Computer Graphics Programming III

The Art Institute of Portland℠

Course Description

VGP353A

Spring 2012, 3 credits

Wednesday, 6:00PM - 9:45PM

Final exam: Wednesday, June 13th, 2012 at 5:30PM

Room #214

In this course students will learn and implement real-time shadow algorithms using OpenGL and OpenGL Shading Language (GLSL). This includes shadow maps, shadow volumes, and several variations and optimizations of each.

By the end of the course, students will be able to:

- Understand terminology and issues related to shadows in real-time graphics.
- Understand and implement shadow map based shadow algorithms.
- Understand shadow volume based shadow algorithms.
- Understand and implement ambient occlusion algorithms.
- Read, understand, and make use of information in academic papers.

The complete, up to date, course syllabus is also available on-line at the course website (http://people.freedesktop.org/~idr/2012Q2-VGP353/). The syllabus is available as both HTML and PDF (http://people.freedesktop.org/~idr/2012Q2-VGP353/SP12_VGP353_A.pdf).

Prerequisite

Successful completion of VGP352 or consent of instructor is required.

This course is both programming and math intensive. A strong background in C or C++ programming is required. Familiarity with object oriented programming principles will be very helpful but is not strictly required. Previous knowledge of matrix math and trigonometry is required and will be extremely important. Particularly tenacious students may be able to learn the required math during the term, but it will be a lot of extra work.

Texts

This is no required text for this course. There will be suggested readings on many topics covered in this course from *Real-Time Rendering*. Either the 2nd edition or the 3rd edition of this book are acceptable. At least one copy of the 2nd edition is available in the school library.

> Akenine-Moeller, Tomas and Haines, Eric and Hoffman, Mathaniel. *Real-Time Rendering (3rd Ed.)*, AK Peters, Ltd., 2008. ISBN 978-1-56881-424-7.

Real-Time Rendering has a website (http://www.realtimerendering.com/) that has a lot of useful, relevant information.

In addition, the following OpenGL reference books may prove to be very useful.

> Rost, Randi J.. *OpenGL Shading Language (2nd. Ed.)*, Addison-Wesley Professional, January 25, 2006. ISBN 0-32133-489-2.

> Wright, Richard S.; Lipchak, Benjamin; and Haemel, Nicholas. *OpenGL SuperBible: Comprehensive Tutorial and Reference (4th Ed.)*, Addison-Wesley Professional, June 2007. ISBN 0-321498-828.

OpenGL Superbible has a website (http://www.starstonesoftware.com/OpenGL/), that includes source code and pre-built binaries. Earlier editions of this book are *not* suitable for this course because they do not cover the OpenGL shading language.

OpenGL Shading Language also has a website (http://3dshaders.com/), that includes example shaders and some references. Earlier editions of this book should also be sufficient for this course.

Required Materials

In addition to paper and writing utensils, each student will need a removable storage device. The storage device will be used to both bring documents and sample code home from class and bring homework completed assignments to class. The storage requirements should be minimal, so a small USB flash-drive (256MB) should be sufficient.

Grading

Each student's grade in this course will be primarily based on a total of 3 multi-week programming assignments. Each student will also be required to read an academic paper and present a summary of that paper to the class. The remainder of the student's grade will be based on bi-weekly quizes and a final exam.

Programming assignments will be graded first and foremost on whether or not correct output is produced. The remaining points are based on the style of the program. This includes, but is not limited to, algorithm selection, code formatting, and naming conventions. A detailed rubric will be provided with each assignment.

Programming Assignments	
In-class presentation	10 pts.
Programming assignments	60 pts.

	Subtotal	70 (50%)

Tests

In-class quizzes	20 pts.
Final Exam	50 pts.

	Subtotal	70 pts. (50%)
	Total	140 pts. (100%)

Some assignments *may* carry extra-credit opportunities, but they will be infrequent.

Grading Scale

A	=	93% and above
A-	=	90%-92%
B+	=	87%-89%
B	=	83%-86%
B-	=	80%-82%
C+	=	77%-79%
C	=	73%-76%
C-	=	70%-72%
D+	=	67%-69%
D	=	60%-66%

Late Work

I do not accept late work. If you miss a deadline, you will not earn the points for that activity. There are no make-up opportunities. If you are unable to attend class on the due date for a assignment, please submit it by e-mail *before* class.

Attendance and Participation

If you are not in class for an in-class exercise, you cannot earn those points. If you miss an entire class, you are responsible for obtaining copies of handouts and other classroom materials from your classmates.

AiPD Policies

Lab Policies

Leave food and drink outside the class. Disciplinary action will be taken toward any student found using the equipment in an inappropriate manner, taking cell phone calls or surfing the web. Disruptive, disrespectful or rude behavior will not be tolerated.

