

# IART - Artificial Intelligence

**Luís Paulo Reis**

[lpreis@fe.up.pt](mailto:lpreis@fe.up.pt)

Director of LIACC – Artificial Intelligence and Computer Science Lab., UPorto  
Associate Professor at Faculty of Engineering of the University of Porto  
President of APPIA – Portuguese Association for Artificial Intelligence



# Artificial Intelligence (AI)

- **Intelligence**

- “Capacity to **solve new problems** through the use of knowledge”



- **Artificial Intelligence**

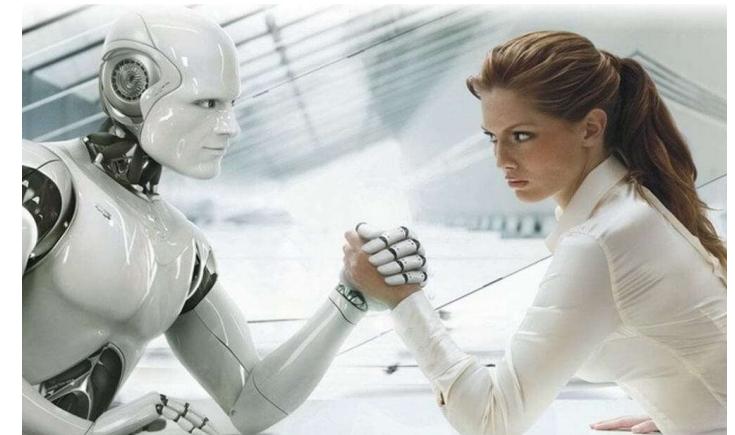
- “Science concerned with building **intelligent machines**, that is, machines that perform tasks that when performed by humans require intelligence”



# Weak and Strong AI

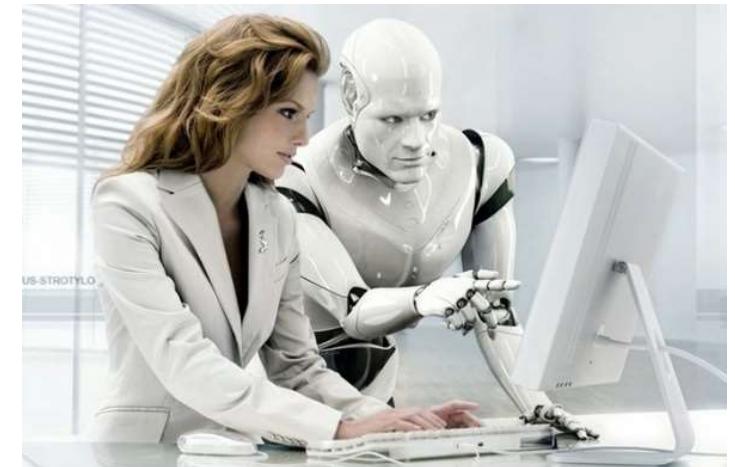
- **Weak Artificial Intelligence**

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



- **Strong Artificial Intelligence**

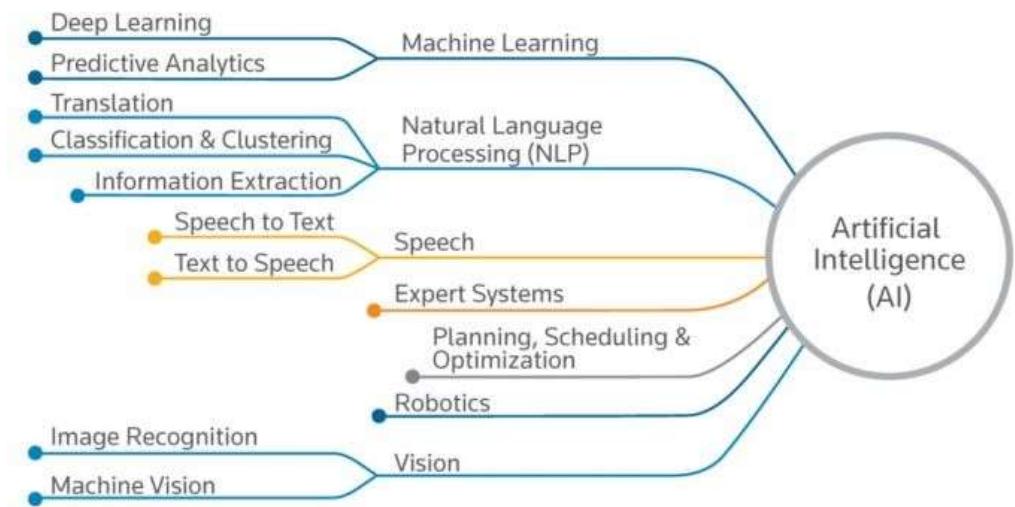
Strong AI or Artificial General Intelligence (AGI) is the intelligence of a machine that could successfully perform **any intellectual task** that a human being can! Science fiction ?



# Areas of Artificial Intelligence

## Some AI Areas:

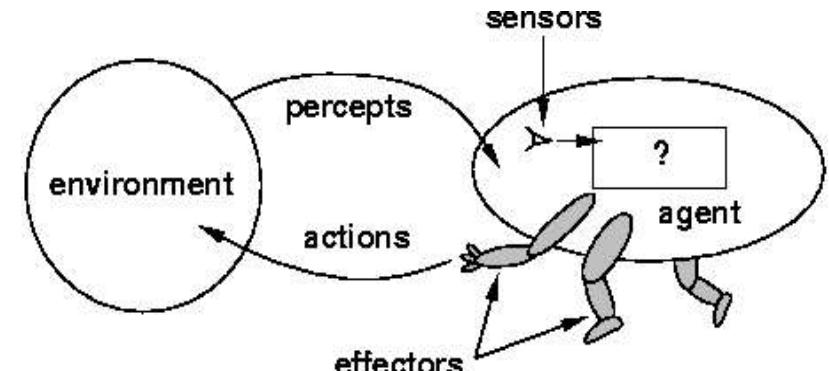
- **Knowledge Representation and Reasoning**
- **Problem Solving**
- **Planning and Scheduling**
- **Machine Vision**
- **Natural Language Processing**
- **Machine Learning**
- **Intelligent Robotics**



# AI - Autonomous Agents and Multi-Agent Systems

## Agent:

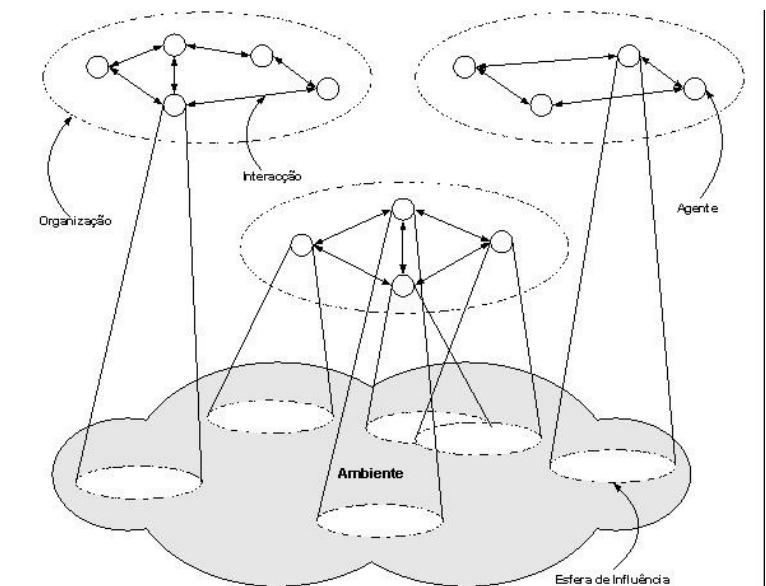
“Computational System, situated in a given **environment**, that has the ability to **perceive** that environment using **sensors** and **act**, in an **autonomous way**, in that environment using its **actuators** to fulfill a given **function**.”



