CSCI3230
Introduction to Neural Network I

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Week 10, Fall 2013

Neural Network Project

Due date: 10th Dec, 2013 (GMT +08:00) 23:59:59

The Angelina Effect

- Angelia is a carrier of the mutation in the BRCA1 gene.
- Angelina Jolie's risk of having breast cancer was amplified by more than 80 percent and ovarian cancer by 50 percent.
- Her aunt died from breast cancer and her mother from ovarian cancer.
- She decided to go for surgery and announced her decision to have both breasts removed.

Neural Network Project

- Topic : Genetic Prediction of Rheumatoid Arthritis (RA)
- Goal: Given data of genetic variants, you are helping a genetic scientist to develop a classifier which can predict if an individual will suffer from RA (or in high-risk).

- Due date: 10th Dec, 2013 (GMT +08:00) 23:59:59
- Do it alone / Form a group of max. 2 students
  (i.e. >= 3 students per group is not allowed.)

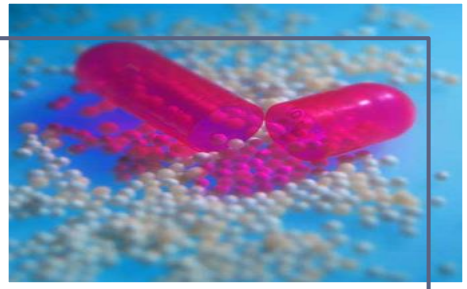
- You can use any one of the following language: C, C++, Java, Swi-Prolog, CLisp, Python, Ruby or Perl.

- However, you cannot use data mining or machine learning packages

- Start the project as early as possible !

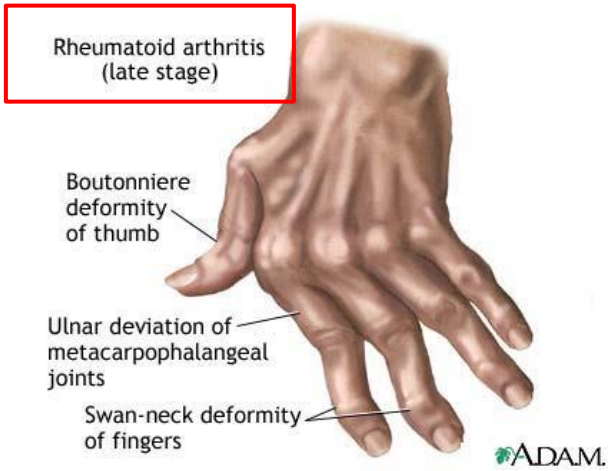
What is Rheumatoid Arthritis? (類風濕關節炎)

Inflammation (發炎)



No effective therapy

No effective diagnosis

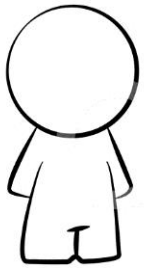


Unknown causes

60,000,000 patients

http://www.geninv.net/category/medicine/
http://trialx.com/curebyte/2011/05/24/what-is-rheumatoid-arthritis
http://www.cosmosmagazine.com/features/online/3445/a-plague-people
http://whymarbella.com/marbella-is-looking-to-host-a-medicine-university/
http://www.onlinemedicinetips.com/disease/y/yeast-infection/Can-Yeast-Infection-Cause-Blisters.html

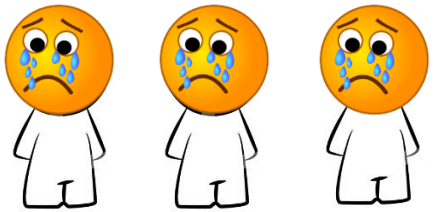
Genome-wide Association Study (GWAS)



DNA Sequencing

3 billion nucleotides (characters)

Case (with disease)



DNA Sequencing

GWAS aims to find the associations ween genetic variations and observable tra

Comparison

Control (without disease)

DNA Sequencing

http://www.sodahead.com
http://www.biol.unt.edu/~jajohnson/DNA_sequencing_process
http://www.illustrationsof.com/63130-royalty-free-human-factor-clipart-illustration

