Introduction to Machine Learning

COMP 606, Machine Learning

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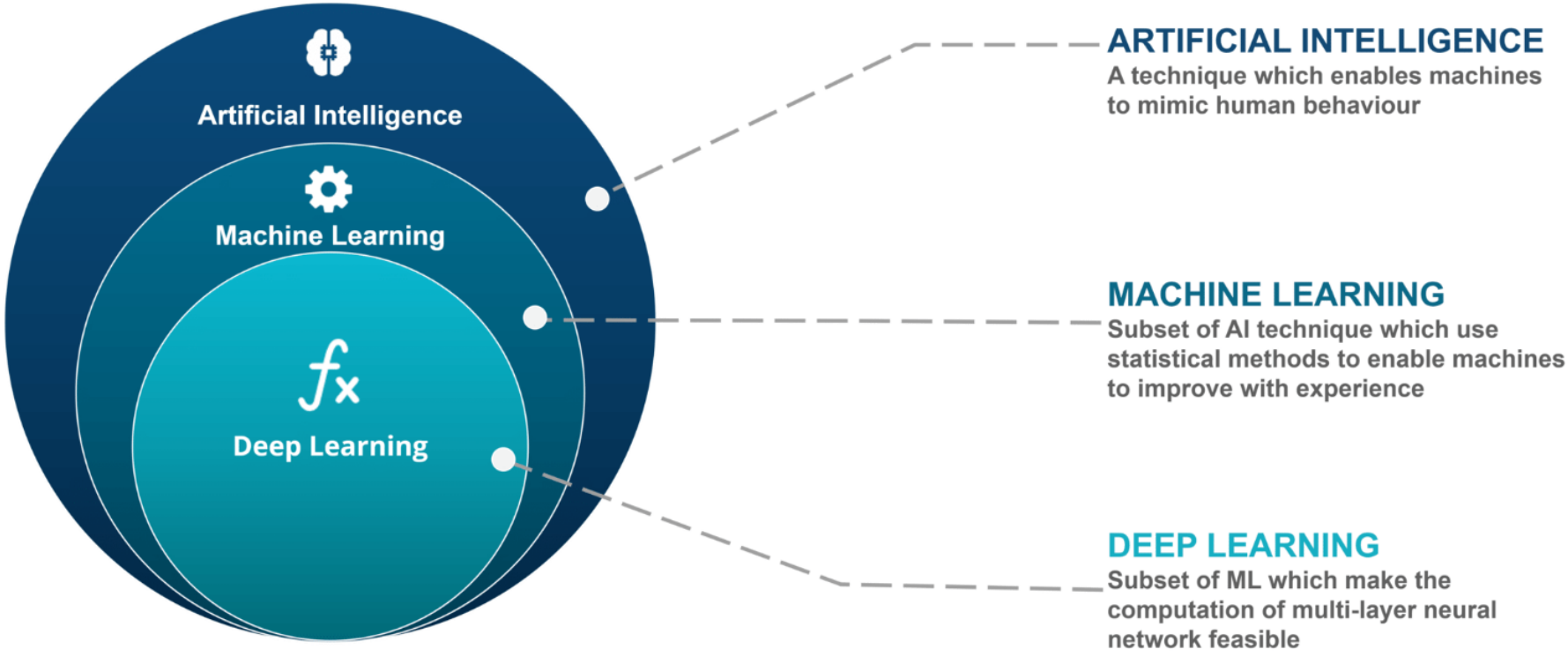
Artificial Intelligence & Machine learning

- **Artificial Intelligence (AI)** is broadly defined as the science and engineering of making intelligent machines, especially intelligent computer programs (McCarthy, 2007).

- **Machine learning (ML)** is an artificial intelligence technique that can be used to design and train computer algorithms to learn from and act on data.

AI vs Machine Learning vs Deep Learning

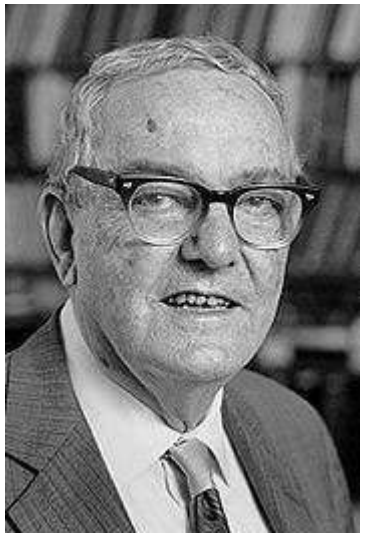
> Artificial Intelligence is the broader umbrella under which Machine Learning and Deep Learning come. And you can also see in the diagram that even deep learning is a subset of Machine Learning. So all three of them AI, machine learning and deep learning are just the subsets of each other. So let us move on and understand how exactly they are different from each other.



