

Computer Graphics Programming II



The Art Institute of PortlandSM

Course Description

VGP352A

Winter 2010, 3 credits

Tuesday, 6:00PM - 9:45PM

Room #202

In this course students will be introduced to principles of 3D computer graphics using the OpenGL programming interface. Students will learn fundamental concepts of transformation, lighting, and texturing.

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

- Understand and implement advanced per-pixel lighting algorithms.
- Understand and implement procedural textures.
- Understand and implement render-to-texture type 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/2010Q1-VGP352/>). The syllabus is available as both HTML and PDF (http://people.freedesktop.org/~idr/2010Q1-VGP352/WI10_VGP352_A.pdf).

Prerequisite

Successful completion of VGP351 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

Required text:

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

There will be weekly assigned readings from this book. Equivalent readings from the second edition will also be listed. This textbook will also be used in VGP352 and VGP353. However, there will be readings in those courses that were added in the third edition.

The book also has a website (<http://www.realtimerendering.com>) that includes numerous additional references and sample code.

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 five single-week programming assignments and one four-week programming project. 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 quizzes 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	20 pts.
Homework programming assignments	50 pts.
Term project	50 pts.
	Subtotal 120 (63%)

Tests

In-class quizzes	20 pts.
Final Exam	50 pts.
	Subtotal 70 pts. (37%)
	Total 190 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
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Course Calendar

Week 1 (January 12th, 2010)

Lecture slides (<http://people.freedesktop.org/~idr/2010Q1-VGP352/20100112 - Curves and per-fragment lighting.pdf>)

Lecture topics:

- Course road-map
- Curves
- Curved Surfaces
- Per-fragment lighting recap
 - Phong shading
 - Surface-space

Homework assignments:

- Read to recap this week:
 - Real-Time Rendering, 3rd edition, chapter 13 sections 1 and 2 (pp. 575 -- 606).
 - Real-Time Rendering, 2nd edition, chapter 12 sections 1 and 2 (pp. 481 -- 512).
- Programming assignment #1 (20100112_Assignment.pdf). Due 1/26.
- Patch data (patches.h) for assignment #1.
- one_cube.cpp demo. You'll need to supply your own vertex and fragment shaders, but each is pretty trivial.

Week 2 (January 26th, 2010)

Lecture slides (<http://people.freedesktop.org/~idr/2010Q1-VGP352/20100126 - Procedural texturing.pdf>)

Lecture topics:

- Bump mapping / Normal mapping
 - Basic usage
 - Normal map storage
- Introduction to procedural textures
 - Fundamental techniques
 - Noise
 - Problems with procedural textures

Homework assignments:

- Read to recap this week:
 - Real-Time Rendering, 3rd edition, chapter 6 sections 3 through 7.4 (pp. 178 -- 193). You may skip section 4, 5, and 6.
 - Real-Time Rendering, 2nd edition, chapter 5 section 7.5 (pp. 166 -- 177). Skip the subsections "Emboss Bump Mapping" and "Environment Map Bump Mapping". Some of the material from chapter 6.3 of the 3rd edition appears on pages 126 and 127, beginning with the sentence "Three-dimensional texture can be synthesized", in the 2nd edition.
 - Toksvig, Michael, Mipmapping Normal Maps. NVIDIA. April 2004.
http://developer.nvidia.com/object/mipmapping_normal_maps.html

Week 3 (January 29th, 2010)

Lecture slides (<http://people.freedesktop.org/~idr/2010Q1-VGP352/20100129 - Render to texture.pdf>)

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

Lecture topics:

- Render to texture
- Environment map
- Improving the reflection model
 - Using environment maps as better lights
 - Fresnel reflection

Homework assignments:

- Read to recap this week:

Wloka, Matthias, Fresnel Reflection. NVIDIA. July 2002.
http://developer.nvidia.com/object/fresnel_wp.html

Jones, Rob, "OpenGL Framebuffer Object 101." .
<http://www.gamedev.net/reference/programming/features/fbo1/>

Green, Simon, The OpenGL Framebuffer Object Extension. NVIDIA. 2004.
http://developer.nvidia.com/object/gdc_2005_presentations.html

- Read to prepare for next week:

Real-Time Rendering, 3rd edition, chapter 7 section 5 (pp. 223 -- 251). The first two sections, 7.5.1 and 7.5.2, are the primary interest for next week. Section 7.5.3 covers Fresnel reflection. At the very least, read these three sections.

