



---

**Chapter 1 : Introduction to Image Processing**  
**1-1 to 1-11**

---

1.1	Introduction .....	1-1
1.2	What Do We Mean by Image Processing ?.....	1-1
1.3	Images .....	1-2
1.4	The Electromagnetic Spectrum .....	1-3
1.5	Units of Intensity.....	1-4
1.6	The Inverse Square Law.....	1-4
✓	<b>Syllabus Topic :</b> Human Visual System .....	1-5
1.7	The Human Visual System ( <b>May 2016, Dec. 2016</b> ) .....	1-5
1.7.1	Image Formation in Eye .....	1-6
1.7.2	Visual Phenomena .....	1-7
1.7.3	Dynamic Range and Contrast.....	1-9
1.7.4	Radiance and Luminance.....	1-9
1.7.5	Applications of Image Processing.....	1-9
1.8	Object Recognition .....	1-10
1.9	Image Processing, Computer Graphics and Computer Vision.....	1-11

---

**Chapter 2 : Image Sensing and Acquisition** **2-1 to 2-11**

---

✓	<b>Syllabus Topic :</b> Steps in Image Processing.....	2-1
2.1	Introduction ( <b>Aug. 2015, Dec. 2017</b> ) .....	2-1
✓	<b>Syllabus Topic :</b> Representing Digital Images.....	2-6
2.2	Image Types .....	2-6
✓	<b>Syllabus Topic :</b> Image File Formats .....	2-9
2.3	Image File Formats ( <b>May 2016, May 2017</b> ) .....	2-9

---

**Chapter 3 : Sampling and Quantization** **3-1 to 3-12**

---

3.1	Introduction .....	3-1
✓	<b>Syllabus Topic :</b> Sampling .....	3-1
3.2	Sampling ( <b>May 2016, Oct. 2016, May 2017</b> ) .....	3-1
✓	<b>Syllabus Topic :</b> Quantization, Spatial and Gray Level Resolution .....	3-7
3.3	Quantization ( <b>May 2016, Oct. 2016, Dec. 2017</b> ) .....	3-7
3.4	Isopreference Curves .....	3-9
3.5	Non-uniform Sampling.....	3-10
3.6	Physical Resolution .....	3-10

---

**Chapter 4 : Image Enhancement in Spatial Domain**  
**4-1 to 4-41**

---

4.1	Introduction .....	4-1
-----	--------------------	-----

---

4.2	Spatial Domain Methods .....	4-1
4.3	Point Processing ( <b>Dec. 2017</b> ).....	4-2
4.3.1	Digital Negative .....	4-2
✓	<b>Syllabus Topic :</b> Piecewise Linear Transformation.....	4-3
4.3.2	Contrast Stretching ( <b>Aug. 2015, Dec. 2016</b> ).....	4-3
4.3.3	Thresholding .....	4-4
4.3.4	Grey Level Slicing (Intensity Slicing).....	4-5
4.3.5	Bit Plane Slicing .....	4-7
✓	<b>Syllabus Topic :</b> Point Log Transformation .....	4-10
4.3.6	Dynamic Range Compression (Log Transformation) ( <b>Aug. 2015, May 2016, Dec. 2017</b> ) .....	4-10
✓	<b>Syllabus Topic :</b> Power Law Transformation.....	4-11
4.3.7	Power Law Transformation ( <b>Aug. 2015, Dec. 2015, Dec. 2016, Dec. 2017</b> ) .....	4-11
4.3.8	Spatial and Intensity Resolution .....	4-12
4.4	Solved Examples on Point Processing .....	4-12
4.4(A)	Image Subtraction ( <b>Dec. 2015, Dec. 2016</b> ) .....	4-17
✓	<b>Syllabus Topic :</b> Mask Processing of Images .....	4-17
4.5	Neighbourhood Processing .....	4-17
4.5.1	Low Pass Filtering (Smoothing).....	4-18
4.5.2	Noise.....	4-18
✓	<b>Syllabus Topic :</b> Filtering Operation - Image Smoothing.....	4-20
4.5.3	Low Pass Averaging Filter (Smoothing) ( <b>May 2017</b> ).....	4-20
4.5.4	Low Pass Median Filtering ( <b>May 2016, May 2017</b> ) .....	4-24
✓	<b>Syllabus Topic :</b> Filtering Operation - Image Sharpening.....	4-26
4.6	Highpass Filtering ( <b>May 2016</b> ).....	4-26
4.7	High-Boost Filtering.....	4-28
4.8	Zooming .....	4-30
4.8.1	Replication .....	4-30
4.8.2	Linear Interpolation.....	4-32
4.9	Solved Examples on Neighbourhood Processing .....	4-34
4.10	Difference between Point Processing and Mask Processing ( <b>May 2017</b> ) .....	4-39

