, various measurements of objects in the scene and information about the camera such as film-back, which will be elaborated later. The information from the set is used to increase accuracy and can be that piece of rescuing data needed for a particular difficult shot. However it is not a necessity to include this information, as recent matchmove programs offer tools which can provide estimates of the focal length and other parameters. In the end it is the individual shot that determines whether or not it makes a difference to include the collected information. Nonetheless it is important for a matchmove artist to be familiar with terms.

In essence, the principle of a camera can be explained as light rays being bundled and focused onto a medium inside the camera by a lens. This medium is known as the film-back. In a traditional film camera the

film-back would be an 8mm, 16mm or 35mm film, which would keep a certain position for 1/24th of a second, before being replaced by the next frame. In a digital camera, the film-back is an image sensor chip, which is smaller than the film. Digital cameras are moving forward in terms of use for professional level work, which can produce issues for a matchmove artist. The shutters for example are now electronic instead of mechanical, which means that the sensor chip (film-back) is scanned certain ways to mimic the effect of a mechanical shutter (Guenther, 2010). This specific example can produce a so-called rolling shutter problem, which is the result of a scan of the sensor chip. An example of the rolling shutter problem is shown below in *Illustration* 3.9.

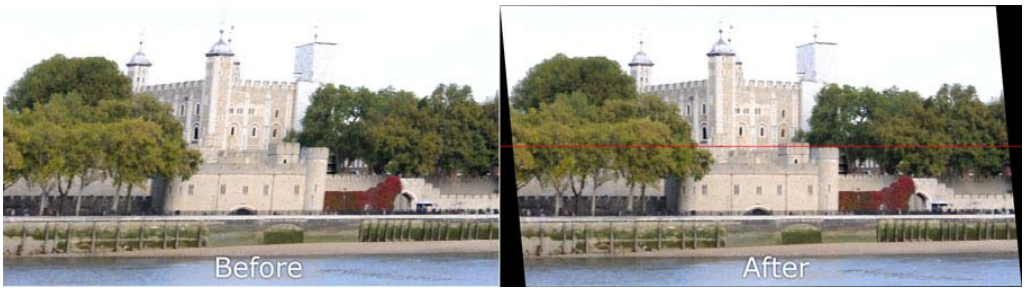

Illustration 3.9 Cameras with image sensor chips can cause the shot to be skew due to the rolling shutter problem. Grapefruit.com © 2009

The rolling shutter problem often happens in relation with fast movements of the camera, such as a quick pan across the scene. A problem arises with the way the digital camera scans its image sensor so that vertical objects in the scene appears skew. However there are ways to solve this problem, which comes in the form of a plug-in for the various types of compositing software. The rolling shutter problem is therefore not something that can potentially ruin an entire shot, but more of an issue of which to be aware of when shooting on digital cameras. Another camera term to be familiar with is the focal length, which is the feature on a lens that has the most prominent effect on the final image (Dobbert, 2005). The focal length is the distance between the center of the primary lens and the film, and this distance can be varied, which is referred to as either short or long focal length. A short focal length produces a wide shot that has a more distinct perspective, larger sense of depth and finally more of the scene visible in the image. In contrast, a long focal length produces a flatter look, less sense of depth and less of the scene present in the image (Dobbert, 2005). An example of short and long focal length is shown in *Illustration* 3.10.

Illustration 3.10 Left: a short focal length which allows more of the scene in the image. Right: a long focal length, which in comparison only shows a part of the scene. This is useful if the purpose is to focus the attention to a specific place or object. Tim Dobbert © 2005

3.3.4 Tracking issues

When constructing a 3D space from a sequence of 2D images, some things are bound to be conflicting. This final section describes what kind of tracking issues that might arise during the process. Motion blur is an

issue, which occurs when the camera or objects that are being filmed move rapidly in the image. Objects in motion for example appear blurred along their axis of motion, as seen in *Illustration* 3.11.

Illustration 3.11 Motion blur makes the sign post appear stretched out and unclear. Notice also that the bird is actually visible through the sign post, which can make such a shot difficult to work with.
Tim Dobbert © 2005

With motion blur, the features in an image not only become stretched and distorted, but also less distinct and they will have less contrast. All points that make such a shot increasingly difficult to track. Matchmoving programs can usually manage a shot with a decent amount of motion blur, but if it becomes too excessive, it will cause the tracing process to fail (Dobbert, 2005). Focus is another, yet similar issue, as motion blur also causes features to be out of focus. The features are softer and more diffuse, which will cause the individual trackers to slide around and thereby produce a less stabile result. An example is the tracking of a feature in front of a building. If the feature is enough out of focus, the tracker might mistake it for something in the background, and start tracking that instead because the colors have become too alike. This way the tracker moves from e.g. a street lamp in front of a building and onto the building in the background, resulting in a very inaccurate track. The last issue again confirms the importance for the matchmover to be aware of the whole process from filming to the point where he would receive the footage. Being on set and able to observe the shot can help ease the matchmoving process, for example with an issue such as occlusion. This is when the features you are tracking move behind other objects or in other ways become untrackable. In such a scenario it is important to have a scene with lots of alternative features to track, or it might be necessary to manually set up features to track like post-its or other distinguishable objects (Dobbert, 2005).

Knowing the essentials of the matchmoving process, such as how the software works and what to be aware of can end up saving a lot of time in the implementation. With this information, the design and planning of shots can become more detailed, and mistakes which would first be found when editing and working with the footage can be handled sooner. We can design camera moves that are easier for the software to handle, avoid rapid movements which would cause motion blur, frame the scene so it contains enough trackable features etc. Basically the shot can be tailored for the matchmoving process.

3.4 DTU field-analysis

In early stages of the project, collaboration with the visualization studio Archivisuals and the architectural firm Christensen & Co was established. These companies already have collaboration in the form of a project at DTU (Danish Technical University). Christensen & Co. designed the building and Archivisuals made the 3D visualizations of it, which included showing it in its initially natural, but now stylized surroundings, as shown in *Illustration* 3.12.

Illustration 3.12 - An initial idea of this project was to compare the project product with these pictures. Christensen & CO Architects, "DTU – new building 324" © 2011

We have been in communication with both of these companies, because there was a unique opportunity for our project here. The already completed 3D visualization in still images could serve as comparison for the product of our project, and the two companies could provide valuable feedback based on both their expertise and involvement in the project. Archivisuals agreed to work with us, but could not give us the model they had received, due to ownership rights. To get that we needed permission from Christensen & Co. whose response took longer than expected. We used the waiting period to visit DTU and record some test shots of the location. To become familiar with the softwareaspect of matchmoving, this footage was brought into PFTrack, which could very well become to chosen matchmoving application for the project, for practice purposes as well as to discover potential issues to be aware of for the final day of filming. *Illustration* 3.13 shows the intended location for the new building at DTU from different angles, and one issue clearly stands out – obstacles.

Illustration 3.13 - All three images reveal obstacles blocking the view despite the varying perspectives. Copyright by the authors

The trees are intervening in the frame in almost every image. The middle image is the most optimal perspective, but the obstructing tree leave very limited possibilities for shots from other angles. Trees are particularly difficult because of their detailed structure. If a 3D building is to be inserted behind them, they need to be masked out in post-production, which would be a time consuming task and would likely not produce a satisfying result. For matchmoving purposes, this location proved to be unintentionally challenging.

When Christensen & Co. responded, we were informed that their project was now so far into development that it was the constructor who owned the rights to the model, and he was not interested in a collaboration with us. The unique opportunity of being able to compare our project based on an architectural model, with industry still images of the same model made by a professional, became impossible. The upside however was that we were no longer limited to the troublesome location at DTU. The test shots from DTU made us aware of the issue of having too many or too dominating obstacles in the scene – particularly trees, and the limited possibilities this creates for framing. After running the footage through PFTrack, we also became aware of the fact that moving the camera around in the scene, without drastic motion, created optimal circumstances for matchmoving. With the DTU location abandoned, this field analysis, along with chapter 3.3 *The technique of matchmoving*, provided a few requirements that needs to be satisfied in the final location:

- Avoid obstacles in the scene
- Find a location that allows the camera operator to move around.

3.5 Film techniques

When working with the media of film, prudence suggest that contemporary techniques and theories within traditional film making should be examined, so as to determine how the film can be structured and shaped to aid in delivering the intended message. As mentioned in chapter 2.4 *The purpose of architectural visualizations* a given mood is the driving element of an industry architectural visualization film, including 3D animations. Whether the desired mood of the film is decided upon as being frantic, soothing, horrifying etc., the way of creating the project movie can most likely benefit the relaying of this mood to the viewer.

3.5.1 Editing

Ever since Edwin S. Porter – the so-called Father of Story film (Rayner, 2005) – began his work with editing in the early 1900's, the technique of editing has been examined and evolved as a tool to help a movie in many ways, including the creation of a mood, making it an important technique for the project movie. Editing is basically the joining of different shots; however there are many ways in which to join shots, such as the dissolve, the fade-in and fade-out or the basic cut (Bordwell & Thompson, 2008, s. 218). How the editing fits together with camera movement, the music and other aspects of the film, greatly affects how the viewer perceives the mood of the film.

Editing between two shots affords the film maker control in four different areas regarding establishing relations between the two shots (shot 1 and 2) (Bordwell & Thompson, 2008, s. 220).

1. Graphic relations
2. Rhythmic relations
3. Spatial relations
4. Temporal relations

Graphical relations between two shots can revolve around matching or contrasting such elements of the picture as color, lines or brightness, how a shot is framed or the mobility of the camera (Bordwell & Thompson, 2008, s. 221). It can do much to help connect shots that are otherwise separate and even work to connect shots from widely different locations, time periods etc. Relevant aspects of graphical relations in relation to the project movie will most likely be limited to camera movement and possibly lines in the image. The project movie will be shot at one or very few locations, so the variances in color will be minimal. The brightness of the scene, while depending on the given time of day of filming, will pertain stability and similarity. However, the scene will be shot from different angles, with a moving camera, among other

reasons, to assist match moving and to show the 3D model from more than one angle. Graphic relations could be used to help the viewer focus on the 3D building in the project movie. An example could be to show the scene with no 3D, then show the 3D building by itself, and lastly show the 3D building matchmoving into the scene.

Rhythmic relations are likely to play a big part in the project movie. It generally involves the length of each shot in relation to each other (Bordwell & Thompson, 2008, s. 226). Cutting between shots can rely on moving objects in the frame or sound/music playing in the scene, as shown in *Illustration* 3.14.

Illustration 3.14 - All three pictures are from the same architectural visualization animation. The editing is fast and fluent and is dictated completely by the up-beat background music, as is the movement and zooming of the camera
Spine 3D, "MGM City Center Las Vegas" © 2010

Other instances can allow the editing to not be controlled directly by elements of the picture, but reversely influence how the audience perceives the movie. The project movie can convey a calm mood, if it is edited using shots all of equal lengths. Furthermore, the longer each shot is, the slower the tempo of the movie becomes, whereas e.g. a frantic action sequence will benefit from the hectic tempo achieved using shots of brief duration.

In fact, an elongated duration of a shot can encourage, if not outright force the viewer to scan the image for details by themselves, rather than relying on editing and camera movement to reveal important information. The longer duration a shot has, the more emphasis is put on the elements of the scene (Bordwell & Thompson, 2008, s. 211). Thus, if the project movie wanted to allow or make the viewer discover the details of the building by themselves, it would require it to consist of long shots. All in all, rhythmic relations between the shots are a beneficial tool to help accomplish the conveying of a mood to the viewer. It furthermore becomes vital to understand how to work with rhythm to avoid creating an incorrect tone of the movie, which could risk creating an unintended mood. Of all four areas of relation control through editing, rhythmic relations will most likely be the most prominent.

Spatial relations arise, when two shots are juxtaposed such as to compel the viewer to connect them (Bordwell & Thompson, 2008, s. 227). When editing spatial relations, shots can be connected through editing to form a whole, even though these shots are shot in completely different locations. Shot 1 might feature a person looking out a window of a building in a city. When cutting to shot 2, whatever this shot displays, as long as it is a believable feature of the city, it can imply this feature as the target of the persons gaze from shot 1, as shown in *Illustration* 3.15.

Illustration 3.15 - The left picture from The Birds (1963) shows the protagonist and two townsfolk looking out a windows. Through spatial relations, the right picture, showing a gas station, is related to being the target of their gaze Universal Pictures, "The Birds" © 1963

Furthermore, if shot 2 shows something entirely unexpected, e.g. a planet in space, relations can still be implied between the two shots (perhaps the person has a destiny awaiting on that planet). For the project movie, spatial editing will likely be done in a straight forward manner. With the aim of the movie being to display the site of the 3D building from various, there will be little reason to venture out and record shots from separate locations and editing them together to imply connectivity. It should be shown as will actually stand on location and as such, the project movie should have a similar goal, giving little reason to juxtapose anything but shots taken from the same location of where the 3D building is meant to be.

Temporal relations revolve around the time of the action in the film (Bordwell & Thompson, 2008, s. 229). Shot 1 might show a person looking at something, with shot 2 showing what the person is looking at. In the story, this object triggers a flashback, so shot 3 is the flashback itself. For this editing to suit the story, shot 3 needs to tail shot 1 and 2, even though shot 1 and 2 might be switched. It might also be used to shorten or lengthen certain actions on camera in relation to their duration in the story. A person walking down a flight of stairs or counting a stack of dollar bills will take a set amount of time in the story, but through editing, shot 1 could display the action beginning (the man taking the first step on the stairs), while shot 2 finished the action (the man reaches the top of the stairs). For the project movie, temporal editing could be useful if displaying a person walking up to the building from a distance, but since the movie should compare to traditional architectural animations, it will most likely be restricted to providing an overview of the building itself, shot from somewhat of a distance. In this case, temporal editing becomes less important; the action of the movie is to show the building, which should not be skipped.

3.5.2 Framing

Defining the image and deciding what the viewer will see on the screen is done through framing (Bordwell & Thompson, 2008, s. 182). Framing determine what is shown and how it is shown. Much more than just defining the aspect ratio of the frame (such as the 2.35:1 Cinemascope standard (Bordwell & Thompson, 2008, s. 183)) the framing can help make the image static or dynamic and it can show the same event in very different manners.

When discussing framing, there are generally four aspects of framing that should be considered (Bordwell & Thompson, 2008, s. 190):

1. Angle
2. Level
3. Height
4. Distance

The camera angle can be placed perpendicularly to the direction of a moving vehicle and simply show it moving from right to left. But if the angle is altered, such that the camera is not longer perpendicular to the direction of movement, but instead shows the vehicle far off in the distance as it moves closer and closer to the camera, the shot can become more filled with anticipation, giving the audience a chance to wonder how fast the vehicle is moving, if it will hit the camera etc. Furthermore, rather than just showing the vehicle from the side, angling the framing will show the front of the vehicle as well, which can provide the audience with more information about what it is and maybe who is piloting it. The usage of framing to display more dimensions of an object is beneficial for the project movie, since it is important to illustrate many features of the building, as shown in *Illustration* 3.16.

Illustration 3.16 - This architectural animation shows the building from two different angles in the left and right picture and gives a better impression of the building's form and theire spatial relations to each other
Spine 3D "MGM City Center Las Vegas" © 2010

Showing it directly from the side could very well cloud the full impression of the building, hide certain contours or maybe even make the dimensions of the building difficult to grasp.

A level framing refers to the camera being parallel to the horizon, which is often how the camera is positioned. When the camera becomes tilted, it is known as canted framing and can have various functionalities. A canted framing can e.g. be used to convey a sense of chaos or instability and can even be used frame an otherwise normal scene, thereby instilling the impression that "something is wrong" (Prunes, Raine, & Litch, 2002). Depending on the desired mood for the project movie, a level or canted framing can be of great use in conveying this mood to the viewer.

When discussing such aspects of framing as a birds-eye view, it falls under the category of height. The usage of height often coincides with the use of angle, since the high camera height may require a high-angle position of the camera. Height can have uses, such as emphasizing differences in the relations between two characters or objects in the shot (Prunes, Raine, & Litch, 2002). Due to a limited access to equipment, the use of height in the project movie will be equally limited and largely dependent on the chosen location for the film, unlike traditional architectural animations, where the camera can be moved and placed completely without limits in 3D space. Furthermore, there is only one object of importance in the movie, so the

aforementioned usage of height to instill relations between two objects becomes less important. The chosen height for the project movie will likely be as shown in *Illustration* 3.17.

Illustration 3.17 - Both the left and right picture shows the expected height to be used in the project movie, as seen from a pedestrian point-of-view
Left picture: LUXIGON, "Halifax Central Library" © 2011. Right picture: LUXIGON, "Songdo Landmark City Block" © 2010

Distance, on the other hand, can be of great use in the project movie. There are numerous camera distances to delve into, such as the long shot, the medium shot or the close-up, although the distance of the camera need not fall into these set definitions. They all serve different purposes; the close-up can provide great detail about a specific object, while the long shot, or even extreme long shot, is well suited for establishing the location of a scene, which is a vital part of what the project movie should attempt to do. Depending on the desired mood, the distance can be kept far away from the 3D building to provide a constant overview, it can be moved close to inspect the finer details or even a mixture of both could be explored.

3.5.3 The mobile frame

Distance can become even more useful to consider, when combining it with the mobile frame, in which the four general aspects of framing change during the shot. By itself, there are many ways of handling a mobile frame. The camera can e.g. be panning (rotating horizontally around itself), tilting (like panning, only vertically) or dollying, where it moves in any direction along the ground (Bordwell & Thompson, 2008, s. 194). These are but a few ways to make the frame mobile, but a mobile frame presents a distinct advantage over the still image, opposite the previously discussed techniques. The mobile frame can follow a moving object and reveal information about the motion. If the camera moves without innately following a subject, it can signify that the camera acts as the eyes of a character and that the audience follows inside its' head, such as shown in *Illustration* 3.17. The moving frame is well suited for a "reveal"-shot, where it moves over the top of e.g. a hill to reveal what is on the other side. Or it can be used to convey information about internal character change, such as zooming in on a characters face to imply that they are learning something important, or zooming far away from them to signify their situation changing to being lonely or suppressed. For the project movie, the mobile framing can be a very important tool. If the camera is allowed to move around a building, it can show how the lines of the building move in relation to each other, revealing much about the contours. For a large building, its' size can be emphasized by keeping only parts of the building on-screen and slowly moving the camera up the building and revealing all of it. The camera can also act as the clients themselves, filming the building as if they are actually walking around next to the building, giving it a sense of presence in the real footage – this technique does in fact coincide well with the result obtained from match moving 3D into real footage, rather than making the entire scene in 3D. The speed of the mobile frame is an important factor when shooting to obtain a certain mood. A slow-moving camera will be more likely to

create a calm expression than would a fast-moving. This can furthermore be seen in many existing architectural animations, so a similar use of the mobile frame could be useful for the project movie.

3.5.4 Lighting

"Much of the impact of an image comes from its manipulation of lighting."

(Bordwell & Thompson, 2008, s. 124)

The importance of lighting when deciding what to show an audience in a film cannot be underestimated. Normally, light merely illuminates, but in a film, the amount of available control over lighting can allow a scene to be greatly influence, if not directly controlled by lighting (Bordwell & Thompson, 2008, s. 124). Light can assume many roles, such as guiding the attention of the audience. Brightly illuminating objects can distinguish them in the frame and reversely, decidedly keeping an object in the dark can also direct the audiences' focus to the object and keep them guessing. Lighting can create shadows and highlights that help define the shape and contours of a character or object, as well as concealing certain parts. This is very useful for the project movie, since the details of the building can be accentuated through lighting, as well as framing. Certain indentions can be partially or completely clouded in attached shadow (shadow on the objects as a result of other parts of the object), drawing attention to their function or appearance in the building in general. Cast shadows (where the objects casts shadow on other objects) can shield surrounding buildings from illumination, keeping focus on the 3D building and help emphasize its' importance in the scene. Light can also help illustrate finder details of the building and reveal information about its' surfaces and texture, as well as emphasize reflective surfaces, such as metal or glass.

Four major features of lighting exist for film (Bordwell & Thompson, 2008, s. 126):

1. Quality
2. Direction
3. Source
4. Color

With the aim of the project movie being to match move a 3D building into real footage, how to utilize the four features of lighting becomes a matter of how stringently realistic the tone of the movie should be.

Regarding quality, it refers to both hard or soft lighting and the shadows each quality of light casts. A hard light will create clear and sharp shadows, whereas a soft light creates more blurred shadows, whose edged are more difficult to define. An interesting note about lighting quality is that regular clear-sky sunlight at noon casts hard light, while a cloudy day will result in soft light, an important consideration for matching the light on the 3D building with the light recorded from the scene (Bordwell & Thompson, 2008, s. 126).

Direction is – as the name suggest – determining the direction of the light source. In film lighting, certain directions of lighting are defined, as well as what they can accomplish. A direction known as frontal lighting lights an object directly from the front and can be used to eliminate its' cast shadows. Backlighting can be used for the exact opposite purpose if combined with no other source of lighting, which will then create silhouettes in the image. However, if combined with e.g. a frontal light, it can be used to create an illuminated contour of an object instead.

In cinematography, light sources are important to work with to provide sufficient lighting for a subject in the scene and a key light and a fill light is often required to control this lighting. The key light is the dominant light source (usually the sun, when using light that occurs naturally in an outdoor scene) and this light

illuminates most of the subject and casts the strongest shadows. The fill light can be subsequently added to divulge further details on the subject, or eliminate unwanted shadows from the key light. Finally, when considering the light sources, it should be decided to work with either high-key or low-key illumination. The difference being, that high-key illumination uses fill light to lessen the contrast between bright and dark areas, creating less prominent shadows. High-key illumination is well-suited for entire genres of film (such as comedies) and can be used in large part to define the mood of the scene. Oppositely, low-key illumination will tend to emphasize darker shadows and stronger light/dark contrasts. As such, the mood of the project movie will depend greatly in the chosen type of illumination, since the perceived mood is such a vital part of the movie. A change of mood based, at least partly on the source of light is shown in *Illustration* 3.18.

Illustration 3.18 - The left picture has the sun as the source of light. The right picture has blue lamps below the building as the source of light
Henning Larsen Architects, "Aquarium in Batumi" © 2010

The color of chosen light in a scene can be restricted to the natural white sunlight for outdoor scenes, but the color can be manipulated as much as any other quality of light. The color can change depending on what source should be perceived as casting the light, such as an orange light from a fire. Light color can also be used with great effect to establish a theme of contrasts, such most Michael Bay movies, which play heavily with contrasting blue and orange/yellow colors, as shown in *Illustration* 3.19.

Illustration 3.19 - The left picture is from Transformers (2007), while the right picture is from The Island (2005). The blue/orange color contrast dominate both movies.
Left picture: Paramount Pictures, "Transformers" © 2007. Right picture: Warner Bros. Pictures, "The Island" © 2005

The color of the lighting can also be used to suggest the time of day of a shot, which becomes very useful for the project movie. The mood might call for the white light of a noon sun, or the more saturated yellow/red light of a quiet evening. The color of light can also be enhanced in saturation, if the mood is not sufficiently achieved using the naturally occurring sun light in the scene. The color of the light could even be changed from white to red to suggest that the movie shows the building during the course of an entire day.

3.5.5 The Dogme film

This concept of moviemaking rebellion against the "superficial, mainstream American production of film" was presented by four Danish movie directors, Lars von Trier, Thomas Vinterberg, Kristian Levring og Søren Kragh-Jakobsen (Trier, Vinterberg, Levring, & Kragh-Jakobsen, 1995). In addition to its' rebellions vision, the concept sought to simplify the production of film, clarifying the communication between film and audience. As of 2009, more than 40 Dogme movies had been produced, such as the Danish Idioterne and Festen Every Dogme movie takes a so-called vow of chastity, which denotes a set of rules to be followed. The entire vow of chastity can be found in appendix 9.3 *The Dogme vow of chastity*, but some of them involve requiring the use of a handheld camera at all times, banning the inclusion of any sound or light not present on the location of filming and always filming on the actual location without adding any additional props not naturally present on location (the only exception being that a single light can be attached to the camera, if the natural light is entirely too dark for filming). Examples of Dogme movies are shown in *Illustration* 3.20.

Illustration 3.20 - the left pictures is from Festen (1998), while the right picture is from Idioterne (1998). Both movies follow the Dogme rules. Comparing these movies with e.g. Michael Bay movies, the forced limitations on e.g. lighting becomes clear. Left picture: Nordisk Film Productions, "Festen" © 1998. Right picture: Centropa Entertainsments, "Idioterne" © 1998

One object of this project is to create a matchmoved movie for a very cheap price, so these Dogme rules become prudent to investigate in relation to the project movie. A film following Dogme rules will be very close to being entirely realistic. Almost everything shown on camera will have actually existed on location. Given that this project does not have large funding available for extra equipment, such as numerous lights or intricate cameras, it will rely on what the location can offer innately, much like the Dogme rules require. More importantly however, is the fact that one benefit of match moving over a traditional animation is the greater sense of realism and that the building is actually present in the real world. Keeping the production of the entire project movie close to reality by following Dogme rules might further emphasize this sense of real presence on the 3D building. Traditional architectural visualization methods often manipulate elements such as lighting and location however, so the Dogme rules might not be the primary way to achieve a proper visualization through match moving, but it should unquestionably be considered when producing the project movie.

3.6 History of architectural visualization aesthetics

When working with architectural visualization, prudence suggests that an examination of its history should be made. Modern digital architectural visualizations involve both the aesthetics that define the purpose of the image but also the technology with which the images are realized. If we gain an understanding the early principles and history, we can better appreciate the evolution and current state of the industry.

Initially, we need to understand what we are examining. Kosara defines three pieces of the minimal set of requirement for any visualization (Kosara, 2007, s. 2):

1. **It is based on (non-visual) data.** This data must come from outside the program and must not merely be image processing or photography. If the source data is an image and is used as an image in the end-result, it is not being visualized.
2. **It produces and image.** One or more images should be produced. Inferring no requirement of the way to perceive these images, a movie/animation falls well within this requirement. Other media are also allowed to contribute, but the visualization should be solitarily valid.
3. **The result is readable and recognizable.** The viewer should be able to read and interpret the image, even if it demands training or education on the part of the user. Visualization should also appear to be visualization and nothing else.

3.6.1 What does aesthetics mean

As mentioned in chapter 2.4 *The purpose of architectural visualizations*, an architectural visualization is generally not meant to be studied for the accuracy in measurements or by examining every individual part of the building closely (e.g. each window and door individually), which could involve e.g. the Simplicity Principle (A. van der Helm, 2005) as a topic of examination in this chapter. Rather, the matter of importance is the mood that the visualization can convey to the user, and more specifically, the aesthetics that the visualizer utilize to convey this mood. A few examples of this aesthetic can be seen in *Illustration* 3.21.

Illustration 3.21 - The aesthetic of modern architectural visualizations can convey different moods, such as that of a calm evening (left picture) or a perfect summer day (right picture).
Left picture: Moose Studio. "Skanska Oeresund" © 2010. Right picture: MIR, "Odense Sykehus, Lush Gardens 3XN" © 2010

We now know that we must examine the aesthetics of the visualizations, but what is aesthetics? What does the term mean? The dictionary definition denotes aesthetics as the study of the beautiful; the aspect of philosophy, which concerns itself with art and the areas associated with art (Gyldendal, 2002, s. 584). Aesthetics became an established philosophy in the 18th century, by efforts of philosophers such as German Immanuel Kant (Gyldendal, 2002, s. 584), but rather than completely clarify the topic, clarification has been obstructed by another term: beauty. If we do not know what beauty is, we cannot presume to understand the modern architectural visualization aesthetic.

Definitions of beauty are as old as definitions of aesthetics. In fact, Kant proposes the following definition of beauty:

"The beautiful is that which, apart from concepts, is represented as the Object of a universal delight."

(Kant, 1914, s. 23)

This definition suggests that beauty, contrary to the opinions of e.g. William Shakespeare (Shakespeare, 1598, s. 15) is in fact not subjective to the viewer. Something might be only personally approving to someone, but for an object to be beautiful, this opinion should be universal. The element of objectivity furthermore validates aesthetics, since a study of anything is hardly valid if only a subjective conclusion can be reached. Missing from Kant's definition however, is the specification of what the element of objectivity entails. Jürgen Schmidhuber emphasized simplicity as beauty. His Theory of Beauty suggests, that if comparing several patterns classified by a user as comparable, the user will find the simplest pattern, the one requiring the least amount of decoding from the user, to be the most beautiful (Schmidhuber, 1997). However, a more detailed definition of beauty, containing the critical specification of aspects of beauty, was proposed by British philosopher, Edmund Burke, in his book "A philosophical inquiry into the origin of our ideas of the sublime and beautiful" (Burke, 1767). According to Burke, beauty is a social quality, which, by being observed by us, inspires in us a sense of joy and pleasure. Beauty stirs emotions and a desire to hold beautiful objects or beings near. But most important of all, Burke defines seven specific features of objects or beings in which beauty reside (Burke, 1767, s. 222). And when examining these, we discover that certain features are directly realtable to the modern architectural visualization aesthetic:

1. They are comparatively small (big objects more often inspire awe than beauty)
2. They are smooth
3. They are varied in directions of their parts (bends and turns, rather than rigid, straight lines)
4. Those variations are not sharp and angular, but soft and melted into each other
5. They are delicate
6. They are of colors clear and bright
7. Should they be of strong and vivid color, they are diversified with others without clear separation of colors

We can now begin to formalize initial reflections of how the modern architectural visualization aesthetic creates beauty in pictures. Nature is often included in architectural visualizations to be visually pleasing, which is consistent with feature 3 and 4. Light and color are some of the primary elements that set a desired mood for an architectural visualization, which fits well with feature 6 and 7. However, the task to examine the early realization of the architectural visualization aesthetic still remains. To this end, we will examine a period in the history of visual arts to discover the initial indications of this aesthetic.

3.6.2 The Hudson River School

The Hudson River School of painting fits the architectural visualization aesthetic and purpose very well. It originated from Romanticism (late 18th century to mid 19th century). Romanticism emphasized such virtues as the subjective, the imaginative, the personal and the emotional, while being characterized by appreciating the beauty of nature, and preferring emotion over reason, senses over intellect (Encyclopedia Britannica, 2011), somewhat like modern architectural visualizations do today. The Hudson River School itself was prominent as the first native American school of painting, between 1825 and 1870 (Encyclopedia Britannica, 2011). The Hudson River painters were landscape painters (although some of their work focus on buildings and people) and celebrated the natural beauty of America. Important painters of this school include Thomas

Cole, who founded the school (Danto, 1997, s. 140), as well as Thomas Doughty and Asher Durand. This school of painting was also influenced by religious thinking, such as the following quote from Asher Durand:

"The true province of landscape art […] is the work of God in the visible creation, independent of man."
(Danto, 1997, s. 140)

The Hudson River painters compared themselves to French painter Claude Lorrain, an artist, whose paintings actually strived for an aesthetic similar to that of modern architectural visualization, in that he sought to depict nature in a manner more beautiful than nature itself (Encyclopedia Britannica, 2011). Furthermore, consider the following description of his works, which is similar to what modern architectural visualizations strive for:

"His trees exist for pleasant shade; his peasants to give us the illusion of pastoral life, not to toil for a living. His world is not to be lived in, only to be looked at in a mood of pleasing melancholy or suave revery,"
(Danto, 1997, s. 139)

Claude Lorrain, and subsequently the admiration of him by the founding Hudson River painters establish the Hudson River School as a school of painting prioritizing the beauty of nature over the realism of nature. Examples of Hudson River paintings are shown in *Illustration* 3.22.

Illustration 3.22 - From both "The Architect's Dream" (left picture) and "The Course of Empire: Consummation" (right picture) by Thomas Cole, we recognize elements of beauty, such as the use of colors and variety of its elements.
Left picture: Thomas Cole, "The Architect's Dream" © 1840. Right picture: Thomas Cole, "The Course of Empire: Consummation" © 1836

As a special note of interest, consider *Illustration* 3.23.

Illustration 3.23 – "Youth" (left picture), a part of Thomas Cole's Voyage of Life-paintings, demonstrate a direct precursor to a common element in mordern architectural visualizations (right picture)
Left picture: Thomas Cole "The Voyage of Life Youth" © 1840. Right picture: Archivisuals "Frederiksberg Centeret" © 2011

From Thomas Cole's Youth we see the white, transparent building in the sky. This building is a large part in the surreal quality of the painting. The transparent building is a stable part of many modern architectural visualization pieces. Included in *Illustration* 3.23 is a picture done by Danish firm Archivisuals. Not only are many of the people deliberately made transparent, but so is the building itself (towards the center of the picture). This transparent quality suggests that reality is not solid and familiar, but that the visualization goes somewhat beyond reality and into the realm of depicting the architectural vision instead.

While Hudson River School emerged from a school of painting, it also led to the rise of another school of painting, called Luminism. This mid-to-late 19th century painting style emphasized the use of light above all other elements in its paintings (Encyclopedia Britannica, 2011). While focusing mainly on landscapes, the central focus on light is very reminiscent of modern architectural visualizations.

Thus, the Hudson River School and the ideas that founded it are close to the modern architectural visualization aesthetic. Furthermore, it emerged from a previous school of painting, as well as founding a subsequent school of painting, both of which revere characteristics similar to the modern architectural visualization aesthetic.

