Set Extension

Innovations Report

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Abstract

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This studies objective was to explore the technique of extending an existing building to create a new structure both in 3D and high definition such that it could be used during a short ‘fly by’ in film or still photography. The report examines alternative techniques to the tried and tested 2D mattes, but without the expense and time associated with the production of a full 3D computer modeling and rendering of both the building and surrounds, as would be used for prolonged filming of sets. The method used was to take an existing suitable building, photograph and film it. I built the extension of the house in Maya© which I rendered out to composite onto the original structure. The photographs included in this report and the film extract show that the desired effect has been achieved with minimal equipment, a very low budget and a little patience. It is possible to view the extended building in some detail from a frontal view as well as a vertical panning shot with some rotation. This study shows that it is possible to create such a building in high definition and 3D which could be used as a set piece in film or television not just for distant viewing but medium to close in work and with the camera viewpoint rotating in 3D to a small degree.

Introduction
Aim

My aim for this project was to modify an old fashioned cottage by extending it up into the sky. Then compositing the modelled extension back on top of the cottage. This is innovative for me as I have never approached set extension before, so did not know the different techniques used to accomplish such a task. It was a challenge to fit the model and textures exactly to the house below as well as fitting the model back into the surrounding landscape.

I decided to approach the project as simply as possible, using only the skills I already know to try and achieve the desired affect. As I progressed I looked into different techniques used to generate such a set extension and compare them to my own. From my research I tried to deduce the simplest way to approach a project such as this, which techniques to use and how to implement them.

Inspiration

My inspiration for the project was from the Harry Potter film 'Harry Potter and the Chamber of Secrets'. A family of characters from the film called, the Weasleys, live in a small cottage in the countryside called 'The Burrow', but as they had many children they had to keep adding extra rooms to the house. The final appearance could hardly have been stable. The external view of the house only appears once in the film, for a very short amount of time, so it would be far too expensive to build for just one scene. Therefore computer graphics were used to accomplish the task. As there is only a short pan of the house it could be a 2D matte painting simply tracked into the image. Although it is more likely to be a 3D model so that shadows appear correct on the bushes behind, as do the reflections in the water. It also allows there to be some rotational panning around the building.

(Fig. 1) - *Harry Potter and the Chamber of Secrets* - The Burrow

I decided to research other films that have used similar sets. In the film Stardust an old inn is magically transformed from an old cart. This was achieved with a green screen in front of the characters, which could then be replaced by the house. As the house appears to grow out of the ground it must have been modelled in 3D.

(fig. 2) - *Stardust* – Lamia's Inn

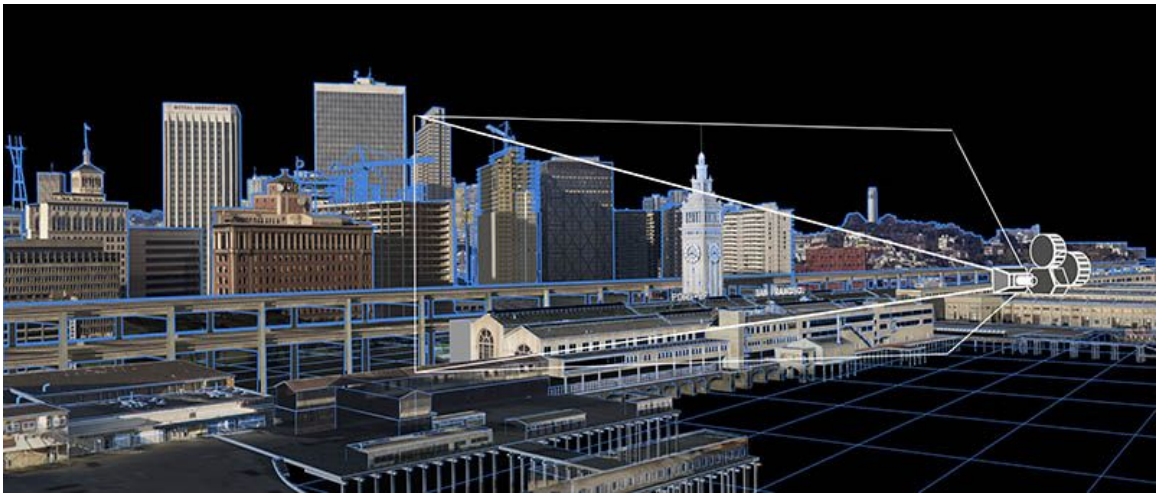
Why use set extension?

