Computer Graphics Programming III

The Art Institute of Portland℠

Course Description

VGP353A

Summer 2009, 3 credits

Tuesday, 6:00PM - 9:45PM

Room #TBD

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/2009Q3-VGP353/). The syllabus is available as both HTML and PDF (http://people.freedesktop.org/~idr/2009Q3-VGP353/SU09_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. *Real-Time Rendering (2nd Ed.)*, AK Peters, Ltd., July 2002. ISBN 1-56881-182-9.

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

In addition, 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.

Students with Disabilities

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 the Disability Services Coordinator.

Amber Perrin
Disabilities Services Coordinator
The Art Institute of Portland
1122 NW Davis Street
Portland, OR 97209-2911
503-382-4836
<aperrin@aii.edu>

Course Calendar

Week 1 (July 14th, 2009)

Lecture notes (http://people.freedesktop.org/~idr/2009Q3-VGP353/20090714 - 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: (20090714_Assignment.pdf) Shadow textures. Due 7/21.
- Read:

  Eric Haines, "Soft Planar Shadows Using Plateaus." *journal of graphics tools* , vol. 6 , no. 1 , pages 19-27. 2001. http://jgt.akpeters.com/papers/Haines01/http://www.acm.org/tog/editors/erich/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 (July 21st, 2009)

Lecture notes (http://people.freedesktop.org/~idr/2009Q3-VGP353/20090721 - Shadow Maps.pdf)

Lecture topics:

- Shadow maps, part 1
  - Implementation over-view
  - Comparison to shadow textures
  - Problems / shortcomings
  - Percentage closer filtering

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/ShadowMaps/

Week 3 (July 28th, 2009)

Lecture notes (http://people.freedesktop.org/~idr/2009Q3-VGP353/20090728 - Shadow Maps, part 2.pdf)

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

Lecture topics:

- Shadow maps, part 2
  - Reducing shadow map aliasing
    - Perspective shadow maps (PSMs)
    - Parallel split shadow maps (PSSMs)
  - Percentage closer soft shadows (PCSS)
  - Depth range optimizations

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.mpi-inf.mpg.de/~brabec/

  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 (TBD)

Lecture notes (http://people.freedesktop.org/~idr/2009Q3-VGP353/20090809 - Shadow Maps, part 3.pdf)

Lecture topics:

- Shadow maps, part 3
  - Resolution matched shadow maps
  - Omni-directional lights
  - Texture atlases for shadow maps

Homework assignments:

- 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.mpi-inf.mpg.de/~dong/SIG08_CSSM.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.mpi-sb.mpg.de/~tannen/

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 (August 11th, 2009)

Lecture notes (http://people.freedesktop.org/~idr/2009Q3-VGP353/20090811 - Shadow Volumes, part 1.pdf)

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

Lecture topics:

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

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 (August 18th, 2009)

Lecture notes (http://people.freedesktop.org/~idr/2009Q3-VGP353/20090818 - Shadow Volumes, part 2.pdf)

Lecture topics:

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

Homework assignments:

- Read:

Timo Aila and Tomas Akenine-Moeller, "A Hierarchical Shadow Volume Algorithm." 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://

Roettger, Stephan; Irion, Alexander; Ertl, Thomas, "Shadow Volumes Revisisted." *Journal of WSCG* , vol. 10 , no. 1-3. 2002. http://wscg.zcu.cz/wscg2002/Papers_2002/C73.pdf

Akenine-Moeller, Tomas; Assarson, Ulf, "Approximate Soft Shadows on Arbitrary Surfaces using Penumbra Wedges." In *13th Eurographics Workshop on Rendering 2002* , pages 309-318. June 2002. http://graphics.cs.lth.se/research/shadows/

Week 7 (August 25th, 2009)

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

Lecture topics:

- Ambient occlusion
  - Generating AO factors using ray-tracing
  - Approximation in real-time

Homework assignments:

- Read: TBD.

Week 8 (September 1st, 2009)

Lecture topics:

- Screen-space ambient occlusion (SSAO)
- TBD.

Homework assignments:

- Read: TBD.

Week 9 (September 8th, 2009)

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

Lecture topics:

- Visibility acceleration, part 1
  - Bouding volumes

- View frustum culling
- Cells and porals

Homework assignments:

- Read: TBD.

Week 10 (September 15th, 2009)

Lecture topics:

- Visibility acceleration, part 2

Homework assignments:

- Prepare for final.

Week 11 (September 22nd, 2009)

FINAL EXAM - TBD.**DO NOT BE LATE TODAY!**