Course Description  We focus on the theory and practice behind the generation and manipulation of digital images within a computer graphics context. Topics include image representation and storage, sampling and reconstruction, color systems, affine and general warps, enhancement and morphology, compositing, morphing, and non-photorealistic transformations.

Digital images have the advantages, over any other form of image, of lossless storage, transmission, and retrieval. Their form enables generation, manipulation, and display within a computing environment, and they provide a natural syntax for image representation that pervades the world of computer graphics and visualization. An understanding of their nature and technology is essential to anyone who will be making use of digital images in their academic or professional career.

Prerequisites  CP SC 212 and MTHSC 311, or DPA 401, or permission of instructor.

Course Objectives  This course will provide a thorough grounding in the state of the art in the treatment of digital images, particularly within the context of computer graphics, and digital effects. It is designed to prepare students to:

• understand existing systems for storage, display, transformation and manipulation of digital images;
• write their own software for working with digital images; and
• undertake creative work and research involving digital images.

Students read, discuss, and are tested on hand-out material, and complete a series of exercises on the computer. Most of the exercises involve programming and making use of graphics libraries.

Programming Labs  Most homework labs involve programming in C++ and require the use of OpenImageIO. Work may be done on any computer supporting C++ and the necessary libraries. However, before turning in an assignment, the program must be compiled and tested under the School of Computing’s Ubuntu Linux environment, and both a working compile script (Makefile, CMakeLists.txt, etc.) and README must be provided.

In order to turn in programming labs, all students will need to use their computer science account and the handin system: https://handin.cs.clemson.edu. All students enrolled in CS courses should automatically be assigned CS accounts. You will need to login early in the semester to change your password, or the account may be expired. If you have problems logging in, send an email to ithelp@cs.clemson.edu from your Clemson email account, or stop by on the first floor McAdams with a picture ID. More information here: http://www.cs.clemson.edu/help/.
Required Text and Handout Materials

- Gritz, OpenImageIO 1.5 Programmer Documentation, found here: https://sites.google.com/site/openimageio/home
- Other handouts, research papers, and materials linked to on the course webpage: http://people.cs.clemson.edu/~levinej/courses/6040

Additional Reference Reading Material The first two, especially, are informative references that we will use supplementary material from at various points in the course.

Content

Course Outline

I. Fundamentals of Digital Images
   • image processing pipeline and the basics of sampling, point spread, and reconstruction

II. Optics and Vision
   • the human visual system, color spaces, perception, acquisition, display

III. Digital Representation and Storage
   • bitmaps and pixmaps, color lookup tables, image file formats, high-dynamic range, deep images, conversion between formats, compression schemes both lossy and lossless

IV. Point Processing Techniques
   • gamma correction, color manipulation techniques, histogram equalization, image arithmetic

V. Compositing
   • alpha channel and opacity, image combination operations, blue-/green-screening, deep images

VI. Regional Processing and Filtering Algorithms
   • convolution filters, morphological operators, edge enhancement

VII. High Dynamic Range Imaging
   • HDR data formats and compression, HDR image acquisition, tone mapping

VIII. Image Warping
   • general image maps, forward warp, inverse warp, affine warps, projective warps, bilinear warp, feature-based warping, morphing

IX. Advanced Sampling, Filtering, and Reconstruction
   • sampling and the aliasing problem, spatial convolution filtering techniques, resampling and the reconstruction problem, reconstruction techniques

X. Frequency Domain Representation
   • image frequency, ideal filtering, DCTs, DFTs, wavelets

XI. Advanced Topics (time permitting)
   • image repair, motion blur correction, image stitching and panoramas, optical flow, etc.
Performance Evaluation

Grades will be assigned based on the following scale. There is no curving; CPSC 4040/6040 is not a competition:
- A ≥ 90%
- B ≥ 80%
- C ≥ 70%
- D ≥ 60% (4040 students only)
- F < 60% (F < 70% for 6040 students)

