Matching changing live action lights
An Experiment Into the use of Video Based Lighting

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Abstract

Image-based lighting was developed by Debevec [1998], it uses photography to light objects based on an environment map. This method along with HDR image based lighting is limited to static lighting. To gather light from a location with changing and/or moving lights we will look into the use of Video-based lighting.

Key words :

Image Based Lighting Techniques, CG Live Action Integration

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Chapter 1

Introduction

This report proposes a method for gathering lighting data for a scene with changing conditions by filming a sequence of environment maps. The method uses very similar ideas and principles of that explained by Paul Debevec [2002] in the tutorial Image-Based Lighting. The technique could be used to easily light an object to match an environment with complicated changing lighting. I am going to explore a technique that may be able improve on some of the limitations of using a single environment map to light a computer generate scene to integrate with a live action plate. I am going to talk through a process of filming a mirror ball at the same time as filming the main film plate to acquire a unique environment map for each frame of the of the scene. I aim to discover if this technique would be useful in film production and to discover the strengths and weaknesses of the approach. I am going to concentrate on the lighting specifically, for the purpose of this purpose of this project creating realistic shadows and the compositing (for example matching grain) are not my main priority.

Chapter 2

Contextual Studies

When lighting a computer generated object to integrate with a live action plate, often an HDRI panorama of the location is used to get the bulk of the lighting done. It has become standard in most post production studios, such as Framstore CFC and MPC, to use image based lighting with the photos used more often than not being High Dynamic Range. Paul Debevec has been very active in the recent developments and applications of HDR Imaging.

“His work with high dynamic range imagery (HDRI) and image-based lighting has been incorporated into commercial rendering systems such as LightWave and RenderMan and has helped influence recent advancements in dynamic range in graphics hardware. The technology used in Debevec's short films at the SIGGRAPH Electronic Theater including "The Campanile Movie", "Rendering with Natural Light", and "Fiat Lux" has contributed to the visual effects in films including "The Matrix", "X-Men", and "The Time Machine".”

Figure 2.1 : Micro-scope taken from Image-Based Lighting
this shows a micro-scope lit entirely with image based lighting.

The dynamic range of an image is described in the HDRI handbook as “the highest overall contrast that can be found in an image”,(page 15). A regular 8 bit photograph will only have a contrast range of between 0 and 1 with a maximum of 256 different colour values able to be displayed. “Traditionally we use one byte per pixel per color channel ” (Debevec et al. 2005).

High Dynamic Range Imaging and Image-Based Lighting , page 1.

To increase the dynamic range of a photo the same image needs to be taken multiple times with different exposures or different stops (see Fig 2). These photos can then be merged together to create a 32 bit High Dynamic Range Image, which uses a float to represent each pixel, giving a much larger colour space.

Figure 2.2 : Taken from High Dynamic Range Imaging & Image-based Lighting
this shows a series of photos with different exposures, these can be merged together with to create a HDR Image.

Environment maps are panoramic images of the location that cover a field of 360 degrees. They gather all the light information for a single point in space as stated by Paul Debevec (2001)

A light probe image is an omnidirectional, high dynamic range image that records the incident illumination conditions at a particular point in space.

This means that I can film a light probe in my scene with one or two cameras and achieve good results for my environment maps.

Light maps should be taken with its centre as close to the area the CG object is going to be placed as possible. These can be taken lots of ways. The two main ways that are used to capture HDRI are with a fish eye lens or by taking photos of a mirror ball.

One photograph of a mirror ball can give an almost complete environment map, but the area directly behind the camera will be heavily distorted, and the reflected camera will appear in the image. Therefore when taking photographs of a mirror ball it is generally better to take images from multiple angles around the ball (keeping the same distance away) so when merged all the images can be utilised to eliminate the majority of the distortions and unwanted reflections.

“We can take omnidirectional images in a number of ways. The simplest way is to use a regular camera to take a photograph of a mirrored ball placed in a scene. A mirrored ball actually reflects the entire world around it, not just the hemisphere toward the camera. Light rays reflecting off the outer circumference of the ball glance toward the camera from the back half of the environment.”

Image-Based Lighting, tutorial, page 2.