As films, TV and adverts are becoming more sophisticated and inventive so are the sets which are used to make them believable. It is not always easy to find or build the sets needed without spending large amounts of money or travelling to distant locations and waiting for appropriate weather conditions.

Throughout cinematic history, to get around this problem a technique called matte painting is used: Craig Barron summaries the method in his recent SIGGRAPH paper 'Matte Painting in the Digital Age' [1]. This technique has been used since the early ages of film whereby environments are painted onto glass and combined with the filmed actors. Although this meant that the camera had to be 'locked off' and a shot could not be much longer than a few seconds before the matte plate became noticeable. Nowadays more modern techniques are used to make these scenes so that they look even more realistic and appear virtually real. These are sometimes called "virtual sets" and "digital backlots". They can be used to create entirely new sets, or to extend portions of an existing set.

2D matte painting is still implemented today but is mainly used on large scale shots as a background plate. Even though this works well for this type of environment, they are limited to movements that don't change the perspective. Computer trickery can additionally be used to split a large matte painting into several layers and project each onto rough geometry in front of one another, known as camera projection or camera mapping. Small camera movements can be made using this technique and parallaxes can occur as they would do if it were a real environment. This is sometimes known as 2½D as it is down to the 2D matte artists to create the textures that match the original set.

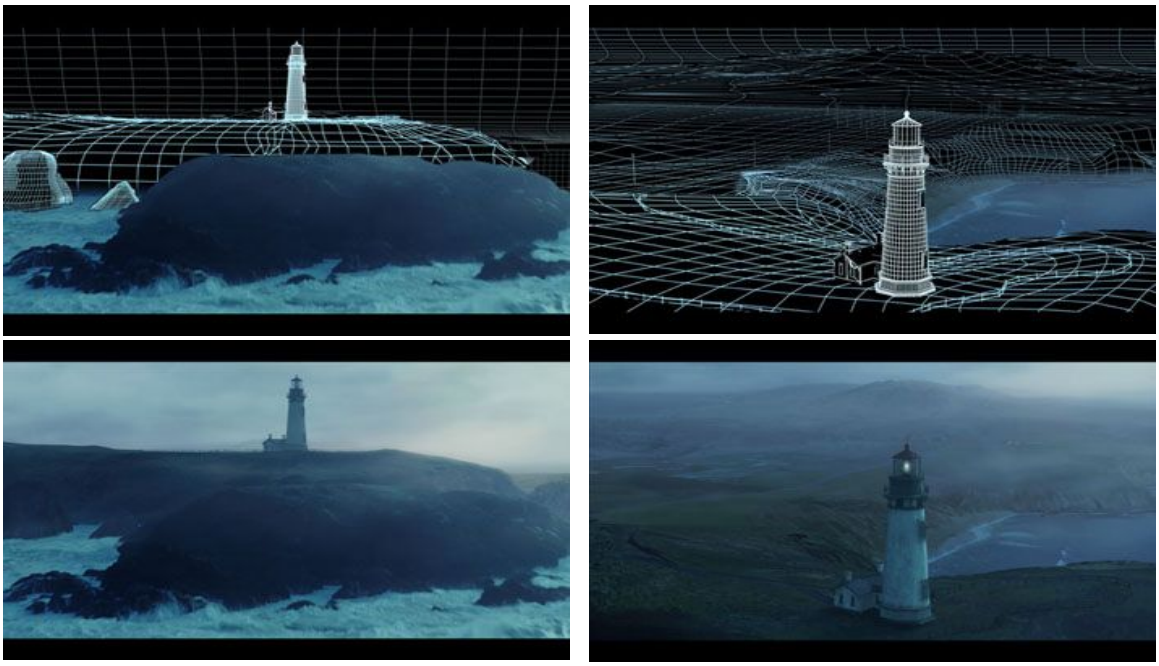
The method is shown in the images below for the 2007 film Zodiac [2]. The film is set in 1969 San Francisco, so photographs of all the current buildings where taken and then altered to give them the appearance of buildings at that time. These matte paintings were then projected onto rough 3D geometry so they could be panned around. The figure 3b shows the final result, quite impressive!