Plagiarism

Presenting the writings, images or paraphrased ideas of another as ones own, is strictly prohibited at the Art Institute of Portland. Properly documented excerpts from others works, when they are limited to an appropriate amount of the total length of a student's paper, are permissible when used to support a researched argument.

ADA Statement

It is AiPD policy not to discriminate against qualified students with a documented disability in its educational programs, activities or services. If you have a disability-related need for adjustments or other accommodations in this class, contact Student Support and Disabilities Coordinator, Daynia Flynn at ext. 4836 <djflynn@aii.edu>

Course Calendar

Week 1 (April 4th, 2012)

Lecture notes (http://people.freedesktop.org/~idr/2012Q2-VGP353/20120404-Shadow-Intro.pdf)

Lecture topics:

- Course road-map
- Introduce shadows
  - Importance of shadows
  - Planar shadows
  - Soft shadows
- Shadow textures
- Projective texturing review

Homework assignments:

- Programming assignment #1: (20120404_Assignment.pdf) Shadow textures. Part 1 is due 4/11. Part 2 is due 4/18.

- Read:

    Eric Haines, "Soft Planar Shadows Using Plateaus." *journal of graphics tools* , vol. 6 , no. 1 , pages 19-27. 2001. http://erich.realtimerendering.com/plateaus.pdf

    Everitt, Cass; Rege, Ashu; and Cebnoyan, Cem, Hardware Shadow Mapping. NVIDIA. Decemeber 2001. http://developer.nvidia.com/object/hwshadowmap_paper.html

Week 2 (April 11th)

Lecture notes (http://people.freedesktop.org/~idr/2012Q2-VGP353/20120411-Shadow-Maps.pdf)

Lecture topics:

- Shadow maps, part 1

    - Implementation over-view
    - Comparison to shadow textures
    - Problems / shortcomings

Homework assignments:

- Read:

    R. Fernando, "Percentage-Closer Soft Shadows." In *Proceedings of SIGGRAPH 2005*. 2005. http://developer.nvidia.com/object/siggraph_2005_presentations.html

    W. Reeves, D. Salesin, and R. Cook, "Rendering Antialiased Shadows with Depth Maps." In *Proceedings of SIGGRAPH '87*. 1987. http://graphics.pixar.com/library/ShadowMaps/paper.pdf

Week 3 (April 18th, 2012)

Lecture notes (http://people.freedesktop.org/~idr/2012Q2-VGP353/20120418-Shadow-Maps-part-2.pdf)

Quiz #1.**DO NOT BE LATE TODAY!**

Lecture topics:

- Shadow maps, part 2

    - Percentage closer filtering
    - Percentage closer soft shadows (PCSS)

Homework assignments:

- Read:

  Brabec, Stefan and Annen, Thomas and Seidel, Hans-Peter, "Shadow Mapping for Hemispherical and Omnidirectional Light Sources." In *Advances in Modelling, Animation and Rendering (Proceedings Computer Graphics International 2002)* , pages 397-408. Springer, 2002. http://www.thomasannen.com/publications.html

  Aaron E. Lefohn AND Shubhabrata Sengupta AND John D. Owens, "Resolution Matched Shadow Maps." *ACM Transactions on Graphics* , vol. 26 , no. 4 , pages 20:1--20:17. ACM, 2007. http://www.idav.ucdavis.edu/publications/print_pub?pub_id=919

Week 4 (April 25th)

Lecture notes
(http://people.freedesktop.org/~idr/2012Q2-VGP353/20120425-Shadow-Volumes-part-1.pdf)

Lecture topics:

- Stencils buffer refresher
- Introduction to shadow volumes
  - Z-pass
  - Z-fail
  - Generating shadow volume geometry

Homework assignments:

- Programming assignment #2: Shadow maps. (20120425_Assignment.pdf) Due 5/2.
- Read:

  Annen, Thomas and Dong, Zhao and Mertens, Tom and Bekaert, Philippe and Seidel, Hans-Peter and Kautz, Jan, "Real-time, all-frequency shadows in dynamic scenes." In *SIGGRAPH '08: ACM SIGGRAPH 2008 papers* , pages 1--8. ACM, 2008. http://www.thomasannen.com/publications.html

  Stefan Brabec and Thomas Annen and Hans-Peter Seidel, "Practical Shadow Mapping." *journal of graphics tools* , vol. 7 , no. 4 , pages 9-18. 2002. http://www.thomasannen.com/publications.html

  Everitt, Cass and Kilgard, Mark, Practical and Robust Stenciled Shadow Volumes for Hardware-Accelerated Rendering. NVIDIA. May 2001. http://developer.nvidia.com/object/robust_shadow_volumes.html

Week 5 (May 2nd, 2012)

Lecture notes (http://people.freedesktop.org/~idr/2012Q2-VGP353/20120502-Shadow-Maps-part-3.pdf)

