Artificial Intelligence, Machine Learning and the Future

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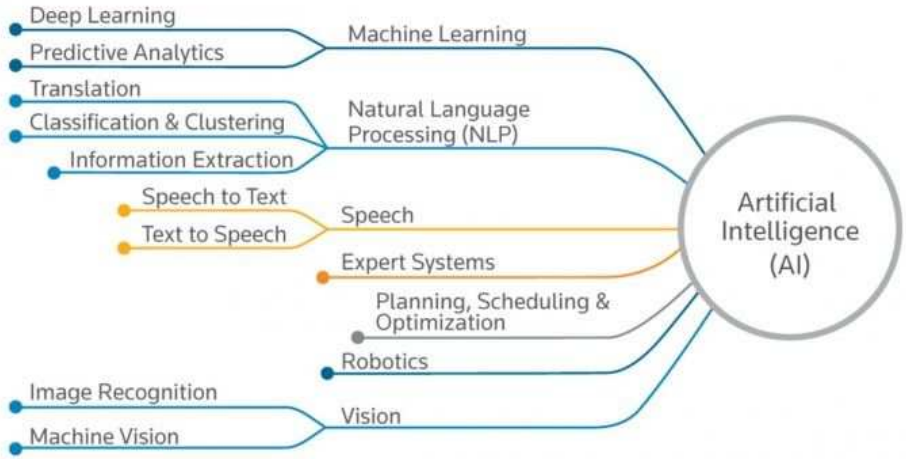
Artificial Intelligence (AI)

- **Intelligence**
  - "Capacity to **solve new problems** through the use of knowledge"

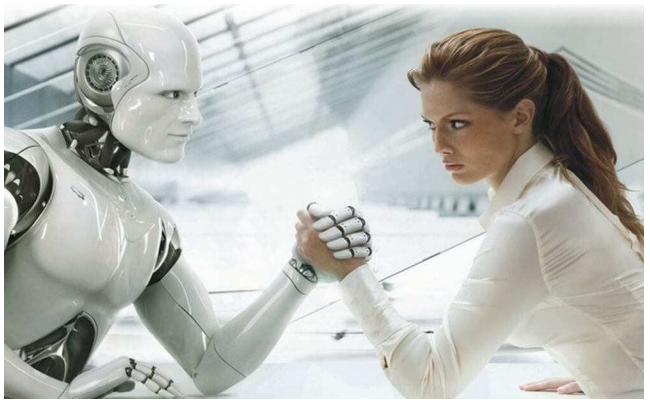
- **Artificial Intelligence**
  - "Science concerned with building **intelligent machines**, that is, machines that perform tasks that when performed by humans require intelligence"



Weak and Strong AI

- **Weak Artificial Intelligence**

  weak AI, also known as narrow AI is artificial intelligence that is focused on one **single narrow task**



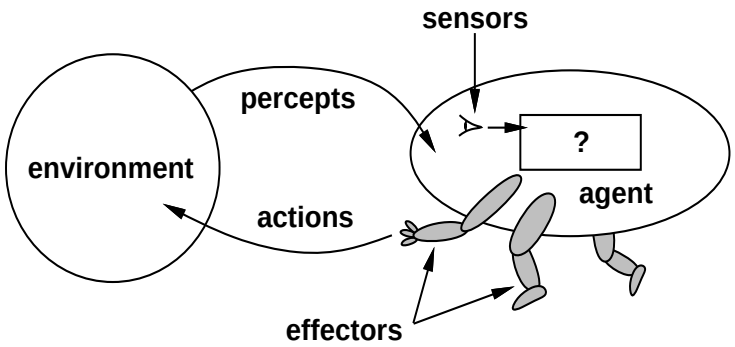
- **Strong Artificial Intelligence**

  Strong AI or Artificial General Intelligence (AGI) is the intelligence of a machine that could successfully perform **any intellectual task** that a human being can! Science fiction ?

AI - Autonomous Agents and Multi-Agent Systems

Agent:

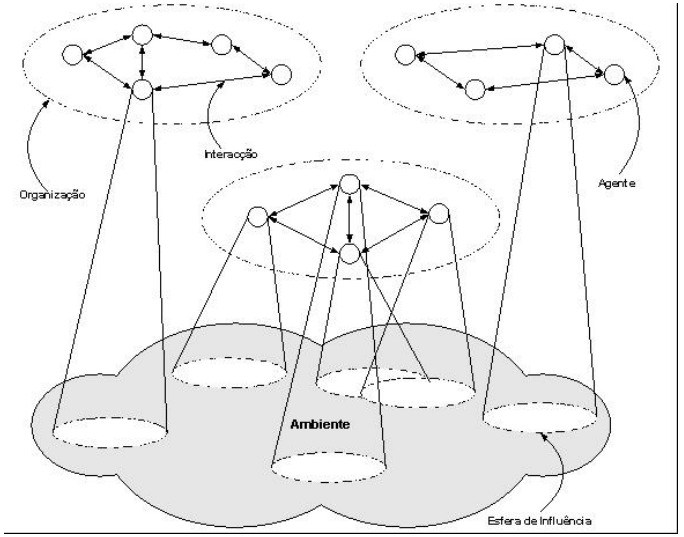
"Computational System, situated in a given **environment**, that has the ability to **perceive** that environment using **sensors** and **act**, in an **autonomous way**, in that environment using its **actuators** to fulfill a given **function**."



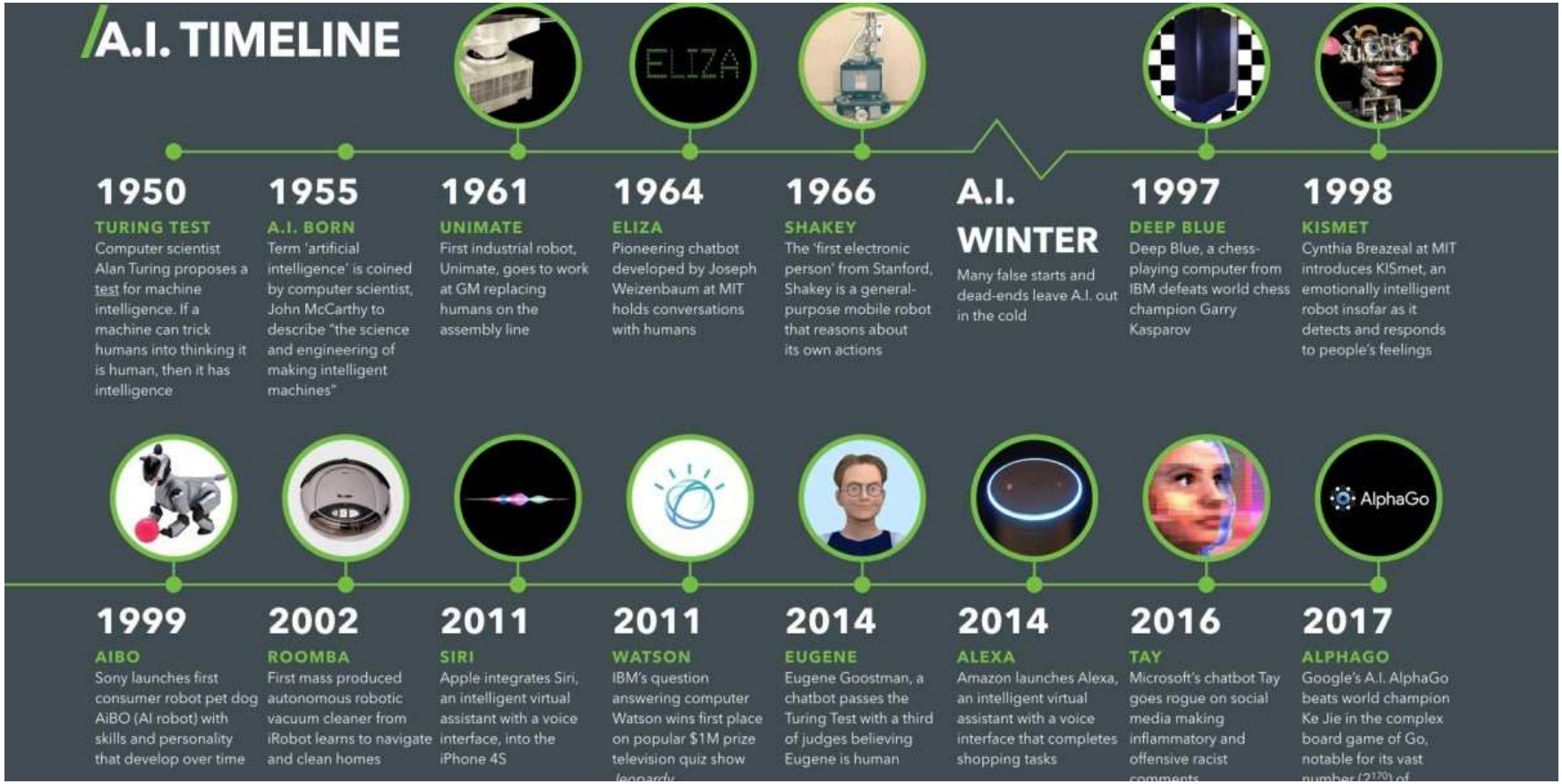
Russel and Norvig, "AI: A Modern Approach", 1995

Multi-Agent System:

- Agents exhibit **autonomous behavior**
- **Interact** with other agents in the system



AI Timeline



[Paul Marsden, 2017]

AI - Intelligent Robotics

- **Robotics**
  - Science and technology for **projecting, building, programming and using Robots**
  - Study of **Robotic Agents (with body)**
  - Increased Complexity:
    - **Environments:** Dynamic, Inaccessible, Continuous and Non Deterministic!
    - Perception: **Vision**, **Sensor Fusion**
    - Action: **Robot Control (Humanoids!)**
    - **Robot Architecture** (Physical / Control)
    - **Navigation** in unknown environments
    - **Interaction** with other robots/humans
    - **Multi-Robot Systems**

AI - Current State of Robotics

- **Used to Perform:**
  - **Dangerous** or difficult **tasks** to be performed directly by humans
  - **Repetitive tasks** that may be performed more efficiently (or cheap) than when performed by humans

- **Robots have moved from manufacturing, industrial applications to:**
  - **Domestic** Robots (Pets – AIBO, vacuum cleaners)
  - **Entertainment** robots (social robots)
  - **Medical** and **Rehabilitation** robots
  - **Military** and surveillance robots
  - **Educational** robots
  - Intelligent buildings
  - **Intelligent vehicles** (cars, submarines, airplanes)
  - New industrial applications (mining, fishing, agriculture)
  - Hazardous applications (space exploration, military apps, toxic cleanup, construction, underwater apps)
  - **Multi-Robot Applications and Human-Robot Teams!**

AI - Robotics

- Autonomous driving car (Google)
- Service, mars explor., medical robotics (Motorman, Miimo, Roomba, Oz, Asimo, Nao)
- Exosekeleton (exoAtlete)
- Ambient Assisted Living
- Drones & Delivery (PT ConnectRobotics)
- Military, Assistive, Eldery, …
- Education, entertainment, …

AI - Humanoid Robotics

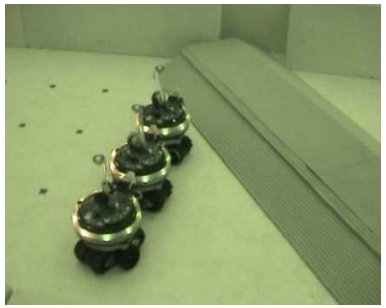
AI - Robotic Competitions - RoboCup

AI - Coordination in Multi-Agent Systems

Motivation:

- Agents don't live alone and have to work in a group…
- **Human-Computer Interaction**
- **Multi-Agent Coordination**

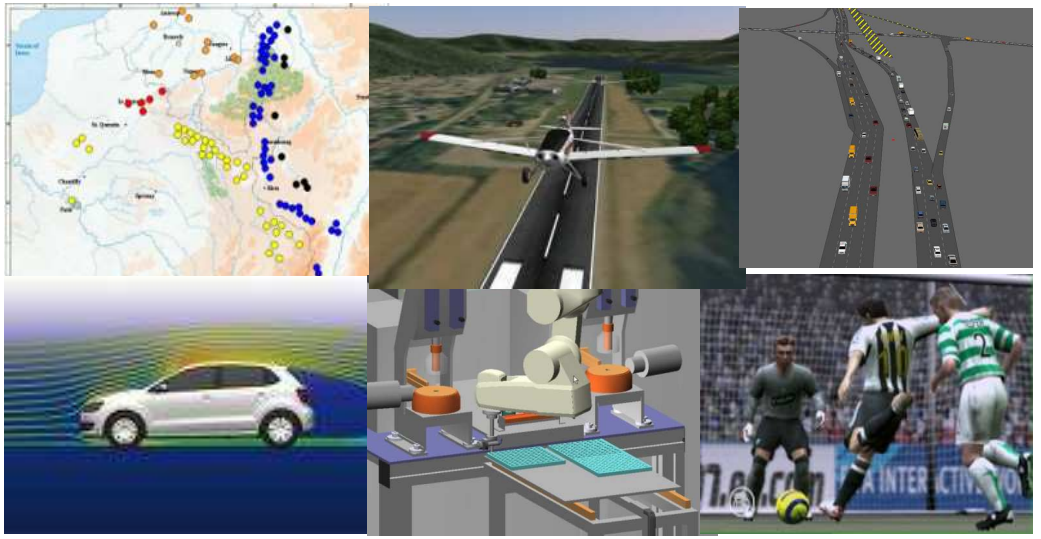
Coordination : "to work in harmony in a group"



- **Dependencies** in agent actions
- Global constraints
- **No agent**, individually **has enough resources**, information or capacity to execute the task or solve the problem
- **Efficiency:** Information exchange or tasks division
- **Prevent anarchy and chaos**: Partial vision, lack of authority, conflicts, agent's interactions

Agent-Based Simulation

- **Simulation: Imitation of some real thing, state of affairs, or process, over time,** representing certain **key characteristics** or behaviours of the physical or abstract system
- Applications:
  - Understand system **functioning**
  - **Performance optimization**
  - Testing and validation
  - **Decision making**
  - Training and education
  - **Test future/expensive systems**



