Introduction to Machine Learning

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Discussion Points

- Machine Learning
  - What, Why and Types
  - Mathematics
  - Applications

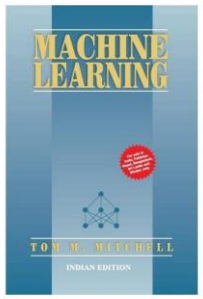
What is Machine Learning

machine learning

noun

the use and development of computer systems that are able to learn and adapt without following explicit instructions, by using algorithms and statistical models to analyse and draw inferences from patterns in data.

Google



"Machine Learning is the study of computer algorithms that improve automatically through experience"

"Machine Learning, Tom Mitchell, McGraw Hill, 1997"

IBM

Machine learning is a branch of artificial intelligence (AI) and computer science which focuses on the use of data and algorithms to imitate the way that humans learn, gradually improving its accuracy.

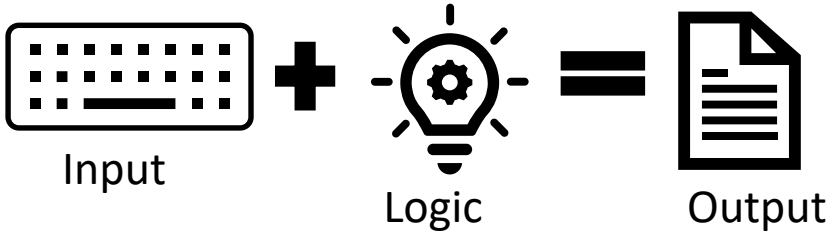
Arthur Samuel, 1959

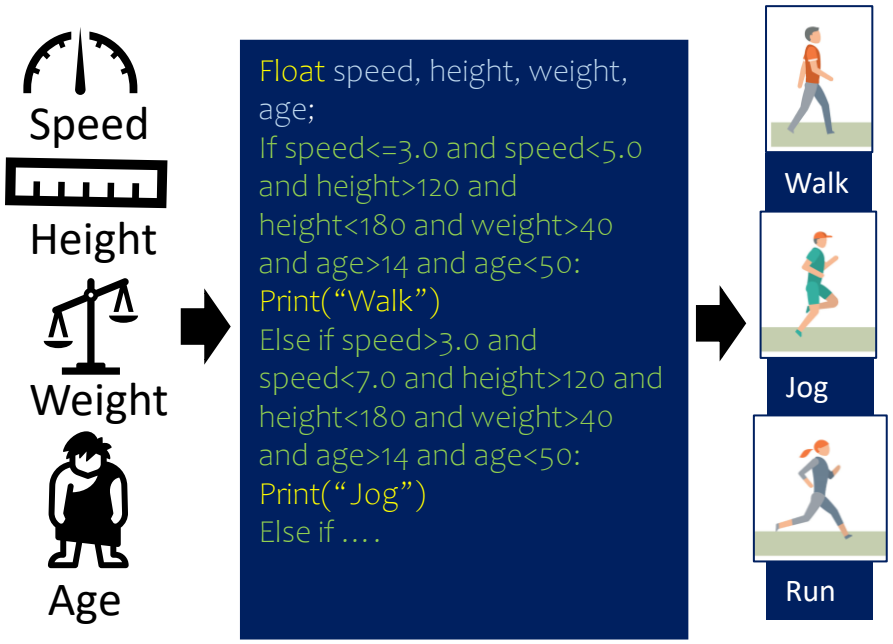
Machine learning (ML) is a core branch of AI that aims to give computers the ability to learn without being explicitly programmed (Samuel)

Arthur Lee Samuel (December 5, 1901 – July 29, 1990)[3] was an American pioneer in the field of computer gaming and artificial intelligence.[1] He popularized the term "machine learning" in 1959