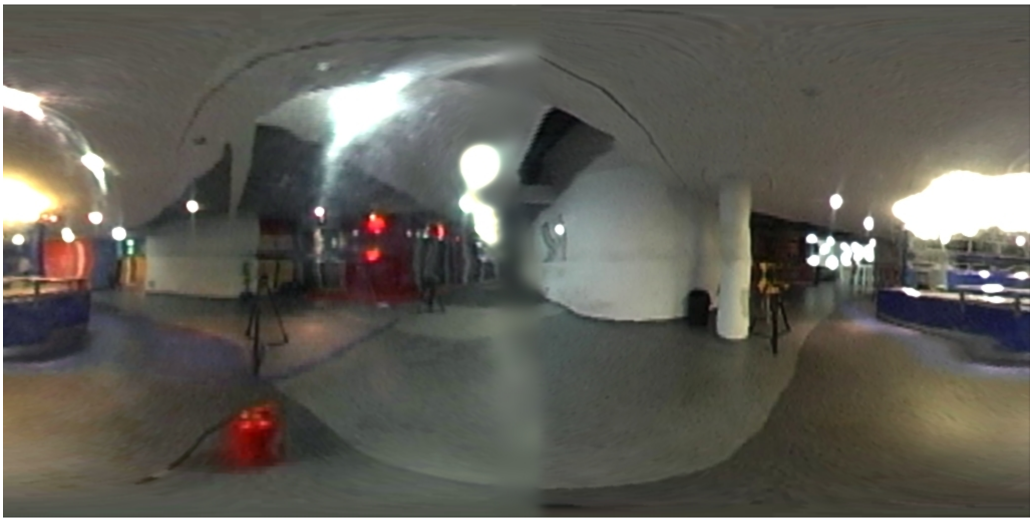

Figure 2.3. Merged Environment Map
A single frame of the environment map used to test static lights, taken by filming a mirror ball with a mini DV camera.

In the recent film The Curious Case of Benjamin Button, HDR lighting would not always get the desired results, so new innovative methods had to be used to achieve the desired results.

“We started off by using straight HDR spheres but slowly came to realize that it wasn't getting us the subtleties we needed in terms of localization of lighting. With a head moving around in a room or gradations of light across the head itself, some of the light sources are very close. There's a candlelit scene and certain types of falloff that you don't get with an infinite sphere, so we developed a hybrid system of taking all the data, mapping some of it onto a sphere and then reconstructing all that geometry and all the bounce cards and light cards and lighting sources and taking high dynamic range textures, putting them on all of that data and then, using custom shaders all in mental ray, driving the lighting from this combination of the HDR sphere and HDR set geometry and the 3D position of the head.”
Taken from Bringing *Benjamin Button* to Life

New methods of lighting CG objects are still being developed and utilised in the commercial world, in the above example they discovered that single HDRI domes alone did not meet there requirements, because of the complex lighting. Possibly a system making use of multiple environment maps would have been advantageous in this situation.

There is a team based in Sweden that have recently made developments into HDR video capture, with cameras that are capable of capturing 25 HDR Images per second with a dynamic range of 1:10,000,000.

“Using commercially available camera systems such multiple exposure methods make it impractical to capture more than a few HDR images in a scene. Therefore, we have designed a high dynamic range imaging system capable of capturing images with a dynamic range of 1:10,000,000 at 25 frames per second.”
Jonas Unger (2009).

As demonstrated by Jonas Unger this system can be used to generate sequences of lighting maps to light CG objects in detailed changing lighting environments. This equipment would be extremely relevant to this project as it would mean that the HDRI would not have to be faked which should result in much more accurate lighting results.

Chapter **3**

Method

Once I had decided that I was going to look into video-based lighting I first experimented with a number of shoots to see the sort of results the method could achieve.

The first step in the testing of video-based lighting was to chose a method of filming the environment. The best way to achieve this is with an approach that prevents any actor or prop from disrupting or blocking the lighting area. This can be achieved a number of ways:

With a chrome ball rig (see figure 3.1) at the same time as the main shoot.

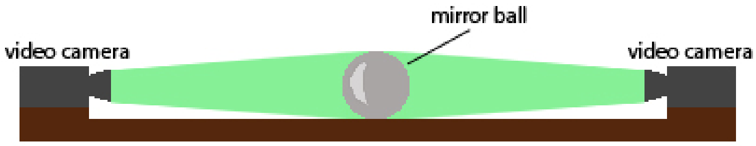

Figure 3.1. Mirror Ball Rig
Shows an example of how a chrome ball rig could be set up, (this one uses supports to hold the whole rig together)

With a fish eye rig (see figure 3.2) at the same time as the main shoot.

