Czech Technical University in Prague
Faculty of Electrical Engineering

Masterer Thesis

Progressive Computation of Global Illumination

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Aknowledgements

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Declaration

I hereby declare that I have completed this thesis independently and that I have listed all the literature and publications used.

Prague, 10. 11. 2012 ______________

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Signature

Abstract

Global illumination always played a key role in realistic computer generated image synthesis. Many algorithms have been developed to compute realistic images in reasonable time, though rendering volumetric phenomenas such as smoke including volumetric caustics and complex glossy reflection and refraction paths is still consuming task. Recently some new light caching approaches and progressive rendering techniques were discovered. This thesis aims to test their accuracy and feasibility on various scenes containing heterogenous participating media.

Abstrakt

Globální osvětlení vždy hrálo klíčovou roli při realistické syntéze obrazu. Existuje mnoho algoritmů které dokáží realistický obraz vypočítat v rozumném čase, ale výpočet globálního osvětlení u scén obsahujících opticky aktivní prostředí, jako je například kouř je stále časově velice náročný. V nedávné době se objevily nové postupy předvýpočtu světelných cest ve scéně a nové progresivní metody výpočtu obrazu.V této diplomové práci chceme prověřit jejich přesnost a rychlost na různých scénách obsahujicích nehomogenní opticky aktivní prostřědí.

Vložit zadani prace

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Chapter 1

Introduction

People have always been curious about new forms of visualization and illusion of reality. In the last decade computer generated imagery has reached a state, when majority of the public can't distinguish real photographs from entirely synthesized images. Thanks to this advancements we can enjoy otherwise impossible film shoots, imaginary worlds, visualizations of non existing buildings and much more. All this become possible, because ways how to represent objects and simulate light transport using computer algorithms have been found. The other important factor is ever growing computation power of these devices, which enables us visualize highly detailed datasets with complex materials and challenging lighting scenarios.

Even though many things are possible to simulate and visualize efficiently these days volumetric phenomenons such as clouds, smoke and other optically active medias are still real challenge even for high-end computers. This is all caused by the fact that the data we try to visualized are volumetric and that light passing through can be absorbed, scattered or even emitted in different wavelength (fig aurea borealis). This means that we can no longer assume that visibility of an object can be determined simply by determining if it is hidden behind other object or not.

In terms of feasible render times only direct illumination component can be computed. This approach can give us satisfying results such as those on the figure (fig good rays). Unfortunately many cool looking effects such as volumetric caustics, which can be seen on the figure (fig lasers) are really hard to simulate.

This thesis focuses on methods, which can render anything with physical accuracy and without restrictions on the rendered scene. The other very important bonus of these methods is their progressive nature. In the first passes the corse illumination of the scene is computed and it's progressively refined (fig image getting better). This for example means, that artist defining lighting mood of the visual effect shots can iterate faster. They have got something to show to the director, which results in quick turnarounds and substantial cost and time savings.

Our aim is to implement these progressive methods in the presence of heterogenous, optically active media and test them on scenes with varying complexity.

1.1 Thesis structure

This Thesis consists of eight main chapters. In the first chapter we have introduced you to the problem. In the second chapter the nifty theoretical details behind realistic image synthesis are exposed and fundamental terms such as BRDF, phase function and rendering equation defined and explained.

The third chapter is an overview of current strategies and algorithms used to visualize the volumetric phenomenons and their pros and cons listed. The fourth chapter leads us to the core of this thesis, the progressive methods of computation the global illumination in the presence of volumetrically active phenomenons.

In the fifth chapter we choose some of the methods mentioned in preceding chapter and further analyze them and propose a way how to and why to use them. In the sixth chapter we present our solution and describe it's internal structure. In the seventh chapter our results and test are shown. And finally eight chapter concludes the information gained and results obtained during this thesis creation.

Chapter 2

Fundamentals of realistic image synthesis

In this chapter we briefly revise fundamental theory behind realistic computer generated imagery. We first describe basic radiometry quantities and inspect problem of light interaction with surfaces. This gives us enough fundaments to formulate rendering equation. We continue with light interaction with participating media, which leads us to extended rendering equation. Algorithms mentioned in the next chapters are based on this theory and they present various methods solving this complex equation.