Dataset

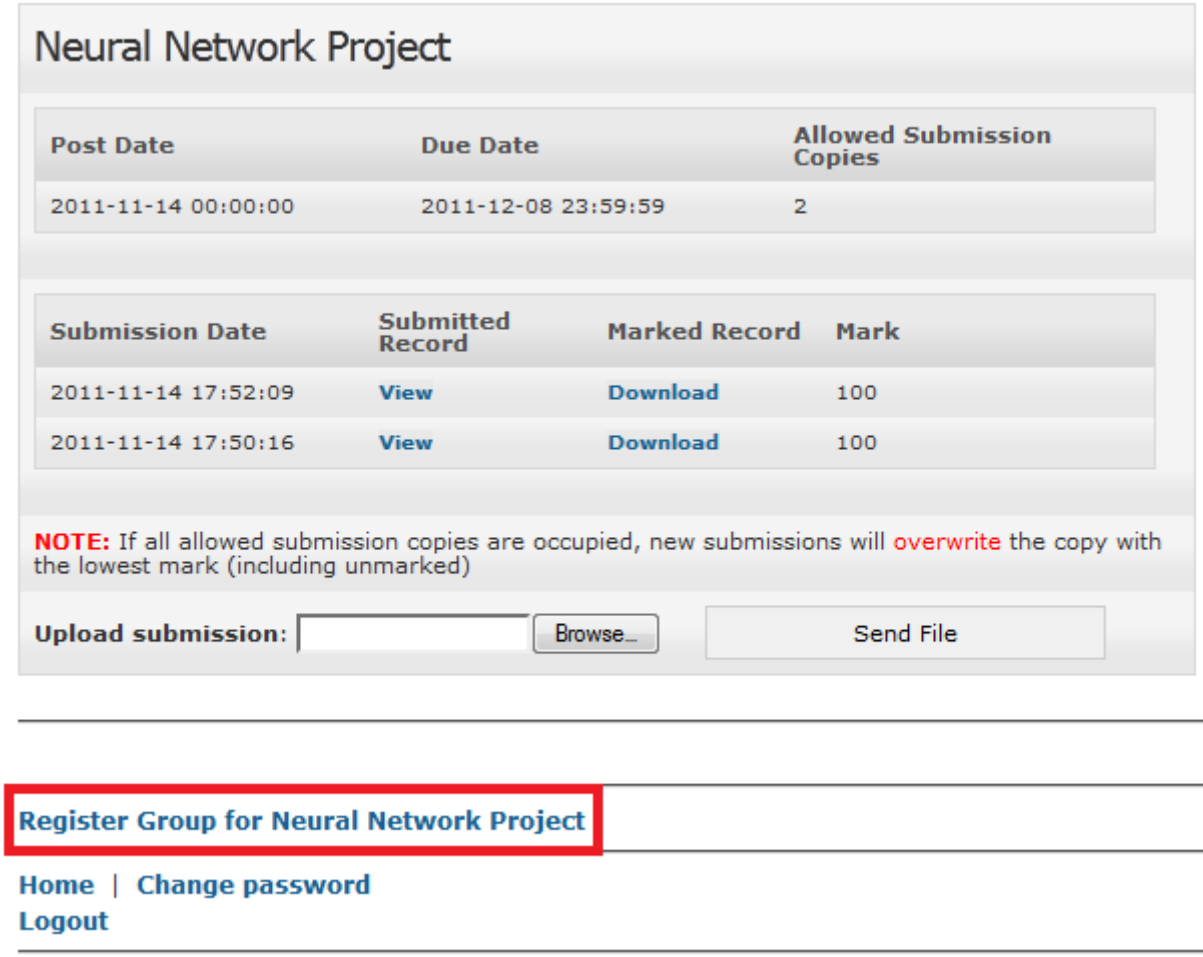
	Attribute	Type	Description
	Genetic Variants		
1	N25	Categorical	The type of SNPs on chromosomal position 25
2	N92	Categorical	The type of SNPs on chromosomal position 92
3	N158	Categorical	The type of SNPs on chromosomal position 158
4	N183	Categorical	The type of SNPs on chromosomal position 183
5	N204	Categorical	The type of SNPs on chromosomal position 204
6	N251	Categorical	The type of SNPs on chromosomal position 251
7	N264	Categorical	The type of SNPs on chromosomal position 264
8	N305	Categorical	The type of SNPs on chromosomal position 305
9	N359	Categorical	The type of SNPs on chromosomal position 359
10	N572	Categorical	The type of SNPs on chromosomal position 572
11	N596	Categorical	The type of SNPs on chromosomal position 596
12	N636	Categorical	The type of SNPs on chromosomal position 636
13	N712	Categorical	The type of SNPs on chromosomal position 712
14	N767	Categorical	The type of SNPs on chromosomal position 767
15	N893	Categorical	The type of SNPs on chromosomal position 893
16	N914	Categorical	The type of SNPs on chromosomal position 914
17	N926	Categorical	The type of SNPs on chromosomal position 926
18	N939	Categorical	The type of SNPs on chromosomal position 939
19	N988	Categorical	The type of SNPs on chromosomal position 988
20	N989	Categorical	The type of SNPs on chromosomal position 989
21	N990	Categorical	The type of SNPs on chromosomal position 990
22	N991	Categorical	The type of SNPs on chromosomal position 991
23	N992	Categorical	The type of SNPs on chromosomal position 992
24	N993	Categorical	The type of SNPs on chromosomal position 993
25	N994	Categorical	The type of SNPs on chromosomal position 994
26	N995	Categorical	The type of SNPs on chromosomal position 995
27	N996	Categorical	The type of SNPs on chromosomal position 996
28	N997	Categorical	The type of SNPs on chromosomal position 997
29	N1005	Categorical	The type of SNPs on chromosomal position 1005
30	N1024	Categorical	The type of SNPs on chromosomal position 1024
	Other attributes		
31	y	Binary	Does the individual suffer from RA?

Genetic Variants Data:

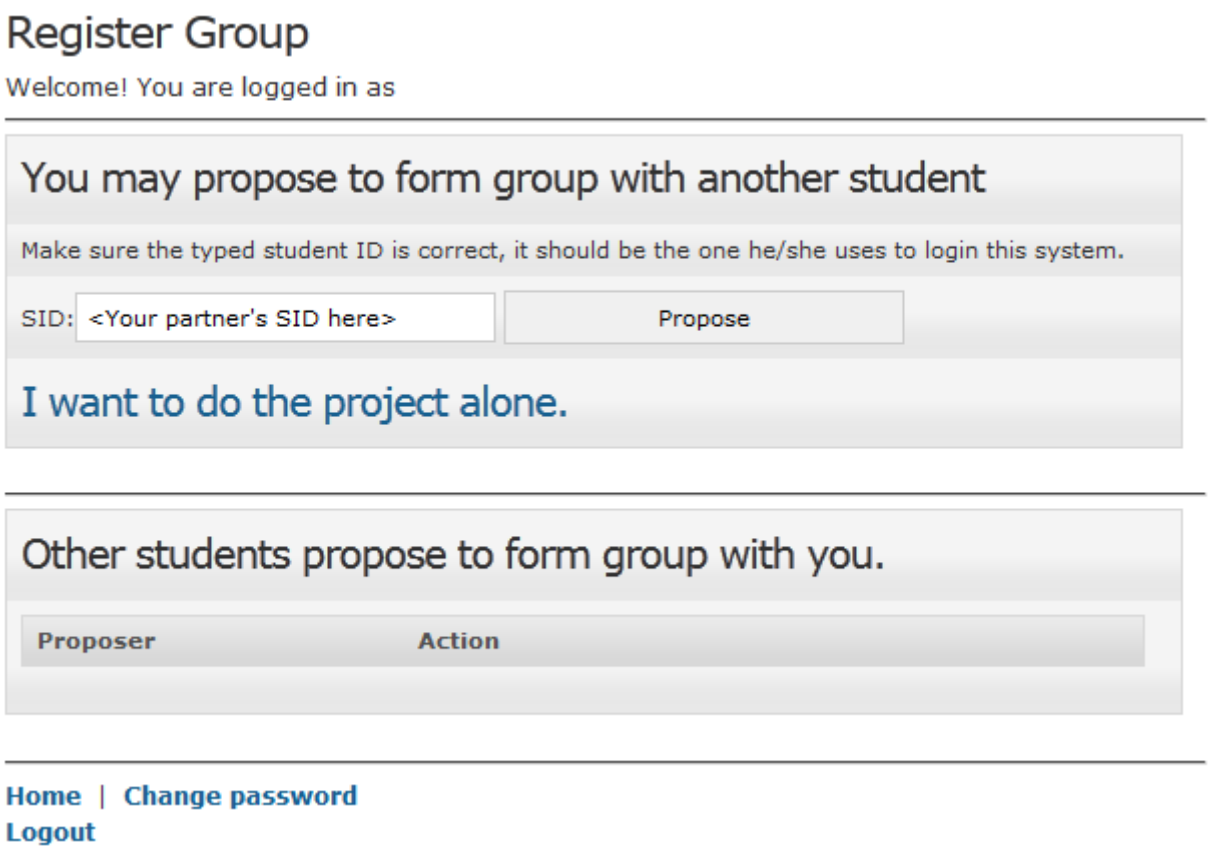
1600 records;

Each record contains 31 attributes;

How to register your group ?



How to register your group ?



What to include in your zip file ?