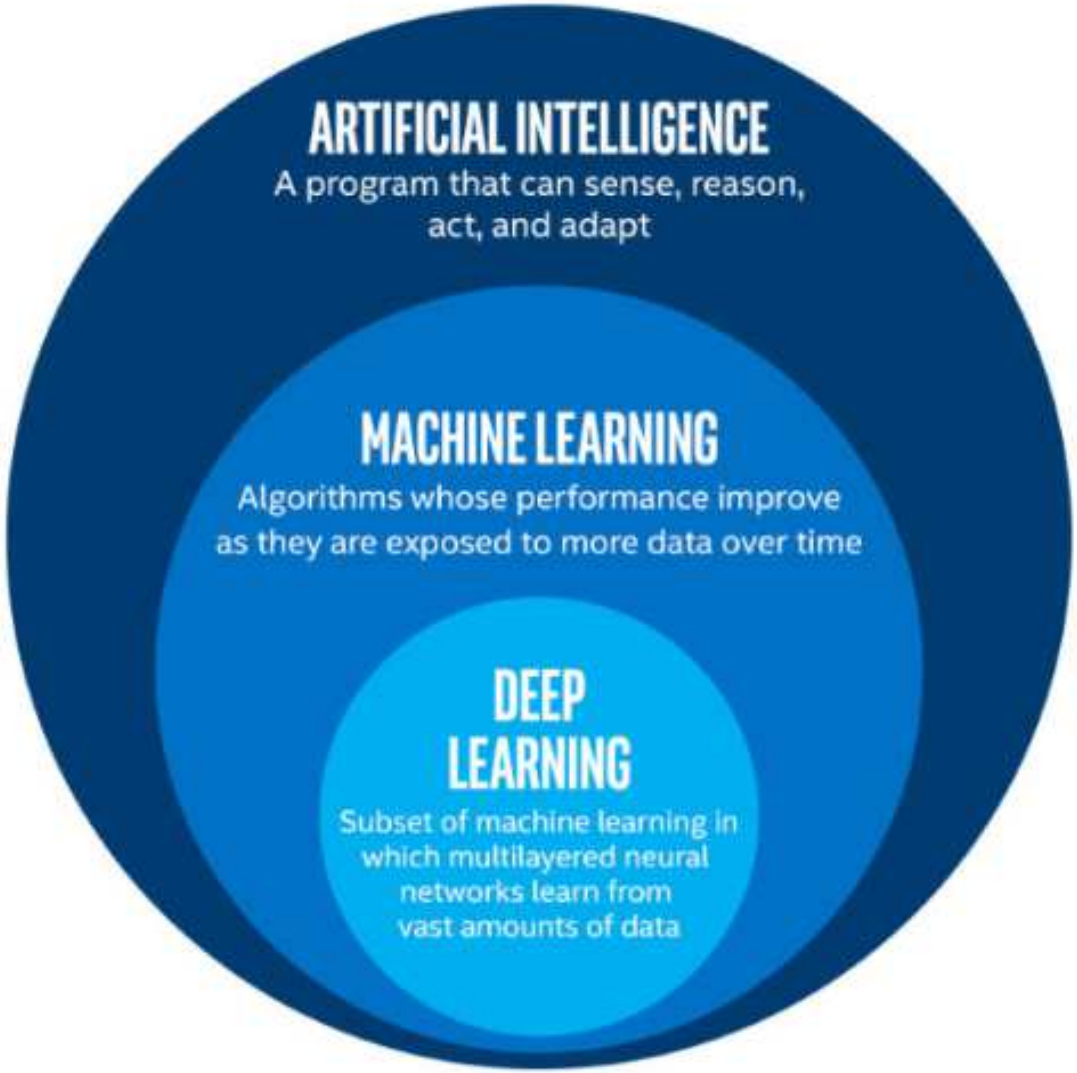
- For complex systems impossible to solve mathematically
- **Agent Based Modeling and Simulation**

Machine Learning

“Machine learning enables a machine to automatically learn from data, improve performance from experiences, and predict things without being explicitly programmed.”

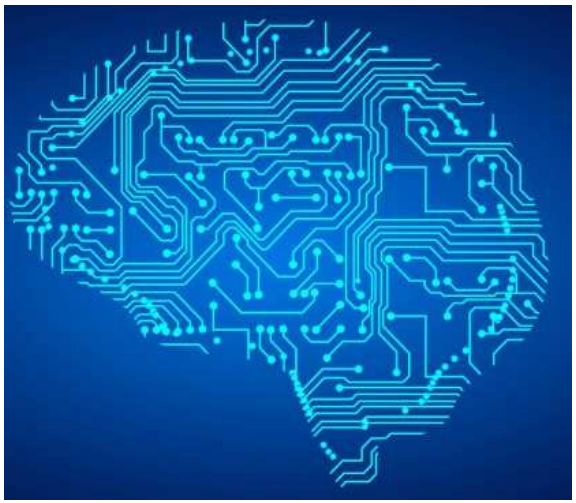
Arthur Samuel, 1959

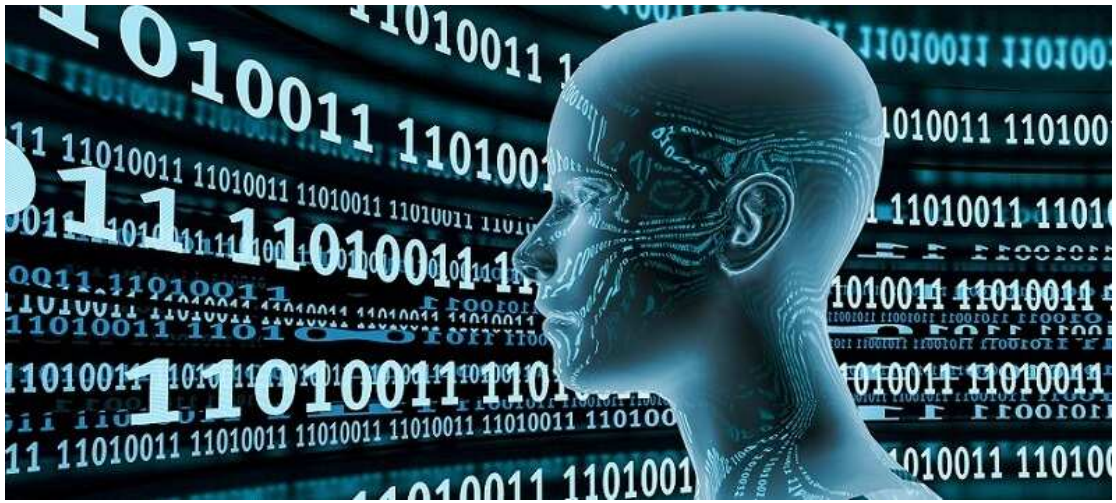
Machine Learning vs. Artificial



AI - Machine Learning

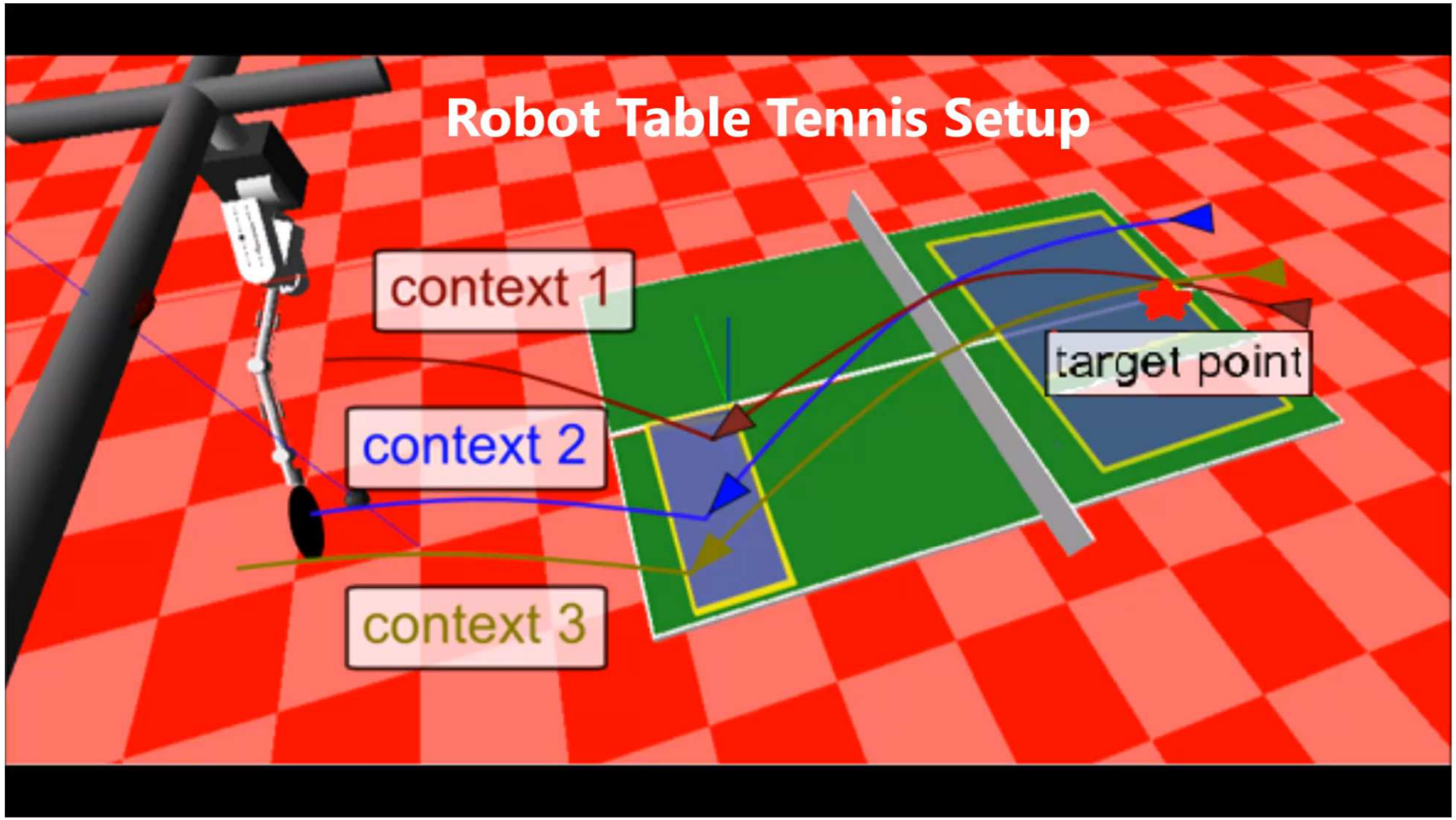
- **Machine learning** is a field of artificial intelligence that gives **computer systems** the **ability to "learn"** (e.g., progressively **improve performance** on a specific task) **from data/results of their actions**, without being explicitly programmed





Artificial Intelligence: Machine Learning

AI: ML – Learning Table Tennis



AI – Natural Language Processing

Natural Language Processing and Understanding

Conversations	Retrieval-Based	Generative-Based
Open Domain	Impossible	General AI (Hardest)
Closed Domain	Rules-Based (Easiest)	Smart Bot (Hard)

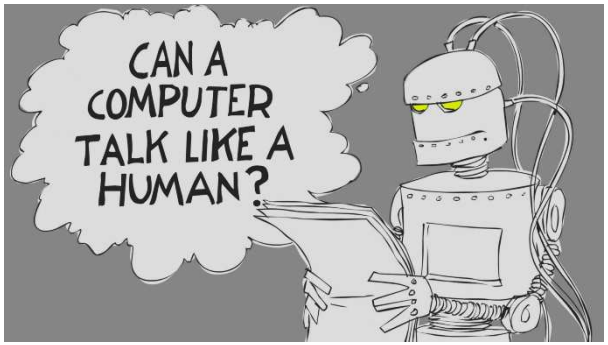
Responses

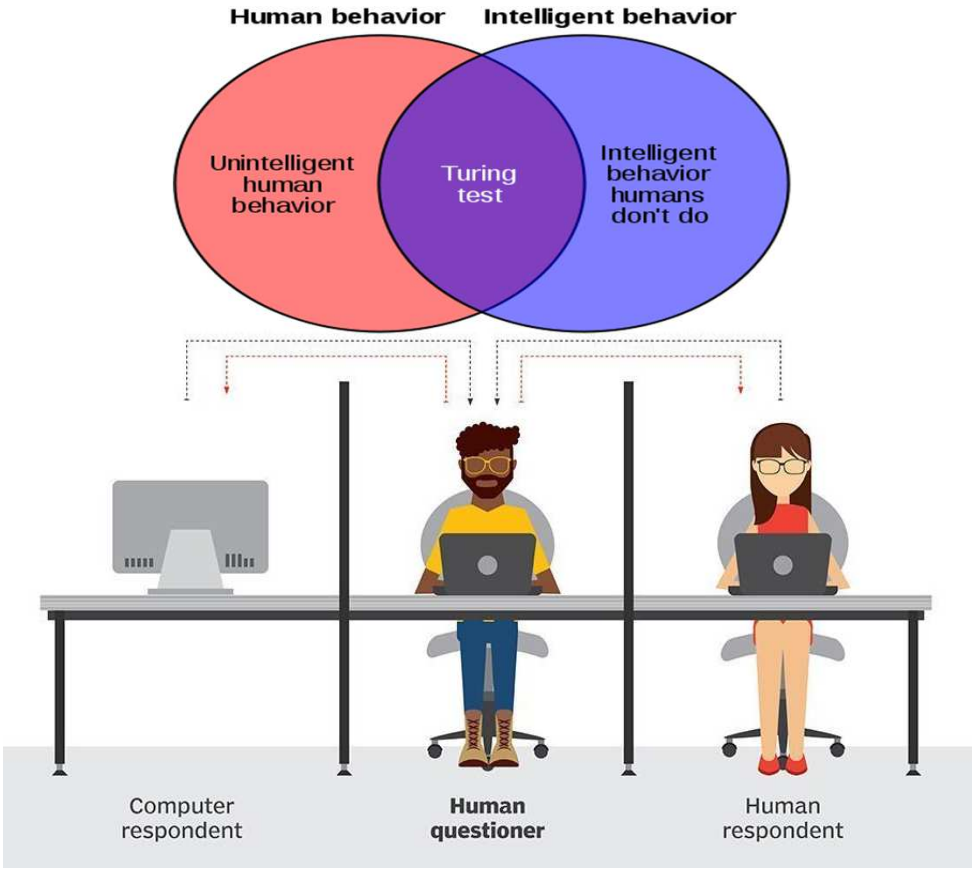
- Without sophisticated NLP capabilities
- Pattern recognition, rule based expression matching, simple machine learning, together with repositories of pre-written sentence templates

AI – NLP: Watson at Jeopardy

AI: NLP - Turing Test

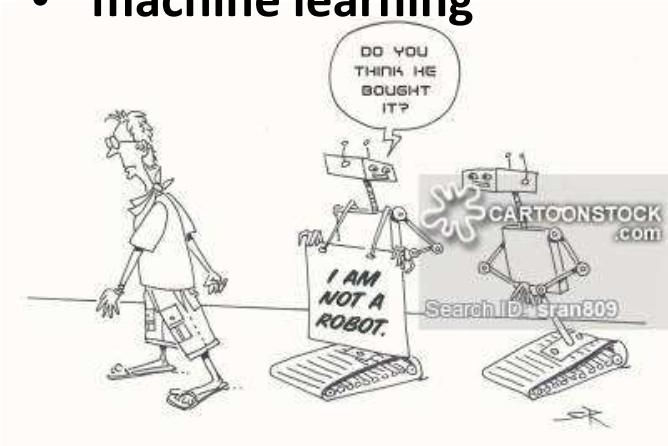
- Can a Computer Talk like a Human?
- Can a Computer Think like a Human?





