Abstract

This course will introduce the student to practical aspects of advanced digital image processing, using specific applications to demonstrate these principles. The use of modern engineering tools such as MATLAB® to solve image processing problems is emphasized. Other solution approaches (C, C++, Java, FORTRAN, IDL, etc.) will be discussed.

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1 Instructor

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Tue and Thu: 1:00–2:00 PM

2 Course Goals and Objectives

Goal: The goal of this course is for the students to understand digital image processing beyond just the fundamental or introductory level, to choose appropriate image processing algorithms to achieve a desired result, to properly implement such algorithms using modern computing tools such as MATLAB, and to correctly interpret and present the results.

Objectives: Students will be able to

- Explain and demonstrate the limitations and tradeoffs of various of digital image representations such as computed tomography, grayscale versus color, and tools such as wavelet transforms and image compression techniques.
- Display the ability to manipulate both binary and grayscale digital images using morphological filters and operators to achieve a desired result.
- Show how higher-level image concepts such as edge detection, segmentation, representation, and object recognition can be implemented and used.
- Demonstrate the programming skills to correctly implement the chosen algorithm in MATLAB, critically interpret the results, and write up a professional-quality report.
- Demonstrate the ability to communicate technical topics clearly, concisely, and with proper grammar.

3 Course Prerequisites

Satisfactory completion of EE 4530 Introduction to Digital Image Processing or an equivalent introductory image processing course is highly recommended.

The student is expected to be comfortable with foundational topics such as basic linear algebra, Fourier transforms, linear signals and systems (i.e., convolution, correlation, etc.), the sampling theorem, quantization, probability (of a single variable), basic spatial domain image processing, basic frequency domain image processing, and programming in MATLAB. If the student feels “rusty” in any of these areas, it would be wise to review such material on your own early in the semester.
4 Course Grading

4.1 Breakdown of Graded Events

Graded material is given the following weights. Note the Final Exam is scheduled for Tuesday, May 12, 2015 from 10:15 AM–12:15 PM.

<table>
<thead>
<tr>
<th></th>
<th>Weight</th>
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<tbody>
<tr>
<td>Exam 1</td>
<td>20%</td>
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<tr>
<td>Final Exam</td>
<td>30%</td>
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<tr>
<td>Computer Projects</td>
<td>40%</td>
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<tr>
<td>Quizzes, Homework, and/or In-Class Exercises</td>
<td>10%</td>
</tr>
<tr>
<td>Total</td>
<td>100%</td>
</tr>
</tbody>
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4.2 Turn-In Policy

All computer project assignments are due NLT 1600L (for civilians, that means “no later than 4:00 PM local time”) on their respective due dates.

The format for project reports is given on the course web site (in the Admin section). A note on software implementation for the computer projects: The student is not allowed to use the MATLAB Image Processing Toolbox or any other pre-written image processing (IP) software unless specifically authorized by the instructor. Many, many past students would agree that writing the code yourself is the best way to understand the IP algorithms.

The normal turn-in method for a computer project is electronic (as e-mail attachments) and should include both your report file (in PDF format only) and any MATLAB m-files of original software you created for the project.¹ Note that your report’s Appendix must include as a minimum the program listings of all your original m-files used for the project, so the report can be a stand-alone document. Pay attention to the required naming conventions for your files, as given in the project assignment instructions.

Late turn-ins will not be accepted unless an extraordinary situation exists. Unforeseen computer, e-mail, or printer problems do not constitute an extraordinary situation—so plan ahead! Computer projects and homework almost always take longer than you expect...

4.3 Grading Scale

The course will be graded on the following scale, where the student’s overall average in the course, as a percentage, is represented by $x$. No grade “curving” will be used.

