Lahore University of Management Sciences

CS 674 / EE 512– Digital Image Processing

Spring 2018

Instructor(s)	Dr. Murtaza Taj
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Course URL (if any)	LMS

Course Basics				
Credit Hours	3			
Lecture(s)	2 Per Week		Duration	75 minutes each
Recitation/Lab (per week)	0/0 Per Week		Duration	
Tutorial (per week)	0 Per Week		Duration	0

Course Distribution	
Core	No
Elective	Yes
Open for Student Category	Graduate, Senior, Junior
Close for Student Category	Freshman

COURSE DESCRIPTION

This is a graduate-level introductory course on the fundamentals of digital image processing. The course will emphasize the general principles of image processing. It will extend the signals and systems knowledge of the students to two-dimensional signals. This is a very important course for any student who wants to do a senior project related to image processing. Towards the end of the course some recent advances in this field will also be discussed to provide understanding about future directions.

Class lectures will be complemented with programming exercises in MATLAB

COURSE PREREQUISITE(S)

- EE310 Signals and Systems OR
  CS 5310 OR CS436(Co-req) Computer Vision Fundamentals OR
  Graduate OR Senior OR Junior

COURSE LEARNING OBJECTIVES

Many of the CLOs will be measure based on the performance in assignments and project. Description of assignments is available at the end of this document.

- Introduce the basic theory of digital processing of images. This objective will be measured through assignment 1
- Expose students to exciting applications of image processing. This objective will be measured through assignment 2 and projects
- To develop a link between time and frequency domain analysis and image processing applications. This objective will be measured through assignment 3
- To teach how to apply 2D signal processing knowledge into image processing applications. This objective will also be measured through assignment 3
- To teach how to combine existing image analysis techniques to solve emerging problems. This objective will be measured through course project

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UNDERGRADUATE PROGRAM LEARNING GOALS & OBJECTIVES	
• • • •	To be able to apply machine learning techniques towards solving image processing problems To introduce on-going research topics in the field of image processing and to provide research opportunities to students To be able to combine existing image analysis techniques to solve emerging problems To develop ability to code various algorithms

Grading Breakup and Policy (Tentative)
Assignment(s): 25% Quiz(s): 5% (around 5 quizzes) Class Participation: 0% Midterm Examination: 25% Project: 15% Final Examination: 30%

Examination Detail	
Midterm Exam	Yes/No: Yes Combine Separate: Duration: 120 minutes Exam Specifications: Written
Final Exam	Yes/No: Yes Combine Separate: Duration: 180 minutes Exam Specifications: Written

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Module	Topics	Sessions	Readings
1	**Introduction** Course introduction, along with an overview of the course, programming assignments and an applications tour of Image Processing, File formats **Digital Image Fundamentals** Visual perception, human eye, sensing and acquisition, sampling and quantization	*1* *1*	Gonzales Ch 1 Gonzales Ch 2
2	**Image Enhancement** **Enhancement in Spatial Domain** Histogram processing, arithmetic operators, linear filters, order-statistics filters, Derivative filters, Laplacian, 2D Convolution **Enhancement in Frequency Domain** 2D DFT and inverse, lowpass filters, sharpening filters, homomorphic filtering	*2* *2*	Gonzales Ch 3 Gonzales Ch 4
3	**Deep Learning** Convolution neural nets, autoencoders, internal layers	*3*	
4	**Image Reconstruction** Unitary transform, PCA and Eigen Faces Image Recognition, ImageNet Challenge, AlexNet, Google LeNet etc	*4*	
	Mid-term	*1*	
Module	Topics	Sessions	Readings
5	**Image Restoration** Noise Models, Noise reduction by spatial filtering, Periodic noise reduction by frequency domain filtering, inverse filtering, geometric transformations, Weiner Filtering, Karhunen-Loève transform ConvNet for Image Denoising	*3*	Gonzales Ch 5
6	**Color Image Processing** Color models, pseudocolor processing, color transformations, color edge detection ConvNet for Image Colorization	*2*	Gonzales Ch 6 Zhang SIGGRAPH 2016, Zhang ICCV 2015
7	**Wavelets and Multiresolution Processing (tentative)** Guassian and Laplacian Pyramids, Haar transform, wavelet functions, series expansion, discrete wavelet transform	*3*	Gonzales Ch 7
8	**Morphological Image Processing** Preliminaries, Dilation and Erosion, Opening, Closing	*1*	Gonzales Ch 9
9	**Image Segmentation** Gestalt Laws, Kernel Density Estimation, K-means, K-NN, Graph Cuts, Mean-shift Image Segmentation using Convolutional Neural Network	*3* *1*	Gonzales Ch 10 SegNet
10	**Image Compression (tentative)** JPEG, JPEG 2000	*1*	

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Assignment	Topics	Sample Output
1	**Histogram, Quantization and Thresholding** • PPM & PGM image read and write • Sub-sampling, Up-sampling • Interpolation (NN, Bilinear) • Quantization • Soft Chroma Keying • Thresholding using EM algorithm	
2	**Image Enhancement** • Histogram Modeling • Histogram Equalization **Content Based Image Retrieval** Retrieving images based on feature analysis of input query image provided by user rather than just text annotations.	 