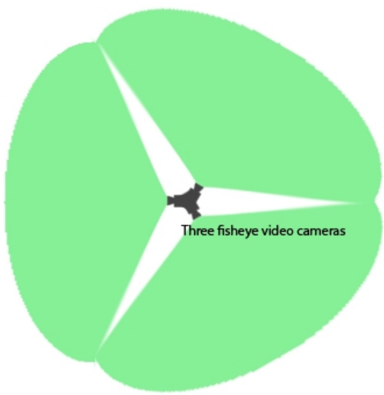

Figure 3.2. Fish Eye Set-up
This shows an example set up of three cameras with fish eye lenses, this can be used rather than a chrome ball.

If this or similar equipment is not available it is possible to achieve good results with two standard video cameras and a chrome ball. Shots using this approach should be planned well to avoid where possible objects or actors getting between the chrome ball and cameras.

The cameras should be set up as in figure 3.3, so that the cameras being used to collect lighting data are out of view of the camera being used to film the main film plate. The cameras being used to collect lighting data should be set up so that the frame is filled as much as possible with the chrome sphere, this way the most possible detail will be captured.

As it will be difficult to paint out the chrome sphere from the scene because of the changing lighting it should be placed in a position where as much as possible it will be covered by the intended CG objects.

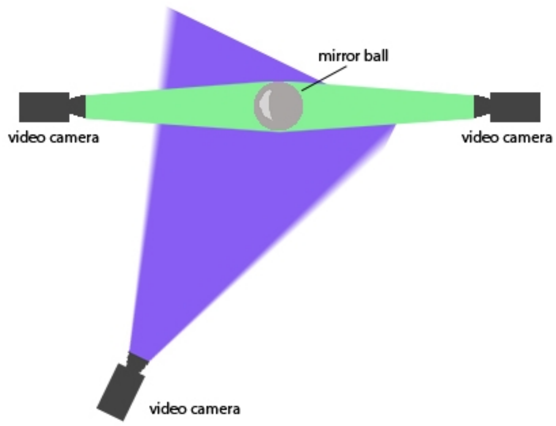

Figure 3.3. Floor Plan
This shows the floor plan of the cameras and mirror ball I used for one of my shoots, for other shoots I used just one video camera to record the mirror ball.

If the lighting can be easily repeated in exactly the same way as it is during the filming of the shot then the environment maps can be gathered after the shoot. Furthermore, If the lighting can be controlled accurately enough to closely control the speed it should also be possible to collect HDR Video-based lighting with standard equipment.

Once all the cameras have been set up and have begun recording a visual and/or audio marker should be used to later sync up the footage. The method I used to do this was to simply clap my hands in an area that would be filmed by all the cameras being used. Once all this has been done the scene can be filmed.

Once the shoot has been completed all the DV tapes need to be digitalised and edited down. This process of digitalizing the footage from the mini DV tape to a tiff sequence and then transfering all the images took a lot longer than I had expected, it took a couple of days to move all the images from my house computer to the University computers because of the large amount of images taken.

The lighting footage then had to be synced together with the marker and cut down to the corresponding shot lengths, to do this I used Shake. These image sequences then needed to be cropped, unwrapped, merged and colour corrected to generate the final panoramic lighting image.

Shake also can be used to crop the image down to just the mirror ball (figure 3.4).

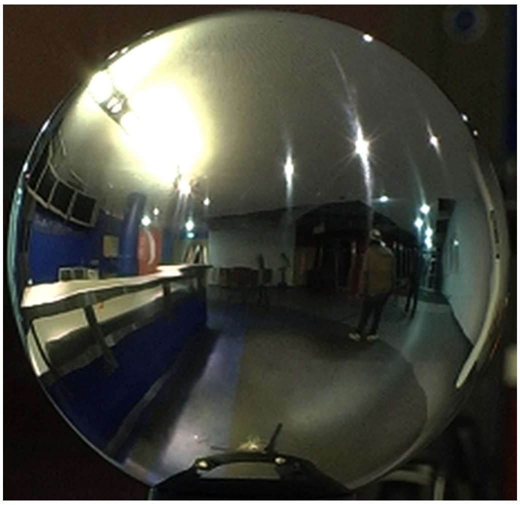

Figure 3.4. Cropped Mirror Ball
The mirror ball after being croped in Shake.

Then all the images need to be unwrapped. There is an HDRI tool set available on http://dctsystems.co.uk. I used the deSphere program, modified by Ian Stephenson, so that it could be used with a simple shell scripted for loop to batch unwrap all the images.

Once again Shake can be used to merge the two sequences of images and colour correct where necessary to create the final panoramic sequence (see Figure 2.3).

As I was not able to film the mirror ball in High Dynamic Range due to the equipment available, I next had to fake the HDRI.

