Introduction to Soft Computing

Brijesh Bhatt, 25th June 2015

Soft Computing

Ability to deal with Imprecision, Uncertainty and Approximation.

Human like abilities

Human like abilities

1. It seems like raining today!!
2. You look like Shahrukh Khan!!
3. Your voice is heavy.

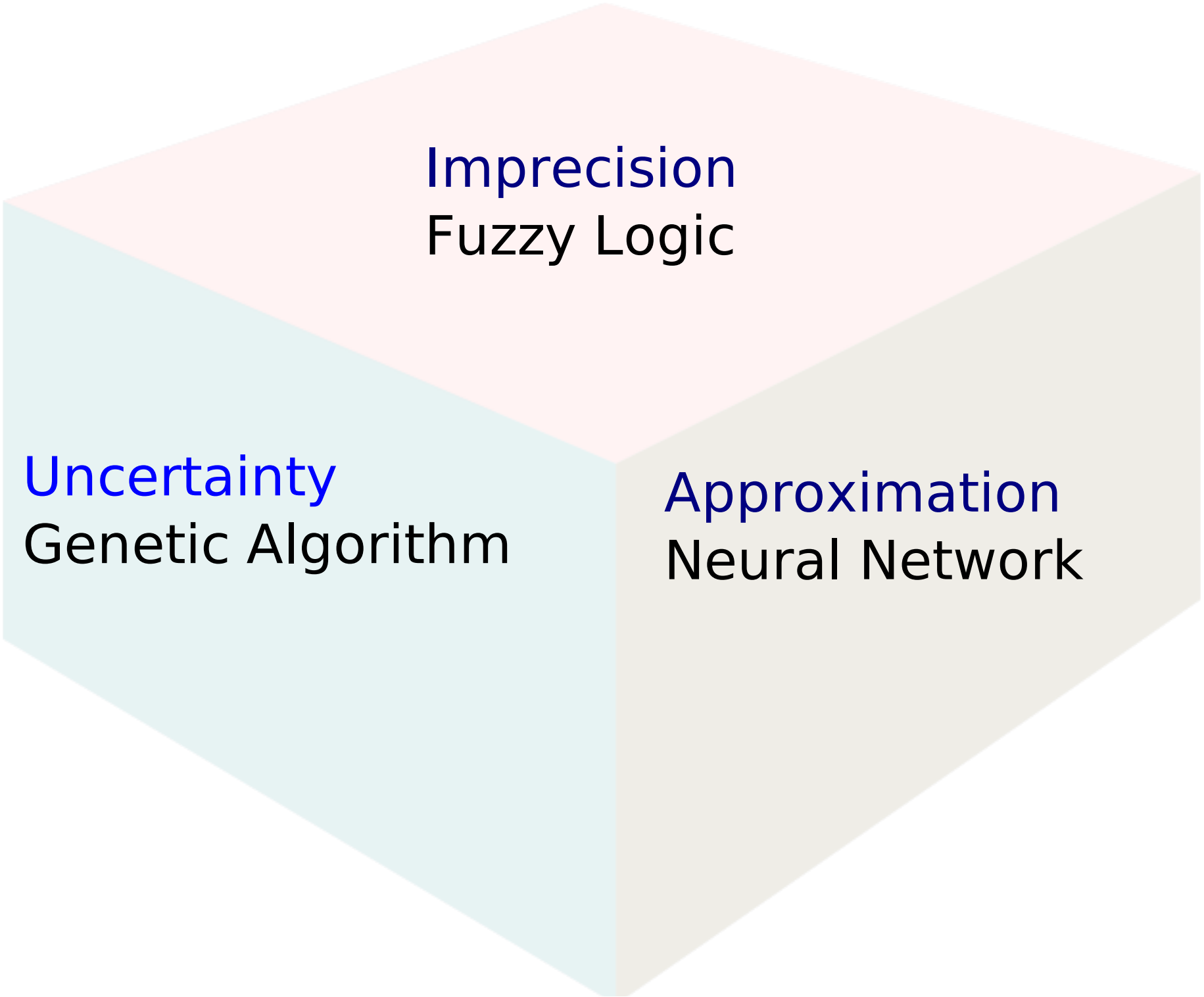
Did you catch cold?

Why Soft Computing?

Hard Computing is Expensive.

Precise Information is often not available.

Identify variables and their range to predict weather!!


Imprecision
Fuzzy Logic
Uncertainty
Genetic Algorithm
Approximation
Neural Network

Imprecision
Fuzzy Logic

Fuzzy Logic

Making Decisions using imprecise knowledge
Playing with subjective variables : tall, fast, hot etc.
'You are too fast, slow down!!'
How tall is tall? Degree of membership!!

