

Radial Basis Function (RBF) Neural Networks

Based on material provided by Professor W. Pedrycz

Neural Networks: Gradient-based Learning

☒ Updating weights relies on gradient of performance index

$$\text{Weight}(\text{iter} + 1) = \text{Weight}(\text{iter}) - \alpha \nabla_{\text{weight}} Q$$

☒ Speed of learning and convergence

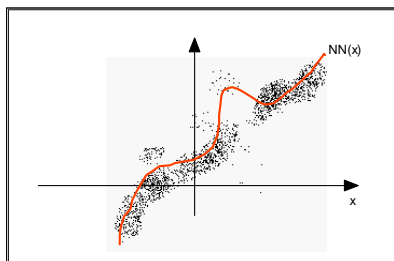
☒ Local or global minimum

☒ Robustness of learning

☒ Dimensionality

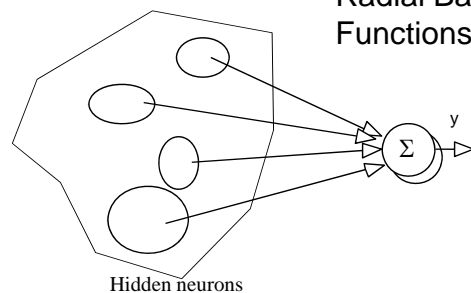
☒ Computational overhead

Neural Networks: Overfitting and Generalization



Radial Basis Function (RBF) Neural Networks

Radial Basis
Functions



Radial Basis Function (RBF): Basic classes

- Gaussian, triangular,...
- Wavelets
- Fourier-like (sin and cos)
-

RBF: Example

Euclidean metric

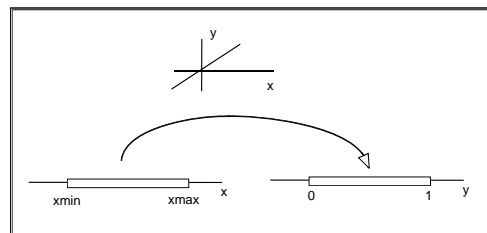
$$v_i = \sqrt{(X - C_i)^2}$$

C_i = center vector of i^{th} hidden layer neuron
 X = input vector

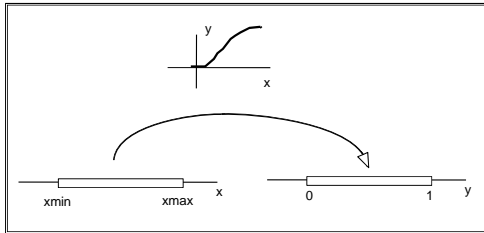
Radial Basis Function (RBF): Main Properties

- ▣ Nonlinear transformation of data (normalization)
- ▣ Data patching - capturing domain knowledge

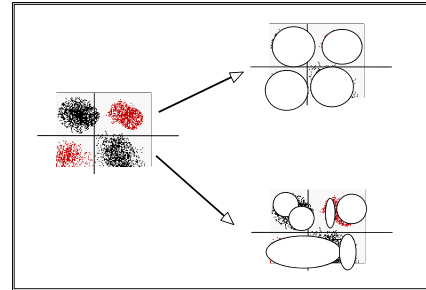
Linear vs. Nonlinear Normalization



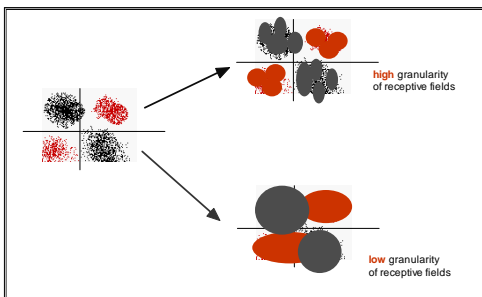
Linear vs. Nonlinear Normalization



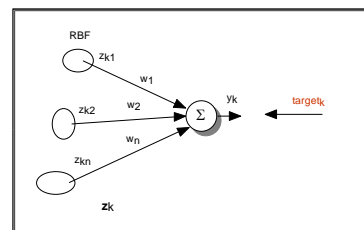
Receptive Fields: Data Patching



Receptive Fields: Granularity Issue



RBF Neural Networks: Learning Algorithm



Notation

$$\mathbf{target} = \begin{bmatrix} target_1 \\ target_2 \\ \dots \\ target_N \end{bmatrix} \quad \mathbf{Z} = \begin{bmatrix} z_1^T \\ z_2^T \\ \dots \\ z_N^T \end{bmatrix}$$

RBF Neural Networks: Learning Algorithm

Performance index

$$Q = \sum_{k=1}^N [\mathbf{w}^T \mathbf{z}_k - \text{target}_k]^2 = [\mathbf{Z}\mathbf{w} - \text{target}]^T [\mathbf{Z}\mathbf{w} - \text{target}]$$

Minimization problem

$$\frac{\partial Q}{\partial \mathbf{w}} = \mathbf{0}$$

Solution

$$\mathbf{w} = (\mathbf{Z}^T \mathbf{Z})^{-1} \mathbf{Z}^T \text{target}$$

Neural Networks in Data Mining

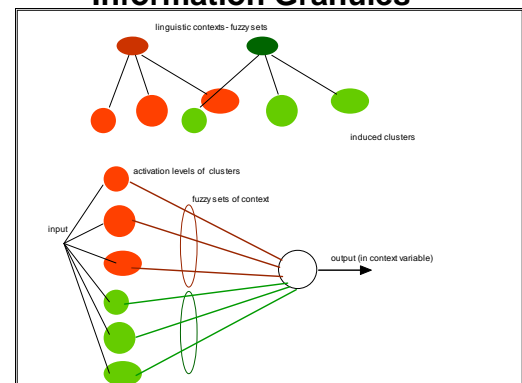
☞ Simple and interpretable
architectures

☞ Easily scalable learning ability

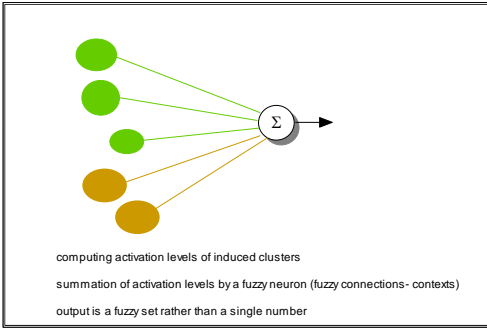
Exploitation of Linguistic Blueprints

- ☞ Direct use of associations between linguistic granules
- ☞ Refinement of associations
- ☞ Linguistic learning

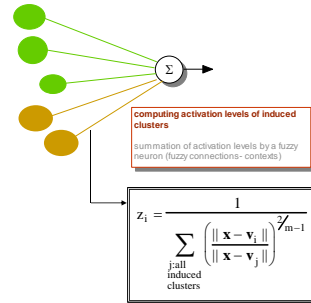
Network Representation of Information Granules



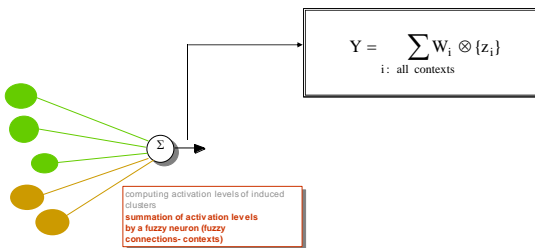
Direct use of Associations between Linguistic Granules



Direct use of Associations between Linguistic Granules



Direct use of Associations between Linguistic Granules



Refinement of Associations