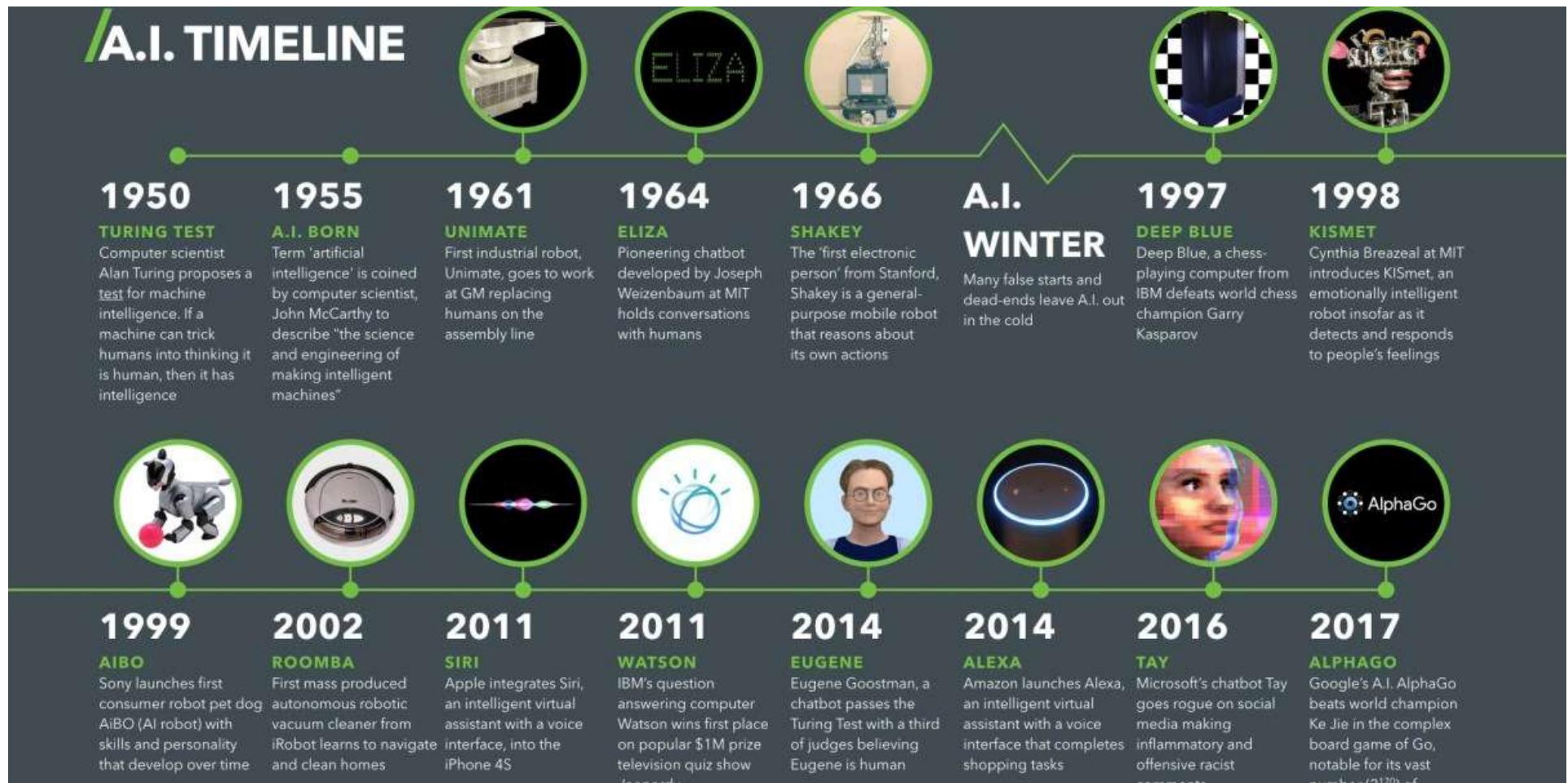
Russel and Norvig, "AI: A Modern Approach", 1995

## Multi-Agent System:

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



# AI Timeline



[Paul Marsden, 2017]

# Some Recent AI Successes



**Watson defeats Jeopardy champions (2011)**



**DeepMind achieves human-level performance on many Atari games (2015)**



**CMU's Libratus defeats top human poker players (2017)**



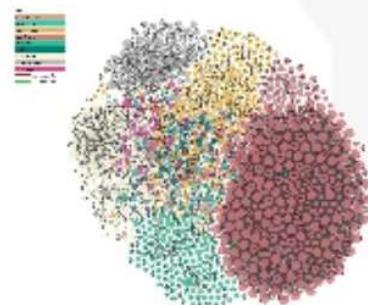
**AlphaGo defeats Go champion (2016)**

# Artificial Intelligence Today

Hardware



Data



Software



ML frameworks



PyTorch

TensorFlow

scikit  
learn

torch

theano

Keras

APACHE  
Spark™ ML

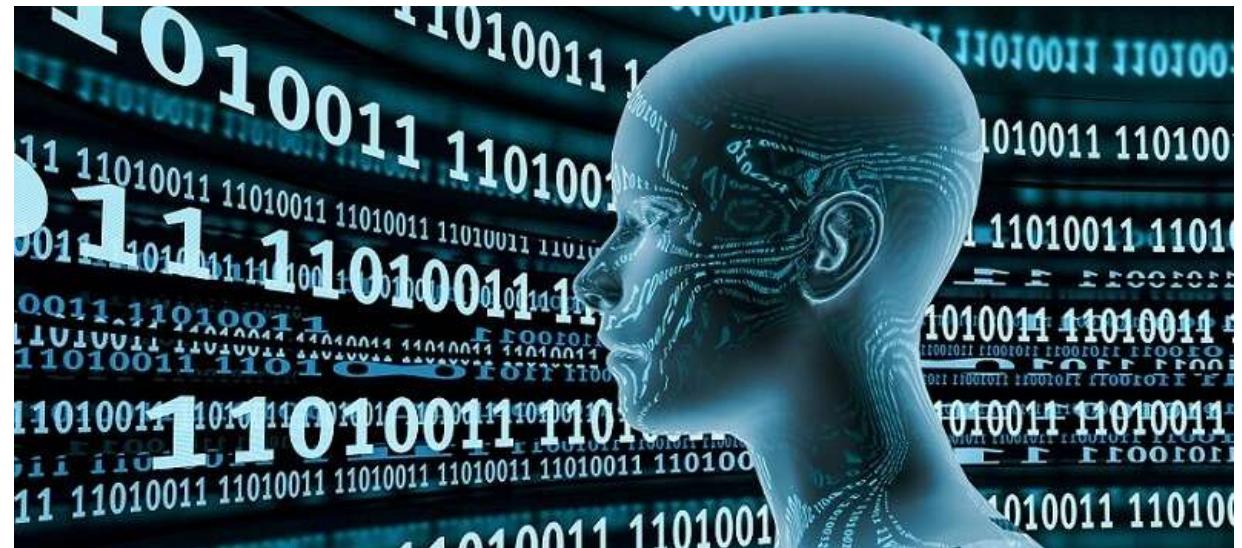
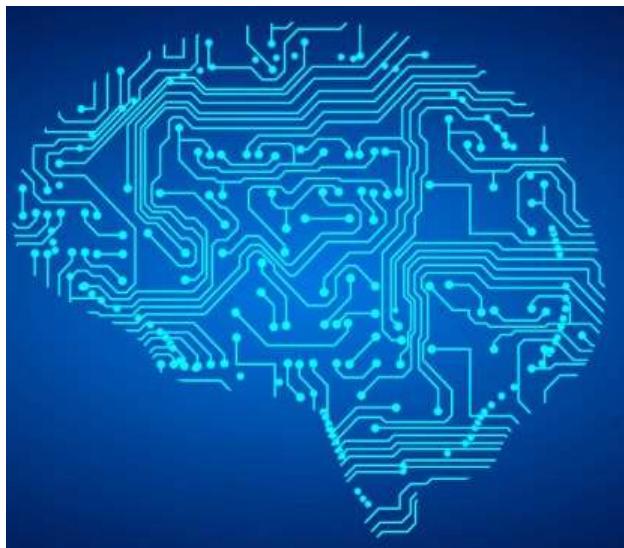
HUGGING FACE

