Artificial Neural Networks (ANN)

Basics

Similar in Structure to Collections of Neurons in Brain

Operate Faster than Biological Counterparts but with less Parallelism

Their Novel Architecture can result in more Elegant Solutions to some Problems

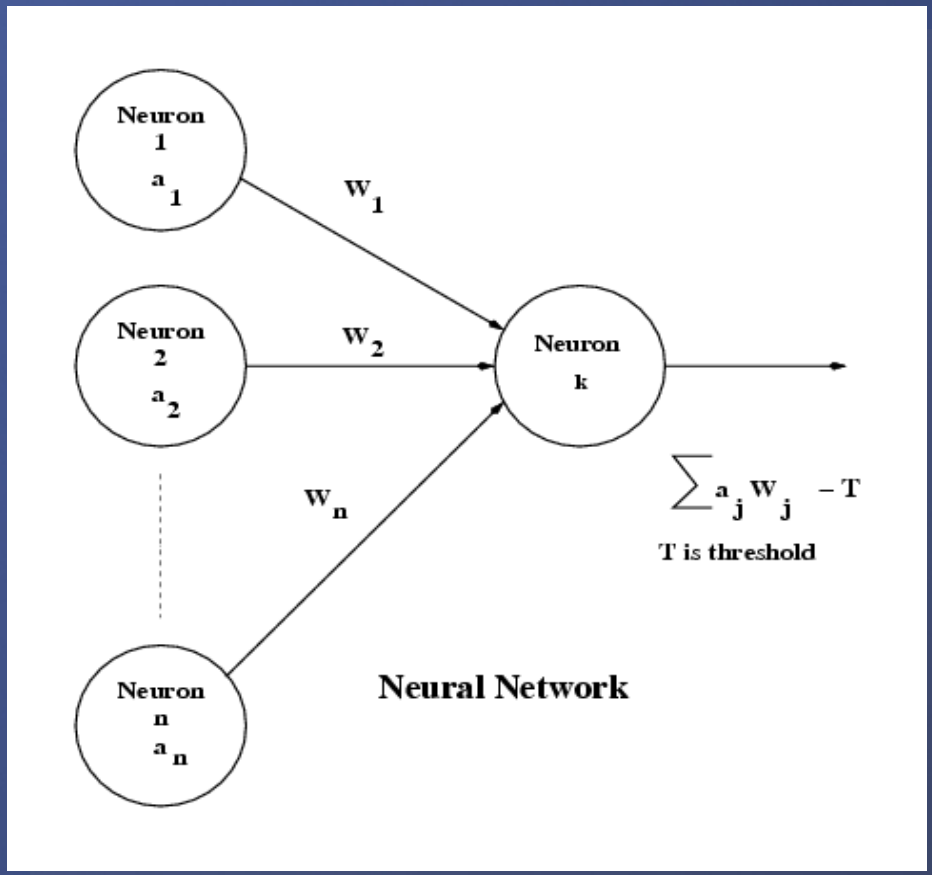
ANN's

General Types of ANN's

Supervised	An Input Vector and the Correct Answer are Provided
Unsupervised	Only Inputs are Provided
Feed Forward	No Feedback
Recurrent	Output Neurons Connected to Input Neurons

ANN's

Simple Feed Forward ANN (Most Common)

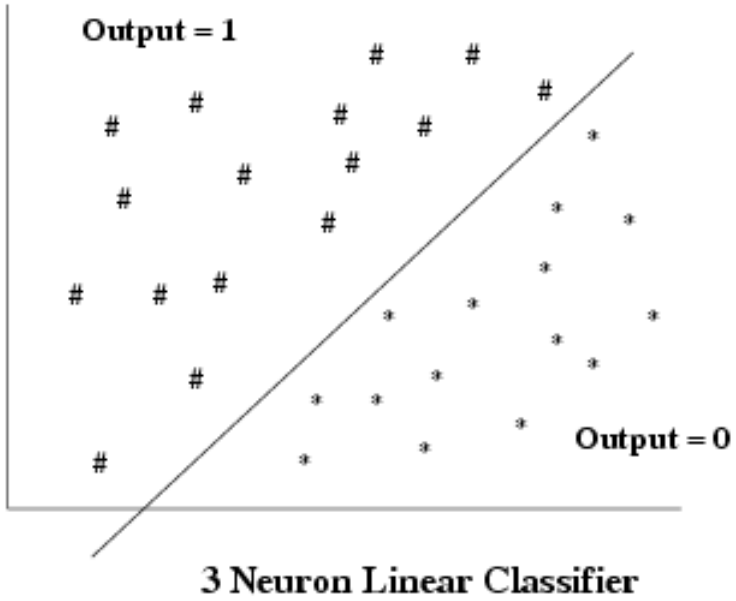


Neuron “Fires” (Output = 1) when Sum of Weights * Inputs > Threshold

ANN's

2 Input Neurons
and one Output
Neurons can find
a Linear Class Partition

A Simple Algorithm
can be used to find
weights



3 Neuron Linear Classifier

ANN's

What about Harder Problems

- Change Output to Threshold Approximation (Sigmoid, Hyperbolic Tangent)