---

**Chapter 5 : Histogram Modelling** **5-1 to 5-24**

---

✓	<b>Syllabus Topic :</b> Image Histogram.....	5-1
5.1	Introduction ( <b>Aug. 2015, Dec. 2017</b> ) .....	5-1
5.1.1	Mean and Standard Deviation of Histogram .....	5-3

---



5.2	Linear Stretching .....	5-4	6.8	Periodic Noise (Sinusoidal Noise) ( <b>Dec. 2015</b> ) .....	6-31
✓	<b>Syllabus Topic :</b> Histogram Equalization.....	5-7	6.9	Relationship between Filtering in the Spatial and Frequency Domain .....	6-34
5.3	Histogram Equalization.....	5-7	6.9.1	Generating $h(x, y)$ from $H(u, v)$ .....	6-34
5.4	Histogram Specification.....	5-14	6.9.2	Generating $H(u, v)$ from $h(x, y)$ .....	6-36
5.5	Additional Examples on Histogram Modelling.....	5-16			
<b>Chapter 6 : Image Enhancement in Frequency Domain</b> <span style="float: right;"><b>6-1 to 6-42</b></span>			<b>Chapter 7 : Image Segmentation</b> <span style="float: right;"><b>7-1 to 7-65</b></span>		
6.1	Introduction .....	6-1	7.1	Introduction ( <b>Dec. 2016, May 2017</b> ) .....	7-1
6.2	The Fourier Transform.....	6-1	7.2	Image Segmentation based on Discontinuities .....	7-2
6.3	1-Dimensional Fourier Transform .....	6-2	7.2.1	Point Detection ( <b>Dec. 2017</b> ) .....	7-2
✓	<b>Syllabus Topic :</b> 2D-DFT .....	6-4	7.2.2	Line Detection .....	7-2
6.4	2-Dimensional Fourier Transform .....	6-4	✓	<b>Syllabus Topic :</b> Edge Detection.....	7-3
6.4.1	Properties of Discrete Fourier Transform.....	6-7	7.2.3	Edge Detection.....	7-3
6.4.1.1	The Separability Property .....	6-8	7.3	Detection of Edges ( <b>Dec. 2015, Dec. 2016</b> ) .....	7-5
6.4.1.2	Translation Property (Shifting Property).....	6-10	7.3.1	Computing the Gradient .....	7-6
6.4.1.3	Periodicity and Conjugate Symmetry Property.....	6-11	7.4	Finding Gradients using Masks .....	7-7
6.4.1.4	Rotation Property ( <b>Aug. 2015</b> ).....	6-13	7.4.1	Roberts Mask .....	7-8
6.4.1.5	Distributive and Scaling Property ( <b>Aug. 2015</b> ).....	6-14	✓	<b>Syllabus Topic :</b> First Order Derivative Prewitt and Sobel.....	7-10