https://www.edureka.co/blog/ai-vs-machine-learning-vs-deep-learning/

Machine Learning

- **Herbert Alexander Simon**: "Learning is any process by which a system improves performance from experience."
- "Machine Learning is concerned with computer programs that automatically improve their performance through experience. "

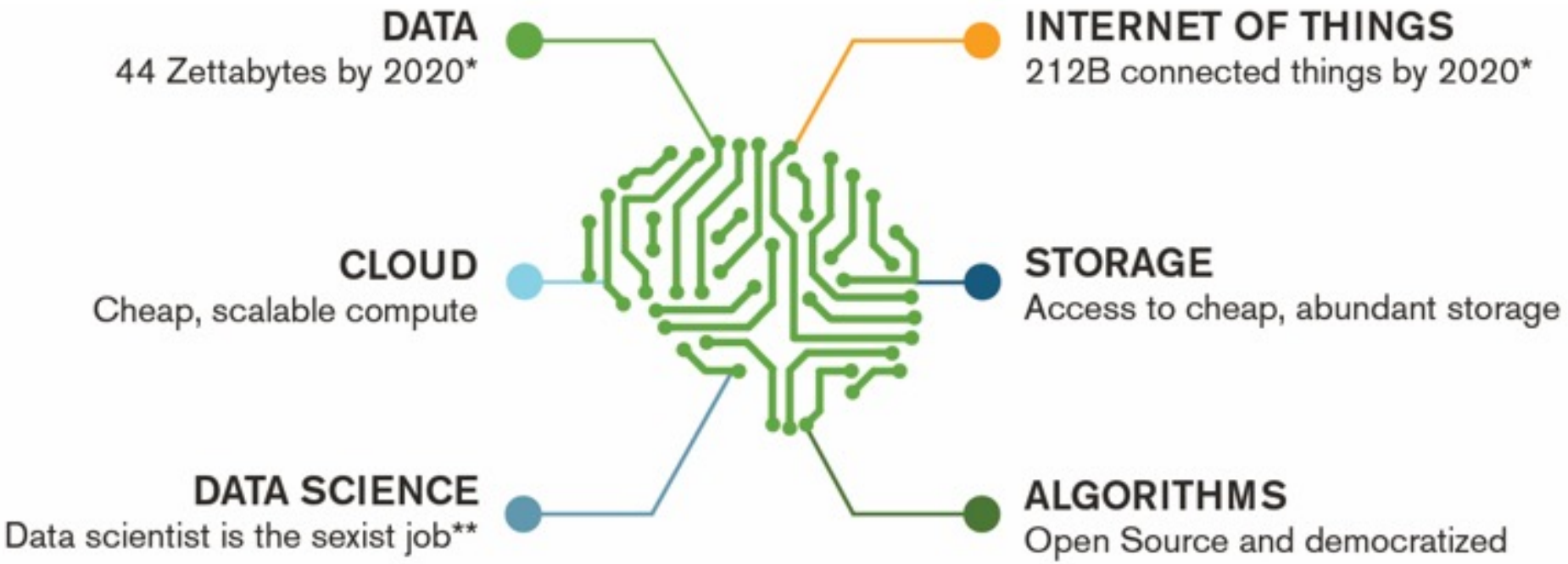


Herbert Simon
Turing Award 1975
Nobel Prize in Economics 1978

Why Machine Learning?

- Develop systems that can automatically adapt and customize themselves to individual users.
  - Personalized news or mail filter
- Discover new knowledge from large databases (***data mining***).
  - Market basket analysis (e.g. diapers and beer)
- Ability to mimic human and replace certain monotonous tasks - which require some intelligence.
    - like recognizing handwritten characters
- Develop systems that are too difficult/expensive to construct manually because they require specific detailed skills or knowledge tuned to a specific task (knowledge engineering bottleneck).

Why Machine Learning Now?



*IDC Digital Universe report, 2014 http://www.emc.com/infographics/digital-universe-2014.htm

**Data Scientist: The Sexiest Job of the 21st Century, Oct 2012 https://hbr.org/2012/10/data-scientist-the-sexiest-job-of-the-21st-century

https://customerthink.com/sales-incentives-and-machine-learning-intelligently-motivate-revenue-driving-behaviors/

Magic?