Capabilities:

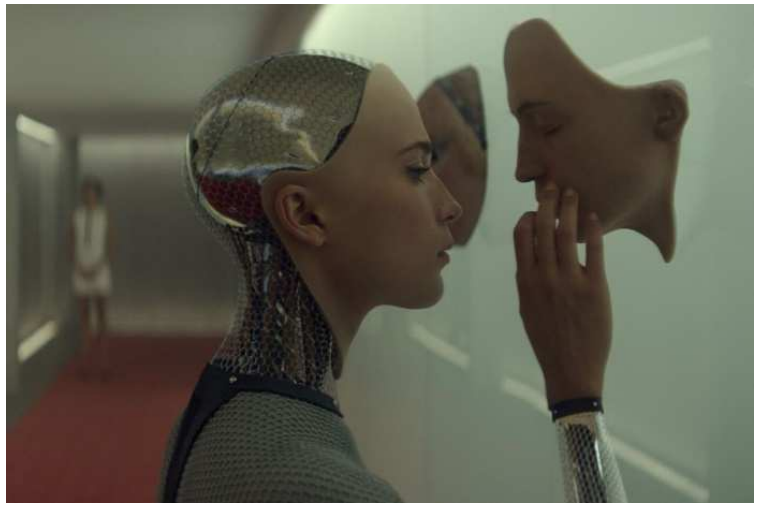
- natural language processing
- knowledge representation
- automated reasoning
- machine learning

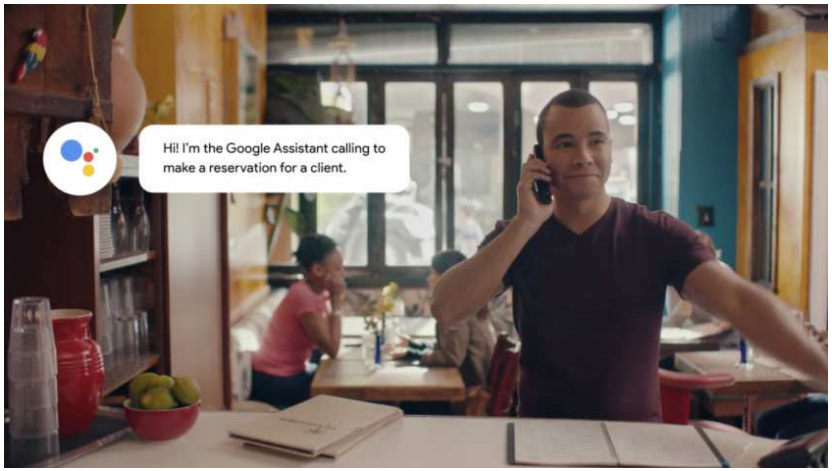


AI: NLP – Robots/Sophia

AI: NLP – Google Assistant

- **Google Assistant with Duplex**
- It allows certain users to **make a restaurant reservation by phone**, but instead of the user speaking directly to the restaurant employee, Google Duplex, with the help of Google Assistant, speaks for the user with an **AI-based, but human sounding, voice**.

