



ARTIFICIAL NEURAL NETWORKS

Faculty

R. Rajkumar

School of Computing | SRMIST

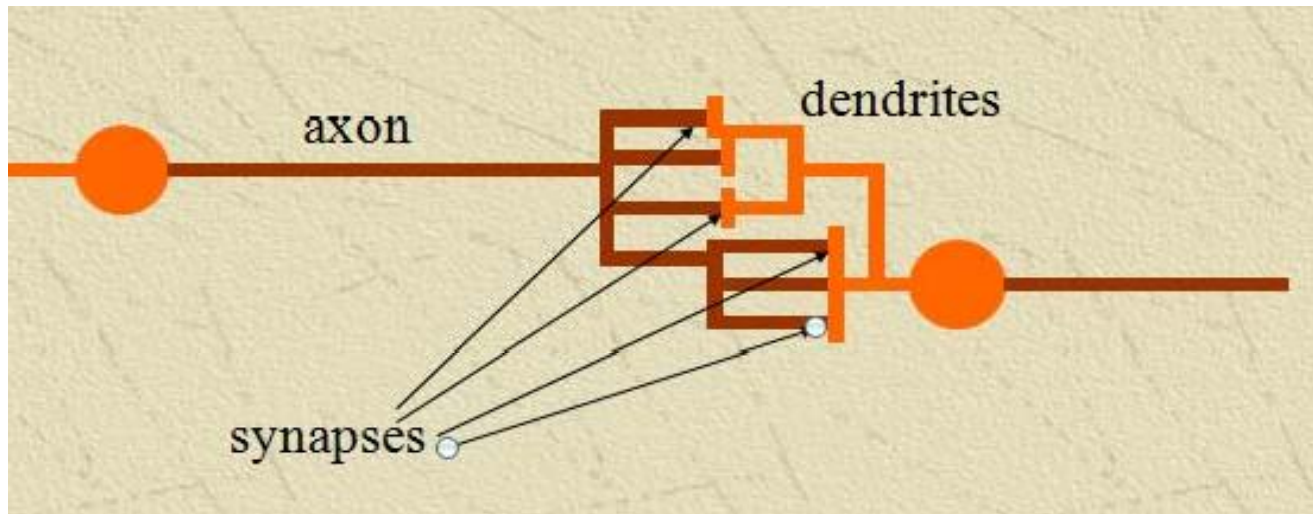
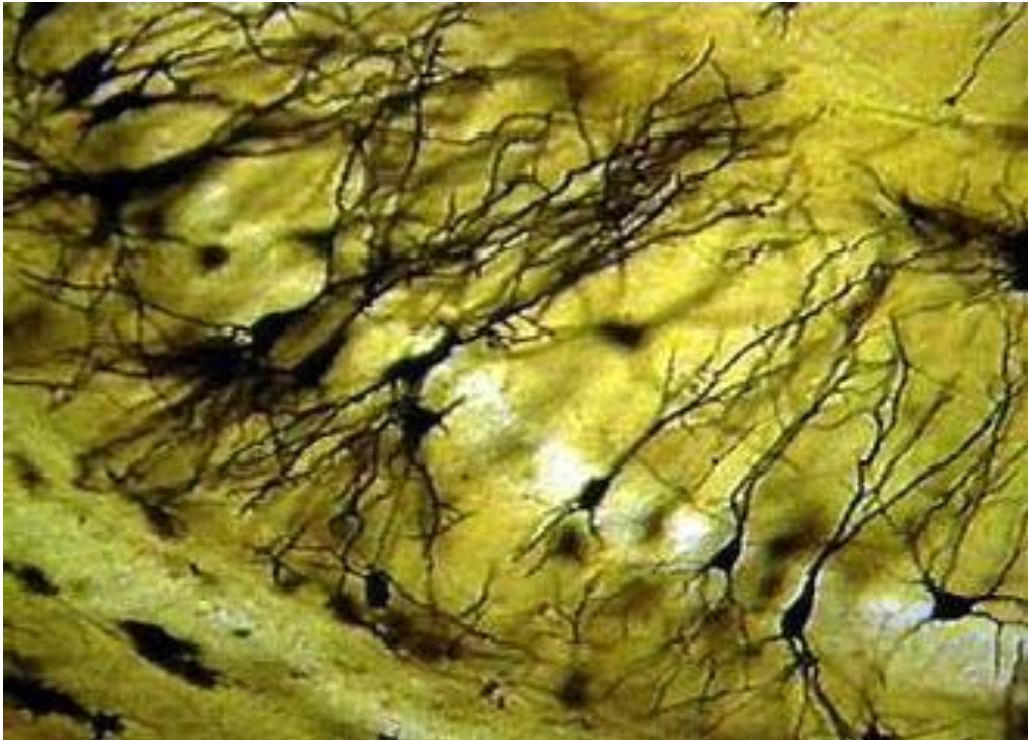
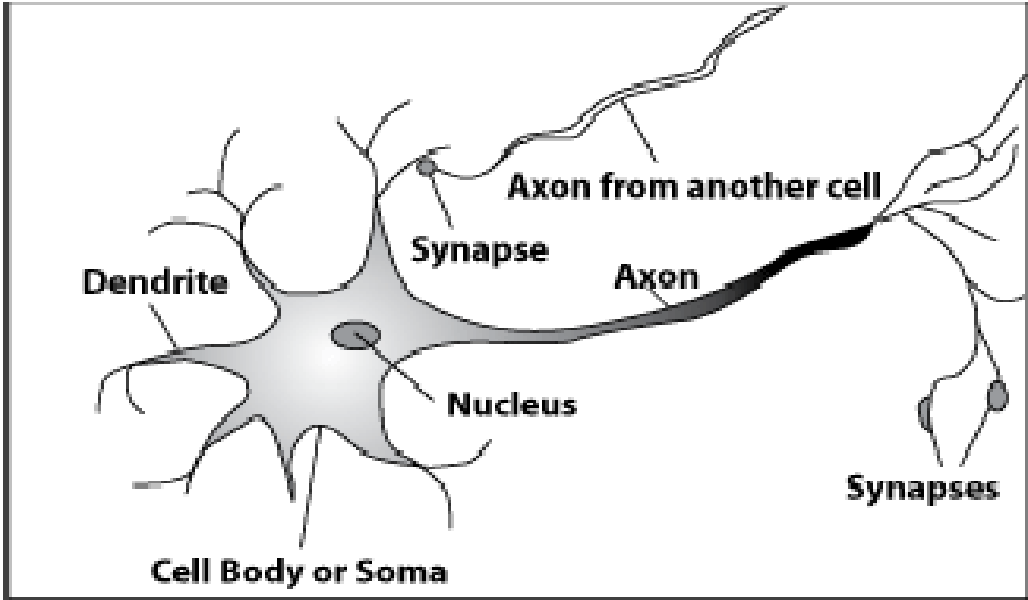
INTRODUCTION