To do this I used Shake, I converted the image to a 32 bits then used lumaKeys along with rotoshapes to select all the areas of the main light sources in the image. I then added values to the pixels to increase the contrast range in these areas and to increase the dynamic range of the image. This method is quite easy to implement and gives an effective result, obviously, this process is not as accurate as genuine HDR images.

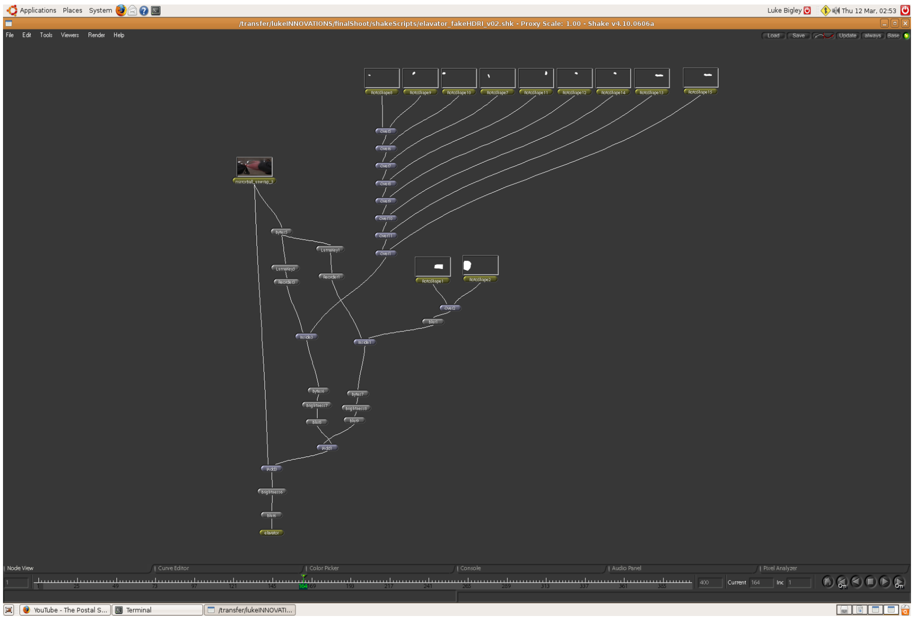

Figure 3.5. HDRI Faking Shake Tree
The shake tree I used to fake the HDRI.

I found that to get good results for the lighting, the environment map needs to be brightened in shake before rendering ready for Maya.

Once the faked HDR panorama's had been brightened and rendered from shake I took them into Maya to use to light my CG objects. In my films I used a fire extinguisher modeled at Framestore CFC and given to students for the Masterclass Project, the texture I used was created by Oliver Hunt.

There are a number of ways to use the panorama's in maya to light the scene. The method I used was to import the image sequence as the colour of a polygon sphere, with a surface shader material.
Then use mental ray with final gather turned on.

To line up the objects with the film plate, I tracked the background plate using PFTrack and exported the camera in Maya format. This can then be imported to Maya and used to easily layout all the objects.

The environment map then has to be rotated so that it lines up correctly with the scene, if this is done incorrectly the lights' positions and reflections will not match up and the final composite will look inaccurate.

Since I was not interested in compositing the separate layers for this project I rendered out only two passes, one being the objects beauty pass, and the other being the shadows produced by the environment map. Shadows produced by the environment map are generally not very good, however for the purpose of this innovations project these were not my main priority. To create good shadows it is normally better to use CG lights.

A possible way to get accurate shadows is to use a method presented by Naveen Dachuri, Seung Man Kim †, and Kwan H. Lee in Estimation of Few Light Sources from Environment Maps for Fast Realistic Rendering

"In this paper we propose a method to estimate few directional light source parameters and a global ambient light from omnidirectional environment maps." (page 266)

Using this technique lights could be estimated for each frame of the environment map to produce the shadow pass. Or alternatively the lights could be manually placed and animated in the scene.

Using the environment map to light the objects will be very render heavy and require a lot of time and machines. I reduced the render time by spreading the renders over a lot of machines.

The method I used to gather my lighting information was the simple set up using three mini DV cameras and a mirror ball as more expensive equipment was not available to me.

During my first shoots I experimented with a number of lighting conditions:

First I tested whether I could use the technique to pick up changes in static lighting. I did this by filming a wide range lighting changes from still lights. (lights are static)

Figure 3.6. Stills taken from a changing static light test
Shows a number of frames taken from the static changing light test

In these trials the light probe picks up all the different lighting conditions very well. It also picks up the gradual brightening and dimming of the lights as they are turned on and off. This makes the lighting of the CG objects very believable when they are placed in the scene.