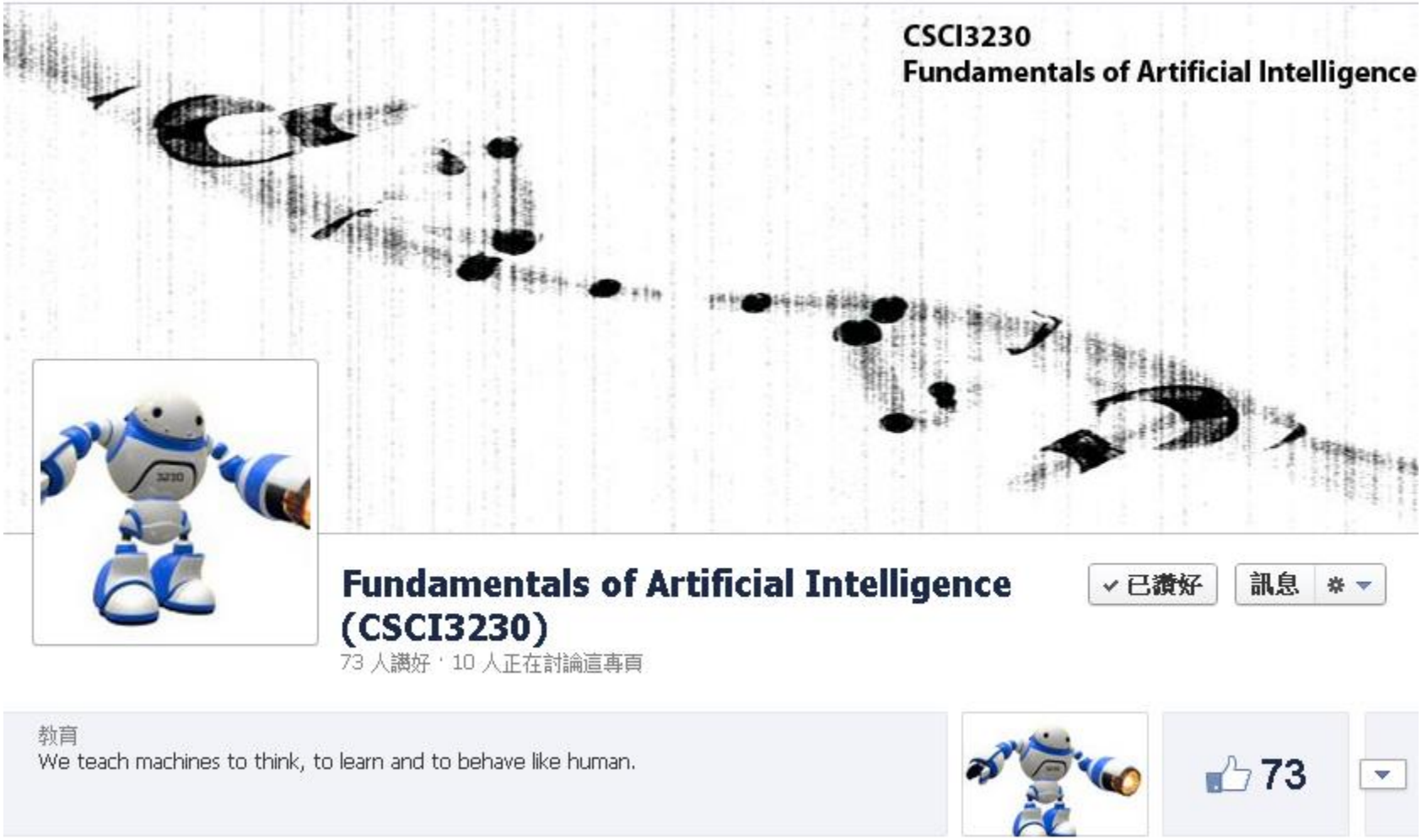
Your zip file should contain the followings:

- preprocess.c – your source code (if you use C)
- preprocessor.sh – a script file to compile your source code
- trainer.c – your source code (if you use C)
- trainer.sh – a script file to compile your source code
- **best.nn** – your Neural Network

Grading

- Please note that the neuron network interfaces/formats are different from the previous years.
- We adopts a policy of zero tolerance on plagiarism. Plagiarism will be SERIOUSLY punished.
- To make the project easier, you will get full marks in any section if your F-measure of your classification result is larger than or equal to 0.75

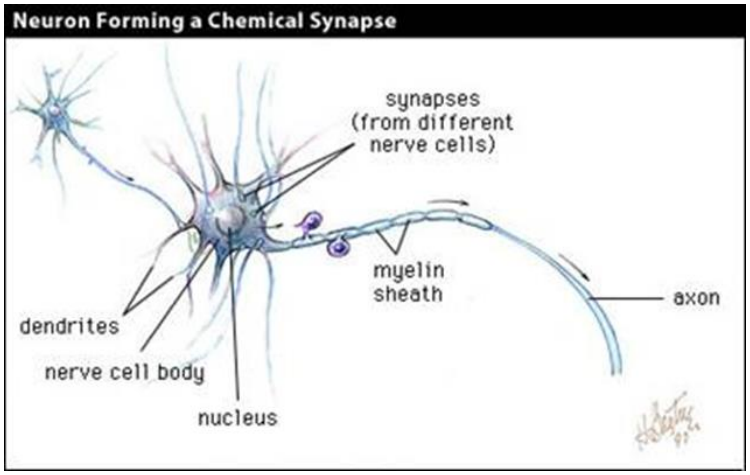
Course Consultation Facebook Page

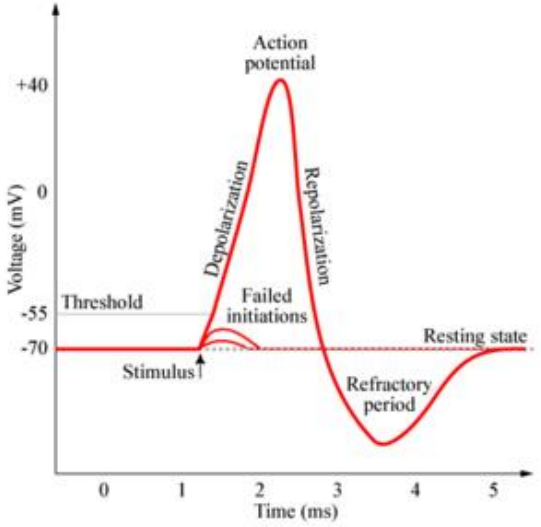


https://www.facebook.com/pages/Fundamentals-of-Artificial-Intelligence-CSCI3230/169738459771018

