This course introduces intelligent numerical computations based on advanced unsupervised and supervised learning of neural networks respectively for independent component analysis, blind source separation, self-organization, classification, data driven function approximation.

Unsupervised learning is subject to data sampled from a d-dimensional space. In the field of neural networks, relevant computational tasks have been formulated for ICA (independent component analysis) and SOM (self-organization). Different perspectives for unsupervised learning have been addressed. Density function estimation focuses on approximating the output of pdf (probability density function) underlying given sample. When all training data are required for density evaluation, density estimation apparently lacks ability of data reduction and feature extraction and can not be regarded as some kind of unsupervised learning. This is because internal representations of unsupervised learning in size should be significatly less than provided samples.

If data size can not be reduced for density evaluation, it will need unlimited memory to store redundancy within samples. Data reduction to efficient internal representations and feature extraction are essential for unsupervised learning.

Training data. ---> Unsupervised learning. -- > Significant features
Structural internal representations

Significant features and Structural internal representations
K-means focuses on locating distributed local means for data clustering.

- Euclidean distance
- Distributed local means
- Quantization
- Clustering by minimization of the average distance between each data point and it's center

Potential extension or alternative

- Euclidean distance vs Mahalanobis distance
- Distributed local means and covariance matrices
- Quantization vs expectation
- Clustering by maximal fitting criteria

ICA

- sampling from multi-channel observations
- linear mixture assumption
- statistically dependency
- Kullback-Leibler divergence between joint PDFs and the product of marginal PDFs of independent components
- de-mixing

Potential extensions

- Time order
- convolutive mixture assumption, multiple linear mixture assumption
- Annealed KL divergence minimization
- blind source extension

Self-organization

- mapping on a cortex like surface
- lattice structure Gaussian mixture
- quantization vs expectation
- Winner take all principle
- Kohonen's self-organizing algorithm
- annealed KL divergence minimization
- Generalized Travelling salesman problem
- Gene sorting
- dimensionality reduction

Supervised learning for classification and function approximation

- paired training data
- testing
- unconstrained optimization vs constrained optimization
- support boudary approximation
- Function approximation and nonlinear regression
- classification and discriminate analysis

A hybrid of unsupervised and
supervised learning will be introduced for structural recurrence relation approximation, density function approximation, signal clustering and covariance matrix analysis with application to biomedical signal and image processes.