- Artificial Neural Network (ANN) or Neural Network(NN) has provide an exciting alternative method for solving a variety of problems in different fields of science and engineering.
- This article is trying to give the readers a :
 - Whole idea about ANN
 - Motivation for ANN development
 - Network architecture and learning models
 - Outline some of the important use of ANN

Origin of Neural Network

- Human brain has many incredible characteristics such as massive **parallelism, distributed representation and computation, learning ability, generalization ability, adaptivity**, which seems simple but is really complicated.
- It has been always a dream for computer scientist to create a computer which could solve complex perceptual problems this fast.
- ANN models was an effort to apply the same method as human brain uses to solve perceptual problems.
- Three periods of development for ANN:
 - **1940**: Mcculloch and Pitts: **Initial works**
 - **1960**: Rosenblatt: **perceptron convergence theorem**
Minsky and Papert: **work showing the limitations of a simple perceptron**
 - **1980**: Hopfield/Werbos and Rumelhart: **Hopfield's energy approach/back-propagation learning algorithm**

Biological Neural Network



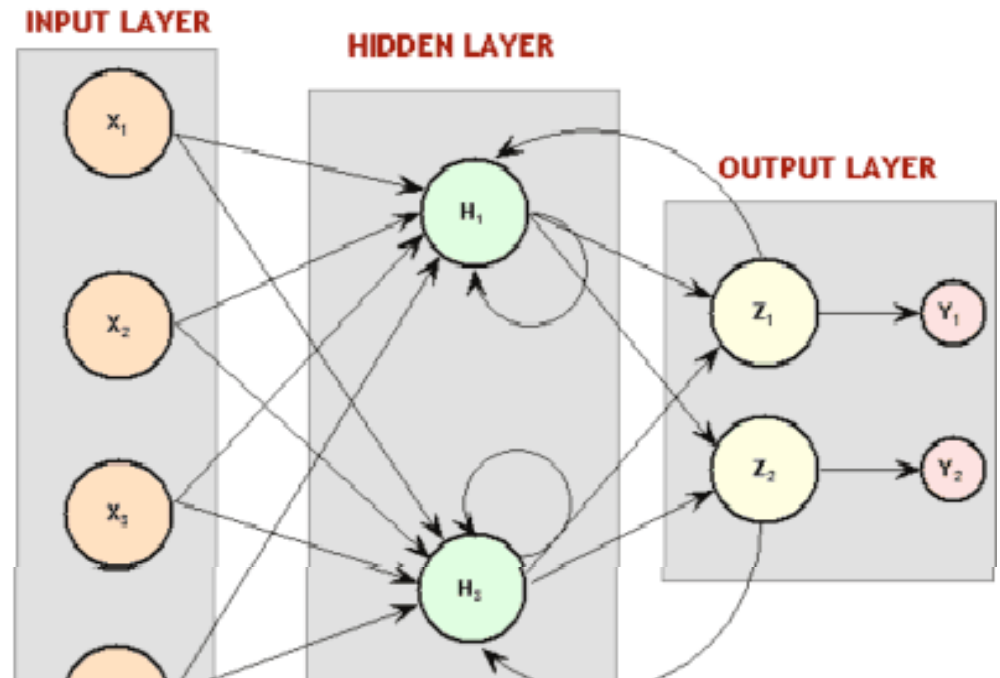
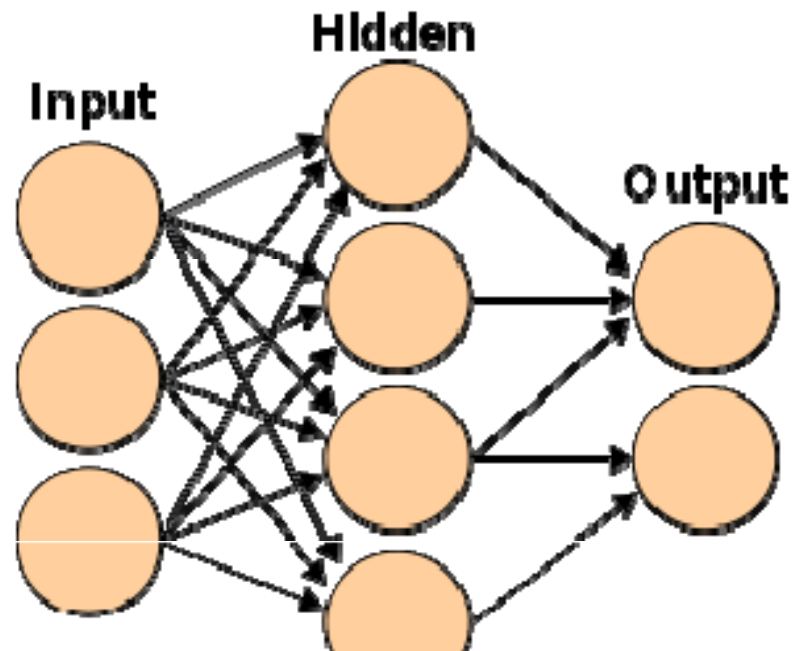
Biological Neural Network

