Rīgas Stradiņa universitāte

Advances and Opportunities in Machine Learning for Data Processing and Analytics

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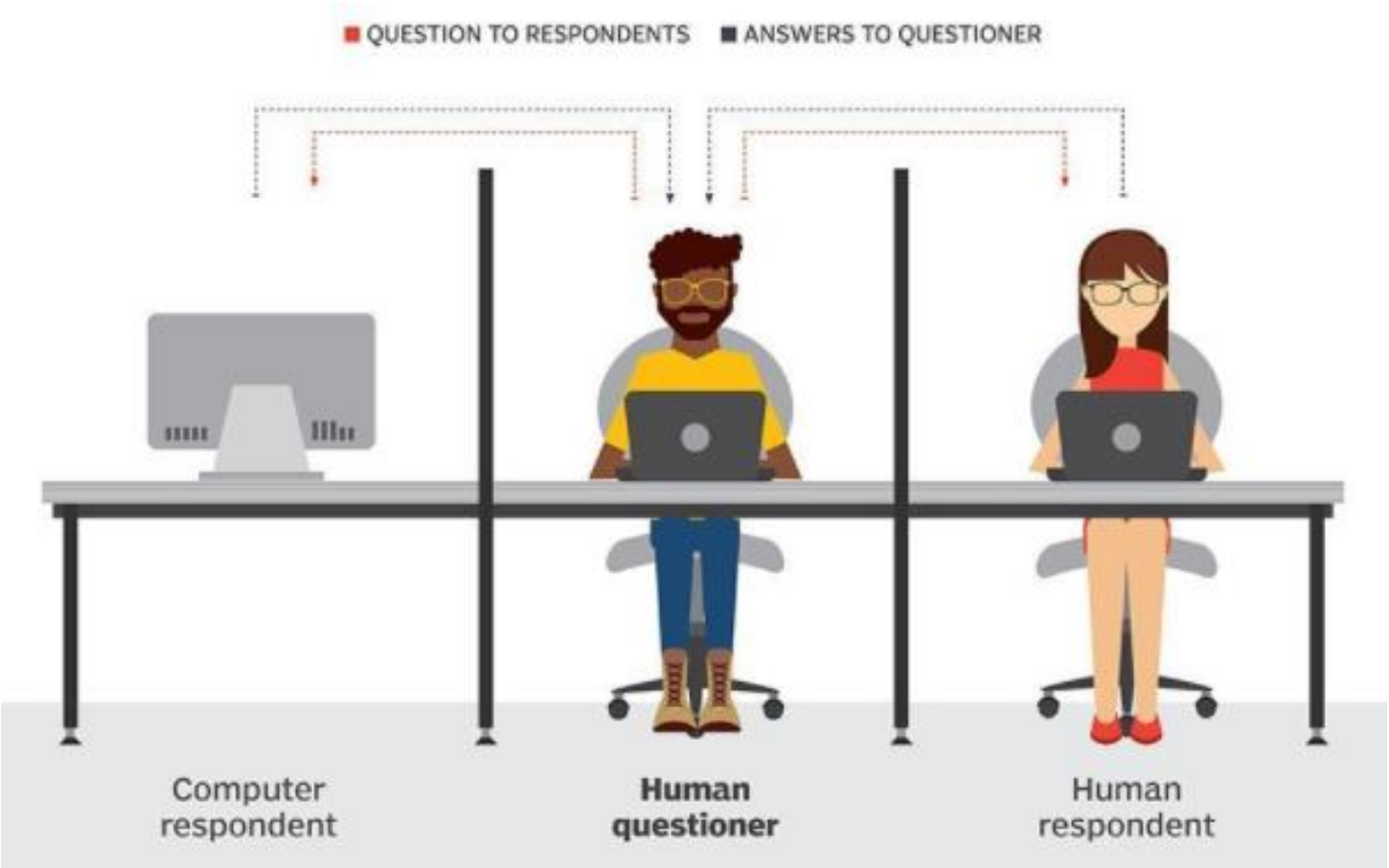
Artificial Intelligence

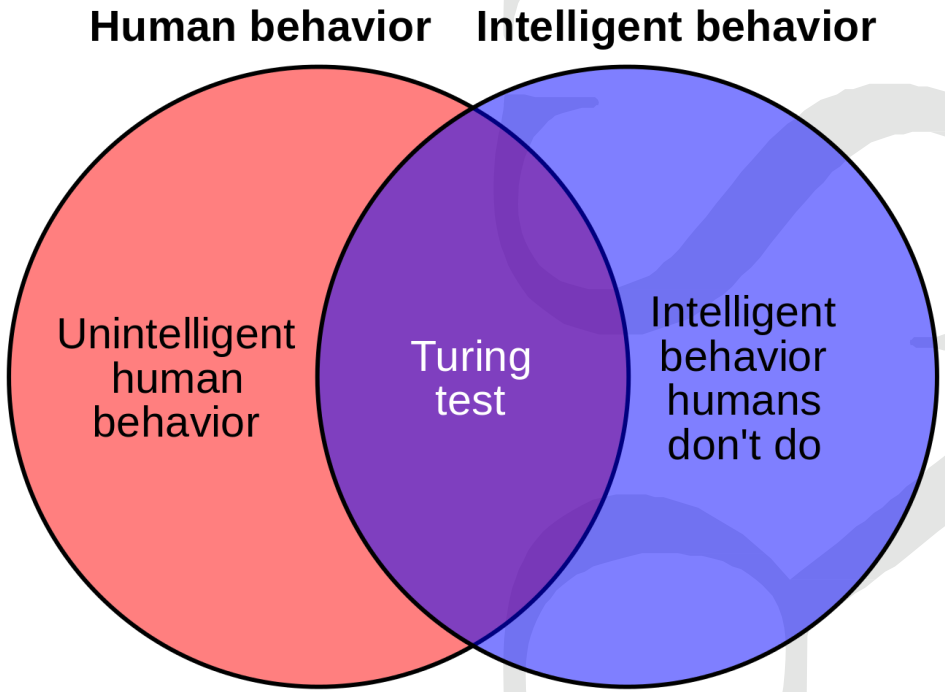
The term “Artificial Intelligence” was introduced by John McCarthy at 1955, when he described AI as “*that of making a machine behave in ways that would be called intelligent if a human were so behaving*.”

Nowadays Artificial Intelligence is defined as the study of "intelligent agents“ – any device that perceives its environment and takes actions that maximize its chance of successfully achieving its goals.

The Turing Test

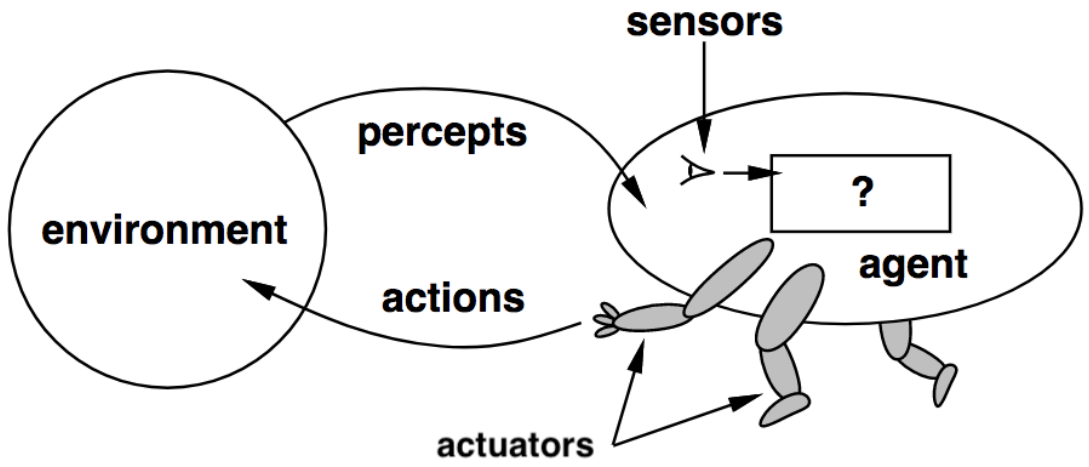
If the questioner cannot reliably distinguish computer respondent from the human, the computer is said to have passed the test





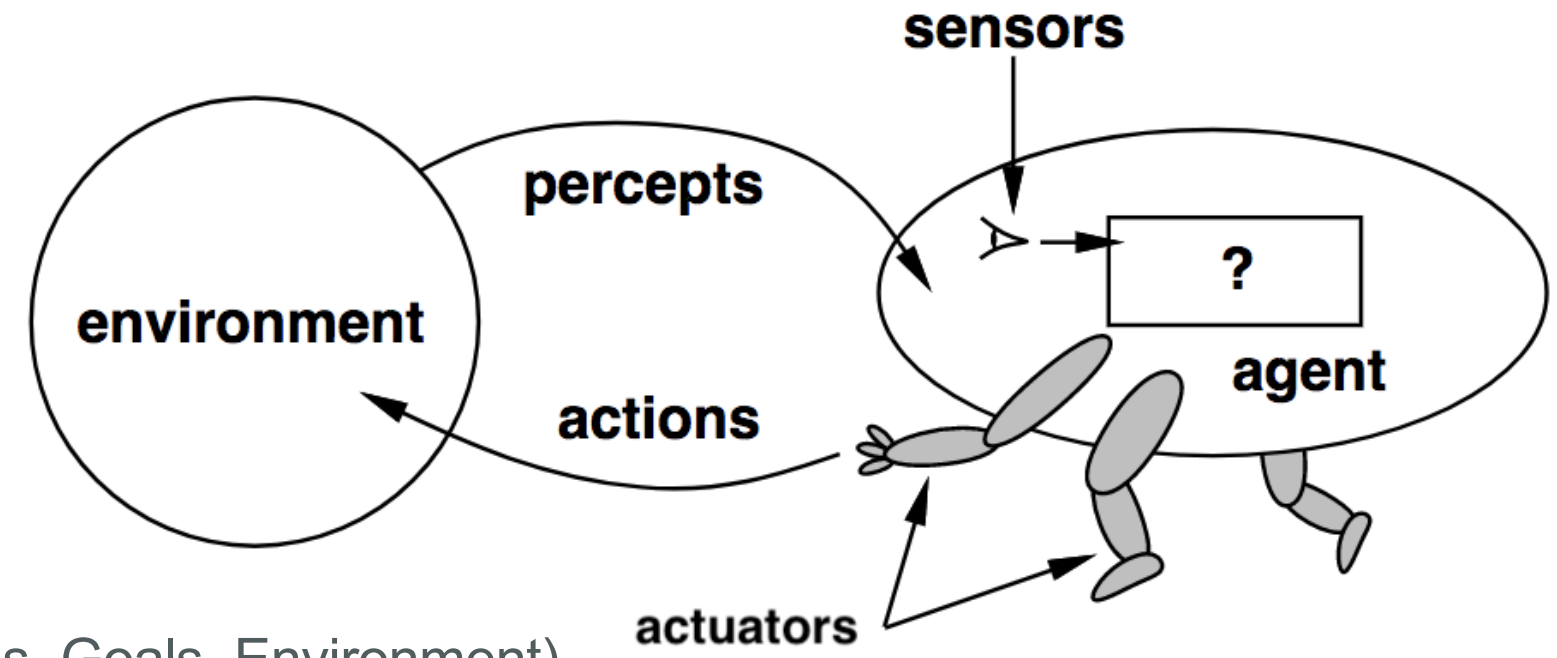
What Would Machine Need to Pass the Turing test?