Fuzzy Systems

1. Define Fuzzy Variables & Rules
2. Fuzzify Input data
3. Fuzzy Inference
4. Defuzzification

Example

Automatic Speed breaking of vehicle

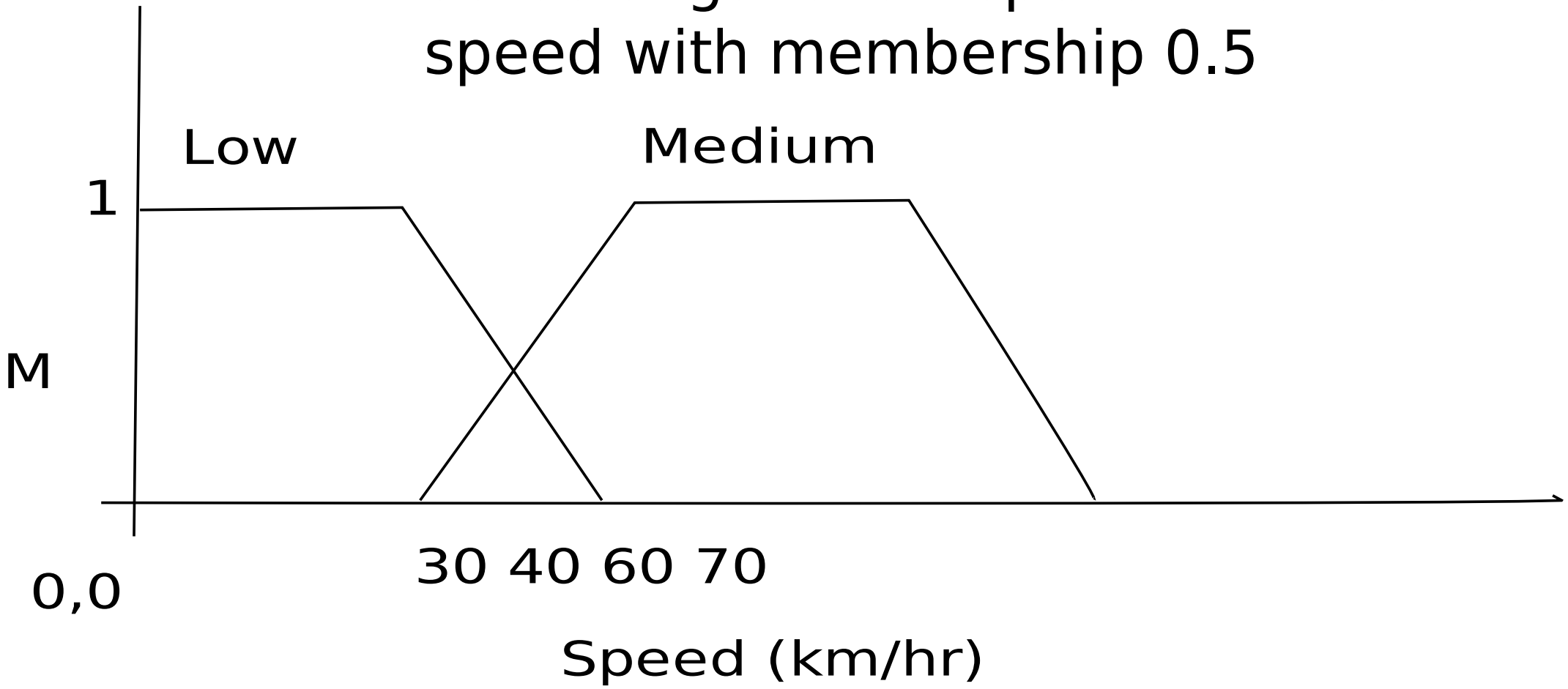
1. Fuzzy Variables

Example

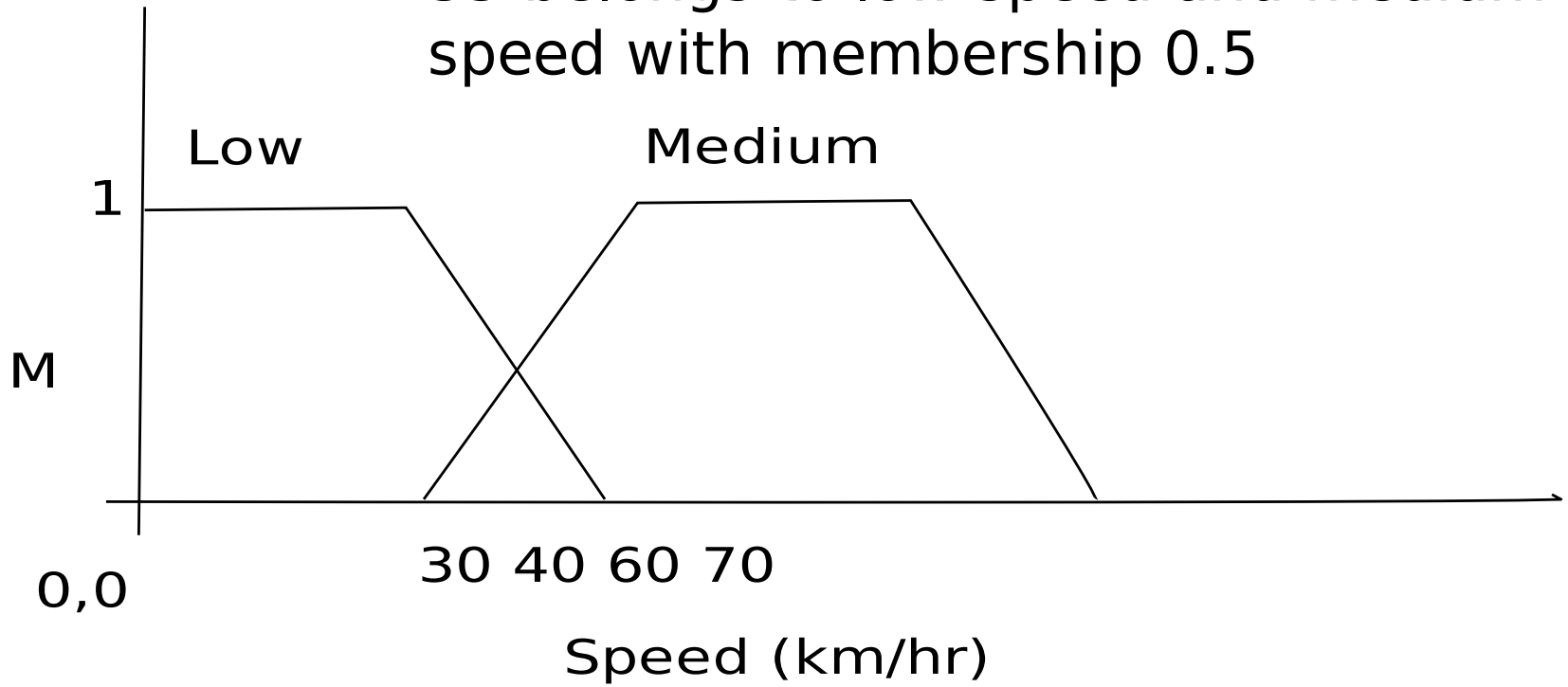
Automatic Speed breaking of vehicle

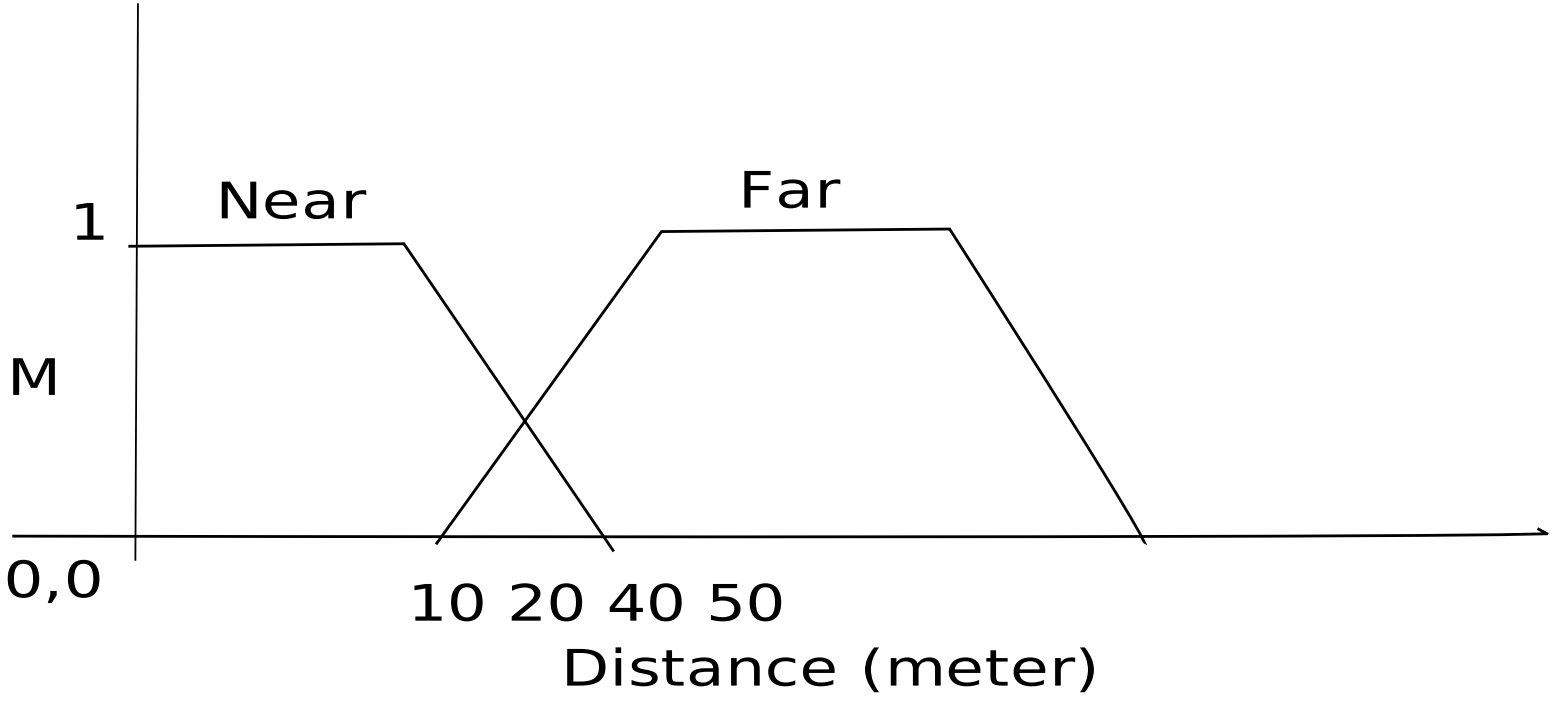
1. Fuzzy Variables

35 belongs to low speed and medium speed with membership 0.5

