

1051-712: Basic Principles of Imaging Science II

The Image Chain ·

Winter, 2004-2005. MW 10:00-11:50pm, Carlson 1155

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/simg712-01/index.html> or
<http://www.cis.rit.edu/people/faculty/easton/BasicPrinciplesII/index.html>

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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.

Michael P. Ekstrom, (Ed.), **Digital Image Processing Techniques**, Academic Press, New York, 1984.

Jack D. Gaskill, **Linear Systems, Fourier Transforms, and Optics**, John Wiley & Sons, New York, 1978.

Rafael C. Gonzalez and Richard E. Woods, **Digital Image Processing**, Second Edition, Prentice Hall, Upper Saddle River, 2002.

Jae S. Lim, **Two-Dimensional Signal and Image Processing**, Prentice Hall, Englewood Cliffs, 1990.

Wayne Niblack, **An Introduction to Digital Image Processing**, Prentice Hall, Englewood Cliffs, 1986.

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.

Shannon, Claude, "Communication in the Presence of Noise," **Proc. IRE** **37**, 10-21, 1949.

Shannon, Claude, "Prediction and Entropy of Printed English," **Bell Syst. Tech. J.** **30**, 50-64, 1951.

Rabbani, M. and P.W. Jones, **Digital Image Compression Techniques**, SPIE, 1991

Raisbeck, G., **Information Theory for Scientists and Engineers**, MIT Press; 1965.