Next I tested a directional light, using a torch with a narrow beam. This method works well for CG objects that are similar in size and location as the light probe. This method is not very convincing if the CG object is a lot bigger than the light probe or in a different location, see Fig 3.7.

Figure 3.7. Stills from a directional lighting experiment
Shows a moving directional light hitting the light probe, with different sizes and locations of objects. (The lighting in the scene with lots of CG fire extinguishers looks unrealistic when the light hits the probe, as the narrow beam lights up every CG object in the scene)

In this experiment I found that there are lots of problems with lighting not being picked up correctly if the CG objects are to big. This is because the light that should be hitting the CG object is not picked up by the mirror ball.

In this test there was an actor in the scene so it also gave me an opportunity to test the reflections of a person moving near the CG objects. The reflections were picked up well, if a bit dark. They moved convincingly and in coordination with the actor in the filmed plate.

Next I attempted a scene with a changing light source using a camera flash.

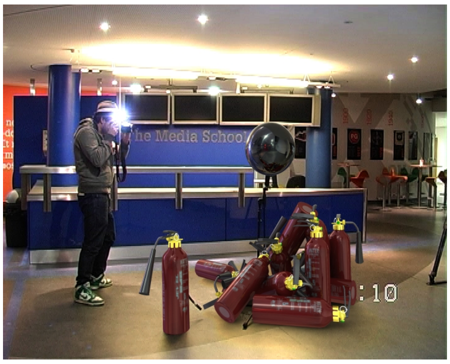

Figure 3.8. Image taken from camera flash experiment
Shows the camera flash lighting the CG objects.

This experiment worked well overall, as the light given off from the flash was wide spread so it could be used to light large objects. However there were some timing issues where the flashes where delayed in lighting the CG objects. I believe this was caused by the fact that the cameras used could not be exactly synced together with each other to start filming at the same time, thus there where slight discrepancy's in the environment maps.

Once all these experiments were complete I did another set of experiments. I carried out one using only one camera to film the mirror ball. In this I also had very slightly increasing lighting conditions by having an elevator door open in a dark landing.

Figure 3.9. Image taken from elevator experiment
Shows the elevator door opening.

This experiment also worked well especially at the picking up of the reflections of the lights and the actor walking through the scene.

I also ran one last experiment with an actor holding a candle walking near the mirror ball in a dark room. Unfortunately I did not get the opportunity to see how this test turned out because I accidentally filmed over that section of the mirror ball tape. I was very disappointed when I realised this because I think it had potential to look really impressive.

Figure 3.10. Image of candle experiment back plate
Shows the actor walking with the candle

Chapter **4**

Conclusion

In this report I have discussed the methods I used to film lighting data and use the image sequence gathered to light CG objects to integrate with the real world scene.

In doing the innovations project I have learnt a lot since this was a very innovative project for me as I have only used imaged based lighting once before. I have also learnt a lot about the advantages and disadvantages of working in this way. I think that the results that I have attained show that this method has a lot of potential as a very cost effective way of gathering lighting data from scenes with complicated and changing conditions.

Going into this project I had thought I had planned it well with my tutor and believed I had a good idea of all the problems I would get, however there are some problems that I had overlooked including the shadows produced by the mirror ball and the extent of harm an actor moving in between the camera an mirror ball can cause to the shot.

One big advantage of filming the environment map is that when the CG object is reflective and there are actors or moving objects moving nearby, all this data is collected and can be used to create a reflection map that includes all the actors movements.

However with the method I have used the reflections caught in the light probe can also cause a problem as the camera equipment used to film the light data will be in the panoramic created. This could be painted out easily if the lighting is not changed and only the reflections of moving actors are needed. However if the lighting is changing it could be a difficult task to convincingly paint out the equipment.

The best way to overcome this problem would be to use a rig that does not rely on reflections in a mirror ball to collect the light data. This would most likely greatly increase the cost of the shoot, e.g. Fig 3.2.

One issue that can arise from having the light probe in the view of the camera filming the main plate is that the light probe is in the image and can therefore cast shadows on the rest of the environment and show up in the footage. If there are obvious shadows and they are not covered by the CG object they can ruin the illusion of the piece.

Overall, I think this project has been very successful, I have experimented with a lot of lighting conditions and most of the time achieved results that I am very pleased with. I have increased my understanding of the subject area incredibly. I also think that If I had had the opportunity to use better quality equipment I know this project could be very impressive. I think I did well with the time and equipment I had.

Chapter **5**

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