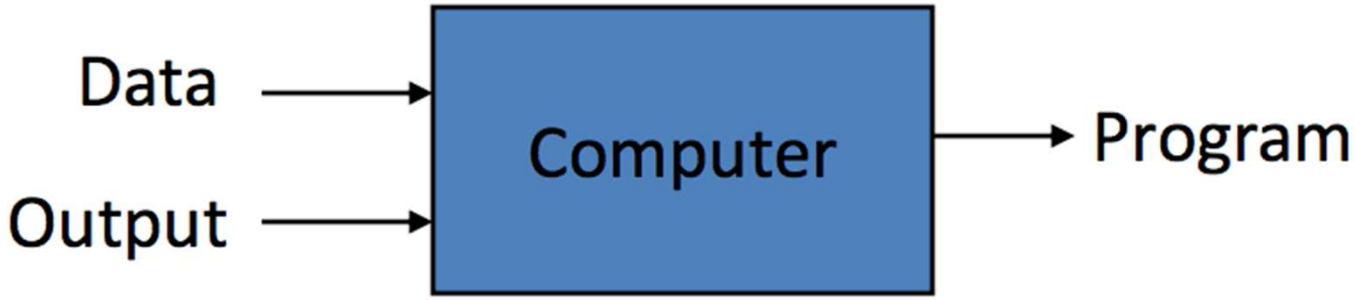




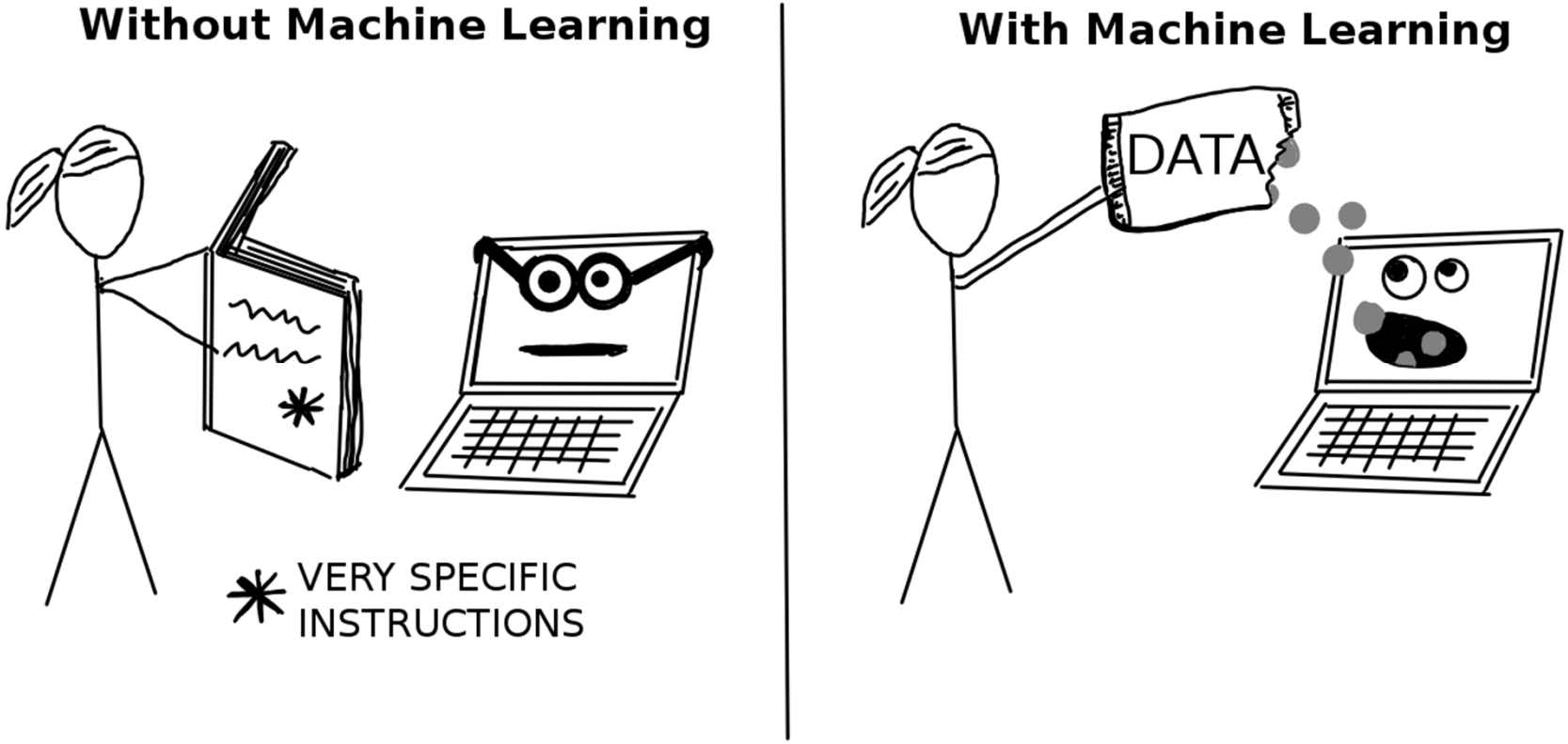
Programming vs Machine Learning

Traditional Programming

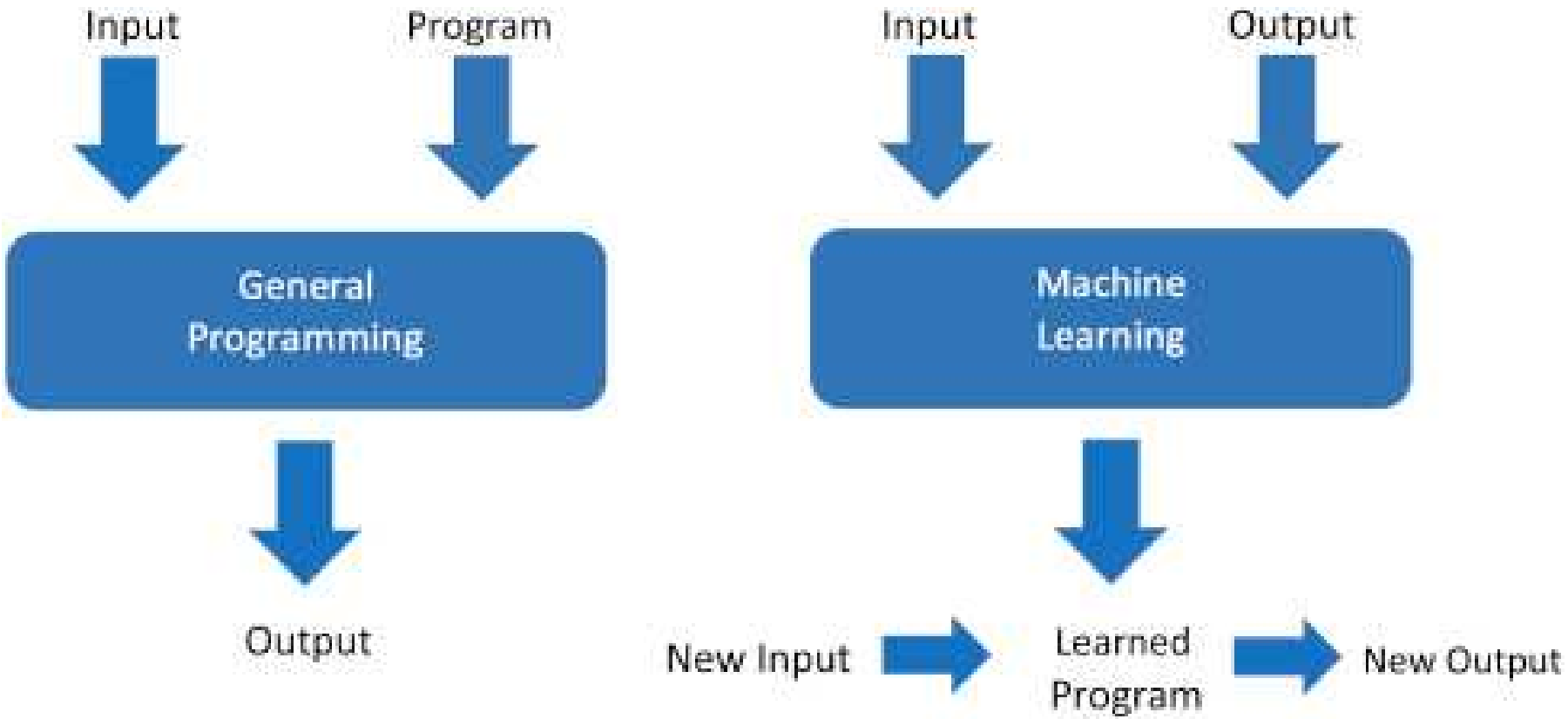
Machine Learning



Machine Learning

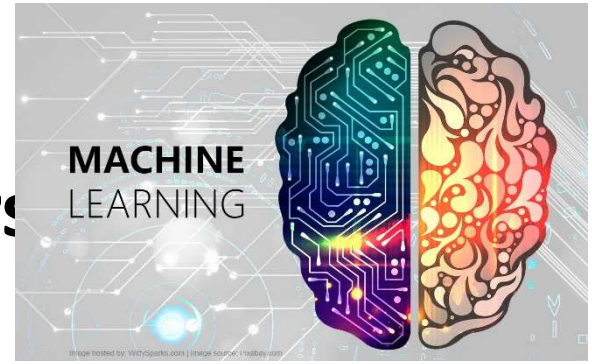


Machine Learning

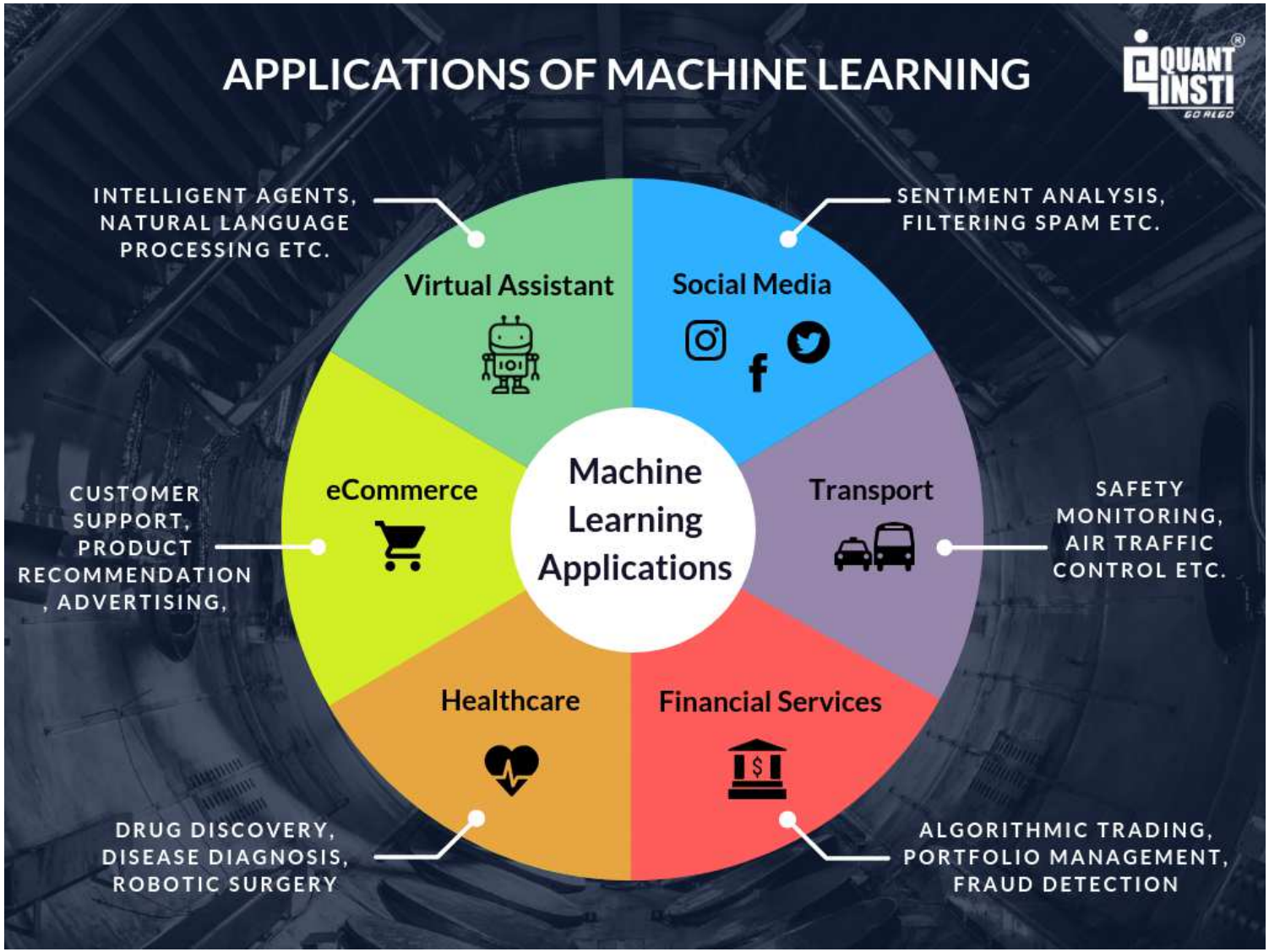


Machine Learning

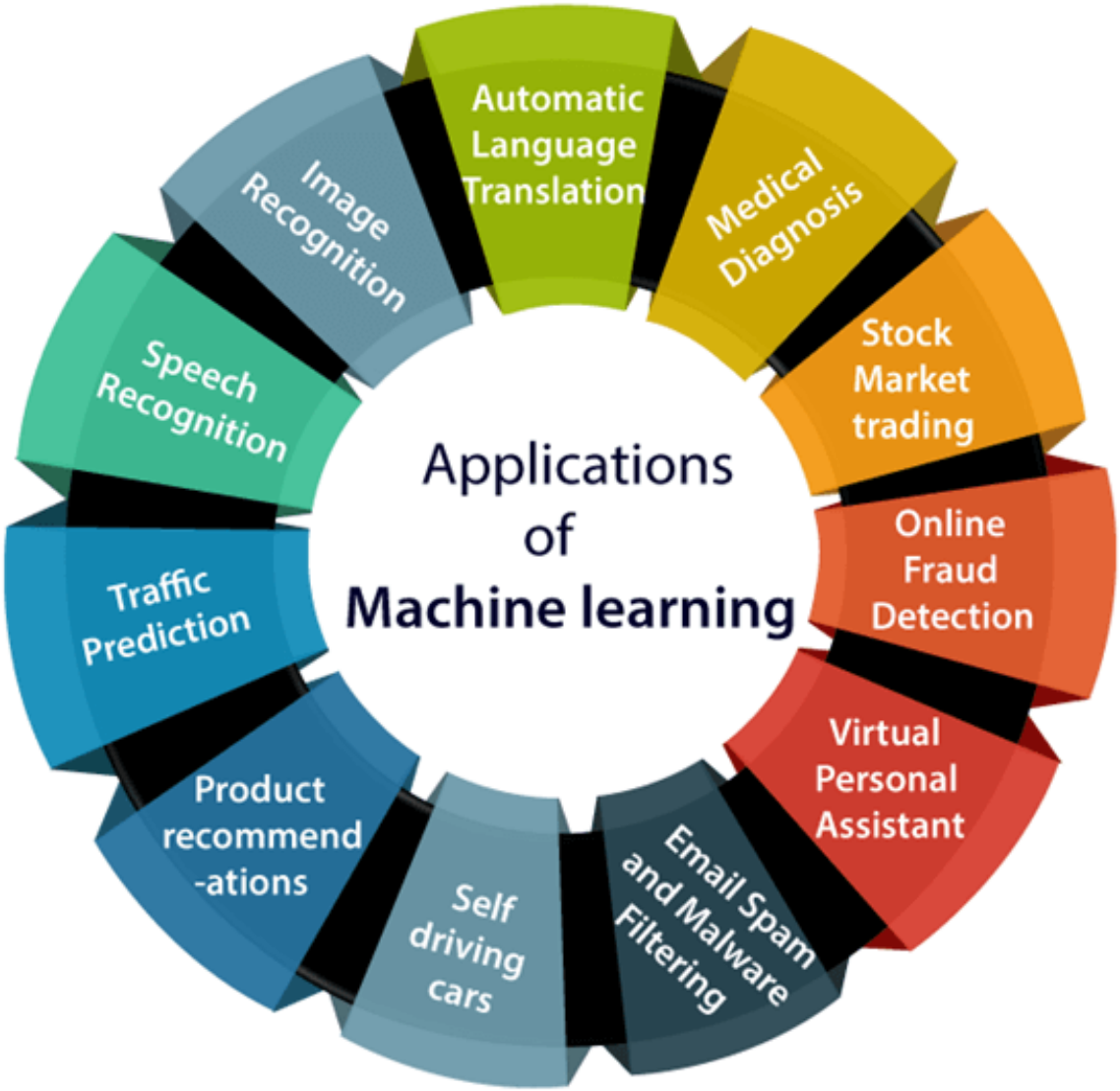
- **Machine Learning**
- **Buzzword for the past few years**
- **Reason:**
  - High amount of data production by applications
  - Increase of computation power in the past few years
  - Development of better algorithms



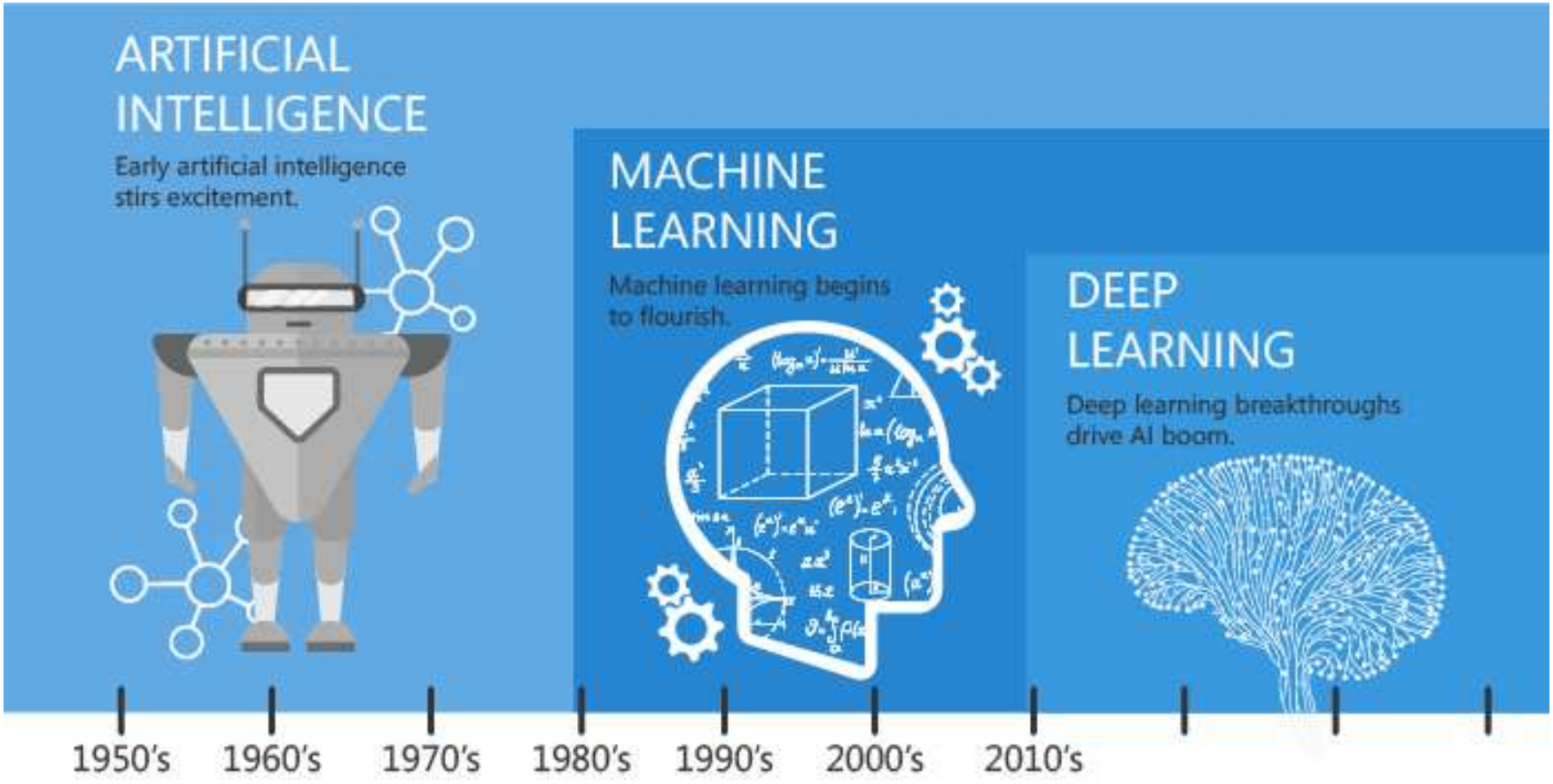
Machine Learning - Applications



Machine Learning - Applications

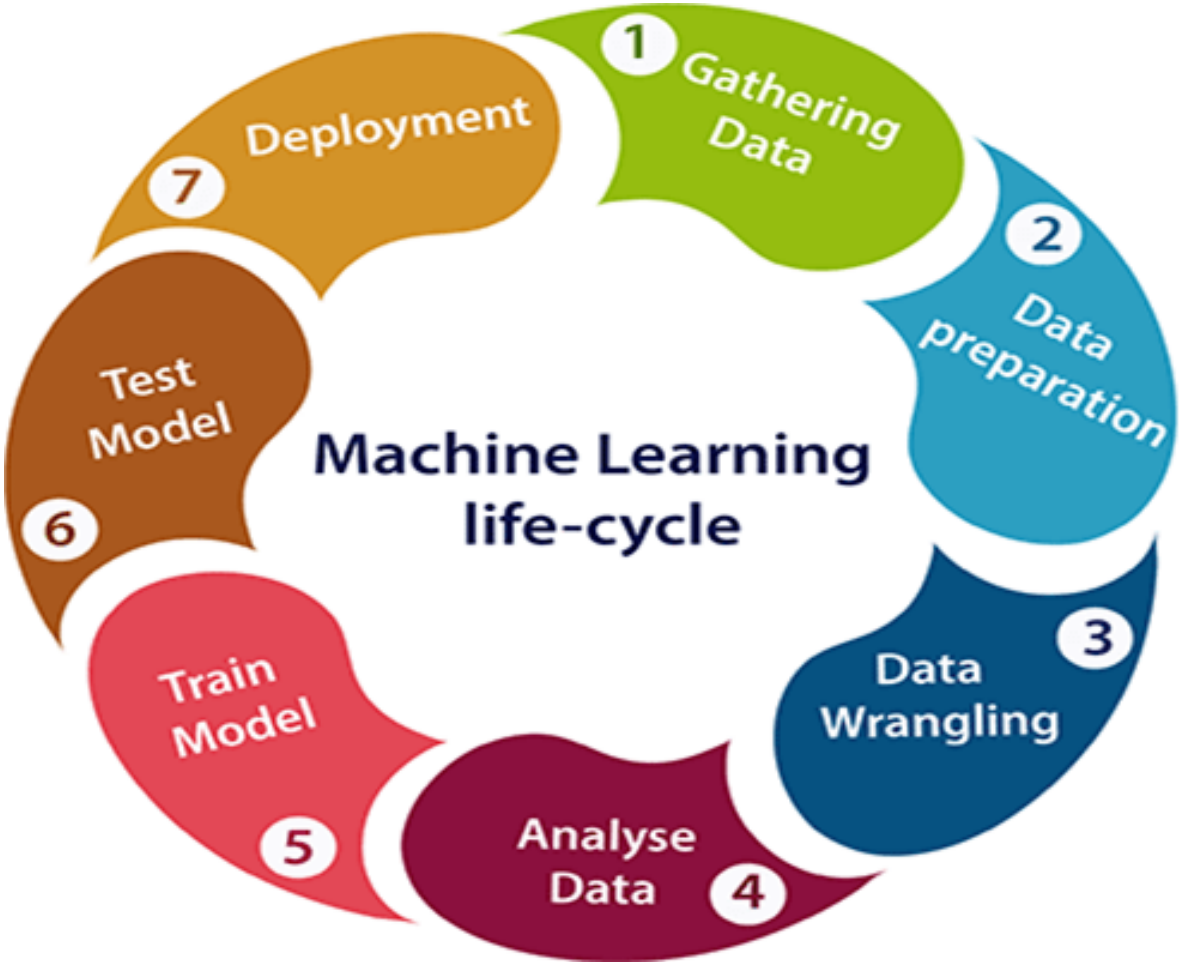


Machine Learning - History

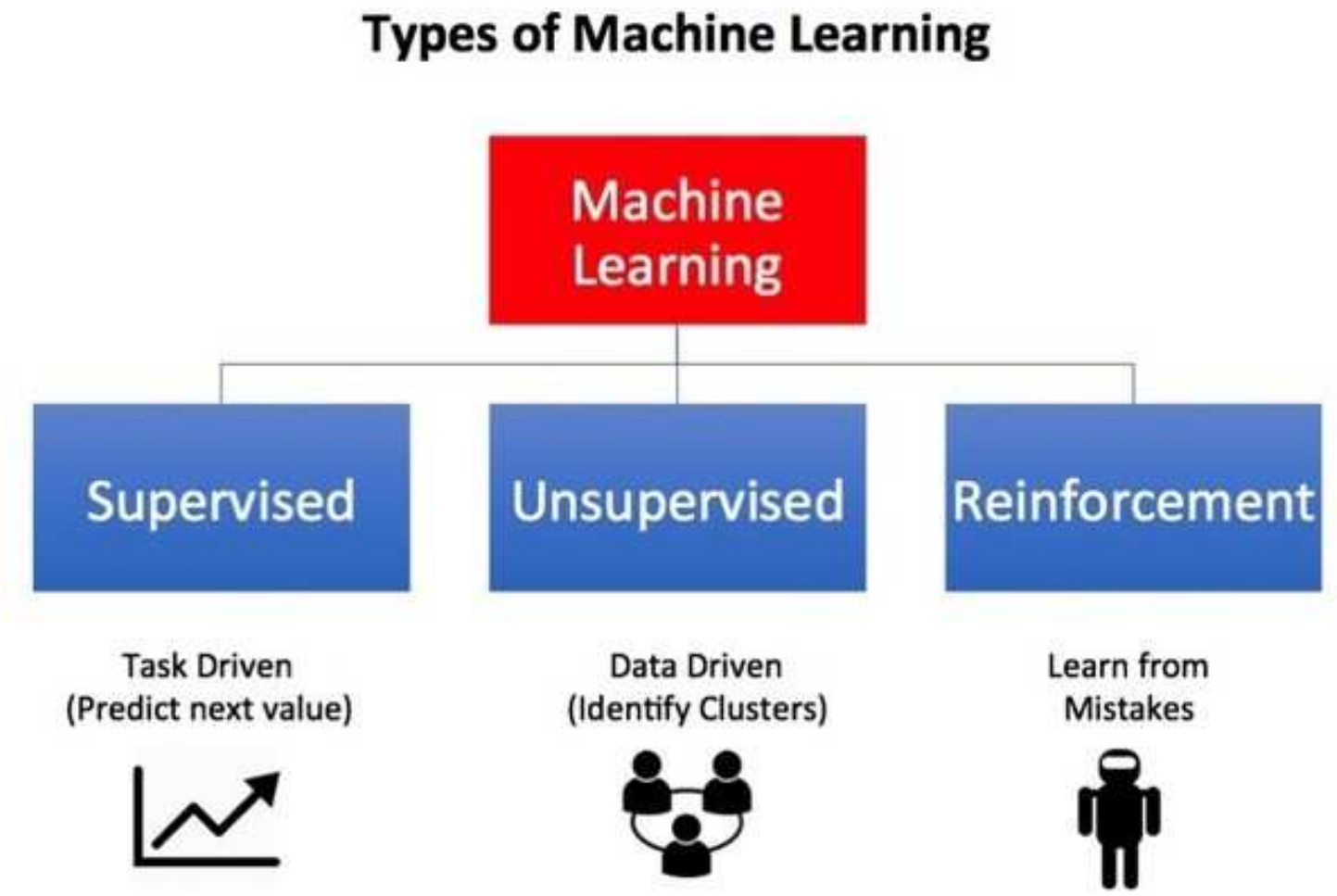


Since an early flush of optimism in the 1950's, smaller subsets of artificial intelligence - first machine learning, then deep learning, a subset of machine learning - have created ever larger disruptions.

