



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

<ul style="list-style-type: none">••••	<ul style="list-style-type: none">To be able to apply machine learning techniques towards solving image processing problemsTo introduce on-going research topics in the field of image processing and to provide research opportunities to studentsTo be able to combine existing image analysis techniques to solve emerging problemsTo develop ability to code various algorithms
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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	<u>Introduction</u> Course introduction, along with an overview of the course, programming assignments and an applications tour of Image Processing, File formats	1	Gonzales Ch 1
	<u>Digital Image Fundamentals</u> Visual perception, human eye, sensing and acquisition, sampling and quantization	1	Gonzales Ch 2
2	<u>Image Enhancement</u> <u>Enhancement in Spatial Domain</u> Histogram processing, arithmetic operators, linear filters, order-statistics filters, Derivative filters, Laplacian, 2D Convolution	2	Gonzales Ch 3
	<u>Enhancement in Frequency Domain</u> 2D DFT and inverse, lowpass filters, sharpening filters, homomorphic filtering	2	Gonzales Ch 4
3	<u>Deep Learning</u> Convolution neural nets, autoencoders, internal layers	3	
4	<u>Image Reconstruction</u> Unitary transform, PCA and Eigen Faces Image Recognition, ImageNet Challenge, AlexNet, Google LeNet etc	4	
	<u>Mid-term</u>	1	
Module	Topics	Sessions	Readings
5	<u>Image Restoration</u> 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	<u>Color Image Processing</u> Color models, pseudocolor processing, color transformations, color edge detection ConvNet for Image Colorization	2	Gonzales Ch 6 Zhang SIGGRAPH 2016, Zhang ICCV 2015
7	<u>Wavelets and Multiresolution Processing (tentative)</u> Gaussian and Laplacian Pyramids, Haar transform, wavelet functions, series expansion, discrete wavelet transform	3	Gonzales Ch 7
8	<u>Morphological Image Processing</u> Preliminaries, Dilation and Erosion, Opening, Closing	1	Gonzales Ch 9
9	<u>Image Segmentation</u> 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	<u>Image Compression (tentative)</u> JPEG, JPEG 2000	1	



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Assignment	Topics	Sample Output
1	<p><u>Histogram, Quantization and Thresholding</u></p> <ul style="list-style-type: none"> • PPM & PGM image read and write • Sub-sampling, Up-sampling • Interpolation (NN, Bilinear) • Quantization • Soft Chroma Keying • Thresholding using EM algorithm 	<p>The sample output for Assignment 1 consists of several images demonstrating image processing techniques. At the top, there is a small text: "From Computer Graphics: Introduction, 8th ed. © The Computer Graphics Club, Inc." Below this, there are two rows of images. The first row shows two people on a motorcycle against a green background, with the original image on the left and the result of chroma keying on the right. The second row shows a "WELCOME TO LAS VEGAS" sign and a person looking up, with the original image on the left and the result of chroma keying on the right. At the bottom, there is a large image of a brown bear, which appears to be the result of a thresholding or quantization process applied to a similar image.</p>
2	<p><u>Image Enhancement</u></p> <ul style="list-style-type: none"> • Histogram Modeling • Histogram Equalization <p><u>Content Based Image Retrieval</u> Retrieving images based on feature analysis of input query image provided by user rather than just text annotations.</p>	<p>The sample output for Assignment 2 is divided into two main parts. The top part shows two side-by-side images of a park at night. The left image is very dark, representing the original input, while the right image is significantly brighter and clearer, demonstrating the result of histogram equalization. The bottom part shows a screenshot of a web-based image retrieval system. The system has a "Query Image" field containing a polar bear image (image1475.ppm) and a "Database" dropdown menu set to "COREL Database". Below the query image, there are several search algorithms listed: "Similarity Model", "LAR + COOC + MVC", "LAR + COOC + FIT", and "LAR + COOC + Lp". The "Similarity Model" is selected. To the right, there is a grid of "Relevant Images" and "Irrelevant Images". The relevant images are all polar bears, showing the system's ability to find similar images based on feature analysis. The irrelevant images are also polar bears but from different angles or backgrounds, showing the system's ability to filter out non-relevant results.</p>






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Assignment	Topics	Sample Output
3	<p>Convolution</p> <ul style="list-style-type: none"> • Horizontal edge • Vertical edge • Mean • Median • Gaussian • Laplacian 	
	<p>Content Based Image Retrieval Using Deep Learning</p> <ul style="list-style-type: none"> • Using already trained networks • Training on a object specific data • Testing and analysis of a classifier • Comparison with SVM 	
4	<p>Frequency Domain Concepts</p> <ul style="list-style-type: none"> • DFT • IDFT • Convolution using DFT • Correlation (template based tracking) • Wavelets 	



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4	<p><u>Image Denoising Using Deep Learning</u></p>	
5	<p><u>Color Image Processing</u></p> <ul style="list-style-type: none"> Generative_Adversarial_Networks 	
6	<p><u>Image Segmentation</u></p> <ul style="list-style-type: none"> 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
	
	<p>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.</p>