# Image Processing

## EECE/CS 253 Fall 2010

## Professor Alan Peters

**Class meets:** Tu&Th 14:35-15:50 in Featheringill Hall, Room 244.

**Labs meet:** There are no formal lab meetings, since all the labs can be done using Matlab on a PC. However, the teaching assistant will be available in one of the ECE labs (FGH 201 or FGH 203) for some hours each week, if you want assistance while working on a lab assignment.

**Prof. Peters:** Office – 332 Featheringill Hall; 322-7924; `Alan.Peters@Vanderbilt.edu`

**Office Hours:** Tu&Th 12:00-14:00 (subject to change), drop in, or by appointment.

**Teaching Assistant:** Ankur Kumar
Office – 367 Featheringill Hall; 732-887-6324; `ankur.kumar@vanderbilt.edu`

**Some Recommended Textbooks:**

The course is taught from notes that will be posted on oak. There will be no direct references to particular textbooks. However, I highly recommend having a textbook for reference. Any of the following would be fine. Alternatively search Amazon books for "Image Processing" to get a list of about 9000.

- K. R. Castleman, *Digital Image Processing*, Prentice Hall, Englewood Cliffs, NJ, 1996, ISBN: 0 – 13 – 211467 – 4.
- R. C. Gonzalez and R. E. Woods, *Digital Image Processing, 3rd ed*, Pearson Prentice-Hall, 2008, ISBN: 0 – 20 – 168728 – 8.*
- R. C. Gonzalez, R. E. Woods, and S. L. Edins, *Digital Image Processing with MATLAB*, Pearson Prentice-Hall, 2004, ISBN: 0 – 13 – 008519 – 7.
- H. R. Myler and A. R. Weeks, Jr., *The Pocket Handbook of Image Processing Algorithms in C*, Prentice Hall, ISBN: 0 – 13 – 642240 – 3.
- M. Petrou and P. Bosdogianni, *Image Processing : The Fundamentals*, John Wiley & Sons, Chichester, UK 1999, ISBN: 0 – 47 – 199883 – 4.
- J. C. Russ, *The Image Processing Handbook*, 2nd ed. CRC Press, Boca Raton, FL, 1994, ISBN: 0 – 84 – 932516 – 1.
- M. Seul, L. O'Gorman, and M. J. Sammon, *Practical Algorithms for Image Analysis: Descriptions, Examples, and Code* Cambridge University Press, Cambridge, UK, 2000, ISBN: 0 – 52 – 166065 – 3.
- A. R. Weeks, Jr., *Fundamentals of Electronic Image Processing*, SPIE/IEEE Series on Imaging Science and Engineering, E R. Dougherty, Ed., SPIE Press and the IEEE Press, ISBN: 0 – 81 – 942149 – 9.

(* available in bookstore.)

**Goals:**

This introductory class in image processing should give the student a working knowledge of the most commonly used methods and procedures for image enhancement and restoration. The emphasis of the class will be on practical results: given an image and a goal for its processing (*e.g.*, feature enhancement, color correction, sharpening, warping, etc.) the student should be able to select and implement an appropriate procedure to achieve that goal. Good practical results often depend on an understanding of the mathematics behind the procedures as well as the ability to write software to implement the mathematics. Thus, there will be significant mathematical and computational components to the class. In the past, most students have spent most of their time associated with this class either writing and debugging computer programs or writing the lab reports. The ability to explain results in writing is essential for a successful engineer. Therefore, the writing of lab reports will be done in the style of archival journal papers. The writing component of the class is very important.

The course is available for both undergraduate and graduate credit. *Those students who are taking 253 as a graduate course will have additional problems to solve in each lab assignment.* These problems will be marked as such in the lab assignment instructions.

**Prerequisites:** Recommended but not required: An introductory course in digital signal processing (such as EECE 214 or EECE 252), a basic understanding of the Fourier Transform, and proficiency in writing computer programs (in C, C++, Matlab, or Mathematica. Matlab will be used in the class and the labs).

**Exams, Homework, and Grading:** Your knowledge of the material will be assessed by your performance on 8 laboratory assignments. Unless an exception is stated explicitly within the instructions, you are to work *alone* on all these. You can obtain help on the mechanics of the programming language that you decide to use. But all writing, programming, logical implementations, and experiments must be exclusively your own work. You may, of course, receive assistance from Prof. Peters or the Teaching Assistant.

