Mentor/Apprentice Approach in the Course

The class will have students at two levels: mentors and apprentices. The mentors will help the apprentices to understand basic digital image processing applications and digital image concepts, guiding the apprentices through a series of exercises and helping them plan and execute their final creative projects. The final creative project will involve imaginative editing of a digital image. Apprentices will use tools at a high level of abstraction and will learn how these tools work mathematically and algorithmically. Mentors will creatively alter digital images with C++ programs that they will write themselves.

Course Content

In this section, students will be exposed to the workings of digital cameras and digital image processing software. They will understand the components of digital images and how these images are edited. A series of exercises will introduce basic concepts and skills. Students will also explore the mathematics and algorithms underlying digital cameras and image processing software. Each student will do his or her own final creative project. No background knowledge or prior experience are required for apprentice students.

Course Emphases: logical, algorithmic, and mathematical problem-solving in the realm of digital image processing; interdisciplinary thinking and creativity

Demonstrable Outcomes

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

- Explain and put into practice basic concepts of digital image processing, including analog vs. digital, pixels, pixel dimensions, resolution, ppi, image file compression, and file types.
- Take digital photographs with proper use of lenses, white balance, apertures, shutter speeds, ISO, etc.
- Edit digital photographs purposefully using tools and features such as the paint dropper, paint bucket, and clone tools
selection tools such as freehand, magic wand, and marquee selection
- eraser
- layers and blending modes
- convolution filters

✓ (Apprentices) Explain the mathematics and algorithms behind contrast and brightness settings, convolution filters, and blending modes.
✓ (Mentors) Apply the mathematics and algorithms behind contrast and brightness settings, convolution filters, and blending modes in C++ programs that they write themselves.

Mentor’s Role
The mentors must already have taken at least one computer programming course. The mentors’ role is to help the apprentices learn how to use digital cameras and high-level image processing software, help them to understand the mathematics and algorithms underlying of digital image processing, and introduce them to ways that digital images can be produced and edited digitally. Mentors will have the additional challenge of working at a lower level of abstraction, manipulating digital images with C++ programs that they write themselves.

Basis for grade
All students will receive a grade of pass (P) or fail (F).

Apprentices
- final creative project
- three short quizzes
- two oral presentations (about 5-7 minutes per presentation)
- level of engagement in the course (attendance, participation, completion of exercises)

Mentors
- final creative project
- mentoring of apprentices (helping them learn software tools as well the underlying mathematics and computer science concepts & helping them prepare for presentations)
- level of engagement in the course (attendance, participation, explanation of exercises)
Course Projects and Overall Approach in this Course

Working at Two Levels of Abstraction – Digital Imaging Processing Software and the Underlying Computer Science and Mathematics

The overarching goal of the STEM Incubator courses is to introduce you to topics within science, technology, engineering, and mathematics in an interesting, engaging, and non-threatening way. To accomplish this goal, the mentors will introduce the apprentices to concepts from mathematics and computer science as they relate to digital image processing.

The main course project for the apprentices will be a digital image that is creatively-edited with digital image processing software – in particular, GIMP or Corel PaintShop Pro.

The main course project for the mentors will be a digital image that is creatively-edited by computer programs that the mentors write themselves, mimicking the editing functions of GIMP or Corel PaintShop Pro.

As the apprentices learn how to use digital editing software from a high-level of abstraction, the mentors will also introduce them to the underlying mathematics and computer programs that make this software work. By the end of the semester, the apprentices should have some understanding of these basic terms related to computer science and digital media:

The apprentices will have three short quizzes during the semester on the material specified in the chart below. Consider the list your study sheet. We won’t be giving you a list of definitions to memorize. We would like you to gain an understanding of these terms through the exercises that your mentors go over with you, along with your hands-on work.