(fig 3a) - A wireframe and textured image of the dockyard

(fig. 3b) – An image from the finished film

Recently full 3D matte paintings have been used in several films. With the advancement in rendering and lighting techniques, complete sets can be made with any camera movement possible. An example of which can be seen in the 2002 film The Ring [3]. In these images the foreground rocks and sea were filmed, the land, lighthouse and sky are all matte paintings on 3D geometry so that the island is fully rotational.



(fig. 4) - The lighthouse on Moesko Island in the 2002 film “The Ring”

Development

Research

I decided the most appropriate technique for me to look into was 3D modelling. I did not want to build a house completely from scratch, but add onto an existing building. I had wanted to have a house quite ordinary at the bottom which I could pan up to reveal a more fantasy like structure with extra rooms protruding and extra towers with balconies. Much like the house I had researched into from the Harry Potter film.

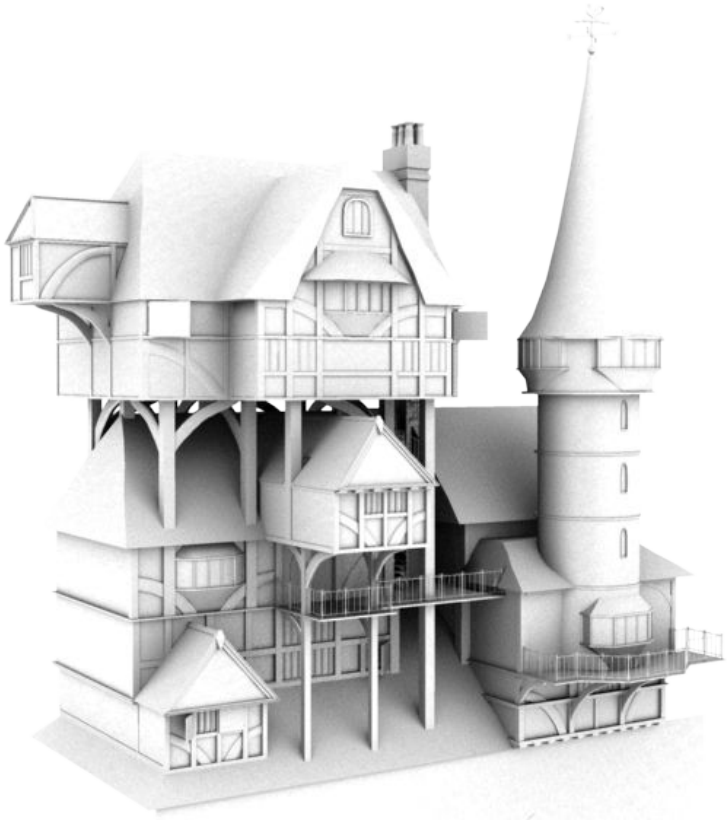
I decided to find an old country cottage with lots of character and unique architectural features. Whilst touring the British countryside I came across many cottages that could have worked, if only there was not for a large hedge or fence or even a car obstructing the frontal view. After researching into Tudor cottages I came across a suitable house in Singleton at the 'Weald and Downland' Open Air Museum, which exhibits many beautiful old Tudor houses which have been restored. I soon found an appropriate house which was perfect for this project.

(fig. 5) - The cottage I have chosen to extend - 'Bayleaf' Farmstead

Modelling

I looked further into Tudor style architecture to come up with a design for the final house. By piecing together pictures of this and other houses I came up with a very quick design for this house which was blocked out as a rough shape in Maya©. As I had not completely decided on the layout of the house this helped me make sure the house look balanced and would fit together realistically. The house has quite a low poly count as the majority of shapes are rectangular,rectangular; this also helps when it comes to texturing. Although it meant that the house would look very uniform, but rather than adding more detail to all of the surfaces so they had a more random finish, I decided to use a series of different bump maps to add texture to all of the surfaces.

