GEOS 622 Digital image processing in the geosciences, Syllabus and course information

Please note that syllabus and other related course materials are also available on the web at www.gi.alaska.edu/~eicken/he_teach/GEOS692_intro.htm

Time & place: Image processing lab, West Ridge Research Building
Instructor: Hajo Eicken, Geophysical Institute, UAF
e-mail: hajo.eicken@gi.alaska.edu
Phone: 474-7280
Office: WRRB 104E (office hours: ad-hoc/by appointment)

Grading criteria:
Term project: 30 %
Homework: 55 %
Quizzes: 15 %

Term project:
A term project, to be completed by the end of the semester, will be aimed at applying skills and expertise acquired during the course to a specific scientific or engineering problem. Students are highly encouraged to define a project of their own (e.g., originating from thesis-related research), but a number of project suggestions (incl. data, samples etc.) will also be offered by the instructor.

Special Needs:
Students with learning or other disabilities who may need classroom accommodations are encouraged to visit the Disabilities website at www.uaf.edu/chc/disability.html and make an appointment with the Office of Disability Services (474-7043). Please meet with the instructor so that the appropriate accommodations and supports to assist in meeting the goals of the course can be made in collaboration with the Office of Disability Services.

UAF Honor Code:
As a UAF student, you are subject to the student Code of Conduct. The university assumes that the integrity of each student and of the student body as a whole will be upheld. It is your responsibility to help maintain the integrity of the student community. For additional information, contact the Dean of Student Services or web http://www.alaska.edu/bor/regulation/9r/r09-02.html/. The UAF Honor Code (Student Code of Conduct) defines academic standards expected at the University of Alaska Fairbanks.

Image processing program resources:
• IDL and Envi as available through licenses for teaching lab
• NIH Image (for either Mac or PC) plus spin-offs will provide the basis for demonstrations and exercises as well as for project work (program and documentation available at http://rsb.info.nih.gov/nih-image/)

• access to other image-processing programs available on request

Selection of textbooks and primary references:

• Castleman K. R. (1996) *Digital image processing,* Prentice Hall, Upper Saddle River, NJ. (thorough treatment, extensive coverage of frequency-domain transforms and pattern recognition; $100)

• *Gonzalez R. C., and P. Wintz (1987) *Digital image processing, 2nd ed.,* Addison-Wesley, Reading, MA. (solid treatment, 3rd edition by Gonzalez and Woods appeared in 1992; $95)

• *Jähne B. (2005) *Digital image processing - Concepts, algorithms, and scientific applications, 6th ed.,* Springer-Verlag, Berlin. (thorough treatment, extensive coverage of motion and space-time image analysis; $80)

• *Jain A. K. (1989) *Fundamentals of digital image processing,* Prentice Hall, Englewood Cliffs, NJ. (thorough treatment focussing on signal processing, with particular coverage of image filtering, restoration and representation; $90)

• *Jong, S. M. de (2004) *Remote sensing image analysis: Including the spatial domain*, Kluwer Academic, Dordrecht. ($95)

• *Rosenfeld A., and A. C. Kak (1982) *Digital picture processing, vols. 1 and 2,* Academic Press, Orlando. (thorough, classic text)

• *Russ J. C. (1991) *Computer-assisted microscopy - The measurement and analysis of images,* Plenum Press, New York. (basic treatment with focus on microscopic techniques, stereology and 3-D reconstruction)

• *Russ J. C. (2006) *The image processing handbook, 5th ed.,* CRC Press, Boca Raton, FL. (mostly non-mathematical, visually oriented text with numerous examples grouped into problem areas; $130)

• *Schowengerdt R. A. (1997) *Remote sensing - Models and methods for image processing, 2nd ed.,* Academic Press, San Diego. (solid, thorough text for remote-sensing aspects, with very good coverage of spectral transforms and classification; $75)

• Serra J. P. (1982) *Image analysis and mathematical morphology,* Academic Press, London. (classic text, a must for the non-linear filtering aficionado, not necessarily required reading for the casual passer-by; summary of concepts of mathematical morphology can be found in more recent textbooks, e.g., Castleman, 1996, or Russ, 1998, for numerous examples)

* books marked with an asterisk will be put on hold for the duration of the semester in the Keith Mather Library (Geophysical Institute & IARC); others are available at Rasmuson Library or with the instructor

N.B.: Comments in parentheses are highly subjective and merely meant to provide some guidance as to the contents and depth; prices quoted are approximate.

