Advance Image Synthesis: Projects

Technische Universität Berlin

Sommersemester 2011

1 Generalities

- Students can work individually or in groups of two on the projects but the size of the work has to correspond to the group size.
- The project will account for 70% of your mark.
- Projects include a final presentation and a written report.
- Project progress presentations are on June 9th in class.
- Project proposals:
  - Project proposals are due on May 12th; via email and with a short presentation in class. They should contain:
    - Description of project.
    - Description of strategy and milestones, including what existing infrastructure, libraries, etc. you are planning to use.
    - Description of the evaluation you are planning to do.
  - Substantial changes in your projects have to be announced and discussed.

2 Extend pbrt's features[1]

- Subsurface scattering, for example Pharr and Hanrahan, "Monte Carlo Evaluation of Non-Linear Scattering Equations for Subsurface Reflection", Walter et al., "Microfacet Models for Refraction through Rough Surfaces", Frisvad, Christensen, and Jensen, "Computing the scattering properties of participating media using Lorenz-Mie theory", and the references in the latter paper.
- Skylight models such as Preetham, Shirley, and Smits, "A Practical Analytic Model for Daylight".
- Explore the effect of different image reconstruction filters, some examples are discussed in Mitchell and Netravali, "Reconstruction filters in computer-graphics" but extensions based on the material presented in the course and recent developments in signal processing should be considered. Also explore some of the filter-based noise reduction techniques that have been proposed in the literature, for example using the bilateral or the median filter.
- Evaluate the effectiveness of advanced importance sampling strategies such as Clarberg et al., "Wavelet Importance Sampling: Efficiently Evaluating Products of Complex Functions"; Jarosz, Carr, and Jensen, "Importance Sampling Spherical Harmonics".

[1] Some of these can in similar form be found in Pharr and Humphreys, *Physically Based Rendering: From Theory to Implementation*.

- Explore the effect of different color representation schemes. Next to RGB and wavelength sampling other models include for example Peercy, "Linear Color Representations for Full Speed Spectral Rendering" and Raso and Fournier, "A Piecewise Polynomial Approach to Shading Using Spectral Distributions".
- Implement a realistic camera model such as Kolb, Mitchell, and Hanrahan, "A Realistic Camera Model for Computer Graphics".
- Evaluate different noise functions such as Cook and DeRose, "Wavelet Noise"; Goldberg, Zwicker, and Durand, "Anisotropic noise"; Lagae et al., "Procedural noise using sparse Gabor convolution" and compare their performance.
- Some scattering functions employed in computer graphics are not symmetric. Modify pbrt so that it correctly handles these functions, cf. Veach, "Robust Monte Carlo Methods for Light Transport Simulation", Chapter 5.
- Implement Veach's original Metropolis Light Transport algorithm and compare the performance to those of pbrt's implementation. What other extensions of Metropolis Light Transport are likely to improve performance in practice? Implement some of them.
- pbrt is multi-threaded but does not employ dedicated general purpose graphics processing units (GPUs) to speed up computations. Analyze pbrt and implement part of its functionality on the GPU using OpenCL or CUDA.
- Various wave effects are relatively easy to "fake" even with a geometric optics based renderer such as fluorescence or polarisation, see for example Wolff and Kurlander, "Ray tracing with polarization parameters"; Tannenbaum, Tannenbaum, and Wozny, "Polarization and birefringency considerations in rendering". Implement such effects in pbrt.

3 Implement a Paper (or part of it)

- Hachisuka, Ogaki, and Jensen, "Progressive Photon Mapping"; Hachisuka and Jensen, "Stochastic progressive photon mapping".
- Lehtinen et al., "A Meshless Hierarchical Representation for Light Transport".
- Ihrke et al., "Eikonal rendering: efficient light transport in refractive objects"; Stam and Languénou, "Ray tracing in Non-Constant Media".
- Some PRT or PRT-like techniques, see the references in Lehtinen, "A Framework for Precomputed and Captured Light Transport".
- Clarberg and Akenine-Möller, "Exploiting Visibility Correlation in Direct Illumination".
- Walter et al., "Lightcuts: A Scalable Approach to Illumination"; Walter et al., "Multidimensional Lightcuts".

4 Research-Oriented Projects

- Contact the course instructor.

References

Clarberg, P. and T. Akenine-Möller. “Exploiting Visibility Correlation in Direct Illumination”. In: *Computer Graphics Forum* 27.4 (2008), pp. 1125–1136. URL: http://doi.wiley.com/10.1111/j.1467-8659.2008.01250.x.

Clarberg, P., W. Jarosz, T. Akenine-Möller, and H. W. Jensen. “Wavelet Importance Sampling: Efficiently Evaluating Products of Complex Functions”. In: *ACM Transactions on Graphics (TOG)* 24.3 (2005). URL: http://portal.acm.org/citation.cfm?id=1073328.

Cook, R. L. and T. DeRose. “Wavelet Noise”. In: *ACM Transactions on Graphics (Proceedings of SIGGRAPH 2005)* 24.3 (July 2005), p. 803. URL: http://portal.acm.org/citation.cfm?id=1073204.1073264.

Frisvad, J. R., N. J. Christensen, and H. W. Jensen. “Computing the scattering properties of participating media using Lorenz-Mie theory”. In: *ACM Transactions on Graphics* 26.3 (July 2007), p. 60. URL: http://portal.acm.org/citation.cfm?id=1276377.1276452.

Goldberg, A., M. Zwicker, and F. Durand. “Anisotropic noise”. In: *ACM Transactions on Graphics (Proceedings of SIGGRAPH 2008)* 27.3 (Aug. 2008), p. 1. URL: http://portal.acm.org/citation.cfm?id=1360612.1360653.