6.4.1.6	Average Value Property.....	6-14	7.4.2	Prewitts and Sobel Operators ( <b>Dec. 2017</b> ) .....	7-10
6.4.1.7	Laplacian Property (Second Derivative).....	6-14	7.4.3	Compass Operators .....	7-13
6.4.1.8	Convolution Property .....	6-15	7.5	Image Segmentation using the Second Derivative - the Laplacian ( <b>Dec. 2015, Dec. 2016</b> ) ....	7-15
6.4.2	Image Enhancement in Frequency Domain ( <b>Oct. 2016, Dec. 2017</b> ).....	6-15	✓	<b>Syllabus Topic :</b> Second Order Derivative - LoG.....	7-17
✓	<b>Syllabus Topic :</b> Smoothing in Frequency Domain...6-17		7.5.1	Laplacian of Gaussian Operator ( <b>May 2016</b> ) .....	7-17
6.5	Low Pass Frequency Domain Filters .....	6-17	✓	<b>Syllabus Topic :</b> Second Order Derivative - Canny ..	7-19
6.5.1	Ideal Low Pass Filter (ILPF) .....	6-17	7.5.2	Canny Edge Detector ( <b>May 2016</b> ) .....	7-19
6.5.2	Butterworth Low Pass Filters (BLPF).....	6-21	✓	<b>Syllabus Topic :</b> Second Order Derivative - DoG ....	7-20
6.5.3	Gaussian Low Pass Filter (GLPF) .....	6-22	7.5.3	Difference of Gaussian (DoG) ( <b>May 2016</b> ).....	7-20
✓	<b>Syllabus Topic :</b> Sharpening in Frequency Domain .6-23		✓	<b>Syllabus Topic :</b> Edge Linking .....	7-20
6.6	High Pass Frequency Domain Filters .....	6-23	7.6	Edge Linking .....	7-20
6.6.1	Ideal High Pass Filter (IHPF) .....	6-24	7.6.1	Local Processing.....	7-20
6.6.2	Butterworth High Pass Filter (BHPF) .....	6-25	✓	<b>Syllabus Topic :</b> Hough Transform .....	7-21
6.6.3	Gaussian High Pass Filter (GHPF).....	6-26	7.6.2	Hough Transform ( <b>Dec. 2016</b> ).....	7-21
6.6.4	High Boost Filtering (Unsharp Masking / High Frequency Emphasis) .....	6-27	7.7	Global Processing via Graph - Theoretic Techniques.....	7-35
6.7	Homomorphic Filtering ( <b>May 2016, Dec. 2016</b> ) .....	6-28	✓	<b>Syllabus Topic :</b> Pixel Classification .....	7-37
			7.8	Connectivity ( <b>Aug. 2015</b> ).....	7-37
			7.9	Distance Transform ( <b>Dec. 2016, May 2017</b> ).....	7-39