- Use Calculus to find weights

- Most Common method is Back Propagation

- PSO is gaining favor

ANN's

Technique

Model

Representation
Number of Inputs and Outputs Desired

Topology
Hidden Layers

Train

Test

ANN's

Train/Test

Divide Data into 3 Sets
Training, Testing, Final Test

Try to get a good Mix
of Data in Each Set
or
Use “Leave-One-Out” Technique

ANN's

Train/Test

If Training Fails

Modify the Network Topology
Modify Learning Rate
Modify Momentum

Avoid Overfitting/Overtraining

ANN's

Recurrent Networks

- Supervised

- Output Tied to Input

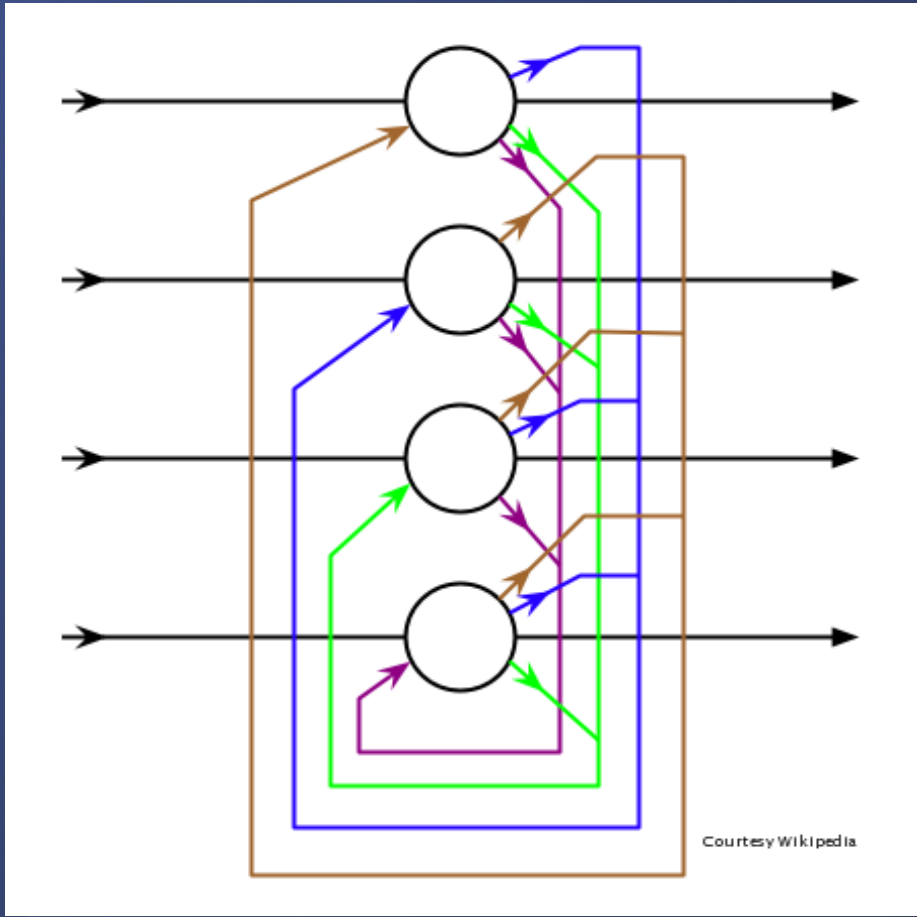
- Learns and Generates Sequences

ANN's

Recurrent Networks

- Unsupervised
- Fully Connected
- Discrete Outputs
  (+1,-1)
- Stores Vectors

- Can Correctly Generalize
  when Input Noisy



Fuzzy Systems

Who Wants Fuzzy Stuff?

Often Exactness just gets in the way of Concepts

Allows Intuitive Linguistics
I.E. “If very hot, turn down thermostat a lot”

A TSP Example

Fuzzy Systems

Fuzzy Sets

Membership Function

1 if Argument is Definitely in Set

0 if Argument is Definitely not in Set

Example

$m(age)=0$ if $age \leq 50$

$m(age)=1/(1+(25/(age-50)^2))$ if $age > 70$

Fuzzy Systems

Different Than Probability

Fuzzy Membership	Probability
Membership in Drinkable Liquid Set = 0.91	Probability of Being Drinkable = 0.91
Expectation That it's not Poison	0.09 Probability That it's Not Drinkable
After Drinking Membership the Same	After Drinking Probability is 1 or 0

