TI0263

# MACHINE LEARNING & ARTIFICIAL NEURAL NETWORK

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# MACHINE LEARNING

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## GARY KASPAROV VS. DEEP BLUE


Garry Kasparov vs Deep Blue (IBM), 1997

- Deep Blue was capable of **analyzing 200 million positions a second**
- Kasparov: "There were many, many discoveries in this match, and one of them was that *sometimes the computer plays very, very human moves*. It deeply understands positional factors. And that is an outstanding scientific achievement"

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## GARY KASPAROV VS. DEEP BLUE (2)

- Traditionally, ***we need more than "look-ahead" moves*** per second in order to beat an expert in a chess game.
- **In order to improve our performance**:
  - **We need experience**
  - **We must be capable of learning**

➡ So do computer system! It should have capability of learning.
➡ Learning capabilities can improve the performance of an intelligent system over time.
➡ Machine learning mechanism form the basis for adaptive system.

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## DEFINITION

➤ Field of study that gives computers the **ability to learn** without being explicitly programmed. (Arthur Samuel, 1959)

➤ A computer program is said to **learn from experience *E*,**
- if its ***performance*** on task ***T***, as ***measured*** by performance measure ***P***, ***improves*** with experience ***E***. (Tom Mitchell, 1998)

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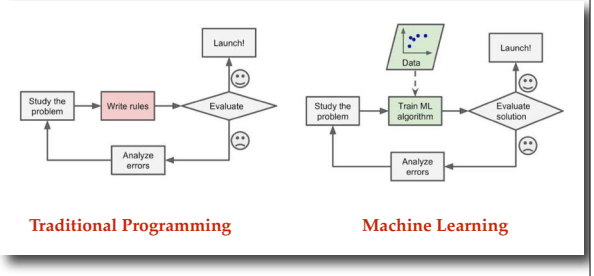
## TRADITIONAL VS. ML




Traditional Programming | Machine Learning

Source: Hands-On Machine Learning with Scikit-Learn & TensorFlow

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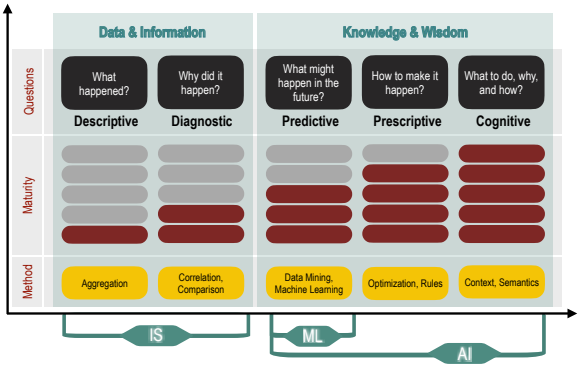
## IS – ML – AI

Sami (2017) in https://melsatar.blog/2017/07/30/the-evolution-of-analytics/

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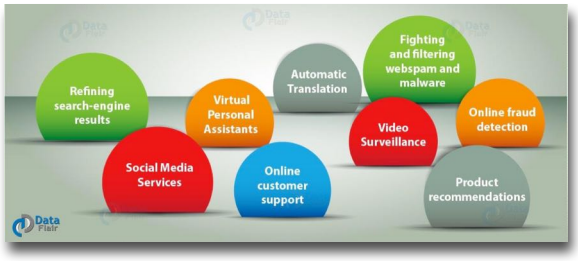
## APPLICATIONS OF MACHINE LEARNING

Informatika

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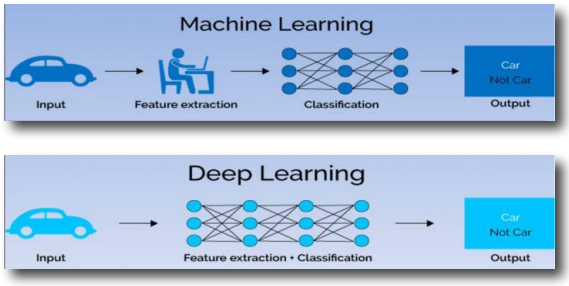
## ML VS. DL

Informatika




Source: https://www.artificialbrain.xyz/oxford-course-on-deep-learning-for-natural-language-processing/

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## TYPE OF MACHINE LEARNING

Informatika

1. **Supervised learning** (= active learning)
   - Learning *with* an external supervisor who presents a training set
   - Categorization process
   - Ex. method: Support Vector Machine, Backpropagation Algorithm
2. **Unsupervised learning** (= self-organized learning)
   - Learning *without* an external supervisor and training set
   - Clustering process
   - Ex. method: K-means, Adaptive Resonance Theory
3. **Reinforcement learning**
   - Sort of between supervised and unsupervised learning
   - Sequential decision making
   - Basic idea: a reward function
   - Ex. method: Markov Decision Processes