- **Natural language processing:** to communicate with examiner
- **Knowledge representation:** to store and retrieve information provided before or during interrogation
- **Automated reasoning:** to use the stored information to answer questions and to draw new conclusions
- **Machine learning:** to adapt to new circumstances and to detect and extrapolate patterns
- **Vision (for Total Turing test):** to recognize the examiner's actions and various objects presented by the examiner
- **Motor control (total test):** to act upon objects as requested
- **Other senses (total test):** such as audition, smell, touch, etc



What is an Intelligent Agent?

• Anything that can be viewed as perceiving its environment through sensors and acting upon that environment through its actuators (effectors) to maximize progress towards its goals



• PAGE (Percepts, Actions, Goals, Environment)
• Task-specific & specialized: well-defined goals and environment

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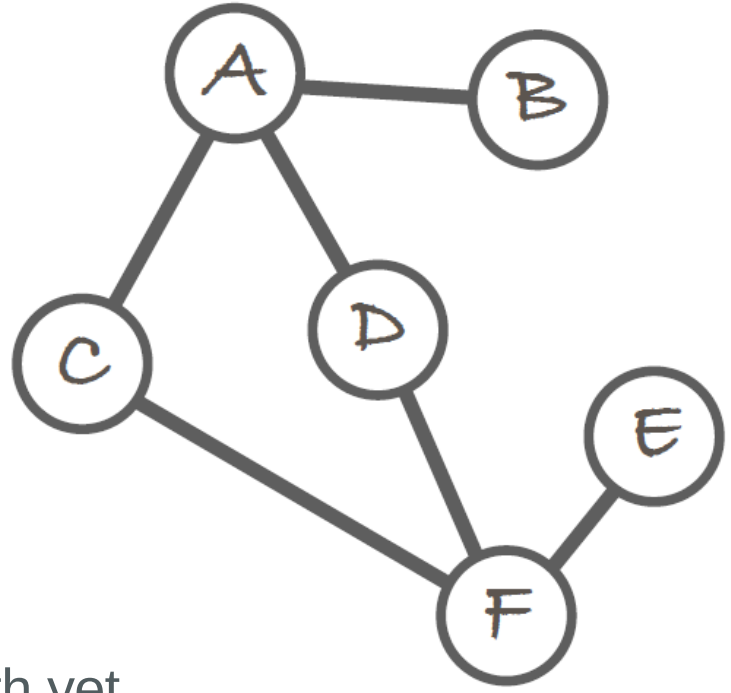
Good Old- Fashioned AI (GOFAI)

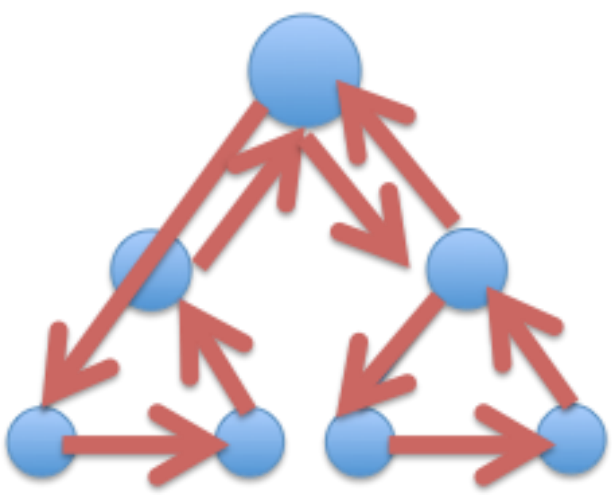


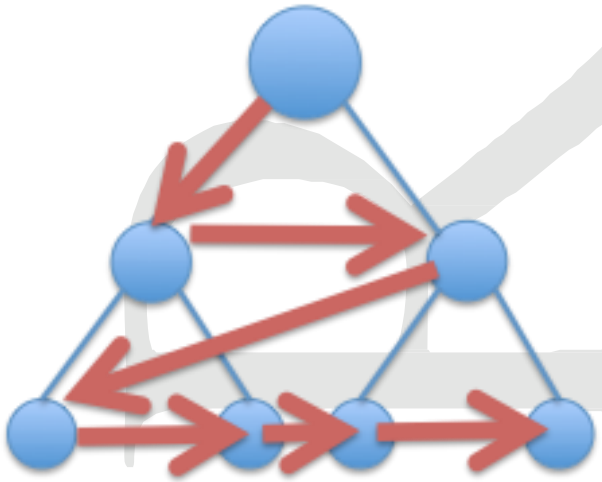
Logic (Programming)
- Expert systems

Search
- **Breadth-first**: the node list is a queue: first-in, first-out (FIFO)
- **Depth-first**: the node list is a stack: last-in, first-out (LIFO)
- Other search algorithms can be obtained by replacing the list with yet other structures, e.g.
- **Best-first search**: Node list is a priority queue: highest-value gets out first

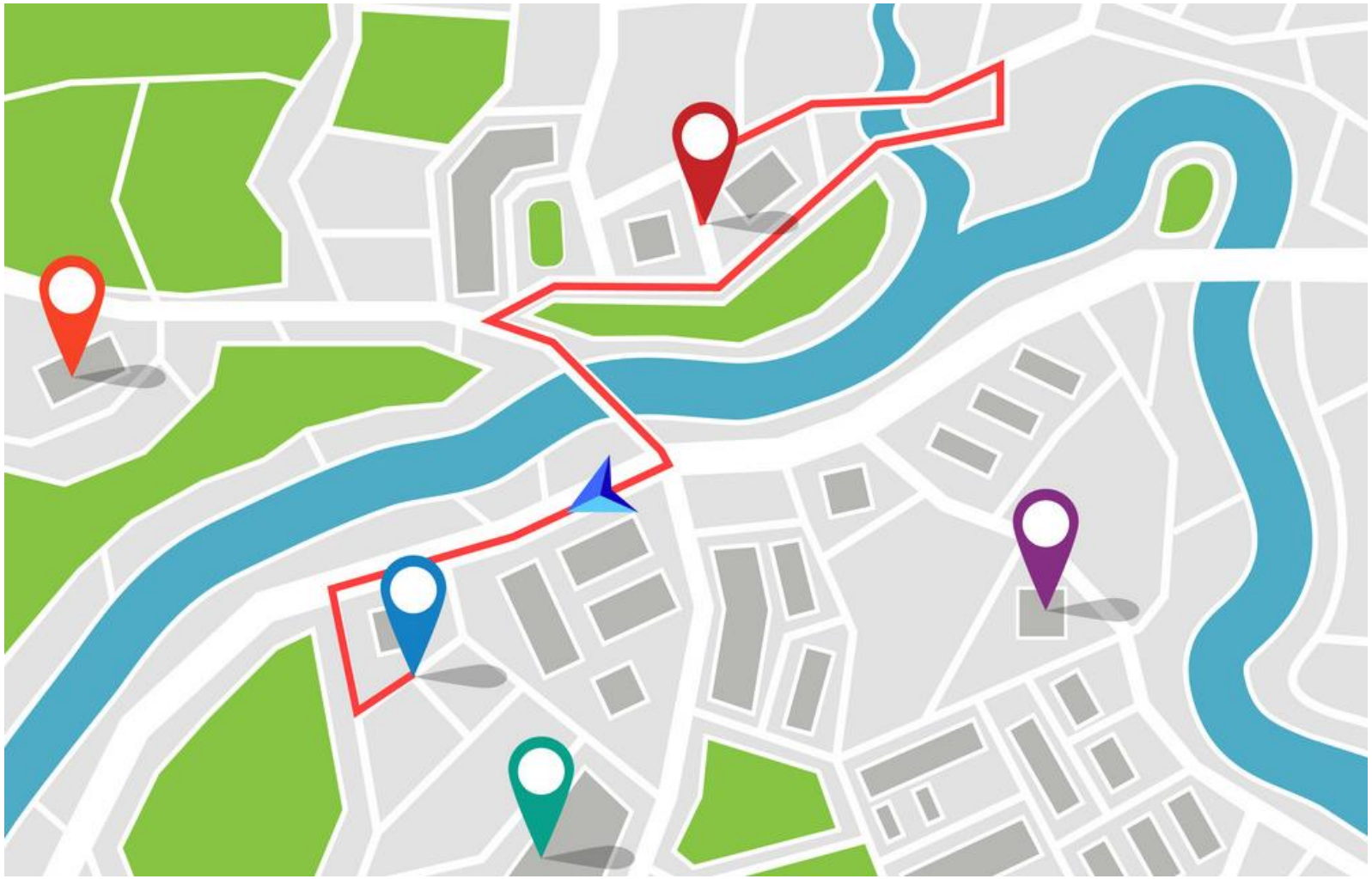
Games
- Minimax
- Alpha-Beta

“if I make this move, then my opponent can only make two moves,
and each of those would let me win.”