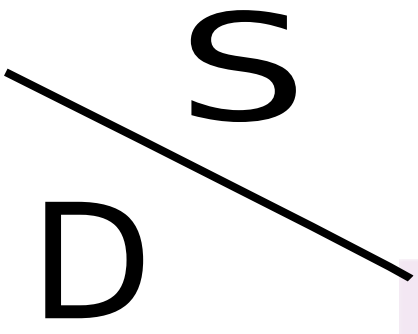


35 belongs to low speed and medium speed with membership 0.5



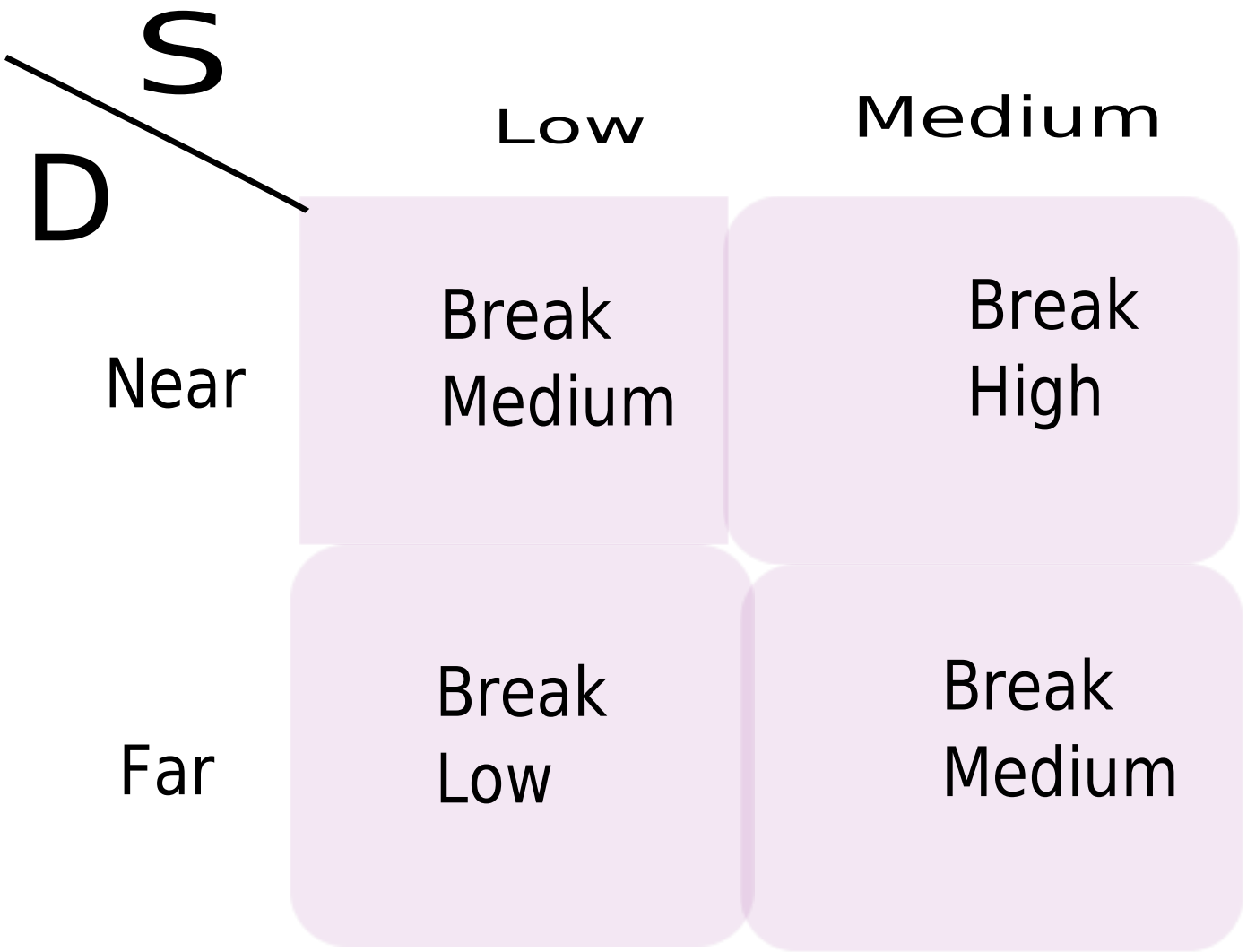


Fuzzy Rules



D \ S	Low	Medium
Near	Break Medium	Break High
Far	Break Low	Break Medium

Fuzzy Rules



Fuzzy Inference

What amount of break should be applied if Speed is 38 kms/hr and Distance is 13 mtr?

Uncertainty
Genetic Algorithm

Genetic Algorithm

Evolutionary method to solve optimization problem.

Optimization : Selecting best out of many feasible solutions.

Genetic Algorithm Process

Genetic Algorithm Process

1. Initial Population : Start with intial set of randomly choosen solutions.
2. Calculate fitness of each solution
3. Select candidates for reproduction using cross over and mutation
4. Generate new population
5. Repeeat until the optimal solution is found