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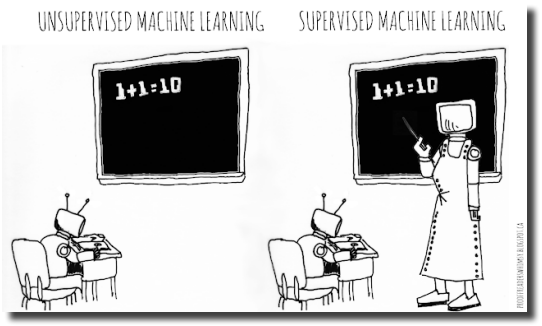
## UNSUPERVISED VS. SUPERVISED

Informatika

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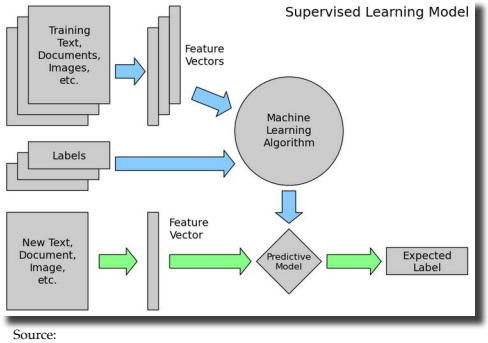
## ML: SUPERVISED LEARNING

Informatika

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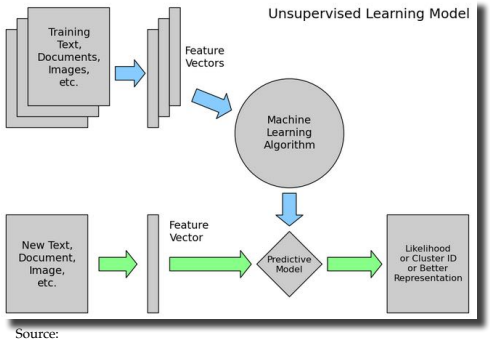
## ML: UNSUPERVISED LEARNING

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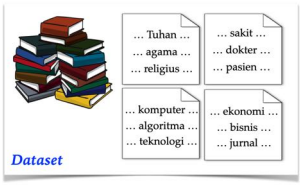
## ML: SUPERVISED LEARNING

- *Categorization = Document classification*
- A process to organize documents into categories, that had been given by someone with knowledge of the document structure (*predefined categories*).
- *Supervised learning*





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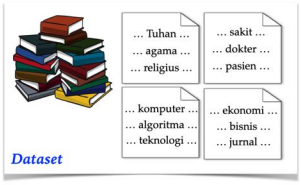
## ML: UNSUPERVISED LEARNING

- = *Document clustering*
- A process to organize documents into *self-detected categories*
- Objective : to group the documents by similarity
- *Unsupervised learning*





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## ML: REINFORCEMENT LEARNING

➡ **Reward** for good behavior

➡ **Punishment** for bad behavior

Source:

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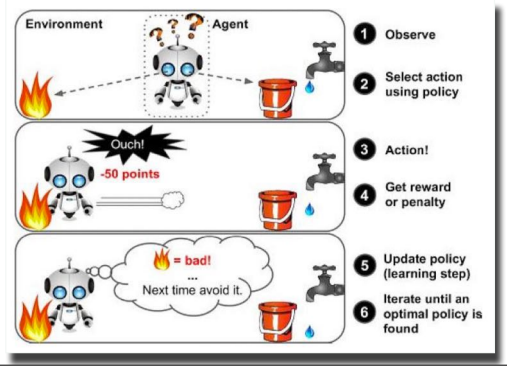
## ML: REINFORCEMENT LEARNING (2)

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## VIDEO

https://youtu.be/dVTTe9WMMqM

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# ARTIFICIAL NEURAL NETWORK

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## DEFINITION

- ANN is an information processing paradigm that is ***inspired by the way biological nervous system***, such as the brain, process information
- A neural network can be defined as a model of reasoning based on the human brain

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## BIOLOGICAL PERSPECTIVE

- Human brain consists of a densely nerve cells, or basic information-processing units, called **neurons**.
- Nearly 10 billion neurons and 60 trillion connections

Source:

Source:

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## BIOLOGICAL PERSPECTIVE (2)

- **The most interesting characteristic: plasticity**
  - In plain English: our brains are not hardwired; it can repair and renew itself
  - Brain ability to **learn by example**:
    - reorganize neural pathways throughout the lifespan as a result of experience
    - In response to the stimulation pattern, neurons demonstrate **long-term changes** in the strength of their connections
    - the connections are strengthened or weaken based on the 'right' or 'wrong' answer
  - Data and its processing are **global** rather than **local**