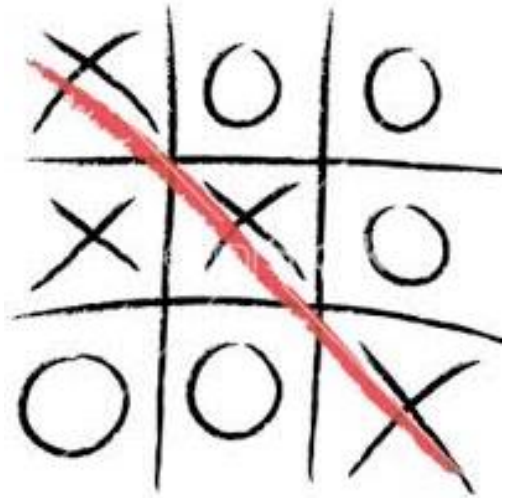

Depth-First Search

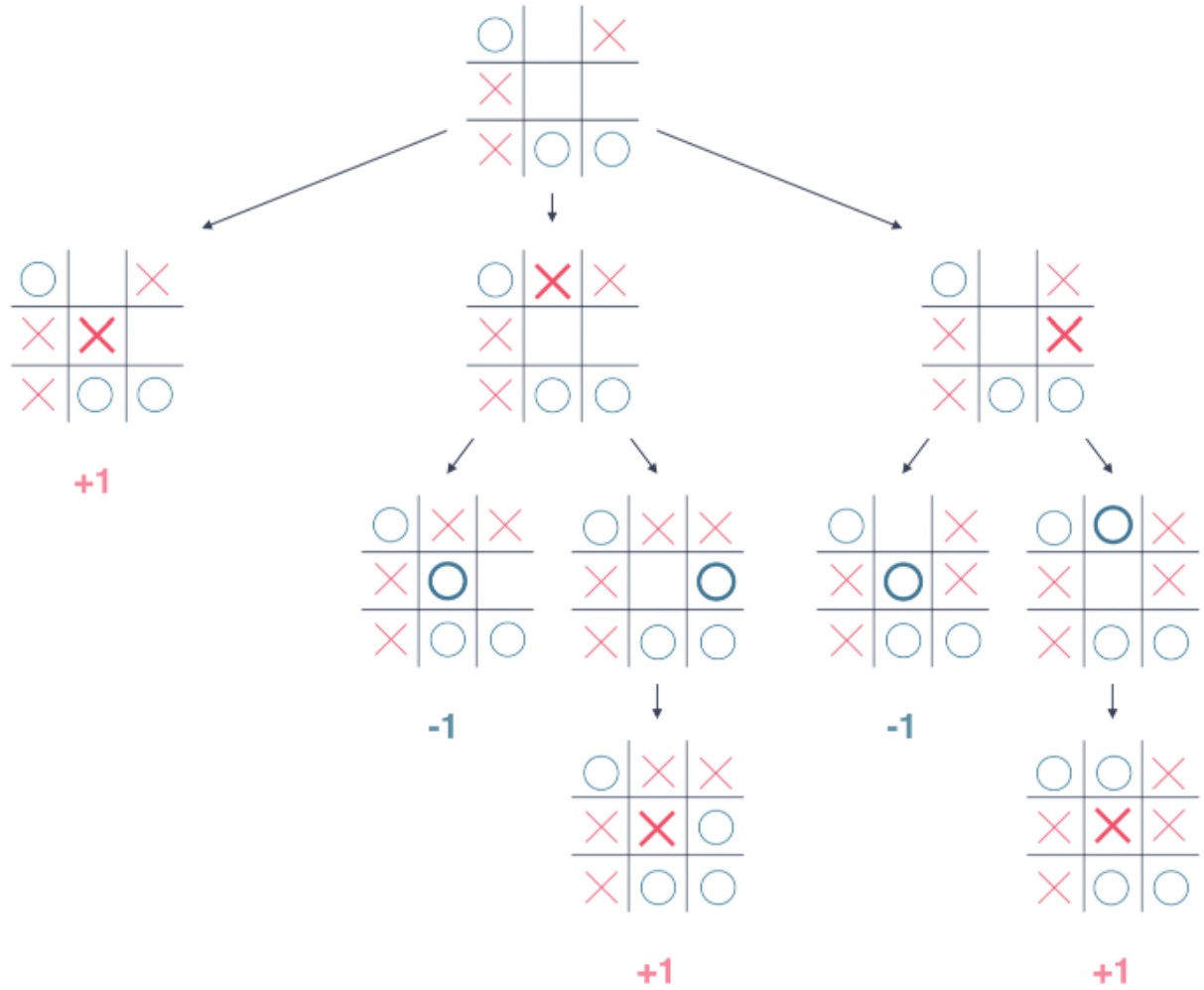

Breadth-First Search

GPS Navigation



Solving Tic Tac Toe with Minimax

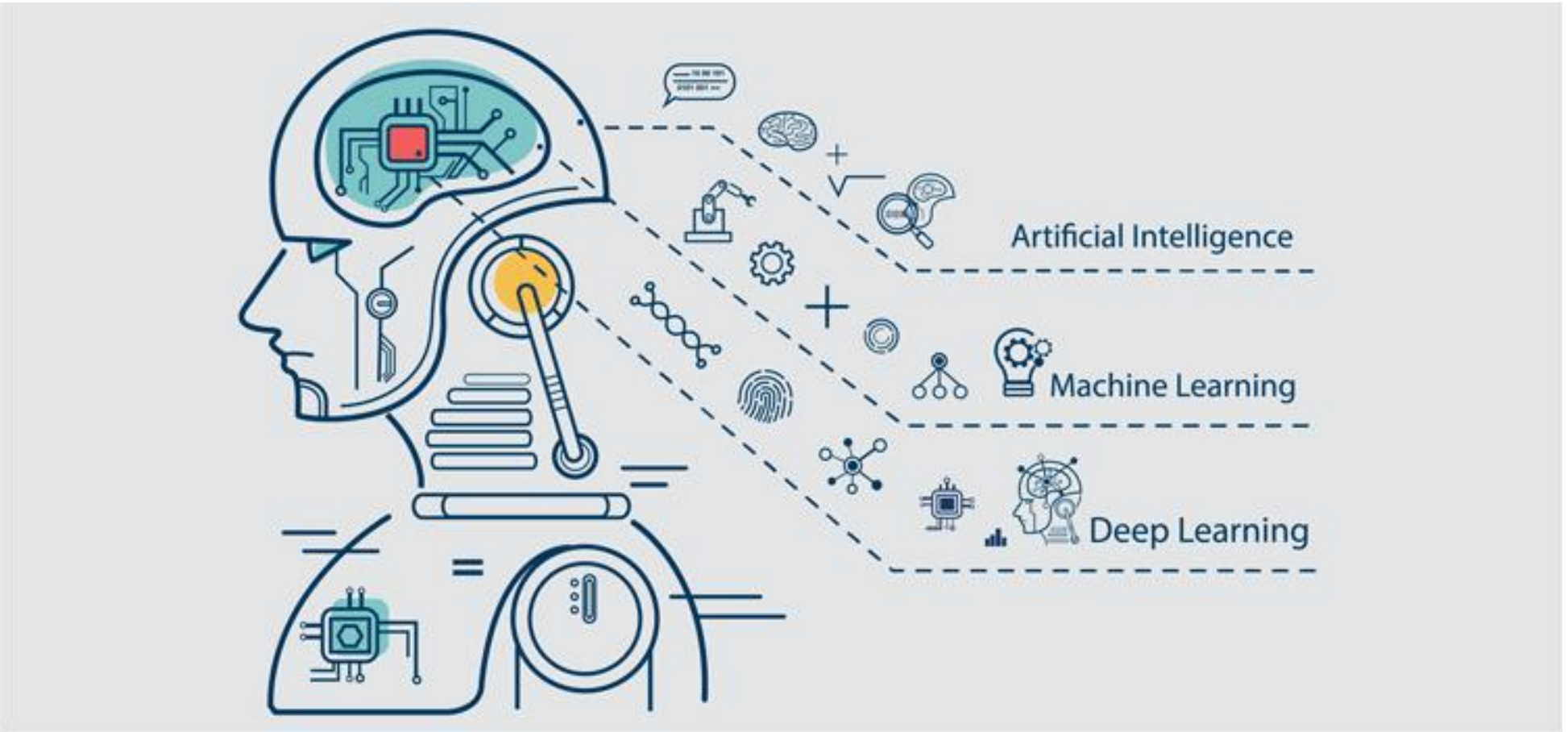




Symbolic Victory for Artificial Intelligence in 1997

Modern AI

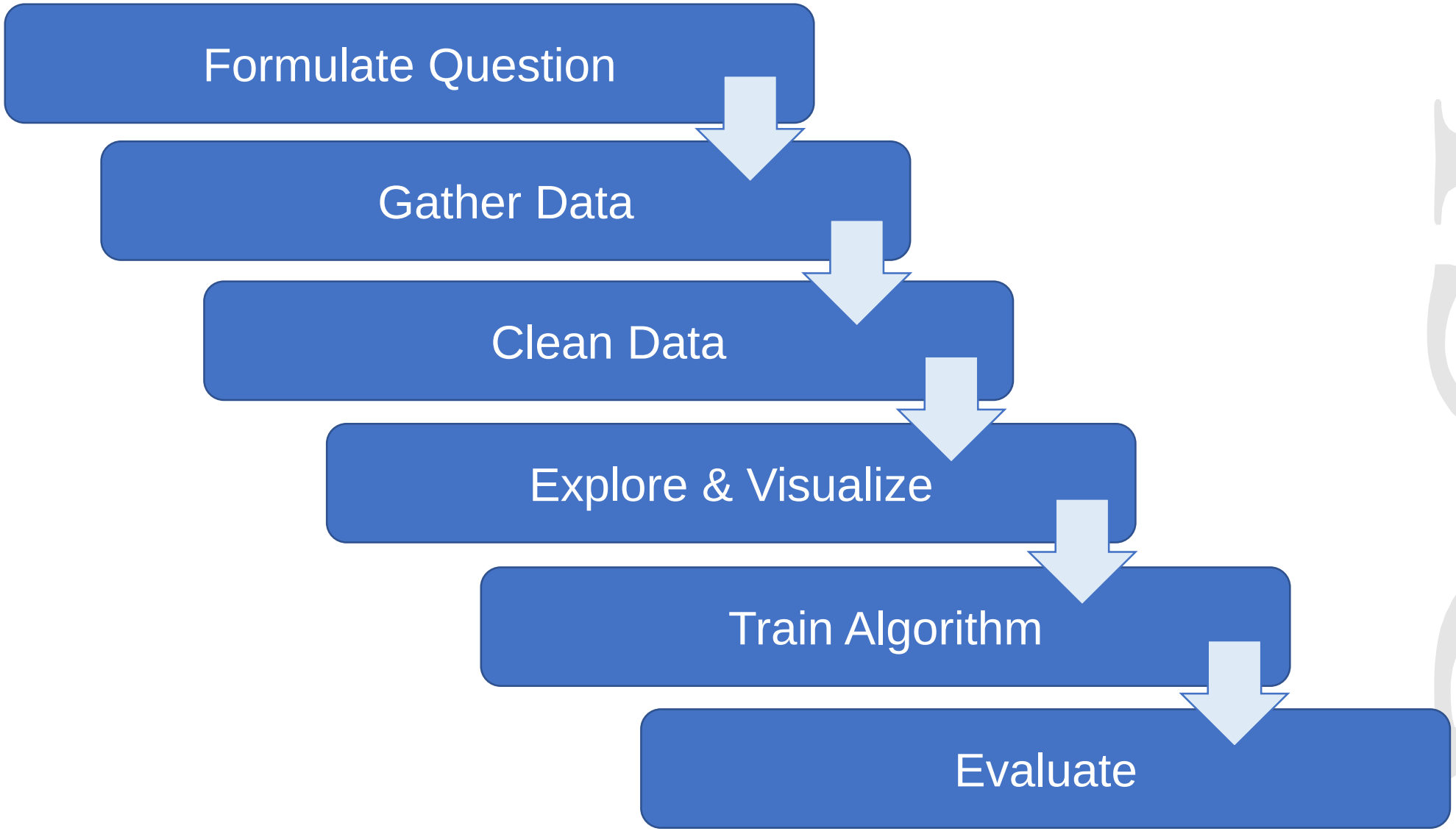
- Machine Learning (ML)
- Natural Language Processing (NLP)
- Robotics



