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
1.7 The Human Visual System....1-5
1.7.1 Image Formation in Eye 1-6
1.7.2 Visual Phenomena 1-6
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....1-10
• Chapter Ends 1-11

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

2.1 Introduction 2-1
2.2 Image Types 2-6
2.3 Image File Formats 2-9
• Chapter Ends 2-11

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

3.1 Introduction 3-1
3.2 Sampling 3-1
3.3 Quantization **(Dec. 15, May 17, Dec. 17)**....3-7
3.4 Isopreference Curves 3-9
3.5 Non-uniform Sampling....3-10
3.6 Physical Resolution 3-10
3.7 University Questions....3-12
• Chapter Ends 3-12

Chapter 4 : Image Enhancement in Spatial Domain 4-1 to 4-46

4.1 Introduction 4-1
4.2 Spatial Domain Methods 4-1
4.3 Point Processing **(Dec. 15)**....4-2
4.3.1 Digital Negative 4-2
4.3.2 Contrast Stretching....4-3
4.3.3 Thresholding....4-4
4.3.4 Grey Level Slicing (Intensity Slicing)....4-5
4.3.5 Bit Plane Slicing **(May 16)** 4-7
4.3.5(A) Applications of Bit Plane Slicing **(Dec. 17)**....4-10
4.3.6 Dynamic Range Compression (Log Transformation) **(Dec. 16)** 4-10
4.3.7 Power Law Transformation....4-11
4.3.8 Spatial and Intensity Resolution 4-11
4.4 Solved Examples on Point Processing 4-12
4.4(A) Image Subtraction 4-18
4.5 Neighbourhood Processing 4-18
4.5.1 Low Pass Filtering (Smoothing)....4-20
4.5.2 Noise....4-20
4.5.3 Low Pass Averaging Filter(Smoothing)....4-21
4.5.4 Low Pass Median Filtering....4-25
4.6 Highpass Filtering....4-27
4.7 High-Boost Filtering....4-29
4.7.1 Advantages of High Boot Filtering **(Dec. 17)**....4-31
4.8 Zooming....4-31
4.8.1 Replication 4-31
4.8.2 Linear Interpolation....4-33
4.9 Geometric Transformation....4-34
4.9.1 Euclidean Transformations....4-34
4.9.2 Affine Transformation 4-35
4.9.2(A) Scaling 4-35
4.9.2(B) Shear 4-36
4.10 Solved Examples on Neighbourhood Processing 4-36
4.11 Difference between Point Processing and Mask Processing 4-44
4.12 University Questions 4-46
• Chapter Ends 4-46

Chapter 5 : Histogram Modelling 5-1 to 5-28

5.1 Introduction **(May 18)** 5-1
5.1.1 Mean and Standard Deviation of Histogram 5-3
5.2 Linear Stretching 5-3
5.3 Histogram Equalization....5-6
5.4 Histogram Specification....5-14
5.5 Additional Examples on Histogram Modelling....5-16
5.6 Difference between Histogram Equalization and Contrast Stretching....5-26
5.7 University Questions 5-27
• Chapter Ends 5-28

Chapter 6 : Image Enhancement in Frequency Domain 6-1 to 6-42

6.1 Introduction 6-1
6.2 The Fourier Transform....6-1
6.3 1-Dimensional Fourier Transform 6-2
6.4 2-Dimensional Fourier Transform 6-4
6.4.1 Properties of Discrete Fourier Transform **(May 18)**....6-7
6.4.1(1) The Separability Property 6-7
6.4.1(2) Translation Property (Shifting Property) **(Dec. 17)** 6-10
6.4.1(3) Periodicity and Conjugate Symmetry Property 6-11
6.4.1(4) Rotation Property 6-13
6.4.1(5) Distributive and Scaling Property....6-13

6.4.1(6) Average Value Property....6-14
6.4.1(7) Laplacian Property (Second Derivative)....6-14
6.4.1(8) Convolution Property **(May 18)**....6-14
6.4.2 Image Enhancement in Frequency Domain **(Dec. 15, May 16, Dec. 16, May 17, Dec. 17)**....6-15
6.5 Low Pass Frequency Domain Filters **(Dec. 16)**....6-16
6.5.1 Ideal Low Pass Filter (ILPF)....6-17
6.5.2 Butterworth Low Pass Filters (BLPF)....6-20
6.5.3 Gaussian Low Pass Filter (GLPF)....6-22
6.6 High Pass Frequency Domain Filters **(Dec. 16)**....6-23
6.6.1 Ideal High Pass Filter (IHPF)....6-23
6.6.2 Butterworth High Pass Filter (BHPF)....6-24
6.6.3 Gaussian High Pass Filter (GHPF)....6-25
6.6.4 High Boost Filtering (Unsharp Masking / High Frequency Emphasis)....6-26
6.7 Homomorphic Filtering **(May 18)**....6-27
6.8 Periodic Noise (Sinusoidal Noise)....6-30
6.9 Relationship between Filtering in the Spatial and Frequency Domain....6-32
6.9.1 Generating h(x, y) from H(u, v)....6-33
6.9.2 Generating H(u, v) from h(x, y)....6-34
6.10 University Questions....6-41
- Chapter Ends....6-42