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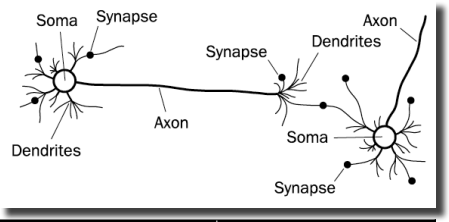
## ANN STRUCTURE




| Biological NN | Artificial NN |
|---|---|
| Soma | Neuron |
| Dendrite | Input |
| Axon | Output |
| Synapse | Weight |

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## ANN STRUCTURE (2)

- ANN posses a large number of processing elements called nodes/neurons which operate in parallel
- Neurons are connected with others by connection link
- Each link is associated with weights which contain information about the input signal
- Each neuron has an internal state of its own which is a function of the inputs that neuron receives - Activation level

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## HOW TO SOLVE PROBLEM?

- From experience: examples/training data
- Strength of connection between the neurons is stored as a weight-value for the specific connection
- Learning the solution to a problem = changing the connection weights
- Problem variables: inputs, outputs, weights
- Example (training data) represent a solved problem (i.e. both input and output are known)
- Thus, by certain learning algorithm we can adapt/adjust the NN weights
- For a new problem, we now have the inputs and the weights, therefore we can easily get the outputs

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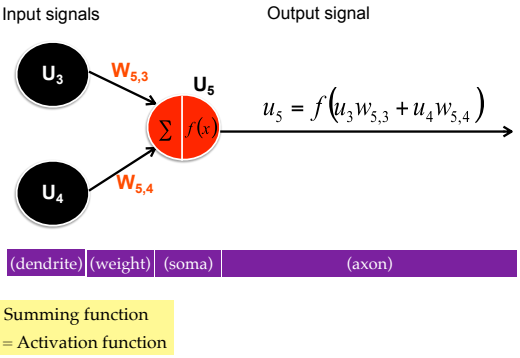
## NEURON AS A COMPUTING ELEMENT




Σ = Summing function
$f(x)$ = Activation function

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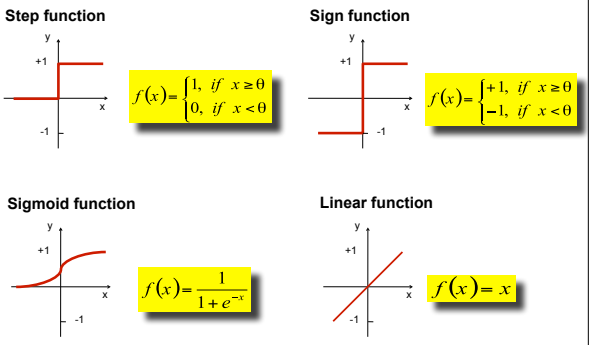
## ACTIVATION FUNCTION

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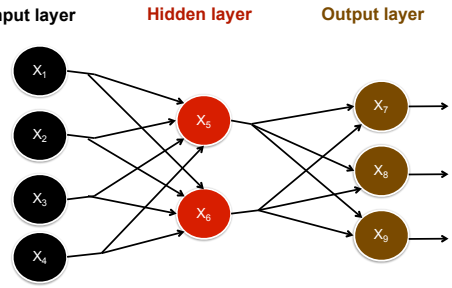
## ARCHITECTURE OF ANN

**Multi-layer NN**

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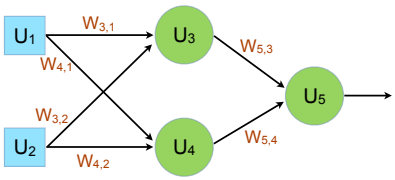
## BASIC PROCESS

**1. Feed forward network**




signals travel in one way direction

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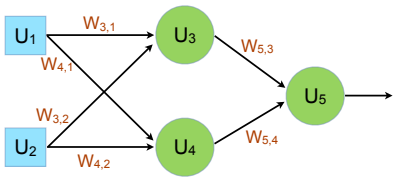
## BASIC PROCESS (2)

**2. Feedback network**




signals travel in two ways direction

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## LEARNING ALGORITHM IN ANN

A. **Supervised learning**
   1. Backpropagation
   2. Hopfield Network
   3. Bidirectional associative memory (BAM)

**B. Unsupervised learning**
   1. Hebbian learning
   2. Competitive learning

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## BACKPROPAGATION ALGORITHM

- **Aim:**
  - To train a neural network to perform some task
  - Supervised learning
- Process of adjusting the weight of each unit in such away that the error between the desired output and the actual output is reduced