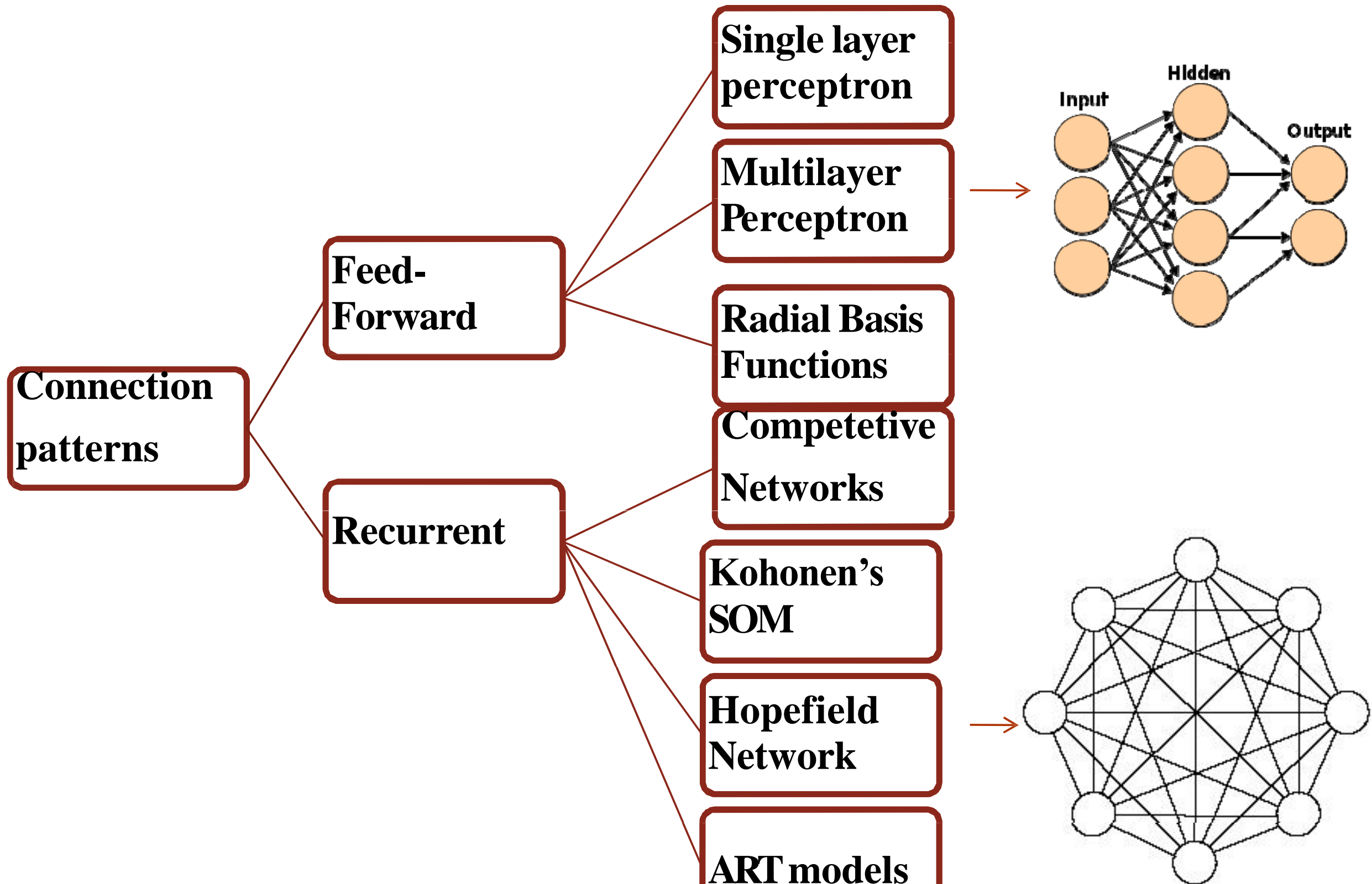
- When a signal reaches a synapse: Certain chemicals called **neurotransmitters** are released.
- **Process of learning**: The synapse effectiveness can be adjusted by signal passing through.
- Cerebral cortex : **a large flat sheet of neurons** about 2 to 3 mm thick and 2200 cm, 10^{11} neurons
- Duration of impulses between neurons: **milliseconds** and the amount of information sent is also small (few bits)
- Critical information are not transmitted directly, but stored in **interconnections**
- The term **Connectionist model** initiated from this idea.