No, more like gardening

Seeds = Algorithms
Nutrients = Data
Gardener = You
Plants = Programs

Sample Applications

Web search
Computational biology
Finance
E-commerce
Space exploration
Robotics
Information extraction
Social networks

Types of Learning

- Supervised (inductive) learning
  - Training data includes desired outputs (labels)
- Unsupervised learning
  - Training data does not include desired outputs
  - Finding the similar patterns
- Semi-supervised learning
  - Training data includes a few desired outputs
- Reinforcement learning
  - Rewards from sequence of actions

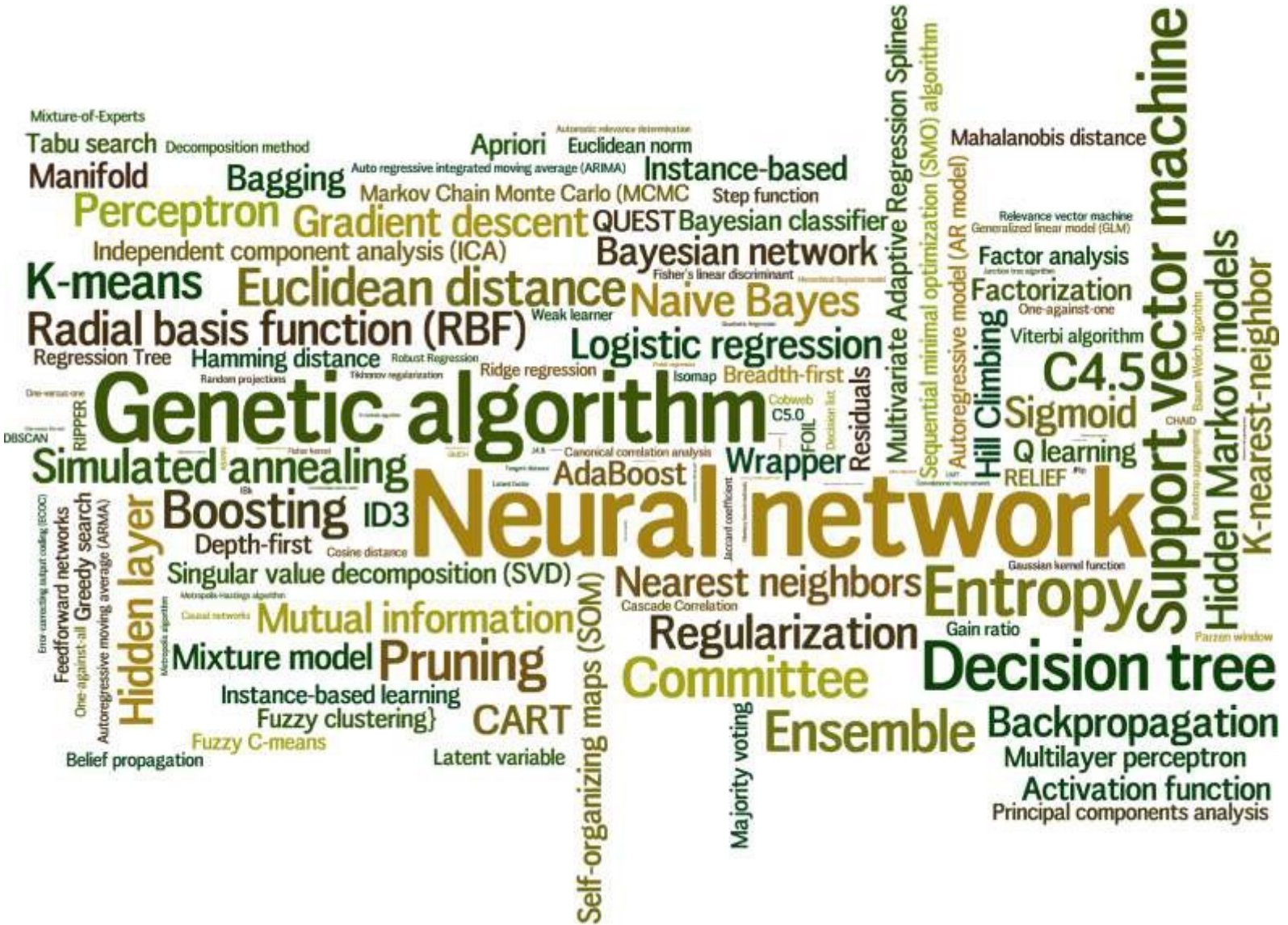
The concept of learning in a ML system

- Learning = Improving with experience at some task
  - Improve over task *T*,
  - With respect to performance measure, *P*
  - Based on experience, *E*.