One problem I found during the design phase is how to fit the new parts of the house onto the flat photographs but make them appear seamless. I decided to build the real house with rough geometry to make sure the two sections matched up exactly.



(fig. 6) – The final modelled house, rendered with occlusion

Texturing

When it came to adding the textures I took many photographs of the house and other houses at the museum so that colours and textures matched. I focused mainly on the render of the wall and roof tilling. Although I found that I could not find any textures appropriate for the decking of the balconies, metal banisters and wooden joists. However after a little research on the Internet I came across an excellent collection of textures from a site called 'cgtextures.co.uk' [4], all of which were available at a very high resolution; all were produced specially for the film and games industries. Using these textures as well as those I had taken myself, I managed texture the complete house appropriately. As the house was mainly made from low poly cubes it was fairly straightforward to texture as they had very simple UV maps.

(fig. 7) – The house textured

Filming

I decided that as the model was 3D it would be good to show how it could be animated in film. The simplest way of doing this was to have a short pan starting at the bottom of the house slowly moving up to reveal the new structure.

I encountered several problems during this process mostly due to equipment and the techniques I used. The first was the weather which was quite windy. No hand held pan would suffice; I had to use a tripod. Even so, getting a smooth camera movement was still quite tricky as a small amount of stiction in the tripod bearings made the pan jump or jerk. I also had not adjusted the camcorder settings correctly and found that when I panned the camera up into the sky, the auto aperture adjustment took over and it made the sky bleed and darkened the house.

I managed to re-shoot, this time adjusting the auto-contrast and aperture setting to fixed, so that it stayed the same whilst filming and no bleeding occurred. However, I still found that the footage was still not of acceptable quality to work successfully. I therefore had to come up with an alternative avenue to follow.

HDR photos

I had read of a technique known as projection mapping or camera mapping. As I described earlier, for the film Zodiac, it is a technique whereby you can take a 2D image and split it onto several different planes so that objects in the foreground can pass in front of those at a distances.

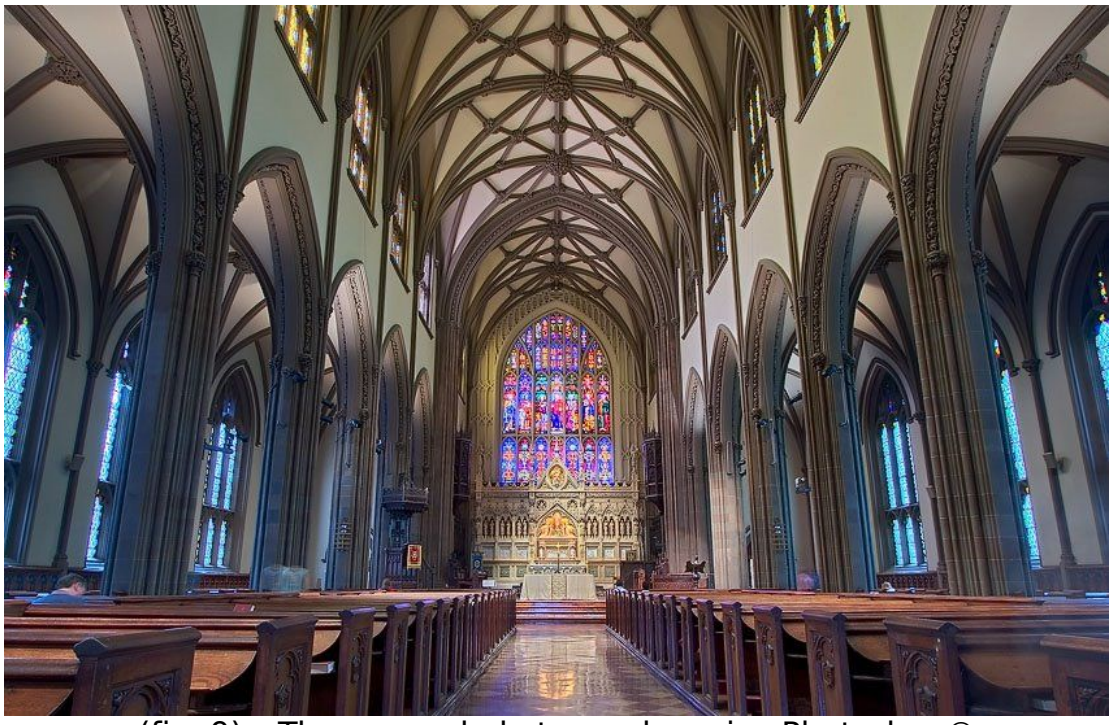
Firstly I decided to take some high quality photographs so that the final image would be as detailed as possible. One of the best ways to get a true coloured image is to use HDR photographs. When taking a standard photograph the camera will normally change its aperture and shutter speed depending on how light or dark the scene is. This means if you are taking a picture of something that is quite bright like a sunset; the camera will automatically change its settings so that the sunset appears at its best. The only problem being that everything else in the image will appear as a silhouette. The eye does not have this problem it can see the sunset and everything else in normal colour. HDR, or High Dynamic Range photos are several photographs of various exposures merged together to get the full information of the scene without having really bright or dark areas [5].