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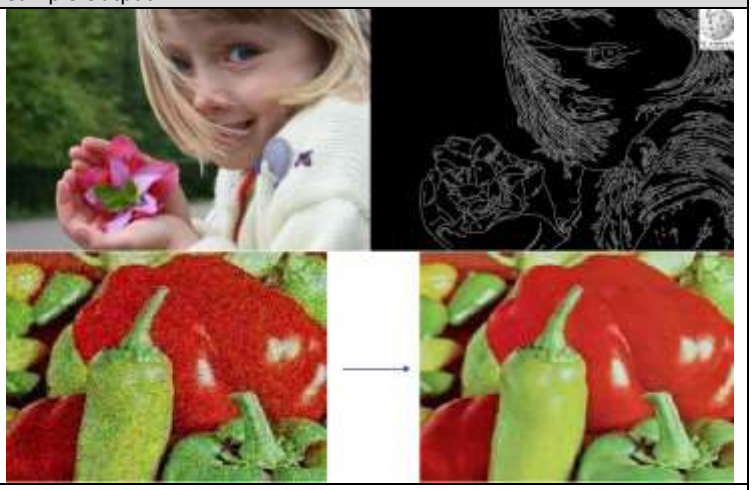
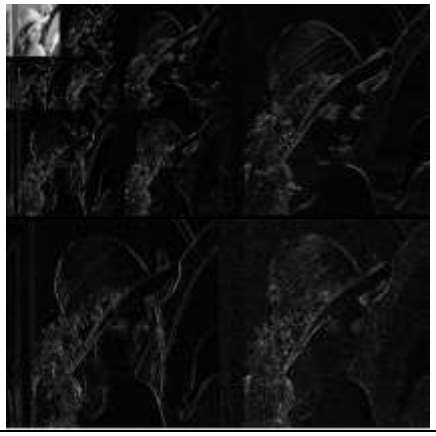
Assignment	Topics	Sample Output
3	**Convolution** • Horizontal edge • Vertical edge • Mean • Median • Gaussian • Laplacian	
	Content Based Image Retrieval **Using Deep Learning** • Using already trained networks • Training on a object specific data • Testing and analysis of a classifier • Comparison with SVM	
4	~~**Frequency Domain Concepts**~~ • ~~DFT~~ • ~~IDFT~~ • ~~Convolution using DFT~~ • ~~Correlation (template based tracking)~~ • ~~Wavelets~~	

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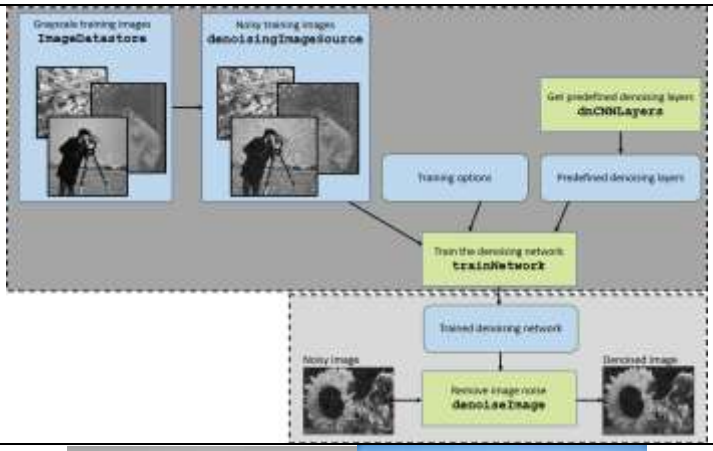
4	**Image Denoising Using Deep Learning**	
5	**Color Image Processing** • Generative Adversarial Networks	
6	**Image Segmentation** • SegNet • Image Segmentation on Satellite Imagery • Instance Counting	

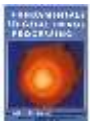
Textbook(s)/Supplementary Readings

Text

[Gonzales] Digital Image Processing/3E, R.C. Gonzales, R.E. Woods, Addison-Wesley, 2008

Digital Image Processing with MATLAB/2E, Gonzales, Woods, Eddins, 2009

Reference



Fundamentals of Digital Image Processing, Anil K. Jain, Prentice Hall, 1989

Programming Environment:
MATLAB: Familiarity with MATLAB is expected. Those who do not have this familiarity will have to put in some extra effort in the beginning.