3.6.3 Hugh Ferris - adapting the idea of the aesthetic for architecture

Hugh Ferriss was an American architectural delineator, who lived from 1889 – 1962 and he can be considered to be pivotal in adapting the aesthetic for architectural visualizations. Painters may have been panting buildings in an attempt to convey a pleasing image or mood for hundreds of years before Ferriss was born. But regarding adapting the aesthetic to architecture, to be used by actual architects instead of painters, Ferriss was key (Schaller, 1997, s. 43). His conception of the purpose of an architectural illustration was that it should tell the "entire truth" about a building or its environment. He defined this entire truth to include both information and interpretation. Whereas information describes objective architectural information, such as specifics of bricks or glass, interpretation refers to a visual representation of the feeling, the spirit or the essence (Schaller, 1997, s. 45). He describes this belief as follows:

"… I find a more persuasive and noble reason…that architecture…always was both the art and science of building"

(Ferris, 1944)

Ferriss did not merely keep this belief to himself; he encouraged other architects to share it. A few examples demonstrating his creation of architectural visualizations showing the entire truth can be seen on *Illustration* 3.24.

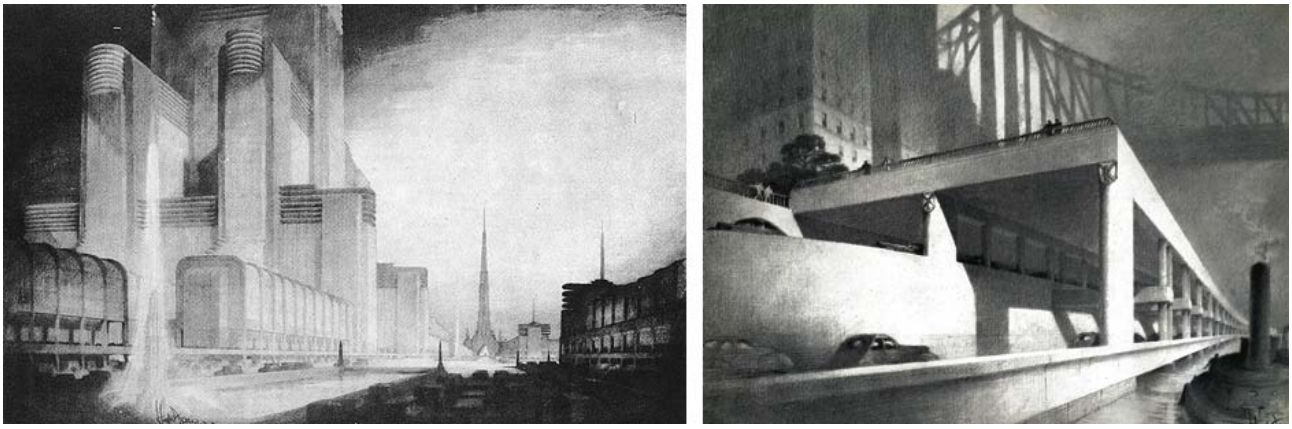

Illustration 3.24 - Hugh Ferriss included his concept of "entire truth" in his architectural visualizations, making them both informative and interpretive
Left picture: Hugh Ferriss, "Segment of Manhattan's East River Drive" © 1940. Right picture: Hugh Ferris, "The Science Center" © 1929

We can see from *Illustration* 3.24 that Ferris did not always strive for the clear-skied summer day, which so many modern visualizations do. However, the idea of the inclusion of an interpretive quality in visualizations does persist in his work as well as modern examples. So while modern visualizations might strive for a different interpretive quality, Ferriss' idea of the entire truth can be argued as being largely responsible for the way much architecture is visualized today.

3.6.4 The beginning of computer graphics

In and of itself, the term Computer Graphics, coined by William Fettel of Boeing Aircraft Co. in 1960 (Carlson, Section 2: The emergence of computer graphics technology, 2003), describes using a computer to create or edit images (Shirley, et al., 2005, s. 1), which comprises 75% of all modern architectural visualizations (Mottle, 2011). But the term has undergone significant evolution to reach its current state. One of the absolute pioneers in this field is Ivan Sutherland (Slater, Steed, & Chrysanthou, 2002) and from him we know, that the photorealistic and stylized images computers can create for architectural visualizations today, images which are often capable of deceiving the human eye, owe their existence to a simple application that allowed a person to draw lines with a Light Pen. In 1963, Sutherland submitted his doctoral thesis on his invention known as Sketchpad (E. Sutherland, Sketchpad, A man-machine graphical communication system, 1963). A 1988-winner of the Turning award, and acknowledged as "one of the most influential computer programs ever written by an individual" (E. Sutherland, Sketchpad: A man-machine graphical communication system, 2003, s. 3), the program can be seen in use in *Illustration* 3.25

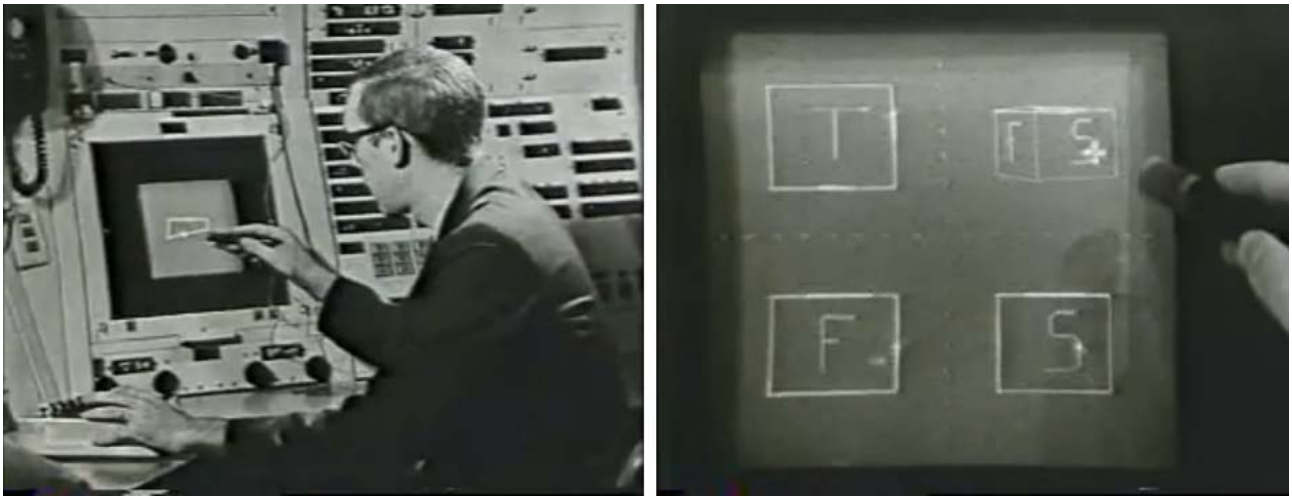

Illustration 3.25 - Sketchpad was most likely the precursor to every computer graphics program ever written. The left picture shows a user interacting with the program. The right picture shows one of the uses of the program up close. Ivan Sutherland, "Sketchpad" © 1963

When examining the functionality of Sketchpad, its importance in the field of computer graphics and the modern architectural visualizations becomes immediately apparent. It eliminated the need for an experienced programmer to be the operator, through the use of the Light Pen interaction device, which opened the door for artists and architects to create computer graphics. The Light Pen allowed even a novice user to merely point at an object on the screen and perform an action, such as deleting or rotating. The program allowed the drawing of a line by having the user placing a point on the screen and then drawing a line from this point to the tip of the Light Pen, until the user specified a second point on the screen. The program introduced the idea of such manipulation concepts as scaling, rotating, deleting or copying. It even explored the concept of a parent-child hierarchy between objects. A "master-object" could be drawn and children made of this object – any changes done to the master would be duplicated to each child, which was further explored in its ability to save a drawing as an object for later retrieval. Sketchpad could calculate visual changes in objects, such as selecting two lines denoted by the user and making them parallel. As seen on the right picture in *Illustration* 3.25, the idea of four viewports, 3 orthogonal and one perspective, was also created by Sketchpad, complete with simultaneous display of user changes in every viewport. Note that the exact layout of these viewport is actually identical to modern versions of the 3D application Autodesk Maya. Most important of all, Sketchpad introduced the concept of the graphical object as an individual entity with responses to interaction (such as how a user could rotate it). So important was this concept, that it directly inspired the invention of the "icon" as a graphical image representing functionality of a programming language (E. Sutherland, Sketchpad: A man-machine graphical communication system, 2003). Not only did Sketchpad make creation of graphics on a computer available to a novice user; many of the ways of interacting and creating graphics are, to varying degrees, present in software used to create modern architectural visualizations. Even some of the ideas for the user interface remain to the present day. The creation of Sketchpad has earned Sutherland recognition as the "Father of computer Graphics" by some (Bissell, 1990, s. 380-381).

3.6.5 The evolution of computer graphics

After its first steps, the field of Computer Graphics started evolving during the 1960's. Many of the techniques essential to modern 3d architectural visualization were invented, researched or evolved at the University of Utah during this decade, by virtue of James F. Blinn, Edmund Catmull, Martin E. Newell and Bui Tuong Phong amongst others (Carlson, Basic and applied research moves the industry, 2003). Some of the techniques and ideas proposed through research done at this university include new developments for the use of light in a 3D scene. In 1977, Blinn published a paper that proposed a model for simulating highlights on a 3D object, with the addition of changing the intensity of the highlight depending on the direction of the light source (Blinn F. J., 1977). This research has proven pivotal for modern architectural visualizations, since light is such a major factor in the aesthetic: A change in the intensity of a light based on direction is needed to convey a believable sun in a scene a conveying a desired mood or e.g. high noon or pleasant evening. That same year, Franklin C. Crow had his research on the use of shadows for computer graphics published. Previously, shadows had been absent from computer generated imagery, but with the publication of Crow's paper, one of the fundamental results of the use of light had been introduced to computer graphics (Crow, 1977). Without shadows, modern architectural visualizations could not convey a sense of the building's form, the quality of the light in the environment or a large part of the general mood of the visualization, making Crow's research essential for modern architectural visualizations. In modern 3d applications, a regularly utilized method for applying textures to 3d objects is via u,v-coordinates, and the importance of texture for architectural visualizations is self evident.. The concept of texture mapping via u,v-coordinates was the work of James F. Blinn and Marin E. Newell in their paper from 1976 (Blinn & Newell, 1976).

The University of Utah was not the sole contributor of Computer Graphics research however. Other universities, such as Cornell University, have made major contributions to Computer Graphics research as well, even research directed specifically towards benefitting architectural images. In 1980, a paper by Eliot Feiburg and Donald P. Greenberg was published, which proposed a system for creating textured renderings of architectural designs (Feiburg & Greenberg, 1980). The system allowed the user to organize textures into libraries, which consisted of digital images of color photographs that were able to be previewed via a sample of the texture, before being applied to an object, much like texture mapping interfaces of modern 3D applications. The system took further strives towards modern architectural visualizations by allowing the textured model to be superimposed onto a background image, enabling the user to translate, rotate or scale the model to proper positioning, while also being able to judge the viability of the chosen texture in relation to the intended background image. An evolution of this idea is precisely what comprises most architectural visualizations today.

These advances in computer graphics and many more (e.g. Global Illumination) all have their roots in the 1960's, 70's and 80's and the field had come a long way from the simple beginnings of Sutherland's Sketchpad.

3.6.6 Modern Architectural Visualizations

The origins of current modern way of visualizing architecture in 3D, in the fashion that this project seeks to challenge, is difficult to pin-point precisely. Due to the reliance on the current state of 3D applications at any given time, we can exclude dates prior to the mid 1980's: 3DS Max, a 3D application used by 83% of the architectural visualization industry (Mottle, 2011) was created by Autodesk, a company founded in 1982 (Carlson, Autodesk (3D Studio and Autodesk Animator), 2003). Much of the research done on computer graphics before the creation of 3D applications did concern many tools used by modern visualizations. However, the focus was always aimed at achieving realism. As such, the aim of Crow's research on shadows

in computer graphics, Blinn and Newell's research on texture mapping techniques or Feibush and Greenberg's research into the use of colored textures for computer graphics to aid architects was all to support and improve verisimilitude. Often when early academic research discussed the use of detailed computer graphics, the contrast always pointed towards detailed and therefore realistic versus a much simpler and more symbolic approach. Such as Richard Helmick's research about the virtues or verisimilitude in design and art (Helmick, Virtues of Verisimilitude in Design and Art, 1995, s. 505-507). On the topic of computer graphics, he describes a problem with realistic graphics:

"The problem with realistic graphics is not that they are too shallow, but instead, that they are too deep and overloaded with information"

(Helmick, Virtues of Verisimilitude in Design and Art, 1995, s. 506)

He further describes the shortcomings of simpler, symbolic visualizations as them requiring the user to image the design as it would appear in reality. Even when early research recognized that digital visualizations can serve several purposes, either to support decision making and production or for marketing and communicating the message to the client, the contrast remained: Detailed and therefore realistic or simpler and thus conceptual (Janols & Stehn, 2004).

However, architectural visualization firms no longer want the viewer to observe their visualizations and correlate it to ontological reality. They instead want to instill a sense of unnatural perfection and present the buildings in a way that a normal day could hardly compete with. In fact, it is arguable that Helmick's view on information contained within realistic graphic have now reversed. For modern architectural visualizations, it is now the realistic graphics that are shallow rather than overloaded. Artists deliberately use realism as a starting point, before proceeding to add even more information to the image, adding elements and pushing realism away from ontology. But even though this aesthetic has been thoroughly explored in traditional art for hundreds of years, it has taken many years for it to find acceptance in digital architectural visualization.

It is likely that the popularization of digital architectural visualization began in tandem with the democratization of computer technologies in the mid 1990's (Koutamanis, 2000, s. 348). There are people working in the industry who began their careers in 3D graphics in the mid 1990's, while others began in the early 2000's (Smith, et al., 2008) (Bekerman, 2011). In the mid 1990's, a typical workstation could cost $100.000 (Smith, et al., 2008, s. ix), whereas modern machines are significantly less expensive and more powerful. Moreover, Autodesk owning many of the major 3D applications has created a centralized hub for these applications, both regarding obtaining them and a community surrounding them. Autodesk furthermore offers free trial versions of their software, as well as offering full versions of their software free to students. Any influence that the ease of becoming familiar with 3D production today, contra 10-15 years ago, has had, can only have been to expand the number or architectural visualizers.

Finally, even though the modern visualization aesthetic is dominant in the industry today, the industry has yet to make a collective switch from traditional analogue to modern digital visualizations. The American Society of Architectural Illustrators has awarded the annual Hugh Fenriss Memorial Prize for "excellence in the graphic representation of architecture" for more than 25 years (American Society for Architectural Illustrators, 2011). The winners throughout the years generally consist of a varied mix of black and white drawings and color drawings, where only winners of the last few years were awarded to digital visualizations. The current entries for the 26th award consist of both digital and analogue visualizations as seen in *Illustration* 3.26.


Illustration 3.26 - Traditional architectural drawings (left picture) still holds relevance next to the modern digital visualizations (right picture).
Left picture: Daniel W. Church, Ferris Award 26 entry 031F © 2011. Right picture: Chen Liang, Ferris Award 26 entry 038F © 2011

The CGarchitect industry survey moreover revealed, that traditional analogue visualizations still occupied 25% of the industry (Mottle, 2011).

Ultimately, the industry generally seems to have settled primarily on the aesthetic that present works of architecture in a way the pushes beauty beyond reality, illustrated in 3D still images and, to a lesser extent, 3D animations. Showing the building as beautifully as possible by the visualizer has generally taken priority over demonstrating it in as realistic a manner as possible: Marketability, not precision, dictates the industry's current direction. And this broad homogenization has established an industry, by some accounts situated in the initial phase on an era (Koutamanis, 2000, s. 348), which already seems to favor gratification in current technological offerings, rather than seeking innovation and evolution of future possibilities.

3.7 Solution requirements

Before moving to the design chapter, a list of requirements for the project film will be listed. This will serve as a guideline of what has to be included in the design. The project film should:

- Be matchmoved, blending a 3D building with real footage
- Attempt to convey a realistic mood to the viewer
- Use real footage, which provides optimal conditions for matchmoving
- Create the realistic mood through a designed aesthetic, which combines matchmoving with appropriate film techniques
- Be testable with regards to matchmoving being a possible addition to contemporary industry visualization methods

4 Design

The requirements for the design were based on the final problem formulation as well as on the investigations conducted in chapter *3 Analysis*. This chapter elaborates the process of designing the aesthetic for the project, how we decided on the location and the look of the building and lastly how we shot the film, considering it had to be matchmoved. In conclusion, the entire design of the project film has been explained and it is thereby ready to be produced.

4.1 Designing the project aesthetic

The design decisions made with regards to the aesthetic of the project are inspired by the Danish film genre of Dogme, explained in chapter 3.5.5 *The Dogme film*. The aesthetic and mood of this genre is what we aim to accomplish for the mood of realism in the project film, and for this reason we have adopted several Dogme rules, which are:

1. Shooting must be done on location. Props and sets must not be brought in (if a particular prop is necessary for the story, a location must be chosen where this prop is to be found).
2. The sound must never be produced apart from the images or vice versa. (Music must not be used unless it occurs where the scene is being shot.)
3. The camera must be hand-held. Any movement or immobility attainable in the hand is permitted.
4. The film must be in color. Special lighting is not acceptable. (If there is too little light for exposure the scene must be cut or a single lamp be attached to the camera.)
5. Optical work and filters are forbidden.
6. The film must not contain superficial action. (Murders, weapons, etc. must not occur.)
7. Temporal and geographical alienation are forbidden. (That is to say that the film takes place here and now.)

There is of course one element that is disregarded from the Dogme rules – the 3D building, which breaks part of Dogme rule 1 of not adding anything to the scene. The building is entirely virtual by nature, as is the light that hits it and the camera that shoots it, even thought this camera, through matchmoving, will mimick the camera that shot the real footage. Even after being rendered from the 3D software, it will possibly undergo post-processing to make it blend the best with the real footage. This break of Dogme rules is essential for the project, but causes the film to fall into somewhat of a grey area between fact and fiction, a topic discussed in chapter 3.2 *Faction – combining the concepts of fact and fiction*. It is however mainly the Dogme rules that are responsible for the three main factors of the project aesthetic:

- Use of matchmoving.
- A pedestrian Point-of-view.
- Grey weather.

While Dogme is a part of the movie industry that serves as a technical foundation of the project, the concept of verisimilitude is another important idea.

> *"The attribute of verisimilitude in the arts refers to a compelling sense of reality and truth"*.
> (Helmick, Virtues of Verisimilitude in Design and Art, 1995).

Since we are not being 100% true to the Dogme rules, the necessity of the 3D building dictates that the project aesthetic cannot strive to solely fulfill the Dogme Vow of Chastity. Instead we use as many Dogme

rules as possible and combine them with the matchmoving of a 3D building, in order to achieve as high a degree of verisimilitude as possible. That is the goal of the project aesthetic.

With the overall goal of the aesthetic explained, the idea of the film is that it could be any normal day, where a person is out for a walk that takes him to the location. The camera is therefore at shoulder height and the movements of it are a bit bumpy, as they are influenced by the walk of the camera operator. The perspective is thus designed to resemble that of a person walking by, attempting to contrast the very mechanical camera movements found in industry animations, as well as contrasting the typical fly-by-shots seen from high above – two aspects of industry animations that we deem too virtual, which is why we seek to take another approach. The aesthetic should convey a realistic mood and a sensation of the 3D building being placed believably in the scenery as the camera moves around in it. For the realistic, the film will be shot on a day with a grey sky. To some extent this decision is the result of our wish to stress the fact that this is an alternative to traditional visualization methods, meaning that choice of weather of the project aesthetic is significantly opposite what is usually found in industry visualizations. We have grey and darkish colors on a cloudy day versus the traditional overly saturated, bright and clear colors. Although this is a design choice on our behalf, it does not mean it is the only way to illuminate the scene. The realistic aesthetic could still be maintained if the film was shot on a sunnier day, but seeing as we attempted to contrast the virtual industry aesthetic as much as possible, shooting in grey weather was considered more suitable for the project aesthetic. Furthermore, the project did not allow for waiting time, until the weather improved towards more sunny.

Combined, the three main aspects of the project aesthetic all serve the purpose of achieving as high as degree of verisimilitude as possible. The grey weather goes largely against stylized blue skies, matchmoving incorporates a realistic element through real footage and the pedestrian point-of-view promotes realism by showing the project movie as a person walking through the scene would see it.

4.2 Choice of location and building

The location displayed in the project film is the final choice, which was reached through several iterations. As explained in chapter 3.4 *DTU field-analysis*, at the early stages of the project, the plan was to receive a 3D building from an Christensen & Co and use the location at DTU where the real building would be placed, as seen in *Illustration* 4.1.

Illustration 4.1 The original location for the project, which turned out to be unusable.
Tim Dobbert © 2005

Unfortunately, the collaboration with the company was not possible, and as a result there was no longer a requirement to use this particular location for the film. In retrospective this worked to our advantage, as chapter 3.4 *DTU field-analysis* also explains: Even though the location worked fine with regards to the tracking process with lots of trackable features, the implementation of a 3D building would be a major

challenge, due to the heavy obstruction cause by trees in the scene. Thus with the experience of a location that is not suited for matchmoving, a list of requirements was formed to better find an ideal place.

- The location needs to have an open space in which a 3D building could fit.
- There need to be a substantial amount of trackable features, which would make an urban location a prudent choice.
- There must be room to move around the location to get both wide and close-up shots of the 3D building.
- As few obstacles as possible. Trees should be completely avoided.

Based upon this list of requirements, the search for a usable location was initiated, using Google Maps for an initial overview of potential open spaces and Google Streetview for examining them in more detail on a ground level. The search area was limited to Copenhagen, since we believed the capital would have plenty of such locations, as well as the scope of this project suggesting that it became limited to Copenhagen: It lies within reasonable traveling distance from IHK, and it is uncomplicated to get around with public transportation. The search provided us with two locations that showed potential. Location 1 is shown in *Illustration* 4.2 and Location 2 is shown in *Illustration* 4.3.

Illustration 4.2 Location 1 was promising due to the possibility of making extreme wide shots from across the water, but also close-up shots from the sidewalk. The adjacent buildings we furthermore somewhat different, allowing greater flexibility when choosing a build to create in 3D.
Tim Dobbert © 2005

Illustration 4.3 The open space in location 2 seemed almost ready for something to be built on it, and the level of obstacles is at a minimum.
Tim Dobbert © 2005

Both locations had interesting features. Location 1 had the wide shot across the water and building flexibility, whereas location 2 had better possibilities with regards to shots taken from the sidewalk and fewer obstacles. At this point in the project process we wanted to keep our options open as much as possible and it was therefore decided to use both locations in the film. Even though it requires some additional work to use two locations, we had the advantage of being able to choose in the end, which one works best in terms of matchmoving and implementation of the 3D building, should we decide to discard one of the locations.

This required performing matchmoving on shots that might not be used in the final film. Ultimately we deemed this a better solution than being forced to re-shoot at another location, in case the first one did not work. It would also prevent the necessity of processing of the raw film and the matchmoving to see if this new location would be better. The two locations are placed close to each other and pose no time or economic problems, thereby making it possible to shoot from both locations in one session. The final choice of location will thus depend on the processing done in the implementation stage.

4.2.1 Building

With the DTU project abandoned, the situation was now that no preexisting requirements for the look of the 3D building were present. We did briefly work with a 3D model provided to us by an architectural student, but that approach was also dropped due to both the state of the 3D model and its intended location, which was basically surrounded by trees, a difficult obstruction for matchmoving. The 3D model was very simple and made up of cubes and pyramid shapes, which could be made in our 3D software in a short amount of time. The 3D model was made in ArchiCad, but due to previous experience, we chose to work with 3D in Autodesk Maya. Rather than facing potential problems when bringing a 3D model from one piece of software to another and working with a very challenging location, we chose an approach in which we would be in as much control as possible over both location and 3D model. Even though we now had the freedom to model any building in Maya, we established certain requirements that the building should fulfill. The 3D building should:

- Have a modern design
- Not be overly detailed and therefore complicated to create
- Be designed by a professional architecture firm to ensure architectural credibility
- Be suitable for the location for the project movie

Following these rules, we investigated various buildings, some already made and some that were under construction. The website Bustler (Bustler.net, 2011) has a self-defined focus on “keeping the design community busy and inspired”, and as a popular place for competitions and event listings in the architecture and design industry, it was a suitable place to find building with a modern design as well as architectural credibility. The one which satisfied our requirements the best was can be seen in *Illustration* 4.4.

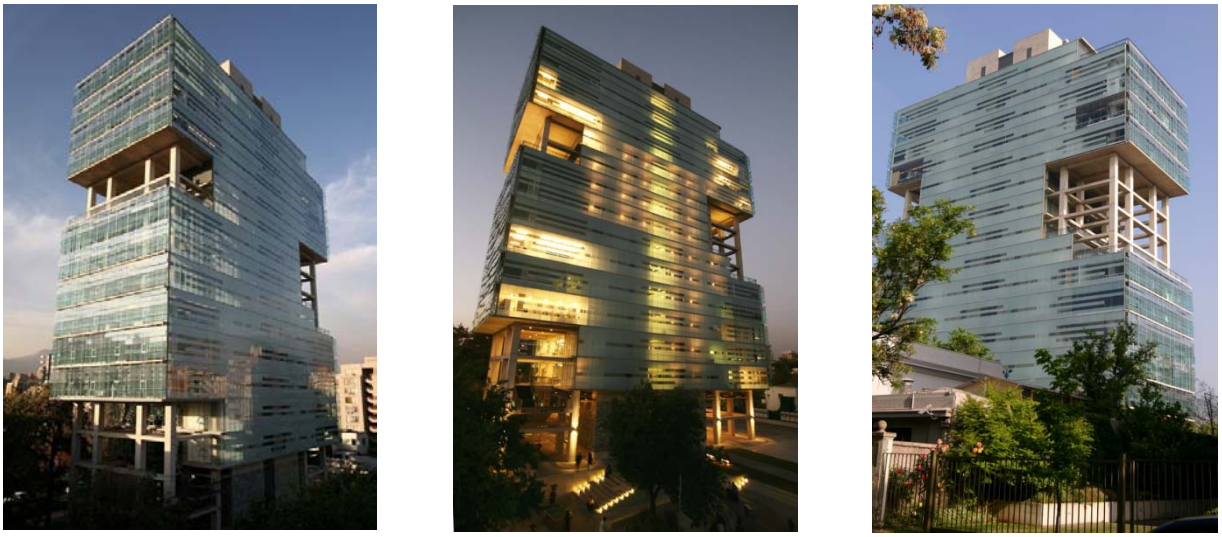

Illustration 4.4 The inspirational building for the project shown from various angles, has the desired combination of modern design, complicatedness and architectural substance.
Sabbagh Arquitectos, "Duoc" © 2008

The building is called Duoc and is a corporate building located in Chile, designed by the company Sabbagh Arquitectos. It was the winner of the "office" category in the 2008 world architecture festival, which is the world's largest architectural award program (World Architecture Festival, 2011). The fact that it is a price winning building argues well for the architectural credibility. However, a change will be made when we adapt the building to the project movie, which is to exclude the glass façade and instead giving it a concrete texture with less prominent windows. This will be done to avoid creating furniture and other interior that would be visible if the building had a transparent glass façade, but it is also done to make it fit better in the new environment. To make sure the project does not grow out of scope, certain decisions have to be made in order to limit the workload and maintain direction. The important part is that the 3D building is placed in the environment and therefore, the modeling of various interior elements is less necessary for the success of the project movie. Fewer glass surfaces is also assumed to reduce rendering time.

4.3 Designing shots for matchmoving

The shots for the film have an additional requirement, than they would have for a film without the inclusion of CGI elements. The 3D building needs to be perceived as being solidly placed in the environment, which can be assisted by planning the shots such that they fulfill the requirements for proper matchmoving. Matchmoving has been investigated in chapter 3.3 *The technique of matchmoving*, and tested in chapter 3.4 *DTU field-analysis*. Both of these chapters mention considerations to be aware of when shooting a matchmove shot, based on theory as well as our own experiences. The considerations that arose are shown in the following list:

- Obstacles
- The number of tracking features
- Motion blur
- Sharp camera focus
- Occlusion
- Parallax
- Reference photos

Some of the considerations have higher priority than others. Obstacles have a high priority because they practically determine whether or not a location is suited for matchmoving. Trees are a common obstacle and have also been discussed in chapter 3.4 *DTU field-analysis*, but merely having trees in the scene in general does prohibit matchmoving. However, it is an indication that a lot more time should be expected to be used on masking them out, to properly place a 3D model behind them. Since we have freedom of choice regarding location, we chose to seek out a location containing as few obstacles as possible. This leads to the next consideration of tracking features. While we should aim for a location with the least amount of obstacles, it still needs to contain features which can be tracked. A wide open space would e.g. be great in terms of few obstacles, but bad in terms of available tracking features. Furthermore the 3D building might also blend better with its environment if there are other buildings in the scene around it, which also would be helpful with regards to comparison and scale between the 3D building and the contents of the scene. Motion blur and sharp focus both relate to the handling of the camera when recording. In order to provide optimal conditions for tracking, we should design our shots so that they have sharp focus and as little motion blur as possible. However, as we are aiming for a handheld way of recording, a certain amount of motion blur is expected to appear. We should at the very least avoid making shots that rapidly pans or tilts the camera. Compensations can be made, if a quickly moving camera becomes required for the project film, which then produces a high amount of motion blur, but more time should then be allocated to the processing of shots containing motion blur.

Occlusion refers to objects being hidden from the camera by other objects in the scene. It is not of the greatest priority to the project film, but is still worthy of mentioning, since it can affect the design of the shots. When features that are being tracked move behind other objects or in other ways become untrackable, it can affect the quality of the matchmove if it is a scene with limited track points. Having a “half” track is not a catastrophe, as long as there is enough trackable features in the scene, which again speaks to the advantage of using an urban location with plenty of diversity in both buildings, light poles, parked cars and bikes etc. The “Parralax” and “Reference photos” considerations are both regarding parallaxing (the experience of nearby objects moving by quickly, while distant objects seem to be moving very slowly, or not at all). Generally a good shot for matchmoving is a shot that contains parallax, because it makes it easier for the software to calculate where in 3D space the tracking features are. Thus to create optimal conditions in our shots, we should be moving around the scene such that objects move in relation to each other, which fits very well with the idea of a Dogme inspired film. It is still possible to make other kinds of shots, such as a pan or tilt shot, provided that it is planned for. It is likely that a pan or tilt shot will be included in the storyboard, but a pan or tilt shot does not produce parallax, due to the stationary position of the camera operator. Thus the software struggles with determining the position of the tracked features in 3D space. A method of helping the software comes in the form of reference photos taken from the same location, but from different positions in the scene than the camera. This way the software can receive information about where a certain feature is located in the shot, as well as in 2D images from various angles, which helps the software calculate the position more precisely.

A film that contains matchmoving shots includes a few requirements. With increased technical skills on behalf of the camera operator, the severity of these requirements should decrease over time, but the considerations discussed in this chapter should still be accounted for, before the shooting of a scene. Careful considerations can save time later in the process and help avoid having to go back and re-record shots, if current recordings prove impossible to perform matchmoving with. With these considerations in mind, the storyboard can be designed before recording at the chosen location, thereby increasing the likelihood that our initial recordings will be sufficient for matchmoving.

4.4 Designing the storyboards

Before shooting at a chosen location, it is a good idea to spend a decent amount of time on creating a storyboard for the film. Creating a storyboard before recording shots can determine in advance: What is supposed to happen in the scene? How can this action be framed? What kind of kind of light is optimal, and can it be achieved with the equipment available to you? How should the camera move? These are but some the possible answer that a storyboard can provide.

The storyboard for this project is based on the theories from chapter 3.5 *Film techniques*, in which several important techniques that apply to our film are mentioned. The aim is to create a realistic mood in the project film, which can be helped along using a couple of techniques. Using rhythmic relations in the form of a similar length of shots helps set the tempo as well as an expression of the film, suitable to resemble the feel of a pedestrian walking about the location on a calm, normal day. Another utilized film technique is the framing, which involves factors such as angle, level, height and distance. Some of these are predefined, as we have decided to for a pedestrian point-of-view, meaning that the camera will be at shoulder height and have angle and level corresponding to that of a person walking down the street. This will include panning and tilting the camera in less smooth motions, when filming the 3D building and the environment around it. Since the project movie is being shot by a handheld camera, the level of the camera will stray from being horizontal at all times. The distance from camera to 3D building will vary as well, starting with the far away establishing shot, where an overview of the location is provided, and ending with close-up shots which will be shot from across the street from the 3D building, in order to get the "pedestrian passing by" effect.

Lighting is another issue to be considered. Because this film is created as an addition to the existing stylized visualizations, the sense of realism should also be conveyed through the illumination of the scene. The stylized visualizations often feature clear blue skies and bright light to communicate a dream-like and perfect-day mood. Therefore to emphasize the difference, this film will be shot on a normal, grey, cloudy day. This will cause shadows to obtain a soft and blurry look, as opposed to the hard and sharp shadows induced by a sunny day with clear blue skies. This choice of light and shadows is further supported through research, indicating that computer generated soft shadows tend to be perceived as more realistic than hard shadows (Rademacher, Lengyel, Cutrell, & Whitted). Without the very distinct edge of hard shadows, the soft shadows should help the 3D building to better blend with the real footage.

With these decisions made, the list of requirements for the film is the following:

- Short duration of the shots. (five to eight seconds)
- Shoot with a handheld camera.
- Contain wide establishing shot and close-up of the 3D building
- Pedestrian-walk-by-shots
- Soft light from a grey cloudy day

The storyboard is done solely to plan the shots in advance. There is no character, whose development the viewer can follow. The purpose is, via a certain aesthetic, to show how a building, currently not existing in the real world, will look when constructed and in place in its intended environment. The film will therefore begin by informing the viewer about this environment and where in the world it is located, a piece of information often missing from industry visualizations, except through text. Our approach to do this is by a zoom shot, going from outer space to the exact intended location of the 3D building on Earth. This shows the viewer, not only an establishing shot of the location, but also where in Denmark this location is, as well as the fact that it is in Denmark. Location 1 had the best conditions for an establishing shot, because we could

set up at the other side of the water. Thus it was chosen to be the specific place at which the Earth zoom shot would end and it would also be the first environment in which to display the 3D building. When the Earth zoom shot is complete, it will blend to reveal our own recordings of a wide establishing shot across the water.