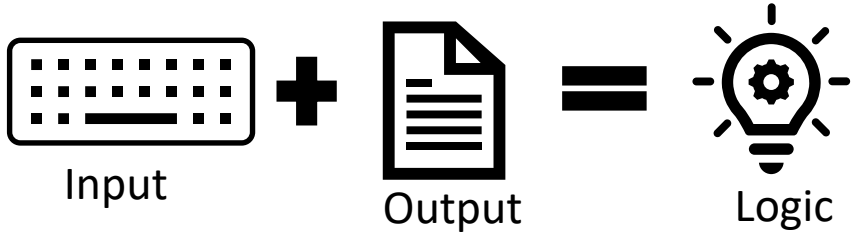
What is Machine Learning

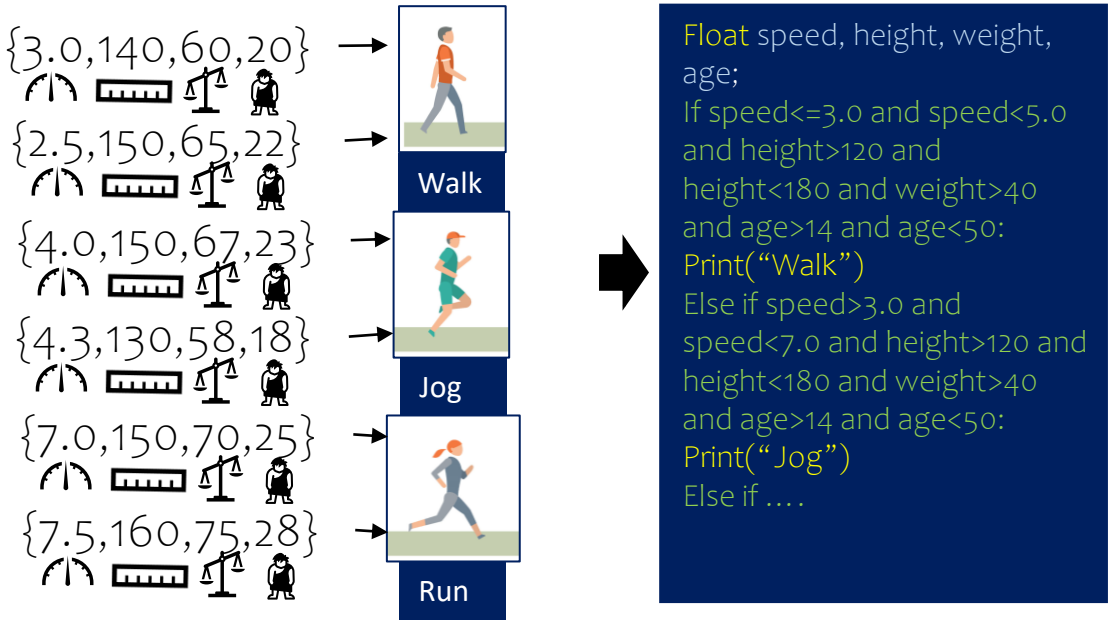
Tradition Programming





Machine Learning





Why Machine Learning Required

- More often the real-world problems are complex [variations are more]
  - Gender, Weight may change the walking pattern for the same age person
  - Age also changes the walking pattern
  - Walking speed of every person is different, some people walk fast and some slow.
- More examples and experience is required to write a generalized rule.
- Rules may not be sufficient in some situations to recognize/predict the output.

Types of Machine Learning

- Supervised
  - The labels are given with the input
- Unsupervised
  - Labels are missing only the input is available
- Semi Supervised
  - Few pair of input and labels are given
- Reinforcement
  - System learns from trail and error.

Machine Learning - Mathematics

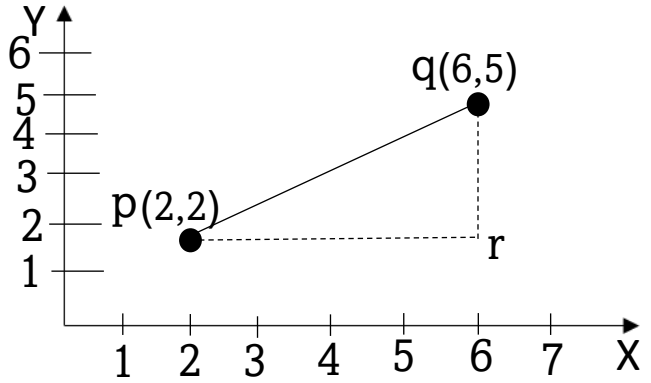
- Scalar, Vector, Matrix
- Distances [Euclidean, Manhattan, Chebyshev, Cosine, Mahalanobis]
- Mean, Median, Mode
- Standard Deviation, Variance, Correlation, Covariance
- Distributions [Gaussian]
- Derivative, Partial Derivative, Inverse of a matrix
- Absolute Error, Mean Square Error, Root Mean Square Error

Machine Learning - Mathematics

- Scalar: A single entity, has only magnitude not direction.
  - Example: integer, float
- Vector: A quantity having direction as well as magnitude.
  - Example: point in space(2,3,…N)
- Matrix: A matrix is a rectangular array or table of numbers, symbols, or expressions, arranged in rows and columns.
  - Example: collection of vectors
  - $\begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{bmatrix}$