Introduction to Neural Network

Biological Neuron

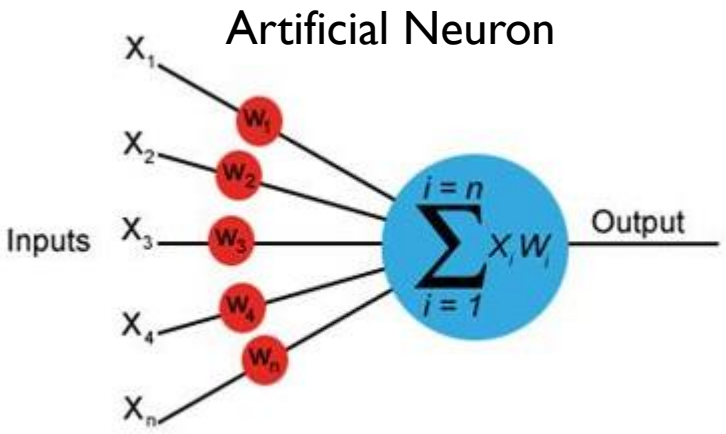




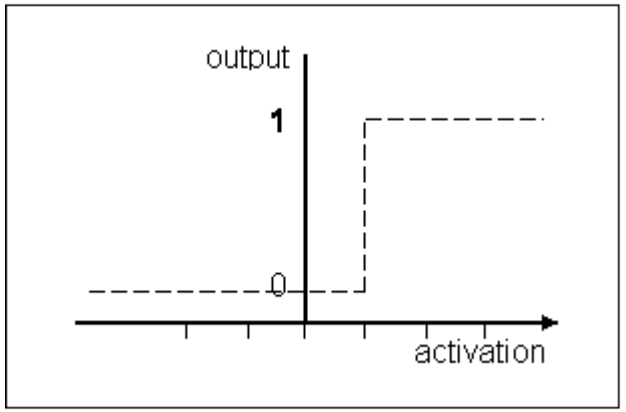
- A neuron is an electrically excitable cell that processes and transmits information through electrical and chemical signals.
- A chemical signal occurs via a synapse, a specialized connection with other cells.

Artificial Neuron

- An artificial neuron is a logic computing unit.
- In this simple case, we use step function as activation function: only 0 and 1 are possible outputs
- Mechanism:
  - Input:
    - $in = x_1w_1 + x_2w_2 + \cdots + x_5w_5$
  - Output:
    - y = g(in)



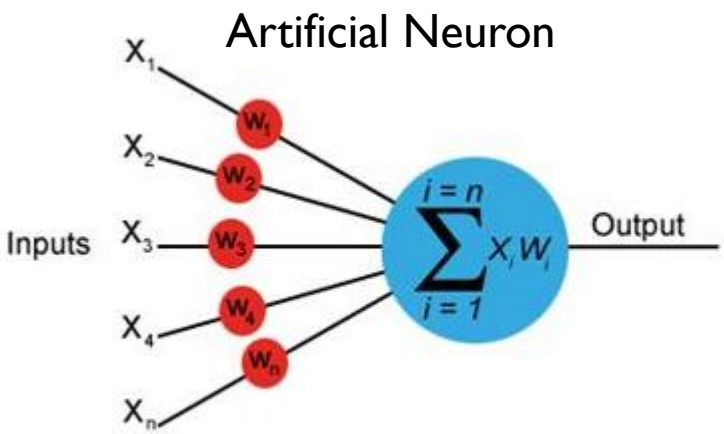
Activation Function (g)



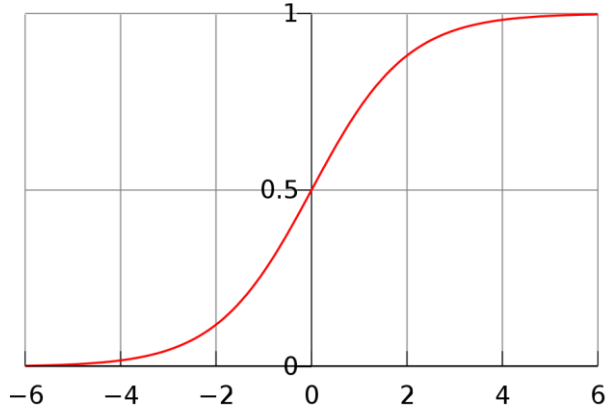
Step function $y = \begin{cases} 1 & \text{if } u \geq \theta \\ 0 & \text{if } u < \theta \end{cases}$

Artificial Neuron

- An artificial neuron is a logic computing unit.
- In this case, we use sigmoid function as activation function: real values from 0 and 1 are possible outputs
- Mechanism:
  - Input:
    - $in = x_1w_1 + x_2w_2 + \cdots + x_5w_5$
  - Output:
    - z = g(in)



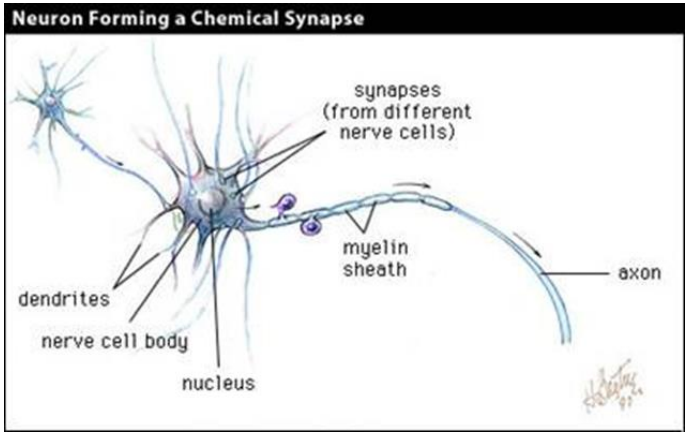
Activation Function (g)

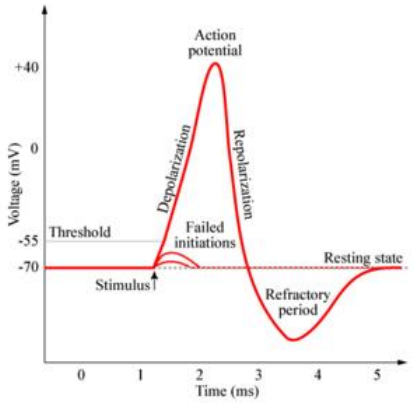


Sigmoid function $g(z) = \frac{1}{1+e^{-z}}$

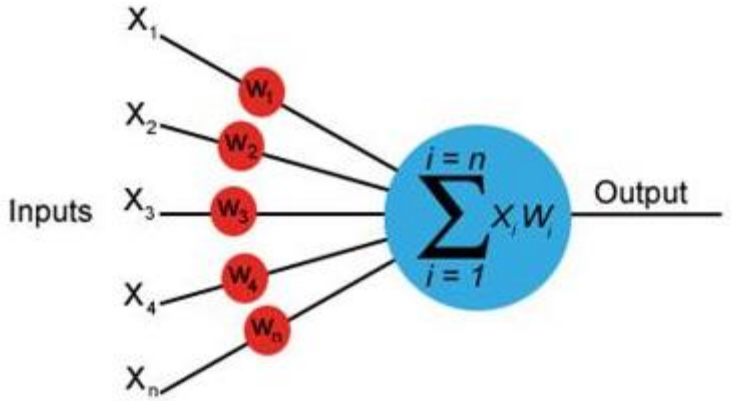
Comparison between Biological Neuron and Artificial Neuron