Undergraduate (4040) students Grading will be based on performance on the set of programming labs, quizzes, the final project, class participation, and the final exam using the following percentage distribution:
- Programming Labs: 40%
- Quizzes: 30%
- Final Project: 10%
- Class Participation: 10%
- Final Exam: 10%

Graduate (6040) students Each programming lab will include an extension involving advanced concepts. Completion of all regular requirements and this extension, on each assignment, is required for graduate students. Grading will be based on performance on the set of programming labs, advanced lab extensions, quizzes, the final project, class participation, and the final exam, using the following percentage distribution:
- Programming Labs: 24%
- Advanced Lab Extensions: 16%
- Quizzes: 30%
- Final Project: 10%
- Class Participation: 10%
- Final Exam: 10%

Programming Labs All programming labs and the class final project will involve developing computer graphics software in C++, using OpenImageIO and occasionally the OpenGL and GLUT API's.

Homework problems and extensions will be graded using a 10 point scale, based on requirements outlined in each individual assignment. Graduate (6040) students’ lab grades will be based on a 6 point scale for completing the same requirements as 4040 students. Weighting for the 4 additional points will be described in the assignment description.

To be on time, work must be submitted by midnight of the due date. A late penalty of 1/2 point will be applied for each of the first seven days that a lab is late. No lab will be accepted beyond seven days from the due date.

In general, to receive full points on an assignment it must have achieved both correctness and clarity. Correctness means that assignment completes all tasks set out to do and is bug free. Clarity means the code is designed with elegance, simplicity, readability, and extensibility in mind.
Documenting your code both with comments and a README file is a necessity, not an option. This criterion tacitly requires that you submit code which is tested and compiles, if it does not, it will receive an automatic zero.

The total programming lab average will be computed by averaging the student’s lab scores.

**Quizzes** Each quiz will have two questions and will be take home. Quizzes must be submitted by the start of class on the due date, and the class will begin by a discussion of the quiz problems. No quizzes will be accepted after the start of class on the due date. Quizzes will be graded as follows:

- 4—Both questions answered correctly.
- 3—One question answered correctly, one question partially correct.
- 2—One questions answered correctly, or both questions partially correct.
- 1—One question partially correct.
- 0—Not a reasonable effort or not submitted.

The total quiz average will be computed by averaging the student’s quiz scores, excluding the two worst quizzes.

**Final Projects** The class project will be graded on a 100 point scale, and will be based on the instructor’s judgement. Grading will include: difficulty level, successful completion, code organization, and presentation quality. A late penalty of 5 points will be applied for each of the first seven days that the project is late. No project will be accepted beyond seven days from the due date.

**Class Participation** The class participation grade is the instructor’s subjective judgement of the student’s contribution to a lively classroom atmosphere. He will consider mainly active, informed participation in classroom discussions, quiz and homework reviews. Obviously, students not attending class are not contributing in this way.

**Final Examination** Students maintaining an “A” average on programming labs and quizzes may elect to waive the final examination. In that case, the grade will be the weighted average of the remaining 90 points. Note that, due to scheduling with regards to the final project presentations and grading, electing to not take the exam may not guarantee you an “A” grade in the course (in rare cases where performance on the final project and/or participation is low). The instructor will put in his best effort to inform students of their individual grade situations in a timely manner.

The exam will be comprehensive. It will consist of ten short answer and two essay style questions. Short answers will require at most a short paragraph, code segment, and/or a figure to answer. Essay questions will require at most two pages, including accompanying figures, to answer.
**Policies**

**Late Instructor** Your instructor will make every effort to be in class on time, or to inform you of any delay or cancellation. In the unusual event that he should not arrive in class or send word by 15 minutes from the class start time, the class is officially cancelled.