Machine Learning

- Machine learning can be broadly defined as computational methods using experience to improve performance or to make accurate predictions
  - **Machine** – computer or computer program
  - **Learning** – improving performance on a given task, based on experience / examples
- Machine learning is inherently related to data analysis and statistics, it consists of designing efficient and accurate prediction algorithms
- Experience refers to the past information available to the learner, which typically takes the form of electronic data collected and made available for analysis
- Training set quality and size are crucial to the success of the predictions made by the learner
- In other words, instead of programming explicit rules for how to solve a given problem, the computer is instructed how to learn from examples

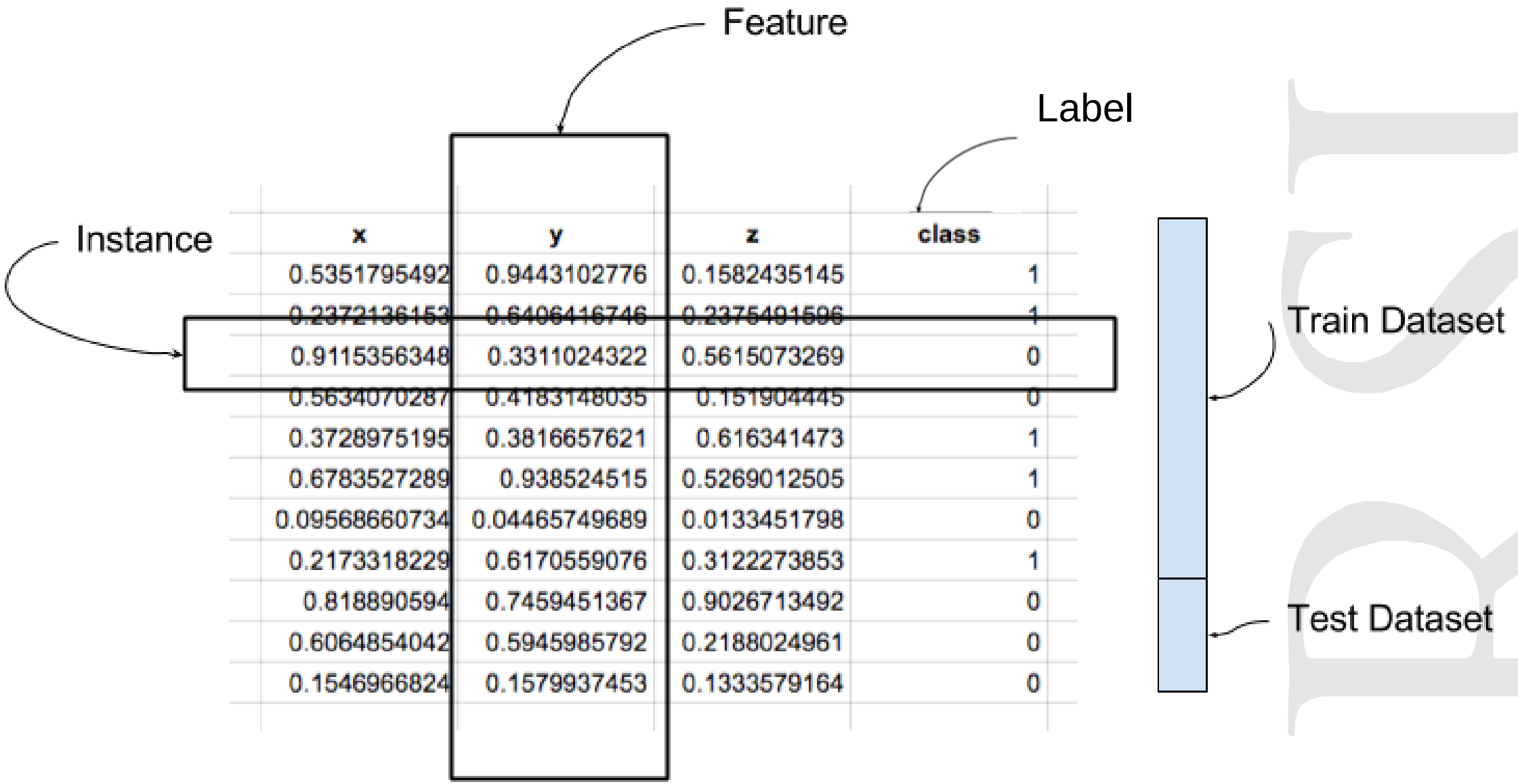
Machine Learning Workflow



Standard Learning Tasks

- **Regression**
  - The learning task becomes regression if the dependent variable is a continuous value
  - Regression task tries to learn a function which map independent variable to a continuous value output
- **Classification**
  - The learning task is called classification if the dependent variable is a categorical
- **Clustering**
  - Partitioning a set of items into homogeneous subsets
- **Dimensionality reduction**
  - Transforming an initial representation of items into a lower-dimensional representation
- **Ranking**
  - Learning to order items according to some criterion

Data Sets



x	y	z	class
0.5351795492	0.9443102776	0.1582435145	1
0.2372136153	0.6406416746	0.2375491596	1
0.9115356348	0.3311024322	0.5615073269	0
0.5634070287	0.4183148035	0.151904445	0
0.3728975195	0.3816657621	0.616341473	1
0.6783527289	0.938524515	0.5269012505	1
0.09568660734	0.04465749689	0.0133451798	0
0.2173318229	0.6170559076	0.3122273853	1
0.818890594	0.7459451367	0.9026713492	0
0.6064854042	0.5945985792	0.2188024961	0
0.1546966824	0.1579937453	0.1333579164	0

Supervised Learning

- Supervised learning is the machine learning task of learning a function that maps an input to an output based on example input-output pairs
- The training data has values of depended variable (label) corresponding to the independent variables (features)
- The goal of supervised learning algorithm is to learn a function that maps independent variables to the dependent variable (features to label)

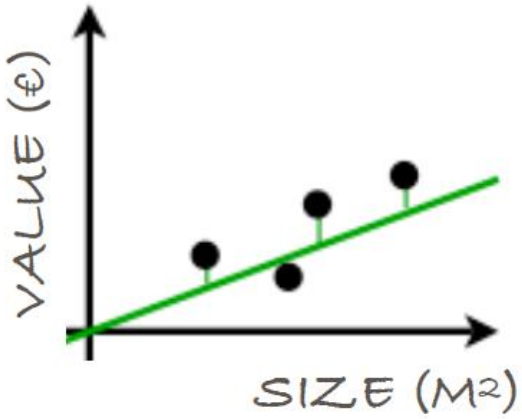
$$Y = F(X)$$

- The label or the dependent variable can be categorical or continuous

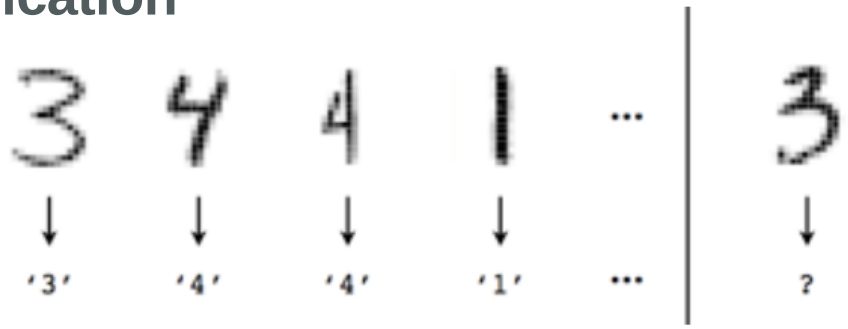
Supervised Learning

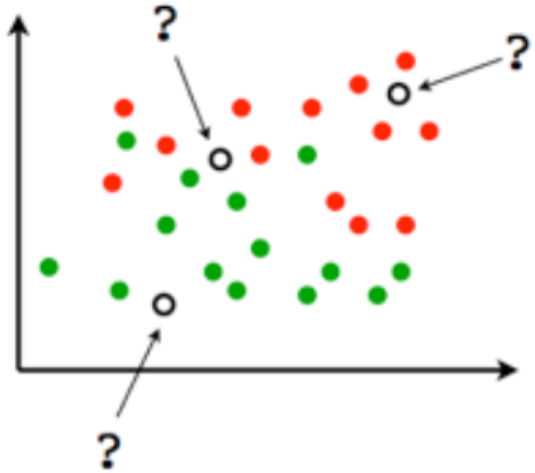
Depending upon the data type of this variable the task changes:

- **Regression**



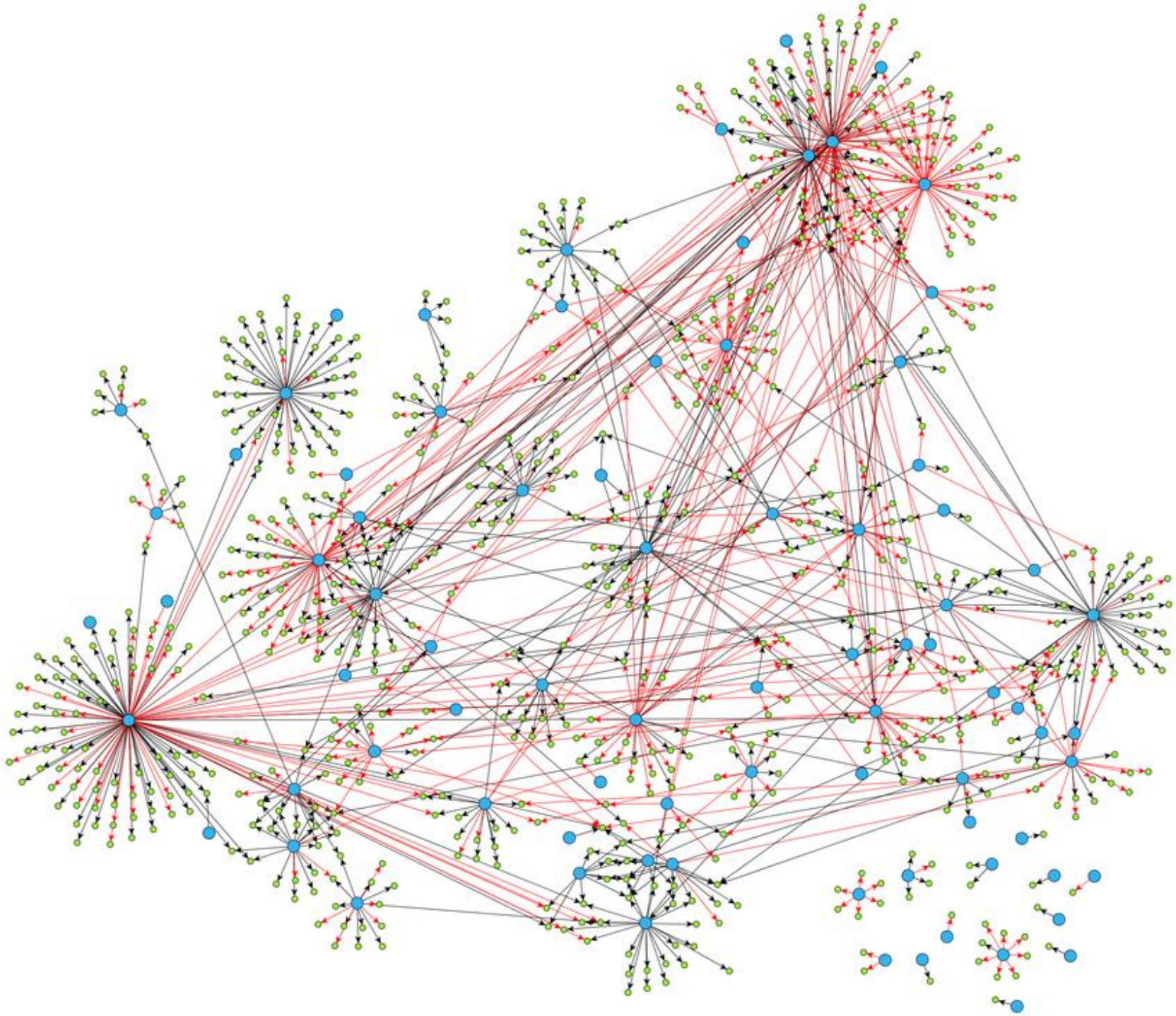
- **Classification**





Unsupervised Learning

- Unsupervised methods are used when labels associated with corresponding features are not available
- Looks for previously undetected patterns in a data set
- Two of the main learning problems of unsupervised learning:
  - Clustering
  - Dimensionality reduction



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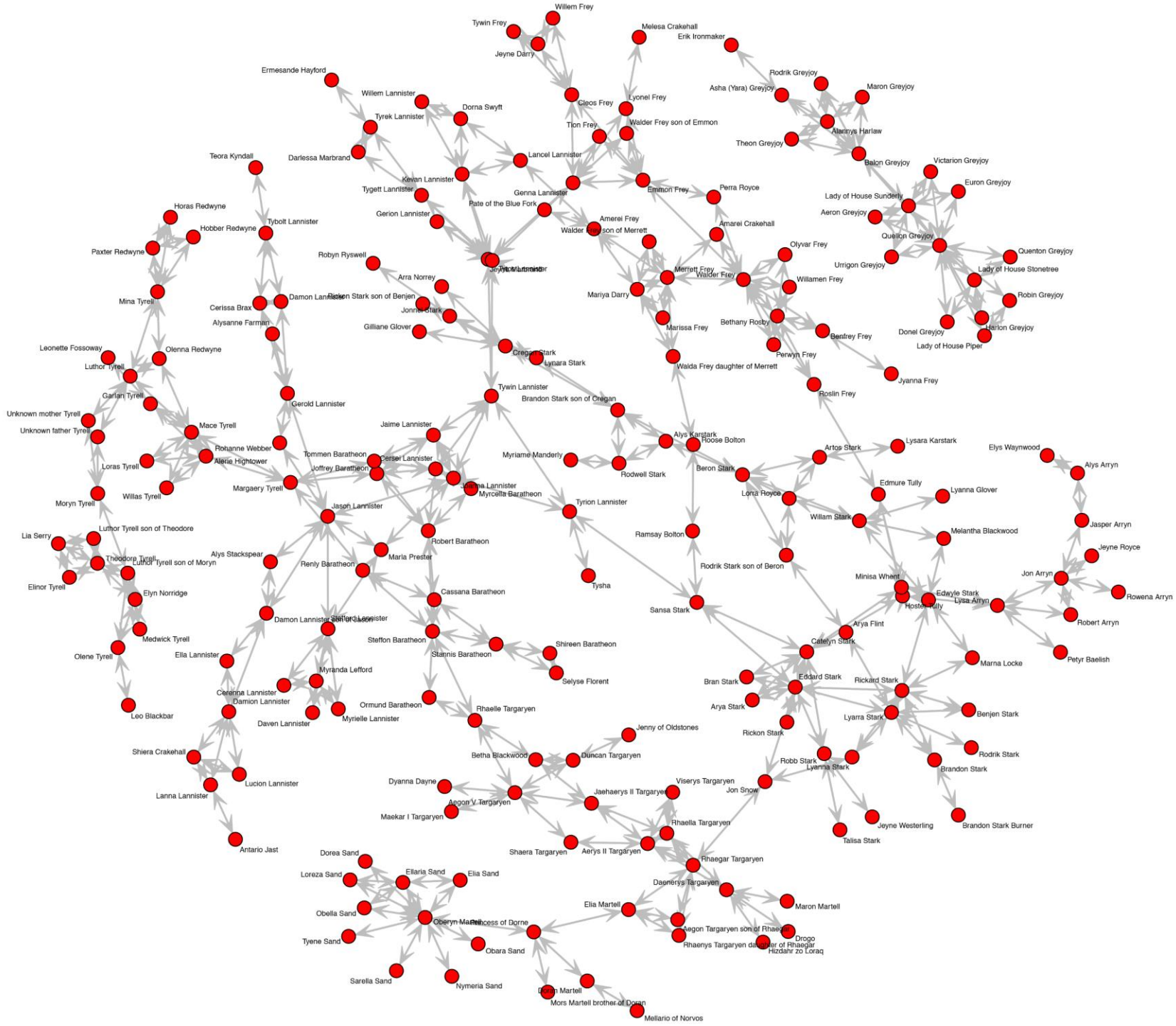
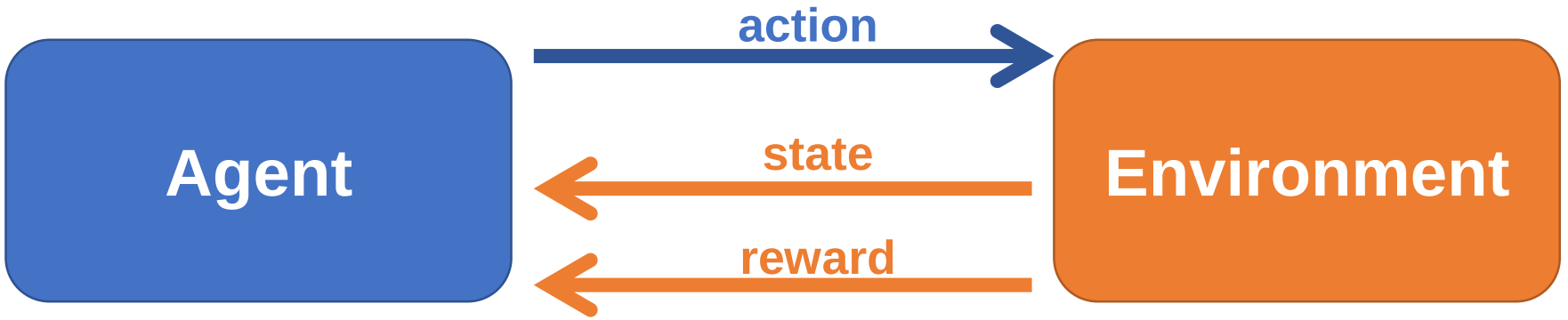