# Real Artificial Intelligence

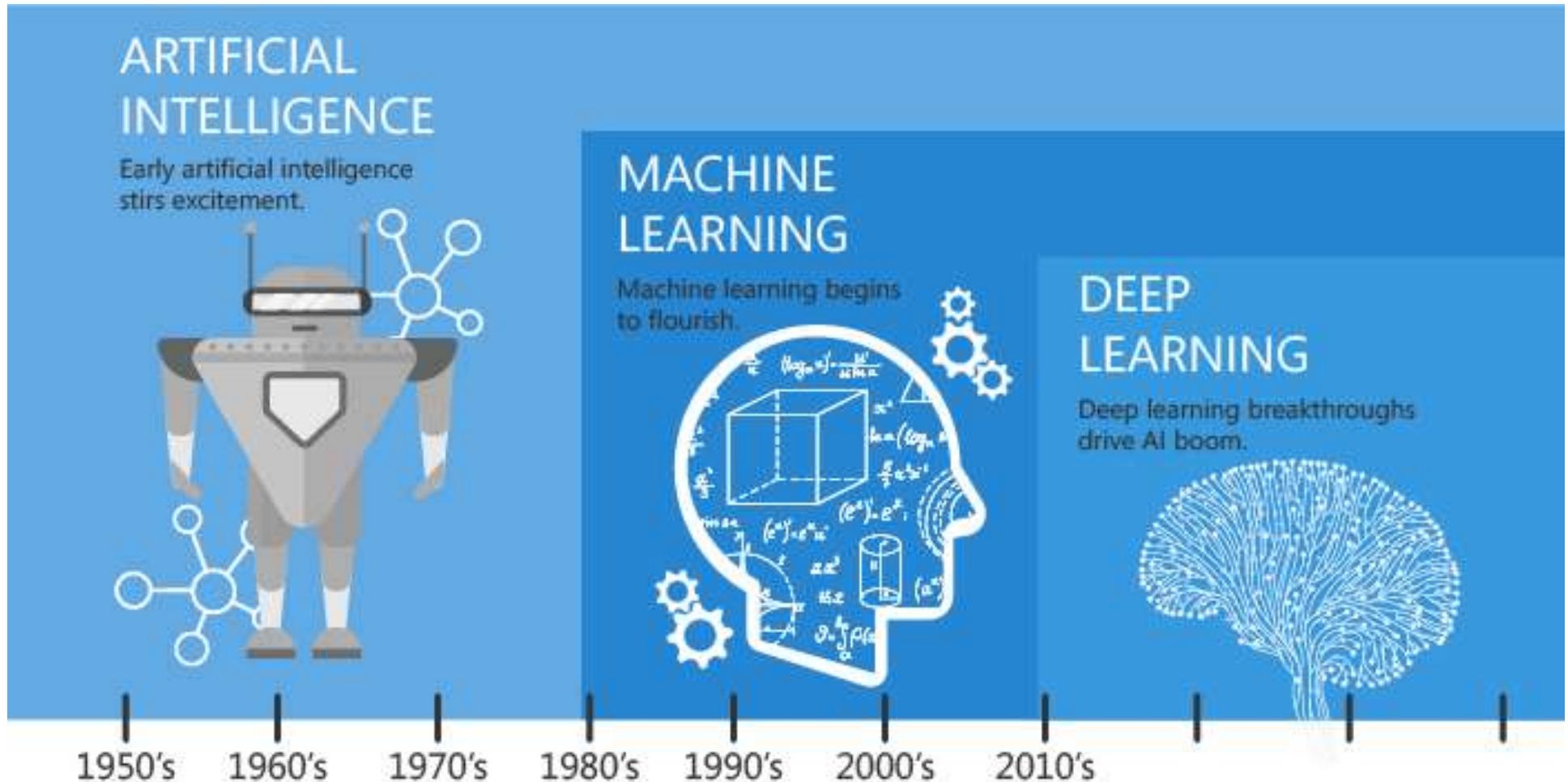
- A very serious science and with incredible developments each year!
- General-purpose AI like the robots of science fiction is still incredibly hard!
- Human brain appears to have lots of special and general functions, integrated in some amazing way that we really do not understand (yet)
- Special-purpose AI is easier and more possible now
- E.g., chess/poker/Go playing programs, logistics planning, automated translation, speech and image recognition, web search, data mining, medical diagnosis, autonomous driving,  
...

