

Computer Graphics Programming II



The Art Institute of PortlandSM

Course Description

VGP352A

Fall 2010, 3 credits

Wednesday, 6:00PM - 9:45PM

Final exam: Wednesday, December 15th, 2010 at 5:30PM

Room #214

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/2010Q4-VGP352/>). The syllabus is available as both HTML and PDF (http://people.freedesktop.org/~idr/2010Q4-VGP352/FA10_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 | = | 95% and above | C+ | = | 77%-79% |
| A- | = | 90%-94% | C | = | 73%-76% |
| B+ | = | 87%-89% | C- | = | 70%-72% |
| B | = | 83%-86% | D+ | = | 67%-69% |
| B- | = | 80%-82% | D | = | 62%-66% |
| | | | F | = | Below 62% |

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 Policy

Plagiarism, presenting the writings, images or paraphrased ideas of another as one's 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 the Dean of Student Services, Jason Clary, at 503-382-4710 or jclary@aii.edu.

Attendance Policy for the Art Institute of Portland

Students who are absent from all scheduled classes over a 14-day period (2 weeks) are subject to automatic attendance suspension -- from the Institute, not just from this course. This means the student is administratively withdrawn from all courses and cannot attend classes or continue in the current quarter unless he/she successfully appeals for reinstatement. Students who anticipate violating the attendance policy should contact their Academic Advisor or Academic Department Director immediately to discuss options such as withdrawing from the Institute or navigating the appeals process.

Adding, Dropping and Withdrawing From Courses

Schedule Adjustment period: The schedule adjustment period runs through the first week of the quarter (ending at 5 pm on Monday of Week 2). To add or drop a course, the student must complete a schedule adjustment form, available from the Registrar's Office. The signature of the student's academic advisor is required to make any changes to the student's schedule.

Withdrawal (W/WF): The student who withdraws from a course or from the program during the first nine weeks of the quarter will be assigned a "W" code for each course. The "W" code is not used in computation of the student's grade point average; however, "W" credits are counted toward total credits attempted. The student who withdraws from a course or from the program after the ninth week of the quarter will be assigned a "WF" code for each course. The "WF" code is the equivalent of a grade of "F" and is used in computing the student's grade point average. Students wishing to withdraw from The Art Institute of Portland must file an official status change form with the Registrar.

Evacuation Procedures

Please proceed to the nearest exit when the strobe lights flash and an audible alarm occurs. AiPD's evacuation location is 10th and Davis; wait there for further instructions. **ALWAYS ASSUME ANY EVACUATION IS REAL!**

Tutoring

Free, one-on-one tutoring is available to you across all subjects through the Tutoring Center. The goal of tutoring is to help you learn and master skills so you can then confidently apply them on your own. Tutoring is helpful for students at all levels -- freshman through senior, whether you want to move from a failing to a passing grade or whether you want to cement an "A." Our tutors are faculty or, most often, fellow students who have excelled in the subject. You may find a tutor by visiting aidepartments.com or dropping by the Tutoring Center in Room 328 inside the Education Department. The Director of the Tutoring Center is Sara Cartmel, whom you are welcome to contact at 503-382-4811 or scartmel@aii.edu.

Campus Email Policy

Email communication will be through eCompanion. Be sure to check your Profile in eCompanion to update your email address so that you will receive course communications in a timely manner.

Absences Policy

Regular attendance is required for successful completion of this course. A student who misses the equivalent of three (3) classes will not pass this class. Exceptions for extenuating circumstances will be considered at the discretion of the instructor.

Course Calendar

Week 1 (October 6th, 2010)

Lecture slides

(http://people.freedesktop.org/~idr/2010Q4-VGP352/20101006-Curves_and_per-fragment_lighting.pdf)

Lecture topics:

- Course road-map
- Reading technical papers
- Curves
- Curved Surfaces
- Per-fragment lighting recap
 - Phong shading
 - Surface-space
- Bump mapping / Normal mapping
 - Basic usage

- Normal map storage

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).

- Read to prepare for next week:

Toksvig, Michael, Mipmapping Normal Maps. NVIDIA. April 2004.

http://developer.nvidia.com/object/mipmapping_normal_maps.html

- Programming assignment #1 (20101006_Assignment.pdf). Due 10/13.

Week 2 (October 13th, 2010)

Lecture slides (http://people.freedesktop.org/~idr/2010Q4-VGP352/20101013-Procedural_texturing.pdf)

Lecture topics:

- 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 sections 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.

- Read to prepare for next week:

Wloka, Matthias, Fresnel Reflection. NVIDIA. July 2002.

http://developer.nvidia.com/object/fresnel_wp.html

Week 3 (October 20th, 2010)

Lecture slides (http://people.freedesktop.org/~idr/2010Q4-VGP352/20101020-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:

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 much 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/>

- Programming assignment #2 (20101020_Assignment.pdf). Due 11/3.

Week 4 (October 27nd, 2010)

Lecture slides (http://people.freedesktop.org/~idr/2010Q4-VGP352/20101027-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 Premo\{z}e, 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>

Week 5 (November 3rd, 2010)

Lecture slides (http://people.freedesktop.org/~idr/2010Q4-VGP352/20101103-BRDFs_part_2.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.danbgoldman.com/misc/fakefur/fakefur.pdf>

Week 6 (November 10th, 2010)

Lecture slides (http://people.freedesktop.org/~idr/2010Q4-VGP352/20101110-BRDFs_part_3.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:

Bruce Gooch and Peter-Pike J. Sloan and Amy Gooch and Peter S. Shirley and Rich Riesenfeld, "Interactive Technical Illustration." In *1999 ACM Symposium on Interactive 3D Graphics* , pages 31--38. 1999.
<http://www.thegooch.org/Publications.php>

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>

Week 7 (November 17rd, 2010)

Lecture slides

(http://people.freedesktop.org/~idr/2010Q4-VGP352/20101117-Nonphotorealistic_Rendering.pdf)

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

Lecture topics:

- Non-photorealistic rendering
 - Cel (toon) shading
 - Silhouette edge rendering
 - Technical illustration

Homework assignments:

- Read to prepare for next week:

Guennadi Rieger, 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/media/gpu_assets/ShaderX2_Real-TimeDepthOfFieldSimulation.pdf

Week 8 (November 24th, 2010)

Lecture slides (http://people.freedesktop.org/~idr/2010Q4-VGP352/20101124-Image_processing.pdf)

Lecture topics:

- Texture rectangles (briefly)
- Post-processing
 - Full-screen post-processing overview
 - General image filters
 - Edge detection filters
 - Separable filters
 - Special effects:
 - Water ripple
 - Depth-of-field

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, Fábio and Oliveira, Manuel M. and Comba, João 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>

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

Week 9 (December 1st, 2010)

Lecture slides

(http://people.freedesktop.org/~idr/2010Q4-VGP352/20101201-Beyond_normal_maps.pdf)

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

Lecture topics:

- Interior mapping
- Parallax textures
- Displacement mapping

Homework assignments:

- Read to prepare for next 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

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

Week 10 (December 8th, 2010)

Lecture slides (http://people.freedesktop.org/~idr/2010Q4-VGP352/20101208-Deferred_Shading.pdf)

Lecture topics:

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

Week 11 (December 15th, 2010)

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