Connection patterns

Feed-Forward

Recurrent





Learning

- **What is the learning process in ANN?**
 - updating network architecture and connection weights so that network can efficiently perform a task
- **What is the source of learning for ANN?**
 - Available training patterns
 - The ability of ANN to automatically learn from examples or input-output relations
- **How to design a Learning process?**
 - Knowing about available information
 - Having a model from environment: **Learning Paradigm**
 - Figuring out the update process of weights: **Learning rules**
 - Identifying a procedure to adjust weights by learning rules: **Learning algorithm**

Learning Paradigm

1. Supervised

- The correct answer is provided for the network for every input pattern
- Weights are adjusted regarding the correct answer
- In reinforcement learning only a critique of correct answer is provided

2. Unsupervised

- Does not need the correct output
- The system itself recognize the correlation and organize patterns into categories accordingly

3. Hybrid

- A combination of supervised and unsupervised
- Some of the weights are provided with correct output while the others are automatically corrected.

Learning Rules

- There are four basic types of learning rules:
 - *Error correction rules*
 - *Boltzmann*
 - *Hebbian*
 - *Competitive learning*
- Each of these can be trained with or without a teacher
- Have a particular architecture and learning algorithm

Boltzman Learning

- Used in symmetric recurrent networks(symmetric: $W_{ij}=W_{ji}$)
- Consist of binary units(+1 for on, -1 for off)
- Neurons are divided into two groups: Hidden & Visible
- Outputs are produced according to Boltzman statistical mechanics
- Boltzman learning adjust weights until visible units satisfy a desired probabilistic distribution
- The change in connection weight or the error-correction is measured between the correlation between two pair of input and output neuron under clamped and free-operating condition

Hebbian Rules

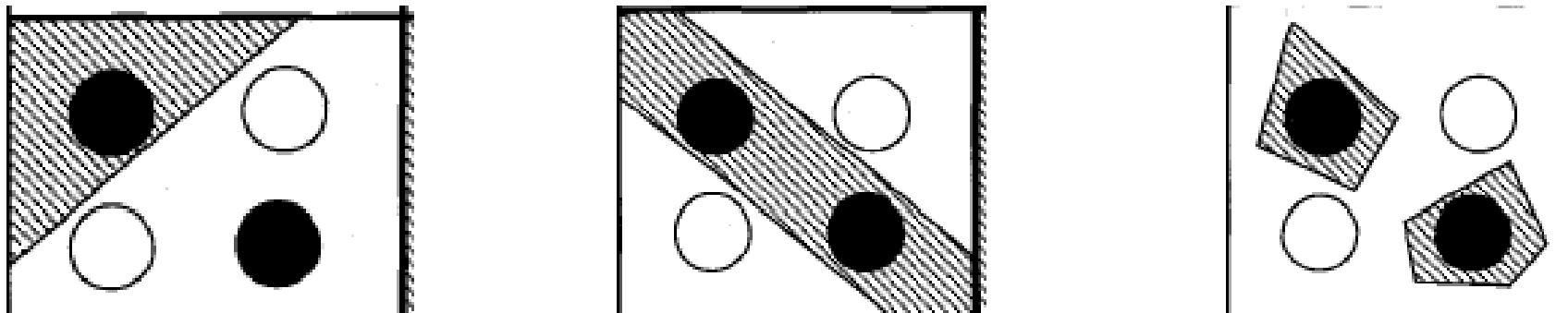
- One of the **oldest** learning rule initiated form neurobiological experiments
- **The basic concept of Hebbian Learning:** when neuron **A** activates, and then causes neuron **B** to activate, then the connection strength between the two neurons is increased, and **it will be easier for A to activate B in the future.**
- **Learning is done locally,** it means weight of a connection is corrected only with respect to neurons connected to it.
- Orientation selectivity: occurs due to Hebbian training of a network