7.10	Region based Segmentation (Segmentation based on Similarities) ( <b>Dec. 2016</b> ).....	7-41	✓	<b>Syllabus Topic :</b> Arithmetic Coding .....8-14
✓	<b>Syllabus Topic :</b> Region growing.....	7-42	8.5	Arithmetic Coding ( <b>Dec. 2015</b> ) .....8-14
7.10.1	Region Growing ( <b>Dec. 2015, Dec. 2016, Dec. 2017</b> ).....	7-42	8.5.1	Bit Plane Coding ( <b>Dec. 2015, Dec. 2016</b> ) .....8-20
7.10.2	Region Splitting ( <b>Dec. 2015, Dec. 2016</b> ) .....	7-46	✓	<b>Syllabus Topic :</b> Lossy Compression .....8-21
✓	<b>Syllabus Topic :</b> Region Merging .....	7-48	8.6	Lossy Compression ( <b>May 2016, Dec. 2016</b> ) .....8-21
7.10.3	Region Merging ( <b>Dec. 2015, Dec. 2016</b> ) .....	7-48	8.6.1	Improved Grey Scale (IGS) Quantization .....8-21
7.10.4	Split and Merge ( <b>Dec. 2017</b> ).....	7-48	8.6.2	Predictive Coding (Differential Pulse Code Modulation - DPCM) .....8-24
✓	<b>Syllabus Topic :</b> Bi-level, Multi-level Thresholding ...	7-50	✓	<b>Syllabus Topic :</b> DCT based Compression .....8-25
7.11	Image Segmentation based on Thresholding ( <b>Dec. 2015</b> ) .....	7-50	8.6.3	Transform Coding (JPEG Coding) .....8-25
7.11.1	Global Thresholding ( <b>May 2016, Dec. 2016</b> ) .....	7-51	✓	<b>Syllabus Topic :</b> Introduction to DCT .....8-25
✓	<b>Syllabus Topic :</b> Adaptive Thresholding .....	7-53	8.7	Discrete Cosine Transform (DCT) ( <b>Dec. 2015, Oct. 2016</b> ) .....8-25
7.11.2	Local (Adaptive) Thresholding ( <b>May 2016, Dec. 2016, May 2017</b> ) .....	7-53	✓	<b>Syllabus Topic :</b> Image Compression Standard - JPEG .....8-29
7.11.3	Optimum Thresholding .....	7-57	8.7.1	Joint Photographic Experts Group (JPEG) ( <b>Aug. 2015, Oct. 2016, Dec. 2016, Dec. 2017</b> ) .....8-29
7.12	Additional Solved Examples .....	7-58	8.7.2	Blocking Artefact ( <b>May 2017</b> ) .....8-35
<b>Chapter 8 : Image Compression</b>		<b>8-1 to 8-47</b>	✓	<b>Syllabus Topic :</b> Image Compression Standard - JPEG 2000, Wavelet based Compression .....8-35
8.1	Introduction .....	8-1	8.7.3	JPEG 2000 ( <b>May 2016</b> ) .....8-35
8.2	Redundant and Irrelevant Data.....	8-1	✓	<b>Syllabus Topic :</b> Compression Models - Information Theoretic Perspective .....8-36
✓	<b>Syllabus Topic :</b> Fidelity Criteria .....	8-2	8.8	Image Compression Model .....8-36
8.3	Error Criteria (Fidelity Criteria) ( <b>Aug. 2015, Dec. 2015, May 2017</b> ) .....	8-2	8.9	Comparison of Lossless and Lossy Compression ....8-38
8.3.1	Objective Error Criteria .....	8-3	8.10	Solved Examples .....8-38
8.3.2	Subjective Error Criteria .....	8-4	<b>Chapter 9 : Image Morphology</b>	
✓	<b>Syllabus Topic :</b> Types of Redundancy.....	8-4	<b>9-1 to 9-37</b>	
8.3(A)	Redundancy in an Image ( <b>Aug. 2015, Oct. 2016, Dec. 2017</b> ) .....	8-4	9.1	Introduction ( <b>Dec. 2015, May 2017</b> ) .....9-1
✓	<b>Syllabus Topic :</b> Lossless Compression .....	8-4	9.2	Arithmetic and Logical Operation .....9-1
8.4	Lossless Compression Techniques ( <b>May 2016, Dec. 2016</b> ) .....	8-4	9.2.1	Arithmetic Operations .....9-1
8.4.1	Dictionary Based Coding .....	8-5	9.2.2	Logical Operations ( <b>Dec. 2015</b> ) .....9-1
8.4.1(A)	Run Length Encoding (RLE) ( <b>Dec. 2016, Dec. 2017</b> ) .....	8-5	9.3	Basic Definitions ( <b>May 2016</b> ) .....9-2
8.4.1(B)	The LZW Compression .....	8-6	✓	<b>Syllabus Topic :</b> Morphological Operator : Dilation ....9-3
8.4.2	Statistical Coding ( <b>May 2017</b> ).....	8-8	9.3.1	Dilation ( <b>May 2017</b> ) .....9-3
✓	<b>Syllabus Topic :</b> Huffman Coding .....	8-9	✓	<b>Syllabus Topic :</b> Morphological Operator : Erosion ....9-3
8.4.3	Huffman Encoding ( <b>May 2016</b> ).....	8-9	9.3.2	Erosion .....9-3
			9.4	A Simple Practical Formula for Implementing Dilation and Erosion .....9-4
			9.5	Structuring Elements .....9-6