Then the 3D building is introduced, which will be shown as a construction animation shot, where all individual parts of the building are connected, until the building is complete in 3D. This CGI shot helps to emphasize what the viewer should focus his attention to for the following scenes. Even though we aim to create the 3D building so that it looks realistic and as a part of the environment, we still want the viewer to know where to focus his attention, as well as to differentiate what is real in the film and what is not, which will be achieved through editing. The differentiation between real and fake is emphasized from the 3D building appearing in the establishing shot, which was just an empty plateau, when the viewer first saw it. Regarding sound in the film, an upbeat song will play through the introductory scenes until the building appears in the scene and the project aesthetic appears. The Earth zoom shot and construction animation shot has no native sound and would therefore create an unintended mute experience. Using a lively piece of music could help prevent the viewer from becoming bored with these shots. No music or sound must be added to the shots displaying the project aesthetic.

The remaining shots of Location 1 deals with close-up shots from an angle opposite of the establishing shot. These are the pedestrian point-of-view shots that show the 3D building up close from the sidewalk. There will be one shot where camera has stopped and observes the location - a panning shot - and there will be a second shot in which the pedestrian walks towards the building. Subsequently, Location 2 will be introduced with an establishing shot from as far back as possible. Just as with Location 1, the viewer will initially see a clean shot of the scene, followed by the insertion of the 3D building. The camera will then move around the location and show the 3D building from various angles, while maintaining the pedestrian perspective.

One final element exists in the film. Although we have decided to work with a realistic mood in the film, we cannot know for sure how this visual style works with regards to the blending between the 3D building and the footage. For this reason the film will also feature a few shots with alternative visual styles, in the form of various color filters. These shots will be shown last from each location. Since the visual style changes, we cease to use project aesthetic and the use of music and sound can reappear. A slow paced song would be prudent for showing the various styles as well as emphasize that fact that this is a new chapter of the film, as well as suggesting, that the film is approaching its end. The various visual styles should of course be included in the test, as an additional attempt to establish how to create a realistic mood and if a better blending between 3D and footage (maybe via color filters) also promotes a realistic mood. The storyboard for Location 1 is shown in *Illustration* 4.5 and the storyboard for Location 2 is shown in *Illustration* 4.6.

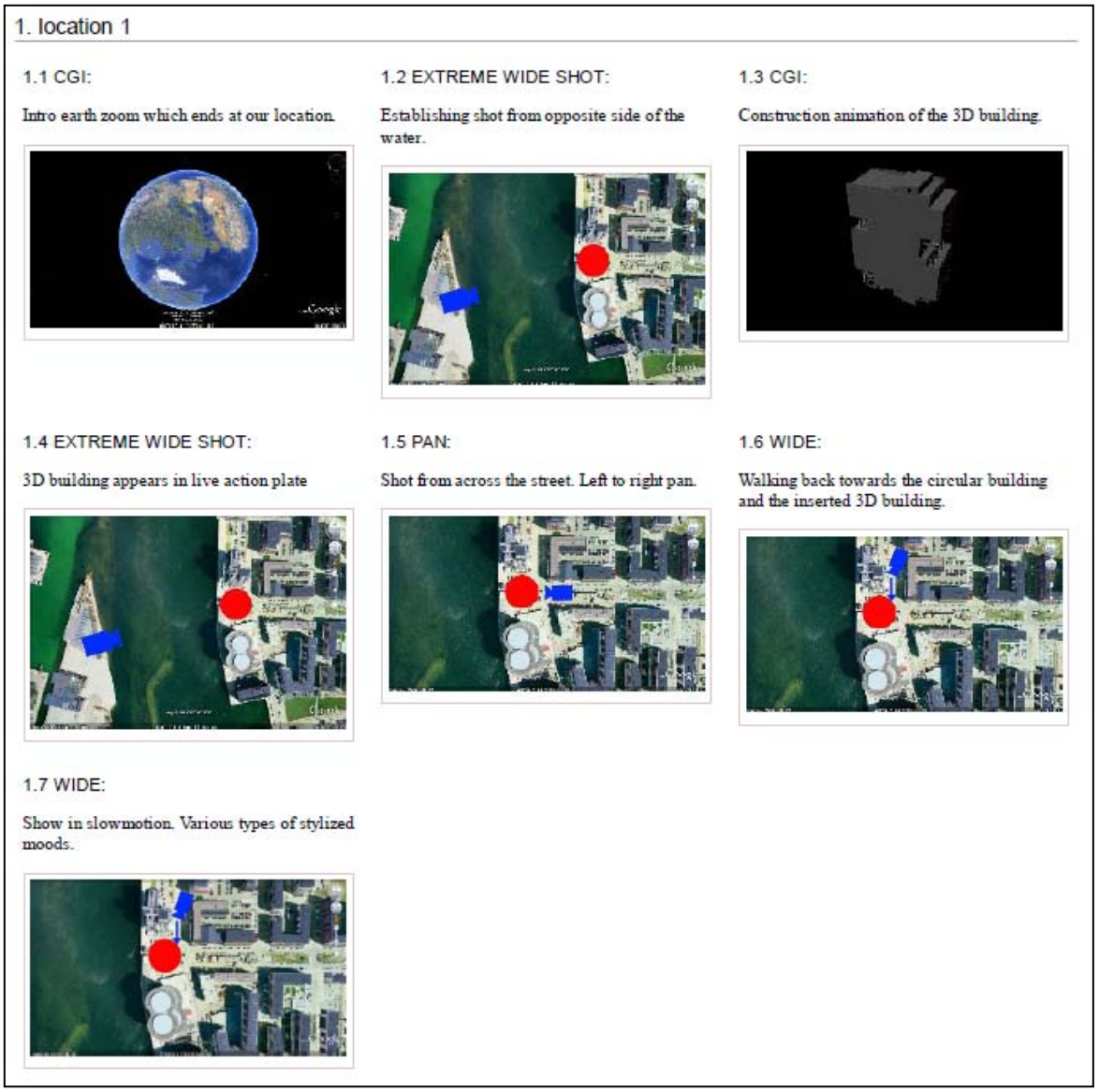

Illustration 4.5 Storyboard for Location 1, featuring information for camera setup and movement. The red dot is the intended location for the 3D building and the blue camera icon is where the footage is recorded from. A blue arrow next to the camera icon will denote the motion of the camera.

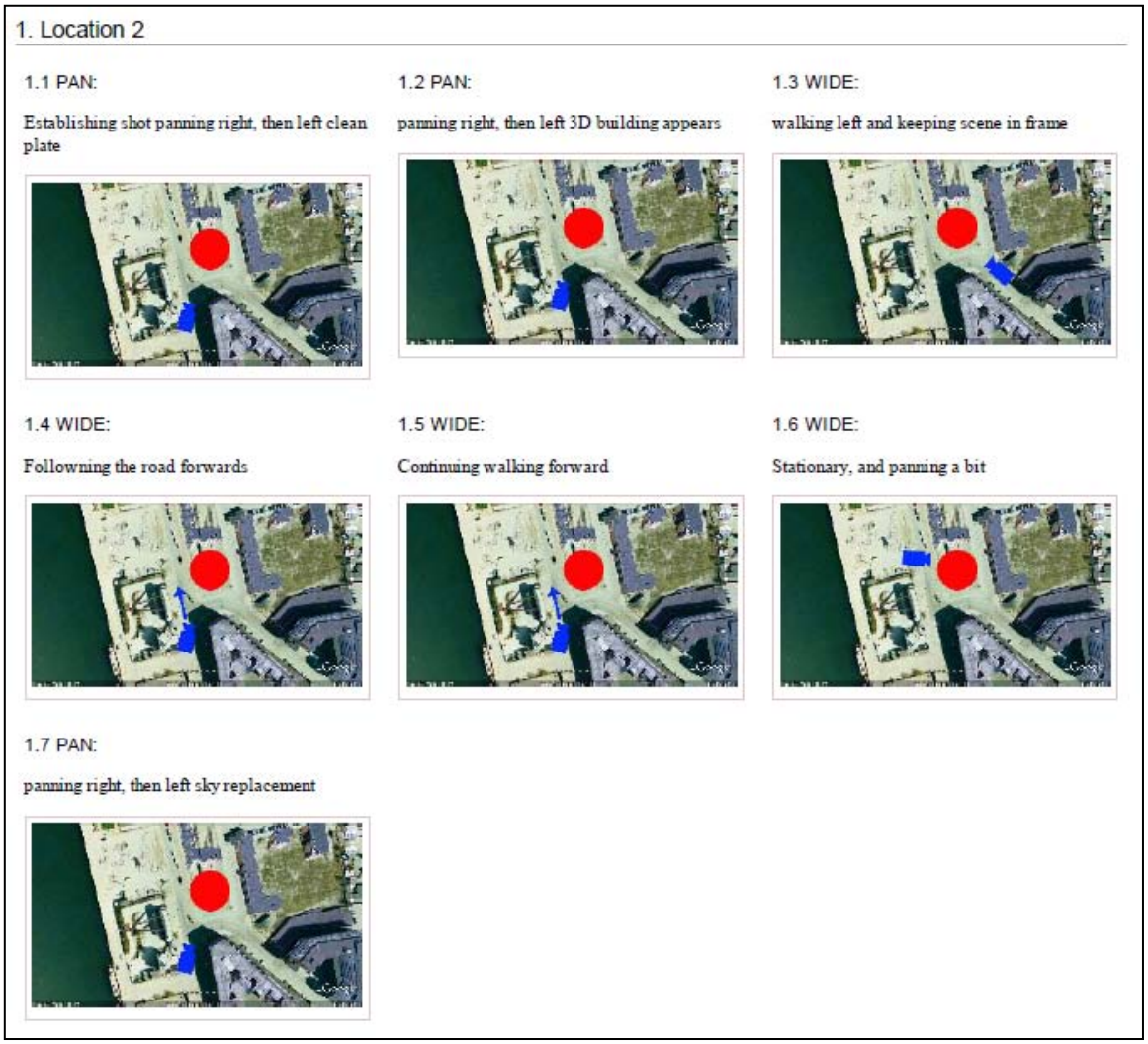

Illustration 4.6 Storyboard for Location 2. Just as with location one, the 3D building will be shown from different angles, but without the introductory zoom shot and construction animation. The red dot and blue camera icon serve the same purpose as for *Illustration* 4.5.

With the storyboard complete, the risk of forgetting certain shots, recording incorrect shots and other types of mistakes, is reduced. We can now work at the location with clear goals in terms of what to shot and how to shoot it. The term “fix it in post”, which refers to the process of doing post-processing on a shot to clean it for mistakes occurring then recording, is well known within the film media, but it can be a dangerous approach to have. Not everything can be fixed in post-production and it might also end up costing more time and effort to fix a mistake that could be avoided by making a well planned storyboard. With the storyboard complete, combined with the experience we gained from the test shoot at DTU, we feel comfortable that a single trip to the location will be sufficient to get what we need.

With the design of the storyboard complete, the project film could proceed to the implementation phase, where all decisions made in this chapter would be utilized to produce a film suitable for testing the final problem formulation.

5 Implementation

This chapter describes the process of implementing the project film, for use in the test. The process consisted of several steps including tracking, modeling, texturing, editing etc. which required working in several different programs such as PFTrack, Maya, After Effects and Premiere, all to achieve the final result as seen in *Illustration* 5.1.

Illustration 5.1 Screenshot from the final film where the 3D building inserted in the environment
Copyright by the authors

This is how the project film looks when used for testing the final problem formulation.

5.1 Performing matchmoving of the video footage

The process of matchmoving can be described in several stages, each of which elaborated in this chapter. Overall the process is about preparing a shot for the placement of a 3D model somewhere in it, which means analyzing the movements of objects in the scene in order to create a scene in 3D space with a camera that replicates the movements of the real world camera that was originally used for shooting. Then the 3D model can be shot with the virtual camera and thereby be placed and fit in the scene. If done properly, the matchmove usually gets by and does not get noticed. If done poorly, it will.

5.1.1 Preparing the shots for matchmoving

The matchmoving process is at times as many other processes, a matter of trial and error. You know where you are headed, but there can be many paths leading to this goal. The shots were first brought into Adobe Premiere to be edited. To make sure we did not have to go back and re-shoot, we had a lot of footage, which should now be trimmed down to the desired length of around five to eight seconds. We wanted around thirty seconds of footage for each location, which after the edit came to be five shots from location one, and five shots from location two. The first problem then appeared when bringing these shots from Premiere to PFTrack. We shot at the highest HD resolution of 1920x1080 pixels to give the best conditions for tracking, but this resulted in a large file size even for short shots, which then resulted in PFTrack really struggling with the processing of them. The struggling was so severe that PFTrack could not work with the shots, causing us to make changes to the format of the shots. Various tutorials showed formats that worked, but which would

also reduce the quality too much. The solutions was then to render the shots from Premiere as individual frames, each maintaining the size if 1920x1080 and thus keeping the sharp quality. Apart from keeping track of what was now hundreds of files instead of ten, the shots were now ready for processing in PFTrack.

5.1.2 Tracking

As mentioned in chapter *3.3 The technique of matchmoving*, the tracking can be done either automatic, manual or as a combination of both. If the automatic tracking gives good results, it is perfectly valid to continue to the solution, but it might also produce something which is not usable at all. The automatic tracking in PFTrack has a default amount of 150 track points. If they all do a good job, that is a lot of data, which alternatively would take an enormous amount of time if done manually. On the other hand, it is a lot of data working against you, should the tracking be faulty. PFTrack provide a few indications as to the quality of the track such as graphs and color, where green is good, yellow indicates issues and red means a bad track. But primarily it depends on what the individual matchmover decides from examining how close the track points stick to their respective feature in the scene. The amount of drift from the feature is a decent indicator for the quality of the track.

Illustration 5.2 Screenshot from PFTrack showing the tracking process with color indication as to the quality of each track point. Copyright by the authors

Overall the track in *Illustration* 5.2 is good, but there are some issues with the trees, as highlighted with red and yellow. The branch on the tree might initially seem like a good track point, because there is such a good contrast with the background. However as the camera moves, the other branches might be seen as closer together with the originally tracked branch or they might overlap with a dark area such as a window in the background, thereby causing the track point to jump back and forth through the length of the shot. Such track points must be deleted, as they otherwise would supply false information to the solution. Generally the shot should be reviewed at least a couple of times to ensure that none of the apparently good/green tracks are not faulty either. With the obviously bad tracks deleted, the validity of the remaining are determined in the solving stage.

Not all the shots were as straightforward as this though. The establishing shot of location one had a large amount of water in it, which must not be included in the tracking, as it would translate the motion of the ocean to the solution of the scene.

Illustration 5.3 Screenshot from PFTrack of the establishing shot, in which almost half of the frame is masked out because of the water.
Copyright by the authors

The purple area in *Illustration* 5.3 is a mask that excludes the area it covers from the tracking. This method was used a couple of other times with cars or people passing by, thereby making sure that only static objects in the scene were tracked. During the processing of the ten shots, both the automatic and manual tracking approach was used, depending on the type of shot. Next step was to verify the quality of the tracks by solving them.

5.1.3 Solving

When a track is being solved, the track points get transformed into solid points in 3D space, and a virtual camera with a motion path is created based on the tracking data. Now it becomes a matter of skills of the individual matchmover in determining whether the solution is usable, or if the tracking stage should be re-done and refined before making another solve. PFTrack has a 3D perspective view functionality that allows the user to see the points and the camera in a viewport very similar the one used in Maya, as shown in *Illustration* 5.4.

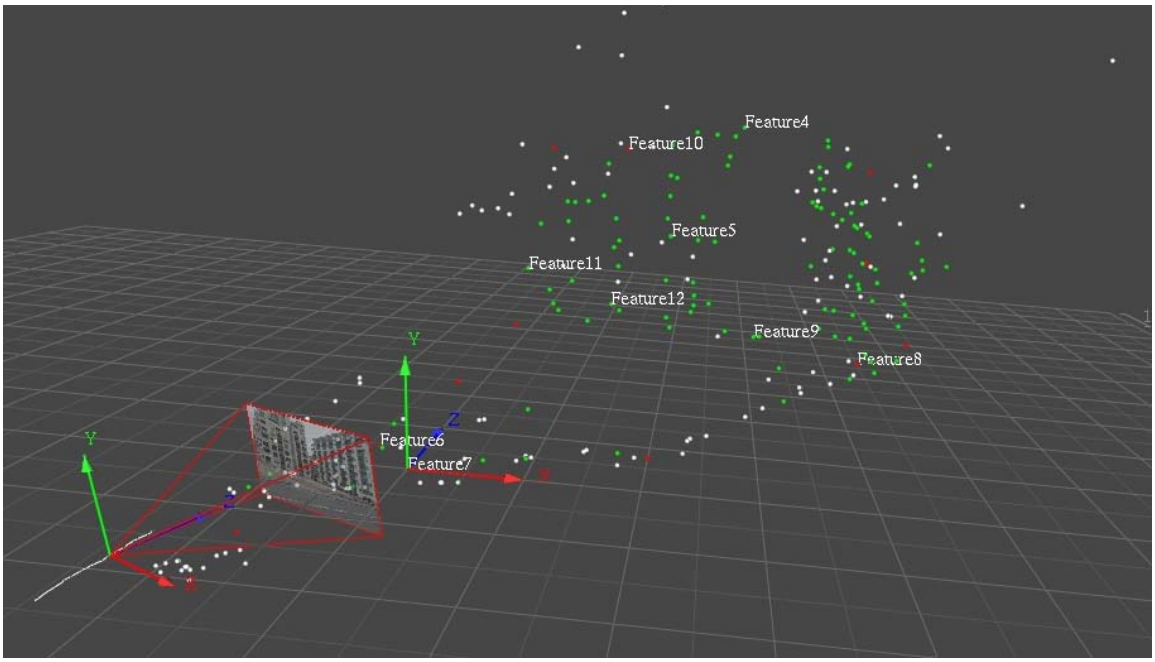

Illustration 5.4 the perspective view in which it can be seen where in 3D space the track points lie.
Copyright by the authors

Illustration 5.5 screenshot of the solution with digital ground grid and coordinate system.

In *Illustration* 5.5, it can be seen how the track points are nicely attached to various features in the scene such as corners of windows, buildings, distinctive rocks etc. When these points are seen in perspective view without the image reference, they become a bit more difficult to interpret. Still there are clues that can help make sense of the scene, such as the coordinate system, which is displayed in both *Illustration* 5.4 and *Illustration* 5.5. It has a decent distance to the camera as well as to the two clusters of points that represent the buildings, and both distances seem to correspond well with the scene. You can choose yourself which point you want to attach the coordinate system to, and a good practice for this is to find a point on the ground, as the coordinate system comes with a ground plane in the form of a grid. This is one, if not the best indicator for the quality of the solution and is elaborated in chapter 5.1.4 *Evaluating*. The camera and its respective path shown in the bottom left part of the perspective view is also a helpful feature because of the graphic representation of it. It required some repetitive viewing switching from one view to another, but it is the best way to determine if the virtual camera path matches the movements of the real camera. However a completed solution does not mean completed matchmove.

5.1.4 Evaluating

There are a couple of things that should be tried, before determining the final validity of a matchmove. The importance of the ground plane has been introduced, so when playing the shot, it should stick to the ground of the scene. This is the ground plane on which the 3D building will be placed later in the process, so it is vital that it is attached to and follows the movement of the real world ground. Making this work has a high priority, because a neglect or mistake will be shown in the form of the 3D building drifting or jumping when inserted. The behavior of the ground plane is usually connected to the track points. If they do not stick to their respective feature, neither will the ground plane. Therefore the most important thing to do with a solution is to view again and again, focusing on the behavior of the points. This evaluation however does not need to rely on the point behavior alone. PFTrack allows you to insert test objects in the scene to give indications as to the look and behavior of a 3D model in the environment.

Illustration 5.6 To help evaluate the solution, a test object can be placed in the scene while inside PFTrack.
Copyright by the authors

Illustration 5.6 shows the test object as a mushroom. There are alternatives, but the tall vertical shape made the mushroom our choice because it resembles the vertical structure of a building. It is very useful to be able to perform this kind of evaluation still within PFTrack, as you do not have to go into other programs to backtrack the process if changes are needed. At this point the shot was reviewed to see how well the test object was planted in the scene, and if it was satisfactory, the solution was exported into Maya to undergo one last evaluation.

5.1.5 Into Maya

When opening the exported PFTrack scene in Maya, it includes most importantly the created virtual camera, the track points and lastly the image sequence, which is a great help for placing the 3D building correctly. But before including the building, we made a test run of the scene with a simple 3D cube to get verification that it would also work outside PFTrack, as shown in *Illustration* 5.7.

Illustration 5.7 The final evaluation of the PFTrack solution was done by inserting a simple 3D cube in the scene.
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The placement of this cube was done very roughly. No use of light other than default, or special render settings was used. We merely placed the cube correctly and rendered with the virtual camera, as the other settings did not have any effect on how the cube would lie on the ground. If this test video turned out to show the cube lying solidly on the ground, we continued with the much more complex setup of placing the 3D building in the scene.

5.2 Implementing the 3D building

After completing the creation of the 3D building, including modeling, texturing, shading and rendering, the final result became as shown in *Illustration* 5.8.

Illustration 5.8 - The completed building, ready to be matchmoved into the project film
Copyright by the authors

The implementation of the 3D building should result in a 3D model, which adhered to the design described in chapter 4.2 *Choice of location and building*. Of importance was also the fact, that it should be implemented to comply with the project aesthetic. This dictated, that the building e.g. had to be covered in soft and diffuse shadows, since the grey weather aspect of the project aesthetic does not permit a clear direction of bright sunlight.

5.2.1 Modeling

Modeling of the 3D building requires a rather somewhat consistent adherence to the original design by Sabbagh Arquitectos. We are not schooled in architecture and therefore lack sufficient knowledge to deliberately design a building, which presents any type of architectural value or principle. Furthermore, while creation of an architectural design is outside the scope and purpose of this project, a complete lack of any architectural value of the building could distract the users when testing the project film. The test will focus primarily on the value and effect of the use of matchmoving, as well as the chosen perspective for promoting a realistic mood. However, should the building be completely without architectural merit, it does pose the risk of test respondents, particularly those involved professionally in the industry, becoming distracted from the use of matchmoving and focusing on the bad quality of the 3D building. Certain inaccuracies, such as the building being somewhat wider or taller than the original is considered acceptable, so long as an easy resemblance between the original building and the 3D building is present.

It will be created using the box modeling technique. It involved starting from a primitive object, namely a box in this project, which is then manipulation by e.g. moving the vertices of the box, extruding its faces to

create additional detail and other modeling techniques. This modeling technique works very well considering the design of the chosen building, as seen on *Illustration* 5.9.

Illustration 5.9- The original building (left picture) merely consists or a number of boxes, which makes box modeling a suitable modeling technique for creating the 3D model (right picture)
Left Picture: Sabbagh Arquitectos, "Duoc" © 2008. Right Picture: Copyright by the authors

In terms of creating the building in 3D, the main body of the building design merely consists of a number of boxes of similar height, but with varying lengths. These boxes are separated by a thin horizontal platform intersecting the building. Modeling the body in 3D was therefore done by duplication of one box of correct height, where each duplicate was subsequently modified to have their lengths fit the building design, which ensured that the height of each floor remained consistent. Almost every element of the building could be constructed by modifying the basic shape of a box. The thick, vertical, center support beams running through the length of the building, the thinner, vertical and horizontal support beams near the edges of the building and the railings among other elements could all be created by rather plain modifications to the basic box shape. To save detail for increased render time, the building was modeled from many separate pieces that were placed appropriately in relation to each other. It was possible to choose to extrude every part of the model from the main body, but this approach would introduce an unnecessary amount of detail in the model, as well as take up additional modeling time. Considering the story board for the project film, not all detail was necessary to actually model. Fine details on the top of the building, as well as the bulges of the min body or contents of the building lobby, as seen in *Illustration* 5.10, were less important, since this detail is either hardly visible on the matchmoved shots or irrelevant to judge the effect of matchmoving on the building's ability to appear realistic in the project film.

Illustration 5.10 - Details of the surface of the building (left picture) or the contents of the lobby (right picture) was not necessary for the purpose of the project film.
Sabbagh Arquitectos, "Duoc", © 2008

For this reason, even though 3ds Max is the prominent modeling application in the industry, the building was modeled in Autodesk Maya. The modeling techniques used in Maya are all present in 3ds Max (such as extruding faces, merging or welding of vertices and adding edges to faces for additional detail), but we had much greater knowledge with using Maya, which allowed the modeling process to take up the least amount of time. Knowledge of terminology, methods of adding finer detail, such as inserting edge loops to prevent corners from appearing unrealistically sharp, cleaning up the model etc. were familiar to us in Maya, but might have taken additional time to properly manage inside 3ds Max. Furthermore, as seen in *Illustration* 5.11, the interface of Mental Ray (the renderer of choice for the project) looks significantly different, requiring further exploration and familiarization with 3ds Max before similar work efficiency to that we already had in Maya could be achieved. Thus, the choice of 3D application relied on work efficiency, not on features specific to each 3D application.

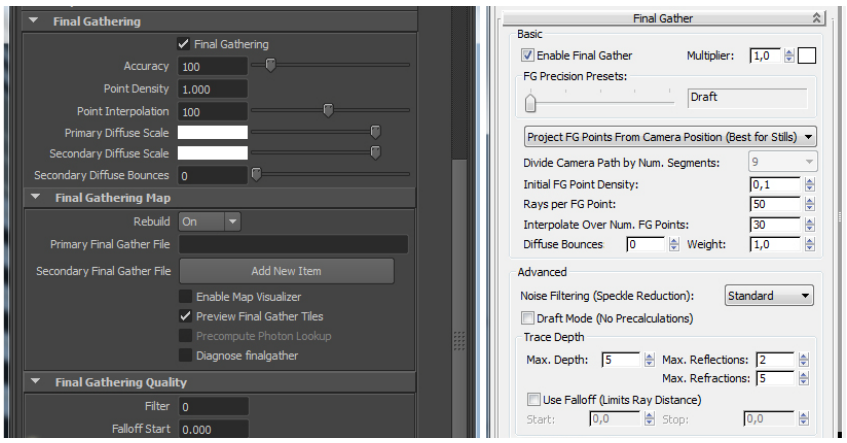

Illustration 5.11 - The many differences between the GUI of Mental Ray for Maya (left picture) and Mental Ray for 3ds Max (right picture) caused the use of 3ds Max to require an undesired amount of learning before efficient use was possible.
Left picture: Autodesk "Maya" © 2011. Right picture: Autodesk "3DS Max" © 2011

5.2.2 Unwrapping and Texturing

For unwrapping purposes, an external application, Headus UVLayout, was utilized. This application makes much of the unwrapping process automatic and easy to approach. UVLayout only accepts .ply, .obj and.uvl-files (.uvl being the program's own file format), but Maya exports effortlessly to .obj-files. UVLayout presents the model in a plain perspective view. In this view, a certain section of the model can be "cut" from the rest and this cut section will then be flattened and stretched in u,v space, as shown in *Illustration* 5.12. The program must manage sections of the model at one time, since e.g. a circle cannot have its uv's laid out without overlapping occurring. In this fashion, the entire building can be cut up in to appropriate pieces and be entirely unwrapped, before being imported as an –obj.file into Maya once more for texturing and rendering.

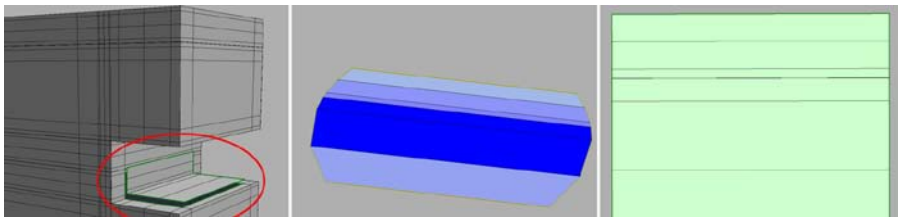

Illustration 5.12 – The left picture shows the model in UVLayout's perspective view, where a section (enclosed in the red circle) has been "cut" off from the rest. The middle picture shows this section being flattened in u,v space. The right picture shows the section being stretched and the uv's have now been laid out properly and is ready for texturing.

Since many parts of the model will have a separate texture applied, with no direct connection between the texture of either part (such as between the main body of the building and the horizontal support beams intersection), it was decided not to create one, single texture map for the entire building. Each major part is rather unwrapped individually. This allows the uv's of each part to take up more uv space, which in turn allows for greater flexibility and opportunity for texture detail. To increase the appearance of texture detail, Maya can apply such techniques as "Repeat UV". Creating separate texture maps, such as for the main body of the building shown in *Illustration* 5.13, allowed this repeating of uv's to create a greater amount of detail.

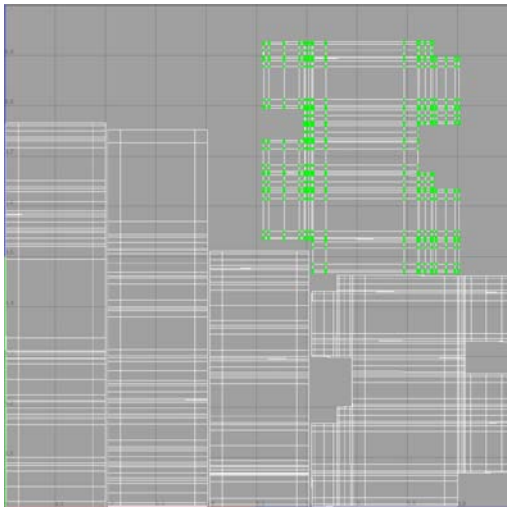

Illustration 5.13 - Unwrapping the main body of the building allowed for much greater detail, without sacrificing detail of other parts of the building, which could occur from one, collective texture map for the entire building.

5.2.3 Shading

Shading – the determination of how the color of a face changes depending on interaction with light – was generally divided into diffuse shaders (the concrete surfaces and railing supports) and more specular and transparent shaders (windows and the glass of the railings). The glass of the railings only really needed a transparent lambert shader, since the transparency was all that would be visible in the project film. However, the remaining parts of the building were equipped with Maya's Mental Ray specific mia_material_x material. This shader is well suited for simulating materials used in architectural renderings, allowing for e.g. control over the quality of Final Gathering for each shader individually, making it prudent for this project. It provides a starting point for many types of material, as seen in *Illustration* 5.14, such as glass and concrete - the main types of shaders used in this project.

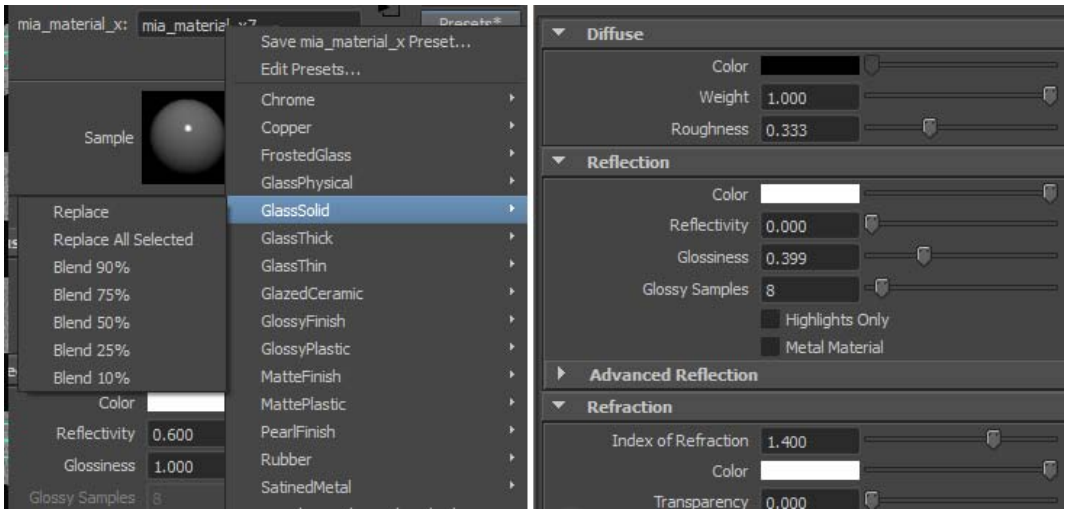

Illustration 5.14 - The GlassSolid and MatteFinish (left picture) were the primary presets used in this project. The right picture shows the final settings for the shader of the main body of the building.
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A certain amount of subsequent tweaking of e.g. Transparency and Reflectivity parameters of the shader was done until a satisfactory result was obtained. Finally, a special useBackground material was for rendering shadows cast by building onto the ground. This material has no color itself, but allows the capture of shadows in an alpha channel, where whiter areas denote darker shadows. For compositing, this created a separate shadow layer, to manual tweaking of shadows without tampering with the color or brightness of the building itself.

5.2.4 Rendering

Rendering was done with Mental Ray. The reason behind this choice consisted of previous working experience with the renderer, the fact that the mia_material_x materials require Mental ray and that neither Maya's Software, Hardware or Vector renders feature Indirect Lighting-possibilities. When real light hits a surface, the light rays are reflected off this surface and hit other surfaces. It gives the model a significantly more realistic look. Due to the weather of the footage for the project film, it is difficult to pinpoint a clear direction for the sun light. Final Gathering in Mental Ray is often created using either its Physical Sun and Sky-setting or Image Based Lighting setting. Physical Sun and Sky generally provides a directional light in the 3D scene in Maya, which did not match the project film footage. Image Based Lighting however can be set to merely use a white texture to determine the color of the lighting, as seen in *Illustration* 5.15, after which it will light the scene and create shadows in a manner much closer to the footage of the project film.

