1051-712-90: Basic Principles of Imaging Science II
The Imaging Chain
Winter, 2004-2005. TBD

Course

Four credit hours, Four lecture hours per week
Prerequisites: Basic Principles of Imaging Science I (1051-711)
Corequisites: Coregistration in Linear Math II
Course Website: http://www.cis.rit.edu/class/simg712-90/index.html or
http://www.cis.rit.edu/people/faculty/easton/BasicPrinciplesII/index.html
Instructor: Roger Easton, 76-2112, 475-5969, easton@cis.rit.edu
Office Hours: TBD, and by appointment

Catalog Description

This course provides the student with a basic understanding of the scientific principles associated with optics and optical image formation, image displays and their characterizations, digital image processing, color, and the human vision system. An end-to-end treatment of the imaging system shall be employed to illustrate the inter-relationship among the concepts introduced throughout the course. Systems analyses including the use of modeling concepts developed in Linear Image Mathematics can be used in concert with materials in this course to describe and assess a simple imaging system.

Objectives

(1) Provide a common scientific foundation for all imaging science students that enables them to describe simple imaging systems.
(2) Enable the student to break an imaging system into component elements and describe the physical and mathematical relationships between the components.
(3) The student should be able to describe a simple imaging process from a systems perspective and be able to characterize relevant quality metrics and predict performance characteristics along the imaging chain.

Course Outline:

I. Imaging Optics
   A. Self review of oscillations and waves
II. Oscillations
   A. Superposition of oscillations
   B. Traveling waves
   C. Doppler effect for waves in a medium ("acoustic" waves)
      1. Nature of light, electromagnetic waves
III. Maxwell's Equations
   A. Vector calculus
   B. Plane-wave solution to Maxwell's equations
   C. Wave equation
   D. Polarization
IV. Optical imaging in ray model
   A. Fermat’s principle
   B. Snell’s law for reflection and refraction
   C. Refraction from a single spherical surface, paraxial approximation
   D. Thin lens equation
   E. Multiple thin lenses
   F. Thick lenses
   G. Pupils and stops
V. Optical Imaging in wave model
   A. Interference
   B. Diffraction
   C. Diffraction limit in imaging
   D. system examples
VI. Digital Image Processing
   A. Review of sampling and quantization
   B. Operations on digital images
   C. Point operations on single images
   D. Point operations on multiple images, vision and color
   E. Local operations; crosscorrelation and convolution
   F. Operations based on shapes and patterns
   G. Geometrical operations
   H. Global operations
   I. Image compression

Instructional Techniques

Lectures, demonstrations

Evaluations

Midterm examination (30%)
Cumulative final examination (40%)
Homework (30%)

Bibliography

Class Notes, available in pdf format
Fundamentals of Electronic Imaging Systems, W. Schreiber, Springer-Verlag, 1991.

Optics
WebTOP "The Optics Project" of Mississippi State University)
http://webtop.msstate.edu/
F. Crawford, **Waves**, Berkeley Physics Series Vol. III, McGraw-Hill, 1968.
D. Falk, D. Brill, and D. Stork, **Seeing the Light**, Harper and Row, 1986.
D. Halliday and R. Resnick, **Physics**, 3rd Edition, Wiley, 1978.
Eugene Hecht, **Optics**, Fourth Edition, Addison-Wesley, Reading MA, 2002.
K. Iizuka, **Engineering Optics**, Springer-Verlag, 1985.
F. Jenkins and H. White, **Fundamentals of Optics**, 4th Edition, McGraw-Hill, 1976.
M.V. Klein and T.E. Furtak, **Optics**, Second Edition, Wiley, 1986
Craig Scott, **Introduction to Optics and Optical Imaging**, IEEE Press, New York, 1998.
A. Nussbaum and R. Phillips, **Contemporary Optics for Scientists and Engineers**, Prentice-Hall, 1976.

Digital Image Processing
Center for Image Processing in Education, (lots of links to software and images)
(http://www.evisual.org/homepage.html)
ImageJ software for image processing and analysis in Java, evolution of NIHImage
http://rsb.info.nih.gov/ij/
Image 2000 from NASA http://www.ccpo.odu.edu/SEES/ozone/oz_i2k_soft.htm
Scion Image Processing Software for PC and MAC
http://www.scioncorp.com/frames/fr_scion_products.htm
Hypercube Image Analysis Software for PC and MAC
http://www.tec.army.mil/Hypercube/)
Gregory A. Baxes, **Digital Image Processing, Principles and Applications**, John Wiley & Sons, New York, 1994.
Ronald N. Bracewell, **Two-Dimensional Imaging**, Prentice Hall, Englewood Cliffs, 1995.
Kenneth R. Castleman, **Digital Image Processing,** Prentice Hall, Englewood Cliffs, 1996.
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Jae S. Lim, **Two-Dimensional Signal and Image Processing,** Prentice Hall, Englewood Cliffs, 1990.
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J. Anthony Parker, **Image Reconstruction in Radiology**, CRC Press, Boca Raton FL, 1990.
William K. Pratt, **Digital Image Processing**, Second Edition, John Wiley & Sons, New York, 1991.
Azriel Rosenfeld and Avinash C. Kak, **Digital Picture Processing**, Second Edition, Academic Press, San Diego, 1982.

Image Compression

Abramson, N, **Information Theory and Coding**, McGraw-Hill, 1963.
Ash, Robert, **Information Theory**, Dover Publications, 1965.
Dainty, C. and R. Shaw, **Image Science**, Academic Press, 1974, §10.
Grant, R. E., A.B. Mahmoodi, and W.L. Nelson, "Image Compression and Transmission", §11 in **Imaging Processes and Materials**, Neblette's 8th edition, Van Nostrand Reinhold, 1989
Huffman, David A., "A Method for the Construction of Minimum-Redundancy Codes," **Proc. IRE 40**, 1098-1101, 1952.
Jain, A.K., "Image data compression: a review", **Proc. IEEE 69**, 349-389, 1981.
Khinchin, Mathematical Foundations of Information Theory, Dover Publications, 1957.
Pierce, J.R., **An Introduction to Information Theory, Signals, Systems, and Noise**, Dover Publications, 1980.
Shannon, Claude, "A Mathematical Theory of Communication I," **Bell Syst. Tech. J. 27**, 379-423, 1948.
Shannon, Claude, "A Mathematical Theory of Communication II," **Bell Syst. Tech. J. 27**, 623-656, 1948.
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Raisbeck, G., **Information Theory for Scientists and Engineers**, MIT Press; 1965.