Course Description

This is a 3-credit course. This course introduces fundamental concepts and techniques for image processing and computer vision. We will address 1) how to efficiently represent and process image/video signals, and 2) how to deliver image/video signals over networks. Topics to be covered include: image acquisition and display using digital devices, properties of human visual perception, sampling and quantization, image enhancement, image restoration, two-dimensional Fourier transforms, linear and nonlinear filtering, morphological operations, noise removal, image deblurring, edge detection, image registration and geometric transformation, image/video compression, video communication standards, video transport over the Internet and wireless networks, object recognition and image understanding.

Course Prerequisites

- EEL 3135 (Discrete-Time Signals and Systems) or undergraduate-level signals and systems
- EEL 4516 (Noise in Devices and communication Systems) or undergraduate-level probability theory/stochastic processes
- Some exposure to MATLAB and C programming language
- Knowledge of basic matrix theory (linear algebra) would be helpful, but not necessary

Required Textbook


or


Recommended Readings
Course Information

Instructor:

Dr. Dapeng Wu  
Office: NEB 431  
Email: wu@ece.ufl.edu

TA:

Jiade Li  
Email: jiadeli@ufl.edu

Course website: http://www.wu.ece.ufl.edu/courses/eee6512f15

Meeting Time

Monday, Wednesday, Friday, period 8 (3 pm - 3:50 pm)

Meeting Room
Office Hours

- Dr. Wu: Monday, Wednesday, period 7 (1:55 pm - 2:45 pm), and by appointment via email.

Structure of the Course

The course consists of lectures, 6 homework assignments, and 1 project.

This course is primarily a lecture course. I cover all important material in lectures. Since EEL 3135 and EEL 4516 are prerequisites, I assume some previous knowledge about DSP, probability theory and stochastic processes, and hence I will cover some material very quickly. Thus, depending on what and how much you recall from earlier study, varying amounts of reading in introductory books on DSP, probability theory and stochastic processes (other than the course textbook) may be necessary; these readings are up to the student. I will only give reading assignments from the course textbook.

Attending lecture is quite important as I may cover material not available in any book easily accessible to you. I use Powerpoint presentation during lecture. Lecture notes will be posted on the course website before the class. The lecture is to engage the students in independent thinking, critical thinking, and creative thinking, help the students organize the knowledge around essential concepts and fundamental principles, and develop conditionalized knowledge which tells them when, where and why a certain method is applicable to solving the problem they encounter.

I do not intend for the WWW material to be a substitute for attending lecture since engaging the students in active thinking, making logical connections between the old knowledge and the new knowledge, and providing insights are the objectives of my lecture. The lecture notes are posted on the web so that you can miss an occasional lecture and still catch up, and it makes taking notes easier. To reward those who attend regularly, there will be some lecture-based material in the exam which is not available via the web.

Course Outline

- Overview of image processing systems, Image formation and perception, Continuous and digital image representation
- Image quantization: uniform and nonuniform, visual quantization (dithering).
- Image contrast enhancement: linear and non-linear stretching, histogram equalization.
- Continuous and discrete-time Fourier Transforms in 2D; and linear convolution in 2D.
- Image smoothing and image sharpening by spatial domain linear filtering; Edge detection.
- Discrete Fourier transform in 1D and 2D, and image filtering in the DFT domain.
- Median filtering and Morphological filtering.
- Color representation and display; true and pseudo color image processing.
- Image sampling and sampling rate conversion (resize).
- Lossless image compression: The concept of entropy and Huffman coding; Runlength coding for bi-level images; CCITT facsimile compression standards.
- Lossy image compression: Image quantization revisited; Predictive coding; Transform coding; JPEG image compression standard.
- Imaging Geometry; Coordinate transformation and geometric warping for image registration.
- Object recognition

Course Objectives

Upon the completion of the course, the student should be able to
know the fundamental techniques for image processing, video processing, and computer vision
understand the basics of analog and digital video: video representation and transmission
acquire the basic skill of designing image/video compression
familiarize himself/herself with image/video compression standards

Handouts
Please find handouts here.

Course Policies

• Attendance:
  ○ Perfect class attendance is not required, but regular attendance is expected.
  ○ It is the student's responsibility to independently obtain any missed material (including handouts) from lecture.
• During lecture, cell phones should be turned off.
• No late submissions of your homework solution, and project proposal/report, are allowed unless U.F. approved reasons are supplied and advance permission is granted by the instructor.
• Software use
  ○ All faculty, staff and student of the University are required and expected to obey the laws and legal agreements governing software use. Failure to do so can lead to monetary damages and/or criminal penalties for the individual violator. Because such violations are also against University policies and rules, disciplinary action will be taken as appropriate. We, the members of the University of Florida community, pledge to uphold ourselves and our peers to the highest standards of honesty and integrity.
• Announcements:
  ○ All students are responsible for announcements made in lecture, on the student access website, or via the class email list.
  ○ It is expected that you will check your email several times per week for possible course announcements.
• Students with disabilities:
  ○ Students requesting classroom accommodation must first register with the Dean of Students Office. That office will provide the student with documentation that he/she must provide to the course instructor when requesting accommodation. For more information on classroom accommodation, please click here.