Chapter 7 : Image Segmentation 7-1 to 7-68

7.1 Introduction....7-1
7.2 Image Segmentation based on Discontinuities....7-2
7.2.1 Point Detection....7-2
7.2.2 Line Detection....7-2
7.2.3 Edge Detection **(Dec. 16)**....7-3
7.3 Detection of Edges....7-5
7.3.1 Computing the Gradient....7-6
7.4 Finding Gradients using Masks....7-7
7.4.1 Roberts Mask **(May 16)**....7-8
7.4.2 Prewitts and Sobel Operators **(May 16)**....7-10
7.4.3 Compass Operators **(May 16)**....7-13
7.4.3(1) Applications/Advantages of Compass Operator **(Dec. 17)**....7-15
7.5 Image Segmentation using the Second Derivative - The Laplacian **(May 16)**....7-15
7.5.1 Laplacian of Gaussian Operator....7-16
7.5.2 Canny Edge Detector....7-19
7.5.3 Difference of Gaussian (DoG)....7-19
7.6 Edge Linking....7-20
7.6.1 Local Processing....7-20
7.6.2 Hough Transform **(Dec. 15)**....7-20
7.6.2(1) Applications/Advantages of Hough Transform **(Dec. 17)**....7-33
7.7 Global Processing via Graph - Theoretic Techniques....7-33
7.8 Connectivity **(May 16, May 17)**....7-37
7.9 Distance Transform....7-39
7.10 Region based Segmentation (Segmentation based on Similarities) **(Dec. 15)**....7-41
7.10.1 Region Growing....7-42
7.10.2 Region Splitting....7-46
7.10.3 Region Merging....7-47
7.10.4 Split and Merge **(May 18)**....7-48
7.11 Image Segmentation based on Thresholding....7-50
7.11.1 Global Thresholding....7-51
7.11.2 Local (Adaptive) Thresholding....7-53
7.11.3 Optimum Thresholding....7-56
7.12 Additional Solved Examples....7-57
7.13 University Questions....7-67
- Chapter Ends....7-68

Chapter 8 : Image Morphology 8-1 to 8-31

8.1 Introduction....8-1
8.2 Arithmetic and Logical Operation....8-1
8.2.1 Arithmetic Operations....8-1
8.2.2 Logical Operations....8-1
8.3 Basic Definitions....8-2
8.3.1 Dilation....8-3
8.3.2 Erosion....8-3
8.4 A Simple Practical Formula for Implementing Dilation and Erosion **(MU - May 17)**....8-4
8.5 Structuring Elements....8-6
8.6 Opening and Closing Operations **(MU - Dec. 15, Dec. 17, May 18)**....8-9
8.6.1 Opening....8-9
8.6.2 Closing....8-9
8.7 Basic Morphological Operations....8-14
8.7.1 Boundary Extraction....8-14
8.7.2 Region Filling....8-15
8.8 HIT - or - MISS Transformation **(MU - Dec. 15, Dec. 16, May 18)**....8-18
8.9 Thinning and Thickening Transformation....8-22
8.9.1 Comparison of Dilation and Erosion **(MU - Dec. 16)**....8-24
8.10 Solved Examples....8-24
8.11 University Questions....8-30
- Chapter Ends....8-31

Chapter 9 : Image Compression 9-1 to 9-44

9.1 Introduction....9-1
9.2 Redundant and Irrelevant Data....9-1
9.3 Error Criteria (Fidelity Criteria)....9-2
9.3.1 Objective Error Criteria....9-2
9.3.2 Subjective Error Criteria....9-4

9.3(A) Redundancy in an Image....9-4
9.4 Lossless Compression Techniques....9-4
9.4.1 Dictionary Based Coding....9-4
9.4.1(A) Run Length Encoding (RLE)....9-5
9.4.1(B) The LZW Compression....9-5
9.4.2 Statistical Coding....9-7
9.4.3 Huffman Encoding....9-8
9.5 Arithmetic Coding....9-13
9.5.1 Bit Plane Coding....9-19
9.6 Lossy Compression....9-20
9.6.1 Improved Grey Scale (IGS) Quantization....9-20
9.6.2 Predictive Coding (Differential Pulse Code Modulation - DPCM)....9-23
9.6.3 Transform Coding (JPEG Coding)....9-24
9.7 Discrete Cosine Transform (DCT)....9-24
9.7.1 Joint Photographic Experts Group (JPEG)....9-27
9.7.2 Blocking Artefact....9-33
9.7.3 JPEG 2000....9-33
9.8 Image Compression Model....9-34
9.9 Comparison of Lossless and Lossy Compression....9-35
9.10 Solved Examples....9-36
- Chapter Ends....8-44

Chapter 10 : Introduction to Machine Vision 10-1 to 10-15

10.1 Introduction to Machine Vision....10-1
10.2 Feature Extraction....10-1
10.2.1 Chain Codes....10-1
10.2.2 First Difference, Shape Number and Order....10-3
10.2.3 Fourier Descriptors....10-5
10.2.4 Signatures....10-6
10.2.5 Euler Number (Topological Descriptors)....10-8
10.2.6 Polygonal Approximations....10-8
10.3 Moments....10-9
10.3.1 Computing μ in Terms of m....10-10
10.4 Texture....10-13
10.4.1 Statistical Texture Analysis....10-14
10.4.2 Structural Texture Analysis....10-15
10.4.3 Spectral Texture Analysis....10-15
- Chapter Ends....10-15

Chapter 11 : Machine Vision Applications in Industry 11-1 to 11-4

11.1 Low Angle Metal Surface (Crosshead) Inspection....11-1
11.1.1 Image Acquisition....11-1
11.1.2 Image Analysis....11-1
11.2 Machine Vision System for Quality Grading of Painted Slates....11-2
11.2.1 Algorithm....11-2
11.3 Inspecting Glass Bottles and Jars/ Stemware Inspection System....11-2
11.4 Glass Thickness Measurement Using Morphology....11-3
11.5 Inspecting Food Products....11-4
- Chapter Ends....11-4
- **Appendix A**....A-1- A-8

❑❑❑