Competitive Learning Rules

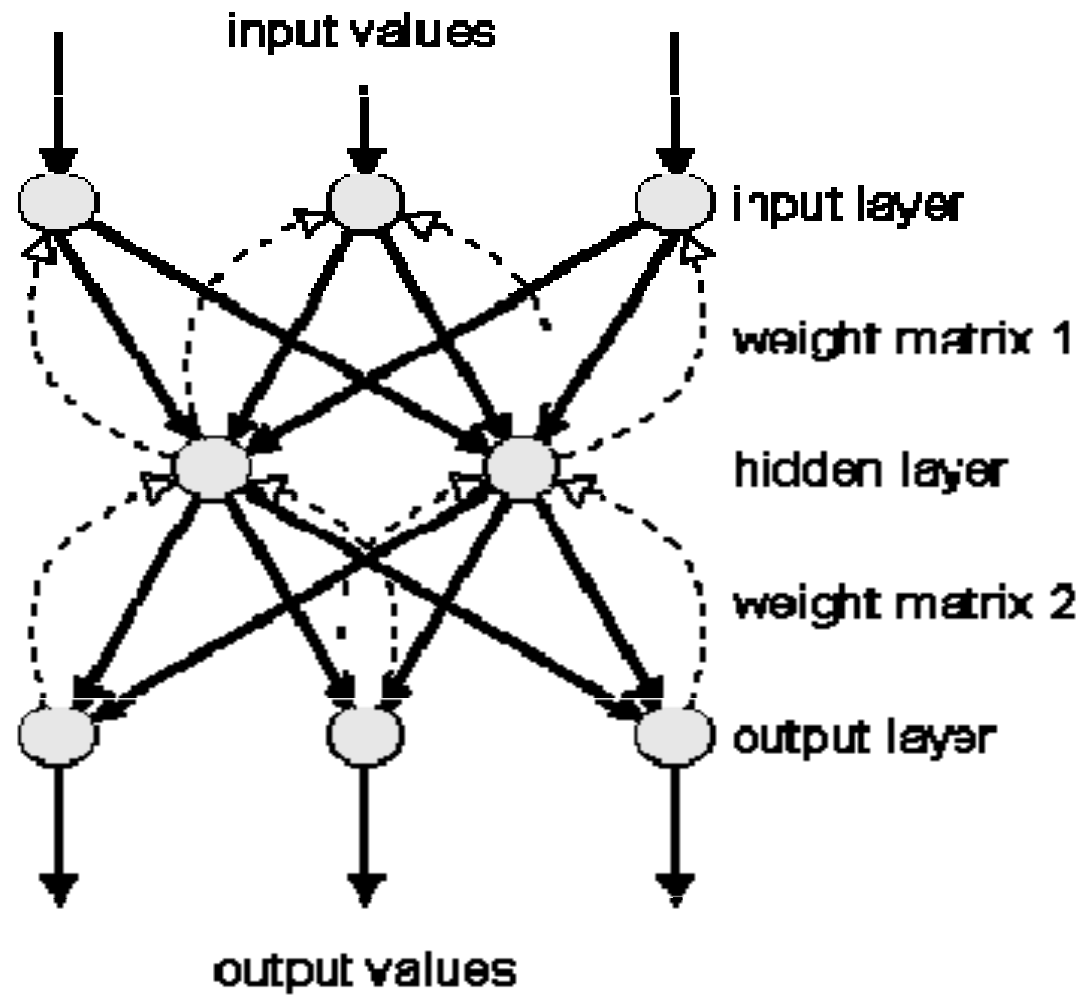
- The basis is the “winner take all” originated from biological Neural network
- All input units are connected together and all units of output are also connected via inhibitory weights but gets feed back with excitory weight
- Only one of the unites with largest or smallest input is activated and its weight becomes adjusted
- As a result of learning process the pattern in the winner unit (weight) become closer to he input pattern.
- <http://www.peltarion.com/blog/img/sog/competitive.gif>

Multilayer Perceptron

- The most popular networks with feed-forward system
- Applies the Back Propagation algorithm
- As a result of having hidden units, Multilayer perceptron can form arbitrarily **complex decision boundaries**
- Each unit in the first hidden layer impose a hyperplane in the space pattern
- Each unit in the second hidden layer impose a hyperregion on outputs of the first layer
- Output layer combines the hyperregions of all units in second layer



Back propagation Algorithm



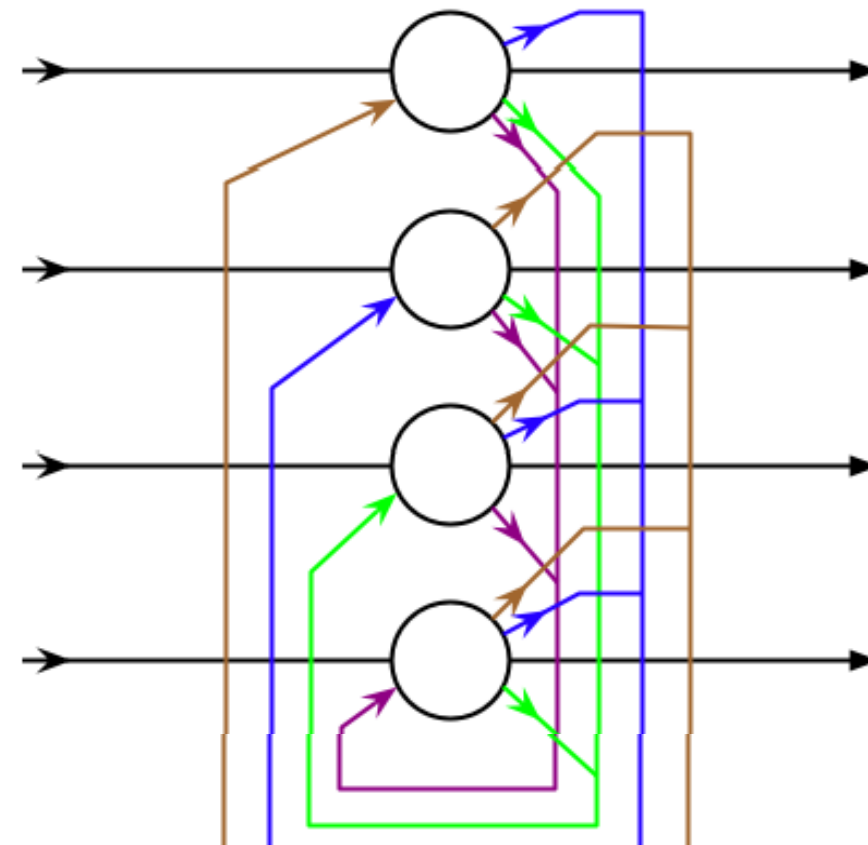
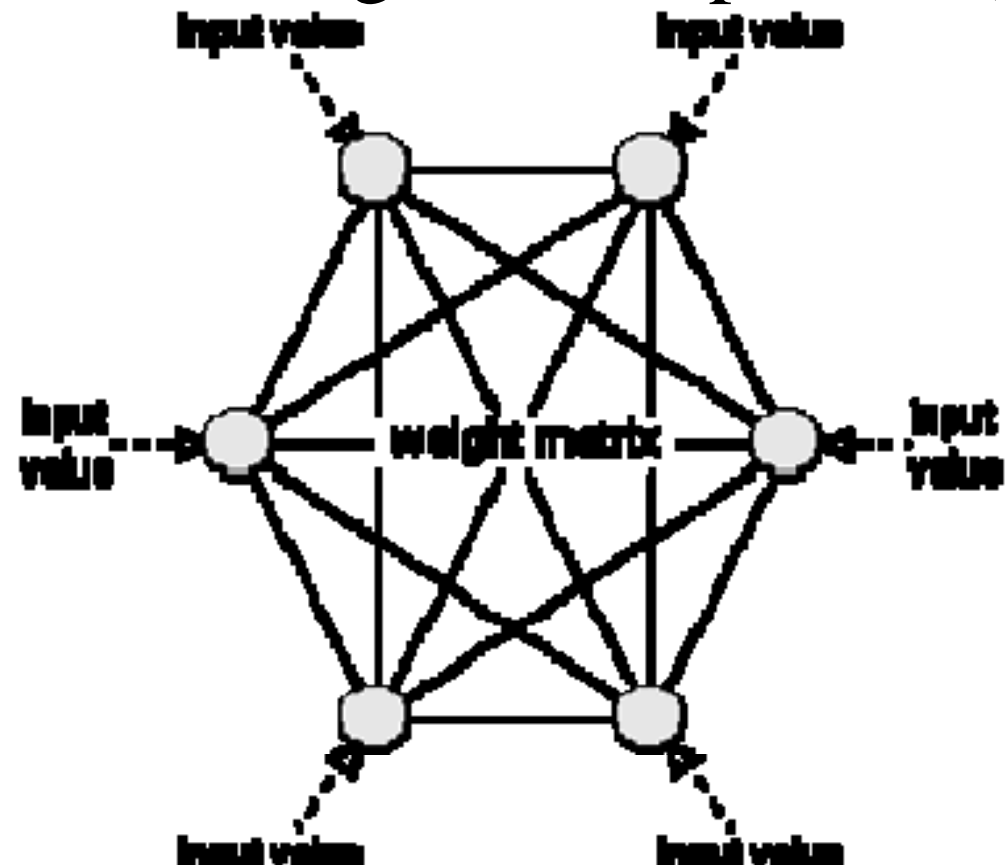
Radial Basis Function Network(RBF)

