

Artificial Neural Networks

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Objective

With the phenomenal growth in the area of intelligent systems and instruments for experimentation in the past years, the subject of artificial neural networks and its application for instrumentation has become very popularity. Another perspective direction of experimentation theory concerns virtual instruments technique and computer-aided software engineering for instrumentation. This course aims to combine two novel instrumentation concepts of neural net simulation algorithms for intelligent data analysis with virtual instruments engineering technology on base of LabVIEW^R Graphical Programming Systems (National InstrumentsTM, USA).

The course provides the background of the neurocomputing methods with an emphasis on application to software instrumentation. Laboratory practice intends to give you an initial knowledge and skill in programming the virtual instruments – special software instrumentation for intelligent data analysis and adaptive machine learning techniques. You will acquaint with original virtual instrumentation technologies and unique general-purpose graphical programming system LabVIEW for design of virtual instruments.

Course Contents

Lecture 1: Neuroinformatics: Theory and Applications.

- Novel technologies of Computer Science via mathematical and technological point of view.
- Intelligent computing: symbol manipulation or pattern recognition?
- Ill-formalizable tasks in data analysis and signal processing.
- Adaptive, self-organizing and machine learning systems.
- Artificial Intelligence and knowledge-based systems.

Lecture 2: Paradigms of Neuroinformatics and Neurocomputation.

- “Brain computer” paradigms
- Biological prototype and artificial neuron.
- Neurocomputing and its paradigms.
- Knowledge representation in Neural Networks

Lecture 3: Mathematical Models and Algorithms of Neurocomputation.

- Formal neuron and its characteristics.

- Models of neurons
- Neural Network architectures.
- Mathematical description of Neural Network

Lecture 4: Learning Theory Background.

- Algebraic approach to Learning via Optimization.
- Unconstrained Optimization: methods and algorithms.
- Stochastic Gradient Optimization, Boltzmann machine, Simulated annealing.

Lecture 5: Advanced Learning Theory

- Modern tendency of learning theory
- Genetic algorithms and adaptive learning.
- Computational models of learning algorithm

Lecture 6: Perceptron – Simplest Neural Network.

- Threshold Logic Units and Vectors Computation.
- Linear separation of Classes: 2-layer Perseptron.
- Nonlinear separation of Classes: Multilayer Perseptron.

Lecture 7: Supervised Learning of Perceptrons.

- Rosenblatt's learning rule
- Delta-rule
- Backpropagation algorithm
- Modification of the Backpropagation algorithm

Lecture 8: Multilayer Feedforward Networks.

- Models and Architectures of MLFN
- MLFN as adaptive filtering. ADALINE and MADALINE nets.
- MLFN as universal approximators

- RBF approximation and RBF-nets

Lecture 9: Pattern Recognition with Neural Networks.

- Formulation of the pattern recognition problem
- Statistical approach to pattern recognition
- Neural network pattern classifier
- General models and algorithms

Lecture 10: Applications of Feed-Forward Neural Networks.

- Intelligent control with neural network
- Medicine diagnostic with neural network
- Sound recognition with neural network

Lecture 11: Self-Organization in Neural Networks: Principle of Unsupervised Learning.

- Self-Organization and unsupervised learning from Observations
- Information Extraction from Redundant Data
- Mathematical Formulation of Self-Organization Task
- Models of Unsupervised Rules for Self-Organizing NN

Lecture 12: Self-Organization via Principal Component Analysis.

- Intuitive principles of self-organization
- Statistic Characterization via principal component analysis
- Self-Organization via Principal Component Analysis
- Self-Organizing Neural Networks model for Principal Component Analysis

Lecture 13: Competitive Models of Self-Organizing Neural Networks.

- Excitement Propagation Models of Self-organizing Neural Networks
- Statistic Characterization via Clustering
- Competitive Learning Rule

- Self-Organizing Feature Maps

Lecture 14: Information Analytical Theory of Self-Organizing Neural Networks.

- Information-Theoretic Models of Self-Organizing Neural Networks
- Information Criterion of Self-Organization
- Independent Component Analysis with Neural Networks

Lecture 15: Applications of Self-Organizing Neural Networks.

- Application of Self-Organizing Neural Networks to Blind Source Separation
- Application of Self-Organizing Neural Networks to Blind Features Extraction

References

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3. Callan R. The Essence of Neural Networks. Prentice Hall Europe, 1999.
4. Bishop C..M. Neural Networks for Pattern Recognition. Oxford University Press, 1966.
5. Gary W.Johnson. “LabVIEW Graphical Programming”. MacGraw-Hill, 1998.
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