# 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

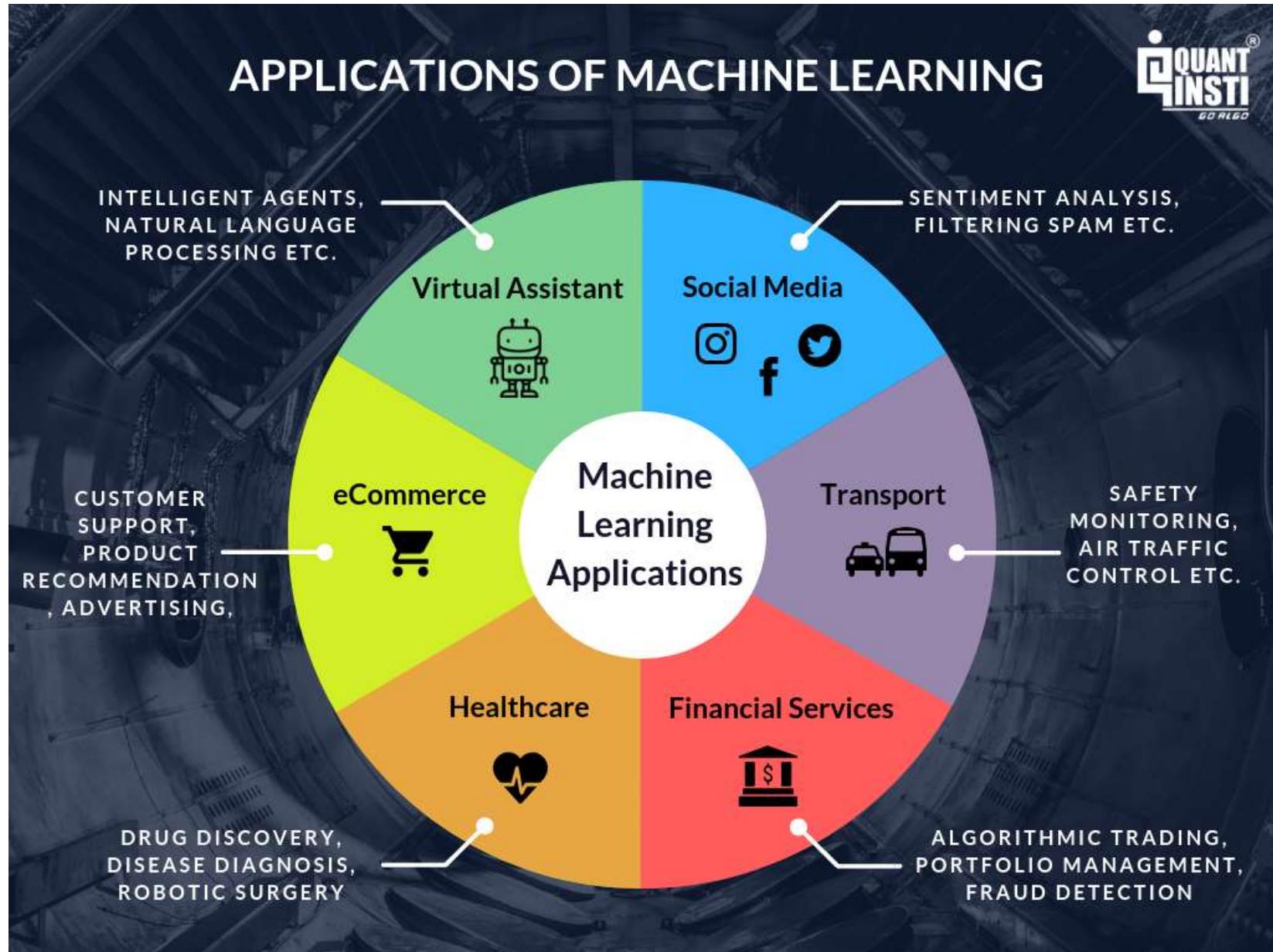


# Machine Learning - History



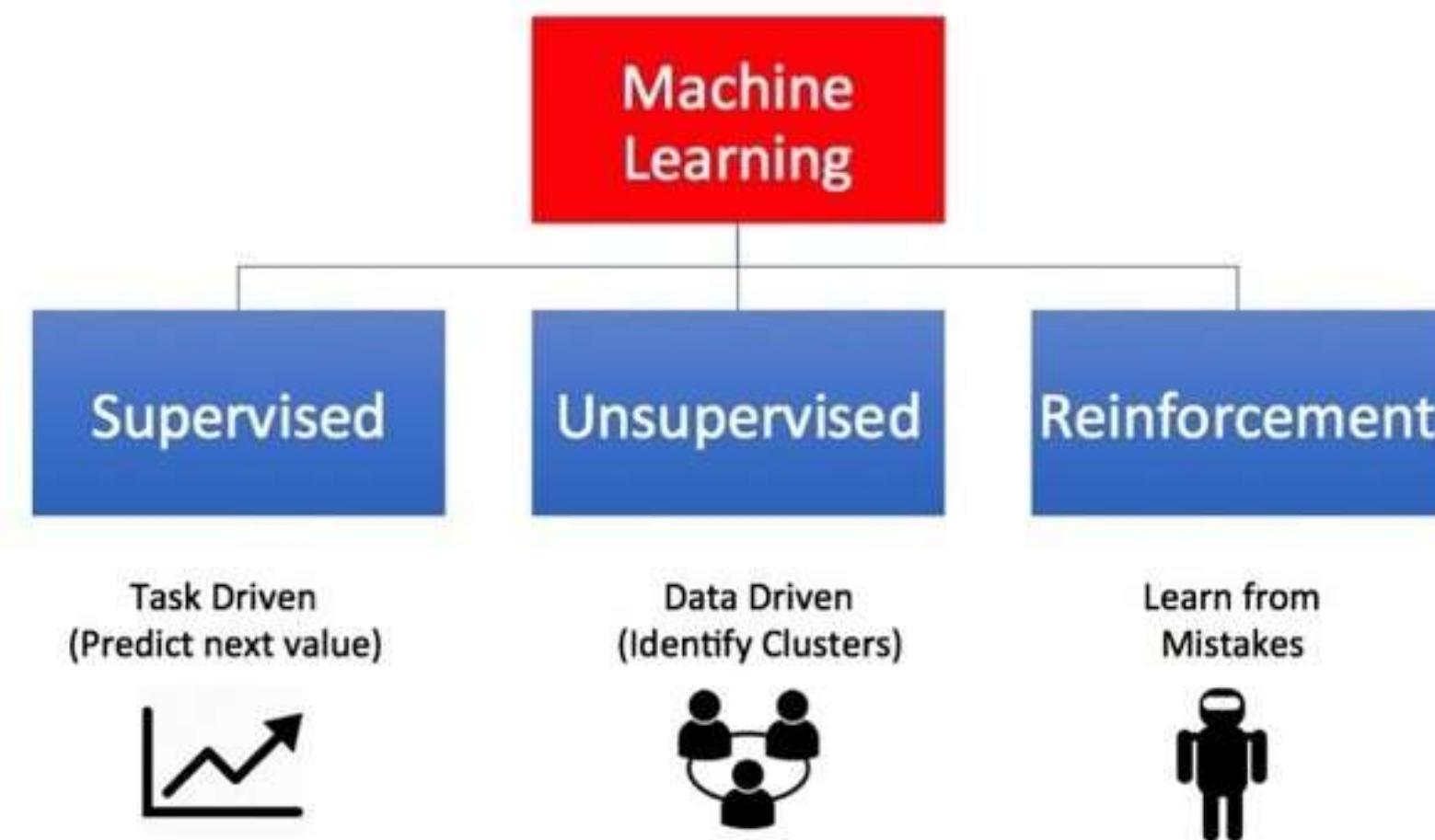
Since an early flush of optimism in the 1950's, smaller subsets of artificial intelligence - first machine learning, then deep learning, a subset of machine learning - have created ever larger disruptions.

