

**Rochester Institute of Technology
Rochester, New York**

COLLEGE of SCIENCE
Chester F. Carlson Center for Imaging Science

Digital Imaging Mathematics 1051-718

- 1.0 Title:** Digital Imaging Mathematics **Date:** December 9, 2005
Credit Hours: 4
Prerequisite(s): 1051-716, Fourier Methods for Imaging
Corequisite(s): none
Course proposed by: Harvey Rhody and Carl Salvaggio

2.0 Course information:

	Contact hours	Maximum students/section
Classroom	4	30
Lab		
Studio		
Other (specify _____)		

Quarter(s) offered (check)

_____ **Fall** **Winter** _____ **Spring** _____ **Summer**

Students required to take this course: (by program and year, as appropriate)
Graduate students in the Imaging Science, PhD track.

Students who might elect to take this course:

Nonmatriculated students with undergraduate degrees in the Physical Sciences or Engineering. Graduate students in the College of Science, Kate Gleason College of Engineering, or Golisano College of Computing and Information Sciences. Graduate students in Imaging Science, M.S. track.

- 3.0 Goals of the course** (including rationale for the course, when appropriate)
To give students a firm understanding of basic imaging models, discrete mathematics, image transformations and computational processes needed to design and analyze image processing algorithms as elements of image processing systems.
- 4.0 Course description** (as it will appear in the RIT Catalog, including pre- and co-requisites, quarters offered)

1051-718

Digital Imaging Mathematics

This course provides a basic understanding of imaging systems, image transformations and associated mathematics and computational. Topics covered include camera models, image projection and rectification, image statistics and point processing, linear and nonlinear image filters, image transforms, image mathematics and computer algorithms. Some laboratory experiments are included. (1051-7xx, Fourier Methods for Imaging) **Class 4, Credit 4 (W)**

5.0 Possible resources (texts, references, computer packages, etc.)

- 5.1 Gonzalez and Woods, *Digital Image Processing*, Addison-Wesley (text)
- 5.2 Easton, R.L., *Linear Mathematics with Applications to Imaging*

6. Topics

- 6.1. Imaging Geometry
 - 6.1.1. World coordinate system
 - 6.1.2. Translation, rotation, scaling, homogeneous coordinates
 - 6.1.3. Transformations: Affine, Projective, Perspective
 - 6.1.4. Camera model and 3D viewing
 - 6.1.5. Stereo model
- 6.2. Image Spectra
 - 6.2.1. $f(x,y,\lambda)$ affected by scene, illumination, sensor
 - 6.2.2. Color Models
 - 6.2.2.1. Color representations: Red-Green-Blue (RGB), Cyan-Magenta-Yellow (CMY), Hue-Saturation-Intensity (HIS) and Hue-Saturation-Value (HSV), Luminance-Chrominance spaces for video (YIQ, YUV)
 - 6.2.2.2. Color Transformations
- 6.3. Sampling & Quantizing
 - 6.3.1. Review of spatial vs. frequency relationships
 - 6.3.2. Ideal uniform sampling
 - 6.3.3. Ideal interpolation
 - 6.3.4. Whittaker-Shannon sampling theorem
 - 6.3.5. Aliasing vs. sampling frequency
 - 6.3.6. Aperture sampling
 - 6.3.7. Quantization
 - 6.3.7.1. Uniform
 - 6.3.7.2. Non-uniform (Lloyd-Max)
 - 6.3.7.3. Quantization in color space
 - 6.3.8. Image reconstruction from quantized samples
 - 6.3.8.1. Rate-distortion tradeoff
 - 6.3.8.2. Color fidelity
- 6.4. Point processing operations
 - 6.4.1. Histogram operations
 - 6.4.2. Equalization & stretching
- 6.5. Neighborhood operations
 - 6.5.1. Convolution kernels & filtering

- 6.5.1.1. Edge detection & sharpening
- 6.5.1.2. Smoothing & noise reduction
- 6.5.2. Order-statistic filters
- 6.6. Discrete Fourier Transform (DFT)
 - 6.6.1. Infinite Support DFT & Inverse
 - 6.6.1.1. Discrete Frequency vs. Periodic Spatial
 - 6.6.1.2. Discrete Spatial vs. Periodic Frequency
 - 6.6.2. Discrete-discrete vs. periodic-periodic
 - 6.6.3. Power calculations (Parseval's theorem)
 - 6.6.4. Number of samples vs. (spatial, frequency) support
 - 6.6.5. Effect of spatial shifting on DFT
 - 6.6.6. Spatial vs. Frequency Domain Filter Design
 - 6.6.7. Windowing Techniques

7. Intended learning outcomes and associated assessment methods of those outcomes

Learning Outcome	In class attendance and evaluation	Homework and Lab Assignments
7.1 Demonstrate knowledge of digital image models and their relationship to fidelity	X	X
7.2 Demonstrate knowledge of the relationships between image representations and related mathematical transformations	X	X
7.3 Demonstrate the ability to implement mathematical processes in computational algorithms	X	X
7.4 Demonstrate the ability to select appropriate models and transformations for classes of image processing tasks	X	X

8. Program or general education goals supported by this course

- 8.1. Satisfies one element of the set of Core Course Requirements for the MS and PhD in Imaging Science.
- 8.2. Provides graduate students in science and engineering with essential knowledge and skills for work that involves images and image processing.

9. Other relevant information (such as special classroom, studio or lab needs, special scheduling, media requirements, etc.)

- 9.1. Classroom with computer projection system.

10. Supplemental information –

- 10.1. Computer techniques will be used throughout the course in lectures and classroom demonstrations and in homework assignments. Appropriate computing languages such as IDL and Matlab will be used in a manner that will enable students to learn by example and experience to implement common computing algorithms.
- 10.2. Laboratory activities
 - 10.2.1. Image mapping by projective transformations.
 - 10.2.2. Sampling and quantizing: Interpolation methods, uniform vs. non-uniform quantization, aliasing and distortion measures.
 - 10.2.3. Point processing operations: histogram equalization, threshold segmentation operations, illumination recovery.