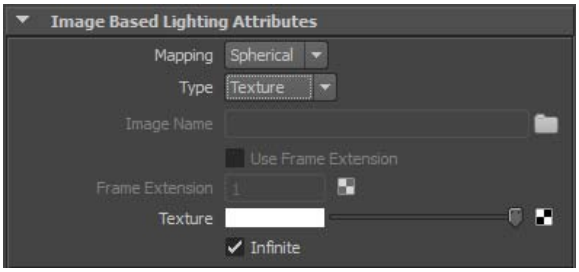

Illustration 5.15 - Setting the Type setting to "Texture" and the Texture color to white is an easy way to create a desired type of lighting on the 3D model.
Copyright by the authors

With Final Gathering, render time increases significantly per frame, but the added realism greatly assists in giving the model a realistic look and helping it fit into the project film footage. A direct difference between rendering with Final Gather and without it can be seen in *Illustration* 5.16.

Illustration 5.16 – Left picture: the lack of Final Gathering create adistinct lighting direction and charp shadow edges. Right picture: features Final Gathering, reuslting in a much more even spread of shadow on the model.
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With the completion of rendering, the building needed no more work done to it. The building could therefore be edited together with the matchmoved footage, allowing the project film to enter the post production process.

5.3 Post production

There were a few developments in the project since the rendering stage began. Rendering the 3D building turned out to be a very repetitive as well as time consuming process, which ultimately caused us to make major design changes to the film. The average rendering time per frame for the 3D building was about 3 minutes, and we had several hundreds of frames that needed rendering. Furthermore there is no alternative but to render an entire shot in order to find out if it works, and this made it a rather slow process as we repeatedly found issues that needed correction. The consequence of the time consuming rendering stage led to the decision of excluding location two from the film entirely. This decision however, was not exclusively based on the rendering issues. We were also faced with the consequence of our beginner level experience with PFTrack in the form of some matchmoves needing that last yard in order to work properly. This combined with the rendering meant abandoning two of the five shots from location one, along with all five

from location two. What was left were three properly working shots from location one, ready to be processed in After Effects and finally edited in Premiere.

5.3.1 Adobe After Effects

With the rendering from Maya completed, the task was now to make the 3D building blend as well as possible with the real footage, a task which was done in After Effects. The 3D building was rendered as a separate layer, thereby making it possible to apply effects to it without making changes to the real footage. Even though the 3D building was rendered with textures, shadows, reflections etc. it still needed to be manipulated to fit in the scene and look like it belonged there. *Illustration* 5.17 shows the difference between the render straight from Maya and the manipulated final 3D building in the scene.

Illustration 5.17 - Left picture: The render from Maya put into the scene. Right: The final shot with all the modifications added. Copyright by the authors

The modifications done to the 3D building included several factors: color correction, blur, matte choker and lastly some masking. Although we were very pleased with the look of 3D building when it came out of Maya, that look only worked out of context. It needed to appear like it was affected by the same light as the rest of the objects in the scene, which required tweaking the colors to give it a brighter look with hints of green and blue. The changing of color is a very obvious modification, but the effect is likewise prominent and can be very effective if done properly. The subsequent modifications were not as dominant visually, but still added to the improved blended effect of the final result. A 3D model has mathematically correct lines, edges, etc. which in a matchmoving context can cause it to stick out because the lines are simply too straight and edges are perfectly angled. The solution to this was to add a slight blur to the 3D building. Not so much that it compromised the texture or other detail, but enough to tone down the mathematical perfectness. Another effect called a matte choker also helped to disguise the edges and corners of the 3D building. The render form Maya had a white background color and although we rendered in a PNG format, which excludes the background and only keeps the object, a white line around the 3D building was visible when brought into After Effects. The matte choker can shrink or expand the edges of the 3D building to reveal either more or less of the background, as seen in *Illustration* 5.18.

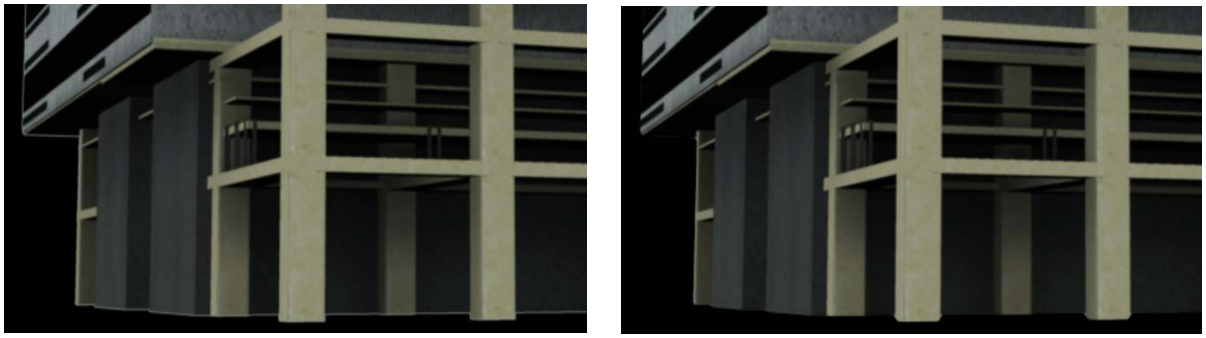

Illustration 5.18 - The effect of the matte choker is visible in the removal of the white line that surrounds the building in the left image, and removed in the right image.
Copyright by the authors

When inserted in the scene, the white line was definitely something that caught the eye and made the 3D building stick out. Removing it reduced both that problem as well as giving it a smoother look.

Masking was done primarily on the shot shown in *Illustration* 5.17, as it was the only one that had obstacles in the foreground, which really overlapped with the 3D building. The parked car suddenly having a pillar from the building through the roof was something viewers would probably react pretty strongly to, so a mask was created around the car, thereby deleting part of the pillar and making it seem as though the rest is placed behind the car, as shown in *Illustration* 5.19.

Illustration 5.19 – Left Picture: The scene without the masking of the car. Right picture: The scene with the masking applied, which is a technique that is very helpful in dealing with foreground obstacles.
Copyright by the authors

This scenario really is a key issue in using matchmoving. Hypothetically if we were working professionally with this project, a pre-determined location would be given to us along with a 3D model of a building. Should this location have a lot of foreground obstacles, there is no telling how much time we might end up spending on masking, which already is a time consuming key frame-by-hand process. The result however is a 3D model with added depth in the scene.

We were working with the 3D building and the environment as two separate layers, but there was another layer being rendered from Maya as well, shadows. We did not manage to get a result we were satisfied with of the building and shadows it casted on the ground together, and so they were rendered individually. The internal shadows the building casts on itself were still kept in the building layer, thereby leaving the ground shadows as its own layer. Since they are all soft shadows, this slightly darker area on the ground might seem like a minor issue, but it is one of those things you would notice if not present, but not think twice about when they are there. When doing the analysis, missing shadows of the people in the stylized images was a repeating factor across the work of many different companies. While the main issue with these images as well as with our film is to show a building, those missing shadows was a very distracting factor for us. A

satisfying final result, be it image or film, comes when all the little things work together to create a whole. A different kind of shadow, which could not be rendered from Maya as a separate layer, was needed for the establishing shot. Here we inserted a 3D model into a scene with a lot of water, and water makes reflections of objects placed at its bank. A missing reflection in the water would emphasize the 3D building as an inserted object, which is why we made a fake reflection as shown in *Illustration* 5.20.

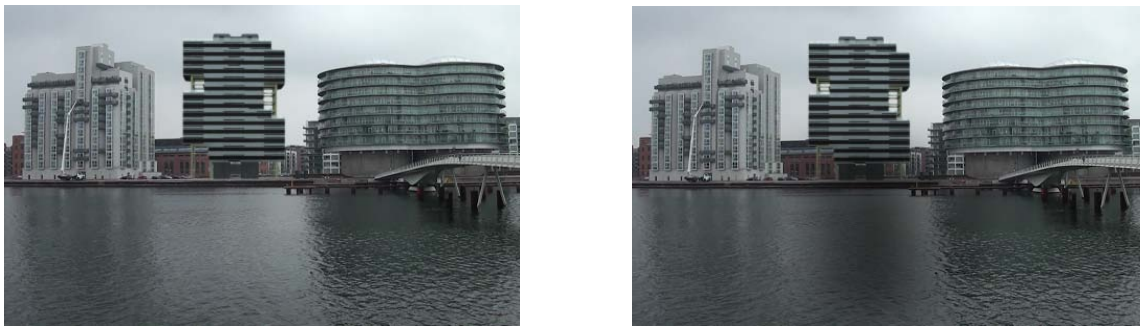

Illustration 5.20 – Left picture: The 3D building seems "pasted in" when it does not have a reflection in the water. This contrast of bright water where it should be dark is reduced in the right image, where the building is integrated better.

The last thing we did in After Effects was create the two stylized shots, shown in the last part of the film. In the film there are three variations of the shot, but one is an unaltered version for comparison. The remaining two were created because we wanted to investigate an issue that had appeared during the modifications on the 3D building layer. At a certain point, we would reach a limit of what effects and other modifications we could add to this layer, but would that be enough? Could we make the 3D building blend at a satisfactory level without interfering with the real footage? Or does aiming at a realistic aesthetic with a matchmoving approach justify making modifications to the real footage, in order to better blend the 3D building with it? We made the two variations by applying a blue and sepia colored filter respectively, as we found these to be the best candidates, based on the experiments with a wide variety of color filters. Other candidates also did a good job at blending the layers, but their color signature was taking us too far away from the realistic direction. Blue on the other hand can be argued to resemble a cold winter morning and sepia with its warm color tones could be the middle of a summer day. These two choices, shown in *Illustration* 5.21, were made because we thought they worked well at blending, while also having real world references.

Illustration 5.21 - The two visual styles of blue (left picture) and sepia (right picture), which were used to investigate whether users found the layers to blend better with modifications added to the real footage as well.

5.3.2 Adobe Premiere

Premiere was the last program to process the now modified shots. In this last stage of the film, each individual shot was at its final stage and they needed only to be combined to make up an entity. Following the storyboard design, the shots were put into their rightful place, to which the only work needed was to make transitions between shots and text pieces stating titles and credits. The main work while editing was the sound design. The requirements for the sound stated that we should follow the Dogme rules in the matchmoved shots, which meant no music or other forms of inserted sound. The only thing the viewer should hear is the sound recorded at location. However the film also contained introductory CGI shots as well as the experimentation with visual styles, and these shots did not have a native sound, which would make for a very quiet film despite the short length of one and a half minute. The plan was therefore to have a lively introductory music piece that would accompany the earth zoom and the construction animation, which sets up for the main matchmoving shots. As these appear, the music disappears with the intention that the contrast of real world sounds versus music will make the viewer more aware of the transition from shots containing obvious CGI to shots appearing to be real footage. The audio contrast, we believed would be more prominent if the introductory music was something more upbeat rather than slow-paced background music, and we therefore decided to use "*Little L*" by Jamiroquai, also because it worked well with the visual transitions if the film. We also needed underlying music for the sequence showing the experimental visual styles and as these were slow motion shots, we thought it suitable to use slower paced music to better match audio and visual elements. The song chosen for this purpose was "*Something about us*" by Daft Punk.

With the editing and sound implementation complete, the final film of one and a half minute contained three of the initial ten matchmove shots. While having experienced various problems and delays during the implementation, we were satisfied with the end result and the fact that we had been able to plan and carry out the project without having to re-visit the location and re-do everything from scratch. The film was finished and now ready to undergo testing at the various companies, with whom we had initially been talking to in the analysis stage of the project.

5.4 Production pipeline

With the implementation complete, we constructed a summary of it in the form of a production pipeline, which has been introduced earlier in chapter *2.1 Choosing matchmoving*. This is a way of creating an overview of the various steps in the process and from this we can document the amount of time used, which should be presented to the companies to get feedback about how this pipeline relates to their preconceptions of matchmoving. The pipeline for this project, showing the general production steps, looks as follows:

1. Find building and locations
2. Create building in 3D, if not provided
3. Craft storyboard
4. Shoot at location
5. Matchmove the shots
6. Render building to match shots (lighting, shadows etc)
7. Compose film
8. Post-production to match building and shots.

Going through all steps took roughly three weeks, to which it will be interesting to hear the responses from the experts related to the project. How does this amount of time compare with what they know about matchmoving? And will this make them more positive or negative towards the idea of using matchmoving in

the industry? Furthermore, as this is our first attempt to make a matchmoved architectural visualization, we do expect to be able to reduce the amount of time spent on production, should we create a second film.

With the creation of the production pipeline, providing an overview of all steps required to create the project film, as well as the required production time, the project film itself was thereby complete. All analysis and subsequent design decisions had served to dictate the creation of this project film and the project was thus able to proceed to its final phase: The test.

6 Test

The purpose of the test is to determine if the project satisfies the final problem formulation. A solid proof is only obtained, if visualization companies generally begin using matchmoving professionally. Therefore, the test is mainly seeking good indications and suggestions of a satisfaction of the final problem formulation, as well as how to proceed with further development of the project. The test was carried out using the same experts from the architectural and visualization industry as we interviewed for our analysis, as described in chapter 2.3 *Why matchmoving is under-used in the industry* and chapter 2.4 *The purpose of architectural visualizations*. Additionally the test was also conducted on a control group, whose respondents represent the general public. An overview of the experts as well as the control group respondents can be seen in *Table* 1.

Group	Name	Company	Demographic	Background	Test conduction by	Questions answered
Expert	Eugen Olsen	3DTree	South Africa	VFX artist	E-mail	10 out of 10
Expert	Peter Krogtoft	Moose Studio	Copenhagen	Autodidactic	E-mail	10 out of 10
Expert	Ernst Krogtoft	Moose Studio	Copenhagen	Autodidactic	Personal interview	10 out of 10
Expert	Poul Erik Christensen	Vistec	Copenhagen	Architect	Personal interview	10 out of 10
Expert	Lars Hilfling Nielsen	Cenario	Copenhagen	Architect	Personal interview	10 out of 10
Expert	Peter Krogh-Hansen	Archivisuals	Copenhagen	Architect	Personal interview	10 out of 10
Expert	Uffe Leth	SEA (Architectural company)	Copenhagen	Architect	Personal interview	8 out of 10
Expert	Intern	SEA	Copenhagen	Cand. Arch	Personal interview	5 out of 10
Expert	Intern	SEA	Copenhagen	Cand. Arch	Personal interview	5 out of 10
Expert	Intern	SEA	Copenhagen	Cand. Arch	Personal interview	5 out of 10
Control group	1 Anonymous by choice				Personal interview	6 out of 8
Control group	2 Anonymous by choice				Personal interview	6 out of 8
Control group	3 Anonymous by choice				E-mail	7 out of 8
Control group	4 Anonymous by choice				E-mail	6 out of 8
Control group	5 Anonymous by choice				E-mail	7 out of 8
Control group	6 Anonymous by choice				E-mail	6 out of 8
Control group	7 Anonymous by choice				Personal interview	6 out of 8
Control group	8 Anonymous by choice				Personal interview	6 out of 8
Control group	9 Anonymous by choice				Personal interview	6 out of 8
Control group	10 Anonymous by choice				Personal interview	6 out of 8

Table 1 - Overview of the test respondents and their respective information.
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In total, we had 20 test respondents divided in the two equal numbered groups of 10 people each. The lack of answers by the people from SEA is because the questions are targeted primarily towards the visualization experts and not architects, although it is interesting to have their opinions as well. This meant that we had questions related to our pipeline and industry potential, to which answers from an architectural company that does not work with these things would be guess work.

6.1 Designing the test

The test design should ensure, that the test gathered data relevant to the final problem formulation. It should clearly establish the main goal in detail, explain how our relationship with the test respondents affected the test, explain and argue for the chosen type of test, as well as examining each question in detail, what type of data should be gained from each question and how to gain this data.

6.1.1 The goals of the test

The main goal of the test was to determine, if the project film fulfilled the final problem formulation – more specifically *if matchmoving could indeed be an addition to contemporary industry architectural visualizations, and subsequently how*. The interview will examine if this project has changed expert respondents' preconceptions of using matchmoving in the industry by presenting the production pipeline for the project film, as well as the time consumption from following this pipeline. If the pipeline has indeed altered perceptions about the usefulness of matchmoving, it might contribute to presenting matchmoving as a valuable addition to contemporary industry visualization methods.

Furthermore, the interview should reveal if the chosen project aesthetic has indeed succeeded in conveying a realistic mood to the viewer, both in general, but also regarding the specific elements that make up the project aesthetic. Any bias of the respondent should be examined, since their opinions might be shaped by how they are used to perceiving architectural visualizations, particularly the expert respondents, who are employed in the industry. Apart from the project aesthetic, the project film also proposes a few different visual styles, which can be assisting in blending the 3D building with the footage and the effectiveness of these visual styles should be examined in the interview.

6.1.2 Relationship with the respondents

All the Experts will have been previously interviewed in relation to this project. During these previous interviews, or through the mail correspondence, the purpose of this final test was explained to them, making them aware of this test in advance. Furthermore, consent has been given to use the data and opinions gathered for this final test in the project. More precisely, if data is presented in the report, we have been given permission to use it for this purpose. Additionally, the respondents are only asked to give whatever opinions they choose, enabling them to protect any form of sensitive information. The interview does not require any personal information, such as age, address etc. We are familiar with their names and company names. However, this information is publicly available online, but even so; person names are not essential to the success of the test and could be excluded on request.

6.1.3 Type of interview

The test was conducted as an interview. We are interested in the opinions of the respondents, since the problem formulation seeks to test a method of visualization generally unused in the industry as a whole. Before the test, the respondents will not have seen the project film and will thus be completely unfamiliar with its specific aesthetic, editing, length etc. Having no previous experience with it, we cannot say with absolute certainty that it fulfills its purpose or is constructed in such a way that every respondent will perceive it as intended. We should therefore allow the respondents to give more open answers, to allow for the possibility, that the project film might fulfill its purpose exactly, might fail to do so or might have an unintended effect.

The interview itself is primarily unstructured, consisting of generally open questions (Sharp, Rogers, & Preece, 2007, s. 298). We are exploring the validity of matchmoving as a new addition to architectural visualization, and open-ended questions, through an unstructured interview, serves this purpose well. For example, when gathering opinions about how the expert respondents view the possible uses of matchmoving for the industry, we are not interested in e.g. the use of a Likert scale (Sharp, Rogers, & Preece, 2007, pp. 313-316) to rate the validity from 1 – 5 for a specific industry use (such as a direct competition to 3d animations). We want to allow our expert respondents to utilize their experience from the industry and give a more free opinion of how matchmoving could be utilized in the industry. With matchmoving being as underused as it is, determining a level of validity for a specific industry use, is not as important as determining where the technique can be used.

An additional possibility for data collection would be using a semantic scale (Sharp, Rogers, & Preece, 2007, pp. 313-316) when examining the result of using the project aesthetic to visualize architecture, compared to the industry aesthetic. Using a semantic scale could let the respondent denote their preference from “heavily favoring the project aesthetic” to “heavily favoring the industry stylized”, thus directly contrasting the two aesthetics. However, this might leave out detail about why their preferences where as they were, as well as for which part of the architectural production their preferences apply. They might prefer the industry aesthetic for marketing, but not for aiding in production of the building. And since this project also attempts to determine how matchmoving can be used in the industry, it’s important not to exclude such details.

Another important reason for using open-ended questions is when determining if the project film conveys a realistic mood. Rather than a yes/no or a rating of how realistic the mood is, either on a Likert or a semantic scale, we are also interested in which parts of the project film that formed this decision. It is the blending of a 3D building with real footage? Is it the rendering of the 3D building? Is it the colors of the project film? Is it the chosen camera angle and camera movements? Not only can these details reveal any inherent bias from the respondent when judging what constitutes a mood in a visualization, but it can also show if many respondents focus on similar elements, which then allows for analysis of why these elements were in focus. And unless directly suggested, it is highly unlikely that a test respondent would rate their level of perceived realism from a mood with a number, further discouraging the use of a Likert scale for gathering data such as this.

Overall, the concept of using matchmoving for architectural visualization is so underused in the industry, that as much detail about how the industry views its validity for visualization is desired. The project film has been created based on previous industry interviews and research of relevant theories and techniques, but the end result might be influenced by many other elements. We are not professionals and do not have extensive working experiences with creating architectural visualizations. Thus, the interview might reveal determining factors that we did not contemplate. However, the test should account for this possibility of unforeseen

opinions and is therefore designed to be open and allow for the respondents to provide as detailed opinions as they see fit. However, there are times where we must ensure that respondents consider the use of matchmoving for more specific purposes, such as determining what matchmoving can provide that the industry visualizations cannot. As such, a more semi-structured approach should be considered for certain questions, where we need to guide the users' focus.

Question 1

What style of mood did the film convey to you?

Initially it was important to clarify for the test respondents that this question, as well as the following two questions of the interview only related to 00:41 – 00:58 of the project, which shows the matchmoved shots. The entire project film moves through various phases, such as establishing where the building is placed in the real world, the actual matchmoved shots that the final problem formulation regards and a comparison of visual styles. However, the first three questions of the interview only sought to reveal the respondents' opinions on the matchmoved shots.

The first question of the interview served several purposes. The project film is designed to convey a specific mood to the user, mainly through two aspects of the aesthetics described in chapter 4.1 *Designing the project aesthetic*, pedestrian POV and a grey sky. This question was meant to gauge if this was indeed the mood conveyed to the respondent, or if the project aesthetics failed to serve their purpose.

Another aspect of this question was to intentionally leave it rather open. Instead of asking the question specifically in regards to the purpose of the realistic mood, the openness of the question could also elucidate any inherent bias that the test respondent might have going into the test. People might have different preconceptions on what the word "mood" entails and might not focus on what the project film adds, but instead how it differs compared to contemporary architectural visualizations or its potential for marketing. Conversely, test respondents not employed in the industry might instead focus on the project film in terms on the overview of the building, the editing etc. Becoming familiar with early bias can be important when analyzing answers to the following questions. If people with similar bias answer concurrently, that test data might only be valid for that segment of test respondents.

Question 2

What did you think of the use of matchmoving in the film, with regards to the purpose?

This second question is significantly more specific, compared to Question 1. The main purpose of the entire interview is to obtain opinions about the realism of the project film, so it was necessary to guide the respondents with this question, letting them know what to judge more specifically. The use of matchmoving is one of the three main aspects of the project aesthetics and thus an essential part of the additional visualization method proposed by the final problem formulation. As such, obtaining opinions about its effectiveness in conveying a realistic mood is central to the interview. "The purpose", which makes the question specific, was defined before the start of the interview, as the realistic project aesthetic in contrast to the stylized industry aesthetic in order to more concisely formulate the question.

There are various elements of contemporary visualization techniques that this question seeks to contrast. The use of matchmoving in this project refers to merely filming actual reality and adding only the 3D building, as opposed to composing the image of many external elements to craft the desired mood, such as is usually

done in the industry. If used successfully, the matchmoving should create a much less virtual and more real mood the industry visualizations. The respondent should get a good sense of the project film showing the building in the real world at the chosen location, as opposed to showing the building in a scene that might not be present in reality, but is merely created for a specific mood.

Question 3

What did you think of shooting the film from a pedestrian point of view, with regards to the purpose?

This question addressed the effectiveness of the second vital aspect of the project aesthetic. With camera placement and movement being a major contributor to the virtual quality of industry visualizations, it was important to determine how well the pedestrian POV supported the project aesthetic. In relation to industry visualizations, while addressing a certain aspects of still images, this question mainly relates to animations, being that animations utilizes both camera placement and movement, establishing a direct contrast between animations of the project film through this question.

If successful, the pedestrian POV should establish in the respondent a sense of walking by or standing and looking at the building. When the camera moves around in a traditional industry animation, the main goal of the movement is to show the building from many angles and with a focus on overview through good framing. This question will illustrate if the pedestrian POV did a sufficient job of focusing not on overview, but more on suggesting a specific observer of the 3D building in the scene. Since walking by a building or standing and looking at it is a normal activity, in contrast to flying around it, this question will thus clarify if the pedestrian POV was a contributor in conveying a realistic mood to the user.

Question 4

Which visual style was best at blending the 3D building with the real world footage?

This question, as well as the following two questions, now switches focus from contrasting matchmoving with contemporary industry visualizations, to instead gathering opinions on the three different visual styles presented as the final part of the project film. Before asking these three questions, the user is presented with an image of each visual style. This question sought opinions about how well a given visual style blended the 3D building with the footage and made it stand out the least. Making the building appear to be a believable part of the scene should increase the realism of the project film as a whole, since an obvious distinction between the 3D and the footage would most likely draw focus to this difference, rather than making the building part of the footage and appear as if it was present in the scene, rather than just being in a layer on top of it. It was important to inform the respondent which building was added to the project film through 3D, but the editing at the start of the project film served this purpose, allowing us to focus the implementation of the build on blending it with the footage, rather than to show that it was what the respondent should focus on when watching the project film. The respondents' perception of realism might be lessened if the 3D building stands out noticeably from the footage, so information about the success of blending 3D and footage was obtained via this question.

Question 5

Was this visual style also the most realistic?

The purpose of this question was to determine if the visual style chosen to be most successful at blending the footage and the 3D building also contributed to enhancing the perceived realism of this visual style. If the

user chose either the sepia or the blue visual style from Question 4, this question could determine if the enhanced blending of 3D and footage made them overlook the addition of a color filter and only perceive enhanced reality, or if the color filter remained sufficiently noticeable so as to detract from the notion that the chosen visual style from Question 4 also looked the most as if it was actually filmed from reality.

Question 6

If you answered no to the question above, what could be changed/improved in the most realistic style to blend the 3d building better with the real footage?

This question served to clarify why the respondent did not perceive the most realistic visual style to also be the best at blending 3D and footage. It might invariably provide answers in the form of contrasting the three suggested visual styles – blue, sepia and unaltered – but the respondent was encouraged to answer more generally as well, without referring solely to the suggested visual styles. This question could reveal if the difference in answers between Question 4 and Question 5 was merely a result of the color filters distracting too much from a perception of reality, or if points of criticism related to aspects unaffected by the change of color filters. A respondent might perceive e.g. the unaltered visual style as the most realistic, a lack of shadows in certain locations or perhaps a perceived incorrect use of reflections in windows. These examples would not be solved simple addition of color, but would rather indicate that more work needed in other areas of implementation of the project film, such as in the rendering of shading of the building in 3D.

Question 7

What did you think of the goal being a realistic mood rather than the typical stylized visualizations?

This question addressed respondents' opinions of the result of focusing on a realistic mood, rather than the industry-standard stylized mood. The open nature of this question allowed the respondent to express broad or narrow ideas of the validity of matchmoving to visualize architecture, including any pros or cons specifically contrasting industry visualizations. While previous questions regarding matchmoving up to this point have been concerned with the ability of matchmoving to convey a realistic mood, this question seeks knowledge about the validity and proposed purpose of any such ability. More than any previous questions, this one addresses what type of addition matchmoving could be to contemporary visualization methods, if not in direct relation to the industry, then merely in relation to the mood expressed by industry standard visualizations, as well as the mood conveyed by the project film.

Question 8

Did this pipeline confirm, deny or change your perception of the usefulness of matchmoving within the area of architectural visualization?

This question sought to test for any bias about the technique on behalf of the respondent, namely its consumption of time in production. This was important for determining matchmoving as a valid or invalid addition to industry visualizations, and maybe remedy its almost complete lack of industry use. Without the demonstration of the project film, the project aesthetic or the determined time required to create the project film, the respondent would have to rely mainly their own preconceptions of the technique. They might not have working experience with matchmoving, or their experience with matchmoving might be through an entirely different pipeline, such as 3D Tree creating their matchmoving via helicopter shots; a very different approach from the project aesthetic. When demonstrating the project film in relation to this question, the

respondent could consider the final result or the time it took to create it, as well as putting it into perspective with their normal way of working with architectural visualizations. This includes comparing the pipeline with how long a 3D image or animation takes to create, how they compare the project film to the purpose of their regular visualizations etc.

However, the question is only relevant for expert respondents; the control group was not suitable to answer this question, as they do not work in the industry and therefore have nothing to relate the pipeline to. Its main focus is to determine if the pipeline and proposed production time of the project film from start to finish, established by this project, was similar to what our expert respondents had experience with from their professional work or their knowledge about the use of this technology in the industry. Since the only true difference between the expert respondents and the control group is, that the control group is not employed in the architecture industry, they have no real basis for answering this question.

Question 9

Do you think this use of matchmoving has potential for industry use?

This question is similar in purpose to Question 7. However, this focuses not so much on what the result of creating a realistic mood is, but rather how this result can be usable in the industry. It allowed the respondent to suggest where they specifically saw a use for matchmoving, if not as replacing industry visualizations, which our previous interviews suggested that it would not. The final problem formulation suggested matchmoving as an addition to 3D images and animations, but did not suggest a specific use for matchmoving in the industry, since we had no knowledge of the industry's perception of matchmoving at that time. This specific use is the goal of this question. It still has a rather broad wording however. The question should not suggest anything in advance. Even though we were somewhat sure that matchmoving would not replace traditional 3D images and animations, including this in the question itself might lead the respondent away from even considering a potential replacement of traditional visualizations with matchmoving. Thus, the question was kept to probing potential industry use in general, allowing the respondent to freely suggest how matchmoving could be utilized in the industry.

Having asked these 9 questions, the interview have given us respondent opinions about the effectiveness of matchmoving on conveying a realistic mood, broken us specifically into the two main elements of the project aesthetics – the matchmoving technique and the pedestrian POV. It has gauged any initial bias from the respondent, regarding their preconceptions on how architectural visualizations should be used, their perceptions of the project aesthetics and if it serves an unintended purpose in relation to the final problem formulation. While not critical to the successful utilization of matchmoving, the blending of 3D and real footage was also examined in the interview, since this blending should further enhance the perception of realism in the project film. Finally, the interview sought opinions regarding the result of aiming for a realistic mood, both in general, and specifically related to any potential use in the industry, both considering the final result of using matchmoving to promote realism, as well as the pipeline and time consumption for creating a matchmoved visualization.

Question 10

This final question allowed the respondent to provide any additional comments they wished. Should they feel, that the previous questions did not allow them to express certain opinions, they could do so here.

6.2 Test conduction

The test was conducted in two different ways and on two different groups, the industry professionals we had interviewed earlier in the analysis stage and a control group consisting of the general public. Since it was not possible for us to visit and interview all the people we have collaborated with, we had to design another way of testing on these. The company 3DTree is located in South Africa, which eliminated the possibility of us going to visit them. Another issue of working with professionals was that they sometimes were too busy to meet with us, which was understandable. They were helping us pro bono and could not lead that interfere with the work they were doing for other clients. The solution to the problem of not being able to meet was therefore to send the test questions by mail, along with a link to our film, thus allowing them to answer when they had time to spare. Fortunately for the expert respondents we only needed to use the secondary test method by mail for 3DTree and for Peter from Moose Studio. Both test methods were used for the control group, interviews for the ones willing to participate at Aalborg University campus in Copenhagen, and by mail for the ones unable to participate in person.

The procedure for the interviews was straightforward, starting with an introduction of our project in case they had forgotten or were not familiar with it. Then, with the audio recorder turned on, they were shown the film on a laptop and one and half minutes later we began the interview. However there was one difference between the two groups. Before we showed our film to the control group, they were shown examples of the traditional stylized visualizations, which was not necessary for the professionals as they are very much familiar with it. Except for the visit at the company SEA where we interviewed four people simultaneously, the interviews were conducted on individuals. We all sat around a table, the two of us side by side and the interviewee at the opposite side. We did not have a strict schedule of who should say what in terms of questions, which was why we found it best to sit side by side so that the interviewee could answer to us as en entity, rather than being in doubt of who to talk to. At the interview with SEA we handed out paper and pencil and asked everyone to write down a couple of keywords to each question so that we would have data for each question individually. When interviewing a group of people, it can occur that some might follow along with other's opinions rather than stating their own, which would not produce the results you could achieve if conducting separate interviews. In this case we interviewed the co-founder of the company and three architect interns, so in terms of power balance, there was definitely a member of the group whose opinion was tempting to follow along with. By having them write individual answers, we could get the opinions that they might have avoided to mention, had the interview been purely vocal.

The conduction of the test by mail was even simpler than the interviews, as it merely consisted of composing a mail with an introduction to the project and test, a link for showing the traditional stylized visualizations (only for the control group), a link to our film and lastly the questions. The advantage of such a test is that you can reach a large amount of people with relatively little effort. The disadvantage though is that the answers might not be as elaborated as desired, whereas in an interview you can follow up on the answers provided and ask them to elaborate.

6.3 Test results

Before presenting and elaborating on the test result, it should be noted that an expert participant will be denoted Expert and a control group participant denoted Control. Furthermore the ten interview questions are listed below for reference reasons as they are being mentioned extensively throughout this chapter.

Question 1. What style of mood did the film convey to you?
Question 2. What did you think of the use of matchmoving in the film, with regards to the purpose?
Question 3. Did the decision to shoot the film from a pedestrian point of view benefit or detract from the purpose?
Question 4. Which visual style was best at blending the 3D building with the real world footage?
Question 5. Was this style also the most realistic?
Question 6. If you answered no to the question above, what could be changed/improved in the most realistic style to blend the 3d building better with the real footage?
Question 7. What did you think of the goal being a realistic mood rather than the typical stylized visualizations?
Question 8. Did this pipeline confirm, deny or change your perception of the usefulness of matchmoving within the area of architectural visualization? (This question was only for Experts)
Question 9. Do you think this use of matchmoving has potential for industry use? (This question was only for Experts)
Question 10. Additional comments?