<table>
<thead>
<tr>
<th>Grade</th>
<th>Average (%)</th>
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</thead>
<tbody>
<tr>
<td>A</td>
<td>$90 \leq x \leq 100$</td>
</tr>
<tr>
<td>B</td>
<td>$80 \leq x &lt; 90$</td>
</tr>
<tr>
<td>C</td>
<td>$70 \leq x &lt; 80$</td>
</tr>
<tr>
<td>D</td>
<td>$60 \leq x &lt; 70$</td>
</tr>
<tr>
<td>F</td>
<td>$0 \leq x &lt; 60$</td>
</tr>
</tbody>
</table>

¹Be sure to include in the comments any needed explanation about your program, its operation, or potential problems running it.
5 Course Materials and Resources

5.1 Textbook

The primary textbook used for this course, by R. C. Gonzalez and R. E. Woods, is listed as [1] in the reference section of this syllabus. This is the same book used for the prerequisite EE 4530 and it is by far the most popular image processing text in the world. You should use the book (and its companion website) extensively in this course. For some topics, handouts may also be used to supplement the text.

5.2 Web Sites

For this course, we will make frequent use of the course web site located at

https://uwyo.instructure.com/courses/331211

Note: This site is hosted under the WyoCourses system. It is a secure web host for UW students, and you will need to log in with your normal UW student account details. We will mainly use the Files area of the website. A copy of this syllabus, lecture slides, assignments, some example MATLAB code, and other supplemental material will be posted on this web site, organized into subdirectories with self-explanatory names. You are responsible for checking this website regularly.

Another web site you may find very helpful is the textbook companion web site:

http://www.imageprocessingplace.com/

This is a richly populated web site with all the figures in the book, tutorials, links to many other sites, etc. Take advantage of it!

5.3 Software and Other Resources

Each student must become familiar with the following software:

- MATLAB, version 7 (or higher), The MathWorks, Inc.

This software is available in the ESIG Labs (EN 1034, 1039 and 1041) and in the ECE Department Student Computing Lab (EN 5038). Note that there are significant price reductions on MATLAB and its Toolboxes for student purchasers if you wish to work at home.

6 Miscellaneous Course Policies

6.1 Collaboration Policy

For all computer projects, you will work as a team of two students.² You may also consult with other students currently enrolled in this course who are not on your team, but you

²If there is an odd number of students in the class, one and only one “team” will have just a single member. This team approach is a reflection of the team-oriented nature of essentially every engineering (and computer science) type of job in today’s workforce.
must document any such help you receive (e.g., as comments directly in the source code of
your program and in the References section of your project report). No comments mean you
are submitting the project as totally your own team’s work; my assumption will always be
that you are an honorable person unless you cause me to believe otherwise. Simply copying
another team’s assignment is not allowed—the actual item you turn in must ultimately be
your own team’s work. You may be called upon to explain to me in person and in detail
how certain answers were obtained or how your software works. Exams and quizzes must
always be the student’s own work.

6.2 Academic Honesty

“The University of Wyoming is built upon a strong foundation of integrity, respect and
trust. All members of the University community have a responsibility to be honest and have
the right to expect honesty from others. Any form of academic dishonesty is unacceptable
to our community and will not be tolerated.” [excerpted from the UW General Bulletin]
All persons should report suspected violations of standards of academic honesty to the
instructor, department head, or dean. See UW Regulation 6-802, “Procedures and Author-
ized University Actions in Cases of Student Academic Dishonesty.” You can read this and
all other University regulations at: http://www.uwyo.edu/generalcounsel/index.html

6.3 Disability Statement

If you have a physical, learning, or psychological disability and require accommodations,
please let the instructor know as soon as possible. You must register with, and provide
documentation of your disability, to University Disability Support Services (UDSS) in SEO,
room 330 Knight Hall.

7 Course Overview

Welcome to Advanced Digital Image Processing! This course will continue where EE 4530
left off, and prepare you to deal competently with a wide range image processing challenges
that may confront you in the future. The subject had consistently been described as fun
and enjoyable by most students, but it isn’t just playing with pictures! There is a consid-
erable need for quantitative, mathematical descriptions and manipulations of images—so
be prepared for that. However, the emphasis in this course is on the underlying principles
and practical applications, rather than esoteric theory or arcane derivations.

Just like with anything worthwhile in life, if you aren’t willing to put in the time, you
won’t ever get good at it. Be prepared to devote considerable time to this class. I promise
to be sensitive to the time requirements of every assignment I give you, but you have to
put forth the effort. As Robert E. Heinlein was known to say, “TANSTAF.”

Some recommendations for success in this class which you might want to consider...