Intellectual Integrity

All students admitted to the University of Florida have signed a statement of academic honesty committing them to be honest in all academic work and understanding that failure to comply with this commitment will result in disciplinary action. This statement is a reminder to uphold your obligation as a student at the University of Florida, and to be honest in all work submitted and exams taken in this class and all others. Refer to the academic honor code for more information.

Students are encouraged to discuss class material in order to better understand concepts. All homework answers must be the author's own work. However, students are encouraged to discuss homework to promote better understanding. What this means in practice is that students are welcome to discuss problems and solution approaches, and in fact can communally work solutions at a board. However, the material handed in must be prepared starting with a clean sheet of paper (and the author's recollection of any solution session), but not refer
to any written notes or existing code from other students during the writing of the solution. In other words, writing the homework report shall be an exercise in demonstrating the student understands the materials on his/her own, whether or not help was provided in attaining that understanding.

All work submitted in this course must be your own and produced exclusively for this course. The use of sources (ideas, quotations, paraphrases) must be properly acknowledged and documented. For the copy of the UF Honor Code and consequences of academic dishonesty, please refer to http://www.dso.ufl.edu/sscr/honorcodes/honorcode.php. Violations will be taken seriously and are noted on student disciplinary records. If you are in doubt regarding the requirements, please consult with the instructor before you complete any requirement of the course.

Useful links:

- UF Counseling Services –Resources are available on-campus for students having personal problems or lacking clear career and academic goals. The resources include:
  - UF Counseling & Wellness Center, 3190 Radio Rd, 392-1575, psychological and psychiatric services.
  - Career Resource Center, Reitz Union, 392-1601, career and job search services.

For university counseling services and mental health services, please visit http://www.counsel.ufl.edu/.

- In order to graduate, graduate students must have an overall GPA and an upper-division GPA of 3.0 or better (B or better). Note: a B- average is equivalent to a GPA of 2.67, and therefore, it does not satisfy this graduation requirement. For more information on grades and grading policies, please visit: http://www.registrar.ufl.edu/catalog/policies/regulationgrades.html

Grading:

<table>
<thead>
<tr>
<th>Grades</th>
<th>Percentage</th>
<th>Dates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Homework</td>
<td>30%</td>
<td>See the course calendar</td>
</tr>
<tr>
<td>Project proposal</td>
<td>10%</td>
<td>4pm, October 30</td>
</tr>
<tr>
<td>Project report</td>
<td>60%</td>
<td>4pm, December 16</td>
</tr>
</tbody>
</table>

The project report consists of

1. (50%) A written report for your project (You must obtain a similarity score for your written report from Turnitin; otherwise, your score will be reduced by 50% in this category of written report.)
2. (25%) Computer programs that you develop for your project
3. (10%) Powerpoint file of your presentation
4. (15%) Your presentation/demo video on YouTube

Grading scale:

Top 25% students will receive A. Average score will be at least B+.
Homework:

- Due dates of assignments are specified in the [course calendar](http://www.wu.ece.ufl.edu/courses/eee6512f15/index.htm).
- **No late submissions** are allowed unless U.F. approved reasons are supplied and advance permission is granted by the instructor.
- If you wish to dispute a homework grade, you must return the assignment along with a succinct written argument within one week after the graded materials have been returned to the class. Simple arithmetic errors in adding up grade totals are an exception, and can normally be handled verbally on-the-spot during office hours of the TA. For all other disputes, the entire homework may be (non-maliciously) re-graded, which may result in increase or decrease of points.

Class Project:

The class project will be done individually (that is, teaming with other students is not allowed). Each project requires a proposal and a final report. The final report is expected to be in the format of a conference paper plus computer programs, a Powerpoint file, and a video. On Oct. 30, the project proposal (up to 2 pages) is due. On Dec. 16, the final report (up to 10 pages) is due. For details about the project, please read [here](http://www.wu.ece.ufl.edu/courses/eee6512f15/index.htm).

Suggested topics for projects are listed [here](http://www.wu.ece.ufl.edu/courses/eee6512f15/index.htm).

Course calendar can be found [here](http://www.wu.ece.ufl.edu/courses/eee6512f15/index.htm).