✓	<b>Syllabus Topic :</b> Morphological Operator : Opening, Closing .....	9-9	10.2.1	Computing $\mu$ in Terms of m .....	10-11
9.6	Opening and Closing Operations ( <b>Dec. 2017</b> ) .....	9-9	✓	<b>Syllabus Topic :</b> Regional Descriptor - Texture .....	10-14
9.6.1	Opening.....	9-9	10.3	Texture <b>(Dec. 2015, May 2016, Dec. 2016, Dec. 2017)</b> .....	10-14
9.6.2	Closing .....	9-9	10.3.1	Statistical Texture Analysis.....	10-15
9.7	Basic Morphological Operations .....	9-13	10.3.2	Structural Texture Analysis.....	10-16
✓	<b>Syllabus Topic :</b> Boundary Detection .....	9-13	10.3.3	Spectral Texture Analysis.....	10-17
9.7.1	Boundary Extraction ( <b>May 2017</b> ) .....	9-13	10.4	Solved Examples.....	10-17
9.7.2	Region Filling.....	9-15	<hr/>		
✓	<b>Syllabus Topic :</b> Hit or Miss Transform .....	9-19	<b>Chapter 11 : Image Restoration</b> <b>11-1 to 11-16</b>		
9.8	HIT - or - MISS Transformation <b>(May 2016, Dec. 2016, Dec. 2017)</b> .....	9-19	11.1	Introduction ( <b>Oct. 2016</b> ) .....	11-1
✓	<b>Syllabus Topic :</b> Thinning, Thickening .....	9-24	11.2	Degradation Model ( <b>Oct. 2016, May 2017</b> ).....	11-1
9.9	Thinning and Thickening Transformation <b>(May 2017)</b> .....	9-24	11.3	Degradation Functions .....	11-2
9.10	Convex Hull.....	9-27	11.3.1	Noise and Degradation .....	11-2
✓	<b>Syllabus Topic :</b> Skeleton .....	9-29	11.4	Discrete Degradation Model .....	11-2
9.11	Skeletonization ( <b>May 2016</b> ) .....	9-29	✓	<b>Syllabus Topic :</b> Restoration using Inverse Filtering	11-3
9.12	Pruning.....	9-33	11.5	Inverse Filtering ( <b>May 2016, Dec. 2017</b> ).....	11-3
<hr/>					
<b>Chapter 10 : Image Representation and Description</b>			<b>10-1 to 10-20</b>		
10.1	Feature Extraction ( <b>Dec. 2015, May 2017</b> ) .....	10-1	11.5.1	Pseudo-Inverse Filtering.....	11-3
✓	<b>Syllabus Topic :</b> Representation - Chain Codes.....	10-1	✓	<b>Syllabus Topic :</b> Restoration using Wiener Filtering.	11-4
10.1.1	Chain Codes ( <b>Dec. 2015, May 2016, Dec. 2016, May 2017, Dec. 2017</b> ).....	10-1	11.6	Wiener Filter.....	11-4
✓	<b>Syllabus Topic :</b> Shape Numbers .....	10-3	11.6.1	Drawback of Wiener Filters .....	11-6
10.1.2	First Difference, Shape Number and Order <b>(Dec. 2017)</b> .....	10-3	11.7	Power Spectrum Equalisation (P.S.E.) .....	11-6
✓	<b>Syllabus Topic :</b> Fourier Descriptors.....	10-5	11.7.1	Geometric Mean Filters .....	11-6
10.1.3	Fourier Descriptors <b>(SPPU - Dec. 2015, Dec. 2016, Dec. 2017)</b> .....	10-5	11.8	Mean Filter .....	11-7
✓	<b>Syllabus Topic :</b> Representation-Signatures .....	10-6	11.9	Max- Min Filter.....	11-8
10.1.4	Signatures ( <b>May 2016, Dec. 2017</b> ).....	10-6	✓	<b>Syllabus Topic :</b> Noise Models.....	11-10
✓	<b>Syllabus Topic :</b> Regional Descriptor - Topological..	10-8	11.10	Noise Models ( <b>Aug. 2015, Dec. 2016</b> ) .....	11-10
10.1.5	Euler Number (Topological Descriptors) <b>(Dec. 2015, Dec. 2016)</b> .....	10-8	11.10.1	Additive White Noise Gaussian Noise (AWGN) Model.....	11-13
✓	<b>Syllabus Topic :</b> Representation-Polygonal Approximation .....	10-8	11.11	Statistical Properties of Image.....	11-14
10.1.6	Polygonal Approximations ( <b>May 2016</b> ) .....	10-8	11.11.1	Mean .....	11-14
✓	<b>Syllabus Topic :</b> Statistical Moments .....	10-9	11.11.2	Variance .....	11-14
10.2	Moments ( <b>May 2016, Dec. 2016, Dec. 2017</b> ) .....	10-9	11.11.3	Signal to Noise Ratio (SNR) .....	11-14
			11.11.4	Peak Signal-to-Noise Ratio (PSNR) .....	11-14
			11.11.5	Standard Deviation.....	11-14
			11.12	Scaling, Rotation and Translation Operations <b>(May 2016, Oct. 2016)</b> .....	11-14