The main bulk of test results consist of very open opinions, apart from the two questions regarding the respondent's preferred visual styles of which blended the best and which looked more realistic, which provides a relatively narrow data set. However, the remaining test data need a form of organization, providing overview over which answers, suggestions and indications it provides towards to final problem formulation. To this end, test answers will be organized in graphs based on the concept of the affinity diagram (Sharp, Rogers, & Preece, 2007, p. 378). An affinity diagram determines common themes amongst the test data and groups them together. These themes can be created according to e.g. individual test questions, but does not necessarily need to be, since the themes should emerge from the test data and not be predefined. Since these affinity diagrams are formed from themes throughout the test data, answers that are only given by a single test participant will be grouped into a category called "Others". A reason to group solitary answers like this is that an idea held by only one person is rarely an indication of anything.

The total amount of test participants is 20 people, and for a group in the affinity diagram to propose a valid indication, it should be constructed from a majority of test participants. Therefore, while a group of 3 participants might not promote a solid indication, a group of 15 participants would.

Was the aesthetic realistic?

Since the final problem formulation was concerned with how to present matchmoving as an addition to contemporary visualization methods, it was important to construct affinity groups to determine if the specific way, chosen by this project, of presenting matchmoving as an addition was successful or if users perceived the project aesthetic in an unintended fashion. The first affinity diagram therefore became as seen in *Illustration* 6.1.

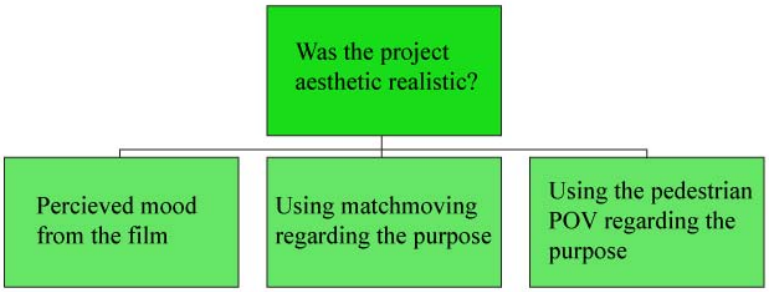

Illustration 6.1 - The affinity theme which involves the first 3 questions.
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This affinity diagram consists of three categories, one for each of Question 1, 2 and 3, since they all concern what a test respondent perceives from the project aesthetic. It will be examined in detail in Illustration 6.2.

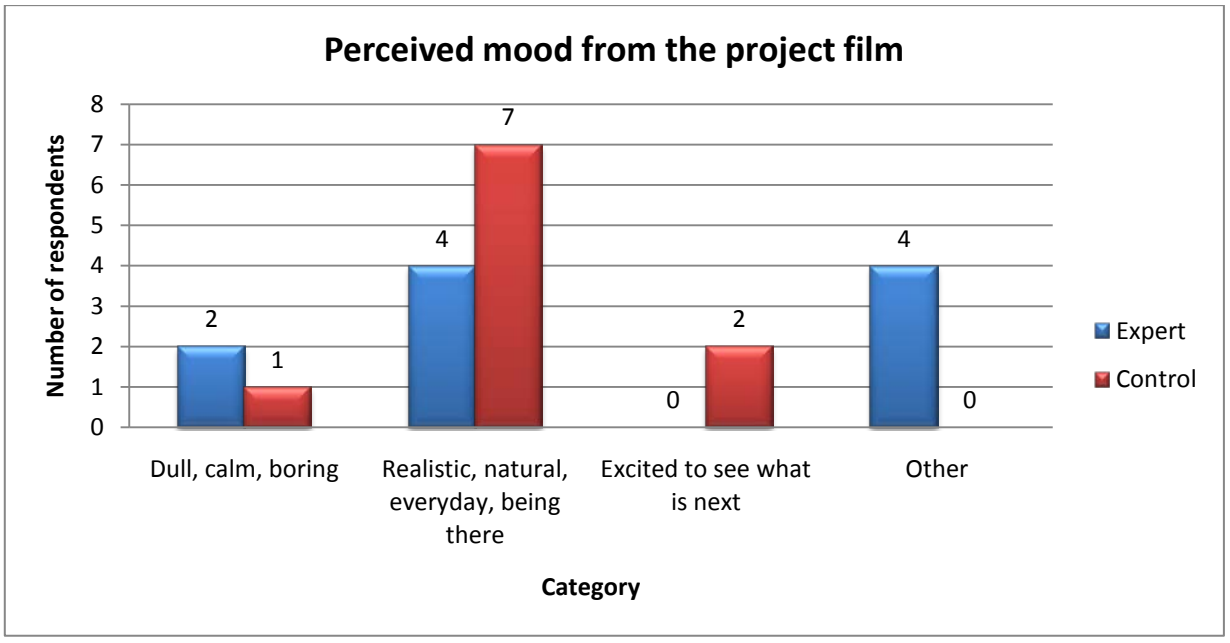

Illustration 6.2 - Categories of the generally perceived mood from the project film.
Copyright by the authors

As seen in *Illustration* 6.2, most respondents perceive a realistic mood from the project film. 11 respondents belong to this category, which consist of answers relating to a realistic mood. With paraphrasing considered, the descriptions of "Natural", "Everyday" or "Being There" are all relatable to "Realistic", since they all convey an answer that refers to the perceived mood being from reality. 3 respondents perceived the project film as dull, calm or boring. These answers indicate that the project film had a minimal effect on these respondents, which allow them to form the same category.

Quotes from realism group:

- *"You get a good sense of this building standing between two other buildings and how it meets the ground."*
- *"Being there, because the camera "walks"."*
- *"Like when you randomly walk on the street and film it. Natural."*

Quotes from Other:

- *Initially it does not feel very realistic, due to the intro and construction animation where you break the illusion.*
- *"If the mood is about the weather, I´m not so sure it would work from a sale point of view. But it looks dramatic and interesting."*

"Excited to see what's next" might refer less to a mood and more to editing, but was nonetheless given specifically by two respondents. In general, more Controls than Experts provided the same answer.

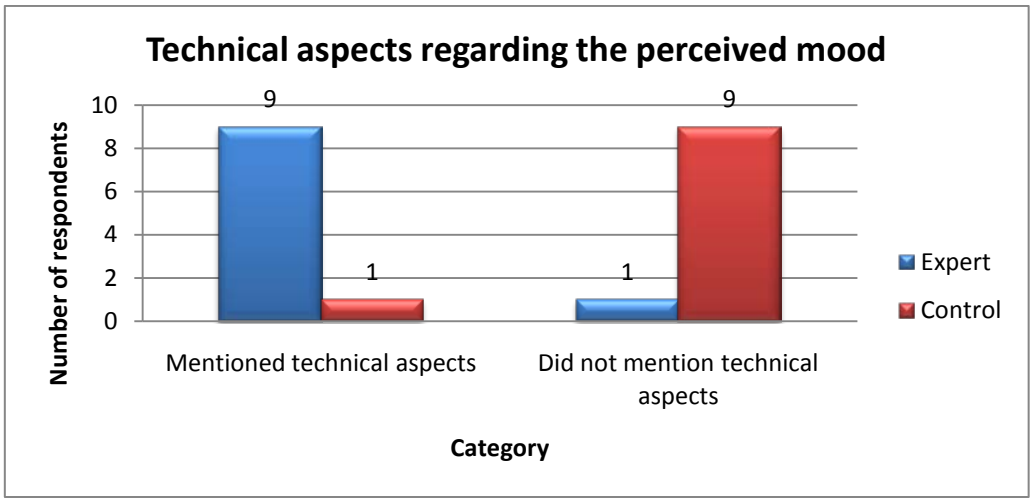

Illustration 6.3 - In relation to the perceived mood from the film, almost all Experts mentioned technical aspects, whereas almost all Controls did not.

Mentioning of technical aspects, shown in *Illustration* 6.3, was a category containing answers from respondents that mentioned technical aspects when answering Question 1, such lacking visual details in the 3D building. The category also covered mentions of elements normally part of industry visualizations, such as a pretty sky or people in the scene, which were missing from the project film. However not all technical comments were about what was missing or could be improved.

- *"From a technical point I think you guys did a great job."*
- *"I found the video to be nicely put together. Entertaining and well-produced."*
- *"a fantastic illusion of moving in relation to a 3D object"*

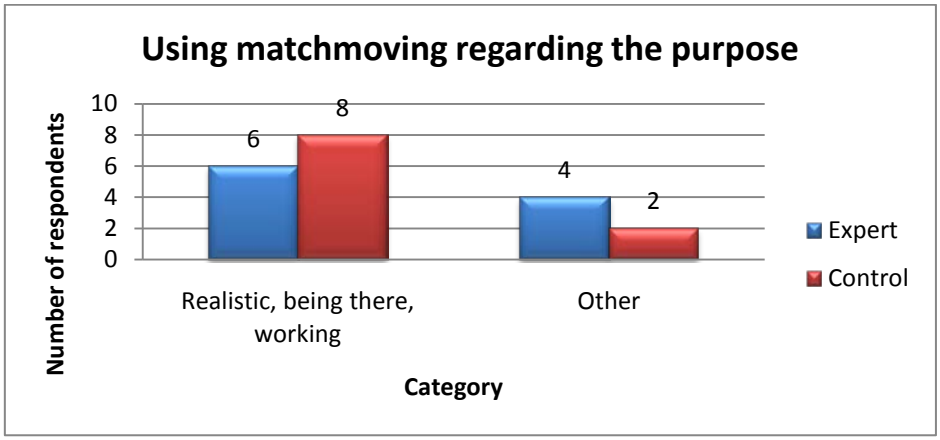

Illustration 6.4 - What participants thought specifically about matchmoving for creating a realistic mood.

Very few disagreements on perceived mood were present for this question, as shown in *Illustration* 6.4. In fact, only a single common mood was given. A total of 14 respondents described the use of matchmoving as working well towards creating a realistic mood in the project film. Once again, descriptions such as "Being There" and "Working" were grouped together with "Realistic", since they provide uniform answers, only with different wording. Almost as many Experts as Controls answered in this category.

- *"This is much more realistic."*
- *"It works well. It seems more probable that the building is there, as opposed to the fly-around style."*
- *"Realistic – not idealized."*

A few lone answers include that the mood was not realistic, but mystic or that the 3D building did not look as good as the footage, which distracted the respondent from perceiving a mood from the matchmoving.

- *"You have very little movement in your matchmoved shots. It could almost have been 3D stills."*
- *"it is important that the project stands out and not everything else. Here it is almost the project that looks the worst."*

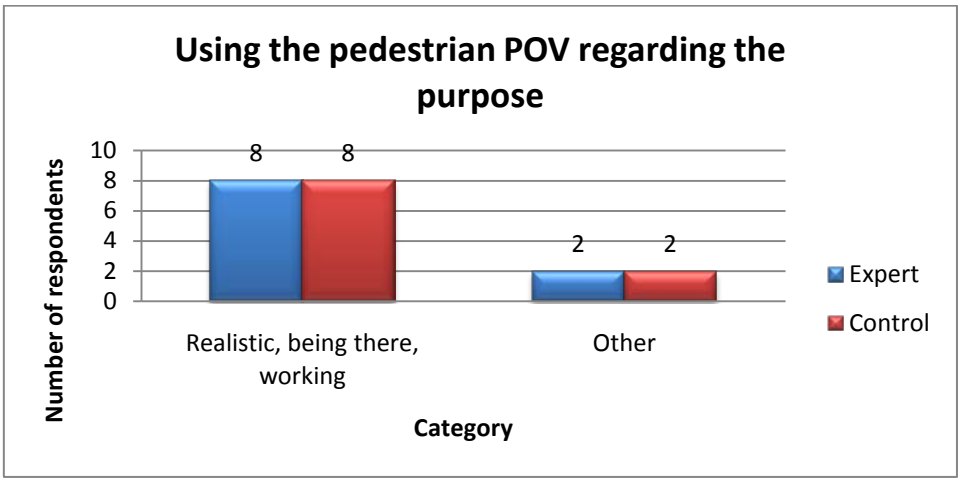

Illustration 6.5 - What participants thought specifically about the pedestrian point-of-view for creating a realistic mood.

This question, shown in *Illustration* 6.5, much like Question 4, created very few differing opinions. Once more, only a single, common mood could be found in the answers, and once again, "Realistic", "Being there" and "Working" created this description. Respondents were in slightly more of an agreement in this category, since 16 respondents, an equal number of Experts and Controls, answered towards a realistic mood.

- *"I think the pedestrian view was particularly beneficial - giving a 'hands-on street perspective' of what the building would be when built. That is always one of the missing factors in architectural visualization"*
- *"Definitely positive because it is the way people would see the building."*
- *"Your movements are decoded as human movements, it's not a machine. It's opposite to the mechanical motions of traditional 3D animations. This is much better. You can make those handheld things, it has potential."*

Some "other" answers included one respondent who was distracted from perceiving a mood by the camera angle or a lack of overview of the building.

- *"It was only the last of the three shots where I felt a 3D feeling. The other two just felt like shaking 2D images."*
- *"Missed that the camera looked up."*

Out of all affinity categories, this included the single greatest amount of agreeing answers of the entire test. More respondents perceived a realistic mood when considering specific elements of the project aesthetic than when they evaluated the project film as a whole, with 11 respondents for a general evaluation, opposite 14 and 16 for more specific evaluations. Notable is also the fact, that slightly more Controls perceived a realistic mood than Experts. For the project film in general, 7 Controls perceived a realistic mood versus 4 Experts. This difference shrunk for specific evaluations to 8 Controls versus 6 Experts regarding the result of matchmoving and no difference with 8 Controls and 8 Experts regarding the result of the pedestrian point-of-view. Ultimately, the realistic mood was the dominant answer given throughout this affinity theme, with answers such as dull or boring being much less common and only being consistently present for evaluating the project film in general.

Visual styles

To get additional information about establishing realism, the ability to blend the 3D building with the footage should be examined. It is expected that the more the 3D and the footage blends together, the more real the project film would look. Therefore, respondent preferences between the suggested visual styles should be considered, which was done through Question 4 and 5. These two questions were unique to the interview, in that they did not gather open opinions, as much as they presented a choice between three options. No affinity diagram was made, since the data obtained from these two questions could not be grouped into categories emerging from the data, but was rather delegated to fixed categories.

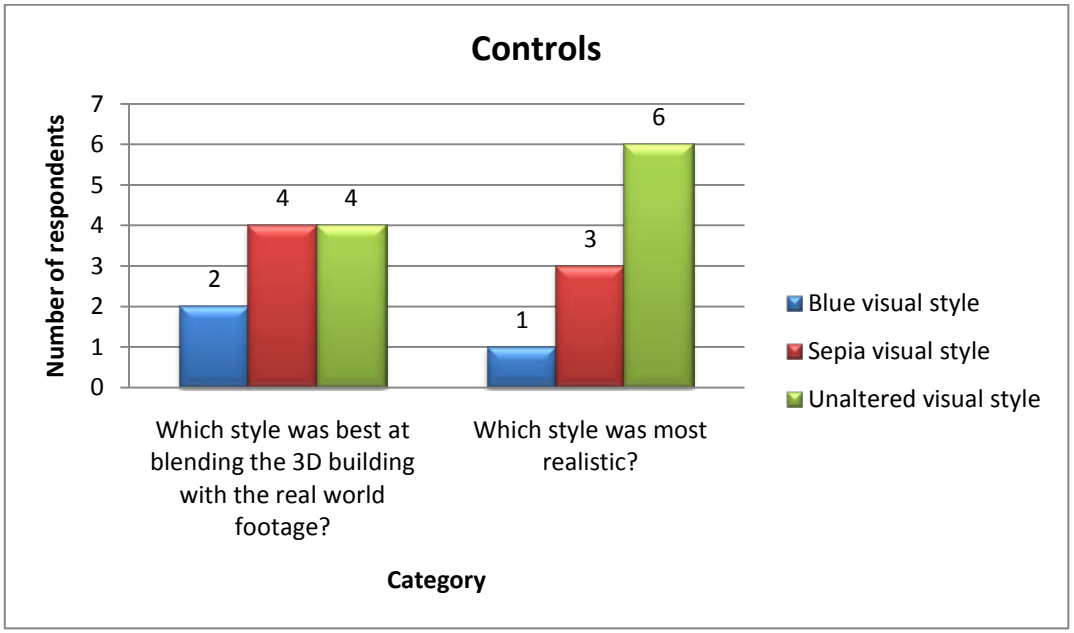

Illustration 6.6 - Opinions from Controls about the visual style investigation.
Copyright by the authors

As shown in *Illustration* 6.6, 4 Controls chose sepia and the unaltered respectively, whereas only 2 Controls found the blue to be the best at blending. The unaltered on the other hand scored the highest regarding the most realistic style, with 6 Controls choosing it, followed by sepia with 3 Controls and lastly the blue with 1.

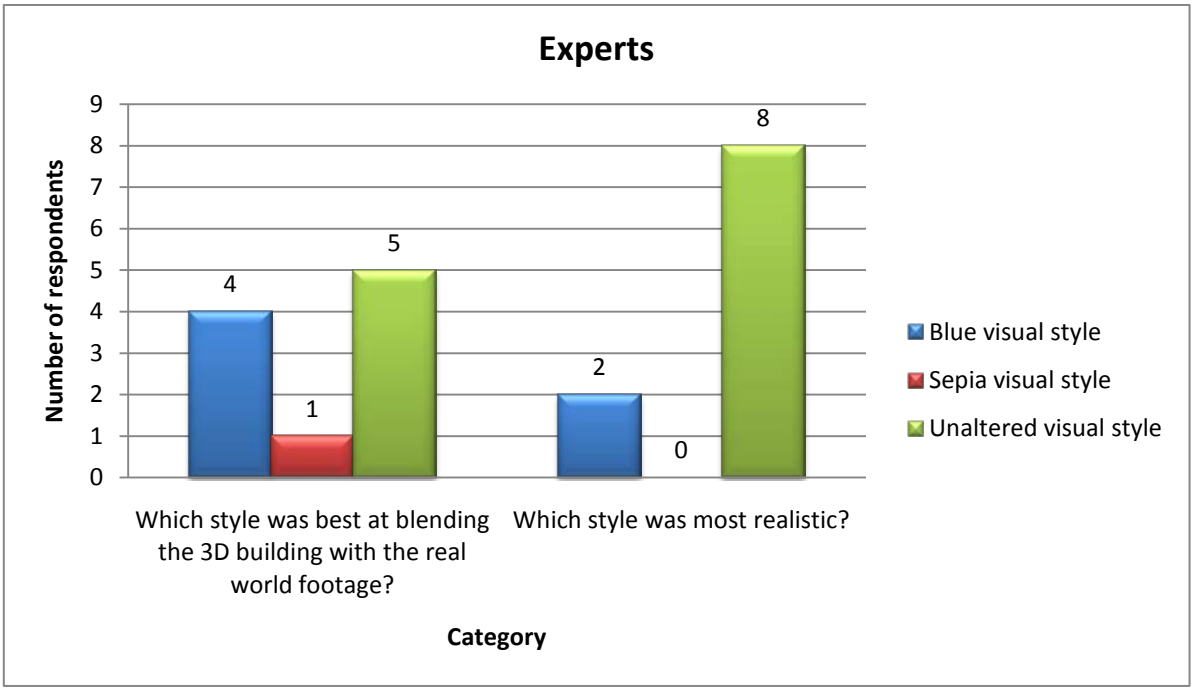

Illustration 6.7 - Opinions from Experts about the visual style investigation.
Copyright by the authors

Illustration 6.7 shows the unaltered as the favorite in both cases. With 5 Experts, it was the most popular choice for blending, closely followed by the blue with 4, where sepia, with 1, was the least favorite. With regards to realism, the unaltered scored 8 of the 10, where the last 2 Experts chose the blue style.

Comparing the two graphs shows that the unaltered style was the preferred for both user groups regarding realism. It was preferred for blending by Experts, but scored similarly to sepia for Controls. Controls chose sepia more often than Experts.

Determining a bias towards sales

This affinity category sought to clarify any bias towards evaluating the project film from a sales perspective between the two groups of respondents, since the only difference between the two groups is the fact that Experts works professionally with architectural visualizations. Even though the final problem formulation aims at presenting an additional visualization method to the industry, the point is not solely to evaluate a potential marketing purpose for the project aesthetic, although it is certainly the primary examination. An inherent sales bias was expected to exist with the Experts, since their professional perspective of visualizations should be to use them for marketing purposes. It was important to ensure if such a bias existed, or to determine if it was maybe the Controls who focused more on sales.

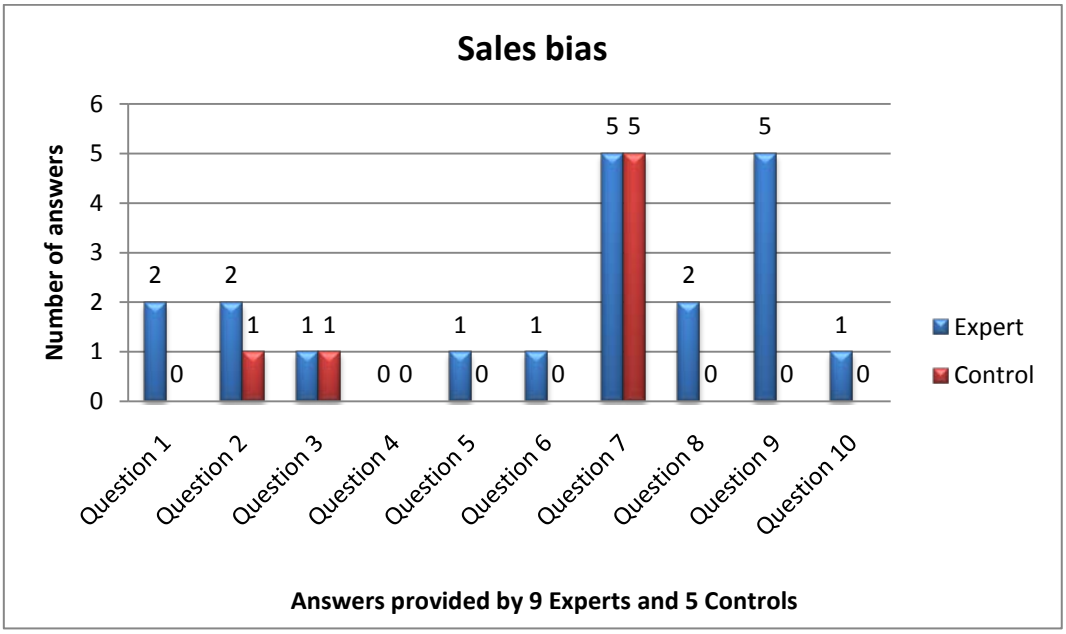

Illustration 6.8 - An overview of how many times the prospect of using the project film in a marketing sense was mentioned. Copyright by the authors

Illustration 6.8 shows how often a respondent answered any question from the perspective of sales, as well as outlining specifically to which question a sales-related answer was given. 8 Experts gave sales-related answers, compared to 5 Controls. Note however, than every single visualization company is represented. Of the 9 questions in the interview, only Question 9 related specifically to considerations about the project film's industry potential – though not specifically towards a use for marketing – and 5 Experts mentioned sales at least in this question. Note however, that Controls were never asked Question 9 and were thus not guided towards evaluating the project movie in relation to use in the industry, but merely towards a general use in Question 7. 5 Controls provided sales-related answers.

Quote from Experts:

- *"If the mood is about the weather, I´m not so sure it would work from a sale point of view."*
- *"For sales, you'd always make sure there was sun. "*

- *"From a sales perspective, showing things in film and showing it in a real context has a huge potential, but it also involves a number of problems, as you have discovered. Fly-by works better for sale and looks more impressive."*

Quote from Controls:

- *"As a client I would be happy to see how the finished project could look like."*
- *"Can understand why they in the traditional style move away from realism in order to sell it. But if I should buy something, I would be more interested in watching how it would actually look."*

The building's physical presence

A theme that emerged outside of the test questions was a specific realistic quality mentioned by respondents, as perceived from the project film in general, or specifically through either using matchmoving or the pedestrian point-of-view. Rather than focusing a general sense of realism, many answers focused on a sense of the building's physical presence in the scene. This included comments related to the building's size or scale in relation to surrounding buildings, how it filled the space between the two adjacent buildings etc. The affinity theme with its respective categories, which are based on comments of building presence from the entire interview, is shown in *Illustration* 6.9.

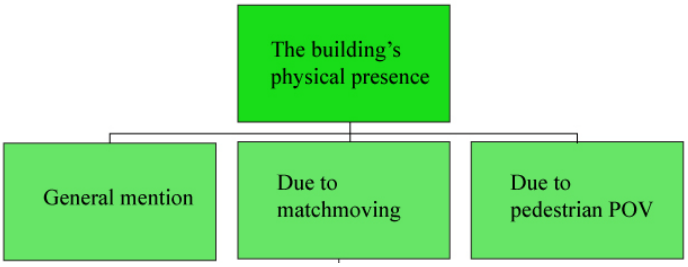

Illustration 6.9 - The building's physical presence was mentioned either from the project film in general, from matchmoving or from the pedestrian point-of-view.
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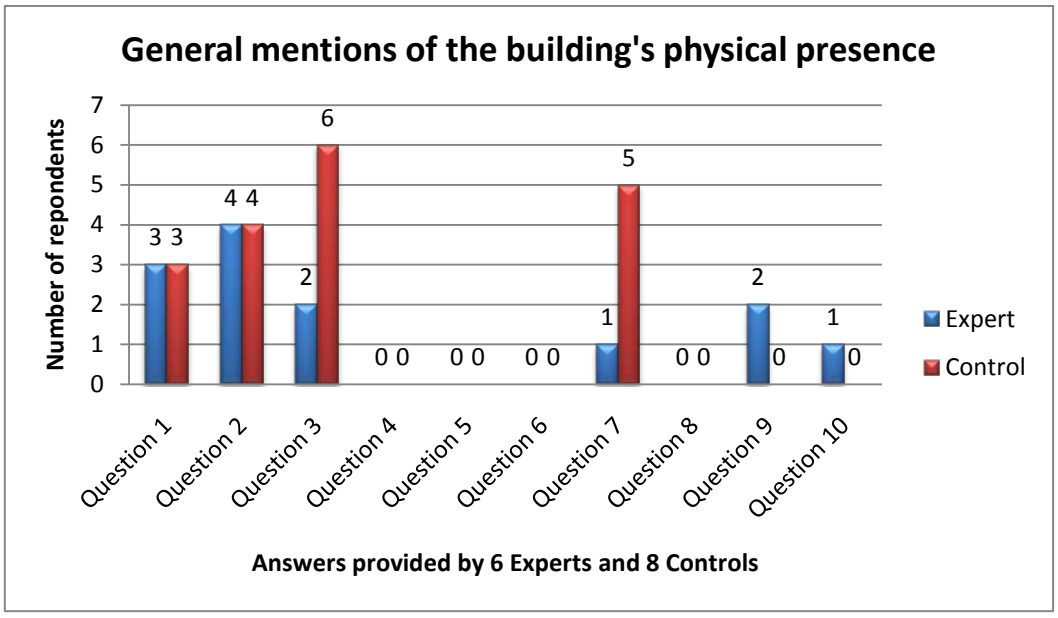

Illustration 6.10 - The amount of mentions of physical presence from the entire interview.
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14 respondents made one or more mentions of the building's physical presence during the interview a total of 31 times, as shown in *Illustration* 6.10. In 5 out of the 31answers, building presence was not mentioned as a direct perception from the movie, but rather as the goal for suggestions made to improve or alter the movie.

Quotes from Experts:

- *"Because it's both interesting to see the building and the surroundings it's placed in."*
- *"I definitely think you get a good sense of this building standing between two other buildings and how it meets the ground."*
- *"It's going the extra mile to bring across another dimension for the client - ultimately what the building will do to the real landscape."*

Quotes from Controls:

- *"You see the connection in if it fits into something else, other architecture."*
- *"It works well, because you get a sense of scale, compared to yourself.Good for imagining how it would look like in reality"*
- *"You see a rock and a car, you can start forming an impression of how high is this [the building] in reality and how much is it up to the first floor with human eyes. There is a lot of realism in this."*

A few more Controls than Experts mentioned building presence, but with 8 to 6, the difference was somewhat narrow. The questions in which presence was mainly mentioned was Question 1 (6 times), Question 2 (8 times), Question 3 (8 times) and Question 7 (6 times), and only 2 mentions in Question 9 and 1 in Question 10. No consistency existed in the 5 answers that suggested improvements towards building presence, with 1 mention in Question 1, 2 and 10 and 2 mentions in Question 3.

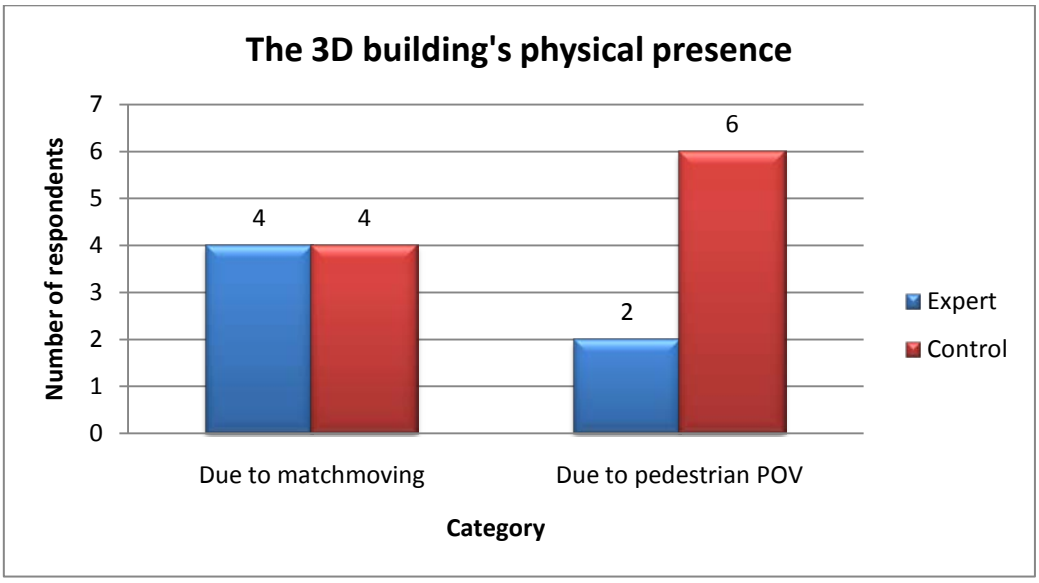

Illustration 6.11 - When presence was mentioned specifically in relation to the use of matchmoving or pedestrian point-of-view. Copyright by the authors

Illustration 6.11 shows specifically regarding matchmoving, that fewer mentions of building presence occur. The amount is almost halved with only 8 mentions, this time with an equal distribution between Experts and Controls, 4 Expert and 4 Controls.

- *"Machmoving the building into the real life scene was great - not only well executed, but immediately put the building into context."*

The category of pedestrian POV features the same amount of mentions as the matchmoving category, thereby also significantly less than from the project film in general. However, this time the distribution is much less equal, with 2 Experts and 6 Controls.

- *"It's really strong that the small movement in the camera still gives so big a 3D-effect and understanding of how big is the building? how do I approach it? What am I approaching?"*

The answers in these categories also contained improvement suggestions toward obtaining building presence.

- *"Maybe you could've started 100 meters further down the road. Maybe also look up, when you get close. Or look out, so you look at what's around the building."*
- *"Perhaps you could make the building more sketch-like and use it to show more how the volume works in this space."*

For the affinity theme in general – The Building's Physical Presence - the respondents made more mentions of the building's physical presence when evaluating the project film in general with 14 mentions, than when focusing specifically on either matchmoving or the pedestrian point-of-view, with 8 mentions in each. There were also generally more mentions from Controls (18), as opposed to the Experts (12).

Thoughts about aiming for a realistic mood rather than a stylized mood

This affinity theme was formed from Question 7, which was concerned with the opinions of the respondents on aiming for a realistic mood, not a stylized mood. It was not directly guided as an evaluation of marketing potential, but could very well give opinions about technical differences, visual appeal etc. This question was the only question proposed to both groups of respondents about their general thoughts on a realistic mood vs. a stylized mood. Since the final problem formulation suggests matchmoving as an addition to contemporary visualizations, it becomes important to determine what respondents think of the chosen aesthetic, achieved through matchmoving, in relation to stylized visualizations.

