Class Presentation of CSC481
- Artificial Neural Networks

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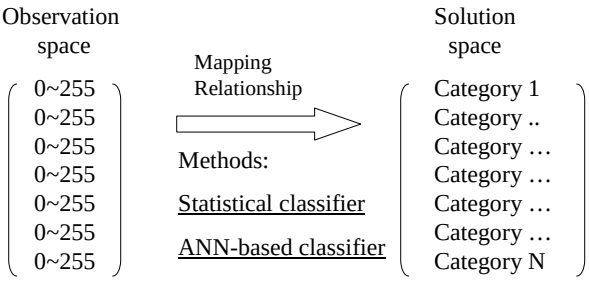
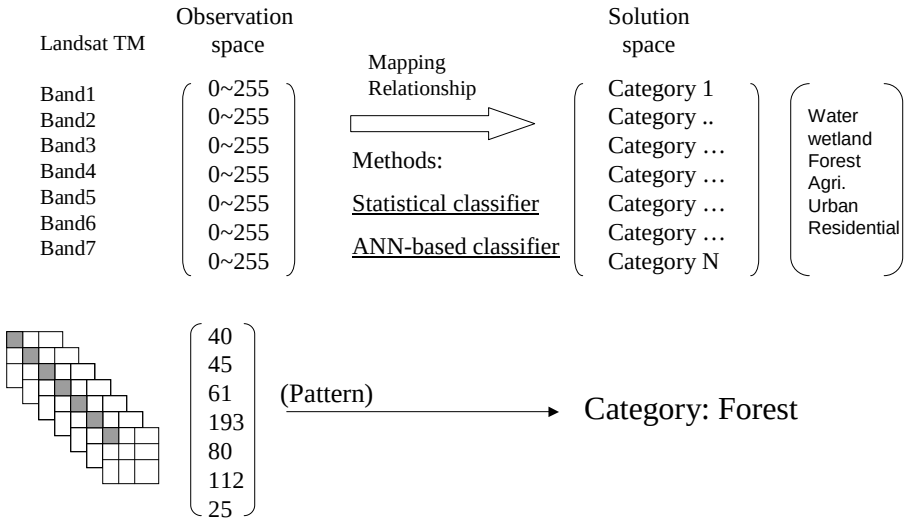
Outline

- Problems in classification systems
- Introduction of neural networks
- How to use neural networks
- Applications
- Summary

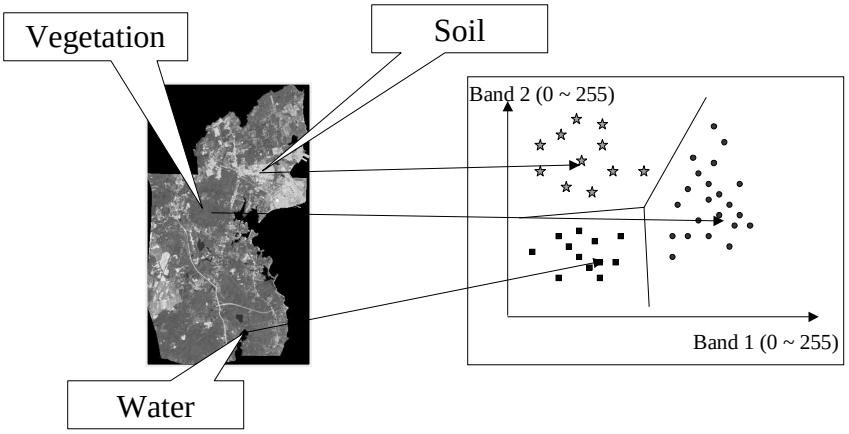
Classification Systems



Classification Process for Remote Sensing Image



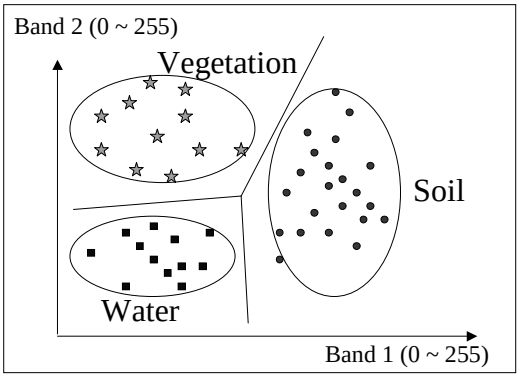
Supervised Remote Sensing Image Classification