# Machine Learning - Applications

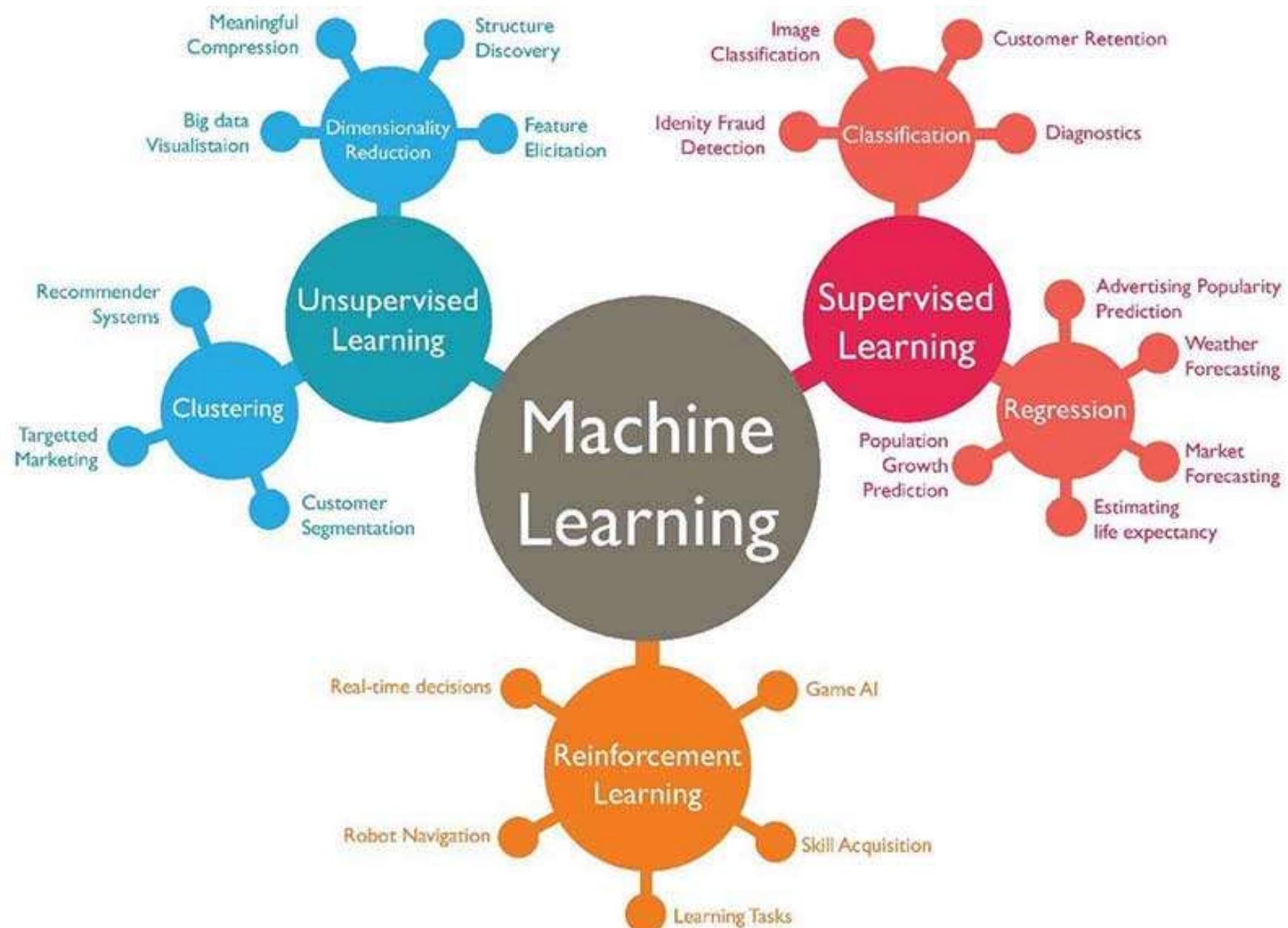


# Machine Learning - Types

## Types of Machine Learning



# AI - Machine Learning



# Programming vs Machine Learning

## Traditional Programming



## Machine Learning

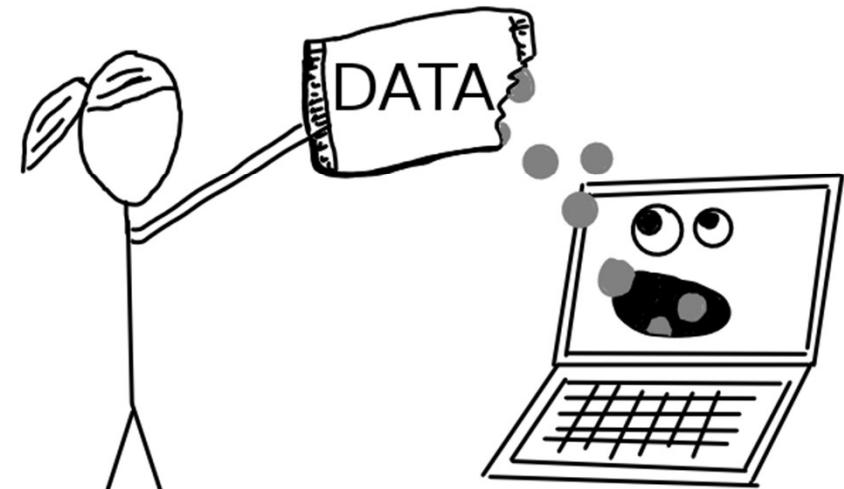