Machine Learning - Mathematics

- Euclidean: Is the length of a line segment between the two points. $d(p,q) = \sqrt{\sum_{i=1}^{n}(q_i - p_i)^2}$
- Manhattan: The distance between two points measured along axes at right angles. $d(p,q) = \sum_{i=1}^{n}(q_i - p_i)$
- Chebyshev: Distance between two vectors is the greatest of their differences along any coordinate dimension. $d(p,q) = max_i(|x_i - y_i|)$
- Cosine: is a measure of similarity between two non-zero vectors of an inner product space. $d(p,q) = \frac{P.Q}{\|P\|\|Q\|}$



Machine Learning - Mathematics

- Mean: is the average of the array.

$$\bar{x} = \frac{1}{n}\left(\sum_{i=1}^{n} x_i\right)$$ where n is the number of items.

$$x = \{2,30,8,11,21,16,5\}$$
$$\bar{x} = \frac{2 + 30 + 8 + 11 + 21 + 16 + 5}{7}$$

- Median: is the middle of the array.
  - First sort the array in ascending order
  - if n is odd then select $x_{(n+1)/2}$ element as median
  - If n is even, then take the average of two median elements. $\frac{x_{\left(\frac{n}{2}\right)} + x_{\left(\frac{n}{2}\right)+1}}{2}$

$$x = \{2,30,8,11,21,16,5\}$$
$$median(x) = ?$$
$$x = \{2,30,8,11,21,16,5,25\}$$
$$median(x) = ?$$

- Mode: The most occurring number in the array

$$x = \{2,3,5,5,7,9,9,9,10,12\}$$
$$mode(x) = ?$$

Machine Learning - Mathematics

- Standard Deviation

The measurement of the standard deviation shows how the items of a set deviates from the mean. It is computed as $\sigma_x = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - \mu)^2}$ $where\ \mu = \frac{1}{N}\sum_{i=1}^{N} x_i$

- Variance

The variance is the average of the squared differences from the mean. It is computed as $\sigma_x^2 = \frac{1}{N}\sum_{i=1}^{N}(x_i - \mu)^2$

- Covariance

Covariance is a measure of the joint variability of two random variables and computed as $\sum_{x,y} = \frac{(x_i - \mu_x)(y_i - \mu_y)}{N}$

- Correlation

It is used to find the relationship between two variables. It is computed as $\rho_{x,y} = \frac{\sum_{x,y}}{\sigma_x \sigma_y}$

Machine Learning - Mathematics

Example:

Sample	Age	Height	Weight
1	14	158	80
2	15	162	60
3	16	165	65
4	17	167	55
5	14	155	58
6	18	170	65
7	20	173	75

Machine Learning - Mathematics

- Derivative

Is used to measure the change in the variable.

Example: $y = x^2 + 2x + 5$, then $\frac{dy}{dx} = 2x + 2$

- Partial Derivative

If y is a function of multiple variables, then the partial derivative assumes other variables as constant.

Example: $y = x^2 + z^2 + 2x + 2z + 5$ then $\frac{\partial x}{\partial y} = 2x + 2$

- Inverse of a matrix

$$A^{-1} = \frac{adj(A)}{|A|}$$

$$A = \begin{bmatrix} a & b \\ c & d \end{bmatrix} \; then \; adj(A) = \begin{bmatrix} d & -b \\ -c & a \end{bmatrix} \; and \; |A| = ad - bc$$

Machine Learning - Mathematics

- Absolute Error

$$E_i = A_i - B_i$$

- Mean Absolute Error

$$\text{MAE} = \frac{1}{N}\sum E_i$$

- Mean Square Error

$$\text{MSE} = \frac{1}{N}\sum {E_i}^2$$

- Root Mean Square Error

$$\text{RMSE} = \sqrt{\frac{1}{N}\sum {E_i}^2}$$

Machine Learning Applications

- Image understanding
  - [Wild images] Scene recognition, object detection, scene description
  - [Medical images] Detection of tumor, COVID-19, blood vessels, etc.
  - Facial Recognition, gender, age prediction
- Speech understanding
  - Speech to text conversion, speaker identification, speaker mood prediction
  - Speech conversion (English to French, etc.), Speech modulation, etc.
- Language understanding
  - Language Translator (English to Hindi, French , etc.), sentiment analysis, information extraction, information classification. Grammar correction, etc.
- Stock price prediction, whether prediction,