Willem Frey
Tywin Frey
Jeyne Darry
Melesa Crakehall
Erik Ironmaker
Ermesande Hayford
Willem Lannister
Dorna Swyft
Tyrek Lannister
Cleos Frey
Lyonel Frey
Tion Frey
Walder Frey son of Emmon
Rodrik Greyjoy
Asha (Yara) Greyjoy
Maron Greyjoy
Alannys Harlaw
Theon Greyjoy
Balon Greyjoy
Victarion Greyjoy
Euron Greyjoy
Lady of House Sunderly
Aeron Greyjoy
Quellon Greyjoy
Urrigon Greyjoy
Quenton Greyjoy
Lady of House Stonetree
Robin Greyjoy
Harlon Greyjoy
Donel Greyjoy
Lady of House Piper
Darlessa Marbrand
Lancel Lannister
Teora Kyndall
Kevan Lannister
Tygett Lannister
Genna Lannister
Emmon Frey
Perra Royce
Pate of the Blue Fork
Gerion Lannister
Amerei Frey
Walder Frey son of Merrett
Amarei Crakehall
Horas Redwyne
Hobber Redwyne
Tybolt Lannister
Paxter Redwyne
Robyn Ryswell
Arra Norrey
Olyvar Frey
Merrett Frey
Walder Frey
Willamen Frey
Mariya Darry
Marissa Frey
Bethany Rosby
Bentrey Frey
Perwyn Frey
Walda Frey daughter of Merrett
Jyanna Frey
Roslin Frey
Mina Tyrell
Cerissa Brax
Damon Lannister
Robben Stark son of Benjen
Jonnel Stark
Alysanne Farman
Gilliane Glover
Leonette Fossoway
Olenna Redwyne
Luthor Tyrell
Cregan Stark
Lynara Stark
Garlan Tyrell
Gerold Lannister
Tywin Lannister
Brandon Stark son of Cregan
Unknown mother Tyrell
Unknown father Tyrell
Mace Tyrell
Rohanne Webber
Alerie Hightower
Jaime Lannister
Alys Karstark
Roose Bolton
Myriame Manderly
Rodwell Stark
Artos Stark
Lysara Karstark
Elys Waynwood
Alys Arryn
Loras Tyrell
Tommen Baratheon
Cersei Lannister
Joffrey Baratheon
Margaery Tyrell
Joanna Lannister
Myrcella Baratheon
Willas Tyrell
Beron Stark
Lorra Royce
Edmure Tully
Lyanna Glover
Willam Stark
Jasper Arryn
Moryn Tyrell
Jason Lannister
Tyrion Lannister
Ramsay Bolton
Melantha Blackwood
Jeyne Royce
Lia Serry
Luthor Tyrell son of Theodore
Robert Baratheon
Rodrik Stark son of Beron
Jon Arryn
Alys Stackspear
Marla Prester
Renly Baratheon
Theodore Tyrell
Luthor Tyrell son of Moryn
Tysha
Minisa Whent
Edwyle Stark
Lysa Arryn
Rowena Arryn
Elinor Tyrell
Elyn Norridge
Sansa Stark
Hoster Tully
Robert Arryn
Cassana Baratheon
Arya Flint
Medwick Tyrell
Damon Lannister
Steffon Lannister
Steffon Baratheon
Stannis Baratheon
Shireen Baratheon
Catelyn Stark
Petyr Baelish
Olene Tyrell
Ella Lannister
Myranda Lefford
Selyse Florent
Eddard Stark
Rickard Stark
Marna Locke
Bran Stark
Cerenna Lannister
Damion Lannister
Ormund Baratheon
Rhaelle Targaryen
Arya Stark
Lyarra Stark
Benjen Stark
Leo Blackbar
Daven Lannister
Myrielle Lannister
Jenny of Oldstones
Rickon Stark
Rodrik Stark
Shiera Crakehall
Betha Blackwood
Duncan Targaryen
Robb Stark
Lyanna Stark
Brandon Stark
Lucion Lannister
Dyanna Dayne
Viserys Targaryen
Jon Snow
Lanna Lannister
Aegon V Targaryen
Jaehaerys II Targaryen
Maekar I Targaryen
Rhaella Targaryen
Jeyne Westerling
Brandon Stark Burner
Talisa Stark
Antario Jast
Shaera Targaryen
Aerys II Targaryen
Dorea Sand
Rhaegar Targaryen
Loreza Sand
Ellaria Sand
Elia Sand
Daenerys Targaryen
Elia Martell
Maron Martell
Obella Sand
Oberyn Martell
Princess of Dorne
Aegon Targaryen son of Rhaegar
Drogo
Tyene Sand
Rhaenys Targaryen daughter of Rhaegar
Hizdahr zo Loraq
Obara Sand
Sarella Sand
Nymeria Sand
Doran Martell
Mors Martell brother of Doran
Mellario of Norvos

Semi-supervised Learning

- The learner receives a training sample consisting of both labeled and unlabeled data, and makes predictions for all unseen points
- Semi-supervised learning is common in settings where unlabeled data is easily accessible but labels are expensive to obtain
- General assumptions:
  - Points that are close to each other are more likely to share a label
  - The data tend to form discrete clusters, and points in the same cluster are more likely to share a label
  - The data lie approximately on a manifold of much lower dimension than the input space

Reinforcement Learning

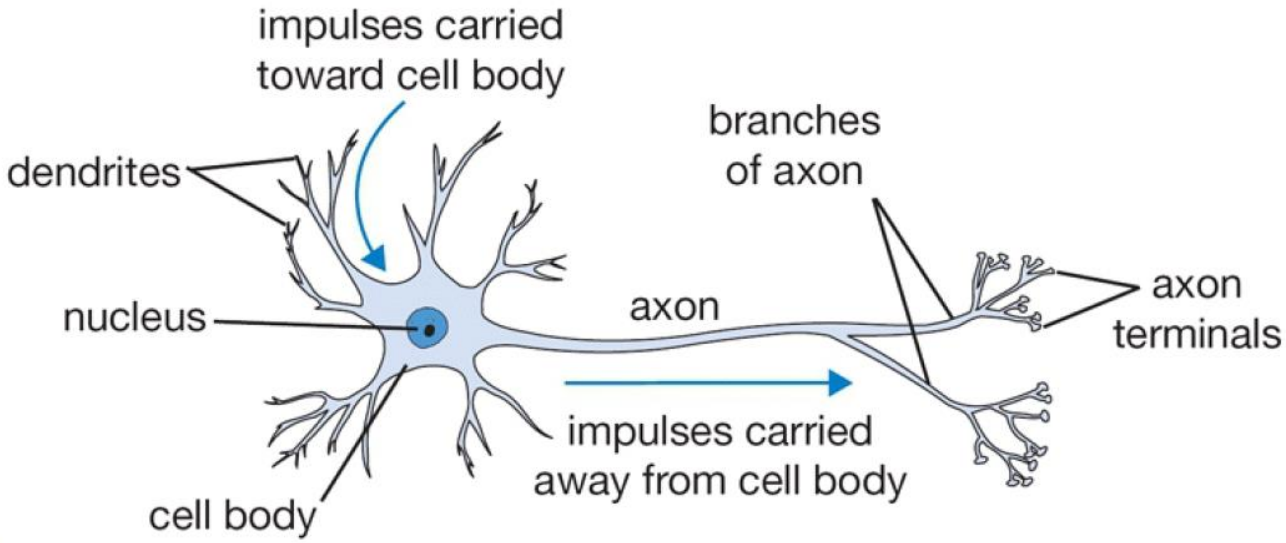
- To collect information, the learner actively interacts with the environment and in some cases affects the environment, and receives an immediate reward for each action
- The object of the learner is to maximize his reward over a course of actions and iterations with the environment
- The focus is on finding a balance between exploration (of uncharted territory) and exploitation (of current knowledge)
- Reinforcement learning is very valuable in the field of robotics
  - The robot's task consists of finding out, through trial and error (or success), which actions are good in a certain situation and which are not



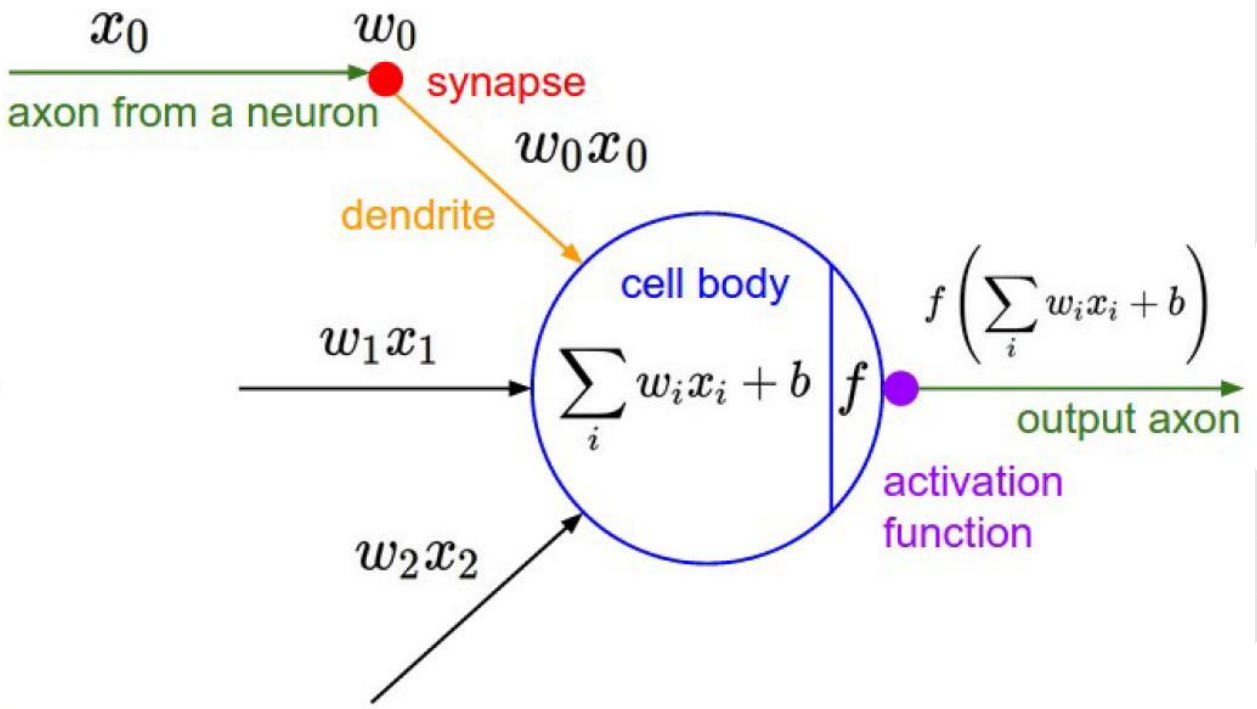
Deep Learning

- Deep learning is based on artificial neural networks
- The idea of artificial neural networks is taken from natural neural networks