As demonstrated in figure 8, here is a classic case where the photographer has taken a photograph inside a church. Even though the original image (middle) is ok, a lot of information is lost because the windows are too bright and the pews are too dark. Changing the exposure down two stops brings out all the colours in the glass windows but everything else is far too dark. Changing the exposure up two stops brings out the detail of the pews but the far end and windows are washed out.

-2 stops **0** **+2 stops**

(fig. 8) - Three shots of the church one using automatic settings, then overexposed by two stops and underexposed by two stops.

Figure 9 shows the three images merged together as a HDR photograph and as you can see all of the detail of the interior and of the windows,windows; this is close to what the eye would see.



(fig. 9) – The merged photographs using Photoshop©

Using this same method I took several photographs of different exposures of the house at Singleton. Using Photoshop© to merge them together creates a HDR image as shown in figure 10. The roof tiles and garden are much brighter and more saturated and there is much more definition in the sky, you can actually see clouds instead of it being completely washed out.

(fig. 10) – The final HDR photograph I will use for projection

Projection Mapping

I used Gnomon tutorial DVD 'Camera Projection Techniques in Maya' by Darin Hilton [6] to help me create the image out of projection maps. I started by creating a camera with the above image projected from its image plane. I decided to split the image into different ranges of depth, which I would then project onto separate pieces of geometry:

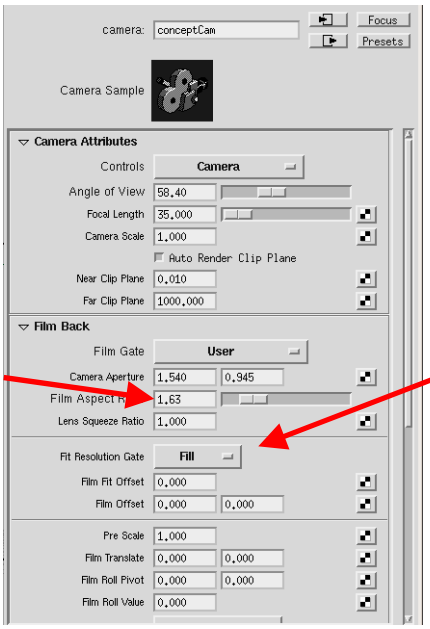
- The foreground fence and garden
- The ground in front of and around the house
- The house itself
- The sky, buildings and trees behind the house

From the camera view, I lined the grid up with the straight lines of the house and built a rough polygon model to match the photograph. From perspective view the geometry looks completely warped but this is acceptable as the texture will be projected from the camera view. I then built the three separate planes which the fence, ground and background will be projected onto, making sure that those planes overlapped the images I wanted to place on them. In perspective view it was essential to make sure these images were proportionate to each other, so that when there is a camera movement they seem to be at the correct distance from one another.

1. After completing all of the geometry, using Photoshop©, I cut each part of the photograph out accurately, saving these images with a white background, and another of their corresponding alpha maps. In Maya© I made each of these images into a shader by plugging the colour image into 'Color' and the alpha image into 'Transparency' of a Lambert material, making sure that they were projected from the camera in perspective view. I then attached each of these shaders to their corresponding planes.