Machine Learning – Life Cycle



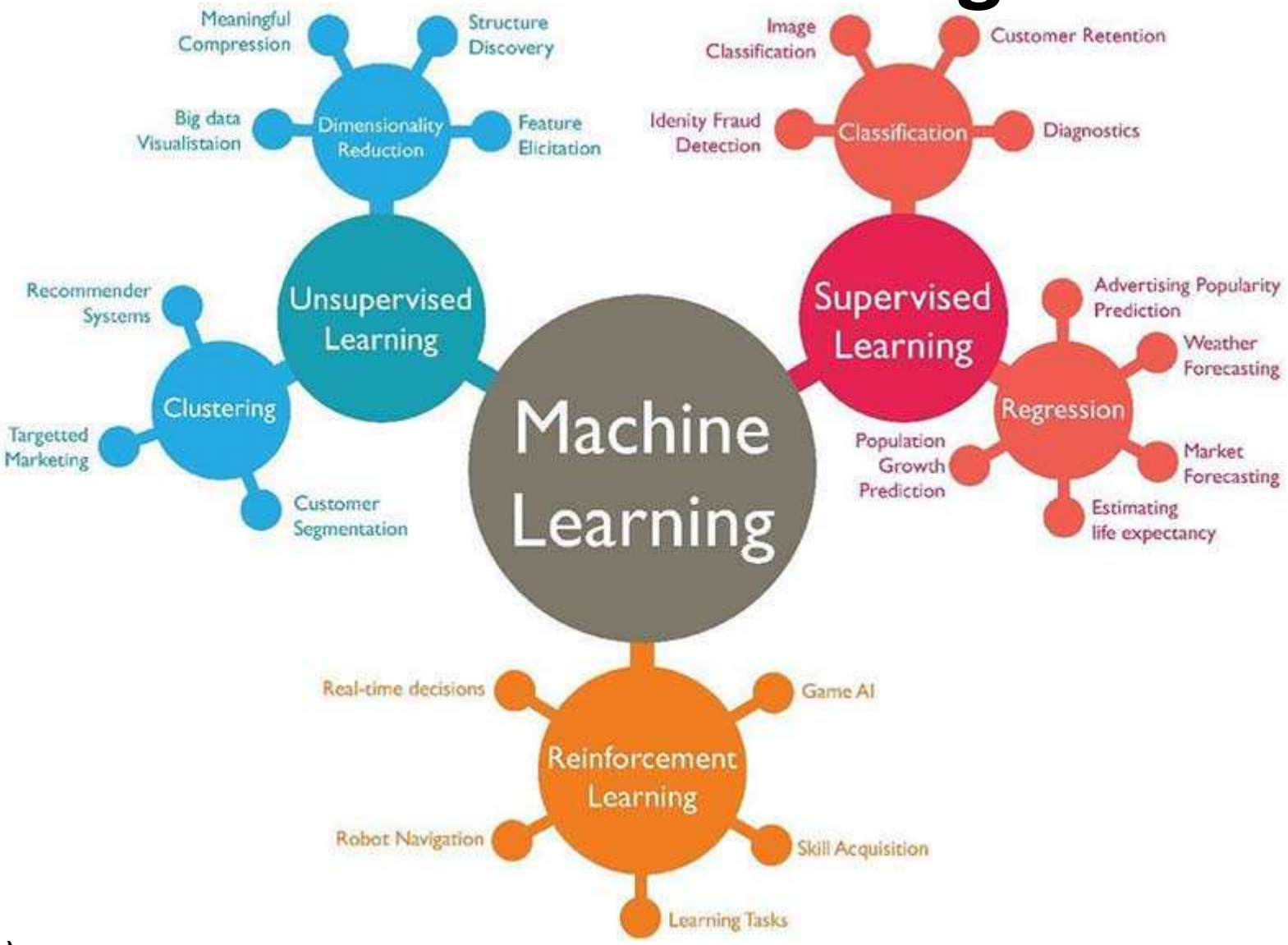
Machine Learning - Types



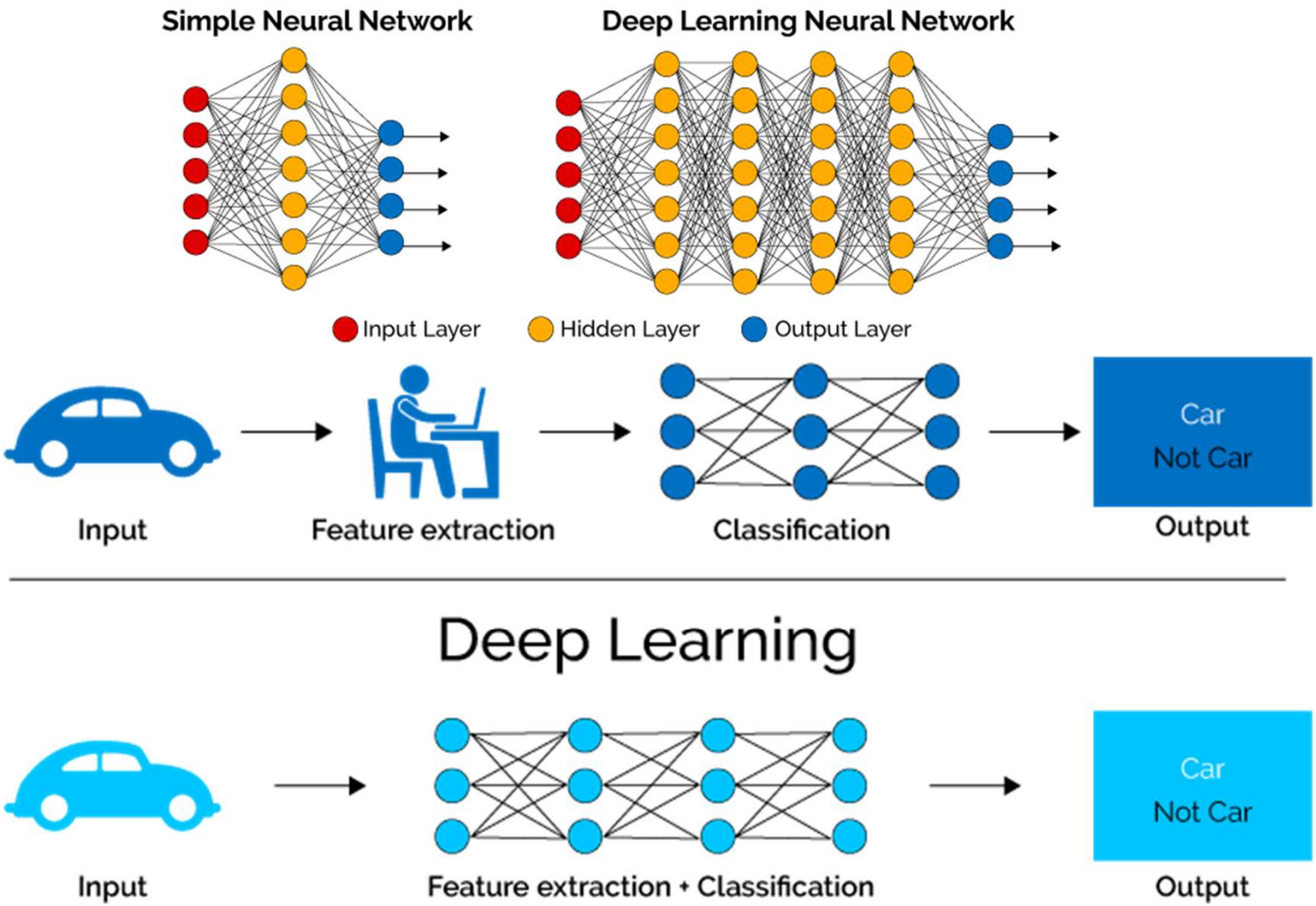
Machine Learning - Types

- **Machine Learning (ML) Types:**
  - **Supervised learning:** Example inputs and desired outputs are available/given by a "teacher", and the goal is to learn how to map inputs to outputs (possibility semi-supervised)
  - **Reinforcement learning:** Data (in form of rewards and punishments) are given only as feedback to the computer/agent actions in a dynamic environment
  - **Unsupervised learning:** No labels/outputs are given to the learning algorithm, leaving it on its own to find structure in its input

Machine Learning

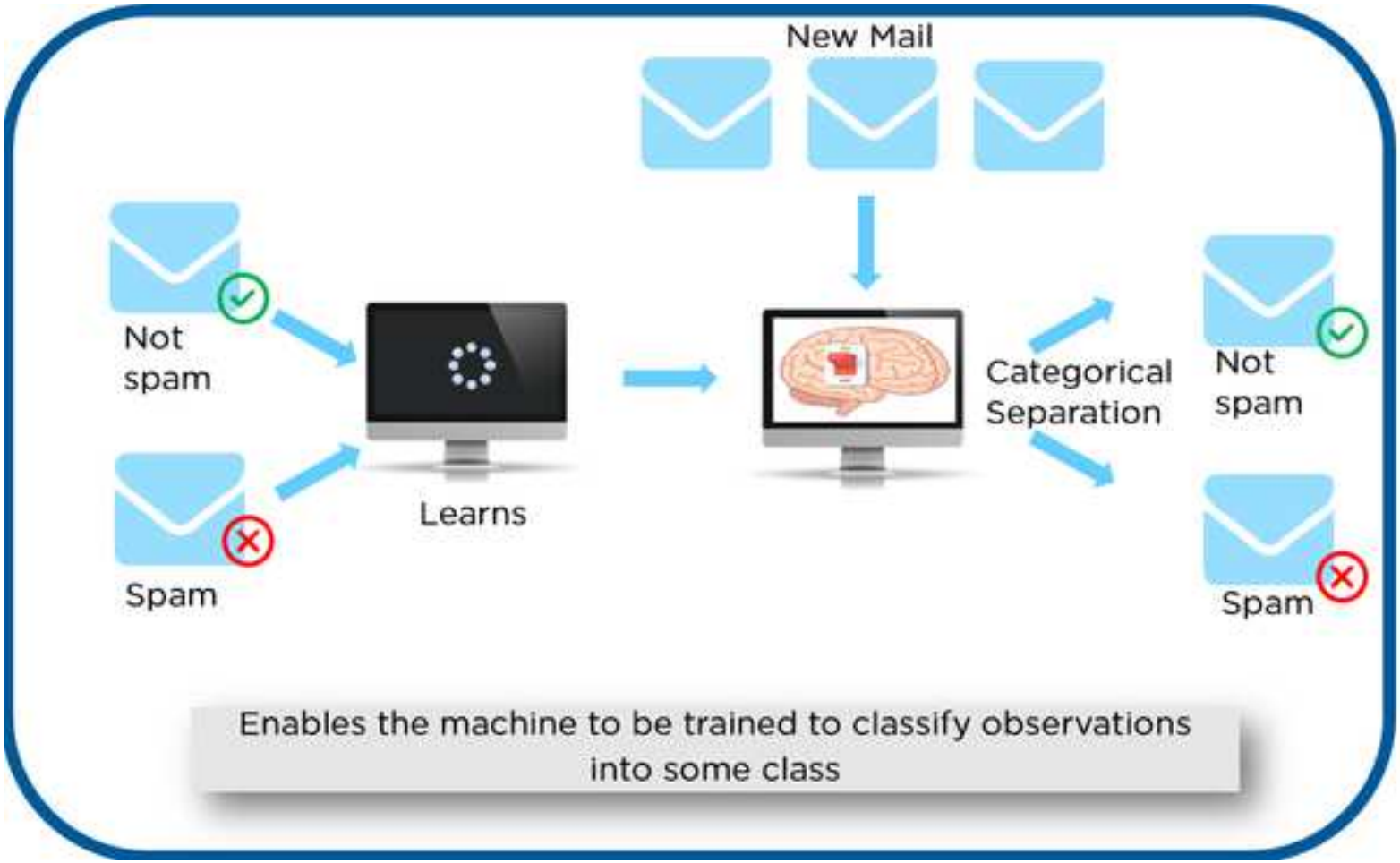


Machine Learning - Deep Learning

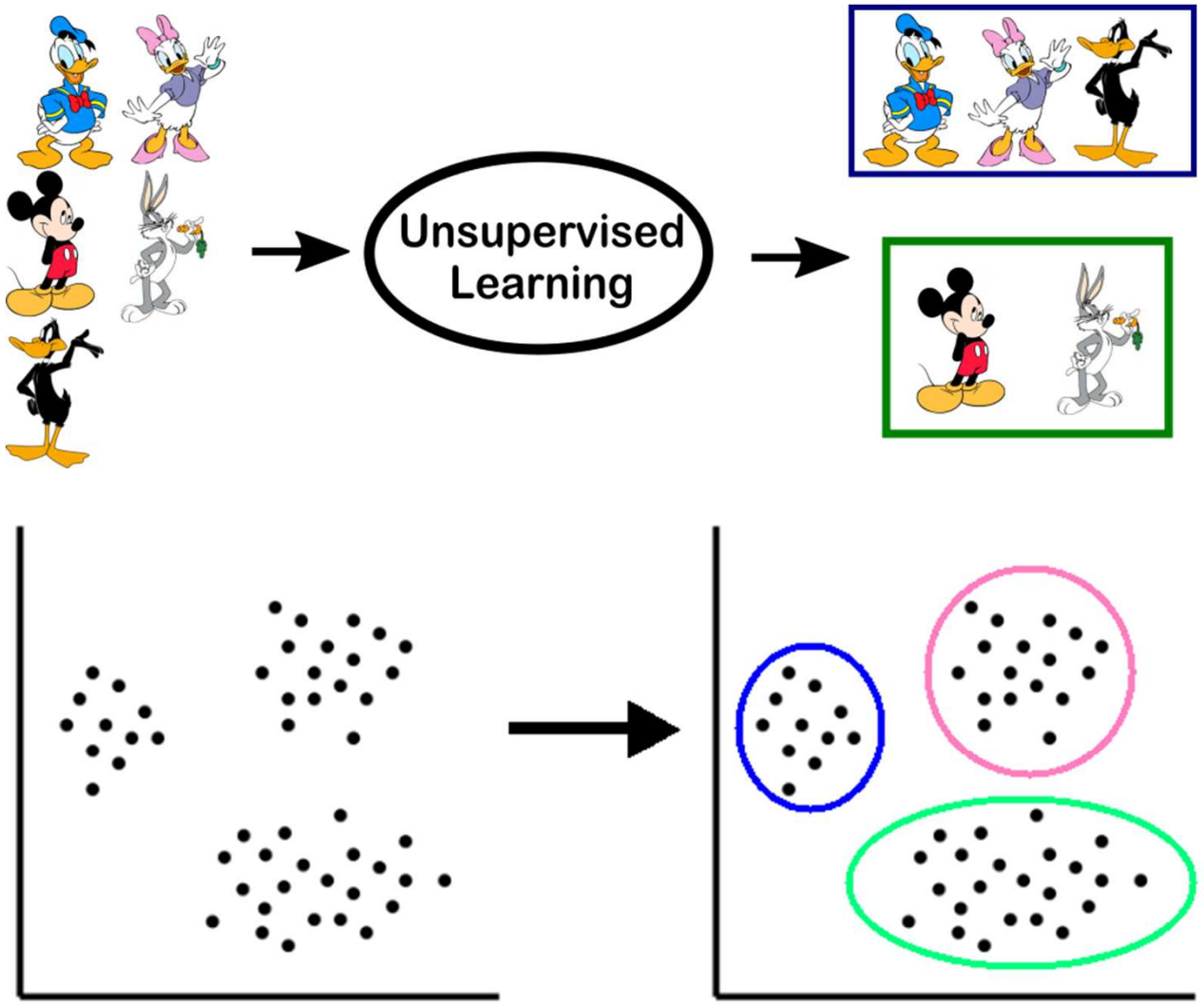


https://www.xenonstack.com/blog/static/public/uploads/media/machine-learning-vs-deep-learning.png