2.1 Radiometry

Quasi Monte Carlo equation

[Dutre et al.(2001)Dutre, Heckbert, Ma, Pellacini, Porschka, Ramasubramanian, Soler, and War
1) what is radiometry - asi z Jarosze + wikipedia

2) quantities: In this chapter I will define basic radiometry quantities to build enough support knowledge for the next chapter. - z meho prehledu z rso flux: irradiance: radiance:

Relationships between named quantities. -prehled rso

2.2 Surface interaction

-advanced illum techniques

assumptions and symplificaitions

2.2.1 BRDF

-pbrt

2.2.2 Rendering equation

-advanced illum techniques Theory behind rendering equation, integration of radiometry quantities. Both surface and solid angle deffinisions

2.3 Volume interaction

assumptions made of particles simplification using probability -advanced illum techniques -popsat absorbci a dalsi veci

2.3.1 Phase functions

-isotropic -anisotropic name hg,shlick aprox, reylight (atmosphere) -jak dochazi k rozptylu svetla -pouzit matlabacky obrazky heney-g funkce ruzne koeficienty

2.3.2 Rendering equation including participating media

hezke odvozeni je v -advanced illum techniques

What steps have to be taken to get rendering equation to the next level.

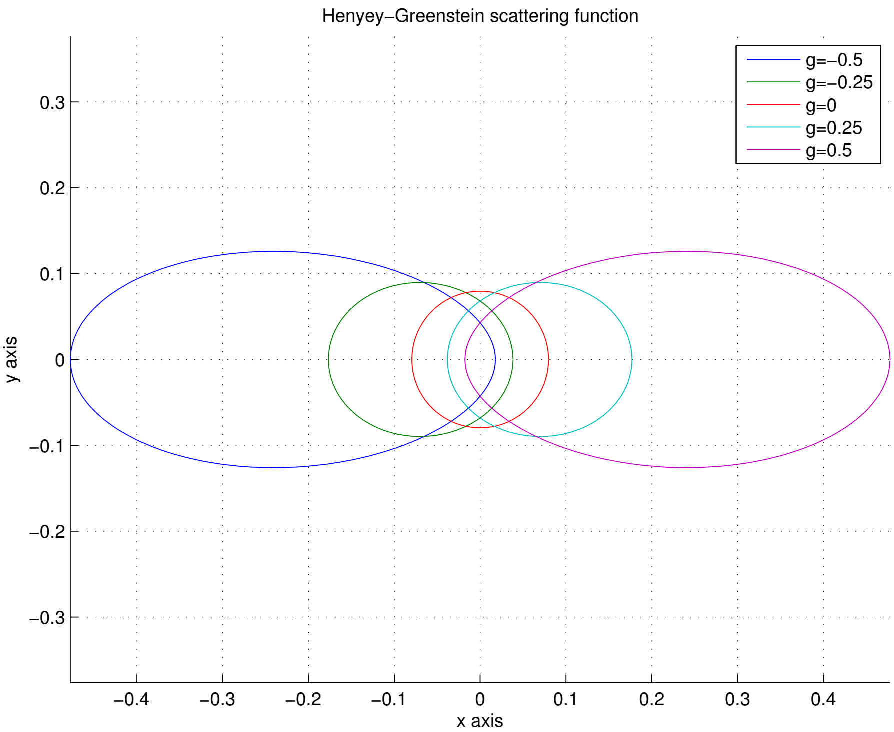

Figure 2.1: Plot of Heney-Greenstein phase function with different g coefficients. For g<0 the function represents backscattering media, for g=0 isometric scattering and for g>0 growing
forward scattering tendencies.

2.4 Volume and surface interaction

In order to properly simulate light transport in the scenes containing both surfaces and volumetrically active media.

Different light transport paths surface surface, surface media, media surface, media media.

2.4.1 Extended rendering equation

Put together all the integrals pokracovat v odvozeni z -advanced illum techniques

Chapter 3

Common solutions

In this chapter we will try to summarize the most common technics for solving the rendering equation in the presence of participating media.

3.1 Rasterization

Films -

krakatoa rendering engine

nvidia smoke particles demo pixar deep shadow maps [Lokovic and Veach(2000)]

Still most used in films and games - fast approximation. Particle rasterization + rendering slices of 3D volumes can solve only direct illumination.