11.13 Comparison of Image Enhancement and Image Restoration (Aug. 2015, Dec. 2015).....	11-15	13.7 Component Video.....	13-5
<b>Chapter 12 : Colour Image Processing 12-1 to 12-23</b>		<b>✓ Syllabus Topic :</b> Digital Video .....	13-6
✓ <b>Syllabus Topic :</b> Colour Fundamentals .....	12-1	13.8 Digital Video .....	13-6
12.1 Introduction .....	12-1	13.8.1 Sampling of Video Signals.....	13-6
✓ <b>Syllabus Topic :</b> Colour Models .....	12-2	✓ <b>Syllabus Topic :</b> Color Models in Video .....	13-7
12.2 Colour Models (Dec. 2015, Oct. 2016, Dec. 2017)....	12-2	13.8.2 The Rec.601 Video Format .....	13-7
✓ <b>Syllabus Topic :</b> RGB Colour Model .....	12-2	13.8.3 Digital Video from a Digital Camera.....	13-7
12.2.1 RGB Colour Model .....	12-2	13.8.4 Process of Capturing Digital Image / Video .....	13-8
✓ <b>Syllabus Topic :</b> YIQ Colour Model.....	12-5	13.9 Advantages of Digital Video .....	13-8
12.2.2 NTSC Colour Model (May 2017).....	12-5	<b>Chapter 14 : Motion Estimation 14-1 to 14-10</b>	
12.2.3 YCbCr Colour Model .....	12-7	14.1 Introduction .....	14-1
12.2.4 CMY and CMYK Models.....	12-8	14.2 2-D Motion and Optical Flow .....	14-2
✓ <b>Syllabus Topic :</b> HIS Colour Model .....	12-10	14.3 Motion Estimation.....	14-3
12.2.5 HSI Colour Model (Aug. 2015, Dec. 2016) .....	12-10	14.4 Region of Support .....	14-4
12.2.6 Comparison of RGB and YIQ Colour Model (Dec. 2015) .....	12-13	14.4.1 Global Region of Support .....	14-4
✓ <b>Syllabus Topic :</b> Pseudo Colouring.....	12-14	14.4.2 Pixel based Region of Support .....	14-4
12.3 Pseudo-Colouring.....	12-14	14.4.3 Block based Region of Support .....	14-4
12.4 Full-Colour Image Processing .....	12-15	14.4.4 Object based Region of Support.....	14-4
12.4.1 Colour Image Smoothing (Low Pass Averaging) ....	12-16	14.5 Motion Estimation Methods .....	14-5
12.4.2 Colour Image Sharpening (High Pass Filtering).....	12-17	✓ <b>Syllabus Topic :</b> Video Compression .....	14-5
12.5 Colour Segmentation.....	12-19	14.6 Motion Estimation Algorithms.....	14-5
12.5.1 Segmentation using HSI Model .....	12-19	14.6.1 Phase Correlation Method .....	14-6
12.5.2 Segmentation using RGB Model .....	12-21	14.6.2 Optical Flow Equation.....	14-6
12.6 Chromatic Adaptation.....	12-22	14.6.3 Block Matching Method .....	14-7
<b>Chapter 13 : Introduction to Video 13-1 to 13-8</b>		14.7 Search Techniques .....	14-8
✓ <b>Syllabus Topic :</b> Fundamental Concepts in Video....	13-1	14.7.1 Exhaustive Search Block Matching Algorithm (EMBA).....	14-8
13.1 Introduction .....	13-1	14.7.2 Hierarchical Search Method .....	14-8
13.2 Basics of Video .....	13-1	✓ <b>Syllabus Topic :</b> Video Compression, Video Coding Standards MPEG .....	14-8
13.3 Persistence of Vision.....	13-2	14.8 Video Compression Standards .....	14-8
13.4 Gamma Correction .....	13-3	• <b>Multicolor Diagrams</b>	
13.5 Colour Video Signals .....	13-3		
✓ <b>Syllabus Topic :</b> Types of Video Signals, Analog Video.....	13-4		
13.6 Composite Video .....	13-4		
✓ <b>Syllabus Topic :</b> Analog Video.....	13-5		