ROCHESTER INSTITUTE OF TECHNOLOGY

CHESTER F. CARLSON
CENTER FOR IMAGING SCIENCE

COS-IMGS-442
Imaging System Analysis and Modeling

1.0 Course Information

a) Catalog Listing (click HERE for credit hour assignment guidance)

Course title (100 characters)	Imaging Systems Analysis and Modeling
Transcript title (30 Characters)	Imaging Systems Analysis and Modeling
Credit hours	4
Prerequisite(s)**	COS-IMGS-211, COS-IMGS-261, COS-IMGS-341, and COS-IMGS-322
Co-requisite(s)	NONE

b) Terms(s) offered (check at least one)

X	Fall
	Spring
	Summer
	Other
	Offered biennially

If "Other" is checked, explain:

c) Instructional Modes (click HERE for credit hour assignment guidance)

	Contact hours	Maximum students/section
Classroom	4	30
Lab		
Studio		
Other (specify, i.e. online, workshop seminar, etc.)		

2.0 Course Description (as it will appear in the bulletin)

The purpose of this course is to develop an understanding and ability to model signal and noise within the context of imaging systems. A review of the modulation transfer function is followed by a brief review of probability theory. The concept of image noise

is then introduced. Next, random processes are considered in both the spatial and frequency domains, with emphasis on the autocorrelation function and power density spectrum. Finally, the principles of random processes are applied to signal and noise transfer in multistage imaging systems. At the completion of the course the student will be able to model signal and noise transfer within a multistage imaging system.

3.0 Goal(s) of the Course

Provide students with practical skills in the mathematical analysis and modeling of signal and noise in imaging systems. Students will be able to characterize and model the transfer of signal and noise in multistage imaging systems.

4.0 Intended course learning outcomes and associated assessment methods

Include as many course-specific outcomes as appropriate, one outcome and assessment method per row. Click HERE for guidance on developing course learning outcomes and associated assessment techniques.

Course Learning Outcome	Assessment Method
4.1 Identify and describe the factors that govern signal and noise in imaging systems.	Homework, Examinations
4.2 Explain spatial aspects of signal and noise, including autocorrelation, autocovariance, and cross-correlation functions.	Homework, Examinations
4.3 Describe the power density spectrum and its application to signal and noise in imaging systems.	Homework, Examinations
4.4 Describe detective quantum efficiency and its use in imaging system analysis.	Homework, Examinations
4.5 Describe how signal and noise are propagated in a multistage imaging system.	Homework, Examinations
4.6 Explain how the concept of signal and noise transfer must be modified for discrete imaging systems.	Homework, Examinations

5.0 Topics (should be in an enumerated list or outline format)

5.1 Modulation transfer function
- 5.1.1 Line spread function
- 5.1.2 Transfer function
- 5.1.3 Modulation transfer function (MTF)
- 5.1.4 MTF, resolution, and resolving power
- 5.1.5 Diffraction MTF
- 5.1.6 Geometrical MTF
- 5.1.7 Sharpness
- 5.1.8 Perception vs. measurement
- 5.1.9 Aperture MTF
- 5.1.10 Sampling MTF
- 5.1.11 Crosstalk MTF

5.1.12 Electronics MTF
5.2 Image noise
5.2.1 Review of probability
5.2.2 Granularity
5.2.3 Noise constant
5.2.4 Photon noise and signal-to-noise ratio
5.2.5 Detector quantum efficiency (DQE)
5.3 Random processes – spatial characterization
5.3.1 First-order stationarity
5.3.2 Second-order and wide sense stationarity
5.3.3 Autocorrelation function and its properties
5.3.4 Cross-correlation function and its properties
5.3.5 Discrete and cyclostationary random processes
5.3.6 Random processes and linear systems
5.4 Random processes – spectral characterization
5.4.1 Power density spectrum (PDS) and its properties
5.4.2 Relationship between the PDS and the autocorrelation function
5.4.3 PDS for discrete and cyclostationary random processes
5.4.4 White noise
5.4.5 Correlated and uncorrelated noise
5.5 Zero-frequency analysis of signal and noise
5.5.1 Rose model
5.5.2 DQE and examples
5.5.3 Photon amplifier modeling
5.5.4 Cascaded DQE
5.6 Fourier analysis of signal and noise in continuous systems
5.6.1 Response of linear systems to random signals
5.6.2 Noise transfer and examples
5.6.3 General equation for system DQE
5.6.4 Quantum accounting diagram
5.7 Fourier analysis of signal and noise in discrete systems
5.7.1 Discrete modulation transfer function (MTF), presampling and aliasing
5.7.2 Discrete Wiener spectrum, presampling and noise aliasing
5.7.3 Discrete DQE
5.7.4 Analysis of a digital detector array
5.7.5 System DQE

6.0 Possible Resources (should be in an enumerated list or outline format)

6.1 Frieden, B.R., *Probability, Statistical Optics, and Data Testing*, Springer, New York, NY

7.0 Program outcomes and/or goals supported by this course

Provides mathematical skills with which to understand and model imaging system performance.

8.0 Administrative Information

a) Proposal and Approval

Course proposed by	Rich Hailstone
Effective term	2191
Required approval	Approval granted date
Academic Unit Curriculum Committee	10/24/2018
Department Chair/Director/Head	10/24/2018
College Curriculum Committee	11/6/2018
College Dean	

b) Special designations for undergraduate courses

The appropriate Appendix (A, B and/or C) must be completed for each designation requested. IF YOU ARE NOT SEEKING SPECIAL COURSE DESIGNATION, DELETE THE ATTACHED APPENDICES BEFORE PROCEEDING WITH REVIEW AND APPROVAL PROCESSES.

Check	Optional Designations	*** Approval date (by GEC, IWC or Honors)
	General Education	
	Writing Intensive	
	Honors	

c) This outline is for a…

X	New course
	Revised course
	Deactivated course

If revised course, check all that have changed

	Course title		Mode of Delivery
	Credit hour		Course Description
	Prerequisites		Special Designation
	Contact hour		
	Other (explain briefly):		

d) Additional course information (check all that apply)

X	Schedule Final Exam
	Repeatable for Credit | How many times:
	Allow Multiple Enrollments in a Term
X	Required course | For which programs: IMGS
	Program elective course | For which programs:

e) Other relevant scheduling information

(e.g., special classroom, studio, or lab needs, special scheduling, media requirements)

9.0 Colleges may add additional information here if necessary

(e.g., information required by accrediting bodies)