Statistical Methods

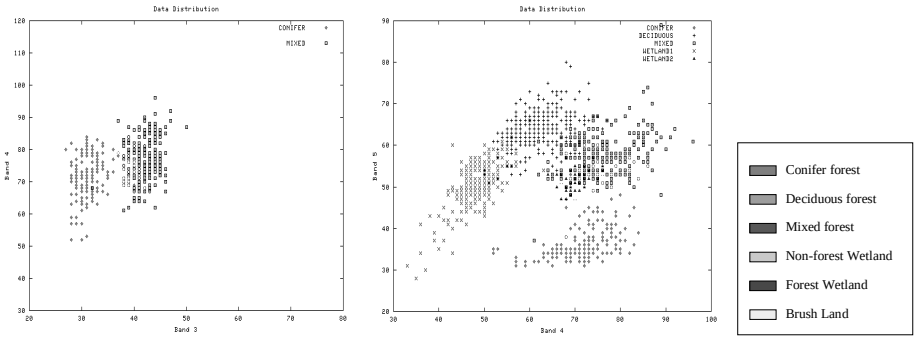
- Need Gaussian (Normal) distribution on the input data which is required by Bayesian classifier.

- Restrictions about the format of input data.



Statistical Methods:

How to find a boundary for the following patterns?

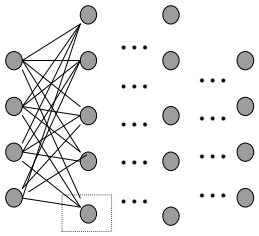


Artificial Neural Network Approach

- No need for normal distribution on input data
- Flexibility on input data format
- Improved classification accuracy
- Robust and reliability

Introduction to Neural Networks

-- Artificial Neural Network Is Defined by ...



- **Processing elements**
- **Organized topological structure**
- **Training/Learning algorithms**

Processing Element (PE)

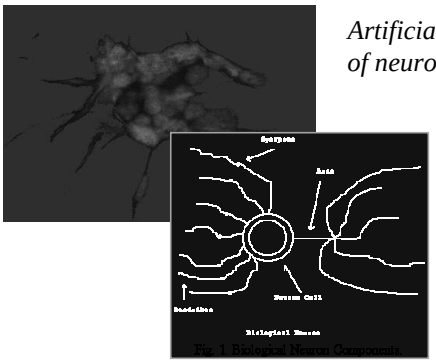
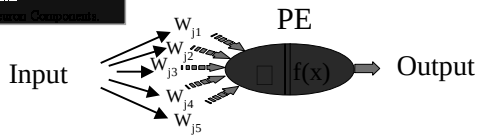
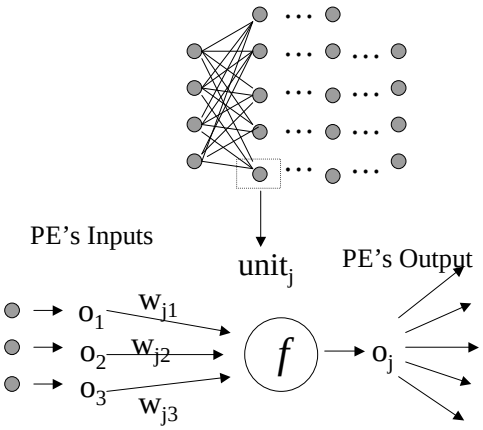