I had some difficulty at this point due to the images not fitting exactly to the geometry; the sides were being cropped off. I found out that it was essential that the 'Film Aspect Ratio' of the camera and the resolution of the projected image must match. Further, the camera 'Resolution Gate' must be set to 'Fill' otherwise the image will be stretched or shrunk depending on the resolution with which you are rendering the scene.

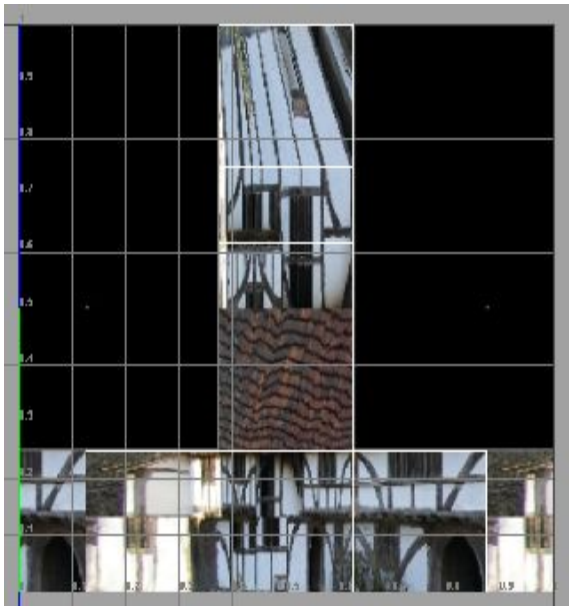
Aspect Ratio is the Width of the image divided by



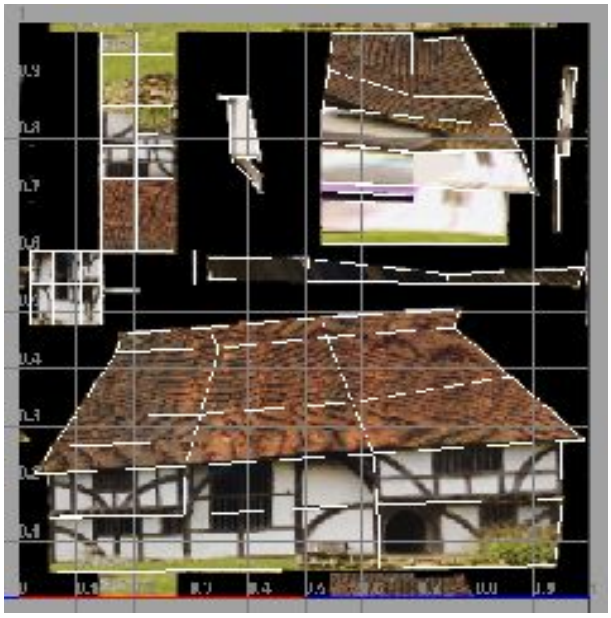
'Fill' the Resolution Gate

(fig 11) - Camera Attribute Editor

I also found that whilst projecting the image, a side effect was to extrude the geometry of the polygon to create the roof. This meant when I projected the image, some of the faces had very stretched images and others would not show an image at all. The workaround was to redo the UV map of the house, as you can see in figure 12a the polygon still has its original UV map so textures are overlapped or warped to fit the extruded shapes I added. The solution was to use 'Planar Mapping' to separate the faces from each angle and repositioned these in the UV editor. The image in figure 12b shows the improved UV map so that none of the faces overlap.



(fig 12a) - UV map Before



(fig 12b) UV map After

Figure 13 shows the final image, with all the anomalies solved so that the resulting render is almost exactly the same as in the original photograph.

(fig. 13) - The Projected image from Perspective view,
Inset - from Camera view

I then created a new camera to use when panning around the projection. Even though I knew the camera would not be able to rotate too far around the geometry, I found any movement seemed to produce these white areas in the render. Moving the camera further meant that parts of the picture were duplicated such as the fence in the foreground as demonstrated below in figure 14.