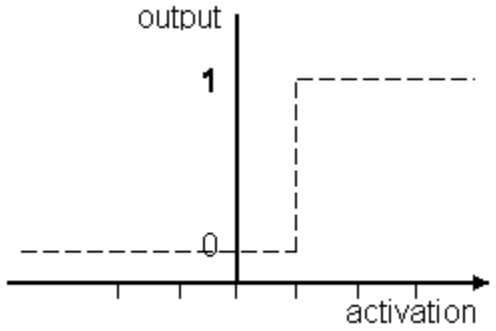
Biological Neuron



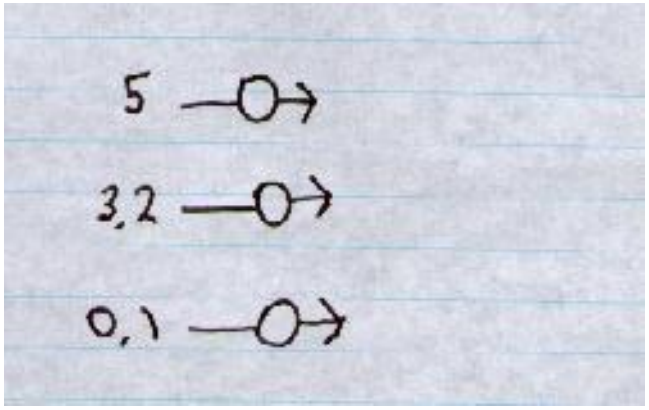


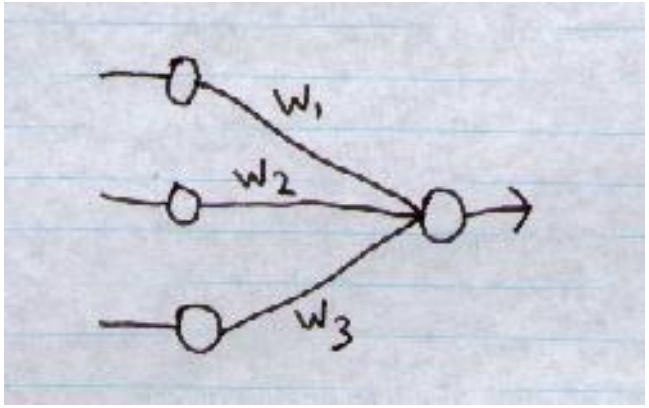
Artificial Neuron





Example





If $w_1 = 0.5$, $w_2 = -0.75$, $w_3 = 0.8$, and step function g (with threshold 0.2) is used as activation function, what is the output?

input $x = (I_1, I_2, I_3) = (5, 3.2, 0.1)$.

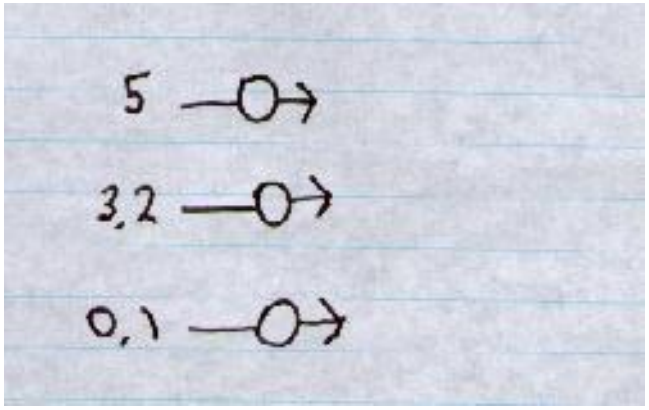
$$\text{Summed input} = \sum_i w_i I_i = 5\,w_1 + 3.2\,w_2 + 0.1\,w_3$$

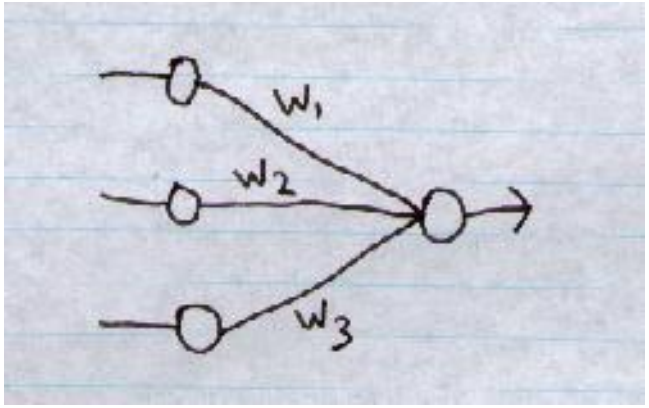
Summed input = 5(0.5) + 3.2(-0.75) + 0.1(0.8) =
= 0.18

Output = g(Summed input)

Since 0.18 < 0.2, so Output = 0

Example





If $w_1 = 0.5$, $w_2 = -0.75$, $w_3 = 0.8$, and sigmoid function *g* is used as activation function, what is the output?

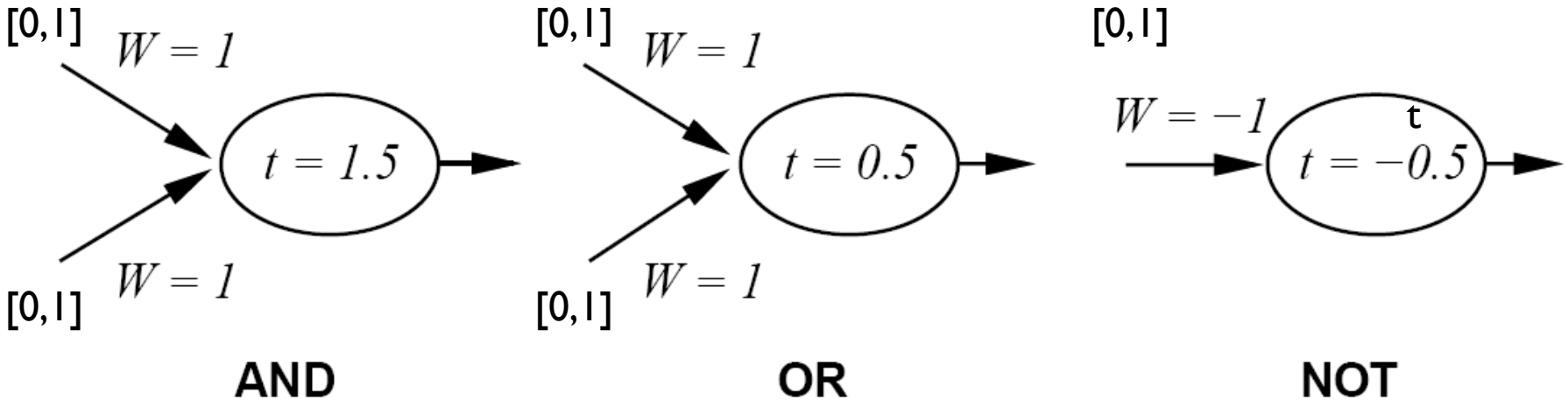
input $x = (I_1, I_2, I_3) = (5, 3.2, 0.1)$.