We hope you won’t let this list scare you away! Our goal is to make this learning experience fun and engaging as you work together on your creative projects.
### Quiz 1
- Difference between analog and digital
- How images are represented digitally so that they can be stored and manipulated in a computer
- Pixels
- Pixel dimensions
- Physical image size (in print and on computer screen)
- Image file size
- Image file types and compression
- Camera settings: aperture, shutter speed, ISO, white balance, focal length

### Quiz 2
- Histograms
- Curves
- Convolutions

### Quiz 3
- Algorithms
- Variables
- Expressions
- Assignment statements
- Data types for representing integers, real numbers, and lists
- Conditional statements
- Iterative statements

The next pages tell more about the respective final projects for apprentices and mentors.
Course Projects – Creative Imaging Processing

The Apprentices’ Assignment
You will work on your course project incrementally as the semester progresses. This overview will help you plan and develop your project as you learn more concepts and skills related to image processing. In general, your assignment is to take a picture with a digital camera, process it creatively with digital imaging software, and deliver it to its intended destination. You may decide that your final product is to be displayed on the Web, printed in a hard copy, or both. The size of your picture and the manner in which you edit it depend on the picture’s purpose. The first three steps are these:

1. Decide on the purpose and destination of your picture.
   Is it to be given to someone? If so, to whom and for what purpose? Will it be ...
   - a card of some kind?
   - a framed work?
   - a picture to be displayed on the Web?
   - an advertisement?
   - a poster?
   - something else?

2. Decide on an artistic vision or motivation for your picture.
   Are you ...
   - expressing an emotion or mood?
   - conveying a message?
   - telling a story?
   - illustrating a poem, song, or story?
   - experimenting with artistic forms, composition, or color?
   - recreating a dream image you’ve had?
   - something else?

3. Edit your picture to achieve your goals using digital imaging processing software.
   This third step is the one that you’ll work on all semester. It will entail that you learn how to use the digital imaging processing software (GIMP or Paintshop Pro) and that you make appropriate choices as you do the following:
   - choose a subject for the picture
   - choose appropriate camera settings
     - pixel dimensions
     - file type (and implicitly amount of image compression)
     - white balance, ISO, aperture, shutter speed, focus, etc.
   - use the digital image processing software that you’re learning about, including
     - paint dropper, paint bucket, and clone tool
     - selection tools
     - layers
We’ll focus especially on convolution filters, blending modes, and tools for brightness and contrast. You are required to use convolution filters in your project, as this is one of the main points of emphasis in the course. Use of a convolution filter is illustrated in Figure 1.

You should also use one or both of the following two category of tools:
- brightness and contrast controls, which include histograms and color levels or contrast adjustments (Figure 3) and the curves tool (Figure 3);
- blending modes (Figure 4).
Your grade on this project will be based on how much you learn and experiment with your tools, how appropriate your choices are with regard to your original creative goals, and how nicely your final picture turns out.

The mentors will help you learn about digital photography and image processing software over the course of the semester. Each week we’ll cover a different topic and give you some practice. It’s up to you to apply what you’re learning to the final course project as the semester progresses.

The Mentors’ Assignment

In general, your assignment is the same as the assignment for the apprentices, except that you’ll process your pictures with “hand-written” C++ programs. You should have at least three programs to experiment with including …

✓ one for convolution
✓ one for contrast
✓ one for blending modes
The instructor will help you with this programming, so it shouldn’t be too time-consuming. As you work on these programs, you’ll explain to the apprentices how the programs work mathematically and algorithmically.

**Note:** Mentors, your programs need to be up and running by Week 13 (November 19). The exercise that week will involve experimenting with your programs.

The mentors and apprentices will put their heads together, experimenting with the mathematics of things like histograms, the curve tools, convolutions, and blending modes.

The idea is to try to understand how the tools work – the relationship between the setting of the parameters and the results you get. You can try to imagine a particular effect that you want to create on your picture, and see if you can make the right settings to get that effect. You can also simply experiment and see what you get by serendipity, and then try to understand why those particular settings give the results that they do.

Your grade on this project will be based on how much you learn and experiment with your tools, how well you understand and explain the mathematics and algorithms, and how well you master these algorithms to achieve particular effects.