# Machine Learning

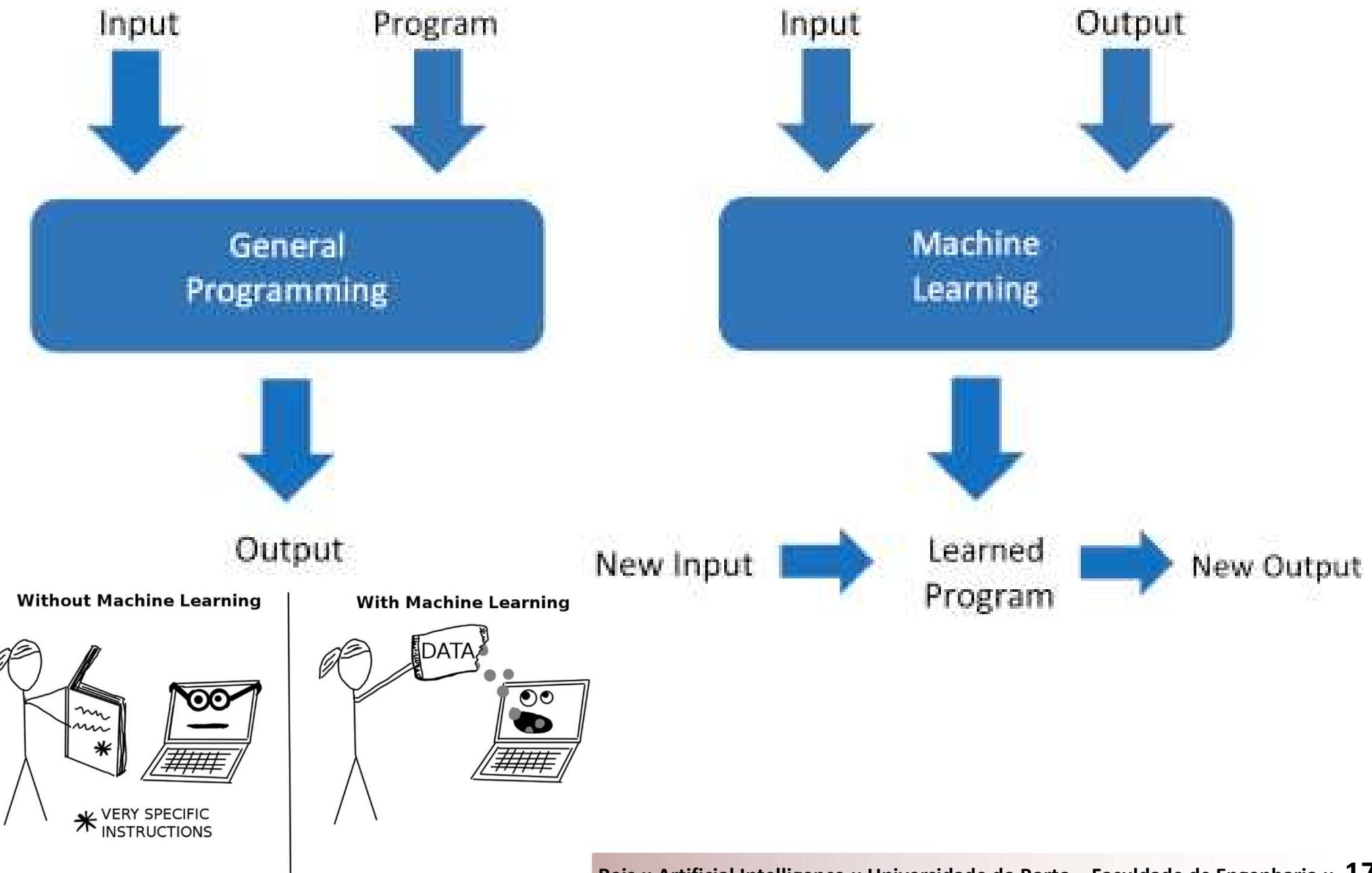
**Without Machine Learning**



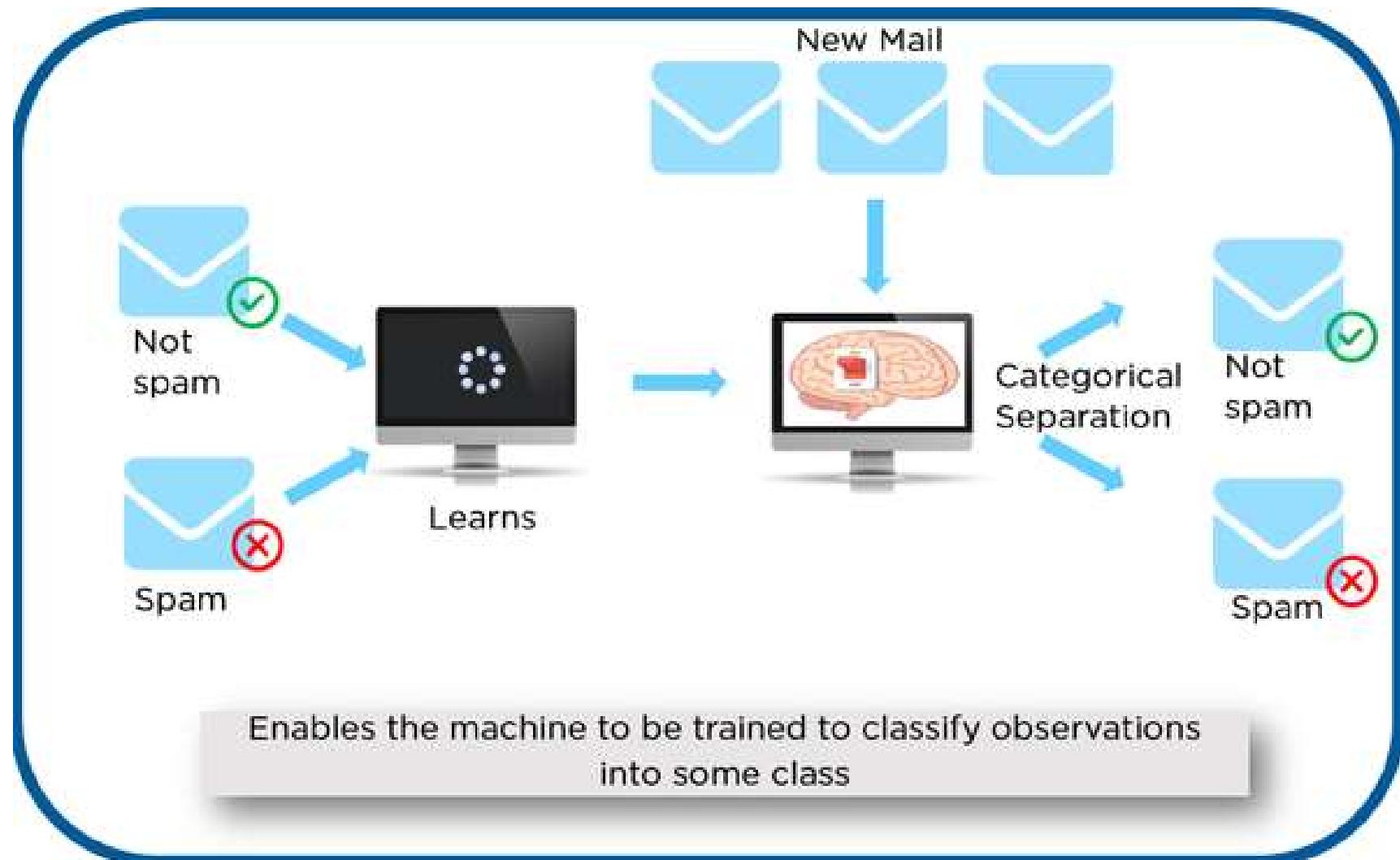
**With Machine Learning**



# Programming vs Machine Learning



# Supervised Learning



# Machine Learning

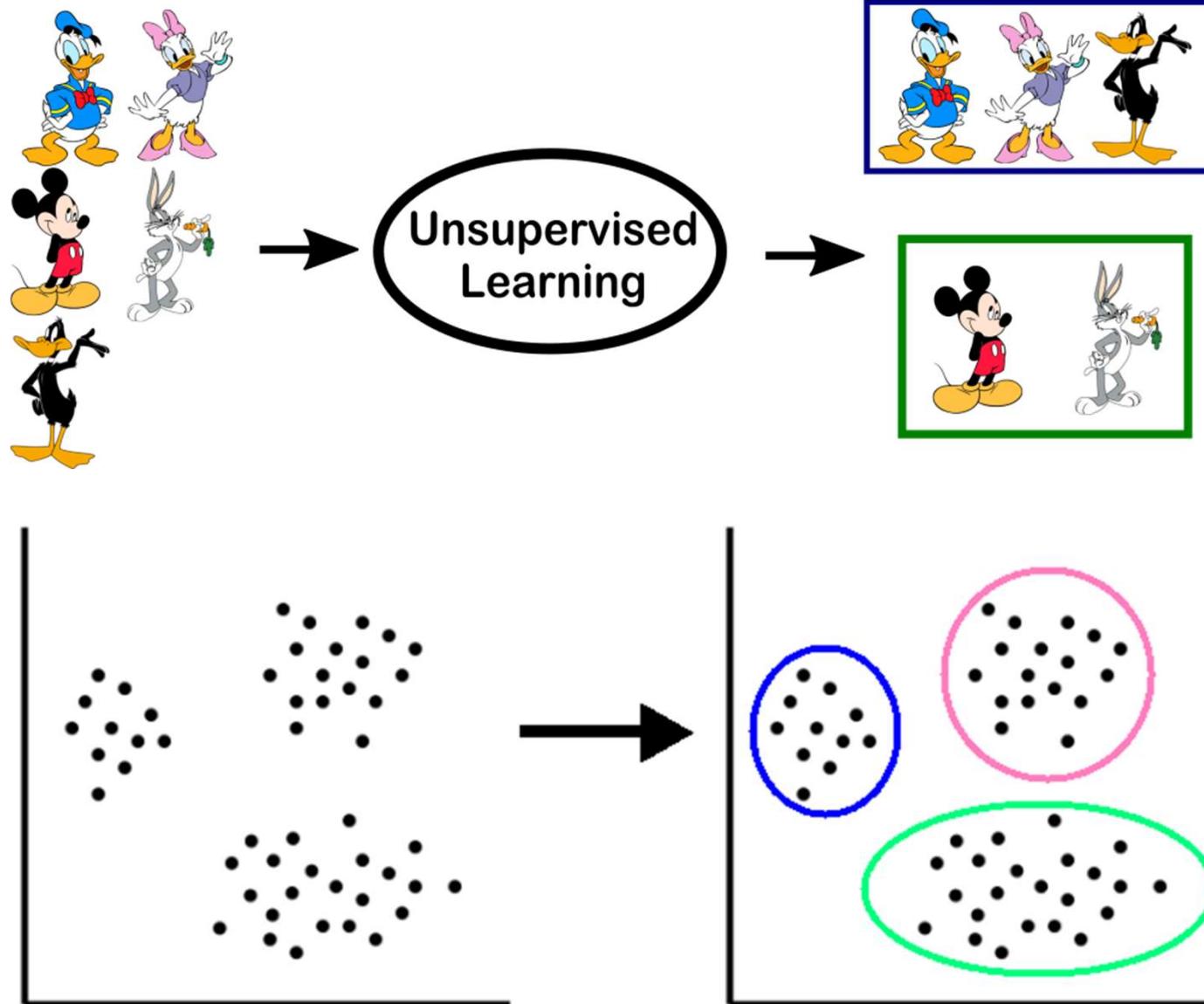


Muffin?