- A Radial Basis Function like **Gaussian Kernel** is applied as an activation function.
- A Radial Basis Function(also called **Kernel Function**) is a real-valued function whose value depends only on the distance from the origin or any other center: $F(x)=F(|x|)$
- RBF network uses a hybrid learning , unsupervised clustering algorithm and a supervised least square algorithm
- As a comparison to multilayer perceptron Net.:
 - The Learning algorithm is **faster** than back-propagation
 - After training the running time is much more **slower**

Let's see an example!

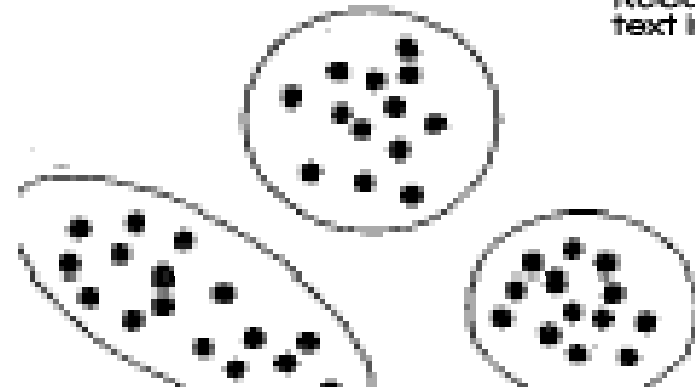
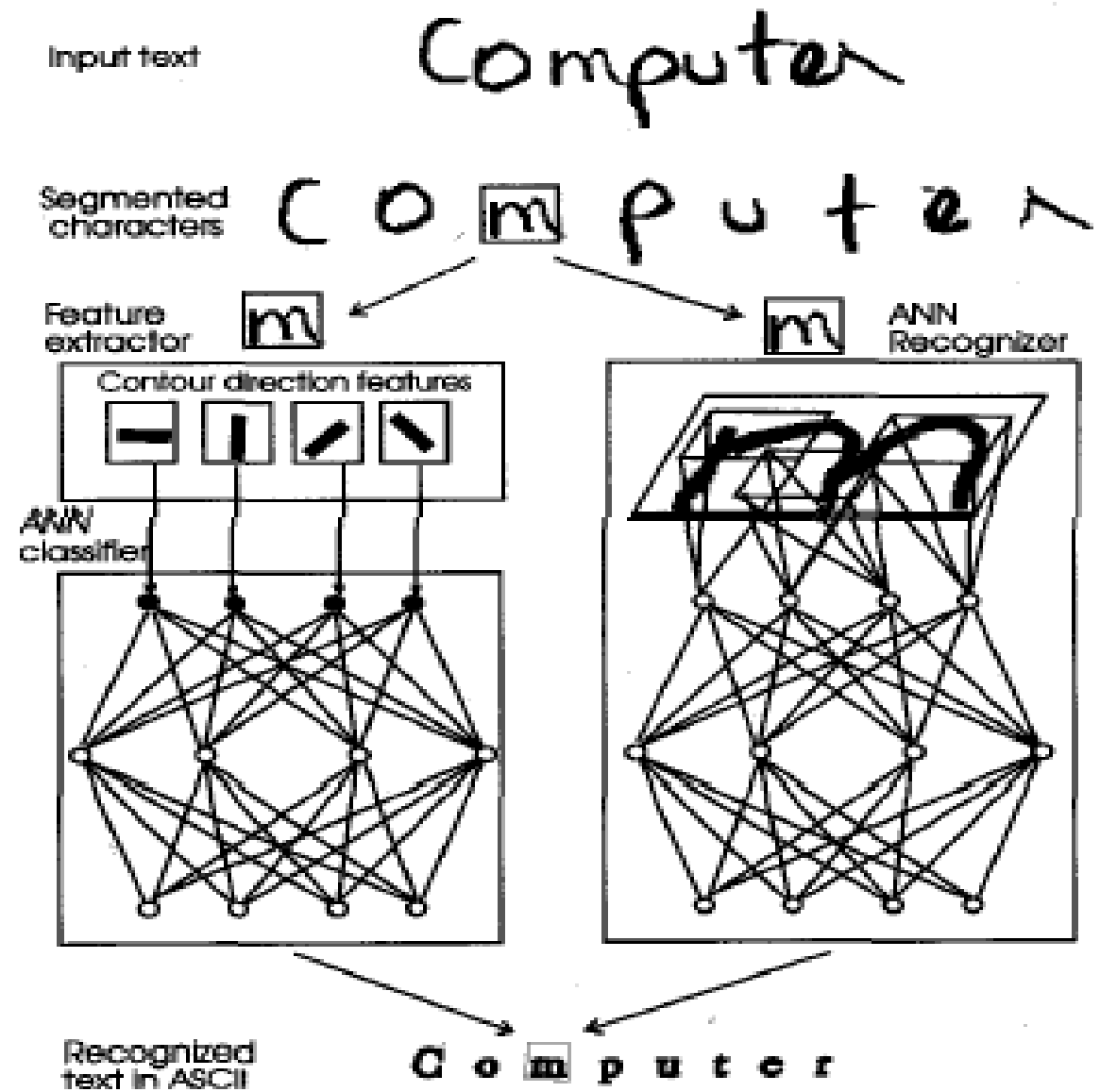
Hopfield Network