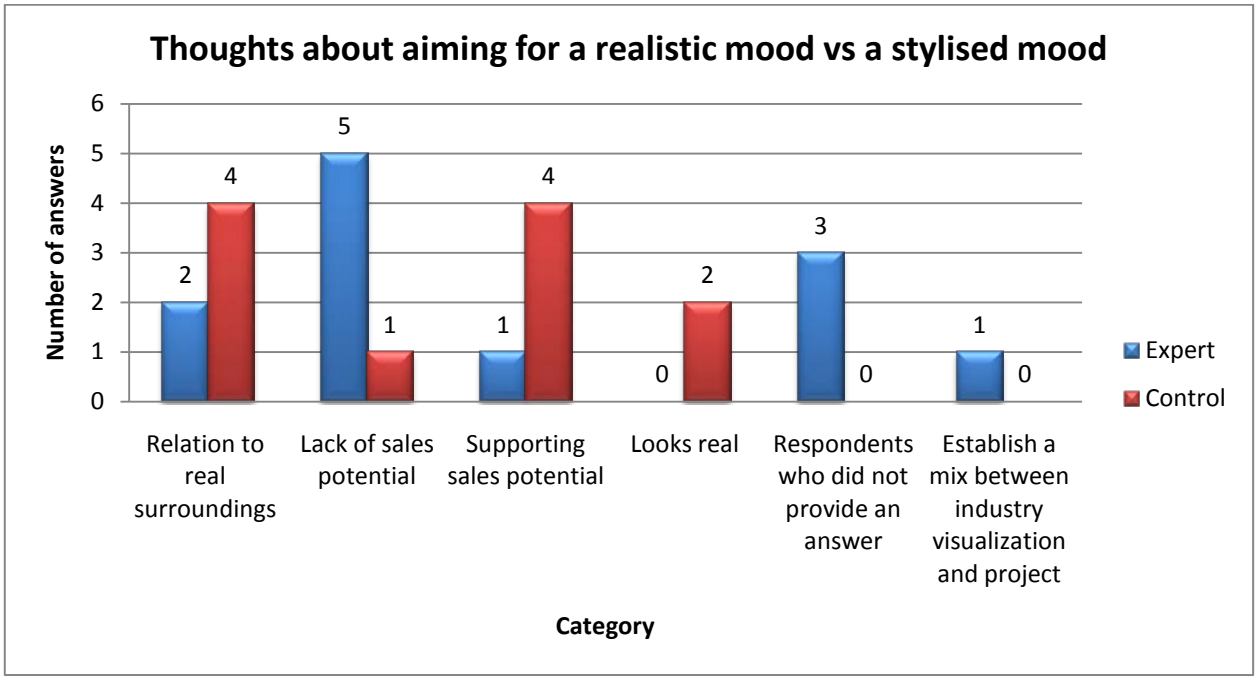

Illustration 6.12 - The categories pertaining to thought on the use of a realistic mood vs. a stylized mood.
Copyright by the authors

Illustration 6.12 shows that 6 categories appeared under this theme. "Relation to real surroundings" groups respondents focusing on the building's physical presence in the scene, which 6 respondents answered. 4 Controls and 2 Experts.

- *"And suddenly it just lies right there between two other buildings, where its' supposed to lie."*

"Lack of sales potential" focused on a perceived lack of sales potential from the project aesthetic, to which 6 respondents answered, 5 Experts and 1 Control.

- *"I really like the mood (weather) Its more dynamic than 12'o'clock sun. But again most clients would never agree on this."*
- *"Could imagine there is a niche in matchmoving and the Dogme inspired handheld camera, although it needs to look a lot better. Handheld could be popular, but there is no sale potential in a realistic look."*

"Supporting sales potential" groups respondents who believed, that the aim of realism would help sell the building, 4 Controls and 1 Expert.

- *"I think that you have a great look and have used some subtle and great techniques (the hand-held, pedestrian POV, etc) to convey a realistic and down-to-earth visualization of the building. It's going the extra mile to bring across another dimension for the client - ultimately what the building will do to the real landscape."*
- *"As a client I would be happy to see how the finished project could look like."*

"Looks real" did not comment specifically on a perceived effect from the realistic approach, but rather affirmed their opinions about the project film conveying a realistic mood – both answers in this category

belonging to the Controls. A solitary answer in the diagram suggested going for a mix between realism and the stylized aesthetic, while 3 Experts did not provide an answer.

Does matchmoving have industry potential?

This question was delegated solely to Experts, with the Controls most likely having no insight into the current status of the industry. Since the final problem statement suggests matchmoving as an addition to the industry, this affinity theme should provide an overview of how the project film was perceived in relation to potential use in the industry by the Experts. With the exclusion of the Controls, the number of answers is lower than normal. However several Experts are represented in more than one category as they provided extensive answers.

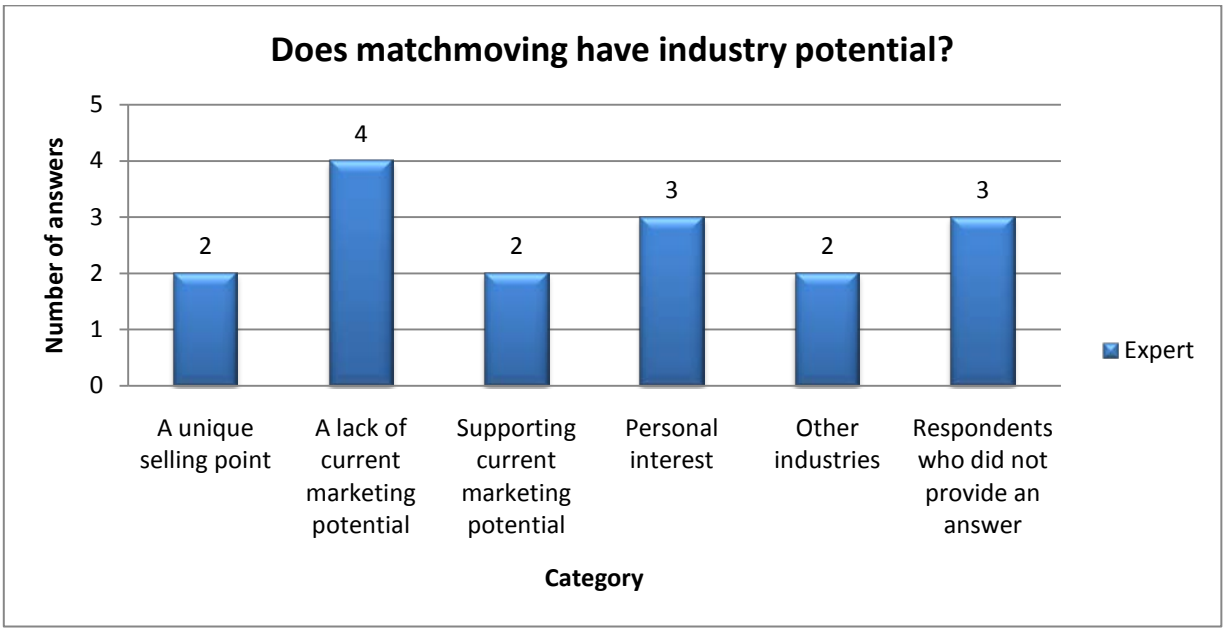

Illustration 6.13 - The general perception of matchmoving's potential for industry use by expert participants. Copyright by the authors

Illustration 6.13 shows that 6 categories emerged from the data. “A unique selling point” categorizes answers suggesting that matchmoving might, at some point in time be useful as a service that fewer competitors can offer.

- *“You could do some things that others cannot, but you would also have limitations.”*

”A lack of current industry potential” denotes answers, where respondents suggested, that the technique could not fulfill a purpose in the industry as it exists today, while “Supporting current marketing potential” does the opposite.

Quotes from “Lack of current marketing potential”:

- *“I would love to see more of it. From a prof. point - No not really. It might be used once and a while.”*
- *“I’m not sure if they (customers) are interested. […] I think it’s difficult to sell.”*

Quote from “Supporting current marketing potential”:

- *"I think matchmoving architectural visualization to real footage is an excellent - if not invaluable - tool for the industry."*

"Personal interest" categorizes answers merely mentioning that a specific respondent was personally interested in seeing matchmoving used in the industry, while "Other industries" categorizes answers suggesting that matchmoving could be used in other industries than architectural visualization.

- *"…this is very cool for virtual scenography for a movie."*

Pipeline

Another indication of validity for industry use is our pipeline. It is prudent to determine if it fits with how matchmoving is usually performed, if it is unsuitable or even if it improves current matchmoving creation methods.

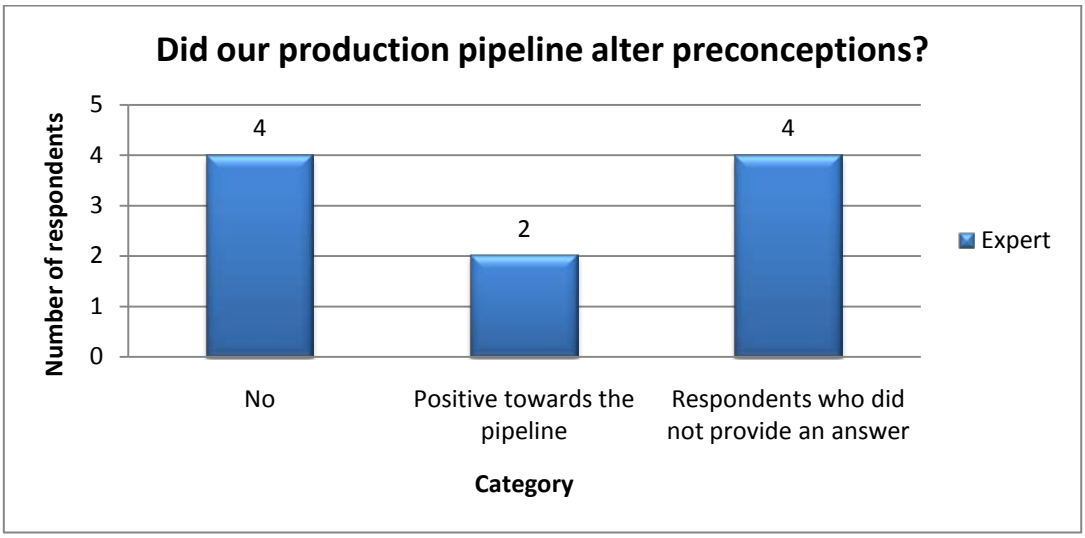

Illustration 6.14 - Affinity theme of investigating our pipeline in terms of preconceptions.

The affinity theme shown in *Illustration* 6.14 is more limited than normal, because it is only directed to the Experts. While we were also interested in feedback about the individual steps in our pipeline, the key issue was the amount of production time we had spent. 4 Experts were not so positive towards the pipeline, the reason generally being that the traditional 2D images does not take nearly as much time to create, which in terms of sales potential does not speak to our advantage.

- *"No, it's fairly normal."*
- *"But for us, spending 3 weeks would cost the client 75.000. They can get many images for that: At least 3 images for less than half."*

2 Experts were positive towards our pipeline and thought the amount of time (about 3weeks) sounded very well, taken into account that this was our first attempt at such a project.

- *"3 weeks sounds pretty good when considering it is an experiment. it points to a well planned project and conduction."*

Only 1 Expert provided detailed feedback regarding how to specifically improve the pipeline. Suggestions were made to use a chrome ball to capture a HDR-image fitting the scene, as well as including animatics to demonstrate the project film to a client, before going to the scene of shooting it. The 4 Experts from SEA did not have sufficient experience with producing matchmoving to be able to provide a proper evaluation of the pipeline and therefore provided no answer.

Improvement suggestions

Suggestions for improvements were obtained to determine potential shortcomings of the project film. The categories that emerged from these answers were related to the chosen camera perspective, the choice of weather for the project film and the elements (or lack thereof) within the scene itself. While these suggestions might not contribute as directly to the final problem formulation, they might reveal unintended mistakes made in editing, framing or the project aesthetic. Even though it also featured as an individual question, the various ways in which we could improve the film was a topic that came very naturally during the interviews. As the majority of the improvement suggestions came from Experts, the answers were mostly related to what they would usually do to an image or how they would present a project. These answers differentiated quite a bit, as they all had their own specific focus and approaches. The affinity theme in *Illustration* 6.15 shows the categories that cover all the various responses from both Experts and Controls.

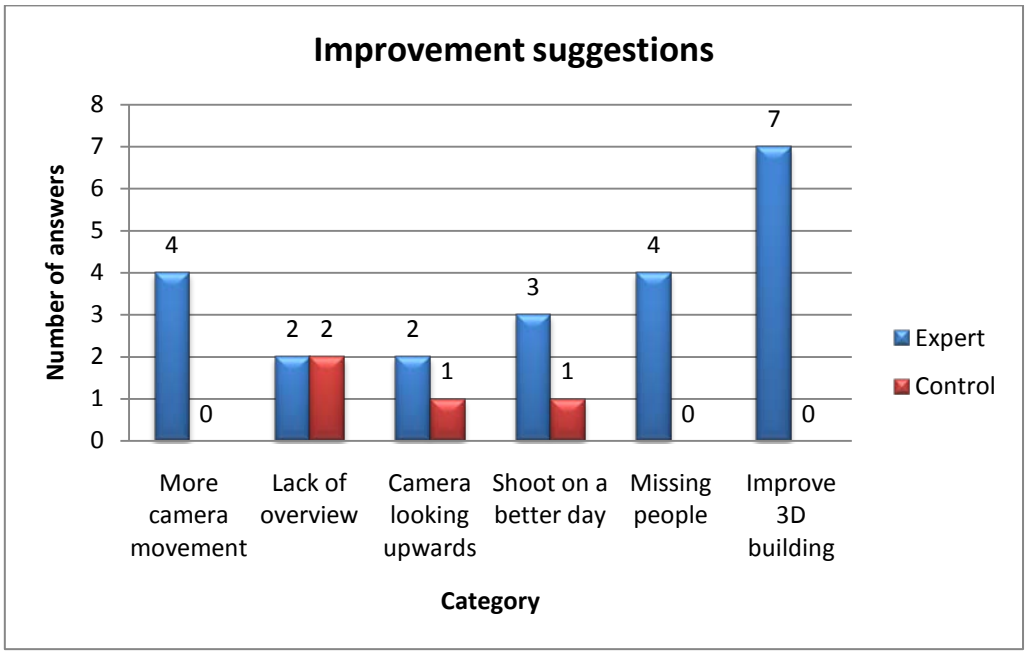

Illustration 6.15 - Affinity theme of the various suggested ways the film could be improved. Copyright by the authors

Only Experts provided suggestions to improve matchmoving. They had no problem with the technique itself, but they mentioned that they wanted to see more movement in the camera. A few comments were made about matchmoving being essentially underutilized, if the camera does not move enough. ”More camera movement” involved suggestions to be more active with the camera or to move it more like a person walking around the building. 4 answers were given in this category - all from the Experts.

- *“You are too conservative with the camera movement.”*
- *“Speed up the camera to walk more around the building. Enhance the matchmoving effect.”*

"Lack of overview" referred to critique towards a restrictive view of the scene. The project film showed the 3D building from a close distance, which only showed its bottom half. Some respondents felt that this concealed the building and contributed to a missing overview of the building in the scene. 4 answers were given to this category – 2 from Experts and 2 from Controls.

- *"What I feel like I'm missing, I don't get a wholeness."*
- *"You can't really see the whole building"*

"Camera looking upwards" consisted of a specific suggestion to remedy the lack of overview. Some respondents felt that the camera should have moved up and revealed more of the building. 3 answers fell into this category - 2 Experts and 1 Control.

- *"Maybe also look up, when you get close. Or look out, so you look at what's around the building."*

"Shoot on a better day" was a category created from suggestions to improve or alter the choice of weather in the project film. The project aesthetic was designed for a grey day and some respondents disagreed with this decision. Four answers belong to the category of shooting on a better day – 3 from Experts and 1 from Control, as they thought the dominating grey colors in the film could be improved this way.

- *"You could've chosen a sunny day. […]The location could've been blue sky, happy people etc and still been real."*

The "Missing people" category refers to suggestions to add life to the project film by adding one or more people to the scene in front of or next to the building. This category got 4 answers, all Experts.

- *"Have people run around in the scene."*
- *"A bit unrealistic without people around"*

Lastly, "Improve 3D building" is a category formed from suggestions to improve the quality of the 3D building itself. These suggestions included adding reflections to the windows, more detail in the modeling or creating a better appearance of the building standing on the ground in the footage. This category contains 7 answers, all from Experts.

- *"Can easily see the building is a render, because of missing reflections and detail. "*
- *"perhaps one thing I would add to shooting on location is taking a few HDRI's of a mirror-ball which will be used as a lighting and reflection object in your 3D work."*

Of the total of 26 answers belonging to this affinity theme -improvement suggestions - only 4 answers came from Controls. The remaining 22 came from Experts.

6.4 Test analysis

The data presented in chapter 6.3 *Test results* needs to be analyzed in more detail, in order to determine what the many categorizations on test data means for the project film. Therefore, the categories will now be examined in detail to establish what each of them signify for the project movie in relation to the final problem formulation.

6.4.1 Was aesthetic realistic?

The test suggests that the project film does indeed convey a realistic mood to the viewer, more than anything other type of mood. With 11 respondents out of a possible 20 perceiving realism, compared to only 3

respondents towards a boring mood and a mere 2 respondents toward a excitement to "see what is next", Realism was the most common answer. The question suggested no specific mood as a result of watching the project film, and still 11 respondents chose realism. It should be noted that a two users misunderstood Question 1 and took into account the sections of the project film which showed e.g. the building being assembled in 3D, which was not an intended as being evaluated from conveyed mood. It is unclear why this misunderstanding occurred, since Question 1, 2 and 3 was being introduced to the respondent as only relating to shots of the project film where the project aesthetic applied (from 00:41 to 00:58) and therefore not e.g. the assembly of the building in 3D.

The respondents' perception of realism becomes increasingly significant, when proceeding to evaluate their answers towards the conveyed realism specifically from the use of matchmoving and the pedestrian point-of-view (henceforth denoted as POV). The amount of respondents perceiving realism grows from 11 for the project film in general, to 14 for realism conveyed by matchmoving, and to 16 for realism conveyed by the POV. With as many as 16 out of 20 respondents perceiving realism from a single element of the project film, compared to only 11 from the project film in general, two points are indicated:

- That the two of the three main aspects of the project aesthetic – matchmoving and POV – are successful in conveying realism individually
- That there are counteracting elements of the project film that work against the users perceiving realism from it in general

Such counteracting elements could be the choice of grey weather: The 3 respondents, who perceived the project film in general as boring, instead perceive realism when evaluating POV by itself, and 2 of them perceived realism when evaluating matchmoving by itself. The grey weather might appear more boring than realistic to the 2 respondents. Notable is also that the respondents who based their perceived from the project film on general on an excitement to "see what is next" also perceived both the matchmoving and POV as realistic. Their excitement to "see what is next" most likely stemmed from a combination of the POV close to the building and the editing showing more shots, prompting an expectation about a possible shot of the entire building to come. When the editing was not part of the evaluation of perceived mood, the perceived mood seemed to instead switch to a realistic one.

Another factor supporting that other elements of the project film distracts from conveyed realism of matchmoving and POV, is the respective number of Experts versus Controls who perceived realism. Generally, more Controls perceived realism than Experts, but the difference was mainly present in the evaluation of the project film in general. The amount of Controls perceiving realism is almost unchanged across Question 1, 2 and 3 (7, 8 and 8 answers respectively). Conversely, the amount of Expert answers increases from Question 1 to Question 2 and 3 (4, 6 and 8 answers respectively). The Experts were therefore the primary reason the less perception of realism of the project film in general. A reason for this could be their familiarity with architectural visualization through their employment in the industry. Controls were not employed in the industry and a natural attention to details in architectural visualizations can therefore be assumed to be higher for Experts than Controls. When answering Question 1, 9 out of 10 Experts mentioned either details about the technical quality of the project film and 3D building or how the look of the project film, such as color of the sky, differed from industry visualizations. Only 1 Control did the same. Expert answers were generally significantly longer and Controls answers as well, since they described other elements than just the mood, which Controls answers were generally limited to. This focus on details and specific elements of the project film could have distracted some Experts from perceiving the project film as a whole. The consideration of details distracting from mood coincides with the fact that, when asked to focus

specifically on one element of the project film, Experts seemed to be less distracted by other elements and could perceive a mood, since more Experts perceived realism specifically from matchmoving or POV.

Summarizing points of this part of the test are:

- Respondents suggest that the project film generally conveys a realistic mood more than any other type of mood
- A realistic mood appears to be conveyed better from matchmoving and POV specifically, than the project film in general. This indicates that elements, other than matchmoving or POV, counteract the realistic mood
- Experts have a technical bias, likely causing their perception of mood to be better when evaluating specific elements of the project film, than when evaluating it in general

6.4.2 Evaluation of visual styles

The only solid result for evaluations of the three visual styles, is that the use of color filters, as done in this project, are not suitable to enhance realism. There was no clear preference of either the blue, sepia or unaltered visual style regarding effectiveness of blending the 3D building with the footage. 2 Controls preferred the blue style, 4 preferred the sepia and 4 preferred the unaltered. For Experts, 4 preferred the blue, 1 preferred the sepia and 5 preferred the unaltered. The combined difference is too small to indicate a general favorite (6 for blue style, 5 for blue style and 9 for unaltered style). A presence did appear when evaluating the visual styles for promoting realism. 1 Control chose blue, 3 chose sepia and 6 chose the unaltered. 2 Experts chose blue, 0 chose sepia and 8 chose unaltered. Combined, blue and sepia each has 3 answers, while the unaltered has 14. Since the unaltered style was perceived as the generally most realistic visual style, and no favorite blending style existed, nothing concrete can be concluded regarding if a blending style, as those presented in this project, can either help establish better realism or if the opposite is the case.

Summarizing point of this part of the test is:

- Visual styles, as done in this project, are not suitable to enhance realism

6.4.3 Determining Expert's Sales bias

Another important bias to test for was a bias towards evaluating architectural visualizations from a sales perspective – how well will it be able to sell a product to a client. And the test showed that the sales bias did exist in Experts. Comparing the amount of Experts and Controls giving an answer in relation to sales, at any point during the test, reveals an initial indication of sales bias in the Experts. 8 Experts mentioned sales at least once, while only 5 Controls did the same. This initial indication grows significantly stronger, when comparing the total amount of times sales were mentioned. The Experts mentioned sales 21 times, while the Controls only mentioned sales 7 times. It is important to note, that Controls were not given Question 8 and 9, so when eliminating those questions from the comparison, Experts mentioned sales 14 times, which is still twice as many as Control. Finally, when examining in which specific questions Experts and Controls mentioned sales, the indication becomes strong enough, that a sales bias can be confirmed in the Experts. Of the questions given to Controls, only Question 7 prompted suggested that they evaluated what use they saw for a realistic mood. And while the question did not direct them to think specifically about use in the visualization industry, the questions nevertheless compared a realistic mood with the industry's stylized mood. All 5 Controls mentioned sales in Question 7, but only 1 mentioned sales in other questions. Experts were given Question 7 and 9, and these questions were expected to yield sales-related answers, just like Question 7 for Controls. 7 of the 8 Experts mentioned sales in either Question 7 or 9. Outside of these two

questions, 5 Experts mentioned sales 11 times, although only 9 times if Question 8 is excluded. Therefore, not only did more Experts mention sales during the test; the total amount of times that sales were mentioned was three times larger for Experts than Controls or double if Question 8 and 9 is excluded. And Experts mentioned sales much more often than Controls outside of questions where a sales-related answer could be expected.

Summarizing point of this part of the test is:

- Experts have a sales bias, as well as a technical bias, compared to Controls

6.4.4 Evaluating physical presence

The test strongly suggests that the project film could be used to convey the building's physical presence, if a use for sales proves unsuitable. Physical presence includes the building's scale in relation to other buildings, how it was connected to the ground in the footage or generally how it occupied space. No specific quality of realism was suggested by any questions, and yet the building's physical presence was specifically mentioned in answers by 14 respondents throughout the test, a total of 31 times. Of these 31 answers, 5 even came in the form of suggestions of how to better achieve a sense of the building's presence and not as a response to what was perceived directly from the project film. 4 of these 5 answers were given by the respondents before they gave an answer about a sense of building presence as a direct result of watching the project film. The reason to note this, is that if an answer mentions building presence as something other than a direct response to watching the project film, it suggests that building presence was believed by the respondent to be the goal of the project film, even though it might have a different goal: If a respondent states, that "he perceived something, but that an additional sense of building presence could be achieved by…", it indicates that certain elements of the project film appears very suited to establish a sense of building presence, regardless of what they are used for. For 3 out of the 14 respondents, this answer was given before any mention of building presence as a direct result of watching the project film. This means that the perception of certain elements of the project film being suitable for conveying building presence came from the 3 respondents themselves and not from goal of the project film. However, this was still just the case for 3 out of 14 respondents, so by itself it is a vague suggestion at best, but it is an additional nod towards building presence being an unintended, but plausible effect of the project film, either as a whole or by specific elements of the project film.

Matchmoving and POV specifically seem to be important contributing factors in the sense of building presence. A sense of building presence from the project film in general is too general to help determine precisely where the sense comes from. Thus it was important to determine specifically if matchmoving or POV was contributing. 16 of the 31 answers were given to either matchmoving or POV, 8 answers for each. Being that this is roughly half the total amount, it indicates that matchmoving and POV are generally important for the sense of building presence and equally important in relation to each other. Answers given towards building presence in Question 7 or 9 might also stem from effect of matchmoving or POV, but it was not mentioned specifically, so it cannot be included with certainty to validate either.

A higher amount of Control answers mention a sense of building presence compared to Expert answers, likely due to the two biases in Experts. Controls provided 18 and Experts provided 13 answers respectively. For matchmoving specifically, 4 Controls and 4 Experts answered, and for POV it was 6 Controls and 6 Experts. Regarding technical bias, Experts might require a higher amount of detail or better quality of the project film, matchmoving or POV, before a perception of presence is established: Archivisuals made 3 comments about the lack of quality regarding how the building touched the ground in the scene and Cenario made 1. No Control made any such comment. Technical bias also entails the fact that Experts are

accustomed to industry visualizations that provide overview of the entire building. This could explain why only 2 Experts mentioned presence in relation to POV, since POV limited the overview of the building, which could steal the focus of the Experts.

Experts generally did not consider building presence for use in sales. There was a general lack of considerations of building presence in relation to sales, especially as an idea to increase sales potential. Therefore building presence, as a specific aspect of realism, should most likely find another use in the industry than being used for sales. Only Ernst of Moose Studio and Archivisuals mentioned building presence specifically as beneficial for sales potential and no Expert mentioned it as harmful for sales. This shows that their sales bias could very well limit their opinions to only comparing the project film to sales purposes, thereby excluding building presence. In fact, building presence was only mentioned as a boon for sales 2 times out of the total 31 answer across Experts and Controls.

Summarizing points for this part of the test are:

- A sense of the building's presence, as a specific quality of realism, is important to consider – particularly if the project film cannot be used for sales
- Matchmoving and POV seem to be important, specific factors contributing to building presence
- More Controls and Experts mentioned building presence in their answers. This is likely due to the technical and sales bias in the Experts
- Building presence was not considered as being used for sales

6.4.5 Thoughts about realistic mood

A conflict appeared between respondents either supporting a realistic mood for sales and those who argued against its sales potential. 5 respondents (1 Expert and 4 Controls) answered that a realistic mood had sales potential, while 6 respondents (5 Experts and 1 Control) – provided the opposite answer.

A probable reason for the difference between Experts and Controls is professional and personal experience with the visualization industry. Experts likely answer from professional experience and thereby compare the project film to current visualizations created to aid sales. Controls are not as familiar with the current visualization industry and likely judge sales potential from their own experiences. Their experiences from purchasing a house, or expectations about future purchases of a house might be visiting a house they desire to purchase, and obtaining as much accurate information about the house as possible. They might also be biased towards the project film due to the design of the test. The project film is shown significantly more than industry visualizations during the test, which could help them form a more comprehensive opinion about the project aesthetic, compared to their understanding of industry visualizations. Another possible source of Control bias towards the project aesthetic could be that the test was not introduced by showing industry visualizations to the Controls and asking them their own initial opinions about it. It could have been advantageous to merely show them a number of industry visualizations along with the project film and obtain their impressions, before informing them about the purpose of the project. As we learned from chapter 6.4.1 *Was aesthetic realistic?*, a lack of professional experience might reduce Controls attention to specific details compared to Experts. Had Controls expressed their own initial opinions about industry visualizations, they might interpret certain elements – elements that this project deems supportive of stylized realism - as realistic elements instead and maybe view industry visualizations as realistic as well.

Despite the conflict, the test indicates that realism - at least designed according to the project aesthetic - does not have an overall sales potential for the current visualization industry. It is important to note, that this

indication arose only from one more than half the respondents. However, 5 Experts answered against sales potential and only 1 Expert answered for sales potential. The Controls might be potential clients, but they only constitute one possible type of client in the current industry. Visualizations are also used to e.g. sell projects to competitions and to public groups, such as when a museum or library is being produced. Experts have experience with these types of clients, but the Controls do not. So while sales potential of realism, according to the project aesthetic, might be valid for a certain type of client, it is more likely to be invalid for the industry in general. Furthermore, Experts have many years of experience with visualizing for sales, while the Controls might have been entirely unfamiliar with the industry before this test, making Experts better equipped to evaluate the industry from experience than Controls.

This test also indicates that building presence should not be considered for sales potential in the industry, but should be used for another purpose. The lack of sales potential from realism is likely due to the look of the project film, not the use of matchmoving. All 5 Experts answering against the sales potential of realism did so, due to how it looked, not due to building presence. None of the Controls, who supported sales potential, mentioned building presence specifically. In fact, the only respondent from both Experts and Controls, who expressly mentioned building presence as a part of realism supporting sales potential, was 3D Tree. Furthermore, the 4 Control respondents mentioning building presence did not consider sales potential at all, while 1 Expert answer (SEA 1) voted against sales potential.

Summarizing points of this part of the test are:

- Experts and Controls disagreed about sales potential of realism according to the project aesthetic. This difference is likely due to their professional and personal experience with the visualization industry
- According to Experts, realism does not seem to have sales potential. And for evaluating the current visualization industry overall (including all types of clients), Experts are better suited due to their experience with the industry
- The test provides another positive indication, that a sense of the building's physical presence should not be used for sales

6.4.6 Industry potential for matchmoving

Only Experts provided answers for this evaluation. The test indicated that matchmoving also lacks sales potential. 2 respondents answered towards a sales potential of matchmoving and 4 answered towards a lack of sales potential. 2 respondents answered that matchmoving should be used in other industries, but 1 of these also answered towards a lack of sales potential. The 4 answers towards a lack of marketing potential, combined with the 2 answers that matchmoving should be used in other industries indicate, that matchmoving, as well as realism, might also not have sales potential in the current industry.

An evaluation of the reasons given to denounce sales potential clarifies, why matchmoving has problems. Matchmoving is largely dependent on the weather and a blue-skied summer day is difficult to film on e.g. a windy autumn day or a snowy winter day. Another reason is time requirement, which is supported by both Archivisuals and Cenario. In fact, a normal amount of still images can be produced to a client in 1/3 the time that the project's current matchmoving pipeline requires. Matchmoving also requires a very generous scene, with trees and other vegetation interfering with the shot, enough detail to track etc. The scene should also consider that the camera is able to film it to allow both the building to be shown properly and still capture sufficient tracking detail and avoid obstructions. Flexibility is also not a strong point of matchmoving. A 3D animation can be edited, in terms on length of shot, camera angles etc. at any time. But once you have shot

footage for matchmoving, any changes require that you go to the location and re-shoot. The effect of matchmoving might be nice, but there are many requirements before it becomes useful.

The indication that matchmoving lacked sales potential was not as strong as when evaluating the sales potential for realism. Critique against realism stems from deliberate desires from clients over many years, which is stronger than critique of the fact, that matchmoving has specific technical requirements to be successful. The requirements for successful matchmoving might be rigorous, but it is nevertheless plausible to start a visualization project in the summer and receive a location, that supports matchmoving. The more experience a company has with matchmoving, the faster it can be performed, so while the project pipeline requires 3 weeks, it might be reduced in the future. Should that occur, the only unaltered major drawback is lack of flexibility. Matchmoving need not be a constant option for visualizations, but can be seen as an additional option when the circumstances are right.

The two categories of "Unique selling point" and "Personal interest" are not relevant for analysis in relation to industry relevance, since only 2 respondents mentioned matchmoving as a unique selling point. The expression of matchmoving as being personally interesting to 3 respondents does not translate into relevant use for the industry – particularly since 2 of those respondents stated that, while they found matchmoving personally interesting, they did not see sales potential. The last of those 3 respondents answered oppositely and found the technique interesting, as well as seeing sales potential.

Summarizing points of this part of the test are:

- The test indicated that matchmoving, as well as realism, also lacked sales potential
- This indication was not as strong as for realism however, since criticism of matchmoving stems from technical demands for success, while criticism of realism stems from deliberate desires from clients over many years.

6.4.7 Evaluating the project pipeline

The project pipeline generally speaks further against the sales potential of matchmoving. Had it changed Expert's expectations about the production of matchmoving, such as required steps or time required from start to finish, it could have spoken for the sales potential of matchmoving, since the respondents generally evaluate the project based on their own experiences with matchmoving. However, the pipeline only produced 2 positive responses against 4 negative, which further indicates matchmoving as unsuitable for the current industry according to Experts. Even the expected reduction in time required by 1 week, for subsequent attempts at matchmoving (the project was our first time producing it from scratch), did nothing to change expectations.

Summarizing points of this part of the test is:

- The project pipeline did not support that matchmoving had sales potential

6.4.8 Evaluating suggestion improvements

Technical bias, through years of experience, appears in Experts, since they provide almost all improvement suggestions. Sales bias seems to slightly guide the type of improvement suggestions, since 16 of them went towards improving the look of the project film, notably to move the look towards that of industry visualizations. A total of 27 improvement suggestions were supplied and only 4 of them by Controls. Suggestions to improve the look included "Missing People", "Improve the 3D building" (such as adding reflections to windows) and "Shooting the project film on a better day" (a blue-skied sunny day). 3 Experts

and 1 Controls suggested shooting on a better day, and all 3 of those Experts also argued the grey weather as the reason that realism lacked of sales potential. The remaining 11 suggestions was towards matchmoving ("more camera movement") and POV ("Camera looking upwards" and "Lack of overview").