Fig. 1 Biological Neuron Components

Artificial counterparts of neurons in a brain

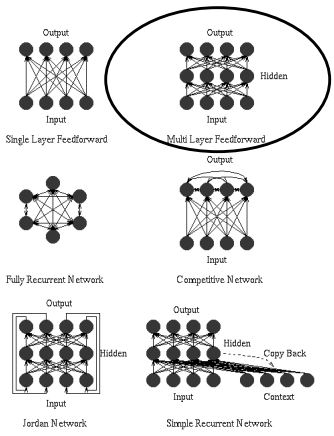


Function of Processing Elements

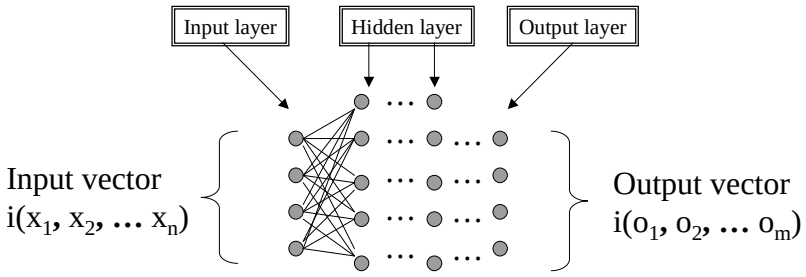


- **Receive outputs from each PEs locate in previous layer.**
- **Compute the output with a Sigmoid activation function F(**Sumof(O**i***W**ji)**)
- **Transfer the output to all the PEs in next layer**

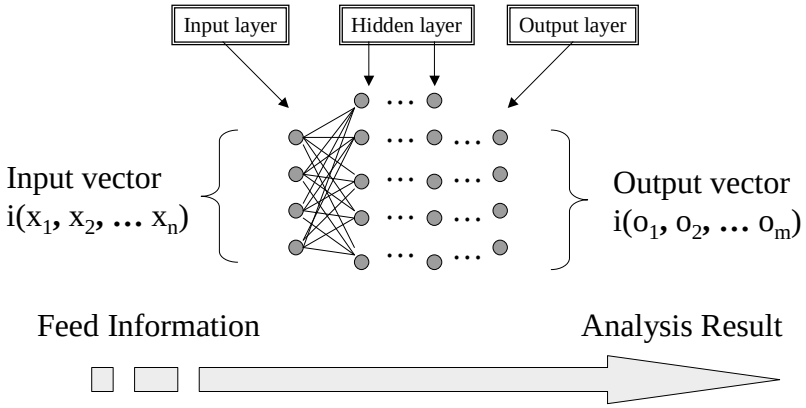
Organized topological structures



ANN Structure
- A multi-layer feedforward NN



Training/Learning Algorithm
- Backpropagation (BP)



