# Department of Computing Degree Project Proposal

*Do not add any front sheets or title pages. Read the notes in italics and remove before submitting.*

**Name:** Michael Smith **Course:** Computer Games Development **Size:** double

**Discussed with (lecturer):** Laurent Serge Noel **Type:** development

## Previous and Current Modules

**Year 2 FdSc Computing:** Network Architecture, Rapid Application Development, Human Computer Interaction, Database Systems, Image Manipulation and Interactive Flash Programming FdSc, Placement Project

**Year 2 Computer Games Development:** Advanced Programming with C++, Software Development, Software Engineering Practices, Professional Skills, Games Development 1, Computer Graphics.

**Year 3 Computer Games Development**: Mobile Computing.

## Problem Context

As the quality of models and environments in today's 3D graphical applications improves, an area that is being under the spotlight more and more is the development of realistic or accurate lighting. The quality of models has increased to the point where simple direct illumination, shadow mapping and ambient light only serve to focus the users attention on the virtual nature of the models and animation. It is now necessary in cases where the image is desired to fool the user into perceiving the image on screen to be a real image that global illumination algorithms are employed to give accurate representation of the way light would behave in the depicted environment.

## The Problem

Many of the global illumination methods that have been used in the past are now failing to live up to user expectations and so the methods that were considered highly accurate but too costly to implement or too processor-intensive are now being reviewed and streamlined to replace older methods. Many of the methods now being looked at focus on tracing the path of the light and its interaction with the environment around it rather than approximating the general direction and attenuation of light.

Photon mapping is a comparatively accurate algorithm for calculating light, even when compared to other global illumination models. However traditionally the method is far too processor intensive to be used in real time simulation, with some simple scenes taking up to 44 minutes to render a single frame.

## Potential Ethical or Legal Issues

There should be no ethical or legal concerns with this project, as the photon mapping algorithm itself has no patents issued to it.

## Specific Objectives

* Project Technical Plan 19th October
* Create a rendering engine that uses direct lighting, specular highlighting, shadow maps, bump mapping. (most likely an optimised version of year 2 graphics project.)

plan to complete by October 31st

* Literature Review 16th November
* implement a ray tracer that runs through the GPU to optimise the photon mapping pass (suggested by Morgan McGuire, David Luebke (2009))

plan to complete by November 30th

* create the photon map storage and testing algorithm, recycling the shadow map to optimize the algorithm for real time use. The shadow map would need to undergo a mathematical sampling method and so this would be best done on the CPU.

Plan to complete by January 14th

* create the method that renders the secondary bounces of light using the photon map. this section should include the inter-diffuse reflections.

Plan to complete by March 1st

* create exceptional case handling for surfaces such as glass.

plan to complete by March 30th

* create the ability to display caustics through or reflected from certain surfaces.

Plan to complete by April 10th

* Hand in report 26th April

## The Approach

Photon mapping is becoming a far more popular method of modelling global illumination, due to its capability of handling diffuse inter-reflection, colour bleeding, sub-surface scattering and caustics. The algorithm has been around since 1995, created as a PhD thesis by Henrik Wann Jensen, but has been used only in high quality pre-rendered clips until recently due to the method taxing the CPU heavily. However, advances in graphics card technology and optimizations to the algorithm and other functions that it relies upon have allowed games and other real time software to start considering it as an option for light simulation.

I intend to create a lighting solution using a variation of the photon mapping algorithm implemented using DirectX 10 and C++. Direct illumination should be calculated first using a shadow map to ensure that the direct illumination does not add additional lighting where it would not be present.

As an optimization, the shadow map can then be used to calculate the first bounce of photons by running a Russian roulette algorithm on the pixels of the shadow map image. This will allow for a large optimization strait away which is to only project the path of the photons which would survive the first bounce, hence removing the most expensive part of the standard implementation of the photon mapping, which is the many ray-traces that occur from the light to the first instance of collision, of which only a few may survive to produce results differing from direct illumination.

Another optimization to the algorithm would be that a photon would be used to estimate the illumination that would occur in an area around the impact area of the photon, reducing the required number of photons in any scene. The light around the photons impact area would be required to blend with the light from other photon impacts in a nearby area to allow for a smooth illumination to be displayed. This helps speed up the process greatly from the more traditional method of photon mapping, which cycles through the photon mapping process until the majority of a surface has been impacted by photons to create the smooth illumination.

## Resources

*Visual Studio2010, DirrectX SDK.*

## Potential Commercial Considerations

### Estimated costs and benefits

if I were I to hire someone to complete this task, assuming that the project takes 400 hours and that 75% of that time would be spent programming, I would estimate the cost of programming to be around £12 per hour, making a cost of roughly £3600

## Literature Review

I intend to review literature to compare the methods and steps in photon mapping in the more traditional way against the more recent development of real time photon mapping. This will allow me to identify key areas of the algorithm that can be improved upon and allow me to create a more efficient technical demonstration

## References

* Morgan McGuire, David Luebke (2009) : Hardware-Accelerated Global Illumination by

Image Space Photon Mapping.

* Zack Waters : Photon Mapping <http://web.cs.wpi.edu/~emmanuel/courses/cs563/write_ups/zackw/photon_mapping/PhotonMapping.html> Accessed (17.07.2012)
* Henrik Wann Jensen, Niels Jorgen Christensen (2000) : A Practical Guide To Global Illumination Using Photon Maps. <http://graphics.stanford.edu/courses/cs348b-01/course8.pdf> Accessed (21.08.2012)
* Wen-Mei W. Hwu (2011) : GPU Computing Gems: Emerald Edition. pp 247- 26
* Andreas Velten et al.(2012) : nature communications 3, article number 745 : Recovering Three-dimensional shape around a corner using ultrafast time-of-flight imaging.
* Ramesh Raskar (2012) : TED talks : Imaging at a trillion frames per second <http://www.ted.com/talks/ramesh_raskar_a_camera_that_takes_one_trillion_frames_per_second.html?utm_source=youtube.com&awesm=on.ted.com_Raskar&utm_medium=on.ted.com-static&utm_content=awesm-publisher&utm_campaign=> Accessed (09.08.2012 )