Related courses in other schools:

- George Mason University, [Computer Vision](http://www.wu.ece.ufl.edu/courses/eee6512f15/index.htm)
- Johns Hopkins University, [Image Compression and Packet Video](http://www.wu.ece.ufl.edu/courses/eee6512f15/index.htm)
- Polytechnic University, [Video Processing](http://www.wu.ece.ufl.edu/courses/eee6512f15/index.htm)
- Purdue University, [Digital Video Systems](http://www.wu.ece.ufl.edu/courses/eee6512f15/index.htm)
- Stanford University, [Digital Video Processing](http://www.wu.ece.ufl.edu/courses/eee6512f15/index.htm)
- University of California, Berkeley, [Multimedia Signal Processing, Communications and Networking](http://www.wu.ece.ufl.edu/courses/eee6512f15/index.htm)
- University of Maryland, College Park, [Digital Image Processing](http://www.wu.ece.ufl.edu/courses/eee6512f15/index.htm)
- University of Maryland, College Park, [Multimedia Communication & Information Security: A Signal Processing Perspective](http://www.wu.ece.ufl.edu/courses/eee6512f15/index.htm)
Useful links

- Subjective evaluation for content aware video processing techniques
- MATLAB Tutorial
- MATLAB Central
- Matlab Primer, Matlab Manuals, Image Processing Toolbox
- Matlab implementation of image/video compression algorithms
- Introduction to Matrix Algebra (free book by Autar K Kaw, Professor, University of South Florida).
- HIPR2: a WWW-based Image Processing Teaching Materials with J
- LIDAR
- Learning by simulations
- OpenCV
- OpenGL
- Download the following free (open source) program to record video with screen capture: http://www.nchsoftware.com/capture/index.html?gclid=CNadw56W6-6wCFSVjTAodbjzTSg
- WebRTC: WebRTC is a free, open-source project that enables web browsers with Real-Time Communications (RTC) capabilities via simple JavaScript APIs.

Standards:

- H.264 tutorial
- H.263
- MPEG4 overview can be found at http://www.chiariglione.org/mpeg/standards/mpeg-4/mpeg-4.htm
- JPEG XR
- KTA (contender for future H.265)

ATSC (Advanced Television Systems Committee) & HDTV (High Definition Television):

- ATSC.org
- HDTV
- SMPTE.org

MPEG (Moving Picture Experts Group):

- MPEG.org
- MPEG standards committee
- MPEG TV
- MP3
  - MPEG Audio Layer-3

Software:

- Video codec
- Virtual Dub: VirtualDub is a video capture/processing utility for 32-bit Windows platforms
XnView: is an efficient multimedia viewer, browser and converter.
ImageJ: Read and write GIF, JPEG, and ASCII. Read BMP, DICOM, and FITS. [Open Source, Public Domain]
Photosynth: you can access gigabytes of photos in seconds, view a scene from nearly any angle, find similar photos with a single click, and zoom in to make the smallest detail as big as your monitor.
Video filtering and compression, by the Video Group, Moscow State University
MSU Lossless Video Codec, by the Video Group, Moscow State University

**HSI color model**


---

**JOURNALS**

**Elsevier**
- Computer Vision and Image Understanding
- Digital Signal Processing: A Review Journal
- Graphical Models and Image Processing
- Journal of Visual Communication and Image Representation
- Real-Time Imaging
- Computers & Graphics
- Data & Knowledge Engineering
- Image and Vision Computing
- Pattern Recognition
- Pattern Recognition Letters
- Signal Processing
- Signal Processing: Image Communication

**IEEE**
- IEEE Transactions on Circuits and Systems for Video Technology
- IEEE Transactions on Multimedia
- IEEE Transactions on Image Processing
- IEEE Transactions on Medical Imaging
- IEEE Transactions on PAMI

**Kluwer**
- International Journal of Computer Vision
- Journal of Intelligent Information System
- Multidimensional Systems and Signal Processing

**SPIE**
- Journal of Electronic Imaging
Digital Video and Multimedia Standards Pages

- MPEG Pointers and Resources
- JPEG Tutorial
- JPEG FAQ
- Compression FAQ
- VRML Homepage
- Internet Engineering Taskforce Homepage

Digital TV and DVD

- Worldwide TV Standards
- More on Digital TV
- DVD FAQ

Overview of the AVI format

Signal Processing Information Base (SPIB)

Computer Vision

- Computer Vision Homepage at CMU
- Annotated Computer Vision Bibliography from USC IRIS
- CVonline: The Evolving, Distributed, Non-Proprietary, On-Line Compendium of Computer Vision

- 3-D for Everyone

- Red-blue glasses or anaglyph for 3D viewing: http://www.best3dglasses.com/anaglyph.html
- Shutter glasses for 3D viewing: http://www.stereo3d.com/shutter.htm
- 3D photos at http://www.jessemazer.com/3Dphotos.html
- 3D video sequences can be downloaded at: http://research.microsoft.com/vision/InteractiveVisualMediaGroup/3DVideoDownload/

Public Domain Image Databases

CMU Database

Patent licensing

As with MPEG-2 Parts 1 and 2 and MPEG-4 Part 2 amongst others, the vendors of H.264/AVC products and services are expected to pay patent licensing royalties for the patented technology that their products use. The primary source of licenses for patents applying to this standard is a private organization known as MPEG-LA, LLC (which is not
affiliated in any way with the MPEG standardization organization, but which also administers patent pools for MPEG-2 Part 1 Systems, MPEG-2 Part 2 Video, MPEG-4 Part 2 Video, and other technologies).

To search patents, visit free patent searching site: www.FreePatentsOnline.com.