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

COLLEGE of Science
Department of Imaging Science

NEW (or REVISED) COURSE: 1051-453

**1.0** **Title**: **IMAGING SYSTEMS III: Noise & Random Processes**
**Date**: ___________
**Credit Hours:** __4__
**Prerequisite(s):** SIMG-452 (Imaging Systems II)
SIMG-xxx (Probability & Statistics for Imaging)
**Corequisite(s)**: ________________________________________
**Course proposed by:** ________________________________________

**2.0** **Course information:**

| | **Contact hours** | **Maximum students/section** |
|---|---|---|
| Classroom | 3 | 30 |
| Lab | 3 | 12 |
| Studio | | |
| Other (specify _______) | | |

**Quarter(s) offered** (check)
_____ **Fall** _____ **Winter** __X__ **Spring** _____ **Summer**

**Students required to take this course**: (by program and year, as appropriate)
___SIMG majors________________________________________

**Students who might elect to take the course**: ______________________

**3.0** **Goals of the course** (including rationale for the course, when appropriate):

To provide students with practical skills in the mathematical analysis and modeling of random noise in imaging systems. Students will be able to measure, characterize, and diagnose the causes of noise in complex systems of imaging processes.

**4.0** **Course description** (as it will appear in the RIT Catalog, including pre- and co-requisites, quarters offered)

**1051-5xx** **Imaging Systems III: Noise & Random Processes**

This course applies the mathematical and computational skills acquired in previous courses to the analysis and modeling of noise and random processes in a sequence of imaging processes. Experimental techniques for measuring noise will be studied and practiced. Noise characteristics of imaging systems will be modeled based on mathematical probability and moment theory. Jacobian operators and Fourier theory will be used to model correlated noise and to propagate noise properties through complex sequences of imaging processes. Practical metrics of noise and signal/noise ratios will be examined for their utility as figures of merit for imaging systems. (1051-5xx) **Class 3, Lab 1,Credit 4 (S)**

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

5.1 Lecture notes provided by the instructor

5.2 Reading assignments from:

- 5.2.2 *Fundamentals of Electronic Imaging Systems*, 2nd Ed. by W.F. Schreiber, (Springer-Verlag, 1991).
- 5.2.3 *An Introduction to Microdensitometry*, by Richard E. Swing, SPIE, 1998.

## 6.0 Topics (outline):

6.1 Early Experimental Observations

- 6.1.1 Visual Merging Distance
- 6.1.2 RMS granularity measurements
- 6.1.3 Selwyn's Law

6.2 The Probability Density Function

- 6.2.1 The image histogram and RMS granularity
- 6.2.2 Expectation calculations
- 6.2.2 Moment theory and useful theorems

6.3 Bernoulli Trials and Modeling a Detector

- 6.3.1 The Bernoulli PDF
- 6.3.2 Poisson PDF
- 6.3.1 Quantum noise limit of noise
- 6.3.2 Signal/noise in a quantum limited detector
- 6.3.3 Transmittance and reflectance modeled as Bernoulli Trials
- 6.3.4 Small noise propagation approximation: $\sigma_D$ vs $\sigma_R$

6.4 Bernoulli Trials in a Detector Array: Image Noise

6.7.2 Measurement of Wiener Spectrum
6.7.2.1 Aperture effect
6.7.2.2 Instrument MTF
6.7.3 Quantum noise characteristics of a CCD camera
6.7.4 Noise Through a System: Camera and Printer
6.7.3.1 Propagating input noise
6.7.3.2 Parsing out the camera noise
6.7.3.3 Parsing out the printer noise
6.7.5 Noise Through a System: Camera, Digital Operator, Printer
6.7.5.1 Modeling the system
6.7.5.2 Tone reproduction vs noise propagation

## 7.0 Intended learning outcomes and associated assessment methods of those outcomes

The successful student will be able to:

7.1 Describe and mathematically model the factors governing noise and signal/noise ratio in a sequence of imaging processes. (homework, labs, exams)

7.2 Perform mathematical analysis of noise properties of imaging systems using moment theory and Fourier analysis. (homework, labs, exams)

7.3 Make experimental measurements of RMS granularity and Wiener spectra, and interpret the data with regard to the measurement aperture, instrument MTF, and measurement noise. (labs)

## 8.0 Program or general education goals supported by this course

This course provides students with quantitative skills in the experimental and mathematical analysis of noise and random processes in systems of imaging processes.

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

Teaching laboratories on the 3rd floor of building 76 will be used.

## 10.0 Supplemental information