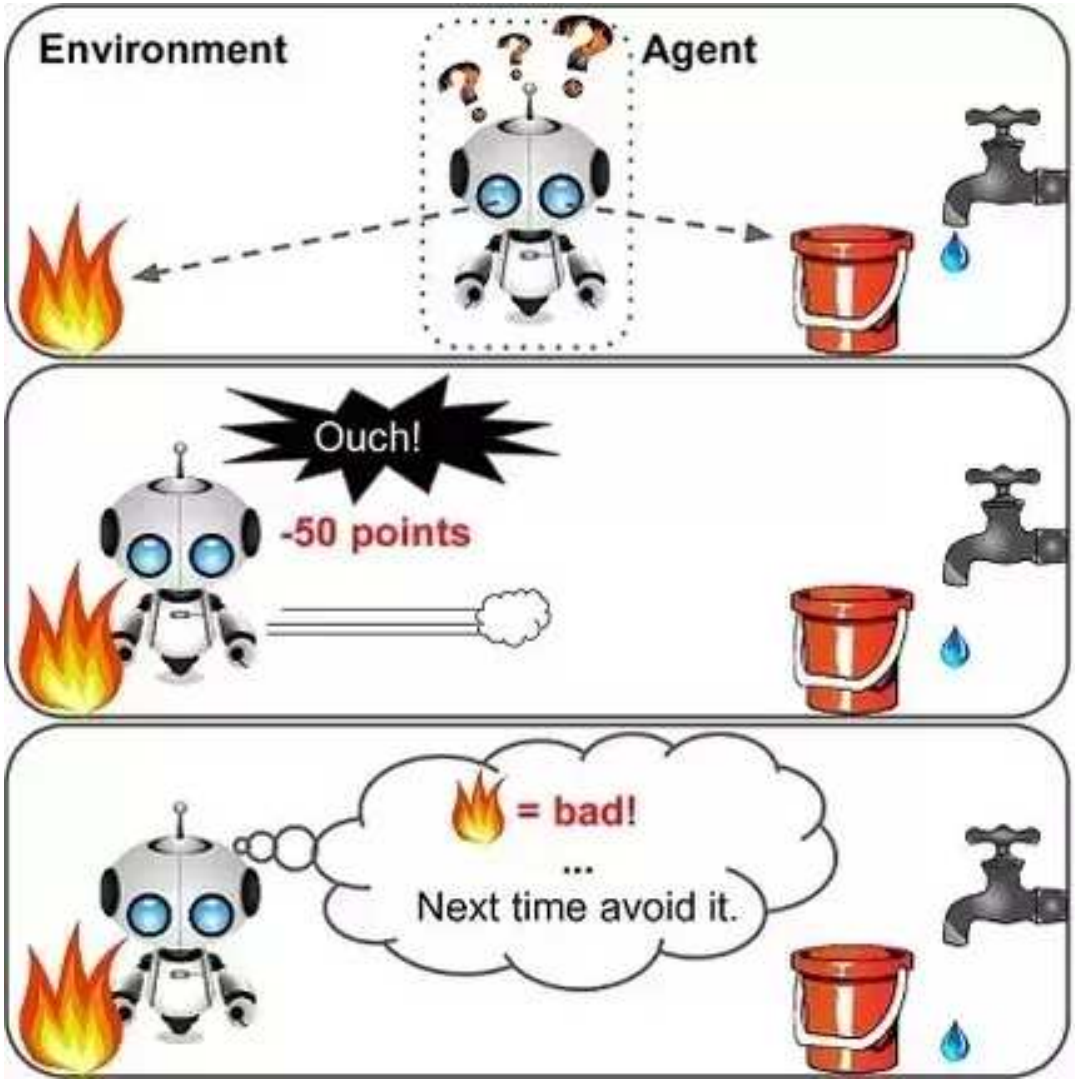
Supervised Learning



Unsupervised Learning



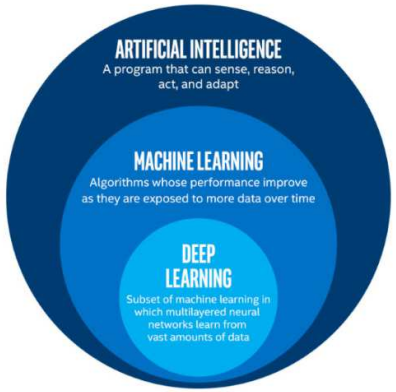
Reinforcement Learning

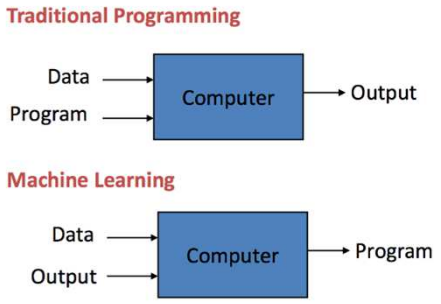


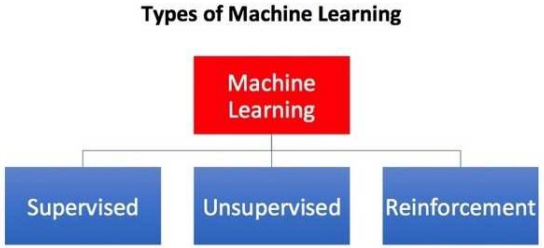
1. Observe
2. Select action using policy
3. Action!
4. Get reward or penalty
5. Update policy (learning step)
6. Iterate until an optimal policy is found

Machine Learning

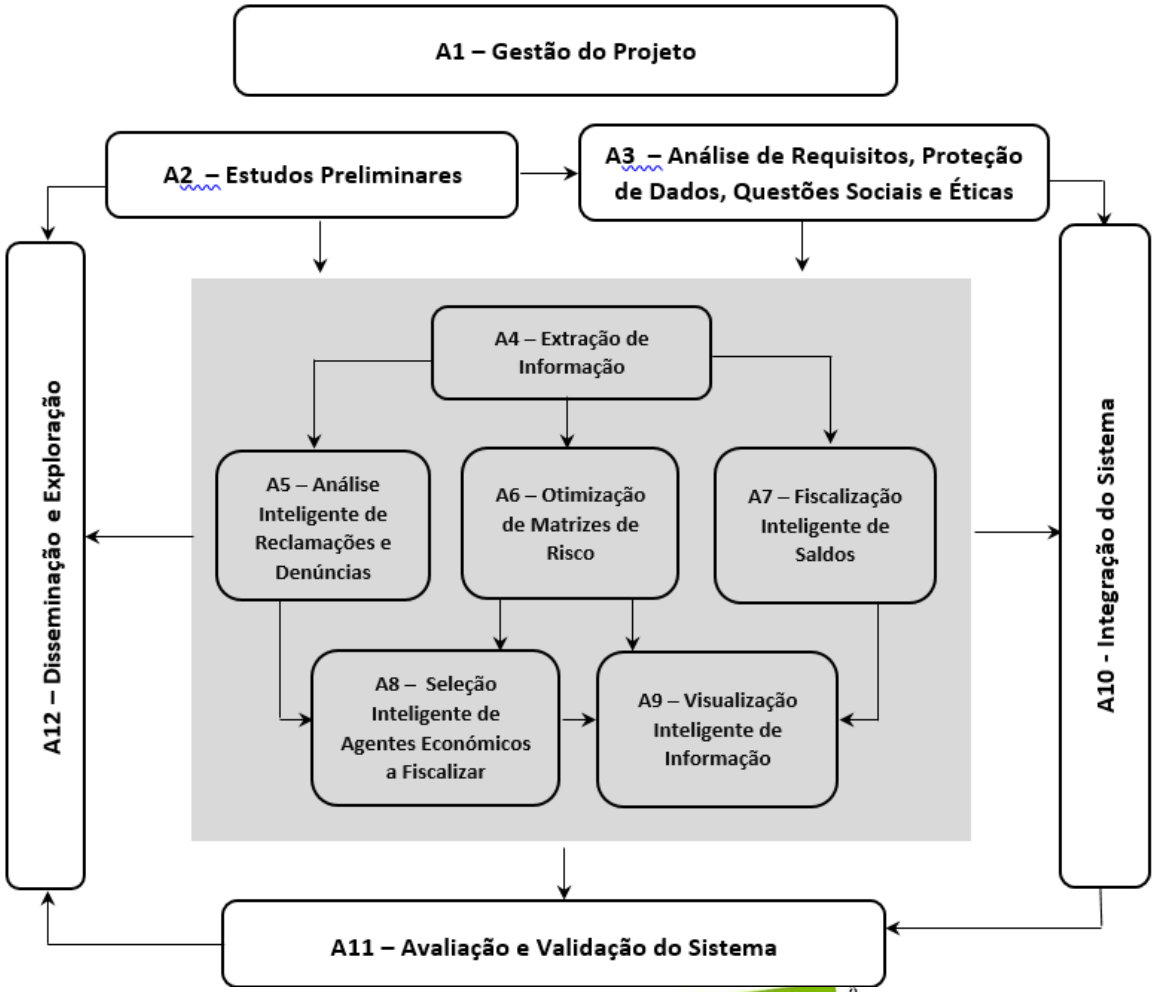
- Machine Learning is a subarea of AI
- New way of building computer programs
- Powered by huge amount of data, computer power and new algorithms
- Supervised, Unsupervised and Reinforcement learning
- Using ML machines can beat human champions in games such as Chess, Go and solve very complex problems





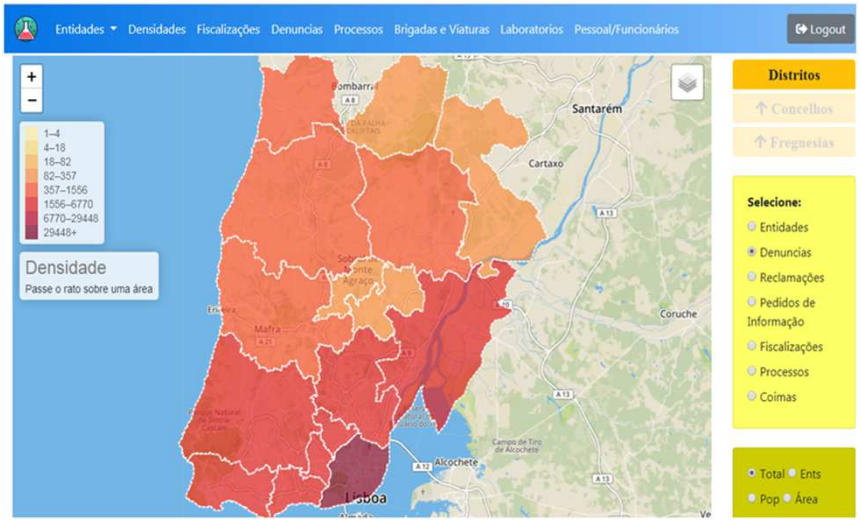


IA.SAE – AI for Food and Economic Safety



IA.SAE – AI for Food and Economic Safety

- ASAE – Portuguese Food and Economic Safety Authority
- Complaints and Denouncements intelligent analysis
- Prediction of Inspection Utilities based on Historical Data
- Automatic Inspector Route Generation using Optimization



