

**Unit I Kernel Methods and Radial-Basis Function Networks:** Cover's Theorem on the Separability of Pattern, The Interpolation Problem, Radial-Basis-Function Networks, Recursive Least-Squares Estimation of the Weight Vector, Hybrid Learning Procedure for RBF Networks, Interpretations of the Gaussian Hidden Units, Kernel Regression and Its Relation to RBF Networks

**Unit II Regularization Theory:** Hadamard's Conditions for Well-Posedness, Tikhonov's Regularization Theory, Regularization Networks, Generalized Radial-Basis-Function Networks, The Regularized Least-Squares Estimator, Estimation of the Regularization Parameter, Manifold Regularization, Differentiable Manifolds, Generalized Regularization Theory, Laplacian Regularized Least-Squares Algorithm

**Unit III Self-Organizing Maps:** Two Basic Feature-Mapping Models, Self-Organizing Map, Properties of the Feature Map, Contextual Maps, Hierarchical Vector Quantization, Kernel Self-Organizing Map, Relationship Between Kernel SOM and Kullback–Leibler Divergence.

**Unit IV Information-Theoretic Learning Models:** Entropy, Maximum-Entropy Principle, Mutual Information, Copulas, Mutual Information as an Objective Function to be Optimized, Maximum Mutual Information Principle, Infomax and Redundancy Reduction, Spatially Coherent Features, Spatially Incoherent Features, Independent-Components Analysis, Sparse Coding of Natural Images and Comparison with ICA Coding, Natural-Gradient Learning for Independent-Components Analysis, Maximum-Likelihood Estimation for Independent-Components Analysis, Maximum-Entropy Learning for Blind Source Separation, Maximization of Negentropy for Independent-Components Analysis, Coherent Independent-Components Analysis, Rate Distortion Theory and Information Bottleneck, Optimal Manifold Representation of Data.

**Unit V Stochastic Methods Rooted in Statistical Mechanics:** Statistical Mechanics, Markov Chains, Metropolis Algorithm, Simulated Annealing, Gibbs Sampling, Boltzmann Machine, Logistic Belief Nets, Deep Belief Nets, Deterministic Annealing, Analogy of Deterministic Annealing with Expectation-Maximization Algorithm

### **Readings:**

1. Simon O. Haykin, **Neural Networks and Learning Machines**, Pearson Education, 3rd Edition, 2016
2. C. M. Bishop, **Pattern Recognition and Machine Learning**, Springer, 2010.

### **MCSC202: DEEP LEARNING [3-0-1]**

**Course Objectives:** The student learns various state-of-the-art deep learning algorithms and their applications to solve real-world problems. The student develops skills to design neural network architectures and training procedures using various deep learning platforms and software libraries.

### **Course Learning Outcomes:**

On completing this course, the student will be able to:

- CO1:** describe the feedforward and deep networks.
- CO2:** design single and multi-layer feed-forward deep networks and tune various hyper-parameters.
- CO3:** analyze the performance of deep networks.

### **Syllabus:**

**Unit-I Introduction:** Historical context and motivation for deep learning; deep feedforward neural networks, regularizing a deep network, model exploration, and hyperparameter tuning.

**Unit-II Convolution Neural Networks:** Introduction to convolution neural networks: stacking,

striding and pooling, applications like image, and text classification.

**Unit-III Sequence Modeling: Recurrent Nets:** Unfolding computational graphs, recurrent neural networks (RNNs), bidirectional RNNs, encoder-decoder sequence to sequence architectures, deep recurrent networks.

**Unit-IV Autoencoders:** Undercomplete autoencoders, regularized autoencoders, sparse autoencoders, denoising autoencoders, representational power, layer, size, and depth of autoencoders, stochastic encoders and decoders.

**Unit V: Generative Adversarial Networks (GANs):** Introduction to Generative Adversarial Networks, GAN Architectures (DCGAN, CycleGAN), Applications of GANs (Image Generation, Style Transfer)

**Unit VI: Large Language Models:** Introduction to Natural Language Processing (NLP), Traditional NLP Techniques, Transformer Architecture, Pre-training and Fine-tuning Language Models, Ethical Considerations and Bias in Language Models, Applications of Large Language Models (Text Generation, Sentiment Analysis, Question Answering)

**Unit-VII Structuring Machine Learning Projects:** Orthogonalization, evaluation metrics, train/dev/test distributions, size of the dev and test sets, cleaning up incorrectly labelled data, bias and variance with mismatched data distributions, transfer learning, multi-task learning.

**Readings:**

1. Ian Goodfellow, **Deep Learning**, MIT Press, 2016.
2. Jeff Heaton, **Deep Learning and Neural Networks**, Heaton Research Inc, 2015.
3. Mindy L Hall, **Deep Learning**, VDM Verlag, 2011.
4. Li Deng (Author), Dong Yu, **Deep Learning: Methods and Applications (Foundations and Trends in Signal Processing)**, Now Publishers Inc, 2009.

**MCSC203: INTERNETWORKING WITH TCP/IP [3-0-1]**

**Course Objectives:**

This course is oriented to provide students, an understanding of the communication process of the Internet. This course will enable students to test and troubleshoot IP-based communications systems, and also the architecture, design and behaviors of the Internet and of the TCP/IP suite of protocols. Furthermore, this course will discuss various Flow , Error and Congestion control mechanisms of TCP and the principles of IPv6 Addressing ,IPv6 and ICMPv6 Protocols.

**Course Learning Outcomes :**

On successful completion of the course, the student will be able to:

CO1: be able to explain the TCP/IP architecture and utility of different layers

CO2: Analyze IP addressing requirements, routing architecture and choose appropriate routing methods;

CO3: Understand the working of internetworking devices and their network configuration;