3.2 Raytracing

3.2.1 Raymarching volumes

More recently, another technique has become popular for sampling distances along a ray in an inhomogeneous medium. The idea comes from the neutron transport community in the 60s and has various names (delta tracking, pseudo-scattering); we'll call it Woodcock tracking in effort to promote original paper.

pbrt single scattering can support procedural volumes and any type of lighting

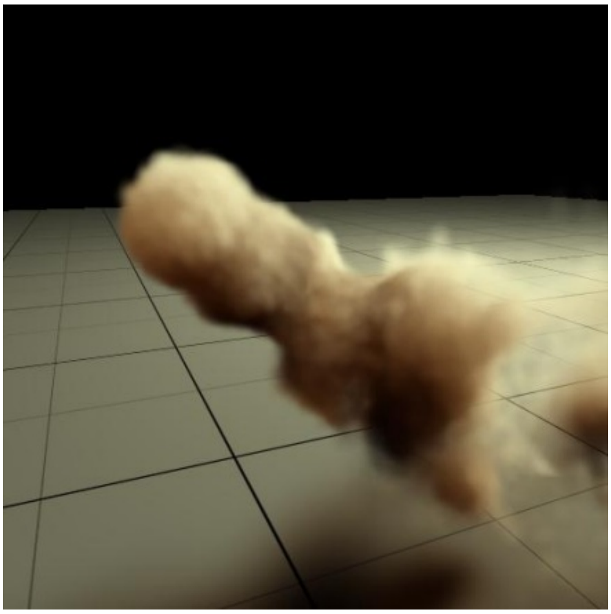

Figure 3.1: This image has been rendered using multiple shadow maps for direct illumination on gpu.

3.2.2 Unbiased methods

Plus and cons - very slow no caching recomputation of visibility factor

3.2.3 Biased methods

[Jarosz(2008)] irradiance caching, Photon tracing, final gather ... Plus and cons

Chapter 4

Consistant progressive methods

what does it mean to be progressive

4.1 Stochastic progressive photon mapping

[]

4.2 Beam mapping

[Jarosz et al.(2011)Jarosz, Nowrouzezahrai, Thomas, Sloan, and Zwicker] Hybrid solution cpu gpu rasterization..

4.3 Virtual point lights

[Keller(1997)] [Hašan et al.(2009)Hašan, Křivánek, Walter, and Bala]

4.4 Virtual ray lights

[Novák et al.(2012b)Novák, Nowrouzezahrai, Dachsbacher, and Jarosz]

4.5 Virtual beam lights

[Novák et al.(2012a)Novák, Nowrouzezahrai, Dachsbacher, and Jarosz]

Chapter 5

Proposed solution

I have chosen these methods and why... How to do it scheme of the progressive raytracing renderer.

co tu ma byt pouzil jsem tuhle a tuhle metodu proc odkazat se na predchozi kapitolu a zminit zmeny ktere jsem provedl a proc.

Co jsem orezal co rozsiril.

A dojit k blokovemu schematu co budu muset imlementovat. Mozna zminit i PBRT.

Chapter 6

Implementation

I have decided to implement it using pbrt. what is pbrt what structures I will use, which I have to create.

V tehle kapitole muzu i ukazat ty veci z matlabu ze funguji a jak. Klidne popsat, i postup implemntace pres jednoduzsi az po slozitejsi metody.

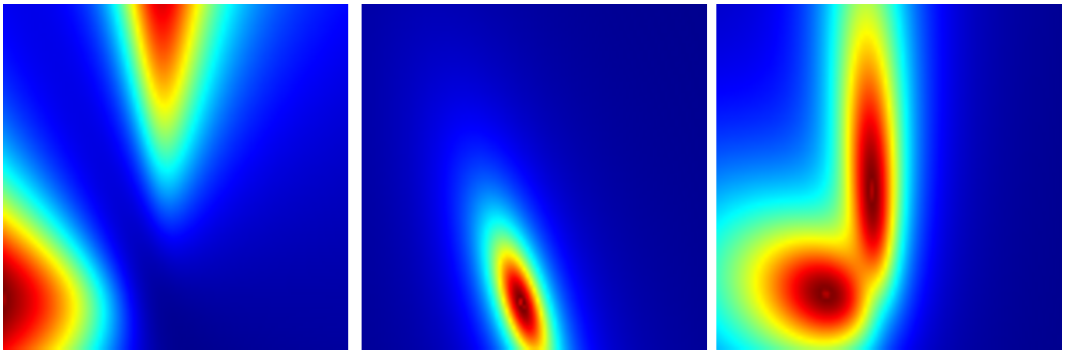

Figure 6.1: Different functions have been evaluated in discreet point pairs (from 0 to 1 parametric range) on two randomly placed rays.
On the left image only contribution using ray moderately forward scattering (g=0.75) Heney-Greenstein phase functions has been evaluated. In the middle inverse squared contribution and on the right contribution using both phase function and inverse sqared distance.

Chapter 7

Results

Mely by tu byt tabulky a srovnani metod a ruzne parametry.

Chapter 8

Conclusion

this method was implemented and results are great

8.0.1 Future work

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Appendinx A

Appendix

abreviations + test scene images

Appendinx B

DVD Content

galerie obrazku test scen