Quiz #2. **DO NOT BE LATE TODAY!**

Lecture topics:

- Shadow maps, part 3

- Reducing shadow map aliasing

  - Perspective shadow maps (PSMs)

  - Parallel split shadow maps (PSSMs)

  - Resolution matched shadow maps

Homework assignments:

- Read:

  Brennan, Chris. "Shadow Volume Extrusion Using a Vertex Shader" in Engel, Wolfgang F. (editor)
  ShaderX, Wordware Publishing, Inc., May 2002.
  http://developer.amd.com/documentation/reading/pages/ShaderX.aspx

  Hornus, Samuel; Hoberock, Jared; Lefebvre, Sylvain; Hart, John C., "ZP+: Correct Z-Pass Stencil
  Shadows." In *Proceedings of ACM Symposium on Interactive 3D Graphics and Games*. ACM Press, April
  2005. http://artis.imag.fr/Publications/2005/HHLH05/

Week 6 (May 9ᵗʰ, 2012)

Lecture notes
(http://people.freedesktop.org/~idr/2012Q2-VGP353/20120509-Shadow-Volumes-part-2.pdf)

Lecture topics:

- Fixing Z-pass and Z-fail with ZP+ and ++ZP
- Soft shadows using shadow volumes
- Hardware extensions that optimize shadow volumes:
  - Depth clamping
  - Depth bounds testing

Homework assignments:

- Read to recap this week:

  Brandon Lloyd and Jeremy Wend and Naga K. Govindaraju and Dinesh Manocha, "CC Shadow Volumes."
  In *Proceedings of the 15th Eurographics Workshop on Rendering Techniques, Norköping, Sweden, June
  21-23, 2004* , pages 197-206. Eurographics Association, 2004.
  http://gamma.cs.unc.edu/CCSV/ccsvEGSR04.pdf

  Timo Aila and Tomas Akenine-Moeller, "A Hierarchical Shadow Volume Al-
  gorithm." In *Proceedings of Graphics Hardware 2004* , pages 15-23. Eurographics Association, August 2004.
  http://graphics.cs.lth.se/research/shadows/http://www.graphicshardware.org/previous/www_2004/Presentations/TimoAila.ppthttp://

- Read to prepare for week:

Iones, Andrey and Krupkin, Anton and Sbert, Mateu and Zhukov, Sergey, "Fast, Realistic Lighting for Video Games." *IEEE Computer Graphics and Applications* , vol. 23 , pages 54--64. IEEE Computer Society Press, 2003. http://ima.udg.edu/iiia/GGG/UsersDocs/mateu/obscurances.pdf

Week 7 (May 16th, 2012)

Lecture notes (http://people.freedesktop.org/~idr/2012Q2-VGP353/20120516-Ambient-Occlusion.pdf)

Quiz #3. **DO NOT BE LATE TODAY!**

Lecture topics:

• Ambient occlusion

 • Generating AO factors using ray-tracing

 • Approximation in real-time

 • Screen-space ambient occlusion (SSAO) introduction

Homework assignments:

• Read to recap this week:

 Pharr, Matt and Green, Simon. "Ambient Occlusion" in Fernando, Randima (editor) *GPU Gems*, Addison Wesley, 2004. http://http.developer.nvidia.com/GPUGems/gpugems_ch17.html

 Bunnel, Michael. "Dynamic Ambient Occlusion and Indirect Lighting" in Fernando, Randima (editor) *GPU Gems 2*, Addison Wesley, 2005. http://download.nvidia.com/developer/GPU_Gems_2/GPU_Gems2_ch14.pdf

Week 8 (May 23rd, 2012)

Lecture notes (http://people.freedesktop.org/~idr/2012Q2-VGP353/20120523-SSAO.pdf)

Lecture topics:

• Bilateral filtering
• Fixing problems with SSAO:
 • Horizon split AO
 • Multi-layer dual-resolution SSAO

Homework assignments:

• Programming assignment #3: SSAO. (20120523_Assignment.pdf) Due at the final 6/13.

Week 9 (May 30th, 2012)

Lecture notes (http://people.freedesktop.org/~idr/2012Q2-VGP353/20120530-HDR.pdf)

Quiz #4.**DO NOT BE LATE TODAY!**

Lecture topics:

• High dynamic range (HDR) rendering

Homework assignments:

• Read to prepare for week:

Shishkovtsov, Oles. "Deferred Shading in S.T.A.L.K.E.R." in Fernando, Randima (editor) *GPU Gems 2*, Addison Wesley, 2005. http://http.developer.nvidia.com/GPUGems2/gpugems2_chapter09.html

Week 10 (June 6th, 2012)

Lecture topics:

• Deferred shading

Homework assignments:

• Prepare for final.

Week 11 (June 13th, 2012)

FINAL EXAM - 5:30PM.**DO NOT BE LATE TODAY!**