- Hopfield designed a network based on an energy function
- As a result of dynamic recurrency, the network total energy decreases and tends to a minimum value (**attractor**)
- The dynamic updates take places in two ways: synchronously and asynchronously
- traveling salesman problem(TSP)



Challenging Problems

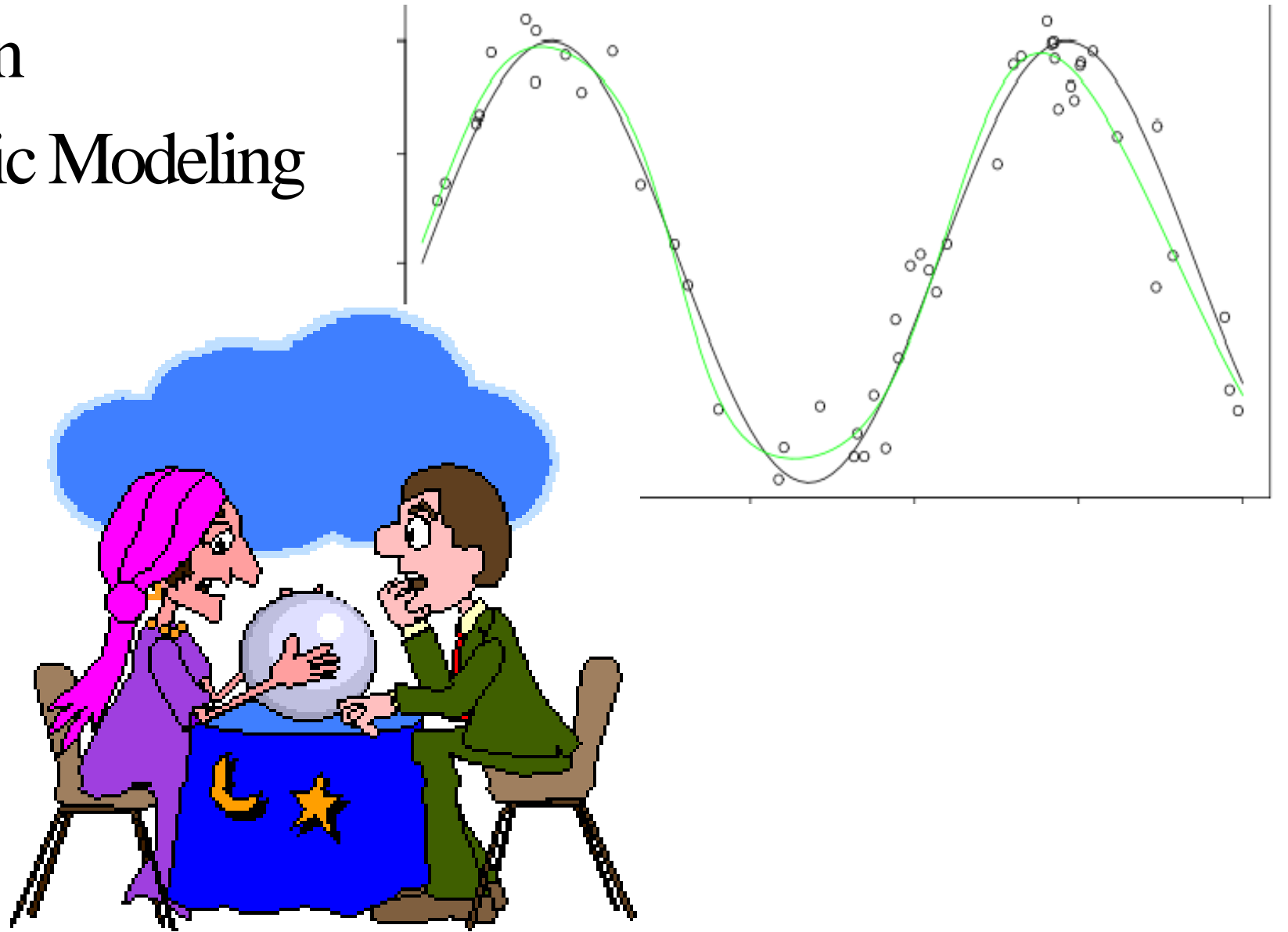
- Pattern recognition
 - Character recognition
 - Speech recognition
- Clustering/Categorization
 - Data mining
 - Data analysis