$$\text{Summed input} = \sum_i w_i I_i = 5\,w_1 + 3.2\,w_2 + 0.1\,w_3$$

Summed input = 5(0.5) + 3.2(-0.75) + 0.1(0.8) =
= 0.18

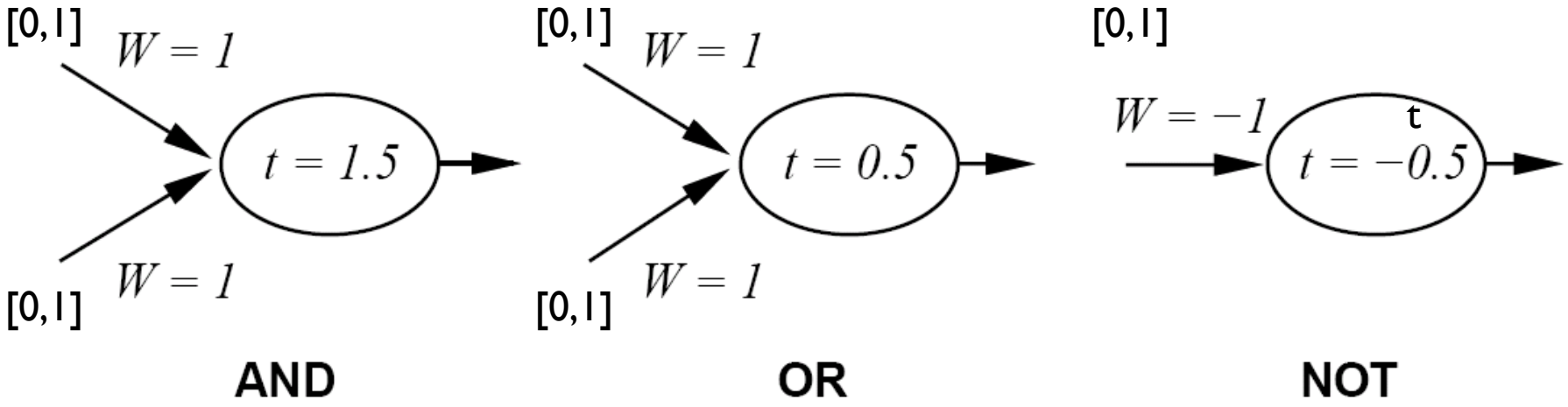
Output = g(Summed input) = $\frac{1}{1+e^{-0.18}}$ = 0.54488

Logic gate simulation



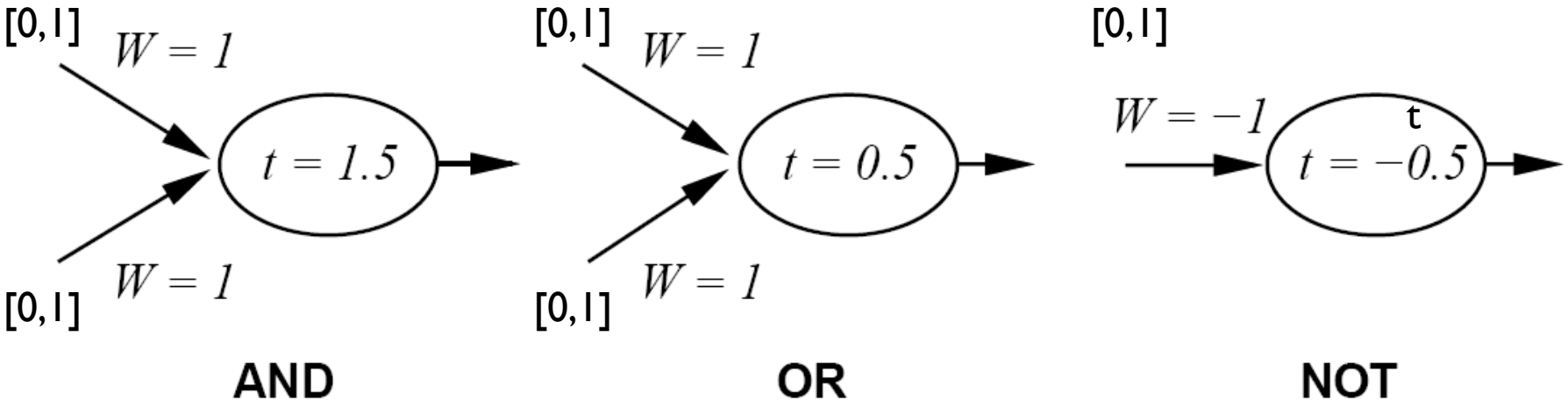
	I_1	I_2	Total Input	t	Output > t?
AND	0	0	0	1.5	0
AND	0	1	1	1.5	0
AND	1	0	1	1.5	0
AND	1	1	2	1.5	1