**Attendance** Optional, but note that a percentage of the grade is based on class participation.

**Collaboration Yes, Plagiarism No** In this course, we want to encourage collaboration and the free interchange of ideas among students and in particular the discussion of homework and quiz problems, approaches to solving them, etc. However, we do not allow plagiarism, which, as commonly defined, consists of passing off as one’s own ideas, words, writings, etc., which belong to another. In accordance with this definition, you are committing plagiarism if you copy the work of another person and turn it in as your own, even if you should have the permission of that person. Plagiarism is one of the worst academic sins, for the plagiarist destroys the trust among colleagues without which research cannot be safely communicated.

Plagiarism also applies to using work and materials from those outside of the class. The same rules apply whether you are asking a friend, unknown student who is not in the class, or another student in this course. If your work includes a significant contribution from someone else, you should also credit sources (as is good scholarly conduct). You will never be penalized for crediting others for their ideas, provided they did not do the work for you.

With respect to coding, having lengthy discussions with others is encouraged. However, directly sharing code, either electronically or in written form, is considered plagiarism and will be reported to the university in accordance with academic integrity policies (see below). The instructor reserves the right to adjust your grade accordingly (both for the assignment in question as well as the final course grade).

**Copyright** Materials in this course are copyrighted. They are intended for use only by students registered and enrolled in this course and only for instructional activities associated with and for the duration of the course. They may not be retained in another medium or disseminated further. They are provided in compliance with the provisions of the Teach Act. Students should refer to the Use of Copyrighted Materials and “Fair Use Guidelines” policy on the Clemson University website. Additional information is detailed at [http://libguides.clemson.edu/copyright/](http://libguides.clemson.edu/copyright/).

**Disability Access** It is university policy to provide, on a flexible and individualized basis, reasonable accommodations to students who have disabilities. Students with disabilities requesting accommodations should make an appointment with Dr. Arlene Stewart (656-6848), Director of Disability Services, to discuss specific needs within the first month of classes. Students should present a Faculty Accommodation Letter from Student Disability Services when they meet with instructors. Accommodations are not retroactive and new Faculty Accommodation Letters must be presented each semester.

Students are encouraged to contact Student Disability Services, Suite 239 in the Academic Success Center, 656-6848, to discuss their individual needs for accommodation. Accommodations are individualized, flexible, and confidential and are based on the nature of the disability and the academic environment, in compliance with Section 504 of the Rehabilitation Act of 1973 and the Americans with Disabilities Act of 1990. Details on policies and procedures are available at [http://www.clemson.edu/sds/](http://www.clemson.edu/sds/).
Title IX (Sexual Harassment)  Clemson University is committed to a policy of equal opportunity for all persons and does not discriminate on the basis of race, color, religion, sex, sexual orientation, gender, pregnancy, national origin, age, disability, veteran’s status, genetic information or protected activity (e.g., opposition to prohibited discrimination or participation in any complaint process, etc.) in employment, educational programs and activities, admissions and financial aid. This includes a prohibition against sexual harassment and sexual violence as mandated by Title IX of the Education Amendments of 1972. The policy is located at http://www.clemson.edu/campus-life/campus-services/access/non-discrimination-policy.html and http://www.clemson.edu/campus-life/campus-services/access/title-ix/. Mr. Jerry Knighton is the Clemson University Title IX Coordinator. He also is the Director of Access and Equity. His office is located at 111 Holtzendorff Hall, and he may be reached at knightl@clemson.edu, 864.656.3181 (voice), or 864.565.0899 (TDD).

Academic Integrity  As members of the Clemson University community, we have inherited Thomas Green Clemson’s vision of this institution as a “high seminary of learning.” Fundamental to this vision is a mutual commitment to truthfulness, honor, and responsibility, without which we cannot earn the trust and respect of others. Furthermore, we recognize that academic dishonesty detracts from the value of a Clemson degree. Therefore, we shall not tolerate lying, cheating, or stealing in any form. In instances where academic standards may have been compromised, Clemson University has a responsibility to respond appropriately to charges of violations of academic integrity.

Refer to the graduate academic integrity policy at http://gradspace.editme.com/AcademicGrievancePolicyandProcedures#integritypolicy. Each graduate student should read this policy annually to be apprised of this critical information.