(fig. 14) – Errors with the Projection Map

To get around his problem I extended the images in Photoshop© to give me some lee-way when moving the camera around the scene. Using the clone tool I extended both the grass on the ground plane and created the lower left side of the building when it appears from behind the bush. Rendering off the same view with these new images in place, figure 15, shows that the projection images still 'hold up' remarkably well.

(fig. 15) – Extended matte painting to cover white spaces and duplications

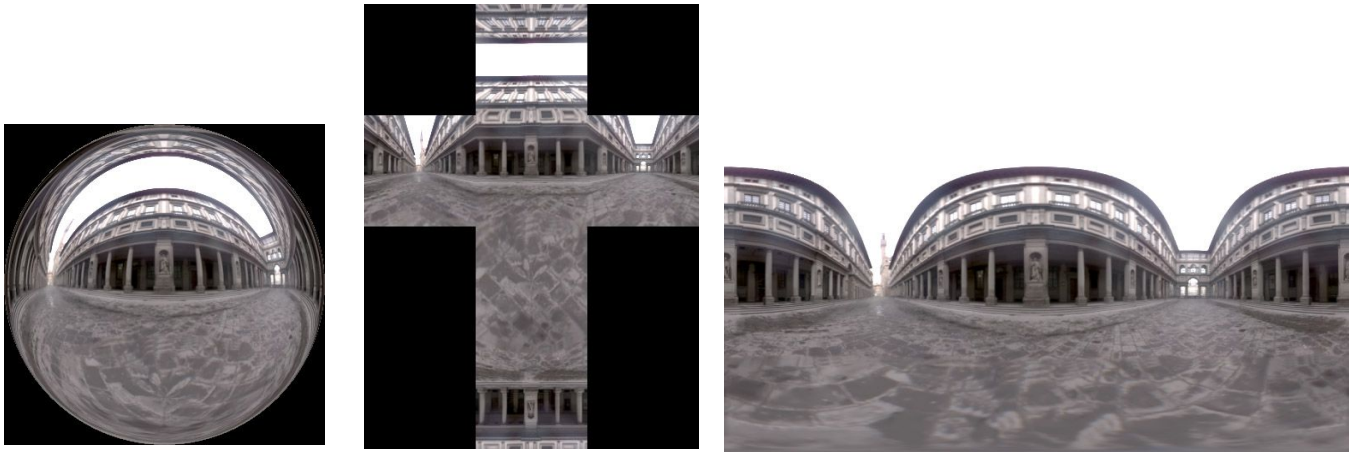
The only thing left was to import my modelled house and position it on top of rough geometry. Whilst fitting the two images together the geometry for the projected image is quite warped around the roof line. By moving the vertices on the roof and reapplying the projection, I eventually managed to match the two together quite convincingly.

(fig. 16) – The projected image with the extended house on top

Lighting

Another reason for taking HDR photos is to light the scene. Using a spherical panoramic image of the surroundings and converting them to HDRI means these images can be used to represent light intensities present in the real world. The technique, known as image-based lighting (IBL), is designed specifically to produce incredibly realistic lighting effects in rendered images, and to essentially replace the more traditional lighting setup [7].

An HDR image using a light probe, which is a mirrored ball, figure 17, allows you to gain a full 360 degree map of the surroundings. Using a package called HDR Shop [8] it is possible to stretch this image out to either a cube map (vertical cross) or latitude/longitude map.



(fig. 17) – Mirrored Ball Cube Map Latitude/Longitude

The significance of using an HDR image it means that the one image can be used to derive the lighting for the entire scene. Not only do HDRIs provide vastly enhanced levels of realism, but also avoid the need of painstakingly setting up complex lighting arrangements. They also allow lighting to be perfectly matched to background images and environments. If this were to be done with an external building shot, the surrounding HDRI would be able to provide not only a convincing approximation to natural daylight conditions, but also include the surrounding environment reflections [9]. I managed to take my own photographs of the scene, figure 18, and merge them to HDR images although I had difficulty setting the system up and decided that a three

point lighting system would do for the scene. Although it is something that I would like to research into further in the future.

(fig. 18) – My HDRI light probe

Rendering and Compositing

With the scene completely set up I created a camera with a short pan of the house, starting from the bottom and revealing the new house I made. I rendered each projection plane off separately, and the extended house as a beauty pass and occlusion pass.