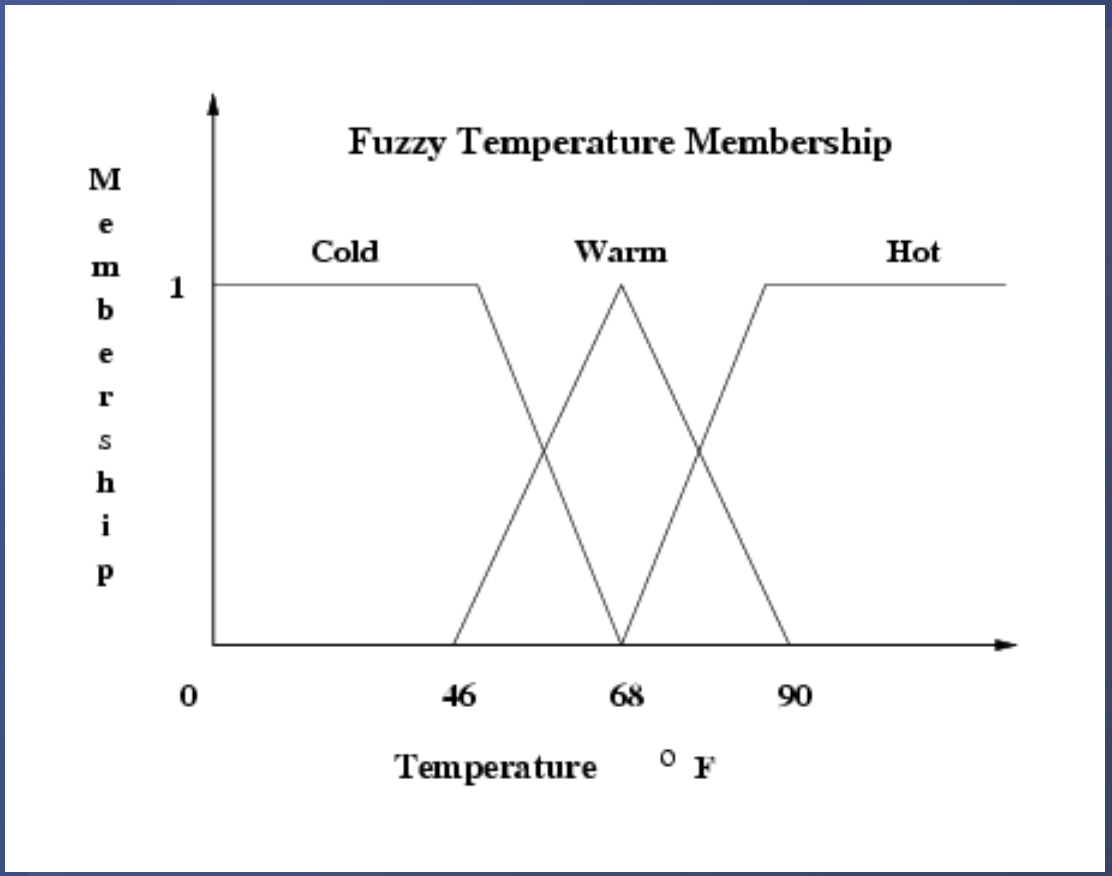
Fuzzy Systems

Set Operations

Equality	All Members Equal
Compliment	1-m
Union (or)	max(m(a), m(b))
Intersection (and)	min(m(a), m(b))

Fuzzy Systems

Fuzzy Temperature



Fuzzy Systems
TSP

Let Longest Possible Path = L

Define Four Membership Functions Short, Medium Short, Medium Long, and Long

Representation

[3,2,4,6,...]
(city list)

Fitness
(Zero is Best)

$$\sum_{j=1}^{N} \sum_{i=1}^{4} \alpha_i \cdot M_{ij}$$

Ant Colony Optimization

Used in Routing and Scheduling Problems

Like PSO, No Central Control

Where is State Kept?

Ant Colony Optimization

Basic TSP Algorithm

```
initialize pheromone deposits
place all k ants in originating city
for t=1 to max {
      - build a trip by choosing
        n-1 cities with probability
        based pheromone distribution
        for each ant
      - compute the trip length for each
        ant
      - if improved route found, update
      - update pheromone deposits
}
   output shortest rout
```

Support Vector Machines

Video

Statistics

Claims

"My Technique is Better Than Yours!"

"I'm Done! My System is Robust"

Need Statistics to Justify These

Statistics

Myths

Better Mean Result Implies Better Technique

Reporting the Mean Result is Good Enough

Reporting the Mean and Standard Deviation is Good Enough

Your Data are Normally Distributed

Statistics

More Myths

The Mean Performance for
Best-of-Run-Individuals is what Matters

10 Runs is Sufficient to show
Differences Between Groups

Statistics

Be Careful

Conclusion

CI is now Practical for Solving Problems

Flexibility and Robustness make it Useful

Understanding the Problem and using Creative Skills are the Key to Successful Application