Example : Knapsack problem

Item	1	2	3	4	5	6
P	8	6	12	14	5	16
W	4	2	3	6	1	8

Example : Knapsack problem

Item	1	2	3	4	5	6
P	8	6	12	14	5	16
W	4	2	3	6	1	8

1. Initial Population

G1 100100
G2 101000
G3 100110
G4 110110

Item	1	2	3	4	5	6
P	8	6	12	14	5	16
W	4	2	3	6	1	8

1. Initial Population

G1 100100
G2 101000
G3 100110
G4 110110

2. Fitness

$$\sum P, \sum W$$

1. Initial Population

G1 100100
G2 101000
G3 100110
G4 110110

2. Fitness

$$\sum P, \sum W$$

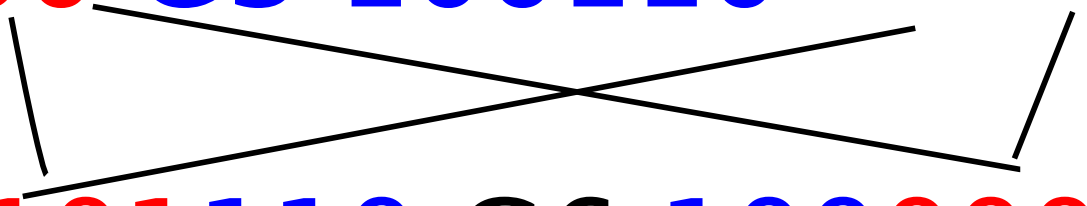
3. Crossover

G2 101000 G3 100110

G5 101110 G6 100000

3. Crossover

G2 101000 G3 100110



G5 101110 G6 100000

4. Mutation

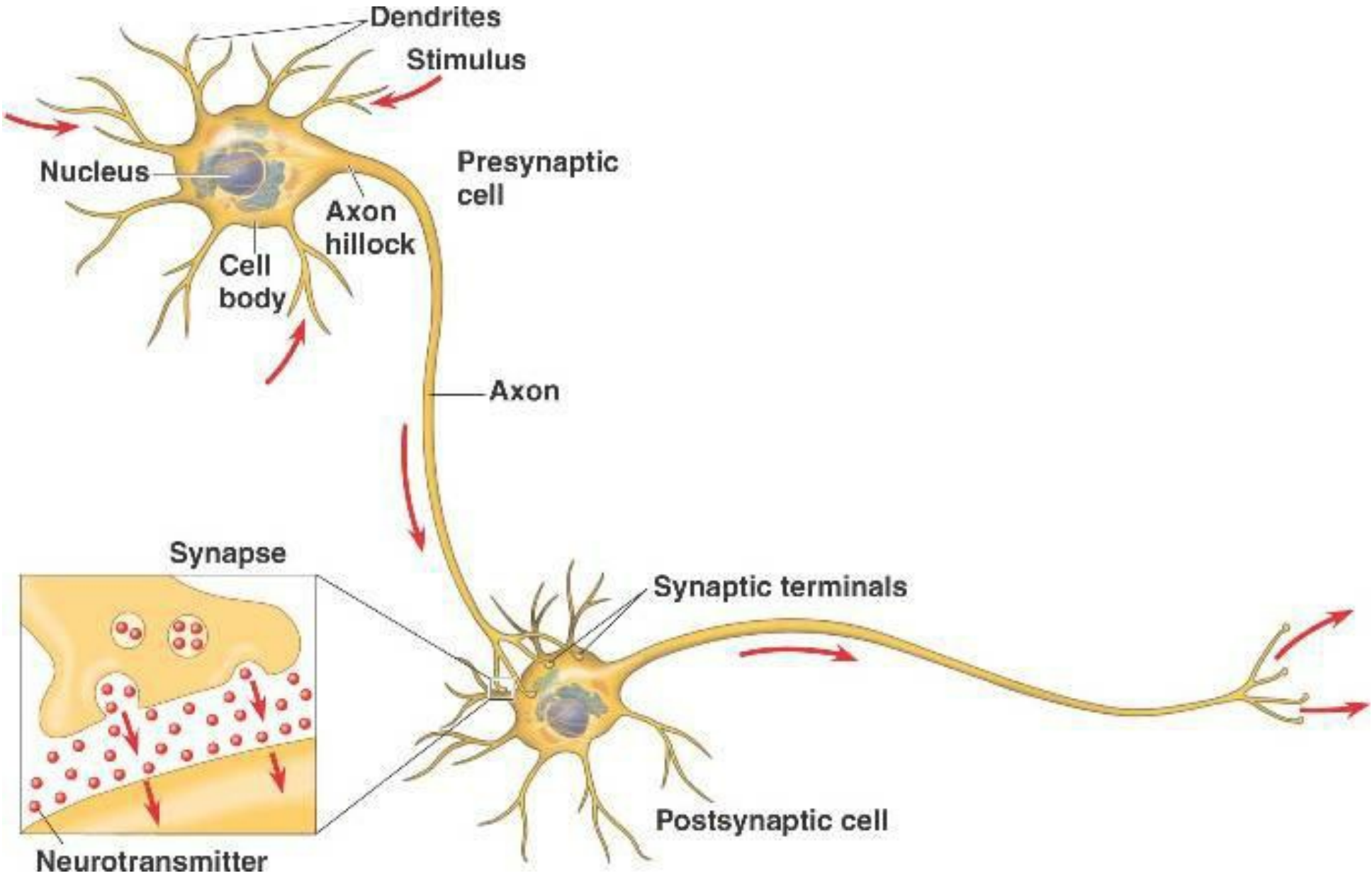
G5 101010

Approximation
Neural Network

Neural Network

Computation method Inspired by functioning of Human Brain.

Human Brain


Dendrites
Stimulus
Nucleus
Presynaptic cell
Axon hillock
Cell body
Axon
Synapse
Synaptic terminals
Postsynaptic cell
Neurotransmitter

Human Brain

-Signals are processed via excitation of neurons

- Summation is the only operation performed

- Information is stored/process

-Signals are processed via excitation of neurons

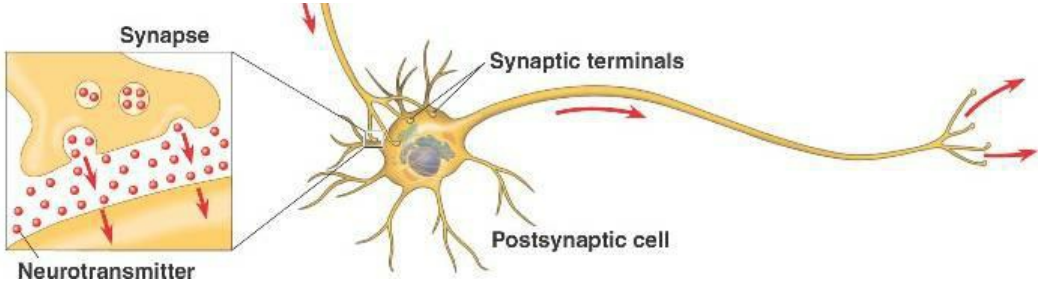
- Summation is the only operation performed

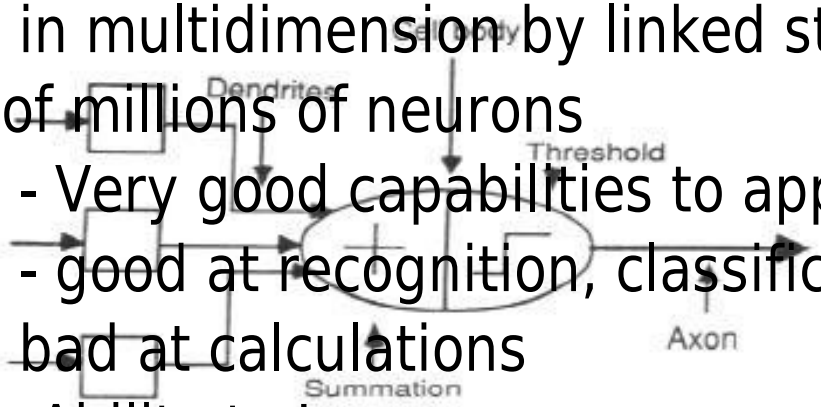
- Information is stored/processed in multidimension by linked structure of millions of neurons

- Very good capabilities to approximate.