Training/Learning Algorithm Back-propagation Mechanism

- Compute total error

$$\frac{1}{2}\sum_{p\in P}\sum_{n}(t_n^p - s_n^p)^2$$

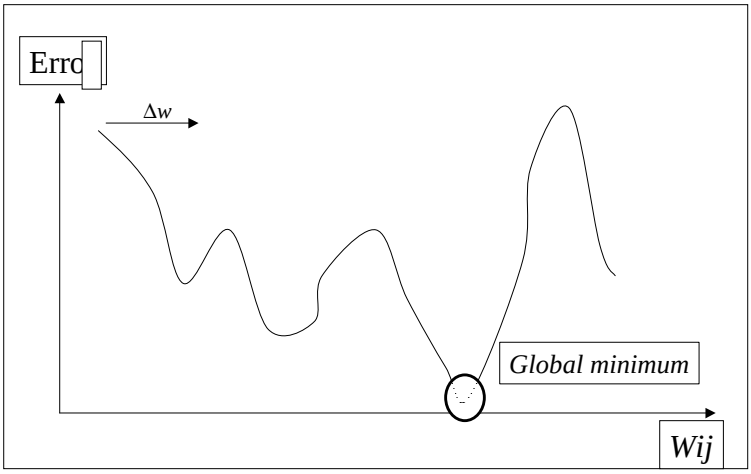
- Compute the partial derivatives

$$\frac{\partial E}{\partial w_{ij}}$$

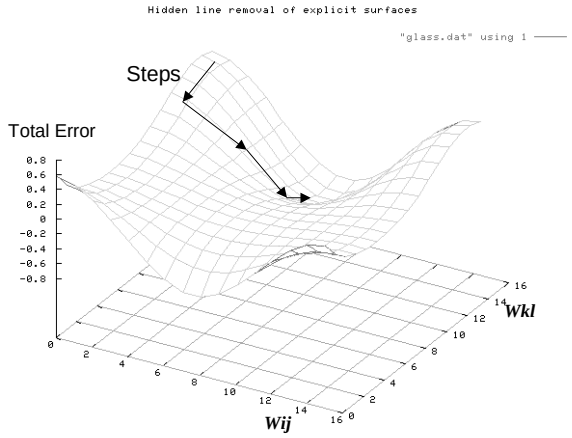
- Update the weights and go to next epoch

$$W(t+1) = W(t) + \Delta W$$

Back-propagation Mechanism



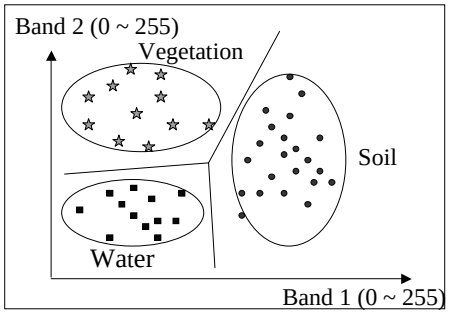
BPANN
Error Space, Weight Adaptive



How to use a neural network

- Analysis the problem domain
- ANN design
  - What structure of ANN to choose
  - What Algorithm to use
  - Input and Output
- Training
- Applying the well-trained neural network to your problem

Pattern Recognition
- Understand the problem



Vegetation:
(10, 89) ------> (1,0,0)
(11,70) ------> (1,0,0)
… … … (1,0,0)
Water:
(10, 21) ------> (0,1,0)
(15, 32) ------> (0,1,0)
… … … (0,1,0)
Soil:
(50, 40) -------> (0,0,1)
(52, 40) -------> (0,0,1)
… … … (0,0,1)

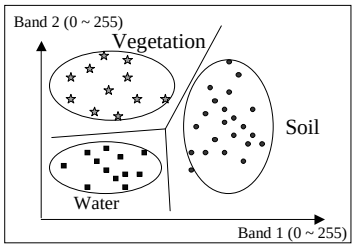
What ANN structure to choose?

– Multi-layer feed-forward

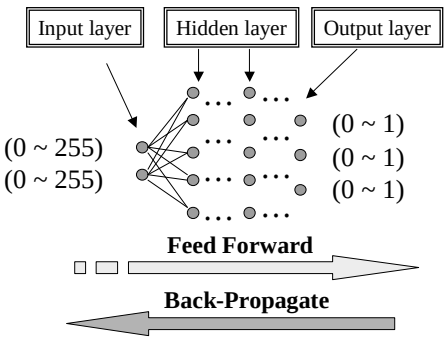
What ANN training algorithm?

– Back-propagation

ANN Design



Pattern



How many PEs we need - Basic rules in designing an ANN.

- **Input layer PEs - by dimension of input vector**
- **Output layer PEs - by total number of patterns (classes)**

ANN Training
- From Pattern to Land Cover Category

Vegetation:
(10, 89) ------> (1,0,0)
(11,70) ------> (1,0,0)
… … … (1,0,0)
Water:
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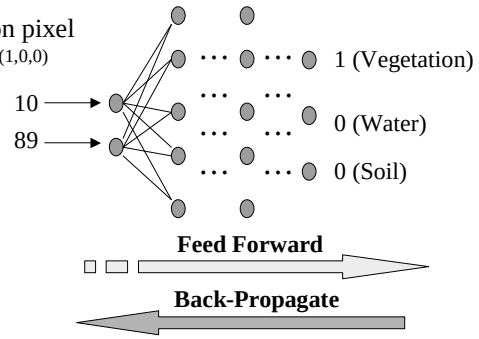
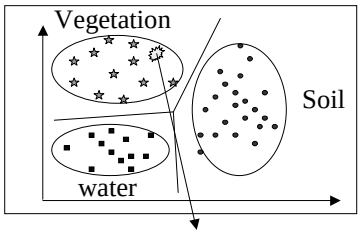
… … … (0,1,0)
Soil:
(50, 40) -------> (0,0,1)
(52, 40) -------> (0,0,1)
… … … (0,0,1)

