EECE 4353/5353 Image Processing Fall 2016

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Electrical Engineering and Computer Science

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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 her office for some hours each week, if you want assistance while working on a lab assignment.

Prof. Peters. Office: 332 Featheringill Hall; 615-322-7924; `Alan.Peters@Vanderbilt.edu`
Office Hours: MWF 14:00-15:00, TTh 16:00-17:00, drop in, or by appointment.

Teaching Assistant, Srijata Chakravorti. Office: 365 Jacobs Hall; 615-322-8478;
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Office Hours: Tu 16:00-18:00, W 15:00-17:00

Some Recommended Textbooks:

The course is taught from notes that will be posted on Blackboard. The complete set of notes from last year can be downloaded from

https://archive.org/details/Lectures_on_Image_Processing.

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.
- R. Szeliski, *Computer vision: algorithms and applications*, Texts in Computer Science Series, D. Gries and F. B. Schneider, Eds. Springer, New York, 2010. ISBN: 978-1-84882-934-3 or 978-1-84882-935-0 and DOI 10.1007/978-1-84882-935-0 (e-book).
  Available for free online at http://szeliski.org/Book/.
- 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, 1996 ISBN: 0-81-942149-9.

Goals:

This introductory class in image processing should give the student a working knowledge of the most commonly used methods and procedures for image analysis, 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 5353, the graduate course, will have additional problems to solve in each lab and homework 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 3214 or EECE 4252), a basic understanding of the Fourier Transform, and experience in writing computer programs (in C, C++, Python, MATLAB , or Mathematica). MATLAB will be used in class and in the lab instructions.

Exams, Homework, and Grading:

Your knowledge of the material will be assessed by your performance on 7 laboratory assignments and 7 homework assignments. The score of each lab and each homework will be normalized to 100 points. The homeworks will count for 20% of your grade and the labs 80%.

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 MATLAB or any other programming language that you decide to use. But **all writing, programming, logical implementations, and experiments must be exclusively your own work.** Any collaboration or plagiarism (*e.g.* copying someone else's report from this year or previous years) is an honor code violation and will be prosecuted. You may, of course, receive assistance from Prof. Peters or the Teaching Assistant.

There are no in-class exams in this course, and there is no final exam. There will be one report due every Tuesday throughout the semester except for 22 November, which is during Thanksgiving break. If a lab is due on a specific Tuesday then a homework will be due the next Tuesday and *vice versa*.

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 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 should submit the report electronically to the assignments section of Blackboard pages for this course. If for some reason you are unable to do so, please contact me to arrange an alternative.

Homeworks

There will be one homework assignment every two weeks alternating with the labs. Homework assignments differ from the labs in that they do not contain as much work as the labs. Also, *Homeworks do not require a formal report.* A homework report can have any format you like – as long as it is electronic. Homework reports will be due every two weeks on Tuesdays at midnight.

Rules for laboratory assignments

1. Perform *all* the tasks listed in the instructions.
2. Explain the tasks you performed in detail.
3. In your report answer in writing all the questions asked in the instructions.
4. Include in the report the original images you used and those resultant images that were specified in the instructions. In general include an image in your report unless told not to in the instructions. (The reports are electronic; it does not matter how large the files are.)
5. *In an appendix:* Include all computer code that you wrote and used, clearly documented.
6. **All work must be yours and yours alone.** Collaboration on the laboratory assignments is forbidden, with the following exceptions:
   (a) You may obtain help on any aspect of the homework from either Prof. Peters or the TA for this course.
   (b) You may obtain technical help on MATLAB from anyone you wish. However *you may not get direct help on the implementation of the specific algorithm* from another person except as noted in (a) above.
   (c) You may get help in obtaining the *input* images for the assignments from anyone you wish.
   (d) You may get help in the formatting, storing, or transmission of your reports, but *not the content*, from anyone you wish.
7. Write the *lab reports* in a classical technical paper form (as shown in the example lab)using MS Word, LaTeX, or any other word processor with which you can embed images in text. **Laboratory reports must be submitted in this format or there will be a significant points penalty (**20%**).** I prefer that the reports be submitted in .pdf format, but that is not absolutely required. Submit your report to me as a file on Blackboard. If for some reason this does not work, please contact me for an an alternative.
8. Name the laboratory report files using the form:

   `EECE_X353_F16_Lab_n_LastName_FirstName.ext`

   where you would replace `X` with 4 or 5 depending on the version in which you enrolled. replace `n` with the number of the lab. Replace `LastName` and `FirstName` with your actual last name and first name. Replace `ext` with `pdf` or `doc`. For example:

   `EECE_4353_F16_Lab_1_Llurbybabbin_Lamoid.pdf`

9. Assignments are due at midnight on the day specified in the instructions or in class. The grade on a laboratory report will be reduced by 10 points (out of 100) for every day (24 hours) that it is late.

Rules for homework assignments

These are identical to the rules for the laboratory assignments with the following exception: *Homework assignments do not have to be submitted in formal technical report format.* The report can have any structure you like as long as the questions are numbered and listed in order and the answers are given below them. Images may be interspersed in the report or included at the end of the report. Any code you write must be included, although it does not have to be in an appendix at the end; it can be listed along with your answers to the questions in the body of the report.
Homework report files should have the form

`EECE_X353_F16_HW_n_LastName_FirstName.ext`

similar to the lab report file name with `Lab` replaced with `HW`.

Late Lab and Homework Report Penalties:

There will be one report due every Tuesday throughout the semester except for 22 November, which is during Thanksgiving break. If the report is due on or before 23:59 on day 0, then for day `n=1:10` the point penalty formula is (in MATLAB):

```
PointPenalty = -(n-1)*10 - round(linspace(1,10,24));
```

I.e. on day n it is $-(n-1)\times 10\ +$

00:00-01:59	-0
02:00-03:59	-1
04:00-06:59	-2
07:00-08:59	-3
09:00-11:59	-4
12:00-14:59	-5
15:00-16:59	-6
17:00-18:59	-7
20:00-21:59	-8
22:00-23:59	-9

Expected Outcomes:

EECE 4353 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 4353/5353 Image Processing

Fall 2016 Topics

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

   Homework Assignment 1: Loading, displaying, and saving images in MATLAB (Due Tuesday 30 August)

   Laboratory Assignment 1: Intro to image processing and MATLAB (Due Tuesday 6 September)

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

   Homework Assignment 2: Point processing (Due Tuesday 13 September)

   Laboratory Assignment 2: Point processing and histograms (Due Tuesday 20 September)

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

   Homework Assignment 3: Color spaces (Due Tuesday 27 October)

   Laboratory Assignment 3: Color correction (Due Tuesday 4 October)

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

   Homework Assignment 4: The Fourier transform (Due Tuesday 11 October)

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

   Laboratory Assignment 4: Convolution and spatial filtering (Due Tuesday 18 October)

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)

   Homework Assignment 5: Image sampling (Due Tuesday 25 October)

   Laboratory Assignment 5: Image warping and stitching (Due Tuesday 1 November)

7. Noise Reduction

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

   Homework Assignment 6: Image Noise processes (Due Tuesday 8 November)

   Laboratory Assignment 6: Image Noise reduction (Due Tuesday 15 November)

8. Nonlinear Image Processing Techniques

   (a) Binary morphological filters
   (b) Grayscale morphology
   (c) Morphological quantitative analysis
   (d) Morphological feature enhancement

   Homework Assignment 7: Mathematical Morphology (Due Tuesday 29 November)

9. High Dynamic Range (HDR) Imaging

   (a) Dynamic Range (Visual vs. Photographic)
   (b) Bracketed images
   (c) Combination techniques

   Laboratory Assignment 7: Nonlinear Image Processing; HDR Images (Due Tuesday 6 December)

10. Image Compression (No related assignments)

    (a) Data compression fundamentals
    (b) Error-free compression methods
    (c) Lossy compression methods

11. Image Segmentation and Compositing (No related assignments)

    (a) Image Thresholding
    (b) Edge, Line, and Point Detection
    (c) Region Based Segmentation
    (d) Image Representation
    (e) Image Compositing