**Laboratories:** The labs in this image processing course are a bit different from those of most other courses. For each lab you will be given a set of image processing tasks to perform. These will require you to write computer programs to do the processing. You will be required to perform a set of experiments on various images and then to document the results in a written report. An example report is posted on the Oak/Blackboard web site for this course. The report will be in the form of a standard technical paper. The report can be prepared in any word processor you like. I will accept only electronic versions of your reports (no paper). You may submit the report to me electronically via OAK/BlackBoard or on a CD-ROM or a zip disk.

**Expected Outcomes:** EECE/CS 253 is an integral part of the EE & CS curricula, for those students who take it. Therefore, its has been designed to support the outcomes specified by the Accreditation Board for Engineering Teaching (ABET). In particular, the course has been design to support a students acquisition of the following ABET outcome requirements:

(a) an ability to apply knowledge of mathematics, science, and engineering,
(b) an ability to design and conduct experiments, as well as to analyze and interpret data,
(e) an ability to identify, formulate, and solve engineering problems,
(g) an ability to communicate effectively,
(j) a knowledge of contemporary issues, and
(k) an ability to use the techniques, skills, tools necessary for engineering practice.

In particular, the course presents probability and statistics in the context of image analysis and enhancement. It applies differential and integral calculus via Fourier analysis, convolution, filtering, sampling, noise reduction, etc., all of which a student implements in software programs for image processing of his/her own design. Many of the techniques taught and used in the course involve differential equations (in the form of difference equations), linear algebra, and discrete mathematics.

**Disabilities:** The Vanderbilt University School of Engineering is committed to equal opportunity for students with disabilities. If you have a disability, you should ask the Opportunity Development Center to assist you in identifying yourself to the professor, so that the professor and the School of Engineering may provide you with appropriate accommodations. Absent notification, the professor will assume that you have no disabilities that will affect your performance in this class or that you seek no accommodation for such.

**Emergency Evacuation Plans:** In the event of a fire or other emergency, the occupants of the class room should leave the building through the nearest exit. The class should assemble at a safe distance from the building at a location indicated by the professor. Please note that VU policy forbids reentry, without authorization from VU Security, into a building in which an alarm has occurred. If you anticipate the need for assistance, please discuss that need with the professor.

EECE 253 Image Processing

Fall 2010 Topics

1. Introduction
   (a) Course requirements
   (b) Evaluation
   (c) Overview of course
   (d) Image formation
   (e) Basic Matlab procedures for image processing (IP)

   Laboratory Assignment 1: Introduction to image processing and Matlab (Due 9 September 2010)

2. Image Enhancement by Point Operations
   (a) An overview of point processing
   (b) Constant and nonlinear operations
   (c) Histogram techniques
   (d) Operations between images

   Laboratory Assignment 2: Point processing (Due 23 September 2010)

3. Color Correction
   (a) Color spaces
   (b) Color vector space operations
   (c) Linear transformation of color
   (d) Color correction

   Laboratory Assignment 3: Color correction (Due 07 October 2010)

4. The 2-D Fourier Transform and Convolution
   (a) The Fourier transform and its properties
   (b) Computation of the discrete Fourier transform
   (c) Spatial convolution
   (d) The convolution theorem

5. Linear Spatial Filtering
   (a) Blurring and sharpening
   (b) Space domain spatial filtering
   (c) Frequency domain spatial Filtering
   (d) Edge detection

   Laboratory Assignment 4: The Fourier transform, convolution, and spatial filtering (Due 21 October 2010)

6. Image Sampling, Warping, and Stitching
    (a) Pixelization and aliasing
    (b) Backward mapping and interpolation
    (c) Image resizing
    (d) Image rotation
    (e) Image warping
    (f) Image stitching (panorama creation)

   Laboratory Assignment 5: Image sampling, warping, and stitching (Due 4 November 2010)

7. Noise Reduction
    (a) Noise in images
    (b) Linear noise reduction, the Wiener filter
    (c) Frequency selective filtering
    (d) Halftone distortion
    (e) Median filters

   Laboratory Assignment 6: Noise reduction (Due 18 November 2010)

8. Nonlinear Image Processing Techniques
    (a) Binary morphological filters
    (b) Grayscale morphology
    (c) Morphological quantitative analysis
    (d) Morphological feature enhancement

   Laboratory Assignment 7: Image processing with mathematical morphology (Due 2 December 2010)

9. High Dynamic Range (HDR) Imaging
    (a) Dynamic Range (Visual vs. Photographic)
    (b) Bracketed images
    (c) Combination techniques

   Laboratory Assignment 8: High Dynamic Range Imaging (Due 16 December 2010)

10. Image Compression
    (a) Data compression fundamentals
    (b) Error-free compression methods
    (c) Lossy compression methods