Real-Time Rendering, 2nd edition, chapter 6 section 3 (pp. 194 -- 202). The 2nd edition has must less coverage of BRDFs. I strongly recommend reading the material from the 3rd edition.

Cook, Robert L. and Torrance, Kenneth E., "A reflectance model for computer graphics." In *SIGGRAPH '81: Proceedings of the 8th Annual Conference on Computer Graphics and Interactive Techniques* , pages 307--316. ACM, 1981. <http://graphics.pixar.com/library/ReflectanceModel/>

Week 4 (February 2nd, 2010)

Lecture slides (<http://people.freedesktop.org/~idr/2010Q1-VGP352/20100202 - BRDFs, part 1.pdf>)

Lecture topics:

- Bi-direction reflection distribution function
- Common terminology and notation
- Cook-Torrance model
- Microfacet-based BRDFs
 - Normal distribution
 - Occlusion

Homework assignments:

- Read to prepare for next week:

Ashikhmin, Michael and Premoze, Simon and Shirley, Peter, "A microfacet-based BRDF generator." In *SIGGRAPH '00: Proceedings of the 27th Annual Conference on Computer Graphics and Interactive Techniques*, pages 65--74. ACM Press/Addison-Wesley Publishing Co., 2000.
<http://www.cs.utah.edu/~shirley/papers/facets.pdf>

- Programming assignment #2: (20100202_Assignment.pdf) Normal mapped BÄzier surfaces. Due 2/16.

Week 5 (February 9th, 2010)

Lecture slides (<http://people.freedesktop.org/~idr/2010Q1-VGP352/20100209 - BRDFs, part 2.pdf>)

In-class notes (http://people.freedesktop.org/~idr/2010Q1-VGP352/20100209_class_notes.pdf)

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

Lecture topics:

- Anisotropic BRDFs
 - What does anisotropy mean in this context?
 - Ward BRDF
 - Ashikhmin BRDF
- Metals
 - How metals reflect light
 - Lafortune BRDF

Homework assignments:

- Read to recap this week:

Walter, Bruce, Notes on the Ward BRDF. Cornell Program of Computer Graphics. April 29, 2005.
<http://www.graphics.cornell.edu/pubs/2005/Wal05.html>

- Read to prepare for next week:

Goldman, Dan B., "Fake fur rendering." In *SIGGRAPH '97: Proceedings of the 24th Annual Conference on Computer Graphics and Interactive Techniques*, pages 127--134. ACM Press/Addison-Wesley Publishing Co., 1997. <http://www.cs.washington.edu/homes/dgoldman/fakefur/>

Week 6 (February 16th, 2010)

Lecture slides (<http://people.freedesktop.org/~idr/2010Q1-VGP352/20100216 - BRDFs, part 3.pdf>)

In-class notes (http://people.freedesktop.org/~idr/2010Q1-VGP352/20100216_class_notes.pdf)

Lecture topics:

- Fur and hair
 - Goldman's "Fake Fur Rendering"
 - Shells and fins
 - Banks BRDF
- Implementing BRDFs in real-time rendering engines

Homework assignments:

- Read to prepare for next week:

Gooch, Amy and Gooch, Bruce and Shirley, Peter and Cohen, Elaine, "A non-photorealistic lighting model for automatic technical illustration." In *SIGGRAPH '98: Proceedings of the 25th annual conference on Computer graphics and interactive techniques*, pages 447--452. ACM, 1998.
<http://www.cs.utah.edu/npr/papers.html#1998>

Lake, Adam and Marshall, Carl and Harris, Mark and Blackstein, Marc, "Stylized rendering techniques for scalable real-time 3D animation." In *NPAR '00: Proceedings of the 1st international symposium on Non-photorealistic animation and rendering*, pages 13--20. ACM, 2000.
<http://software.intel.com/en-us/articles/intel-3d-software-technologies/>

Card, Drew and Mitchel, Jason. "Non-Photorealistic Rendering with Pixel and Vertex Shaders" in Engel, Wolfgang F. (editor) *ShaderX*, Wordware Publishing, Inc., May 2002.
<http://developer.amd.com/documentation/reading/pages/ShaderX.aspx>

- Programming assignment #3: Improved lighting with BRDFs. Due 3/2.

