IT507—Advanced Image Processing

Course Placement: Advanced image processing is a core course for 1st year (2nd semester) M.Tech ICT-ML specialization

Course Format: It is **3 hours lecture** and **2 hours lab** every week.

Course Content:

The objective of this course is to introduce some basic to advanced levels of techniques for processing image. The techniques include various spatial domain, transformed domain techniques to enhance, to restore, and to segment image for higher level processing.

1) *Basics of digital image* – Basic steps of processing, Sampling and quantization, Pixels relationship
2) *Intensity transformations* – Log, Gamma, Histogram equalization, specification, Advanced application
3) *Spatial domain filtering* – Correlation, Convolution, Filtering for image smoothing and sharpening, Advanced spatial domain filters
4) *Frequency domain filtering* – Impulse and its properties, Fourier series, Fourier Transform of one variable, two variables (continuous and discrete), Aliasing, signal reconstruction from sampled data, DFT, Frequency domain filters and its operation
5) *Image Restoration* -- Mathematical model of degradation, Noise models, Linear position-invariant degradation, Estimating the degradation function, Inverse filtering, Wiener filtering, Constraint least square filtering. Advanced applications
6) *Image Segmentation* -- Point, line and edge detection, Hough Transformation, Thresholding, Region-based segmentation, Motion-based segmentation. Advanced Techniques
7) *Representation and Description* -- Representation, Boundary descriptors, regional descriptors, Principal components for description, SIFT.
8) *Object Recognition:* Bayes Classifier, Neural Network based Classifier, CNN-based classifier

Readings:

1. R. C. Gonzalez, R. E. Woods, "Digital Image Processing", 3rd Edition, Pearson Prentice Hall, 2008.
2. M. Sonka, V. Hlavac, R. Boyel, "Image Processing Analysis, and Machine Vision", 2nd Edition, PWS Publishing, 1999.
3. S. E. Umbaugh, "Digital Image Processing and Analysis", 2nd Edition, CRC Press, 2010.
4. A. L. Bovik, "The Essential Guide to Image Processing", Academic Press, 2009.
5. Research Articles (suggested by the instructors)

Assessment Method: In-semester examinations, End-semester examination, Lab assignments, Mini-project, Quizzes (online mode)

Course Outcomes:

After completion of this course, students should be able to:

- Understand the methods of processing an image for a particular application. [P1]
- Identify the reason of image degradation, and formulate the model to address the issue. [P2]
- Get ideas to develop new algorithms for processing images. [P3, P4, P5]
- Analyze the shortcomings of existing methods, and ponder upon those. [P2, P5]
- Work in a group for a project, and present their work to engineering community [P9, P10].

P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12
x	x	x	x	x				x	x		

Lecture Schedule

Sl. No.	Description		No. of Lectures
1	**Basics of Digital Image and Processing Steps**		9
	1.1	Concepts of Signal, Image; History; Applications	
	1.2	Fundamental processing steps; Human visual system; Formation model; Sampling; Quantization	
	1.3	Pixel Relationship, Operations on Images (Pixels, spatial), Affine transformations	
	1.4	Image Registration, Image Interpolation	
2	**Intensity transformations**		3
	2.1	Contrast, Image negative, Log transform, Gamma Transform, Contrast Stretching, Intensity level slicing, Bit-plane slicing	
	2.2	Histogram, Histogram Equalization, Histogram Specification, Local Histogram Processing	
	2.3	Advanced Application	
3	**Spatial Filtering**		5
	3.1	Concept of filtering, Mechanics of spatial filtering, spatial correlation and convolution	

	3.2	Filtering for image smoothing and sharpening	
	3.3	Convolution by matrix vector multiplications	
	3.4	Advanced spatial domain filter	
4	**Frequency Domain Filtering**		**7**
	4.1	Fourier Series, Impulses and their sifting properties	
	4.2	Fourier transform of one continuous variable, Fourier transform of convolution, Fourier transform of sampled functions, Sampling theorem	
	4.3	Signal Recovery, Aliasing, DFT, 2D DFT	
	4.4	Fourier magnitude spectrum and phase, 2D convolution theorem, Fundamental steps of filtering in frequency domain	
	4.5	LPF with Ideal, Butterworth, Gaussian, HPF with Ideal, Butterworth, Gaussian, Laplacian, Homomorphic filtering, FFT	
5	**Image Restoration**		**6**
	5.1	Degradation model, Noise models, Estimation of noise parameters	
	5.2	Noise only restoration by mean filters, order statistic filters, frequency domain filtering	
	5.3	Estimation of degradation function, and restoration	
	5.4	Advanced topics	
6	**Image Segmentation**		**6**
	6.1	Point, line and edge detection	
	6.2	Edge linking	
	6.3	Thresholding	
7	**Representation and Description**		**3**
	7.1	Representation	
	7.2	Boundary Descriptors, Regional Descriptors	
	7.3	PCA, SIFT	
8	**Object Recognition**		**3**
	8.1	Bayes Classifier, NN Classifier, CNN Classifier	