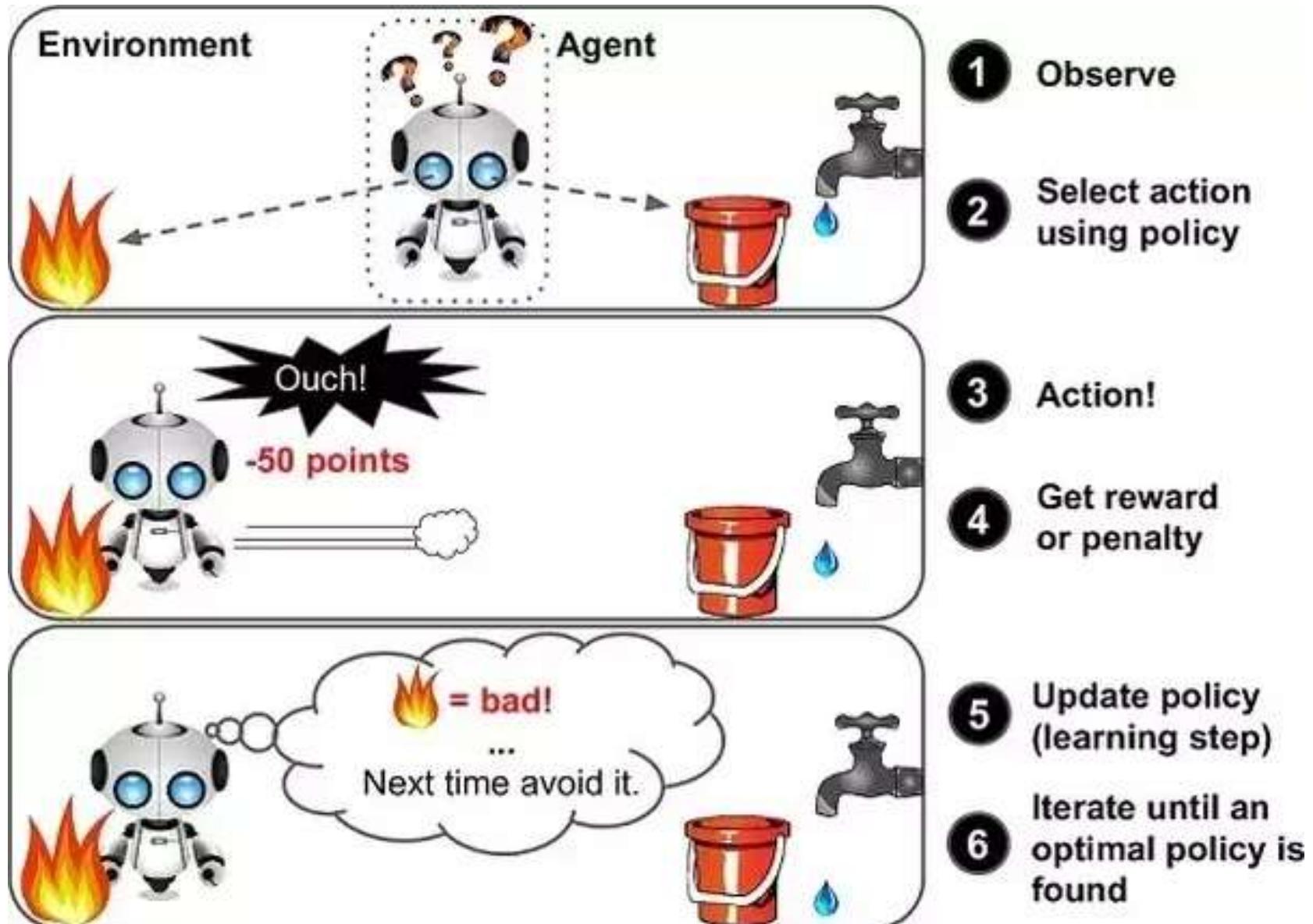
Bagel?

Mop?

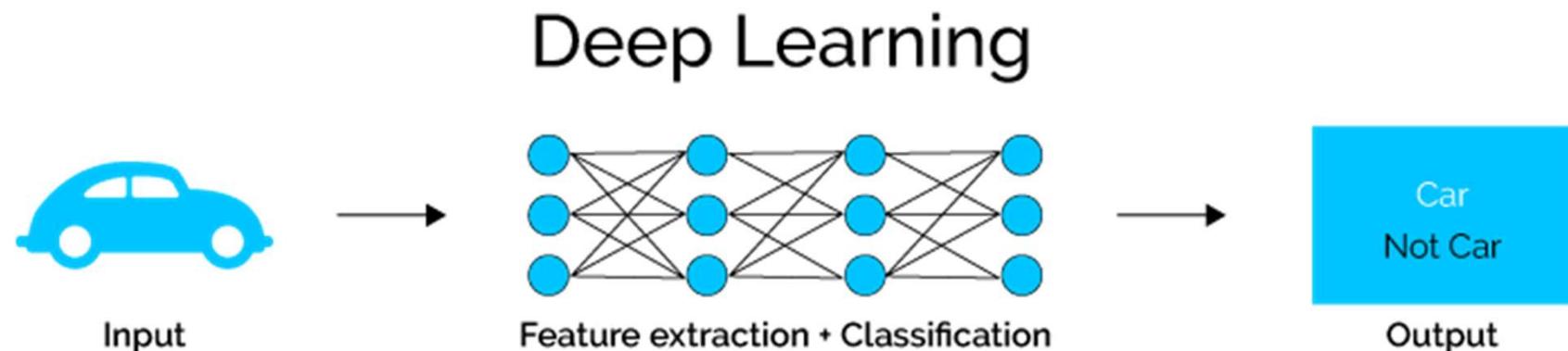
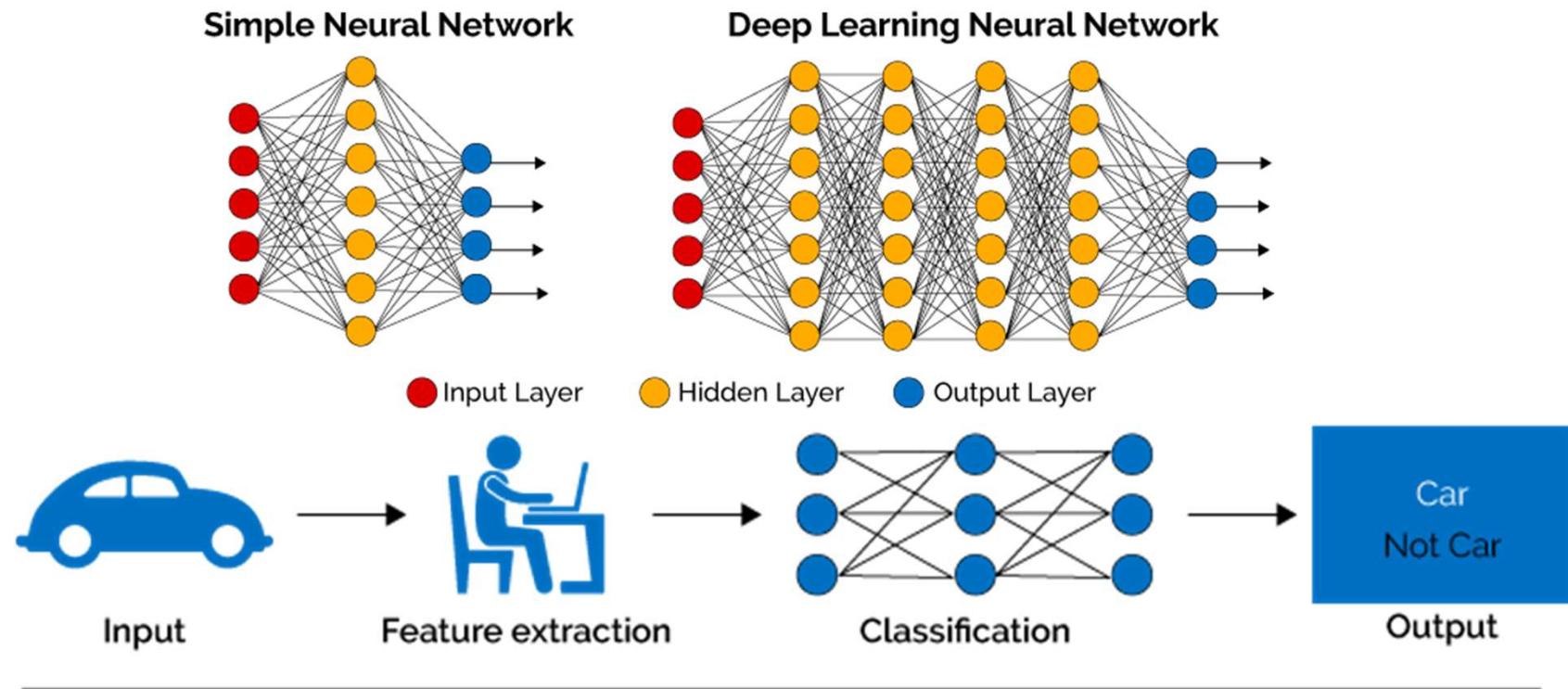
# Unsupervised Learning