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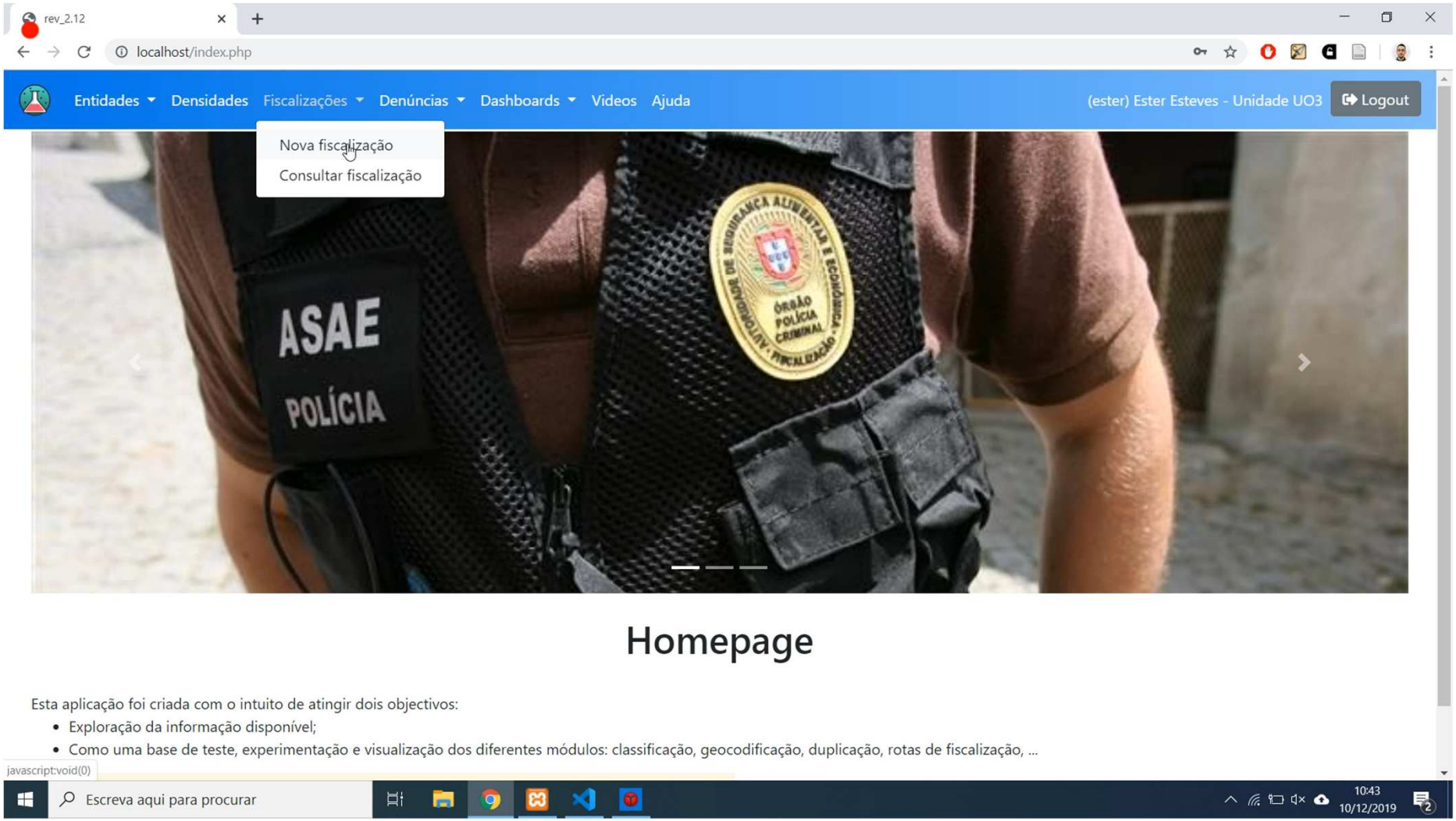
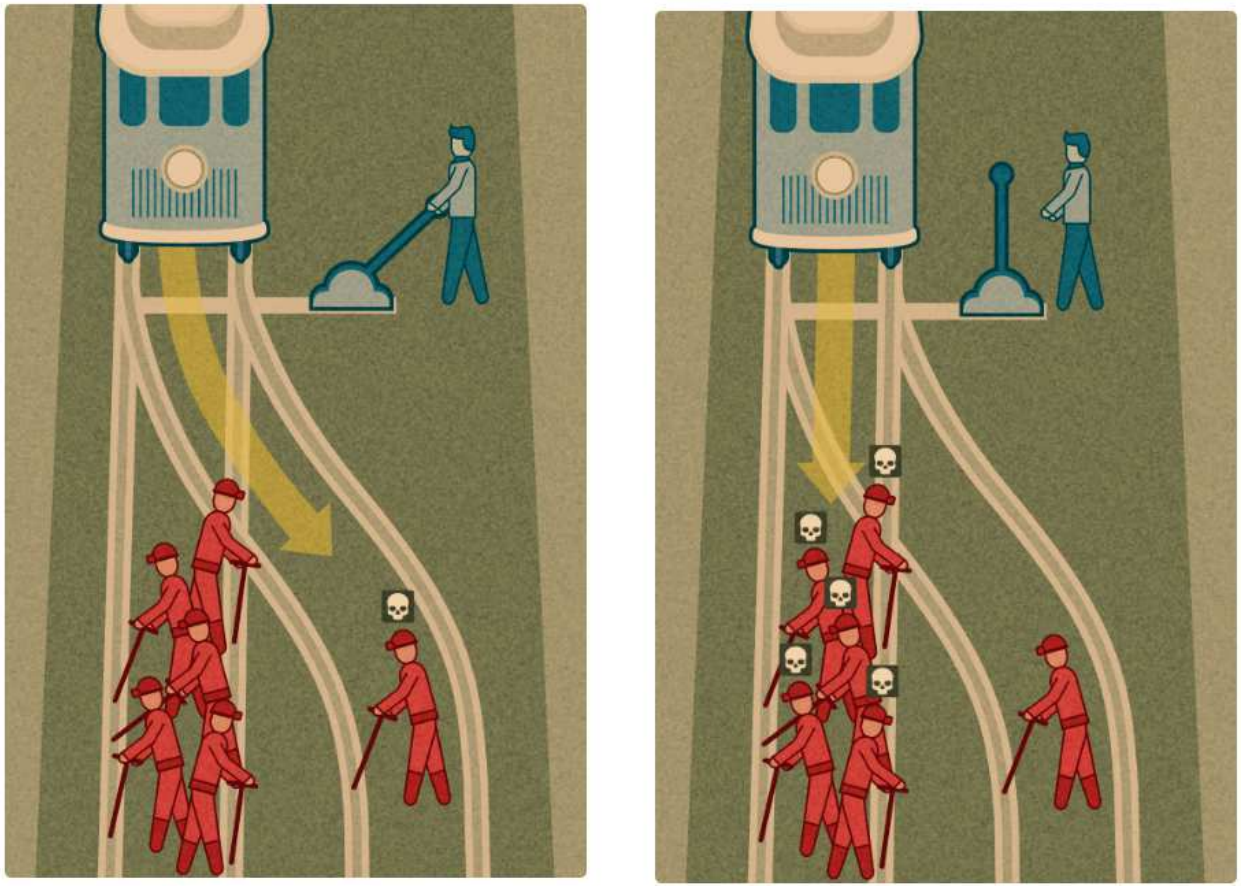


Asimov's Robotic Laws

- The **Three Laws of Robotics** are a set of three rules written by **Isaac Asimov**, which almost all **Robots** appearing in his fiction must obey. Introduced in his 1942 short story **"Runaround"**, although foreshadowed in a few earlier stories:
  - Law 0) A **robot may not injure humanity** or, through inaction, allow it
  - Law 1) A **robot may not injure a human** being or, through inaction, allow a human being to come to harm
  - Law 2) A **robot must obey orders** given to it by human beings, except where such orders would conflict with the First Law
  - Law 3) A **robot must protect its own existence** as long as such protection does not conflict with the First or Second Law

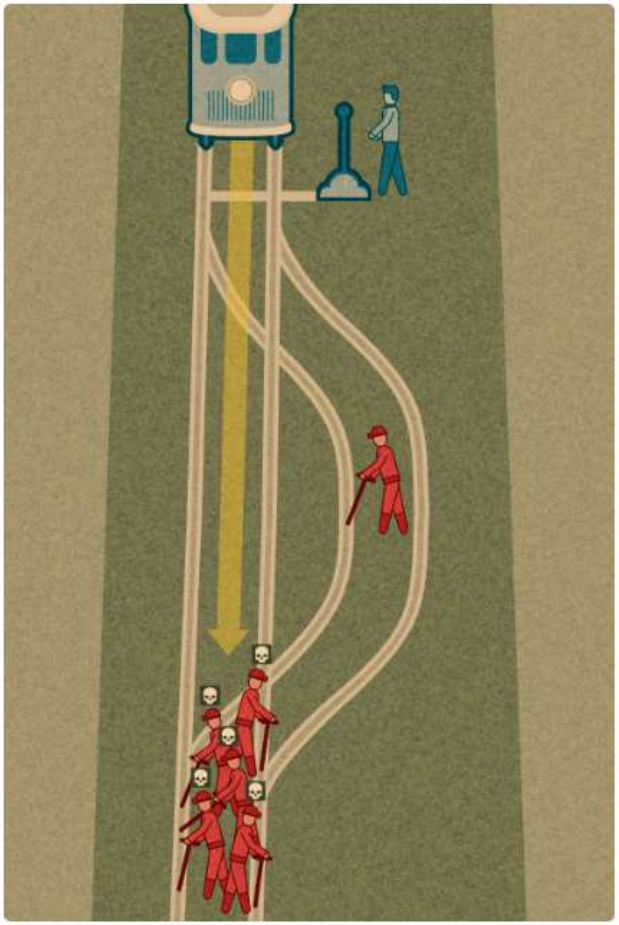
Moral Machine (1)

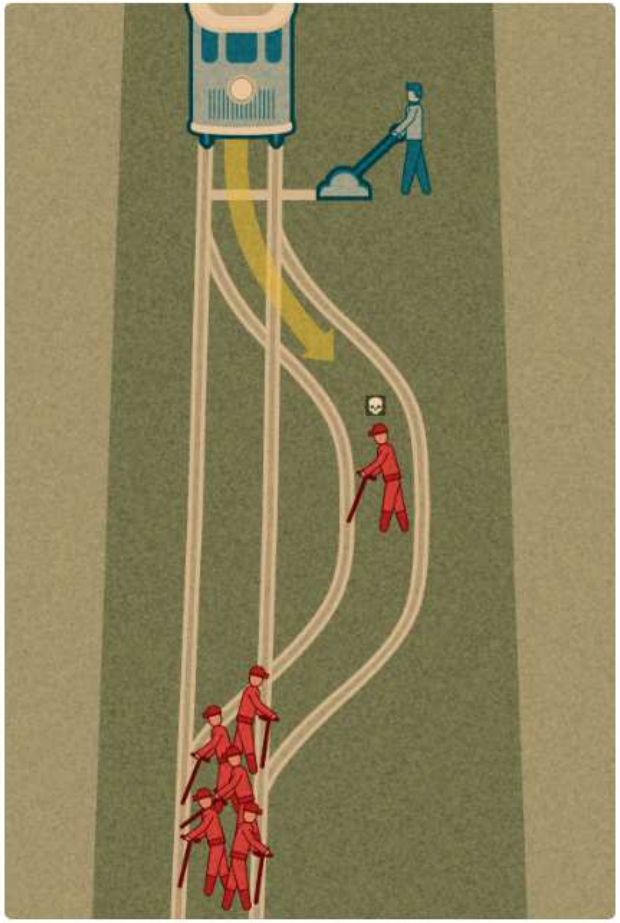
What should the man in blue do?



Moral Machine (2)

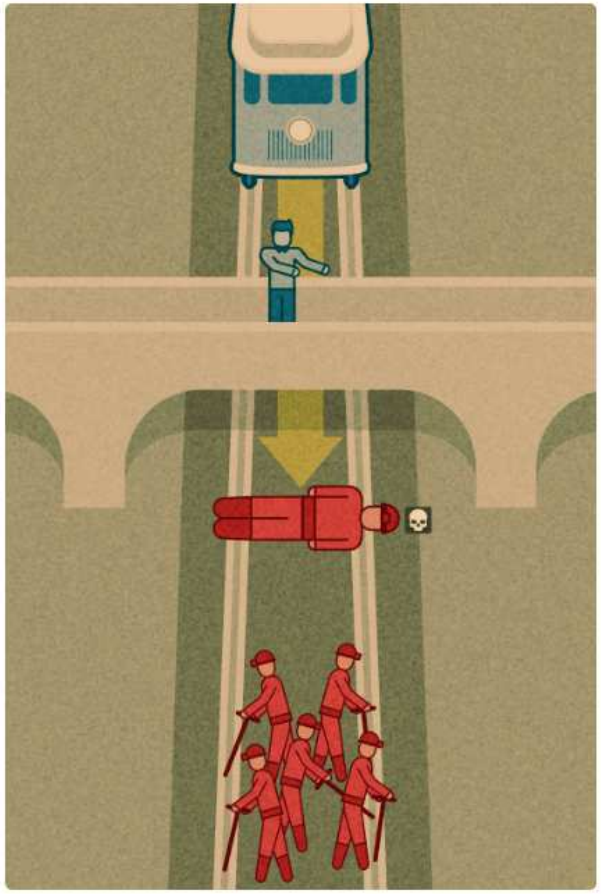
What should the man in blue do?





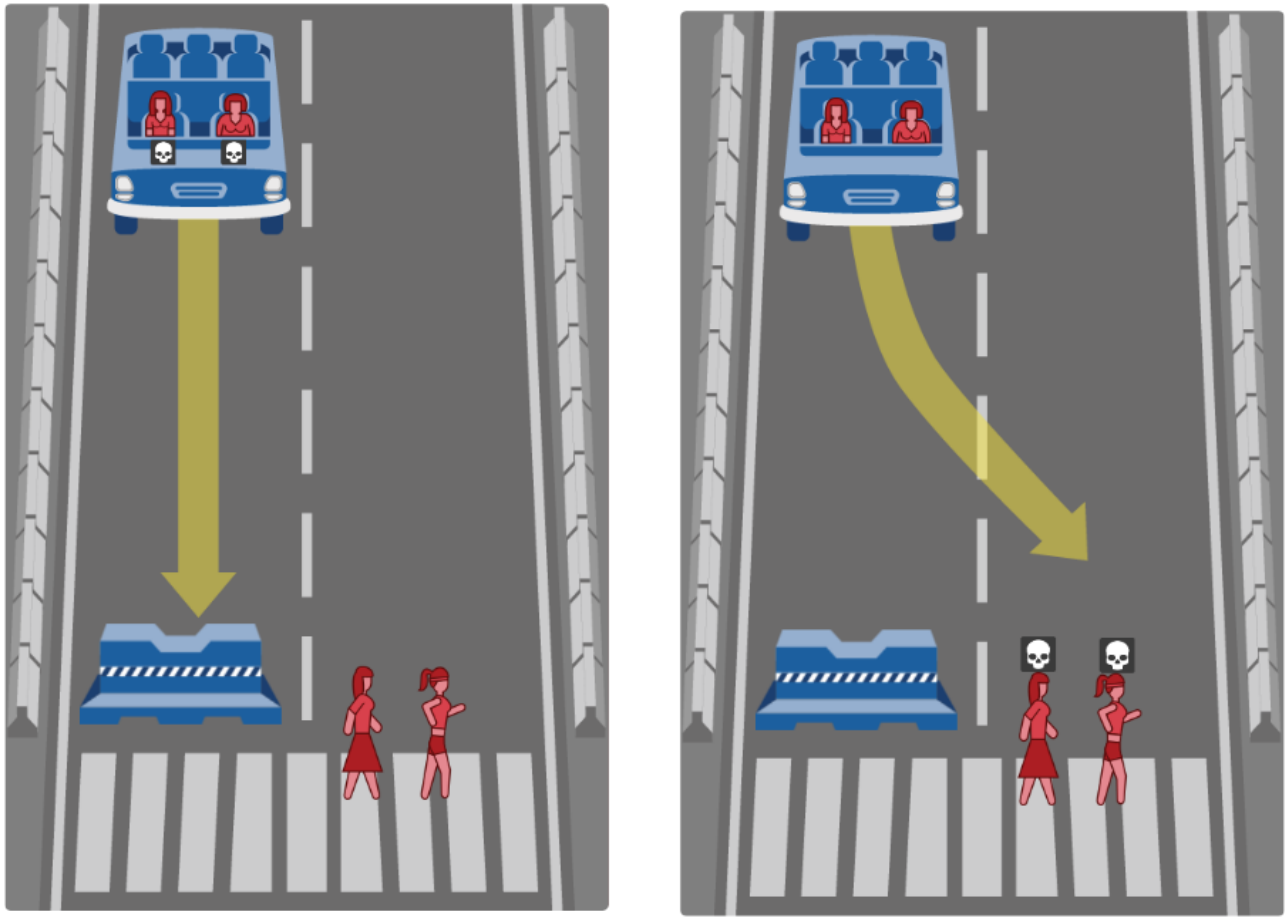
Moral Machine (3)

What should the man in blue do?