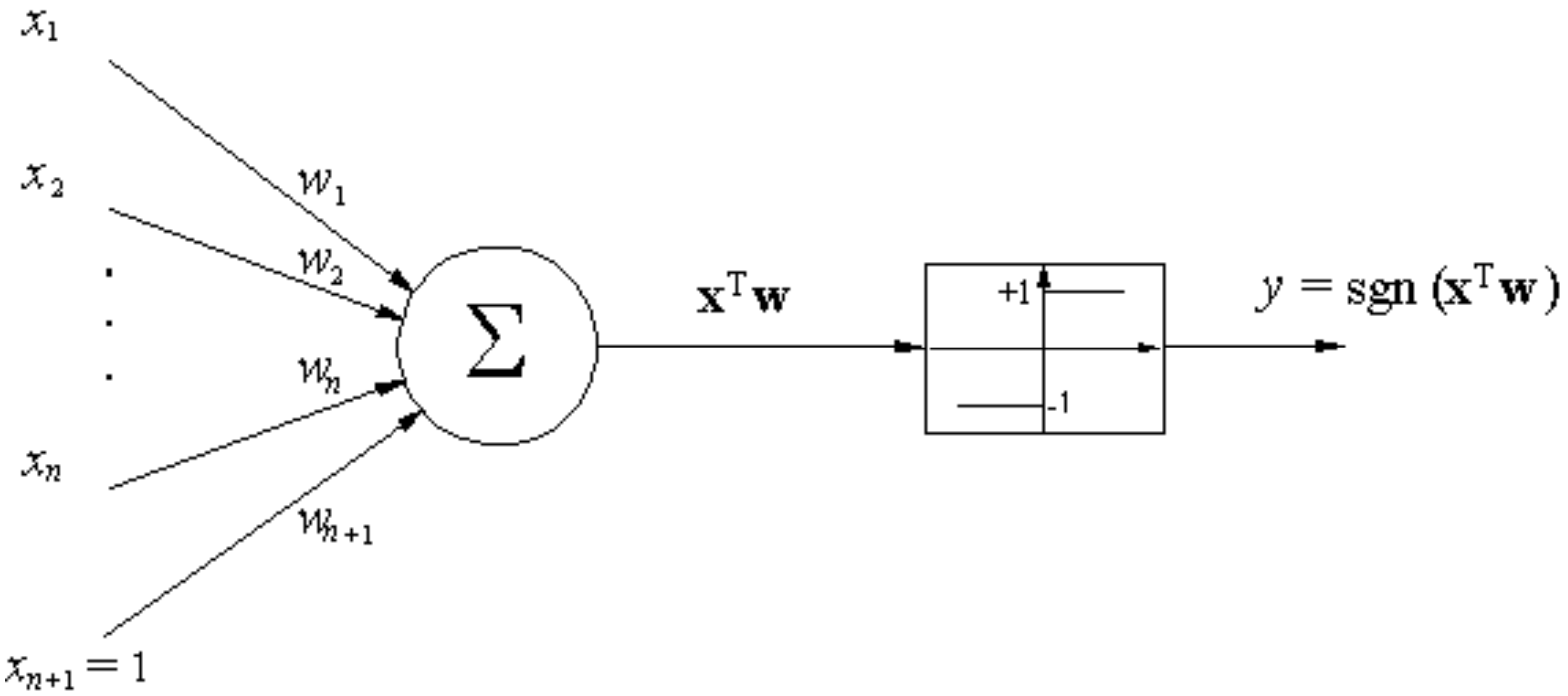
- good at recognition, classification tasks, bad at calculations

-Ability to Learn

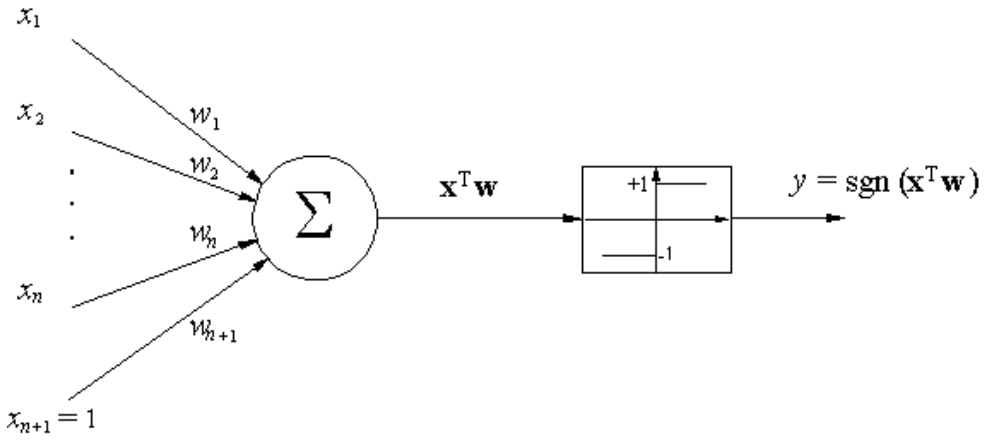




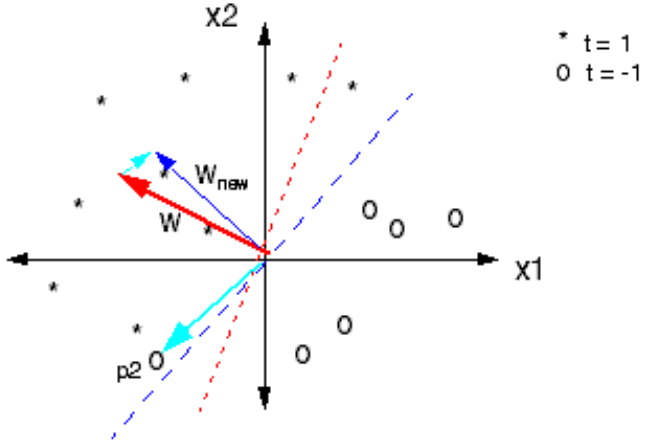
Perceptron


x_1
x_2
x_n
$x_{n+1} = 1$
w_1
w_2
w_n
w_{n+1}
Σ
$\mathbf{x}^T\mathbf{w}$
+1
-1
$y = \text{sgn}(\mathbf{x}^T\mathbf{w})$

