ROCHESTER INSTITUTE OF TECHNOLOGY
COURSE OUTLINE FORM

COLLEGE OF SCIENCE

Chester F. Carlson Center for Imaging Science
NEW COURSE: COS-IMGS-715: Computational Photography

1.0 Course Designations and Approvals

Required course approvals:	**Approval request date:**	**Approval granted date:**
Academic Unit Curriculum Committee	9/13/12	9/13/12
College Curriculum Committee	12/12/12	12/18/12

Optional designations:	**Is designation desired?**		***Approval request date:**	****Approval granted date:**
General Education:		No		
Writing Intensive:		No		
Honors		No		

2.0 Course information:

Course title:	Computational Photography
Credit hours:	3
Prerequisite(s):	Graduate standing in a science or engineering program, or permission of instructor.
Co-requisite(s):	None
Course proposed by:	Jinwei Gu
Effective date:	Fall 2013

	Contact hours	**Maximum students/section**
Classroom	3	15
Lab		
Studio		
Other (specify)		

2.a Course Conversion Designation* (Please check which applies to this course).**
*For more information on Course Conversion Designations please see page four.

	Semester Equivalent (SE) Please indicate which quarter course it is equivalent to:
	Semester Replacement (SR) Please indicate the quarter course(s) this course is replacing:
X	New

2.b Semester(s) offered (check)

Fall X	Spring	Summer	Other

All courses must be offered at least once every 2 years. If course will be offered on a bi-annual basis, please indicate here:

2.c Student Requirements

Students required to take this course: (by program and year, as appropriate) None
Students who might elect to take the course: Graduate students in imaging science, color science, computer science, and electrical engineering.

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

Computational photography is an emerging field that aims to overcome the limitations of conventional digital imaging and display devices by using computational techniques and novel programmable sensors and optics. This course has three goals:

3.1 Equip the students with fundamental skills in computer vision and imaging, such as camera calibration, structured light, photometric stereo, and appearance capture.

3.2 Introduce the students to the latest frontier research topics, such as mobile imaging, light field capture and display, computational flash photography, and computational sensors.

3.3 Stimulate student research with paper reading/discussion sessions and open-ended term projects.

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

COS-IMGS-715 **Computational Photography**

Computational photography is an emerging field that aims to overcome the limitations of conventional digital imaging and display devices by using computational techniques and novel programmable sensors and optical devices. In this course, we will study start-of-the-art techniques for capturing, modeling, and displaying complex appearance phenomena. We will cover topics such as computational sensor with assorted pixel designs, mobile camera control, light field capture and rendering, computational flash photography, computational illumination for appearance modeling and 3D reconstruction, light transport analysis, and light sensitive display and printing techniques. We will integrate the latest smart imaging devices into the course for homework and term projects. (Graduate standing in a science or engineering program, or permission of instructor) **Class 3, Credit 3 (F)**

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

5.1 Richard Szeliski. *Computer Vision: Algorithms and Applications*. Springer, New York, NY.
5.2 Berthold K. P. Horn. *Robot Vision*. The MIT Press, Cambridge, MA.
5.3 David Forsynth and Jean Ponce. *Computer Vision: A Modern Approach*. Pearson, Upper Saddle River, NJ.
5.4 Rastislav Lukac. *Computational Photography: Methods and Applications.* CRC Press, Boca Raton, FL.
5.5 IEEE International Conference on Computational Photography (ICCP)
5.6 Readings assigned by instructor
5.7 Online resources assembled and distributed by instructor

6.0 Topics (outline):

6.1 Introduction: Image Formation, Radiometry, and Camera Optics
6.2 Plenoptic Function (Light Field)
- 6.2.1 Light Field Modeling and Capture
- 6.2.2 Light Field Applications: Refocusing, Synthetic Aperture, and 3D
- 6.2.3 Case Study: Lytro or similar camera