The reason that more suggestions went towards the look of the project film rather than matchmoving or POV, could be that the use of matchmoving worked better than the look of the project film. It could also be a result of the fact that Experts have much more experience in working with the looks of a visualization, than they have in working with matchmoving. This significantly increased familiarity would enable Experts to better express opinions about looks in greater detail, compared to matchmoving or POV. In fact, 15 Experts suggested improvements towards the looks of the project film, while only 8 suggested matchmoving or POV improvements. A final possibility is that Experts simply care more about looks of the project film due to their increased familiarity with working with the looks of a visualization.

Summarizing points for this part of the test are:

- Experts provided almost all improvement suggestions, likely due to their experience in the industry
- Experts had more comments towards the look of the project film
- This was probably due to either them caring more about looks, them being more familiar with looks of a visualization than with matchmoving, or that the looks of the project film had more problems than the use of matchmoving

6.5 Test conclusion

The test provided indications that a realistic mood was being conveyed by the film in general. Even stronger indications pointed towards the use of matchmoving and the pedestrian POV as specific elements of the project film, which could convey a realistic mood. The three suggested visual styles did not show anything specific about blending of 3D and footage and its effect on the realistic mood, but merely provided a good indication that when not considering blending, the unaltered visual style was best for realism.

The Experts was determined as possessing a sales and technical bias, which affirmed the primary reason for including a control group for the test. Many Expert answers did evaluate the project film in comparison to the visualization industry, also when not prompted to, so the control group proved important to balance the test.

The numerous mentions of building presence from the respondents, with no guidance from the questions, establish it as a specific aspect of realism worthy of further exploration, particularly in case the project film is unsuitable for sales in the visualization industry. The balance between Experts and Controls showed its importance with the discovery of the building's physical presence as an important, specific part of realism. This was not suggested by the test, but emerged from the test data on its own. Building presence was often mentioned during the test and was mentioned more by Controls than Experts. Without Controls, it might not have been as prevalent in the test. However it should explore a purpose other than sales, since the test showed no indications of building presence being considered relevant for sales.

The realistic mood as designed by the project most likely does not have sales potential. The main point of criticism seemed to relate to the look of the project film, rather than the realistic result from matchmoving or POV. Going for a different look, such as a blue, sky might produce a more positive result for a realistic mood, but regarding the project film, realism was deemed to be unsuited for sales.

The test also suggested that matchmoving might not have sales potential, however this suggestion was less strong than for realism. The project pipeline did nothing to improve the sales potential of matchmoving. Matchmoving criticism was mainly based on strict technical requirements in order for matchmoving to be successful, while realism indications were based on deliberate client desires over many years. Matchmoving might not be as usable as contemporary industry visualization methods, but can still be useful in certain circumstances.

With Experts providing almost all improvement suggestions, there were more suggestions of how to improve the looks of the project film, which also suggested that the respondents disagreed more with the realism than the use of matchmoving, had more experience in working with the looks or simply cared more about the looks.

7 Conclusion

The motivation for the entire project was to produce a realistic addition to contemporary stylized architectural visualization methods. The architectural visualization industry seems largely constrained to focus on creating stylized, virtual 3d still images or animations for the purpose of sales. We felt that the opportunity for a client to perceive how the building would look in reality when constructed, was a sufficiently interesting addition to contemporary industry visualization, for us to explore it in this project.

Through the pre-analysis we determined that matchmoving could offer what industry 3D still images and 3D animations could not: maintain the realistic and take advantage of the 3D capabilities of the building. Our investigation of the history of matchmoving confirmed the technique as a suitable choice for the project. Interviews with architectural visualization companies revealed that matchmoving is under-used in the industry, mainly due to technical requirements and the time it takes to produce. We discovered the creation of a mood was essential to architectural visualizations, not a realistic presentation. And finally we determined industry professionals to be the target group for the project. The pre-analysis lead to the final problem formulation:

How can we, through a short film, present matchmoving to the industry, as a realistic addition to contemporary visualization methods, while maintaining the sales oriented purpose of the visualizations?

The analysis investigated important elements of the final problem formulation in detail. The concept of faction was explored. It is defined as a mix of fact and fiction, which served as a foundation for comparing the industry's stylized visualizations with the realistic visualization that this project focuses on. The technique of matchmoving was investigated, enabling us to utilize it for the project film. A field analysis at DTU was conducted in an early stage of the project, from which we obtained hands-on experience with recording footage for matchmoving, as well as certain obstacles arising when matchmoving the footage. Many film techniques were investigated, which allowed us to use the medium of film to help achieve a realistic mood in the project film. The history of the architectural visualization aesthetic was explored, to obtain a comprehensive understanding of its current use in the industry. The final part of the analysis established a set of solution requirements, which served as a guideline for the design of the project film.

During the design, the project aesthetic was defined through three main areas – use of matchmoving, a pedestrian point-of-view and grey weather. The combination of these areas should strive to achieve as high a degree of verisimilitude as possible. Two possible locations were determined, due to them being suitable for matchmoving requirements. The specific 3D building was chosen, since it had a proper architectural design and was suitable for the location. The footage was shot to ensure that the 3D building would be shown from different angles, that the camera would move in relation to the 3D building and that the footage would comply with the requirements for proper matchmoving. And finally the storyboard design determined exactly how and where on location to record the footage.

In implementation the footage was converted into individual frames in Adobe Premiere and then processed in PFTrack. In this program the frames were tracked, solved, evaluated, which resulted in the creation of a virtual camera that mimicked the movements of the camera used to record the footage. The virtual camera could subsequently be imported into Autodesk Maya. The 3D building was modeled inside Maya. It was then imported into UV layout, where unwrapping prepared the uv-coordinates for texturing. Importing the building back into Maya again, where textures and shaders were applied to it. The building was rendered with Mental Ray and the inclusion of indirect shadows via Final Gathering. The 3D building and the footage

was brought into Adobe After Effects for post processing, which included color correction, masking of foreground obstacles and general compositing. During compositing it was decided to use only location 1, due to technical difficulties. As a last part of the implementation, the production pipeline was defined.

The test showed that the project film in general conveyed a realistic mood more than any other, but also that matchmoving and the point-of-view individually were better at conveying a realistic mood. The suggested visual styles of the project film were unsuccessful in enhancing the realistic mood. The test determines that the expert respondents possessed both a sales related bias and a technical bias compared to the control group respondents. A sense of the building's physical presence in the scene emerged from the data as a specific aspect of the realistic mood, which was worthy of further exploration. Answers from expert respondents indicated that the realistic mood of the project film did not have sales potential. Expert respondents also indicated that the matchmoving also lacked sales potential, although this indication was not quite as strong. Almost all suggestions for improving the project film came from expert respondents, and there was a somewhat higher amount of comments on the visual appearance rather than on the use of matchmoving or the point-of-view.

Ultimately, the test provided no solid proof of matchmoving being valid as a realistic addition to contemporary architectural visualizations. Comparing the realistic look of the project film with the use of matchmoving for sales potential, expert respondents were less critical towards matchmoving. Additionally, a sense of the building's physical presence in the scene proved worthy of future exploration. Therefore, the project now has two likely directions in which to proceed:

1. Maintain the technique of matchmoving, since this was the lesser criticized aspect of the project aesthetic, and attempt to alter the realistic look according to the many improvement suggestions, which is closer to the look of industry visualizations
2. Make the building's presence the focus of the project film and find a suitable purpose for such a visualization

As it stands however, expert respondents provided strong indications that the current architectural visualization industry is not yet ready to accept the project film as a valid addition to contemporary visualization methods for the purpose of sales.

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9 Appendix

9.1 Email correspondence with 3DTree for Analysis

University master project on matchmoving and architectural visualization
12 meddelelser

Mikkel Lykkegaard Jensen <mikkel.l.jensen09@gmail.com> **25. feb. 2011 08.58**
Til: johan@3dtree.co.za, berdy@3dtree.co.za, eugen@3dtree.co.za, ronel@3dtree.co.za

Hi 3DTree.

We are two master students doing a project on digital visualization of architecture. The purpose is to move away from the classical 3D illustration/animation and instead explore the use of matchmoving to present an alternative way of showing architectural projects.

We found your video which is similar to what we are aiming at (http://www.youtube.com/watch?v=6NCvs2Nsua8), and we were wondering if it was possible to get a bit more information about it and about this topic?

In Denmark, the use of matchmoving is limited if not used at all. Is this also the case in South Africa?
Any information about matchmoving and the use of this technique within architectural visualization would be greatly appreciated.

best regards

Mikkel Lykkegaard Jensen
-master student in Medialogy at Aalborg University in Copenhagen.
Denmark

Eugen 3DTree <eugen@3dtree.co.za> **25. feb. 2011 09.20**
Til: Mikkel Lykkegaard Jensen <mikkel.l.jensen09@gmail.com>

Hi Mikkel,

Thanks for the interest - matchmoving is definitely an awesome way to do visualization. Not only does it put the illustration into a real and tangible environment (with the feel of the real world) but it is in the organic and natural movement of the camera that shot the original footage (most 3D animation suffers from the very lifeless and mechanical camera moves that are mathematically precise and therefore unnatural).

This process which uses matchmoving is rather limited - it's sometimes used in commercials and mostly in effects-driven big-budget Hollywood films. I've hardly seen it used in architectural visualization. I think the reason is that the process involves a number of processes that are highly specialized. For example, not only does the model need to have pretty realistic texturing, the scene needs to be matchmoved, and some of the scene needs to be modeled (the buildings or topology that interact, reflect, or cast shadows onto or from the new building) and good lighting and rendering (probably image-based lighting, like HDRI panorama or something similar) followed by good compositing to make sure the 3D blends right with the

imagery.

So you can see it's not that straightforward (which is probably why it's hardly done) but the results are far more impressive and relatable than the normal 3D animation that's done. We've been working in 3D for a number of years, and are quite experienced in the whole process... We'd love to work with you and help you achieve your goals in your work. Feel free to ask questions and let's see how we can work together!

By the way, although I'm South African, my dad is Norwegian - so I've got a little Scandinavian in me... Although I can only really say hello, thank you, and count to 10 :)

Kind regards,
Eugen Olsen

-----Original Message-----
From: Mikkel Lykkegaard Jensen [mailto:mikkel.l.jensen09@gmail.com]
Sent: Friday, February 25, 2011 9:58 AM
To: johan@3dtree.co.za; berdy@3dtree.co.za; eugen@3dtree.co.za; ronel@3dtree.co.za
Subject: University master project on matchmoving and architectural visualization
[Citeret tekst er skjult]

Mikkel Lykkegaard Jensen <mikkel.l.jensen09@gmail.com> **25. feb. 2011 10.36**
Til: Eugen 3DTree <eugen@3dtree.co.za>

Hi Eugen.

Thanks for the quick response.. small world :) I noticed your last name Olsen. That's also very popular in Denmark. :)

So what was the purpose of the video you made? was it for an architectural company, or merely something you did for yourselves? I'm trying to find out if this technique is used at all for architectural visualization, and so far I haven't found anything. The 3D visualization companies I've talked to in Denmark say its because the process is too expensive, which it sounds like is the case in South Africa as well??
From your response I am beginning to understand why. :)

We are working with some visual engagement theory, and I hope you will allow us to refer to this correspondence in our report, because it really supports our hypothesis regarding the possibilities of using matchmoving in this area.
I don't think our University will sponsor a trip to South Africa so we could meet :) But would it instead be possible for us to use you guys as a kind of external expert supervisors? This would mean that we could maybe send you some visual material and receive some feedback and critique?

Best Mikkel

2011/2/25 Eugen 3DTree <eugen@3dtree.co.za>:[Citeret tekst er skjult]

Mikkel Lykkegaard Jensen <mikkel.l.jensen09@gmail.com> **25. feb. 2011 10.49**
Til: ketzer09@student.aau.dk

---------- Forwarded message ----------
From: Mikkel Lykkegaard Jensen <mikkel.l.jensen09@gmail.com>
Date: 2011/2/25
Subject: Re: University master project on matchmoving and architectural visualization
To: Eugen 3DTree <eugen@3dtree.co.za>
[Citeret tekst er skjult]

Eugen 3DTree <eugen@3dtree.co.za> **25. feb. 2011 11.01**
Til: Mikkel Lykkegaard Jensen <mikkel.l.jensen09@gmail.com>

Hi Mikkel,

Yeah - small world! We were working with an architectural visualization company (our company actually focuses on 3D animation and visual effects) to take their 3D model of a building that is planned for the business sector in Johannesburg, and incorporate it into some live-action helicopter shots of the area... The reference we got was done by a large postproduction house in London (check it out here: http://www.youtube.com/watch?v=REj9uL_NOjo) and we did that piece as a test on how to approach the process. We've done something similar on a much larger scale (and it turned out really good, very similar to the link above), but it was a closed project so I don't have it available to show.

We'd be happy to help where we can - give you advice and maybe run through some of the stuff you're working on to see how we can help. I'm always eager to get involved - especially in a little experimentation.

Kind regards,
Eugen

-----Original Message-----
From: Mikkel Lykkegaard Jensen [mailto:mikkel.l.jensen09@gmail.com]
[Citeret tekst er skjult]

Mikkel Lykkegaard Jensen <mikkel.l.jensen09@gmail.com> **25. feb. 2011 11.36**
Til: Eugen 3DTree <eugen@3dtree.co.za>

Hi Eugen..

That video looked awesome! and thank you for your help.
I would love too see the one you did as well. Please let me know if it gets published so we can see it!
We are in the very beginning of the project now and will be working until the deadline in the end of May. So we will not be sending you anything for a while. :)
But it's really cool to see the technique being used, and I must admit we now have something to live up to.

We might also end up sending you a questionnaire or something similar, because we have to do a test on what we create. And feedback from you would weigh much heavier than just asking fellow students what they

think about it. I hope this would be okay?

The idea is to use matchmoving, but not in connection with helicopter shots. Rather we will focus on a street-view approach so the viewer would have the perspective of an average pedestrian. Also we are thinking of breaking the aim for complete realism in the sense that a wall would suddenly become transparent, thereby showing the inside (e.g. the lobby) of the building as well.

Just to let you know the rough idea so far.. :)

thanks very much Eugen

best regards
[Citeret tekst er skjult]

Eugen 3DTree <eugen@3dtree.co.za> **25. feb. 2011 12.11**
Til: Mikkel Lykkegaard Jensen <mikkel.l.jensen09@gmail.com>

Sure thing - we'll help where we can.

On shooting from the street, it'll help tremendously when it comes to the matchmoving (if the camera is not moving much, particularly if it's on one spot, like on a tripod). There are a couple things to consider when approaching this - plan it shot by shot (if you can, do a storyboard and/or an animatic of the process) and while filming, take as many reference photos as you can, as well as an HDRI environment shot (get a medium-sized mirror-ball, and photograph it at 3 exposures and combine it in photoshop to help light you scene later). We did this also for a video under the youtube.com/3dtree channel - putting a ford mustang into a live-action scene. If you need more info on this, feel free to contact me.

Good luck on the project!!

-----Original Message-----
From: Mikkel Lykkegaard Jensen [mailto:mikkel.l.jensen09@gmail.com]
[Citeret tekst er skjult]

Mikkel Lykkegaard Jensen <mikkel.l.jensen09@gmail.com> **25. feb. 2011 14.12**
Til: Eugen 3DTree <eugen@3dtree.co.za>

Hi again Eugen.

Just a quick question...
Is there any tracking software you would recommend we use?
We have both PFTrack and MatchMover as available choices.

best
[Citeret tekst er skjult]

Eugen 3DTree <eugen@3dtree.co.za> **25. feb. 2011 16.11**
Til: Mikkel Lykkegaard Jensen <mikkel.l.jensen09@gmail.com>

Sure - I've used both, and Matchmover has gone out of development as a standalone - I think it's bundled with autodesk's Maya and Max... It's a

very good one. PFTrack has a whole lot more to offer, and uses a very good algorithm. I've moved on to PFMatchit because of its node-based and 64-bit system, but they're similar.

Both are very good, and whichever you've used or have more training material on, use that!

-----Original Message-----
From: Mikkel Lykkegaard Jensen [mailto:mikkel.l.jensen09@gmail.com]
[Citeret tekst er skjult]

Mikkel Lykkegaard Jensen <mikkel.l.jensen09@gmail.com> **3. mar. 2011 11.25**
Til: ketzer09@student.aau.dk

---------- Forwarded message ----------
From: Mikkel Lykkegaard Jensen <mikkel.l.jensen09@gmail.com>
Date: 2011/2/25
Subject: University master project on matchmoving and architectural visualization
To: johan@3dtree.co.za, berdy@3dtree.co.za, eugen@3dtree.co.za, ronel@3dtree.co.za

[Citeret tekst er skjult]

Mikkel Lykkegaard Jensen <mikkel.l.jensen09@gmail.com> **3. mar. 2011 13.53**
Til: Eugen 3DTree <eugen@3dtree.co.za>

Hi Eugen.

I was wondering if I might pick your brain a bit more? :)

We are in the process of planning the shot, and there are some things I thought you could help clarify.
for example, we have different cameras available through the University, but we are unsure of which would be best. The top model is probably the Canon XL2, But it does not record in HD.. other alternatives are smaller handy-cam types, and they do have the HD option. But is this even important? what did you use?

Also, could you elaborate a bit on the whole mirror ball technique? I get that its about capturing the light from the scene, but after its converted into an HDR image, what do you do with it? Do you import it into Maya or is it used in the compositing software?

any other pieces of advice/tips and tricks will of course also be appreciated.. :)

very best regards

Mikkel and Kim
[Citeret tekst er skjult]

Eugen Olsen <eugen@3dtree.co.za> **3. mar. 2011 21.52**
Til: Mikkel Lykkegaard Jensen <mikkel.l.jensen09@gmail.com>

Hi Mikkel,

While anything shot in HD does give you better resolution, unfortunately the lower-end HD cameras have inconsistent chips (often really stretching the pixels) and the compression can sometimes screw up the shots a lot. So while I'd prefer shooting in HD, I always prefer a prosumer camera over the consumer ones. The XL2 is a great camera, and I suspect you're producing this at SD anyways, so rather work on that. You'll probably also be able to get the specs of the lens and chip of the XL2 (more easily that the other cams) and use that if you have any problems with the camera tracking...

Keep in touch, and all the best!
Eugen

9.2 Email correspondence with Moose Studio for Analysis

Hej Mikkel og Kim

Tak for jeres ved mail. Det lyder spændende med jeres master projekt.

Vi har mange års erfaring med arkitekturvisualisering men har aldrig brugt match moving i vores film. Det skyldes generelt at det er for dyrt at lave den slags her i Danmark. Jeg ved at det er udbredt i udlandet, specielt i USA og i bl.a. Dubai.

Problemet her hjemme er prisen og tilgængeligheden af udstyr. Deriblandt helikopter, kamera og mandskab. Vores erfaring siger os at danske kunde er meget tilbageholdene med at bruge penge på 3d om det er til markedsføring af projekter eller til et dommerpanel.

Jeg personligt har arbejdet utrolige meget sammen med Henning Larsen Architects og selv et firma i den kaliber, og projekter med store budgetter vil bruge meget få midler til 3d visualisering, altså billeder og film.

Normen er at enten at løse det hele i 3d eller det der hedder 2.5d - eller at lave photo match på still billeder, altså sætter 3d modeller ind i rigtige billeder.

Jeg glæder mig til at høre mere om jeres projekt og i skal være meget velkommen til at skrive tilbage.

De bedste hilsner
Peter Krogtoft

Peter Krogtoft
Moose Studio
Kompagnistraede 33, 3th

DK-1208 Copenhagen K
Denmark

-----Oprindelig meddelelse-----
Fra: Mikkel Lykkegaard Jensen [mailto:mikkel.l.jensen09@gmail.com]
Sendt: 22. februar 2011 15:20
Til: themoose@moose-studio.com
Emne: Samtale vedr universitetsprojekt om digital arkitektur

9.3 The Dogme vow of chastity

THE VOW OF CHASTITY

I swear to submit to the following set of rules drawn up and confirmed by DOGMA 95:

1. Shooting must be done on location. Props and sets must not be brought in (if a particular prop is necessary for the story, a location must be chosen where this prop is to be found).
2. The sound must never be produced apart from the images or vice versa. (Music must not be used unless it occurs where the scene is being shot.)
3. The camera must be hand-held. Any movement or immobility attainable in the hand is permitted.
4. The film must be in color. Special lighting is not acceptable. (If there is too little light for exposure the scene must be cut or a single lamp be attached to the camera.)
5. Optical work and filters are forbidden.
6. The film must not contain superficial action. (Murders, weapons, etc. must not occur.)
7. Temporal and geographical alienation are forbidden. (That is to say that the film takes place here and now.)
8. Genre movies are not acceptable.
9. The film format must be Academy 35 mm.
10. The director must not be credited.

Furthermore I swear as a director to refrain from personal taste! I am no longer an artist. I swear to refrain from creating a "work", as I regard the instant as more important than the whole. My supreme goal is to force the truth out of my characters and settings. I swear to do so by all the means available and at the cost of any good taste and any aesthetic considerations.

Thus I make my VOW OF CHASTITY.

Copenhagen, Monday 13 March 1995
On behalf of DOGMA 95
Lars von Trier Thomas Vinterberg

9.4 Test answers

9.4.1 Test answers from Control group

1. What style of mood did the film convey to you?

CG 1: An excitement to see the rest. It's shown a lot from below. You can't really see the whole building

CG 2: It's a very nature-like, it's a very natural reproduction of the house. It is where it's supposed to end up being. It's where I can see it now.

CG 3: comparing to the traditional, I think this feels very different as well as more real.

CG 4: I felt it was believable

CG 5: Realistic mood.

CG 6: excitement to see what was coming.

CG 7: Realistic approach. Grey lighting, not super saturated kind of image. Like when you randomly walk on the street and film it. Natural.

CG 8: being there, because the camera "walks". Youtube video feel. But you don't get to see the building as much as you would in the traditional one.

CG 9: Dull. Sterile, not much is happening.

CG 10: everyday look. Down to earth presentation. I could have walked down the street.

2. What did you think of the use of matchmoving in the film, with regards to the purpose?

CG 1: I think you get a much bigger sense of how it looks compared to other wholes and where it's supposed to lie. You see the connection in if it fits into something else, other architecture. The other [traditional architectural visualizations] you can't really, it's sort of like a beauty painting that you can have anywhere, so you don't know what lies next to it or around it. But this [the project film] I think, it just gives sort of, there is another unique building in relation to others, which lie there and are also special.

CG 2: This [our project film] is much more realistic.

CG 3: Thought it worked well. Even though the graphics are limping a bit, the mood was believable.

CG 4: there could easily be a building there.

CG 5: It provides a good picture of what you as client can expect in relation to the product. You quickly get the sensation of what can be expected because it seems very realistic and believable.

CG 6: It fits 100 % for the purpose.

CG 7: shake camera reminds me of blair witch project. More personal feeling. Not sure if it is a much more professional level, but it feels like it is closer to you. Felt like it was trying to connect to the person, and not being super over produced.

CG 8: It works well. It seems more probable that the building is there, as opposed to the fly-around style. Looks more real. Noticed the issues with matchmoving.

CG 9: works well, because you place the building in an extisting area. But not necessarily more exiting. This also depends on the level of detail on the 3D model. Hard light would be more exiting.

CG 10: when going for a realistic look, you lower the requirements for the presentation of the building. The strength of matchmoving is that you can hide 3D objects in the scene.

3. Did the decision to shoot the film from a pedestrian point of view benefit or detract from the purpose?

CG 1: It gives a very… when you see a rock and a car, you can start forming an impression of how high is this [the building] in reality and how much is it up to the first floor with human eyes. There is a lot of realism in this.

CG 2: The house appears very large. You can see the real size ratio.

CG 3: this I think worked very nicely because there was movement, and thereby immersion. However the graphical aspect seemed more obvious here than other places in the film. The immersion still works though.

CG 4: It works well, but from this angle the realism is not quite convincing, because something natural is missing like a bike leaning up the building, garbage cans etc.

CG 5: the pedestrian perspective was positive in relation to the purpose, as this type of recording seems very realistic in terms of the product it tries to deliver. It was not until the 5th time I watched it, that I saw the building was not real and only a 3D model. It provides a very realistic feel of what it might actually will look like, compared to the fully animated product, which looks good in the image, but does not convey the same realism. If the recording was more floating and not so “Dogme” it would work better.

CG 6: positive. It is nice that you can relate to what it will look like if you were out for a walk on Islands Brygge. A birds eye view would be nice, but I assume none of you have a helicopter.

CG 7: a lot more personal. Noticed that you did not really see the entire house . The traditional shows better how the building looks in the environment, whereas yours is more how your front door would look like. This is how it would feel to live there.

CG 8: missed that the camera looked up. But apart from that, it worked well.

CG 9: works well, because you get a sense of scale, compared to yourself. Good for imagining how it would look like in reality.

CG 10: To give overview, the helicopter perspective would be the best choice. Does not think it makes that big a difference. The main benefit of this perspective is to show how tall the building is.

4. Which visual style was best at blending the 3D building with the real world footage?

CG 1: Sepia

CG 2: The unaltered

CG 3: Sepia

CG 4: Unaltered

CG 5: Blue

CG 6: Unaltered

CG 7: blue

CG 8: Sepia

CG 9: blue and unaltered are equally good.

CG 10: Sepia

5. Was this style also the most realistic?

CG 1: Sepia

CG 2: The unaltered

CG 3: yes,

CG 4: yes.

CG 5: Yes.

CG 6: unaltered

CG 7: unaltered

CG 8: yes

CG 9: unaltered

CG 10: unaltered

6. If you answered no to the question above, what could be changed/improved in the most realistic style to blend the 3d building better with the real footage?

7. What did you think of the goal being a realistic mood rather than the typical stylized visualizations?

CG 1: I thought it was very effective, the start I saw in your video where you construct this [the 3d building] in this and this and this fashion. And suddenly it just lies right there between two other buildings, where its' supposed to lie. I thought that was very effective. What bothers me a bit is that I can't see it all. I have problems forming an impression of the building [in the closer POV-shots]. But there is more calm in it, in the

first shot anyways. Here [the following two shots] I start to think “where” and “what” and “how does it look”.

CG 2: The advantage is that you see the building in relation to where it’s supposed to be.

CG 3: this living movement the film has works very good.

CG 4: Since there is a real background, it feels like you are there, which makes the experience of the building more real than an image. The traditional seems artificial.

CG 5: it gives a better impression and overview of the product.

CG 6: serves the purpose. As a client I would be happy to see how the finished project could look like. A showcase however would also be nice.

CG 7: depends on who you are selling it to. Super stylized for high budget projects, but for e.g. students yours could work because its not so polished. You know what awaits you. It could work well to explore the house.

CG 8: Depends on what you are showing. Here it works well. Likes it because it is more down to earth. Regarding the fly-arounds, they look good, but how is it really going to look?

CG 9: Can understand why they in the traditional style move away from realism in order to sell it. But if I should buy something, I would be more interested in watching how it would actually look.

CG 10: the traditional has more Wow factor, where yours feels more like what you can experience when the building is finished. The traditional sells better because it catches the user better.

8. Additional comments?

CG 3: seems very convincing, because you almost move right next to the building. The graphics follows along nicely, but seen from the pedestrian perspective I think the building should be more detailed.

CG 5: Good work.

9.4.2 Test answers from Professional group

1. What style of mood did the film convey to you?

3DTree: First off - overall, I found the video to be nicely put together. Entertaining and well-produced. The mood was light, particularly the playful way in which the 3D concept of the building was put together, and the music being light-hearted and fun.

Peter from Moose: I think the film is too short to really talk about a mood. But from a technical point I think you guys did a great job. If the mood is about the weather, Im not so sure it would work from a sale point of view. But it looks dramatic and interesting.

Vistec: Initially it does not feel very realistic, due to the intro and construction animation where you break the illusion. Track was good. Missing more movement. Can easily see the building is a render, because of missing reflections and detail.

SEA 1: Realistic – not idealized. A bit spooky. Sketch-like building is a stranger in the scene. Model works best from far away. Google earth aesthetic.

SEA 2: calm. A bit unrealistic without people around, and there were also not so much architectural details. Details are needed for it to better fit in the scene.

SEA 3: I think the film is very realistic. It is only because I work with 3D models that I can reconize the difference and the problems.

SEA 4: quite sad, bad weather. It would be better if there were some people on the ground.

Ernst from Moose: Rain. It was a bit grey, I think. I don't know if the visual was supposed to have an impact, when you watch the movie. Shooting on grey day: Sensible to avoid struggling with cast shadows, it leaves everything diffuse. But it becomes somewhat suburban. It should maybe have been more contrasted, so you would've had color and bigger differences between light and dark. A bit home-camera-ish color-wise. I would have pulled a bit in the colors. Make both the 3D and the footage stand out. As soon as it becomes visual, everybody has an opinion. It's difficult to have an opinions about something that's not there. What I feel like I'm missing, I don't get a wholeness. The first [shot of matchmoving] is an establishing shot, but the others only show the bottom of the building. They don't show anything about "what does the matchmoving do here". It mainly shows that matchmoving has been used. This [a traditional 3D image] I can see all the details and get a sense of the building in a better whole, than I can in that [the project film]. If the technique [matchmoving] is worked with, you can get something from all angles, a sense of how the building will look, if you approach it from the street. So the technique is very exciting and much more exciting than a 2D image.

Cenario: It has an expression of documenting, rather than seling. For sales, you'd always make sure there was sun for instance. This [project film] looks more like a study of cohesion, how it lies next to the adjacent buildings. It doesn't have the happy-go-lucky , use of light etc.

Archivisuals: Obvious potential in making those things [matchmoving] in relation to the human scale. What we talk about as architects is that you are like a person in the city and city space. When you make those movies, you have an opportunity to get close to the building in a much more movable fashion. Get up to the building, standing next to it. The clips you show, which are very short, I definitely think you get a good sense of this building standing between two other buildings and how it meets the ground. Would require

going further with building's connection to the ground, an important part when approaching the building in the movie. In relation to mood, the only thing really missing is sunlight. It's a bit grey. To get positive mood, don't show the boring backside or the sad grey weather day. It's primarily the lighting, and some of the green; grass, trees, flowers, plants [the absence of them] – this can add atmosphere to the image. The actual location itself it very city-like, with pavements, asphalt and thus not like botanical garden, but a plant or two is still allowed and would enable good-looking pictures. And record on a sunny day, determining the direction of sunlight = place the building better on the ground. Despite these omissions, it [project film] gives a fantastic illusion of moving in relation to a 3D object, which architects normally depict as being 2D. This [the matchmoving] can really do something different = immediately gives a pretty good sense of size of what you look at. It gives a good sense of the house.

2. What did you think of the use of matchmoving in the film, with regards to the purpose?

3DTree: Machmoving the building into the real life scene was great - not only well executed, but immediately put the building into context. Not only its design and look in the real world, but giving a good idea of its scale and space, which is often never achieved, or simply lost in a 3D illustration.

Peter from Moose: For matchmoving to really work and standout, there need to be some thought and story behind it. It like a action packed movie with lots of really cool special effects but a lame and forgetteable story. It might be cool but you're only gonna watch it once. Dont get me wrong, there is potential in what you are doing.

Vistec: it's brilliant. It is the way to go.

SEA 1: it is important that the project stands out and not everything else. Here it is almost the project that looks the worst. This is why animations often feature sketched environment and high level of detail on the main building. How can this be achieved in this media?
Perhaps you could make the building more sketch-like and use it to show more how the volume works in this space.

SEA 2: it would be good for people who does not have a clear idea from plans and blueprints of what the building would look like. It could also be a good way to show some funny or shocking ideas.

SEA 3: it is realistic, but I can recognize the render. Would be good to show to people who are not architects or otherwise are able to recognize the render.

SEA 4: It is a really good idea to show people how it will look like in a real place between existing buildings.

Ernst from Moose: I think it's really good. Traditional architect visualizations are very much beauty shots, they don't reflect reality in any way. They stand entirely clean, delicious and will never be that way. But I also like that. It's good at selling, but maybe not physically accurate. If you, as a potential renter/buyer/builder can't get a sense of how the light actually is – and you get that from a place like this [project film] because you put it into the surroundings, so you get a sense of room and everything without guessing about it, so I think that's exciting.

Cenario: You have very little movement in your matchmoved shots. It could almost have been 3D stills. Maybe use movement around an object. The matchmoving itself doesn't create the grey weather. But it does

give a somewhat mystic mood, when it moves slightly, sort of a spooky mood. Maybe film while driving over the cycle-bridge, or study of changing light, from day to evening (timelapse).

Archivisuals: I think it's fine. You've succeeded in creating a neutral, somewhat boring day. You can work more with placing the building on the location; work on small things, details. Sun or grey weather = not as important. A grey weather day can still look good. There are two opinions = Show it as honestly as possible, don't add sun or gloss. The other is to create the good day, the best way, nice sun. Visualizations work on an agreement when presenting, that it still doesn't show reality. We still look at a produced image. And when you're producing an image, why imitate reality to such an extend that you take all the bad elements. The picture must show something and it shouldn't be perceived as being real. It should be a scenario or situation. If you show a good idea through a picture on a sad grey weather day – you wouldn't do that. The pretty situations still occur in reality, so we can show that in images, even though people know it doesn't look like this when the sun doesn't shine. Even though you aim for the grey day, you can still work with e.g. contrasts and make the picture a bit more friendly to look at. It would be difficult to sell apartments in this building [the project film]. And then = what's the purpose? Is it just to show something nice? It could work to make people not build the building. Don't underestimate how powerful it can be to show these small movie clips [project film] = can move many people's attitude towards smaller building projects.

