Paper-III

CSE 903 TH: Machine Learning and Image Processing **Credit:4**

Course Outcomes (CO):

i. Understand the fundamental of machine learning and deep learning methodologies with real-time examples.
ii. Understand the fundamental of artificial neural networks with real-time examples.
iii. Understand the basic theory and algorithms/ techniques that are widely used in digital image processing.
iv. Understand image analysis algorithms.
v. Apply the definitions of the image classification and analysis problem to common problems in computer vision.
vi. Understand current applications of Image Processing.
vii. Develop hands-on experience in using computers to process images.
viii. Design and execute an implementation of an image processing system using tools such as PyTorch or TensorFlow.

Syllabus:

Machine Learning – Introduction: Machine learning applications, concepts learning, types of learning; **Feature extraction:** SIFT, Wavelet, HoG, GLCM, First and Higher Order Statistical features, PCA, SVD; **Instance-based Learning:** Nearest neighbor classification, k-nearest neighbor, modified k-nearest neighbour, nearest neighbor error probability; **Bayesian learning theory:** regression, feature selection, supervised learning, class conditional probability distributions, Examples of classifiers Bayes optimal classifier and error, learning classification approaches, handling continuous attributes; **Decision tree algorithms:** Inference model, general domains, symbolic decision trees, consistency, learning trees from training examples, entropy, mutual information, handling continuous and missing attributes, confidence, overfitting, pruning; **Support Vector Machine (SVM):** Kernel functions, implicit non-linear feature space, theory, hypothesis class, finite covering, margin-based bounds on risk, maximal margin, classifier; **Artificial Neural Network:** Hebbian Adaptation, Competitive Adaptation, Error Correction Adaptation; Single-layer and multi-layer feedforward and feedback neural networks, linear reparability, general gradient descent, perceptron learning algorithm, multi-Layer perceptron: two-layers universal approximators, backpropagation learning, important parameters, Margin of a classifier, dual perceptron algorithm, learning non-linear hypotheses with perceptron; **Self-Organization Maps (SOM):** Two Basic Feature Mapping Models, Self-Organization Map, SOM Algorithm, Properties of Feature Map; Associative Memory Network: Introduction, Algorithms for Pattern Association; Hetero Associative Memory Neural Network, Auto Associative memory Network, Bi-directional Associative Memory; **Machine learning assessment:** Statistical model selection, structural risk minimization, bootstrapping, bagging, boosting; Unsupervised learning: Introduction, Hard Clustering, Soft Clustering, Partitional Clustering, Hierarchical Clustering; **Deep learning methods**: Why deep learning? Intuition about deep representation, Training deep neural networks, Forward propagation and Backward propagation in Deep Neural Networks. Local minima problem, Gradient vanishing and explosion problem, pre-training, Auto-encoders, Activation functions-Sigmoid, ReLu, Tanh, Softplus, Approximated Sigmoid, etc. and their comparisons, Concepts of hyper parameters.

Image Processing – Introduction: image definition and its representation, neighbourhood. Orthogonal transformations like DFT, DCT, and Wavelet; **Enhancement:** contrast enhancement, smoothing and sharpening, filtering and restoration; **Segmentation:** pixel classification, global/local gray level thresholding, region growing, split/merge techniques, edge detection operators, Hough transform. Image

feature/primitive extraction, component labelling, medial axis transform, skeletonization/thinning, shape properties, textural features – moments, gray level co-occurrence matrix, structural features, Fourier descriptor, polygonal approximation. Compression: coding, quantization, spatial and transform domain-based compression. Color image processing: color model, enhancement, and segmentation; **Mathematical morphology:** basic concepts, erosion, dilation, opening, closing. Advanced applications like biomedical image processing, digital watermarking, etc.; **Image Compression:** Loss-less Compression by Run Length Coding, Huffman Coding, Predictive Coding, Lossy Compression by Block Truncation Coding, Vector Quantization, JPEG Compression

References:

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3. Chanda and D. Dutta Mazumdar, Digital Image Processing and Analysis, Prentice Hall of India, New Delhi, 2000.
4. T. M. Mitchell, Machine Learning, McGraw-Hill, 1997.
5. E. Alpaydin, Introduction to Machine Learning, Prentice Hall of India, 2006.
6. C. M. Bishop, Pattern Recognition and Machine Learning, Springer, 2006.
7. R. O. Duda, P. E. Hart, and D.G. Stork, Pattern Classification, John Wiley and Sons, 2001.