Data for machine learning

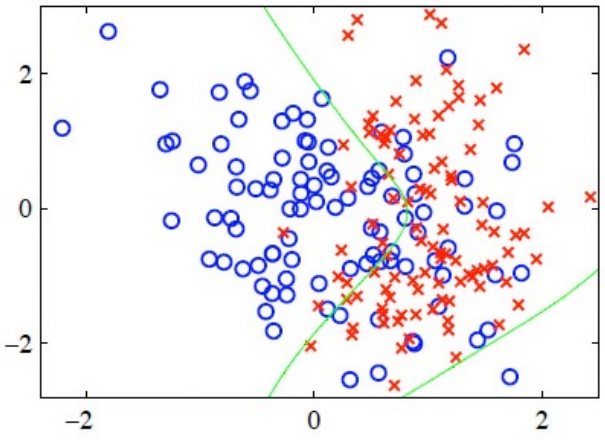
- Training set: the feature vectors of N patterns $\{x_1,\ldots, x_N\}$
- Target vector: Unique vector (label) t for each pattern
- Test set: some patterns with labels not in the training set just for testing
- The function to be learned: f(x) such that $f(x_i)\approx t_i$
- Training phase: Process for determining f(x)

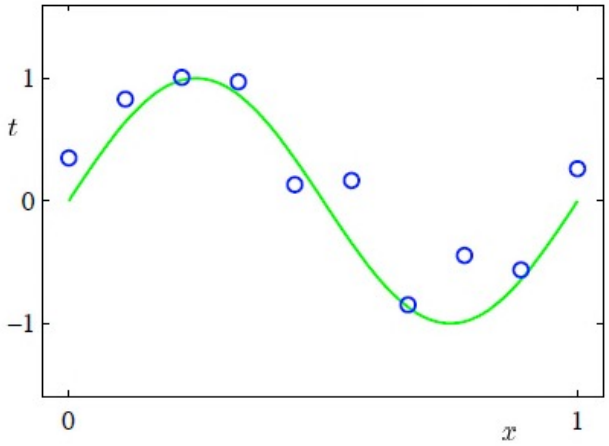
Learning Algorithms



Supervised Learning

Input vector $\mathbf{x}_i$ is matched to a target vector $\mathbf{t}_i$



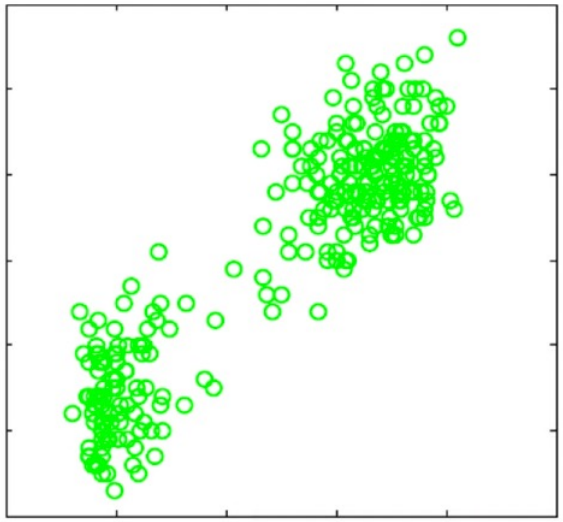


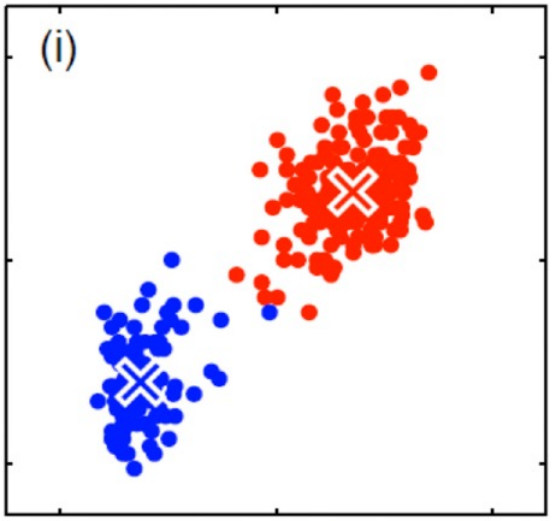
Classification:
$\mathbf{t}_i$ falls into discrete categories

Regression :
$\mathbf{t}_i$ is continuous

Unsupervised Learning

Only input vector $\mathbf{x}_i$ present; no $\mathbf{t}_i$





- Clustering (above): Discover groups of similar examples within data
- Density estimation: Determine distribution of data
- Dimensionality reduction: Find low-dimensional representations for, e.g., visualization