Challenging Problems

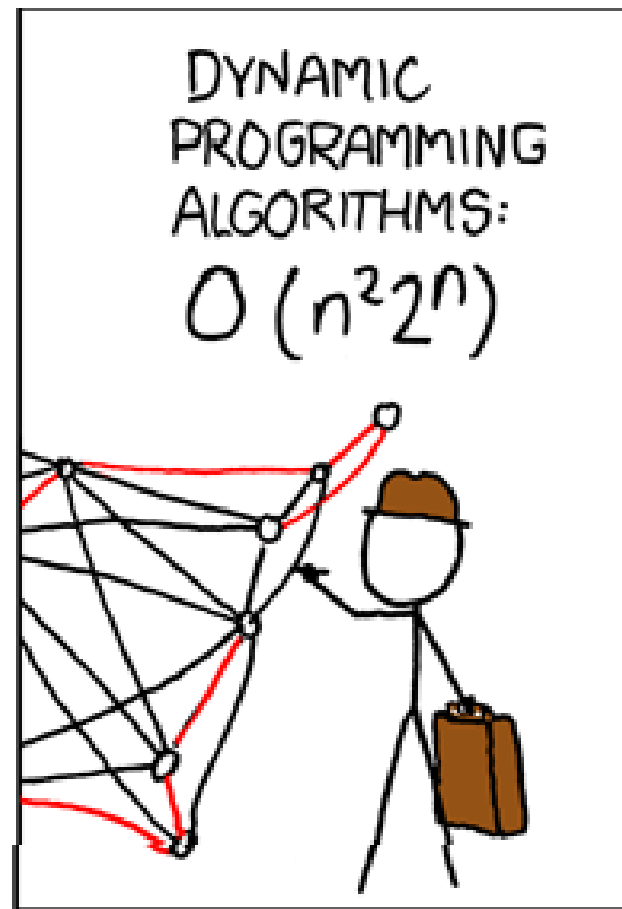
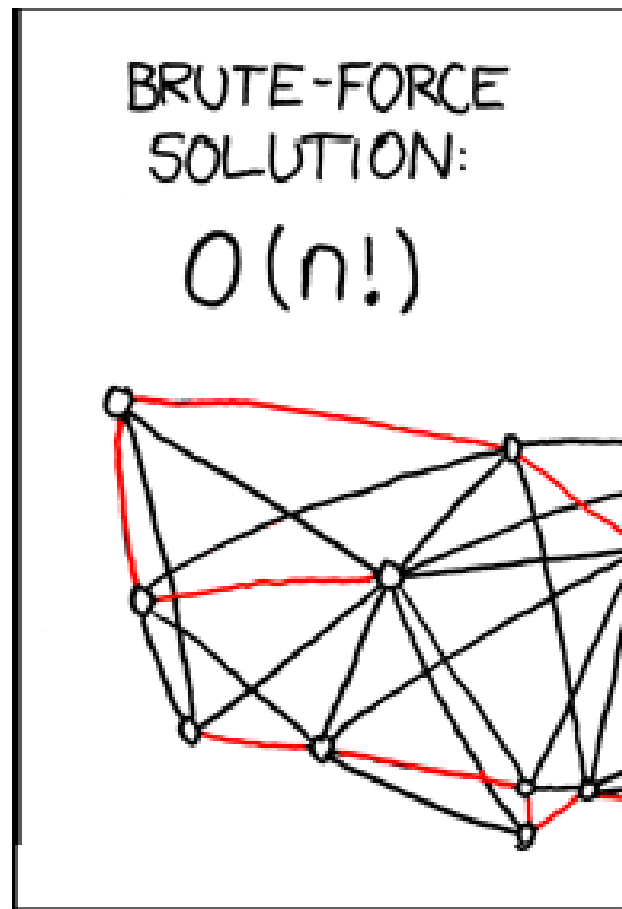
- Function approximation
 - Engineering & scientific Modeling

- Prediction/Forecasting
 - Decision-making
 - Weather forecasting



Challenging Problems

- Optimization
 - Traveling salesman problem(TSP)



Summery

- A great overview of ANN is presented in this paper, it is very easy understanding and straightforward
- The different types of learning rules, algorithms and also different architectures are well explained
- A number of Networks were described through simple words
- The popular applications of NN were illustrated
- The author Believes that ANNS brought up both enthusiasm and criticism.
- Actually except for some special problems there is no evidence that NN is better working than other alternatives
- More development and better performance in NN requires the combination of ANN with new technologies