Using Shake© I composited them back together focusing on making the extended house the same grain and colour as the photograph.

Due to time restraints I could not work on this area of the set extension as much as I would have liked and as a result I still feel the extended house is a little too dark. I also found that a couple of frames in did not have aligning projection maps, meaning I had to go in and paint out the white spaces in Shake© itself.

One area that did cause an issue was the background plate of the sky. Because I had only been concerned with how the house and image match together I did not take into consideration that as soon as I ravelled up the image the background plate was not big enough to cover

it all. I managed to get away with it by taking a picture of just the sky, projecting it on a plane in Maya© and rendering it on its own with the same camera movement. This was ok as the house covered the majority of the sky but I would like to look into other methods of how this would really be accomplished.

fig.19 - Final Render/Composite

Conclusion

Overall this project has been fairly successful; my initial aim of extending an existing cottage is proven by the photographs in this report and my final pan of the house. My goal at the start was to find a series of simple techniques to achieve this; however it quickly became apparent that I would need to do more detailed research.

Areas such as Modelling and Texturing I have done in previous projects, but the use of Projection Mapping is new to me and has proved a worthwhile learning experience. This technique has worked well in the film; I wanted a slight rotation as well as the pan to show off the model. The projection map held up quite well during this process and the scene does appear to move as it though it was 3D.

The use of Image Based Lighting is also new to me, but even after the preparation of the photographs the technique has eluded me because of time constraints. This is an area I would like to explore further in future projects.

One of the techniques I used in this project has proved intriguing. As I am a keen photographer outside of this work, the High Dynamic Range Images which I took and processed are fascinating. I have read up quite a bit on this subject for this study, and it is defiantly an area I would like to pursue.

At the outset of this study when I first researched into set extension and matte painting, I thought that I would use only one of the three methods I looked into originally (2D, 2½D, 3D). In fact, I have used all three to some extent. The modelling and texturing was completed in 3D. Projection mapping is a form of 2½D matte painting, and editing the photographs so that they would fit the projections is a form of 2D matte painting.

During the investigation into this subject I contacted four major film companies about how they accomplish similar tasks. One has replied and I have been given the opportunity to talk to one of the Compositing Supervisors at Moving Picture Company in the week following this project. Hopefully from this I will be able to find out the methods and order in which these techniques are implemented on a full scale film.

Should I approach this subject again the one lesson learnt, is that there are many alternative techniques for achieving this result. Therefore I would conduct far more research and contact CG companies earlier in the project. This would provide a better foundation for my work and a more pro-active approach to problems I might encounter.

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Images:

fig. 1 - *Harry Potter and the Chamber of Secrets*, 2002, Directed by Chris Columbus, Warner Bros. Pictures,
The Burrow,
http://www.veritaserum.com/info/places/

fig. 2 - *Stardust*, 2007, Directed by Mathew Vaughan
Lamia's Inn,
http://www.imdb.com/title/tt0486655/

fig. 3 - *Zodiac*, 2007, Directed by David Fincher, Warner Bros. Pictures,
San Francisco's historic ferry terminal,
http://www.matteworld.com/film/2007/chronicles1.html

fig. 4 - *The Ring*, 2002, Directed by Gore Verbinski, Dreamworks SKG,
The lighthouse on Moesko Island
http://www.matteworld.com/film/2002/ring.html

fig. 5 - The cottage I have chosen – 'Bayleaf' Farmstead,
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fig. 6 - The final modelled house, rendered with occlusion

fig. 7 - The house textured

fig. 8 – Three shots of the church one using automatic settings then overexposed by two stops and underexposed by two stops.
http://backingwinds.blogspot.com/2006/10/how-to-create-professional-hdr-images.html

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fig. 12 - The projected image with the extended house on top.

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fig. 17 - Mirror Ball, Cube Map, Latitude/Longitude - *HDR Shop*
http://gl.ict.usc.edu/HDRShop/

fig. 18 - My HDRI light probe

fig.19 - Final Render/Composite

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Project Animation:

snicholson.mp2, 2008, Animation by Sarah Nicholson