6.3 Computational Sensors
- 6.3.1 High Dynamic Range Imaging with Assorted Pixel Sensors
- 6.3.2 Radiometric Camera Calibration, Noise Modeling, Denoising

6.4 Computational Cameras
- 6.4.1 Camera Control Algorithms
- 6.4.2 Post-processing Pipeline within Camera
- 6.4.3 Franken-Camera: An Open-Source Framework for Programmable Camera
- 6.4.4 Coded Aperture Imaging: Good and Bad

6.5 Computer Vision Fundamentals
- 6.5.1 Geometric Camera Calibration, Camera Models
- 6.5.2 Binocular Stereo, Stereo Matching
- 6.5.3 Structured Light 3D Reconstruction
- 6.5.4 Structure From Motion

6.6 Computational Illumination
- 6.6.1 Illumination Multiplexing
- 6.6.2 Computational Flash Photography
- 6.6.3 Photometric Stereo for 3D Reconstruction
- 6.6.4 General Appearance Capture

6.7 Light Transport Analysis
- 6.7.1 Direct/Global Illumination: Modeling, Extraction, and Applications
- 6.7.2 Dual Photography
- 6.7.3 Compressive Sensing for Light Transport Capture

6.8 Computational Displays
- 6.8.1 Image Relighting
- 6.8.2 Light and View Sensitive Displays
- 6.8.2 Light Field Displays and other 3D Displays

7.0 Intended course learning outcomes and associated assessment methods of those outcomes (please include as many Course Learning Outcomes as appropriate, one outcome and assessment method per row).

Course Learning Outcome	Assessment Method
7.1 Explain and apply basic skills of 3D computer vision, such as camera control algorithms, camera calibration, binocular stereo, structured light, photometric stereo, illumination multiplexing.	Homework
7.2 Explain, compare, and apply theoretical models to describe scene appearance, such as plenoptic functions, light field, light transport, and noise.	Homework
7.3 Explain, summarize, and critique recent research papers and results	Paper reading/discussion sessions
7.4 Formulate and execute a research-oriented course project (from project proposal, literature search, implementation, and report) with instructor guidance.	Term project

8.0 Program outcomes and/or goals supported by this course

Prepares graduate students in science and engineering for careers in imaging science by educating them in the construction of sophisticated mathematical models of realistic problems associated with imaging systems and the implementation of computations with practical programming tools for testing, evaluation, and refinement of designs.

9.0

	General Education Learning Outcome Supported by the Course, if appropriate	Assessment Method
Communication		
	Express themselves effectively in common college-level written forms using standard American English	
	Revise and improve written and visual content	
	Express themselves effectively in presentations, either in spoken standard American English or sign language (American Sign Language or English-based Signing)	
	Comprehend information accessed through reading and discussion	
Intellectual Inquiry		
	Review, assess, and draw conclusions about hypotheses and theories	
	Analyze arguments, in relation to their premises, assumptions, contexts, and conclusions	
	Construct logical and reasonable arguments that include anticipation of counterarguments	
	Use relevant evidence gathered through accepted scholarly methods and properly acknowledge sources of information	
Ethical, Social and Global Awareness		
	Analyze similarities and differences in human experiences and consequent perspectives	
	Examine connections among the world's populations	
	Identify contemporary ethical questions and relevant stakeholder positions	
Scientific, Mathematical and Technological Literacy		
	Explain basic principles and concepts of one of the natural sciences	
	Apply methods of scientific inquiry and problem solving to contemporary issues	
	Comprehend and evaluate mathematical and statistical information	
	Perform college-level mathematical operations on quantitative data	
	Describe the potential and the limitations of technology	
	Use appropriate technology to achieve desired outcomes	
Creativity, Innovation and Artistic Literacy		
	Demonstrate creative/innovative approaches to course-based assignments or projects	
	Interpret and evaluate artistic expression considering the cultural context in which it was created	

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

Smart classroom