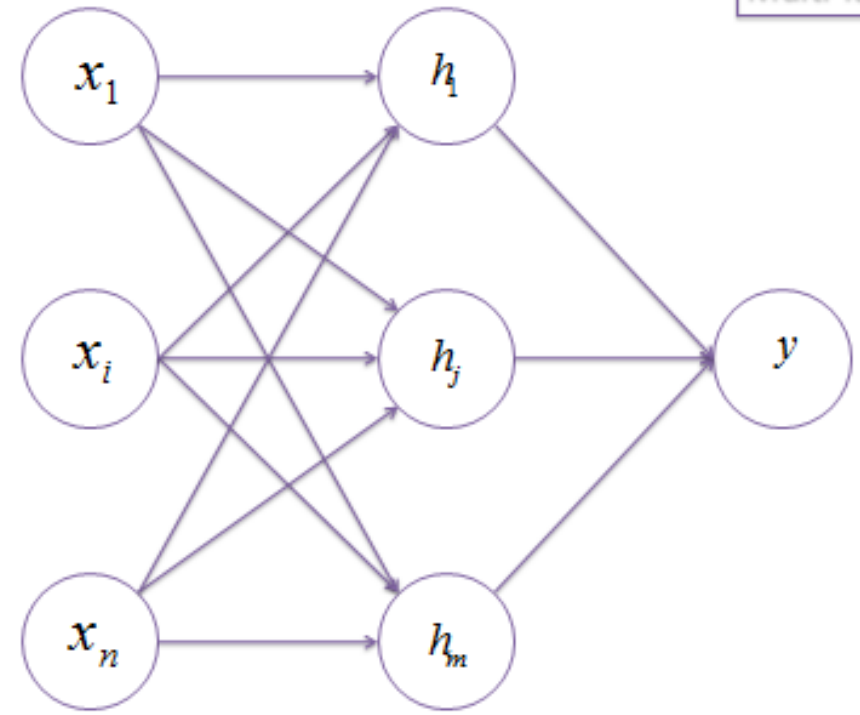
Perceptron

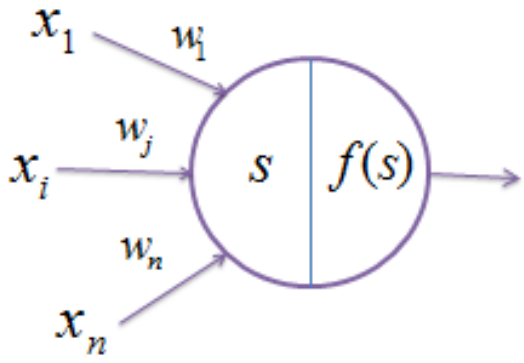


Linear Classifier



Multi-layer Perceptron





Summation

$$s = \sum w \cdot x$$

Transformation

$$f(s) = \frac{1}{1+e^{-s}}$$

Learning

Brain stores information as synaptic weight.
If a neuron is more frequently excited then it becomes easier to excite it.
Learning happens in form of updation of weights
Weights values can be updated in a controlled or uncontrolled way: Supervise or Unsupervise learning

Unsupervised Learning : (Learning without teacher)

The neurons which are fired more frequently gets strongers

Supervised Learning : (Learning with teacher)

update the weight of neurons to match output with expected value

Supervised Learning Algorithm

1. Created tagged data set.
2. Apply input to network
3. Calculate output
4. calculate error = f(output - target)

 if(error > minE)

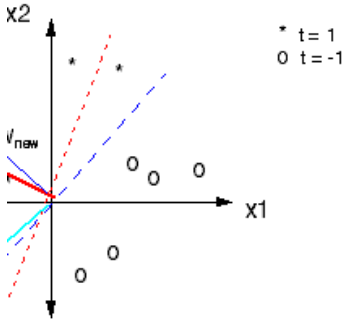
 Update the weight in

 proportion to error

 Repeat 2

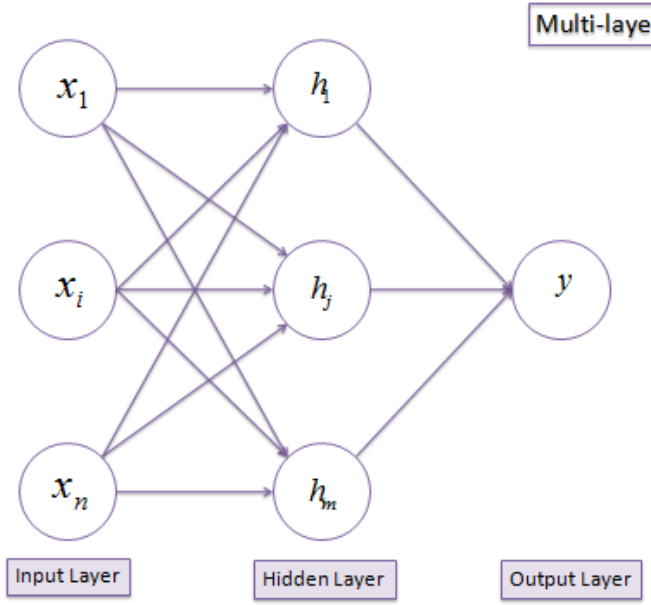
r Classifier

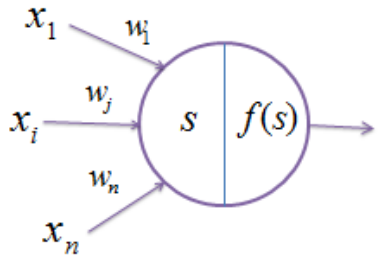
Supervised Learning Algorithm



1. Created tagged data set.
2. Apply input to network
3. Calculate output
4. calculate error = f(output - target)

if(error > minE)
Update the weight in
proportion to error
Repeat 2





Summation

$$s = \sum w \cdot x$$

Transformation

$$f(s) = \frac{1}{1+e^{-s}}$$

lue

Error reduction

With each update in weight error should reduce.

Convergence

Algorithm should terminate with min. error

Gradient Descent

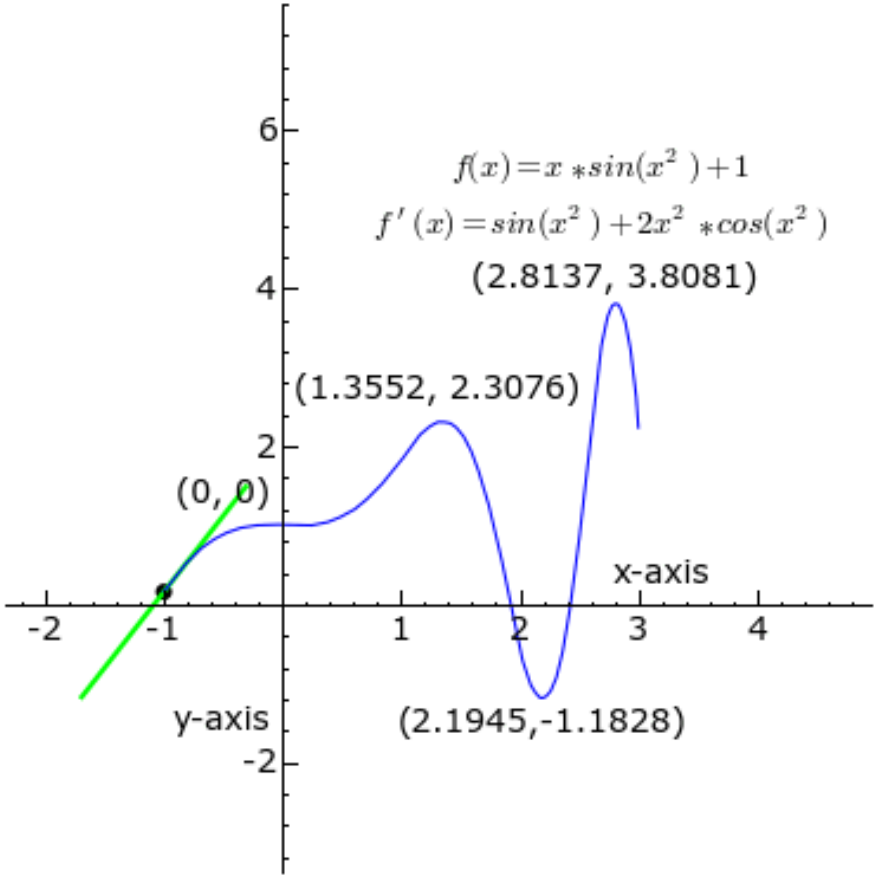
Update the weight in proportion to gradient of error.