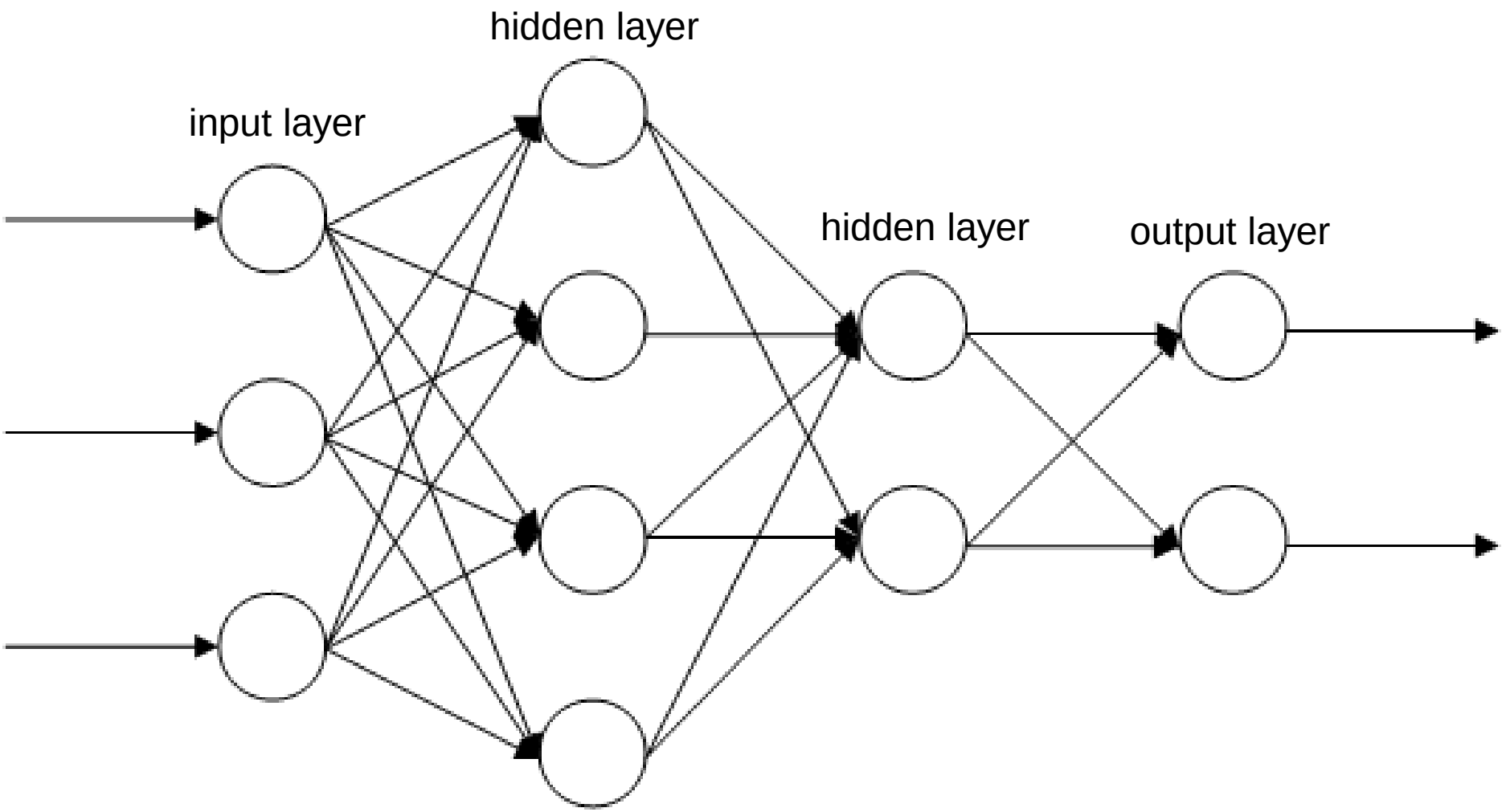
Biological neuron

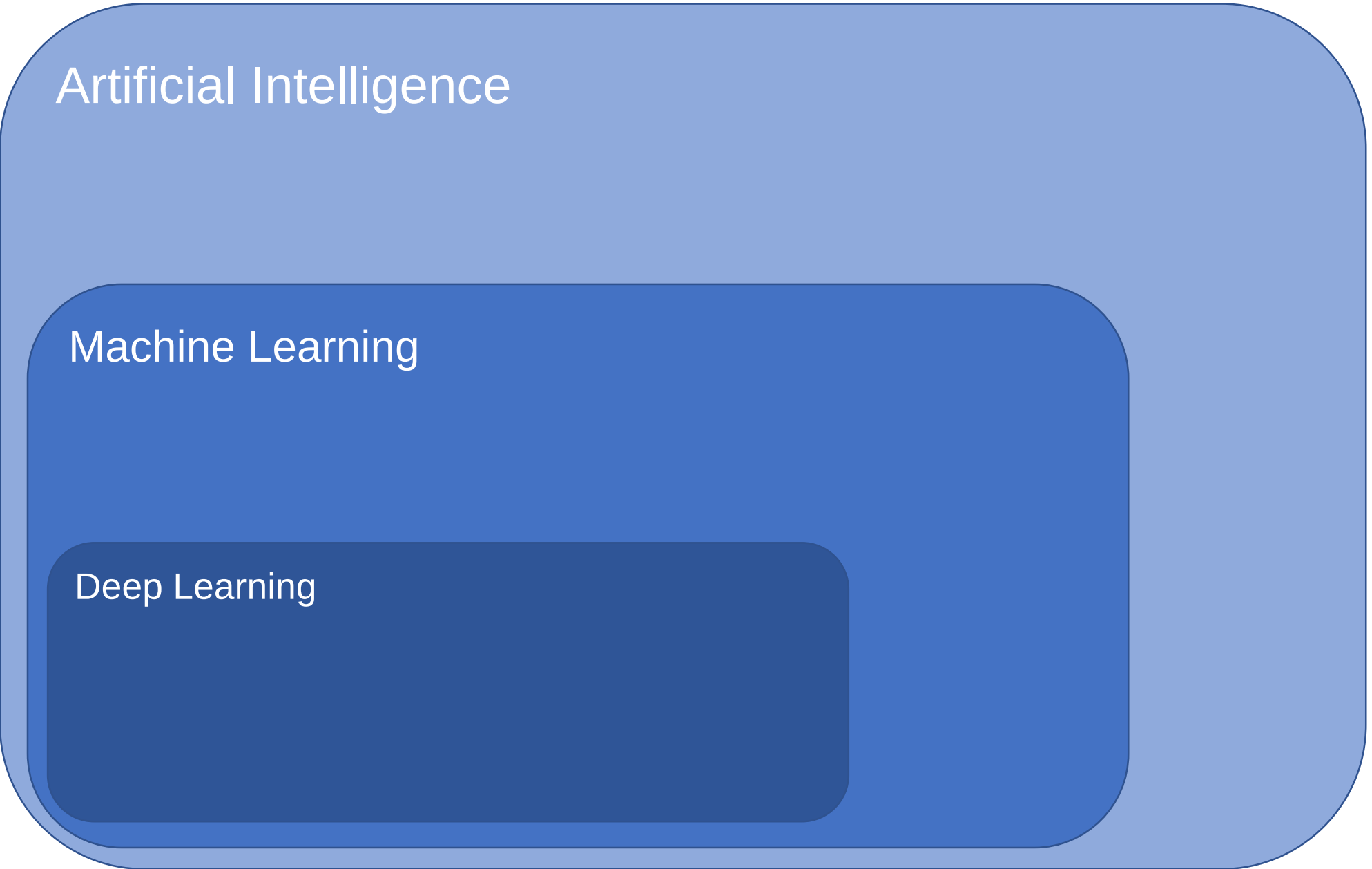


Artificial neuron – Perceptron



Deep Learning – Artificial Neural Networks

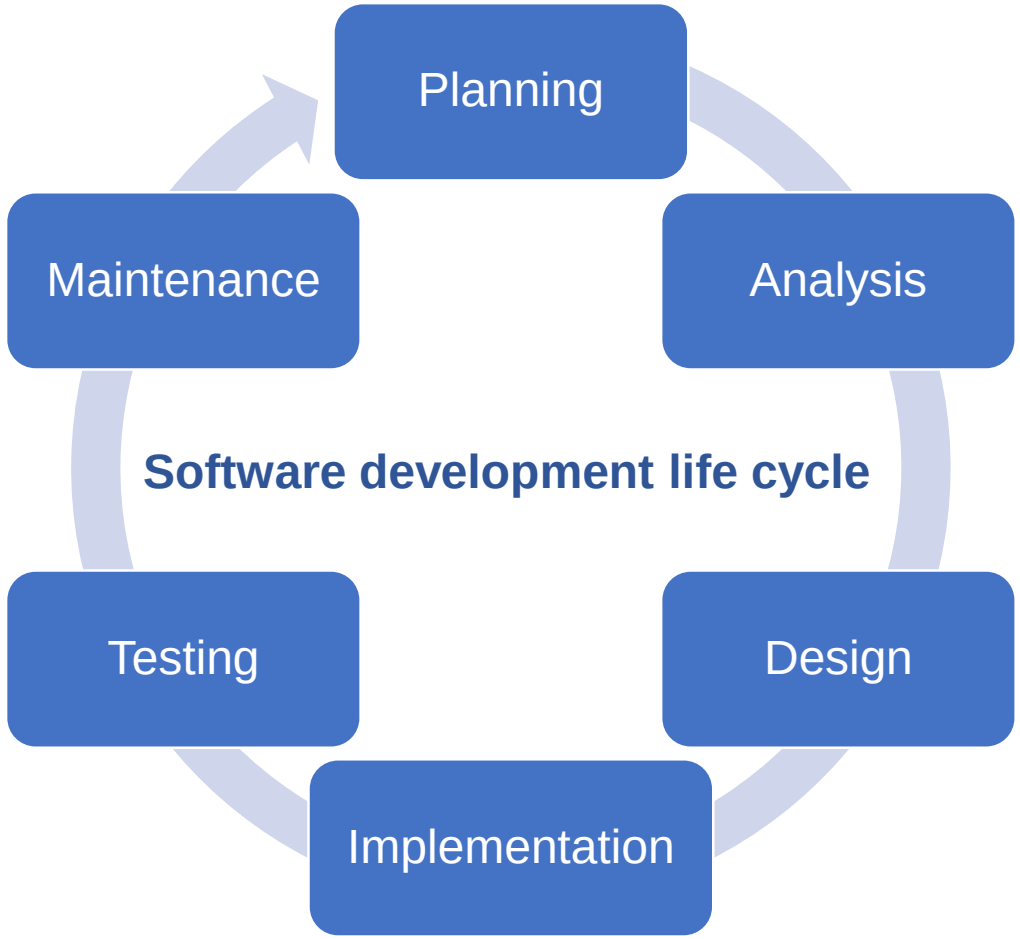



Artificial Intelligence
Machine Learning
Deep Learning

Implementing Machine Learning Solutions

Coding from scratch

- Extensive coding and debugging of code that implements machine learning algorithm, improving and optimizing the code
- Expensive, long-term project



Implementing Machine Learning Solutions

Existing machine learning libraries and tools

- Low-code solutions
- Exploring existing libraries and their community support
- Training the machine learning model, improving model performance