Logic gate simulation



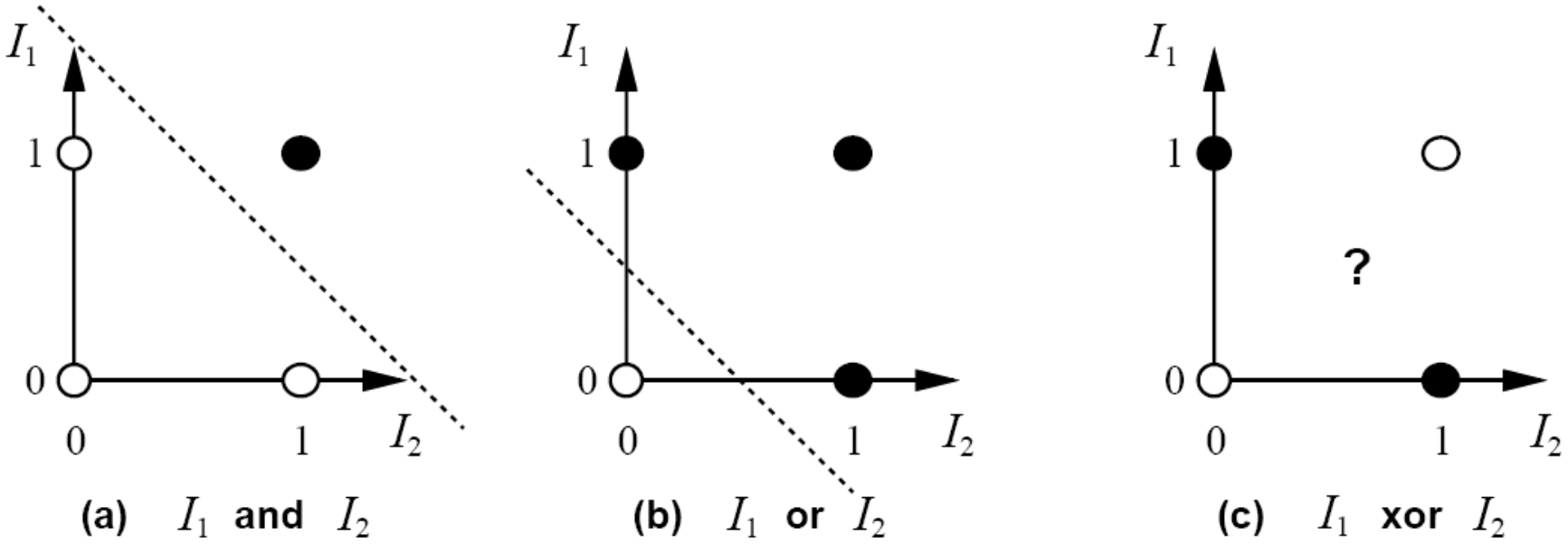
	I_1	I_2	Total Input	t	Output > t?
OR	0	0	0	0.5	0
OR	0	1	1	0.5	1
OR	1	0	1	0.5	1
OR	1	1	2	0.5	1

Logic gate simulation



	I_1	I_2	Total Input	t	Output > t?
NOT	0	N/A	0	-0.5	1
NOT	1	N/A	-1	-0.5	0

Logic gate simulation



For the previous cases, it can be viewed as a classification problem:

separate the class **0** and class **1**.

The neuron simply find a line to separate the two classes

And: $I_1+I_2 - 1.5 = 0$

Or: $I_1+I_2 - 0.5 = 0$

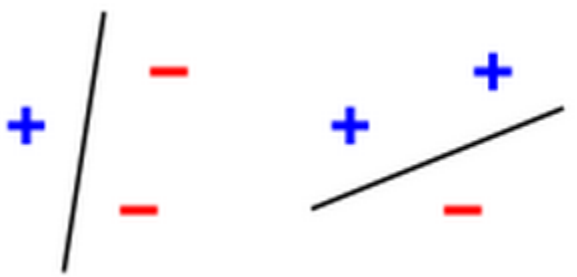
Xor: ?

I_1	I_2	Output
0	0	0
0	1	1
1	0	1
1	1	0

http://www.compapp.dcu.ie/~humphrys/Notes/Neural/single.neural.html

Linear Separability

Two classes ('+' and '-') below are linearly separable in two dimensions.

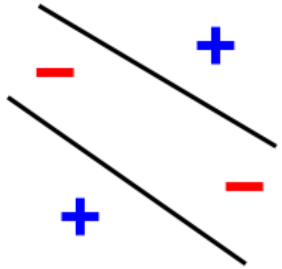


Every point x belongs to class '+' satisfy $\sum_{i=1}^{n} w_i x_i \geq t$

&

Every point x belongs to class '-' satisfy $\sum_{i=1}^{n} w_i x_i < t$

Two classes ('+' and '-') below are linearly inseparable in two dimensions.



The above example would need two straight lines and thus is not linearly separable.

http://en.wikipedia.org/wiki/Linear_separability

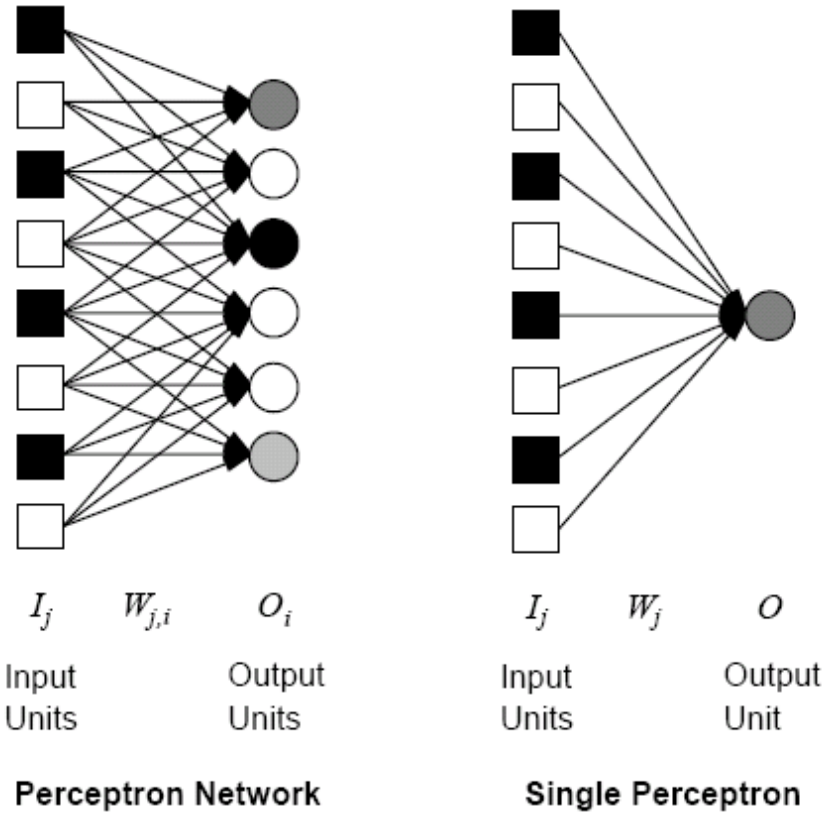
Artificial Neural Networks

Important concepts:

- What is perceptron? What is Single-layer perceptron? What is Multi-layer perceptron?
- What is the feed forward property?
- What is the general learning principle ?