A vegetation pixel
(10, 89) ------> (1,0,0)



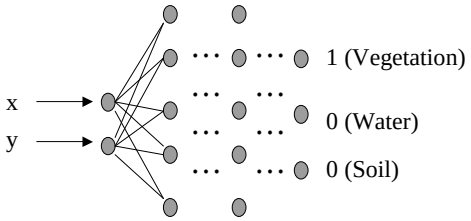
Pattern → Land Cover Category

After Training



A new pixel (x,y), x in band 1, y in band 2

A Well-trained Neural Network

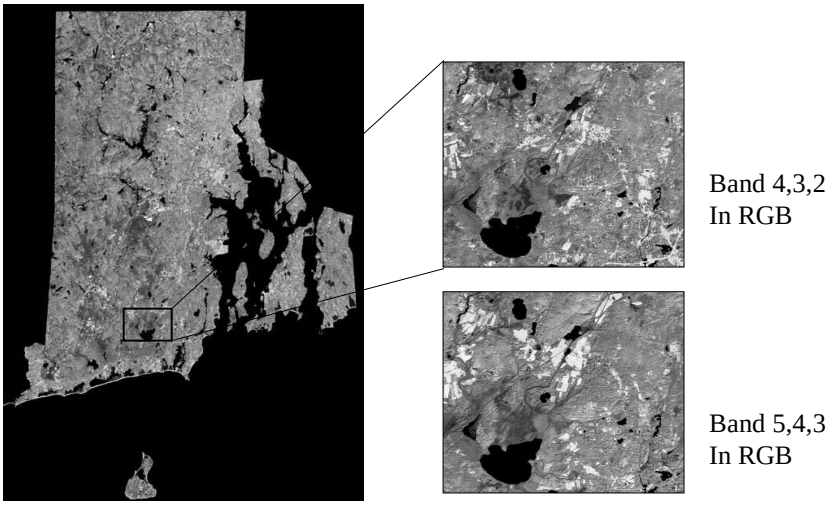


Real-world Applications

- Pattern recognition - Remote sensing image classification
- Banking – credit evaluation
- $tock market data analysis and prediction

Remote sensing image classification

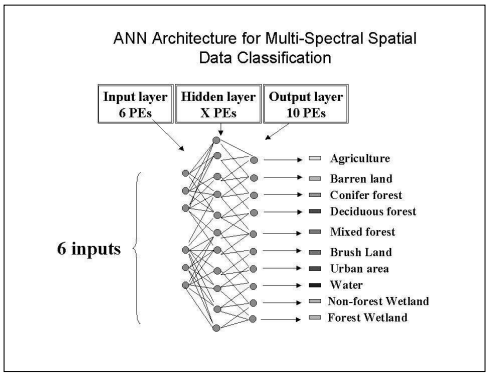
Rhode Island 1999 Landsat-7 Enhanced Thematic Mapper Plus (ETM+) Image