Implementing Machine Learning Solutions

Cloud services

- Low-code solutions & no-code solutions
- Training the machine learning model, improving model performance
- Most of cloud providers supports libraries and tools discussed earlier
- Costs can include subscription fee, data storage and transfer, computation power used

Machine Learning cloud service providers

- Microsoft Azure
- Amazon Web Services (AWS)
- Google Cloud

Azure Machine Learning

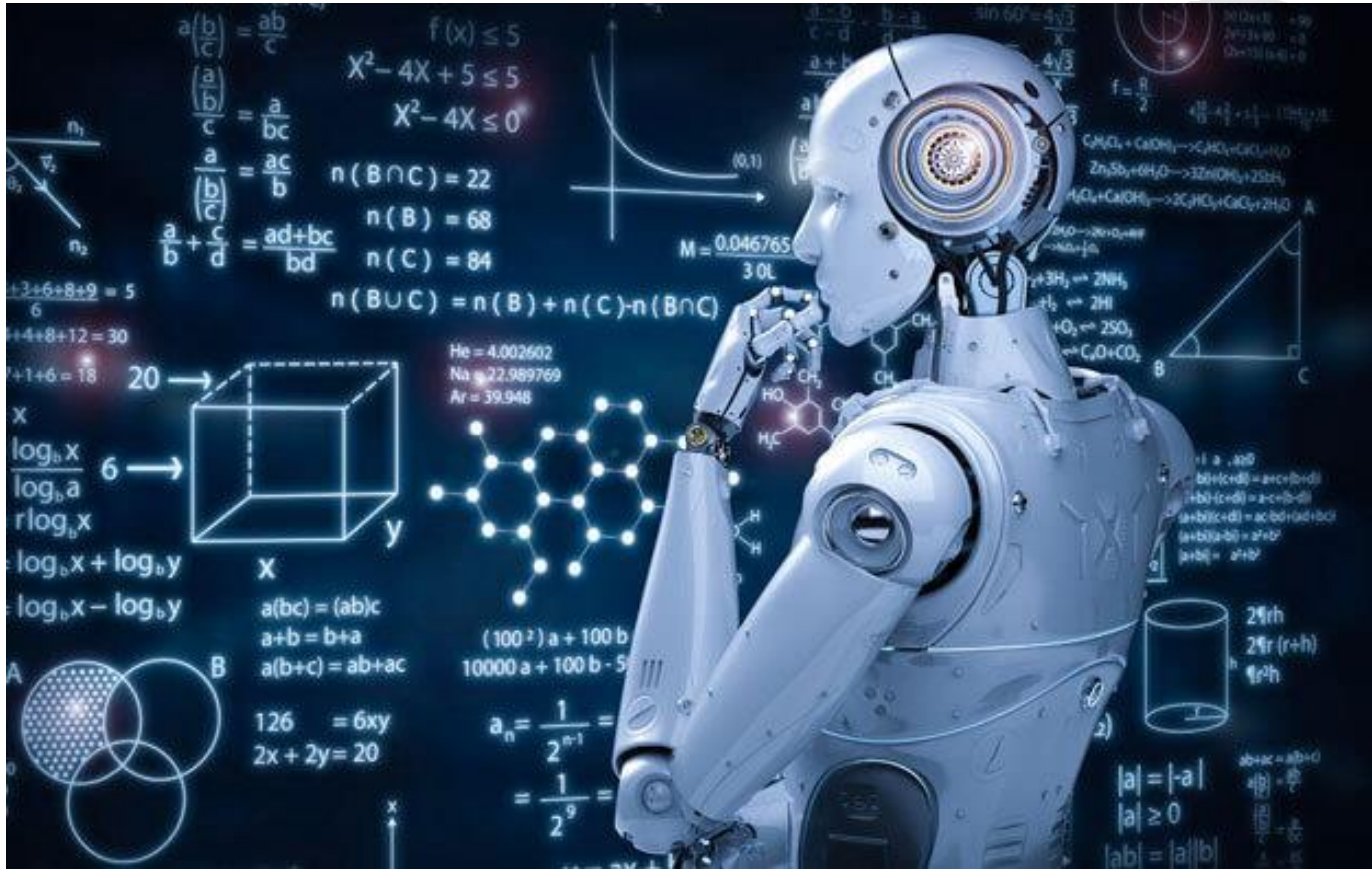
Google Cloud

Machine Learning Use Cases in Daily Life

- **Smartphones**
  - Voice Assistants
  - Camera
  - App Store and Play Store Recommendations
  - Face Unlock
- **Transportation**
  - Traffic lights
  - Maps
- **Online services**
  - Email filtering
  - Search
  - Translation
  - LinkedIn and Facebook recommendations and ads

Machine Learning Use Cases

- Healthcare and medicine
  - Medical Imaging & Biomedical Diagnostics
  - Decision Support & Hospital Monitoring
  - Digital Medicine & Wearable technology
  - Robotic Technology & Virtual Assistant
  - Precision Medicine & Drug Discovery
- Education
  - Personalized Learning
  - Smart and Adaptable Content
  - Automatic Grading
- Smart homes and robots
- Environment & energy
- Security
- Transport and logistics
- Employment
- Economy, business, and finance
  - process automation
  - profit optimization



Research Fronts on Machine Learning

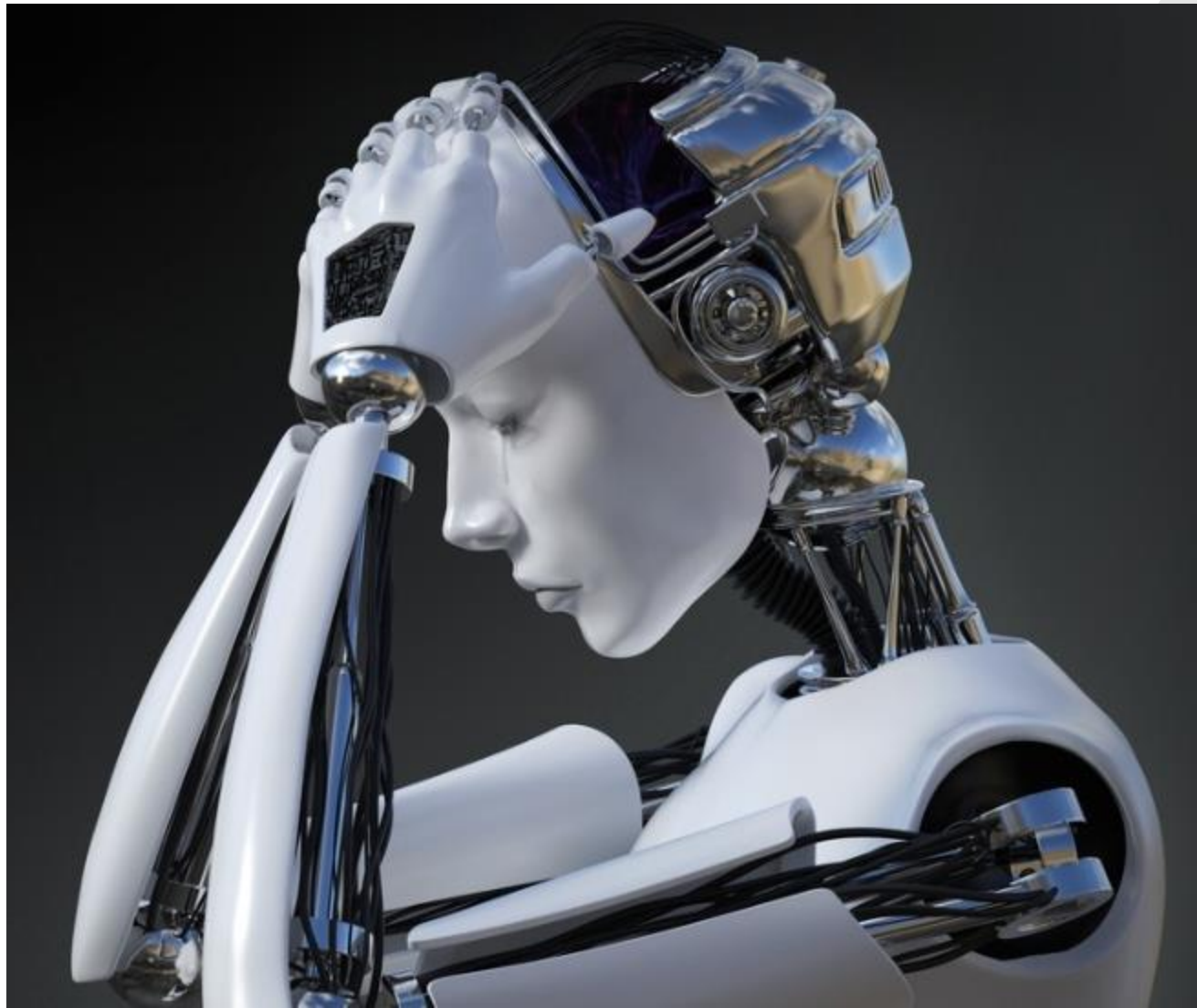
- Engineering
  - Deep learning-based speech enhancement approaches
  - Deep asymmetric video-based person re-identification
  - Electric energy consumption forecasting models
- Neuroscience & Behaviour
  - Hierarchical deep neural networks
- Biology & Biochemistry
  - Protein structure prediction methods
- Physics
  - Machine learning quantum phases
- Computer Science
  - Novel robust structured subspace learning
- Chemistry
  - Predictive qsar models
- Clinical Medicine
  - Deep learning convolutional neural networks
- Geosciences
  - Hyperspectral image classifications

Common Misconceptions About Artificial Intelligence

Understanding
- Interpreting, not analyzing
- Going beyond pure numbers
- Considering consequences

Discovering
- Devising new data from old
- Seeing beyond the patterns
- Implementing new senses

Empathizing
- Walking in someone’s shoes
- Developing true relationships
- Changing perspective
- Making leaps of faith



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- Mehryar Mohri, Afshin Rostamizadeh, and Ameet Talwalkar. Foundations of Machine Learning. MIT Press, Second Edition, 2018.

- Python: https://www.python.org/
- TensorFlow: https://www.tensorflow.org/
- Anaconda: https://www.anaconda.com/products/individual
- NumPy: https://numpy.org/doc/stable/
- Pandas: https://pandas.pydata.org/docs/
- Scikit-Learn: https://scikit-learn.org/stable/user_guide.html
- Matplotlib: https://matplotlib.org/contents.html
- Graph theory https://en.wikipedia.org/wiki/Graph_theory

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Thank you!

Any questions?