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0. Course overview and essentials (download/view pdf document, 20 kB)

1. Fundamentals of image processing (download/view pdf document, 820 kB)
1.1. *Images*: Image representation, components of an image processing sequence
1.2. *Image acquisition and digitization*: Biology and optics of image processing, cameras, scanners and other acquisition devices; digitization

Homework problem 1 (download/view pdf document, 429 kB)

2. Greyvalue histograms and point operations (download/view pdf document, 470 kB)
2.1. *Greyvalue histograms*: Greyvalue distributions & statistics, thresholding & segmentation
2.2. *Point operations*: Histogram transforms, pixels, gridding & quantization

Homework problem 2 (download/view pdf document, 9 kB)

3. Spatial transforms (download/view pdf document, 827 kB)
3.1. *Geometric transformations*: Interpolation, geometric operations and projections
3.2. *Linear filtering*: Neighbourhoods, kernels, convolutions & their applications
3.3. *Non-linear filtering*: Morphological operators, erosion & dilation of binary and greyscale images, variant operations

Homework problem 3 (download/view pdf document, 8 kB)

4. Frequency domain transforms (download/view pdf document, 1.1 MB)
4.1. *Fourier transforms*: 1-D and 2-D transforms
4.2. *Applications of frequency domain transforms*: Analysis, restoration &compression of images

5. Pattern recognition: Image segmentation & texture analysis (download/view pdf document, 106 kB)
5.1. *Global and local thresholding*
5.2. *Gradient/edge detection*
5.3. *Adaptive segmentation*
5.4. *Texture analysis*: Definitions and measures of texture, point- and neighbourhood-based methods

Homework problem 4 (download/view pdf document, 6 kB)

6. Processing of colour and multi-spectral images (download/view pdf document, part 1/2, 19 kB, download/view part 2/2, 525 kB)
6.1. *Acquisition and representation*: Image acquisition from colour camera, spectral radiometer etc.; colour representations and transforms
6.2. *Multispectral transforms*: Statistics, principal component analysis, classification

7. Object measurements

7.1. *Size, shape and orientation*: Statistics of size distributions, resolution and scale; shape analysis, orientational statistics
7.2. *Stereological models and microstructural analysis*
7.3. *Analysis of 3-D data sets*

8. Image-processing applications in the geosciences: Strategies, applications and caveats - A summary

Preliminary timeline of the class

Week 1	Fundamentals
Week 2	Fundamentals; Grey values and point operations
Week 3	Grey values and point operations
Week 4	Spatial transforms (**1st homework** assignment due)
Week 5	Spatial transforms
Week 5	Spatial transforms
Week 6	Frequency-domain transforms
Week 6	Frequency-domain transforms (**1st quiz** - covers everything up to and including Spatial transforms)
Week 7	Frequency-domain transforms
Week 7	Spatial/frequency-domain transforms: Synthesis
Week 8	Pattern recognition: Image segmentation
Week 8	Pattern recognition: Texture analysis (**2nd homework** assignment due)
Week 9	Pattern recognition
Week 9	Pattern recognition
Week 10	Multispectral analysis
Week 10	Multispectral analysis
Week 11	Multispectral analysis (**2nd quiz**)

Week 11	Multispectral analysis
Week 12	Outline semester project: Problem, proposed solution, data etc.
Week 12	Multispectral analysis
Week 13	Synthesis Presentations (**3rd homework** assignment due)
Week 13	Synthesis/Project Presentations
Week 14	Project Presentations (**4th homework** assignment due)
Week 15	Final exam week - **Project work complete by Tuesday Dec 18**

* Lecture notes are saved as Adobe Acrobat pdf documents.