10 51 718 Digital Imaging Mathematics

Instructor:
María Helguera, Ph.D.
Office: 76-2100
Phone: 475-7053
Email: helguera@cis.rit.edu
Office hours: F 2:00-3:00 or by appointment

Class schedule:
M-W 2:00-3:50

Goals of the course:
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. **Prerequisites:** 10 51 716 Fourier methods for imaging.

Text, references, etc.:
Easton, R L. *Linear Mathematics and its Application to Imaging*
González and Woods, *Digital Image Processing*, Prentice Hall

Outline:

1. Imaging Geometry
   1.1 World coordinate system
   1.2 Translation, rotation, scaling, homogeneous coordinates
   1.3 Transformations: Affine, Projective, Perspective
   1.4 Camera model and 3D viewing
   1.5 Stereo model
2. Image Spectra
   2.1 Image $f(x,y,\lambda)$ affected by scene, illumination, sensor
   2.2 Color models
      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 vide (YIQ, YUV)
      2.2.2 Color transformations
3. Sampling and Quantizing
   3.1 Review of spatial vs. frequency relationships
   3.2 Ideal uniform sampling
   3.3 Ideal interpolation
   3.4 Whittaker-Shannon sampling theorem
   3.5 Aliasing vs. sampling frequency
   3.6 Aperture sampling
   3.7 Quantization

        3.7.1 Uniform
        3.7.2 Non-Uniform (Lloyd-Max)
        3.7.3 Quantization in color space
    3.8 Image reconstruction from quantized samples
        3.8.1 Rate-distortion tradeoff
        3.8.2 Color fidelity

4. Point Processing Operations
    4.1 Histogram operations
    4.2 Equalization and stretching

5. Neighborhood Operations
    5.1 Convolution kernels and filtering
        5.1.1 Edge detection and sharpening
        5.1.2 Smoothing and noise reduction
    5.2 Order-statistic filters

6. Discrete Fourier Transform (DFT)
    6.1 Infinite support DFT and Inverse
        6.1.1 Discrete frequency vs. Periodic spatial
        6.1.2 Discrete spatial vs. Periodic frequency
    6.2 Discrete-discrete vs. periodic-periodic
    6.3 Power calculations (Parseval's theorem)
    6.4 Number of samples vs. (spatial, frequency) support
    6.5 Effect of spatial shifting on DFT
    6.6 Spatial vs. Frequency domain filter design
    6.7 Windowing techniques.

Course evaluation:
Lab + HW 30%
Midterm exam 30%
Final exam comprehensive 40%
No late assignments, no makeup exams.

Course schedule:

December

Week 1	12/4 IDL quick tutorial	12/6 Imaging Geometry
Week 2	12/11 Imaging Geometry	12/13 Imaging Geometry
Week 3	12/18 Image Spectra	12/20 Image Spectra

January

Week 4	1/8 Sampling and quantizing	1/10 Sampling and quantizing
Week 5	1/15 Sampling and quantizing	1/17 Sampling and quantizing
Week 6	1/22 Midterm exam	1/24 Point processing operations
Week 7	1/29 Point processing operations	1/31 Point processing operations

February

Week 8	2/5 Point processing operations	2/7 Discrete Fourier Transform
Week 9	2/12 DFT	2/14 DFT
Week 10	2/19 DFT	2/21 DFT
Finals	Final exam	