Hachisuka, T. and H. W. Jensen. “Stochastic progressive photon mapping”. In: *ACM Transactions on Graphics (Proceedings of SIGGRAPH Asia 2009)* 28.5 (Dec. 2009), p. 1. URL: http://portal.acm.org/citation.cfm?id=1661412.1618487.

Hachisuka, T., S. Ogaki, and H. W. Jensen. “Progressive Photon Mapping”. In: *ACM Transactions on Graphics (TOG)* 27.5 (2008). URL: http://portal.acm.org/citation.cfm?id=1409060.1409083.

Ihrke, I., G. Ziegler, A. Tevs, C. Theobalt, M. Magnor, and H.-P. Seidel. “Eikonal rendering: efficient light transport in refractive objects”. In: *ACM Trans. Graph.* 26 (2007), p. 59.

Jarosz, W., N. A. Carr, and H. W. Jensen. “Importance Sampling Spherical Harmonics”. In: *Computer Graphics Forum* 28.2 (2009), pp. 577–586. URL: http://www.ingentaconnect.com/content/bpl/cgf/2009/00000028/00000002/art00043.

Kolb, C., D. Mitchell, and P. Hanrahan. “A Realistic Camera Model for Computer Graphics”. In: *Proceedings of SIGGRAPH ’95*. New York, New York, USA: ACM Press, Sept. 1995, pp. 317–324. URL: http://portal.acm.org/citation.cfm?id=218380.218463.

Lagae, A., S. Lefebvre, G. Drettakis, and P. Dutré. “Procedural noise using sparse Gabor convolution”. In: *ACM Transactions on Graphics (Proceedings of SIGGRAPH 2009)* 28.3 (July 2009), p. 1. URL: http://portal.acm.org/citation.cfm?id=1531326.1531360.

Lehtinen, J. “A Framework for Precomputed and Captured Light Transport”. In: *ACM Trans. Graph.* 26 (2007), p. 13.

Lehtinen, J., M. Zwicker, E. Turquin, J. Kontkanen, F. Durand, F. X. Sillion, and T. Aila. “A Meshless Hierarchical Representation for Light Transport”. In: *ACM Trans. Graph.* 27 (2008), pp. 1–9.

Mitchell, D. P. and A. N. Netravali. “Reconstruction filters in computer-graphics”. In: *ACM SIGGRAPH Computer Graphics* 22.4 (Aug. 1988), pp. 221–228. URL: http://portal.acm.org/citation.cfm?id=378456.378514.

Peercy, M. S. “Linear Color Representations for Full Speed Spectral Rendering”. In: *SIGGRAPH ’93: Proceedings of the 20th annual conference on Computer graphics and interactive techniques*. New York, NY, USA: ACM, 1993, pp. 191–198.

Pharr, M. and P. Hanrahan. “Monte Carlo Evaluation of Non-Linear Scattering Equations for Subsurface Reflection”. In: *SIGGRAPH ’00: Proceedings of the 27th annual conference on Computer graphics and interactive techniques*. New York, NY, USA: ACM Press/Addison-Wesley Publishing Co., 2000, pp. 75–84.

Pharr, M. and G. Humphreys. *Physically Based Rendering: From Theory to Implementation*. second ed. San Francisco, CA, USA: Morgan Kaufmann Publishers Inc., 2010.

Preetham, A. J., P. Shirley, and B. Smits. “A Practical Analytic Model for Daylight”. In: *Proceedings of SIGGRAPH ’99*. New York, New York, USA: ACM Press, July 1999, pp. 91–100. URL: http://portal.acm.org/citation.cfm?id=311535.311545.

Raso, M. and A. Fournier. “A Piecewise Polynomial Approach to Shading Using Spectral Distributions”. In: *Proceedings of Graphics Interface ’91*. Calgary, AB, Canada, 1991, pp. 40–46.

Stam, J. and E. Languénou. “Ray tracing in Non-Constant Media”. In: *Proceedings of the Eurographics Workshop on Rendering Techniques ’96*. London, UK: Springer-Verlag, 1996, p. 225.

Tannenbaum, D. C., P. Tannenbaum, and M. J. Wozny. “Polarization and birefringency considerations in rendering”. In: *Proceedings of SIGGRAPH ’94*. New York, New York, USA: ACM Press, July 1994, pp. 221–222. URL: http://portal.acm.org/citation.cfm?id=192161.192204.

Veach, E. “Robust Monte Carlo Methods for Light Transport Simulation”. Ph.D. thesis. Stanford University, 1997.

Walter, B., S. Fernandez, A. Arbree, K. Bala, M. Donikian, and D. P. Greenberg. “Lightcuts: A Scalable Approach to Illumination”. In: *SIGGRAPH ’05: ACM SIGGRAPH 2005 Papers*. New York, NY, USA: ACM Press, 2005, pp. 1098–1107.

Walter, B., S. Marschner, H. Li, and K. E. Torrance. “Microfacet Models for Refraction through Rough Surfaces”. In: *Rendering Techniques 2007 (Proc. Eurographics Symposium on Rendering)* (2007). URL: http://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.69.983.

Walter, B., A. Arbree, K. Bala, and D. P. Greenberg. “Multidimensional Lightcuts”. In: *SIGGRAPH ’06: ACM SIGGRAPH 2006 Papers*. New York, NY, USA: ACM Press, 2006, pp. 1081–1088.

Wolff, L. B. and D. J. Kurlander. “Ray tracing with polarization parameters”. In: *IEEE Computer Graphics and Applications* 10.6 (1990), pp. 44–55. URL: http://portal.acm.org/citation.cfm?id=616014.617602.