Band 4,3,2
In RGB

Band 5,4,3
In RGB

ANN Design



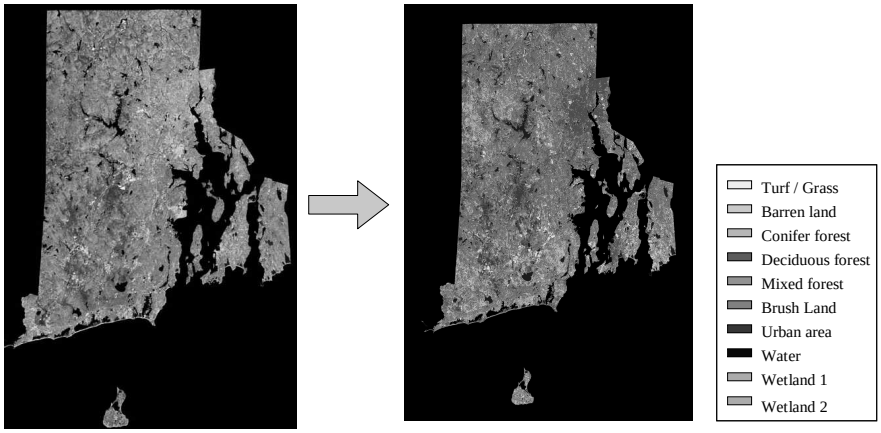
What ANN structure to choose? – Multi-layer feed-forward
What ANN training algorithm? – Back-propagation & RPROP
PE in each layer? -- 6 – X – 10

Training and Testing Pattern

Training sample and Testing sample

Class Name	Training Sample Size (pixels)	Testing Sample Size (pixels)
Agriculture	116	153
Barren Land	146	125
Conifer Forest	173	146
Deciduous Forest	343	217
Mixed Forest	265	155
Brush Land	75	75
Urban Area	287	108
Water	238	133
Non-forest Wetland	248	163
Forest Wetland	52	57
Total Pixels	**1943**	**1332**

Classification Result

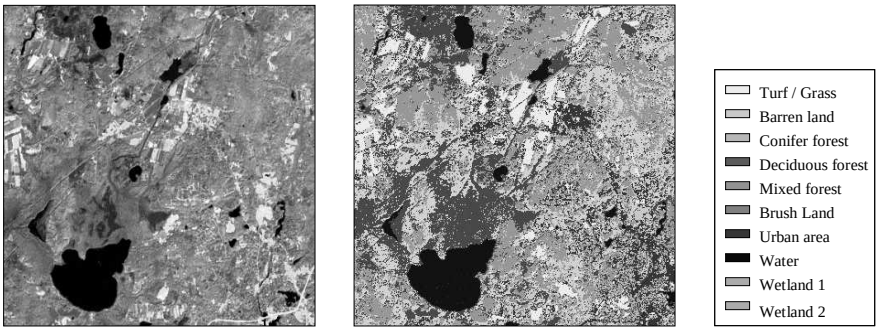


Some stats on the classification:

Training: 1943 pixel, ANN structure: 48-350-11, Training time: 5 hours, final error: (100% - 92.7%)

Classification: over 9 Million pixels, takes 6 hours to get the land-cover map.

Classification Result - A Close Look



Rhode Island 1999 ETM+

Rhode Island 1999 Land-use and Land-cover map

Banking – credit evaluation

- 10 ~ 20 attributes as input
  - Yearly income, marriage status, credit history, residence, children, etc
- Expert to choose typical training data set
- Choose NN structure and training algorithm
  - A dynamic NN structure applied
  - Self-growing algorithm …

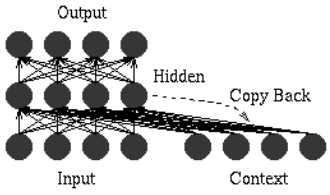
Stock market data analysis and prediction – a world full of patterns

- 10 ~ 20 attributes
  - P/E, Weekly Volume, Book Value etc
- Expert to choose training data set
  - Typically upon a certain pattern/theory
- NN structure – this time, it is different, "time" plays an important rule.

NN structure and training algorithm in stock market

- Recurrent network, Generalized neural network
- Normal BP, Conjugate Gradient Method(CG), Quick-Prop

Hopfield Network
(Recurrent network)



Simple Recurrent Network

Summary

- A Neural Network consists
  - Processing Element(PE)
  - Topological structure
    - Multi-layer feed-forward
  - Training/learning algorithm
    - Back-propagation
  - Numbers of PEs in each layer

Summary – cont.

Basic Back-propagation has the following shortcomings:

- Time-consuming
- Black box - uncontrollable training
- Training result unpredictable

Some reference

- A good starting point
  - Timothy Master's "Practical neural network Recipes in C++"

  Other site:

  IEEE Neural Network community

Thank You!