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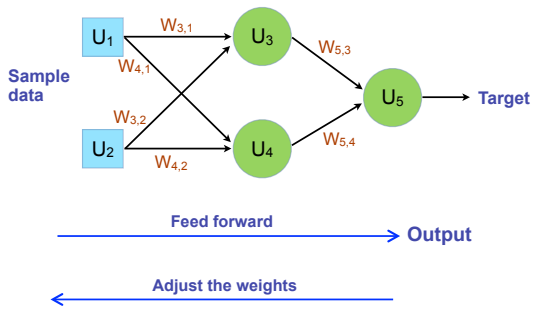
## BACKPROPAGATION ALGORITHM (2)

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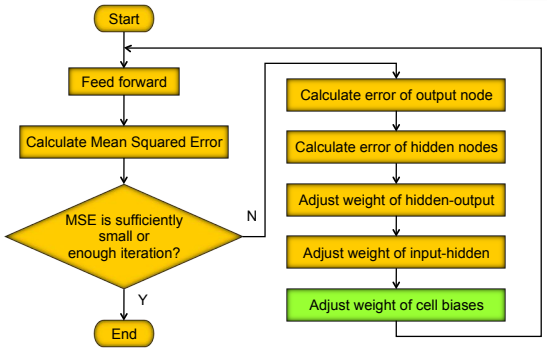
## BACKPROPAGATION ALGORITHM (3)

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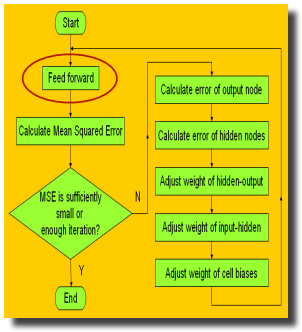
## FEED FORWARD




- Calculate nodes value using:

$$u_i = f\left(\sum_j^n u_j w_{i,j}\right)$$

- Sigmoid Function as the activation function:

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

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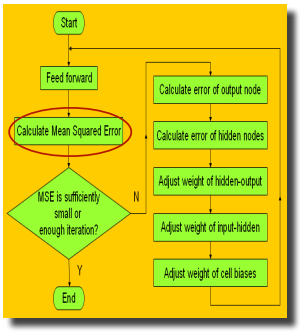
## MEAN SQUARED ERROR




- Quantify the error of the network

$$err = 0.5 * (O_{desired} - O_{actual})^2$$

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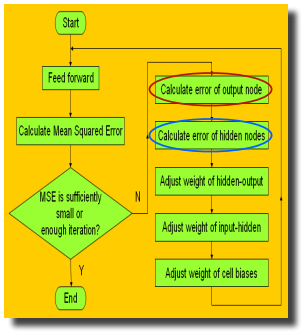
## CALCULATE THE ERROR OF NODES




Error of output node :

$$\delta_0 = (C_i - u_5)u_5(1 - u_5)$$

$C_i$ : Correct response / Target

Error of hidden nodes :

$$\delta_i = \left(\sum_{m:m)i} w_{m,j}\delta_0\right)u_i(1 - u_i)$$

m : all nodes connected to the hidden node

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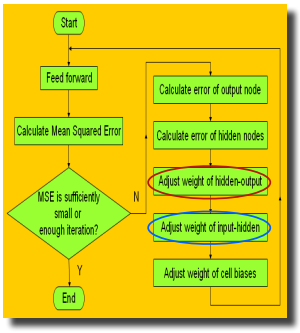
## ADJUST CONNECTION WEIGHTS




Weight of hidden-output :

$$w^*_{i,j} = w_{i,j} + \rho\delta_0 u_j$$

$\rho = learning\_rate$

Weight of input-hidden :

$$w^*_{i,j} = w_{i,j} + \rho\delta_i u_j$$

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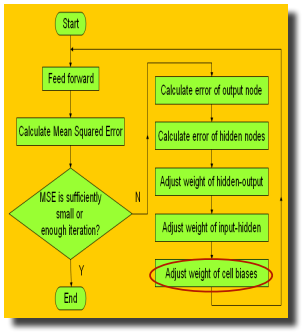
## ADJUST WEIGHTS OF CELL BIASES




Weight of output cell bias :

$$w^*_{i,b} = w_{i,b} + \rho\delta_0 bias_i$$

$\rho = learning\_rate$

Weight of hidden cell biases:

$$w^*_{i,b} = w_{i,b} + \rho\delta_i bias_i$$

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## APPLICATIONS

- General Pattern Recognition
- Fault Diagnosis
- Monitoring Patients in Medical Settings
- Character Recognition
- Data Filtering
- Odor/Aroma Analysis
- Fraud Detection

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## REFERENCES


- "Neural Networks" by Christos Stergiou and Dimitrios Siganos
- "Jean-Baptiste Lamarck (1744-1829)" http://www.ucmp.berkeley.edu/history/lamarck.html
- "Neural Network Bibliography" http://www.computelligence.org
- "Machine Learning", Department of Computer Science, Iowa State University


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