It guaratees covergence!!!

Gradient Descent

Update the weight in proportion to gradient of error.

It guaratees covergence!!!



Conclusion

Soft computing techniques are inspired by behavior of intelligent species

Used to solve Hard Optimization problems

Intelligent: ability to learn

Introduction to Soft Computing

Brijesh Bhatt, 25th June 2015

Why Soft Computing?

Hard Computing is Expensive.
Precise Information is often not available.
Identify variables and their range to predict weather!!

Genetic Algorithm

Evolutionary method to solve optimization problem.
Optimization : Selecting best out of many feasible solutions.

Genetic Algorithm Process

1. Initial Population : Start with intial set of randomly choosen solutions.
2. Calculate fitness of each solution
3. Select candidates for reproduction using cross over and mutation
4. Generate new population
5. Repeeat until the optimal solution is found.

Example : Knapsack problem

Item	1	2	3	4	5	6
P	8	6	12	14	5	16
W	4	2	3	6	1	8

1. Initial Population

G1 100100
G2 101000
G3 100110
G4 110110

2. Fitness

$\sum P, \sum W$

3. Crossover

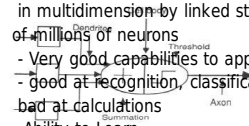
G2 101000 G3 100110

G5 101110 G6 100000

4. Mutation

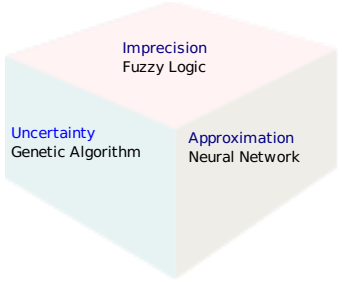
G5 101010

Human Brain
-Signals are processed via excitation of neurons
- Summation is the only operation performed
- Information is stored/processed in multidimension by linked structure of millions of neurons
- Very good capabilities to approximate.
- good at recognition, classification tasks, bad at calculations
-Ability to Learn



Fuzzy Logic

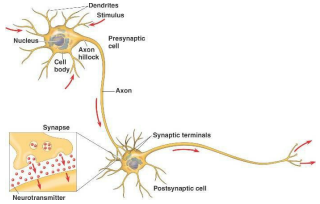
Making Decisions using imprecise knowledge
Playing with subjective variables : tall, fast, hot etc.
'You are too fast, slow down!!'
How tall is tall? Degree of membership!!



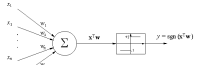
Neural Network

Computation method Inspired by functioning of Human Brain.

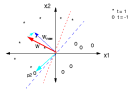
Human Brain



Perceptron



Linear Classifier

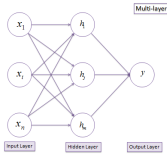


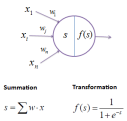
Supervised Learning Algorithm

1. Created tagged data set.
2. Apply input to network
3. Calculate output
4. calculate error = f(output - target)
if(error > minE)
Update the weight in proportion to error
Repeat 2

Learning
Brain stores information as synaptic weight.
If a neuron is more frequently excited then it becomes easier to excite it.
Learning happens in form of updation of weights
Weights values can be updated in a controlled or uncontrolled way: Supervise or Unsupervise learning

Unsupervised Learning : (Learning without teacher)
The neurons which are fired more frequently gets strongers
Supervised Learning : (Learning with teacher)
update the weight of neurons to match output with expected value





Soft Computing

Ability to deal with Imprecision, Uncertainty and Approximation.

Human like abilities
1. It seems like raining today!!
2. You look like Shahrukh Khan!!
3. Your voice is heavy.
Did you catch cold?

Fuzzy Systems

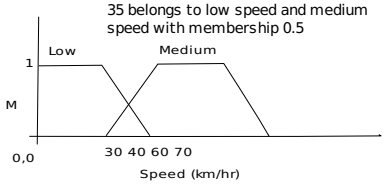
1. Define Fuzzy Variables & Rules
2. Fuzzify Input data
3. Fuzzy Inference
4. Defuzzification

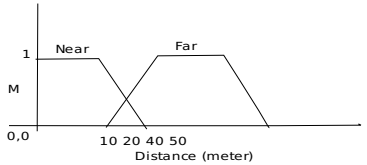
Example

Automatic Speed breaking of vehicle

1. Fuzzy Variables

35 belongs to low speed and medium speed with membership 0.5





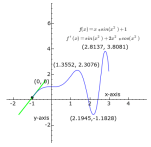
Fuzzy Rules

S / D	Low	Medium
Near	Break Medium	Break High
Far	Break Low	Break Medium

Fuzzy Inference

What amount of break should be applied if Speed is 38 kms/hr and Distance is 13 mtr?

Error reduction
With each update in weight error should reduce.
Convergence
Algorithm should terminate with min. error
Gradient Descent
Update the weight in proportion to gradient of error.
It guaratees covergence!!!



Conclusion
Soft computing techniques are inspired by behavior of intelligent species
Used to solve Hard Optimization problems
Intelligent: ability to learn

Thank You!!

Thank You!!