Technical terms

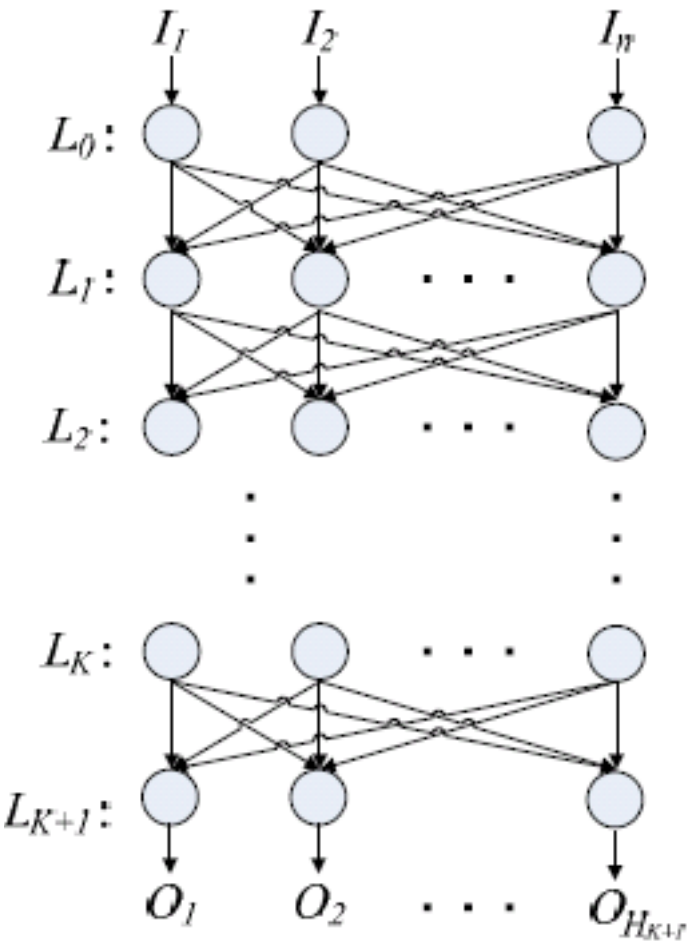
- Perceptron = Neuron
- Single-layer perceptron = single-layer neural network
- Multi-layer perceptron = multi-layer neural network
- The existence of **one or more hidden layer** is the difference between single-layer perceptron and multi-layer perceptron



What are their limitations ?

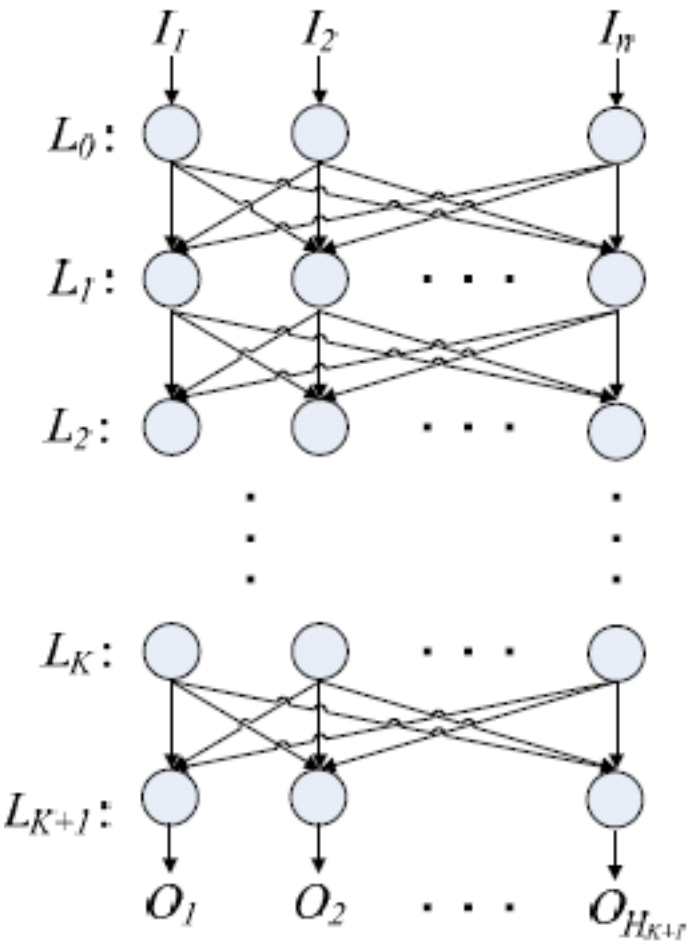
Multi-layer Perceptron

- Multi-Layer
  - Input
  - Hidden layer(s)
  - Output layer
- Feed-forward
  - Links go one direction only



Feed forward property

- Given weights and inputs, outputs of neurons in L1 can be calculated.
- Outputs of neurons in L2 can be calculated and so on…
- Finally, outputs of neurons in the output layer can be calculated

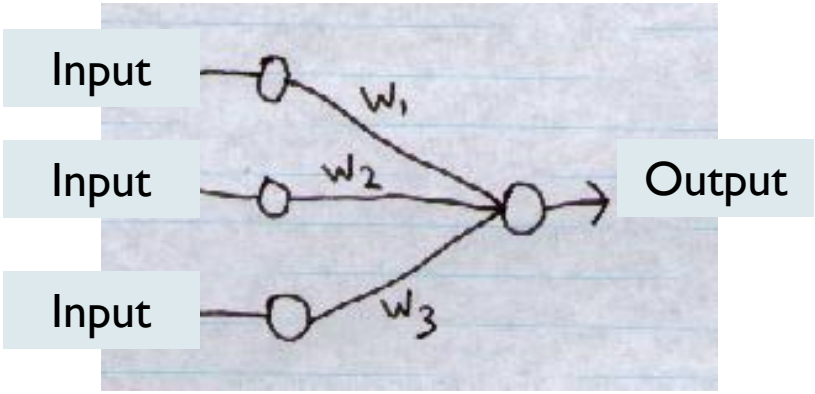


General Learning Principle

1. For supervised learning, we provide the model a set of inputs and targets.
2. The model returns the outputs
3. Reduce the difference between the outputs and targets by updating the **weights**
4. Repeat step 1-3 until some stopping criteria is encountered

Target | Input

	A	B	C	D	E	F
1	Y	X1	X2	X3	X4	X5
2	0.754146	0.762883	0.827033	0.340149	0.834167	0.145904
3	0.805553	0.159068	0.790367	0.50529	0.368874	0.287317
4	0.935603	0.196626	0.750472	0.005161	0.124383	0.338216
5	0.475093	0.941213	0.004147	0.920922	0.692663	0.75291
6	0.765624	0.780739	0.609544	0.796086	0.664215	0.733656
7	0.872094	0.677136	0.28072	0.418843	0.83341	0.01389
8	0.381704	0.270435	0.95286	0.561531	0.709781	0.90491
9	0.273056	0.462169	0.214569	0.378295	0.898127	0.058751
10	0.31369	0.668121	0.439105	0.399858	0.682646	0.906417
11	0.648147	0.353544	0.454941	0.442574	0.544956	0.748201
12	0.792176	0.163763	0.96012	0.585569	0.630604	0.107816



Summary

1. We have learnt the similarity between the biological neurons and artificial neurons
2. We have learnt the underlying mechanism of artificial neurons
3. We have learnt how artificial neurons compute logic (AND, OR, NOT)
4. We have learnt the meaning of perceptron, single-layer perceptron and multi-layer perceptron.
5. We have learnt how information is propagated between neurons in multi-layer perceptron (Feed-Forward property).
6. We have learnt the general learning principle of artificial neuron network.