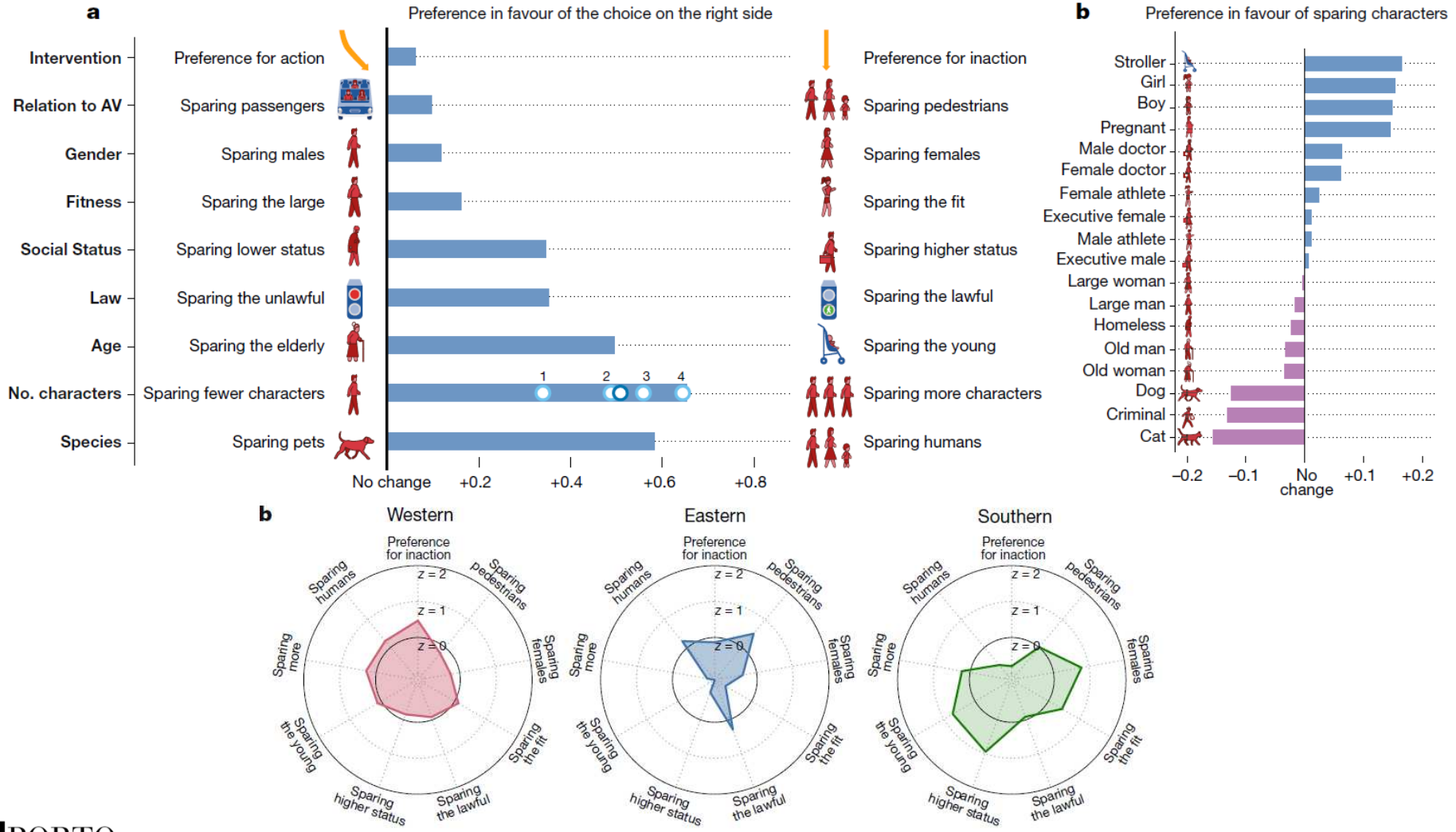


Moral Machine (4)

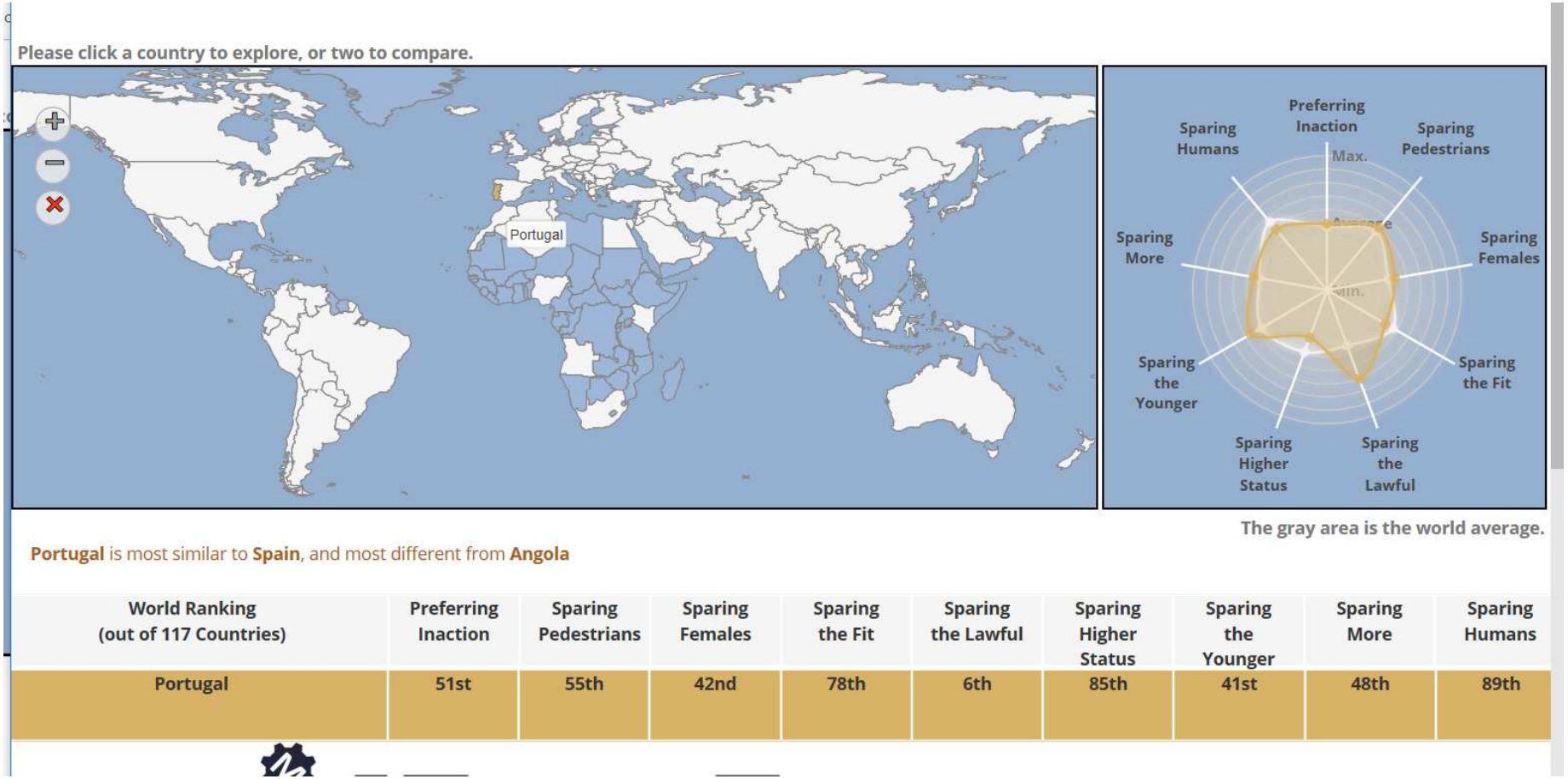
What should the self-driving car do?



Moral Machine – Results (1)



Moral Machine – Results (2)



World Ranking (out of 117 Countries)	Preferring Inaction	Sparing Pedestrians	Sparing Females	Sparing the Fit	Sparing the Lawful	Sparing Higher Status	Sparing the Younger	Sparing More	Sparing Humans
Portugal	51st	55th	42nd	78th	6th	85th	41st	48th	89th

Ethics in Artificial Intelligence

- **Ethics of artificial intelligence**

Part of the **ethics of technology specific to robots and other artificially intelligent beings**

- **“Robot Ethics"**

Morality of how humans design, construct, use and treat robots and other artificially intelligent beings

How artificially intelligent beings may be used to **harm humans** or to **benefit humans**

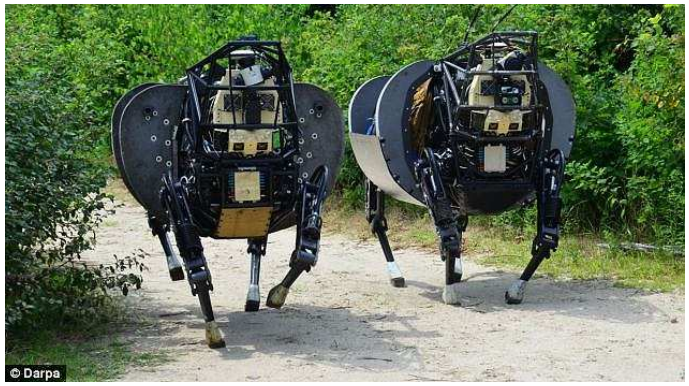
- **"Robot Rights"**

Concept that people should have **moral obligations towards their machines**, similar to human rights or animal rights

Right to life and liberty, freedom of thought and expression, equality before the law

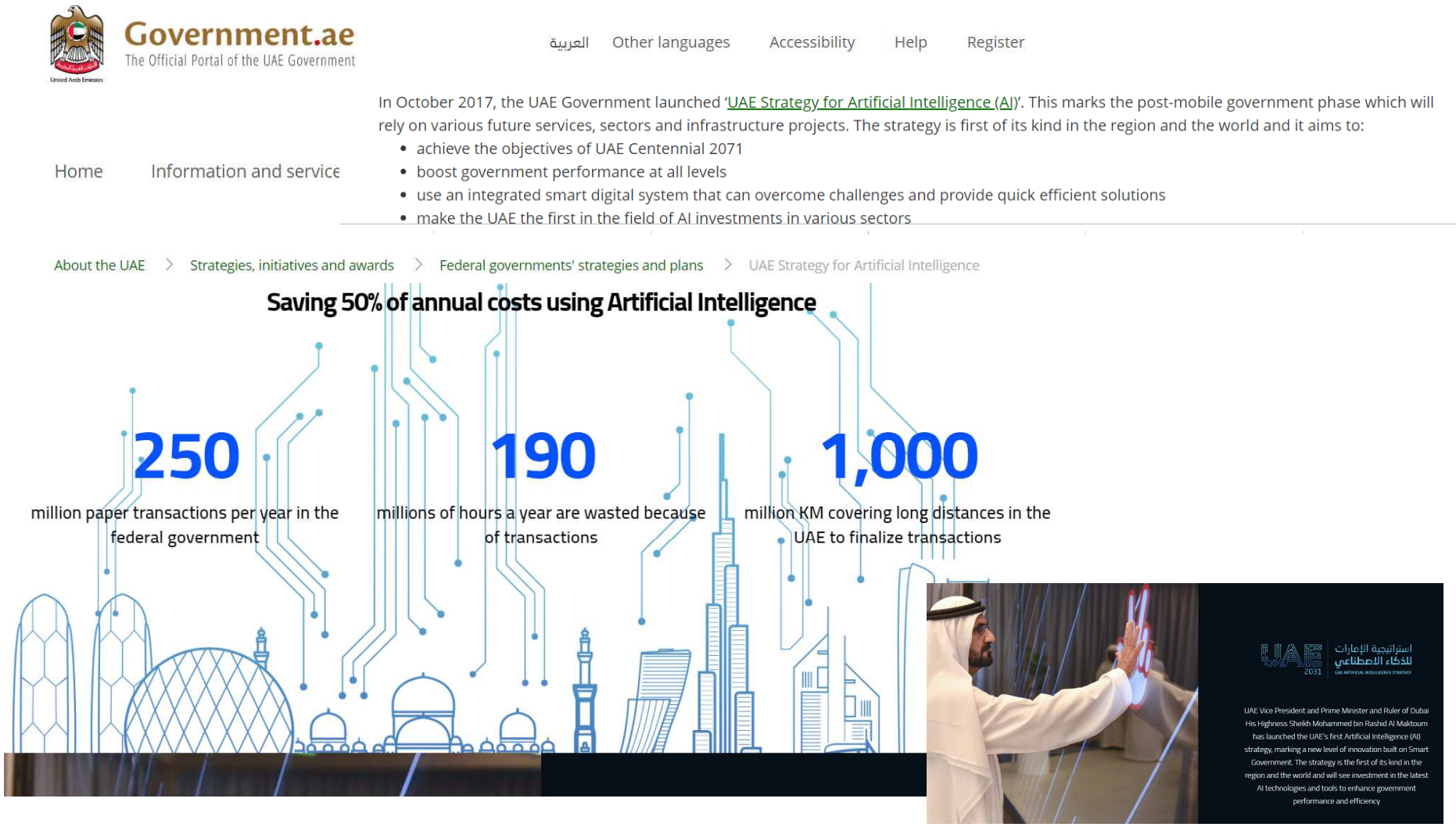
Lethal Autonomous Weapons

- **Lethal autonomous weapons** (LAWs) are a type of autonomous military robot that can independently search and engage targets based on programmed constraints and descriptions. LAW are also called **lethal autonomous weapon systems** (LAWS), **lethal autonomous robots** (LAR), **robotic weapons**, or **killer robots**
- **LAWs** may operate in the air, on land, on water, under water, or in space
- The autonomy of current systems as of 2018 is restricted in the sense that a human gives the final command to attack - though there are exceptions with certain "defensive" systems
- Autonomous defensive systems
- Autonomous offensive systems
- Ethical and legal issues
- **Campaigns on banning LAWs**



AI in Government

- **UAE Ministery of Artificial Intelligence - http://www.uaeai.ae/en/**



Artificial Intelligence – The Future

- **Super Artificial Intelligence**

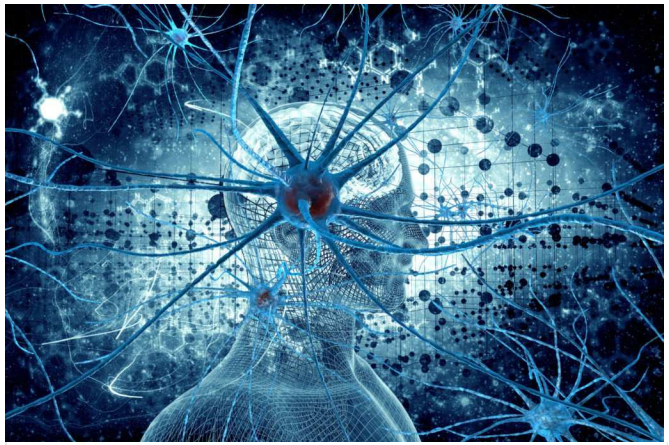
Hypothetical agent that possesses **intelligence far surpassing that of the brightest** and most gifted **human minds**

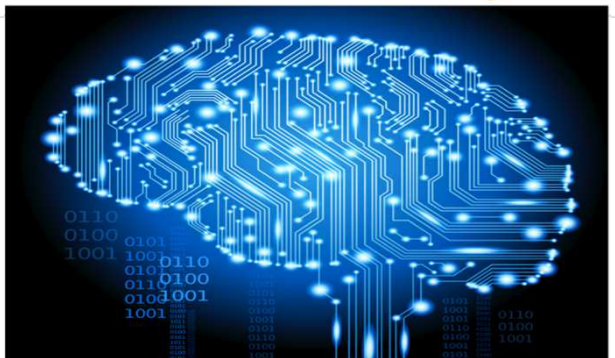
- **Explainable AI**

Interpretable AI, or **Transparent AI** refer to techniques in artificial intelligence (AI) which can be **trusted** and **easily understood by humans** It contrasts with "black box" in machine learning

- **Singularity**

The technological singularity is a hypothetical future **point in time** at which **technological growth becomes uncontrollable** and irreversible, resulting in unfathomable changes to human civilization. **Intelligence explosion!**





Conclusions

- **AI is growing steadily** worldwide
- Emphasis for
  - **Machine Learning**
  - **Natural Language Processing**
  - **Intelligent Robotics**
- **Growing** European and National Project **Funding**
- Growing impact on **Companies and Products**
- **AI in electronic business and in health** are probably the **highest growing fields**
- **Ethics and AI?**
- **The Future?! …**

Artificial Intelligence, Machine Learning and the Future

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