3. Did the decision to shoot the film from a pedestrian point of view benefit or detract from the purpose?

3DTree: I think the pedestrian view was particularly beneficial - giving a 'hands-on street perspective' of what the building would be when built. That is always one of the missing factors in architectural visualization - what will the building ultimately do to the street look, design and how will people perceive it - and the 'pedestrian POV' conveys this very well (I like the fact that you mixed some 'handy-cam' audio to it, keeping down-to-earth and that it feels un-tampered with (although you certainly put a lot of effort into it!

Peter from Moose: It certainly did work, I think combined with some other shots it could be really cool (and properly a lot more expensive)

Vistec: it is an obvious thing to do. Matchmoving is a great tool for communicating experiences and immersion. You are too conservative with the camera movement. discussing the limitations with matchmoving in terms of obstacles.

SEA 1: It was only the last of the three shots where I felt a 3D feeling. The other two just felt like shaking 2D images. More movement.

SEA 2: Definitely positive because it is the way people would see the building. But you should add something extra like a view from the building itself, and not just how it would look.

SEA 3: there is a problem with the personal view because people can see with a field of view of about 145 degrees. With a camera it is not possible to render this view without deforming the image too much.

SEA 4: positive.

Ernst from Moose: I think it's fine. I would prefer to approach it from a distance to get a sense of the building as a whole. When cutting close, I have no sense of how high the building is. With more time maybe

you could've started 100 meters further down the road. Maybe also look up, when you get close. Or look out, so you look at what's around the building. Because it's both interesting to see the building and the surroundings it's placed in. But the intro was good with from up high and down.

Cenario: It seems very realistic. It's not flying around, up and down and about. It does give a limitation in it being a tiny cut-out. What does it tell about the surroundings? Focus is only on the house.

Archivisuals: It's insanely positive. It's the strong in your way of presenting. There's not a lot of it, but I can see that you want to approach this building in a walking, almost nonchalant way, in a natural way. It's really strong that the small movement in the camera still gives so big a 3D-effect and understanding of how big is the building? how do I approach it? What am I approaching? There are still omissions, such as how the building meets the ground, but there is extremely big potential in the fine movement [of the camera]. It shouldn't be as much as Trier's Dogme film. In the amount you use it's fine, combined with some more immovable: The establishing shot. I like that it is soft movements and that you can clearly see it. It's great. Your movements are decoded as human movements, it's not a machine = it's opposite to the mechanical motions [of traditional 3D animations]. This [project moving] is much better. You can make those handheld things, it has potential.

4. Which visual style was best at blending the 3D building with the real world footage?

3DTree: When it comes to the visual style I would say that the most realistic was the 'unaltered' version of course - but the blue hue also played very well with the image. However, I would say that if you are using a visual style like that, it should be consistent throughout the entire video, and while the shots are realistic, changing the color (to a degree) doesn't take away much of the realism (except for the sepia look, which has become so over-used and common that it's immediately picked up as an altered video). What matters is what style you're trying to convey using color. It really helps to use color to bring across these concepts - for example, if you can bring across a cool blue 'intellectual' feel, or a warm orange & yellow 'inviting' feel - it must simply be consistent throughout the entire video (or the related scene). Although I recommend keeping the style as minimal and subtle as possible. There's an excellent book on the topic of using color in film and imagery called 'If it's Purple, Someone's gonna die' by Patti Bellantoni (http://www.amazon.com/Its-Purple-Someones-Gonna-Die/dp/0240806883) that gives a lot of motivation for color use to convey mood and style. The first thing (which I think you've achieved rather well) is to get the image looking as realistic and matching up to the 3D as possible - then after that, the addition of color is simply to convey a mood.

Peter from Moose: Hmm tough one. Blue has a nice kinda movie look. But then again Im not sure its the way to go with this kind of project. If the film was shot more like a real movie, it could work.

Vistec: it is not so much a question of realism as it is a question about expressionism. Blue works best. Blue reminds of large movie productions and Hollywood. You could have done a lot more in terms of color correction.

SEA 1: blue

SEA 2: blue and unaltered

SEA 3: unaltered

SEA 4: Blue

Ernst from Moose: Generally, I would think this is the best [the unaltered] because everything's grey already, so this seems more natural. But I still think it's very grey and flat.

Cenario: Sepia. The unaltered is so good, that you might not need to add color filter. However, the vertical columns might appear a bit lighter than the footage. But for the Sepia, you probably think it's just a house standing there.

Archivisuals: Sepia. Some of the ground/gravel tones blend with the [vertical] columns of the 3D building. Color filters are an easy way of attempting to make everything fit more together. Editing together four different pictures each have their own visual, and often a color filter can easily add a bit of color to everything, making them fit better together. The building itself has light that appears to be the same as the footage. It's not bad in the unaltered. You might not need color filters to make it fit in the image. Color filters risk of making everything the same color. Blending is fine, but it shouldn't be muddled together. So a slight difference could be nice.

5. Was this style also the most realistic?

3DTree: Another idea to try is to go straight black & white (this is often used to convey realism as well) and perhaps try making it feel old and 'filmic' with grain and scratches, a bit of film jumping. That really sells it as realistic - if that's maybe the style you're going for :) Otherwise, stick to the 'unaltered' or a slightly cooler, blue feel to keep it realistic.

Peter from Moose: Unaltered

Vistec: unaltered

SEA 1: yes, but that is mainly looking at the project.

SEA 2: yes

SEA 3: The reality is often worse than imagination.

SEA 4: the building is boring. The realistic view is worse the a fantasy view if you want to sell it.

Ernst from Moose: The unaltered.

Cenario: The unaltered. Everyone can see the sepia has been color altered. It becomes its own aesthetics.

Archivisuals: The unaltered

6. If you answered no to the question above, what could be changed/improved in the most realistic style to blend the 3d building better with the real footage?

Peter from Moose: I dont think the look alone does the blending. Its also about how real the cg looks, reflection, lights, materiales and so on. I think you did a good job on the lighting and it fit nice in the cloudy

mood from the live action. I know that if a client saw this they would be commenting on where all the people have gone. Most of out clients want the picture to come a live and show that its a nice place to be. If its to dark and dead, it will not give the right kinda feeling to the viewer.

Vistec: there is a problem with the very dark glass that has no reflections. The white balance is also off. There is a temperature difference in the image in that the yellow columns stick out. But this can also work to your advantage, as it can help direct focus to a specific object.

SEA 1:

SEA 2:

SEA 3:

SEA 4:

Ernst from Moose:

Cenario: The columns are the only thing I notice. They're too bright in relation to the other things. The bottom of the columns might be the problem. The body of the building lies very well. The connection between building and ground could have been better.

Archivisuals: You want the building to lie on this location. You can't go all the way just through color filters. The building should be its own, but to lie on this location, it should have certain tones of the surrounding buildings and sky. Reflections should also be considered, buildings should be reflected. Without, everything looks weird, but when reflections are there, it fits and makes the building fit better. The sepia gives a small sense of the possibility of a sun, while the blue suggests subzero temperatures. They suggest a mood. Color filters would be the first step towards gong for a mood, rather than realism. Blue = cool mood. Sepia = soft, warm, calm. Lighting would be next.

Reading the meeting between building and ground, something happens at contact point. It could be one material meeting another material. It would often be placed on a foundation, not just gravel. A slight shadow would be present at contact point. It would help the building lie completely on the scene, also since this is what you're closest to as a viewer. Some internal shadows are pretty dark and the shadows from the building on the ground isn't completely convincing.

7. What did you think of the goal being a realistic mood rather than the typical stylized visualizations?

3DTree: As I said, I think that you have a great look and have used some subtle and great techniques (the hand-held, pedestrian POV, etc) to convey a realistic and down-to-earth visualization of the building. It's going the extra mile to bring across another dimension for the client - ultimately what the building will do to the real landscape.

Peter from Moose: I really like the mood (weather) Its more dynamic than 12'o'clock sun. But again most client would never agree on this.

Vistec: it is a likable project. Could imagine there is a niche in matchmoving and the Dogme inspired handheld camera, although it needs to look a lot better. Handheld could be popular, but there is no sale potential in a realistic look.

SEA 1: It is good to have this idea to show things as they really are, but there is also a point in showing things in nice light because it makes objects stand out. From a sales perspective, showing things in film and showing it in a real context has a huge potential, but it also involves a number of problems, as you have discovered. Fly-by works better for sale and looks more impressive.

SEA 2:

SEA 3:

SEA 4:

Ernst from Moose: I'm for both. Maybe if they can meet in the middle. So you still have somewhat of a glossiness, but also maintain a sensible relationship with the real world. People working in our industry have no problem seeing the difference and relate to it. However, people not working with it might have trouble distracting themselves from it looking strange, that it looks different than reality. So it would be fantastic to establish a middleground.

Cenario: You have a preconception, that this [project film] is realism. You could question that: what is realism? You made a specific mood. It's somewhat dogme-like. You could've chosen a sunny day. The reason you think traditional visualizations are very chromed, is because they are ordered to sell an idea or project. It's not so much if it's a media/handheld camera or not. It's a sale I 99% of the cases. You seem to have pulled color out of the buildings. You movie is a choice, but not realistic. It looks very well and functions well, but you've made clear choices. The location could've been blue sky, happy people etc and still been real.

Archivisuals:

8. The creation of the film took roughly 3 weeks.
Did this pipeline confirm, deny or change your perception of the usefulness of matchmoving within the area of architectural visualization?

3DTree: I think your pipeline is great - perhaps one thing I would add to shooting on location is taking a few HDRI's of a mirror-ball which will be used as a lighting and reflection object in your 3D work - and if client wants approvals during the process from 5-8, perhaps do an animatic (rough render of the building matched to the video between 6 and 7).

Peter from Moose: I think that there is a lot of potential to matchmoving. But I dont think it will ever be a big deal in Denmark, its way to expensive and takes to many and specialized resources.

Vistec: 3 weeks sounds pretty good when considering it is an experiment. it points to a well planned project and conduction.

SEA 1:

SEA 2:

SEA 3:

SEA 4:

Ernst from Moose: I'll say that matchmoving causes it to take 3 times longer than usual. Often you have numerous issues you have to overcome. Your scene is manageable, but sometimes the scene just isn't there.. [So basically no].

Cenario: I can't say if it takes more or less time for others to make this. I haven't an hour count of the few times we've made it. But for us, spending 3 weeks would cost the client 75.000. They can get many images for that: At least 3 images for less than half. A week is roughly 20-25.000. But oppositely, this is very cool for virtual scenography for a movie. It might not be expensive compared to model building. 75.000 might also not bee too much for a project like Gemini buildings [the rounded building next to the 3D building], where an apartment costs 6.000.000.

Archivisuals: No, it's fairly normal.

9. Do you think this use of matchmoving has potential for industry use?

3DTree: And I think matchmoving architectural visualization to real footage is an excellent - if not invaluable - tool for the industry. Good work, guys!

Peter from Moose: From my personal point, I would love to see more of it. From a prof. point - No not really. It might be used once and a while.

Vistec: you would come in and compete with other guys who are making films. You would not be able to replace the 2D image industry. However comparing to the existing animations being done, you could present an interesting addition. You avoid doing a lot of rendering in the form of cars etc. in a full 3D scene, but instead you have other challenges. You could do some things that others cannot, but you would also have limitations.

SEA 1: i think it would work better for smaller objects, as you run into problems with building size objects.

SEA 2:

SEA 3:

SEA 4:

Ernst from Moose: I think it could. But I don't control the money, the money control the process. Everything is expressed in the economy. With big building projects, an extremely small part of a budget is used on stuff like this. If they gave maybe an extra 50.000 we could make videos etc. But I'm not sure if they [customers] are interested. The freedom you have when making everything on a computer is, that the producer can come in and say "we want to change a bit here. The camera should go a bit right or left." When you have shot for matchmoving, you have no flexibility, so therefore the pre-production and storyboard has to be super tight. Another difficulty is that many animations are where you come flying from far out, through trees, which you couldn't do in reality. Both [animations and matchmoving] have pros and cons. Maybe you should just mix

the two, so the things that are impossible with a real camera, you would have with animation. What you could do with both, you would do with reality. But then a production of two fields would create double the amount of problems. I have trouble imagining it [matchmoving being used]. I think the project is exciting and the idea is good, because many people doing this [architectural visualizations] today have no clue how to do matchmoving, they don't know it. So it's exciting in relation to having a dialogue about the future. If you, as a drawing studio, feel like you have to do something new, put yourself on the map, it's interesting to be able to do what nobody else can. So I think it's difficult to sell.

I see this [matchmoving] as somewhat of a platform leading to augmented reality, where people can have the building placed on the location through their phones, allowing people to move for themselves around the building. It can be done somewhat simple technically.

Cenario:

Archivisuals: What is the need for an assignment? It must be cheap and fast, conceptual. You must reach a good result, quickly. This [project film] is about approaching the building, which space appears between the building, the general scale. It can always be better. The greatest would definitely be to have really sharp and nice reflections etc.

Matchmoving takes time. You can be stuck in 3 weeks of bad weather. If you produce a grey weather movie, it can't be used. It must be sun, green trees, happy people. Then you have to go with maybe a night shot. A real day doesn't need to be grey. It's not about glossy images or showing something that's not there, just show stuff on a good day. Doing that would give it [project film] more color.

10. Additional comments?

Peter from Moose: Først vil jeg sige at jeg rent teknisk er i rigtigt godt på vej. Det ser overbevisende ud. Jeg kunne måske godt have tænkt mig at der var arbejdet lidt med noget hdri og reflektioner. Det ville have solgt det helt ind. Men det er kun når jeg tager kritik brillerne på. Og det var jo ikke det opgaven drejede sig om. En side note, som jeg har gjort mig efter mange år i branchen er at der er reelt to slags overordnet målgrupper. Den ene er der hvor vi bruge visualiseringer, animation, film osv. til at markedsføre et produkt. Det andet er til beslutningstagerne. Altså bestyrelse, kommune, dommerkomite osv.Den førstnævnte falder i uden for, men jeg ser klart muligheder for at arbejde videre med det og bruge det til beslutningsformål.

Vistec: You should commit more to the concept of Dogme, as this is your inspiration. Don't use soft music. Have people run around in the scene, perhaps screaming. The intro is too matrix like. People will not buy this project, because frankly the building next to the 3D model looks a lot better. Its too grey and dull.

For the next time: get on a bike and make more movement. Exploit the difference from 2D images in that you are able to move around. You need to be explicit in showing what your project is about and what it can do. This rather feels like a demonstration stating, yes, you can track. What is different about this idea, compared to the existing methods?

Ernst from Moose: Better overview. Reflections in the building windows. Use matchmoving to better effect. Look up, speed up the camera to walk more around the building. Enhance the matchmoving effect. Film on a prettier day. No matter what you say, it's grey and boring. People want to have a prettier day, they don't

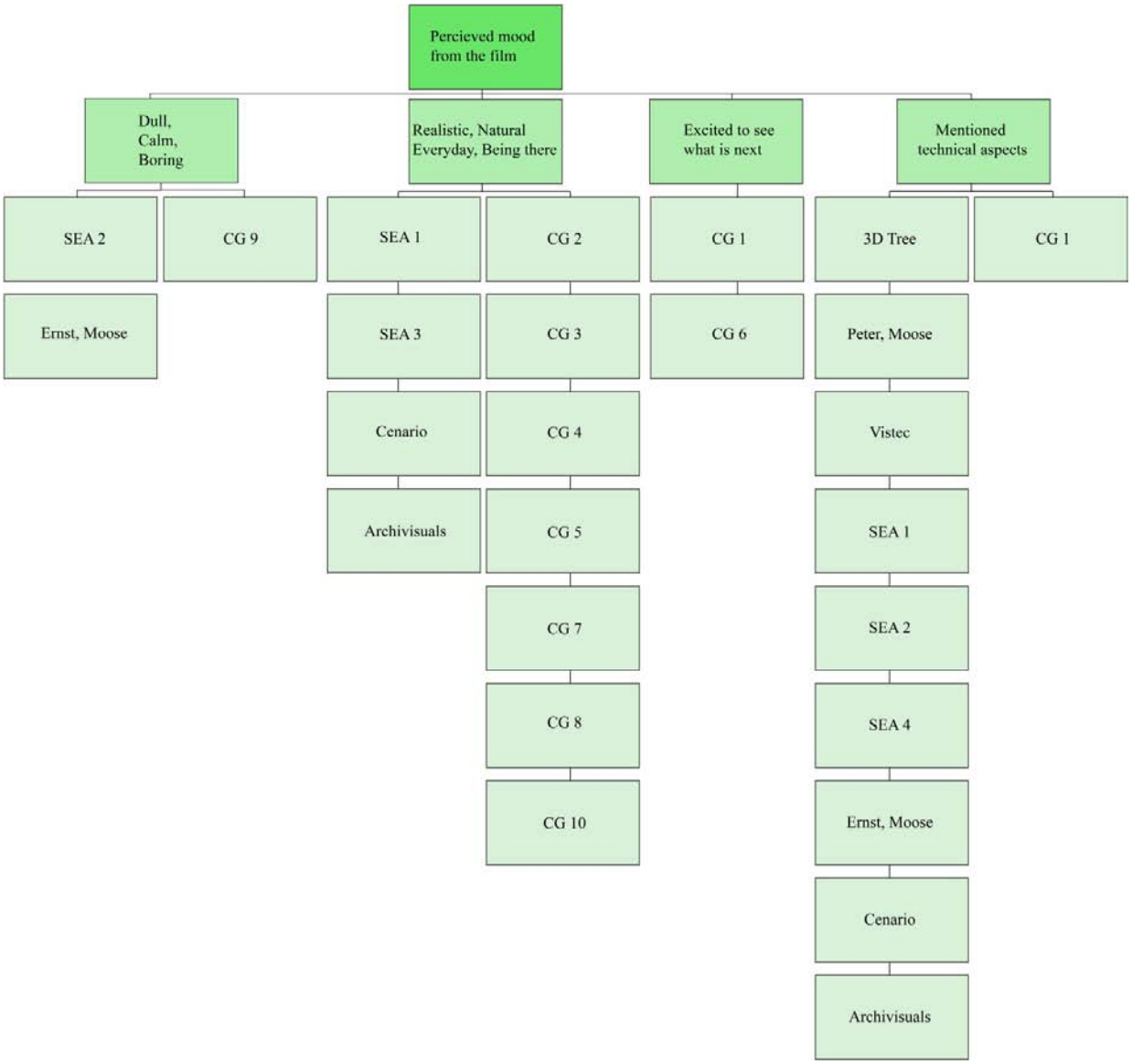
want that. Your starting point might as well be as good-looking as possible. Take notice of camera distortion. Adjusting color should always be done from more color to less.

Cenario: It would have been nice to add a person to the footage. Walking on camera, but not in front of the building. Would add scale. The quiet camera movements could allow for the addition of a person. Make better use of the medium. Move the camera to look up the building. Break the limits of still images. Adding sunshine would approach the normal visualization for marketing. I'm normally dictated towards the pleasant, sunny aesthetic.

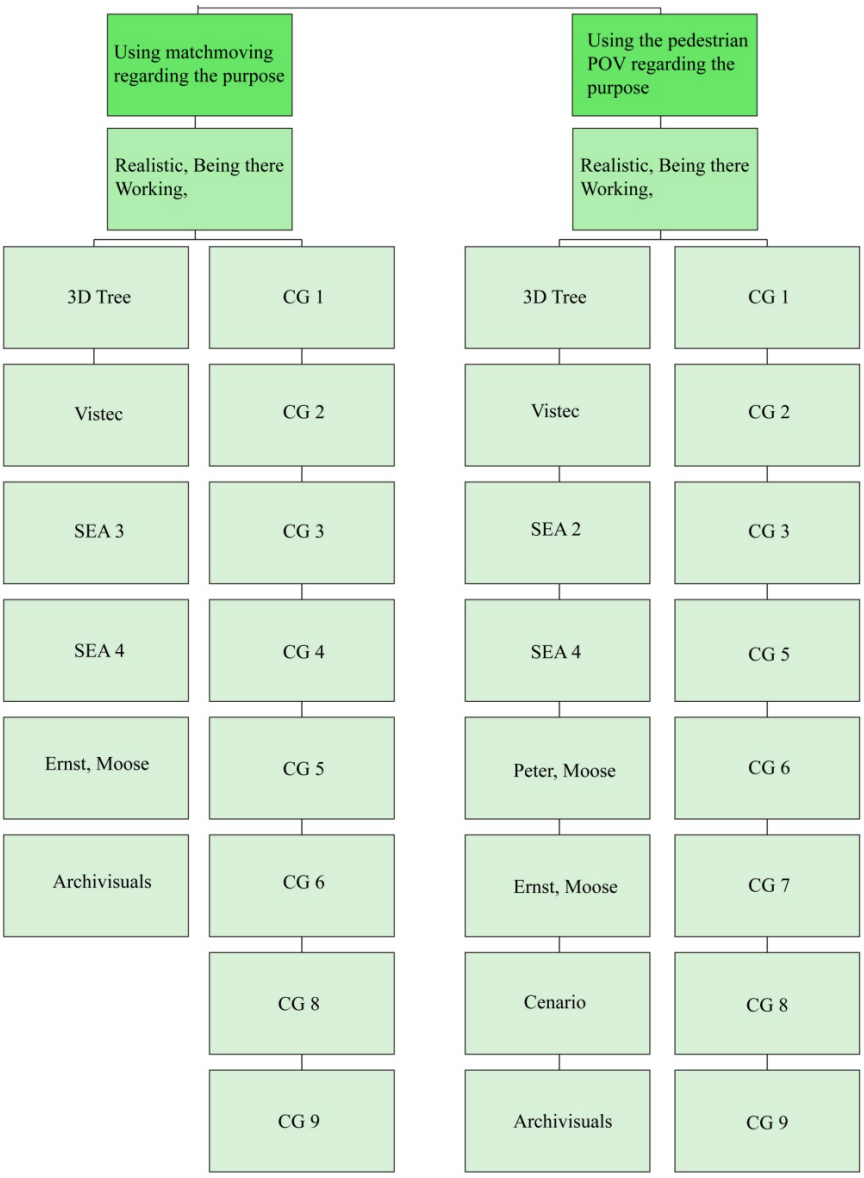
I'd wish I was allowed to make stuff in this greyer aesthetic.

9.5 Affinity diagrams

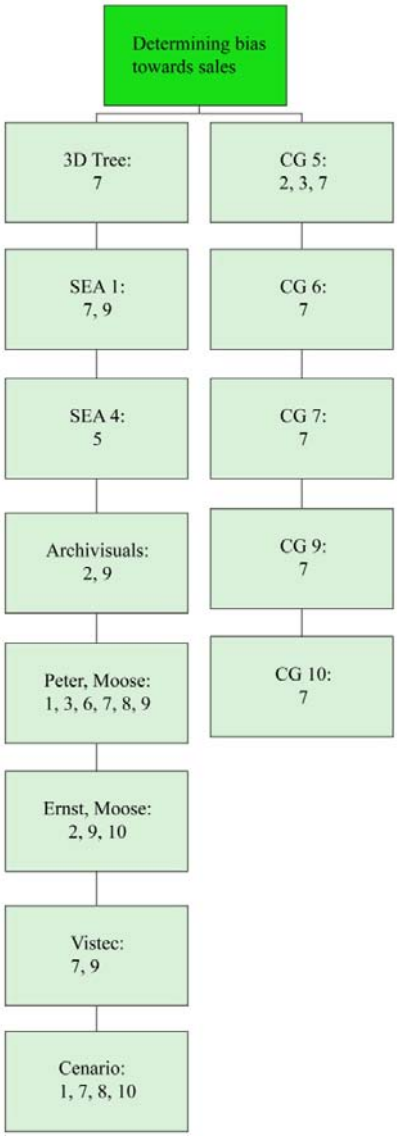
9.5.1 Perceived mood



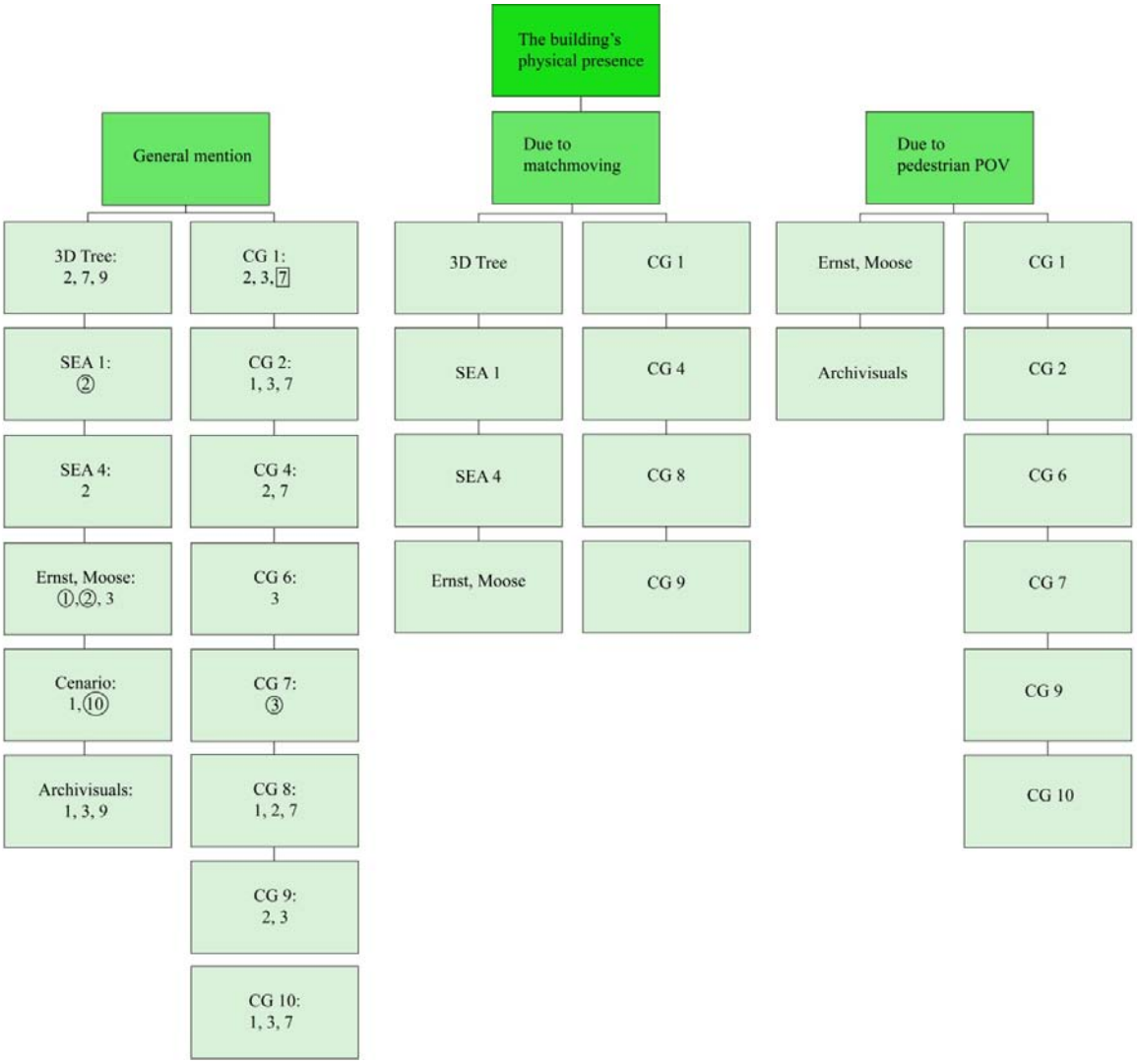
9.5.2 Matchmoving and POV with regards to the purpose



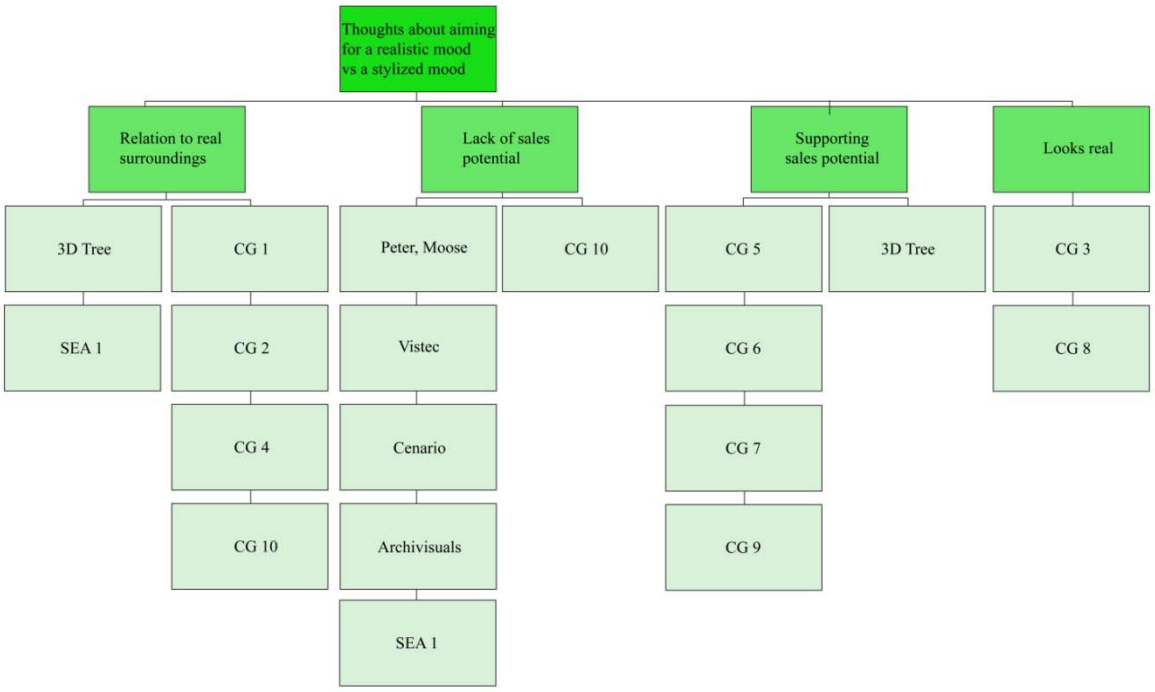
9.5.3 Sales bias



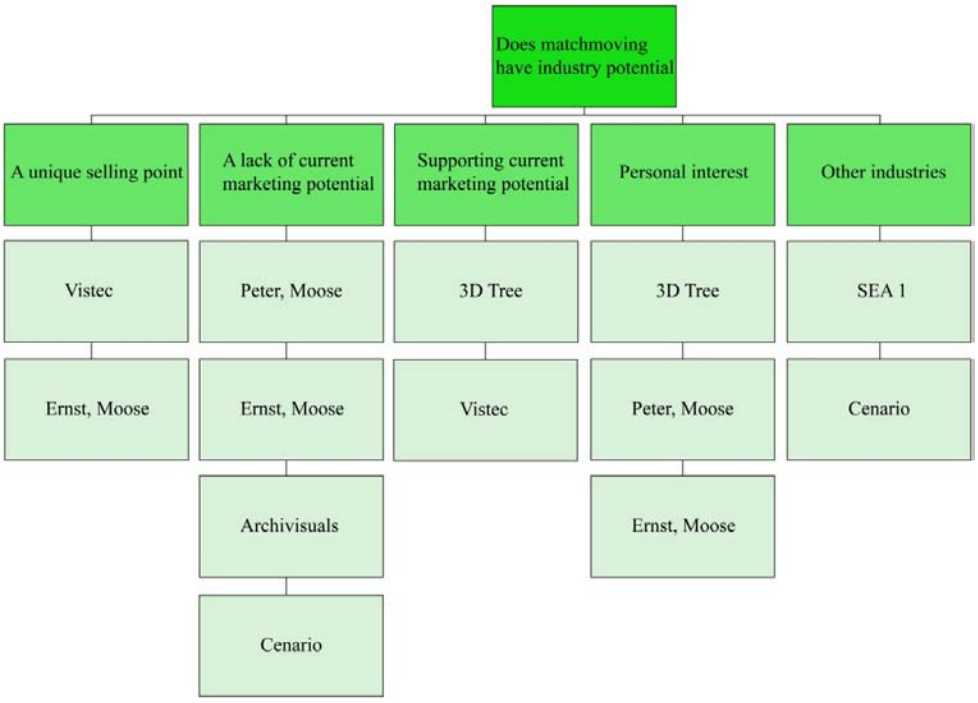
9.5.4 Buildings physical presence



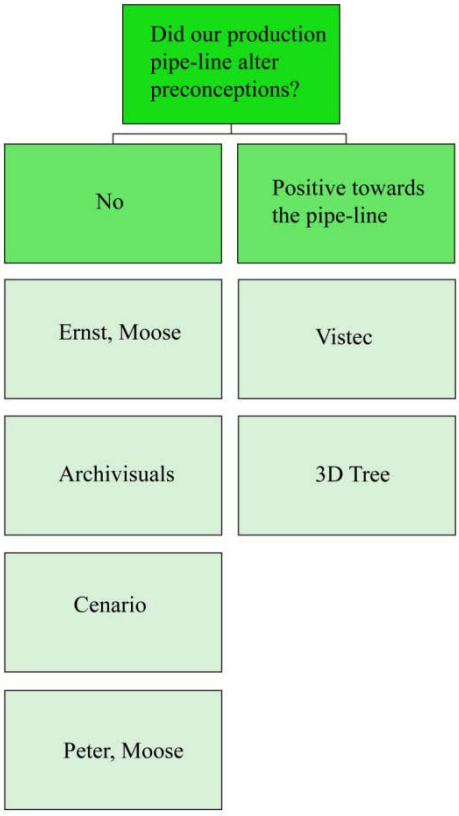
9.5.5 Realistic vs. stylized mood



9.5.6 Does matchmoving have industry potential?



9.5.7 Pipeline



9.5.8 Improvement suggestions