Week 7 (February 23rd, 2010)

Lecture slides (<http://people.freedesktop.org/~idr/2010Q1-VGP352/20100223 - Nonphotorealistic Rendering.pdf>)

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

Lecture topics:

- Non-photorealistic rendering
 - Cel (toon) shading
 - Silhouette edge rendering
 - Technical illustration
- Texture rectangles (briefly)
- Post-processing, part 1

Homework assignments:

- Read to prepare for next week:

Guennadi Riguer, Natalya Tatarchuk, and John Isidoro. "Real-Time Depth of Field Simulation" in Engel, Wolfgang F. (editor) *ShaderX2*, Wordware Publishing, Inc., October 2003.

<http://developer.amd.com/documentation/reading/pages/ShaderX.aspx>

Week 8 (March 2nd, 2010)

Lecture slides (<http://people.freedesktop.org/~idr/2010Q1-VGP352/20100302 - Image processing.pdf>)

Lecture topics:

- Post-processing, part 2
 - General image filters
 - Separable filters
 - Depth-of-field
 - High dynamic range (HDR) rendering

Homework assignments:

- Read to prepare for next week:

van Dongen, Joost, "Interior Mapping - A new technique for rendering realistic buildings." In *Computer Graphics International Conference (CGI)*. 2008.

<http://student-kmt.hku.nl/~joost1/Oogst3D/index.php?file=CODING/InteriorMapping/InteriorMapping.txt>

Donnelly, Willaim. "Per-Pixel Displacement Mapping with Distance Functions" in Fernando, Randima (editor) *GPU Gems 2*, Addison Wesley, 2005.

http://download.nvidia.com/developer/GPU_Gems_2/GPU_Gems2_ch08.pdf

Policarpo, F' {a}bio and Oliveira, Manuel M. and Comba, Jo\, {a}o L. D., "Real-time relief mapping on arbitrary polygonal surfaces." In *SIGGRAPH '05: ACM SIGGRAPH 2005 Papers* , pages 935--935. ACM, 2005. <http://www.inf.ufrgs.br/~oliveira/RTM.html>

Week 9 (March 9th, 2010)

Lecture slides (<http://people.freedesktop.org/~idr/2010Q1-VGP352/20100309 - Beyond normal maps.pdf>)

Lecture topics:

- Interior mapping
- Parallax textures
- Displacement mapping

Homework assignments:

- Read to prepare for next week:

Fabio Policarpo, Francisco Fonseca, Deferred shading tutorial. Pontifical Catholic University of Rio de Janeiro. 2005. http://www710.univ-lyon1.fr/~jciehl/Public/educ/GAMA/2007/Deferred_Shading_Tutorial_SBGAMES2005.pdf

Benjamin Segovia and Jean-Claude Iehl and Bernard PÃ©roche, "Non-interleaved Deferred Shading of Interleaved Sample Patterns." In *Eurographics/SIGGRAPH Workshop on Graphics Hardware '06*, pages 53--60. 2006. <http://liris.cnrs.fr/publis/?id=2476>

Week 10 (March 16th, 2010)

Lecture slides (<http://people.freedesktop.org/~idr/2010Q1-VGP352/20100316 - Deferred Shading.pdf>)

In-class notes (http://people.freedesktop.org/~idr/2010Q1-VGP352/20100316_class_notes.pdf)

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

Lecture topics:

- Multiple render targets
- Deferred shading
- Real-time global illumination

Week 11 (March 23rd, 2010)

FINAL EXAM - 5:30PM - 7:30PM.**DO NOT BE LATE TODAY!**