Don’t miss class. New material is covered each lecture. Attendance isn’t strictly re-
quired, but if you miss class, you are responsible for covering the missed material on
your own. Repeat lectures will not be given during office hours.
Read in advance. Based upon the topics we’re covering or are about to cover, use the table of contents and/or index of your text (and any supplementary references you use) to read about these topics in advance.

Start your projects early. Give yourself some time to consider the problem and determine whether or not you need instructor assistance. Last-minute questions are a bad idea.

Do your best on the projects. They comprise 40% of your grade!

Ask questions. This includes during class, during discussions, and during office hours. I don’t like a silent class—feel free to ask questions or make reasonable comments at will (but no distracting side conversations).

Don’t arrive late for class. If you know you’ll be delayed (or absent) for some reason, just let me know ahead of time in person or via e-mail. It’s the courteous and adult thing to do.

Let’s have fun in this class! I like lively, attentive, alert students with an active sense of humor. It’s more fun that way for all of us...

8 Course Topic Outline

The following outline lists the basic sequence of course topics. We will begin with a quick review of topics from EE 4530, then concentrate on the last part of Chapter 5 (reconstruction from projections, as in computerized tomographic imaging used for CT scans, PET scans, MRIs, etc.). Following this, we’ll proceed to Chapters 6–12 in the text. The speed and depth of coverage will depend to some degree upon the students, but remember: this is a graduate-level class. That means a greater amount of independent reading and more work outside of class is expected of you than for an undergraduate class. More specific lesson-by-lesson guidance will be given when needed as the semester progresses.

- Review of basic digital image processing (Chap. 1–5)
  - Spatial domain image processing
  - Frequency domain image processing

- Computerized tomographic imaging (end of Chap 5 and handouts)
  - History and applications of computed tomography
  - Mathematics underlying computerized tomographic imaging
  - Methods of forming a computed tomography image

- Color models, representation, and image processing (Chap. 6)
  - RGB, CMYK, HSI models, and pseudocolor
  - Important color models not in book: e.g., YIQ, YUV, YPbPr, YCbCr
- Closely related topics not in book: color models versus video/monitor standards (e.g., NTSC, PAL, SECAM, composite, S-video, component, VGA, ATSC, DVB, DVI, HDMI; interlaced versus progressive scanning; SD versus HD)
- Color transformations
- Color image filtering and enhancement
- “Green screen” techniques (not in book)

- **Wavelets and multiresolution processing (Chap. 7)**
  - Multiresolution representations
  - Subband coding and filter banks
  - Not in book: bandpass sampling (related to subband coding)
  - Wavelet transforms in 1-D and 2-D

- **Image compression (Chap. 8)**
  - Information content (entropy) of an image
  - Lossless versus lossy compression algorithms
  - Compression standards (including the new JPEG XR, not in the book)
  - Compressive sampling (a very hot topic today! not in book)

- **Morphological image processing (Chap. 9)**
  - Intro to image morphology
  - Binary operations
  - Grayscale operations
  - Applications of morphological image processing

- **Image segmentation (Chap. 10)**
  - Edge detection
  - Edge linking and boundary detection
  - Thresholding
  - Other methods of segmentation

- **Image representation and object recognition (Chap. 11–12)**
  - Descriptors: boundaries, regions, global
  - Pattern recognition as applied to images
References


[14] D. Marr, *Vision*, W. H. Freeman and Company, 1982. **ANNOTATION:** While Marr died soon after this book was published, it is still revered as one of the best references on the entire phenomenon of vision and imaging.


...one more page to the end...
Finally . . .

Congratulations on reading this far! Lesser mortals gave up several pages earlier. As a reward, perhaps these quotes will inspire you in a positive manner . . .

To study, and when the occasion arises to put what one has learned into practice—is that not deeply satisfying?
—Confucius

The purpose of computing is insight, not numbers.
—Richard W. Hamming

Great minds discuss ideas, average minds discuss events, small minds discuss people.
—Admiral Hyman G. Rickover (“father” of the nuclear Navy)

If I have seen further than others, it is by standing on the shoulders of giants.
—Sir Isaac Newton

You do not really understand something unless you can explain it to your grandmother.
—Albert Einstein

That which does not kill us makes us stronger.
—Friedrich Nietzsche