# Reinforcement Learning

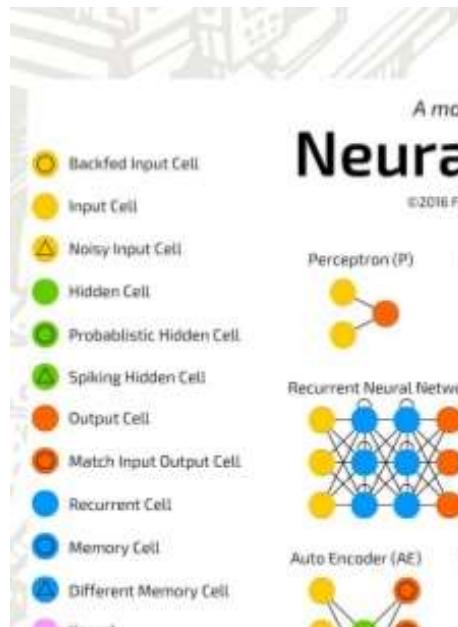


# AI - Deep Learning

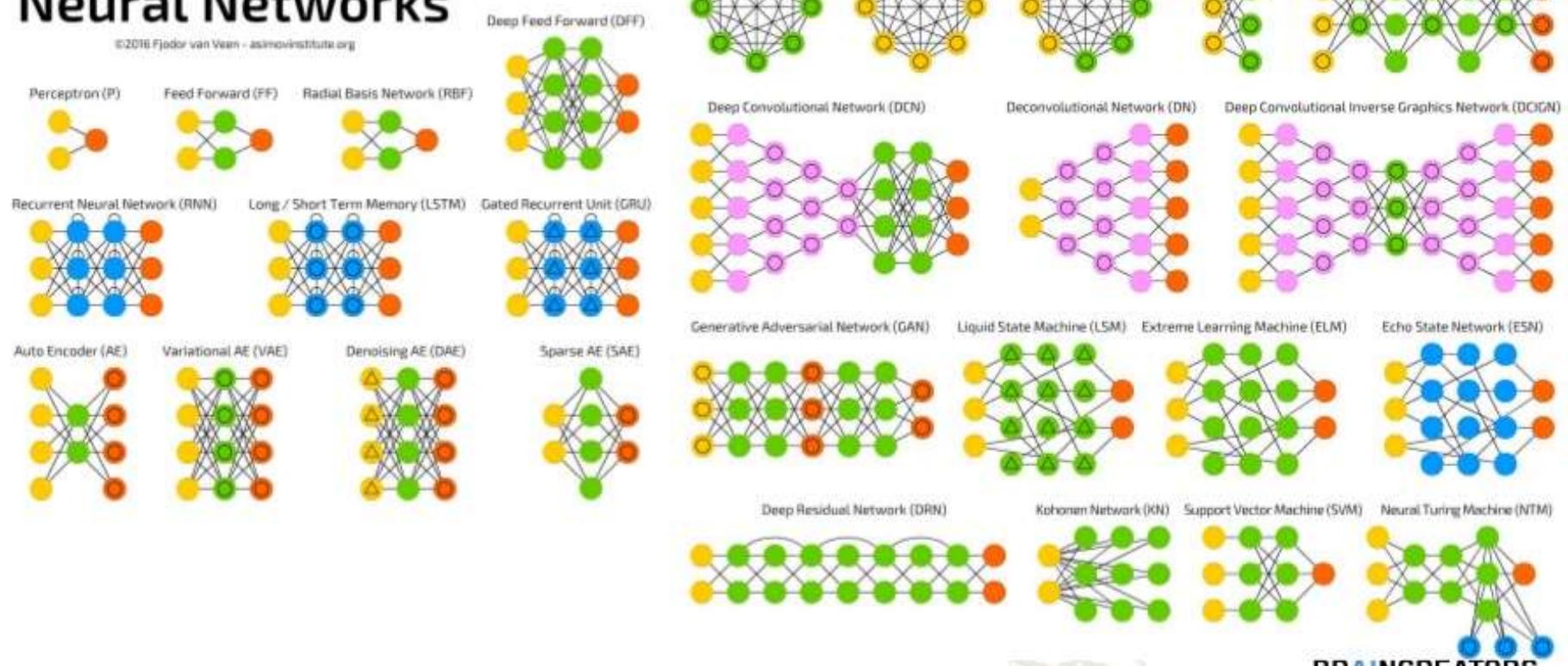


<https://www.xenonstack.com/blog/static/public/uploads/media/machine-learning-vs-deep-learning.png>

# Neural Networks Endless Configurations



## Neural Networks



<http://www.asimovinstitute.org/neural-network-zoo/>

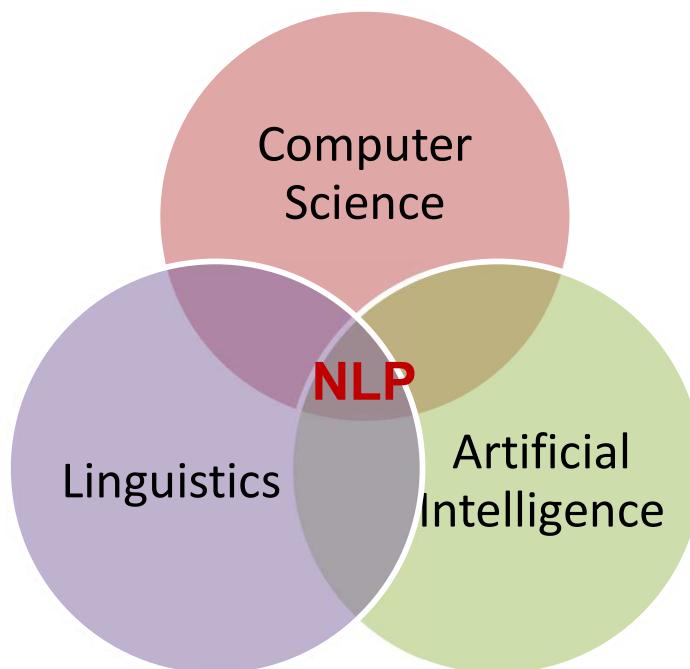
BRAINCREATORS

# Artificial Intelligence: Machine Learning



# AI - Natural Language Processing

Natural language processing (NLP) is a field of computer science, artificial intelligence and computational linguistics concerned with the interactions between computers and human (natural) languages, and, in particular, concerned with programming computers to fruitfully process large natural language corpora



## Challenges:

- natural language understanding
- natural language generation
- language and machine perception
- dialog systems

# AI – Natural Language Processing



- **Machine translation**

- Based on multilingual textual corpora
- Text translation and multilingual real-time conversations



- **Sentiment analysis**

- Determine polarity about specific topics
- Identify trends of public opinion in social media



- **Speech-to-text/text-to-speech**

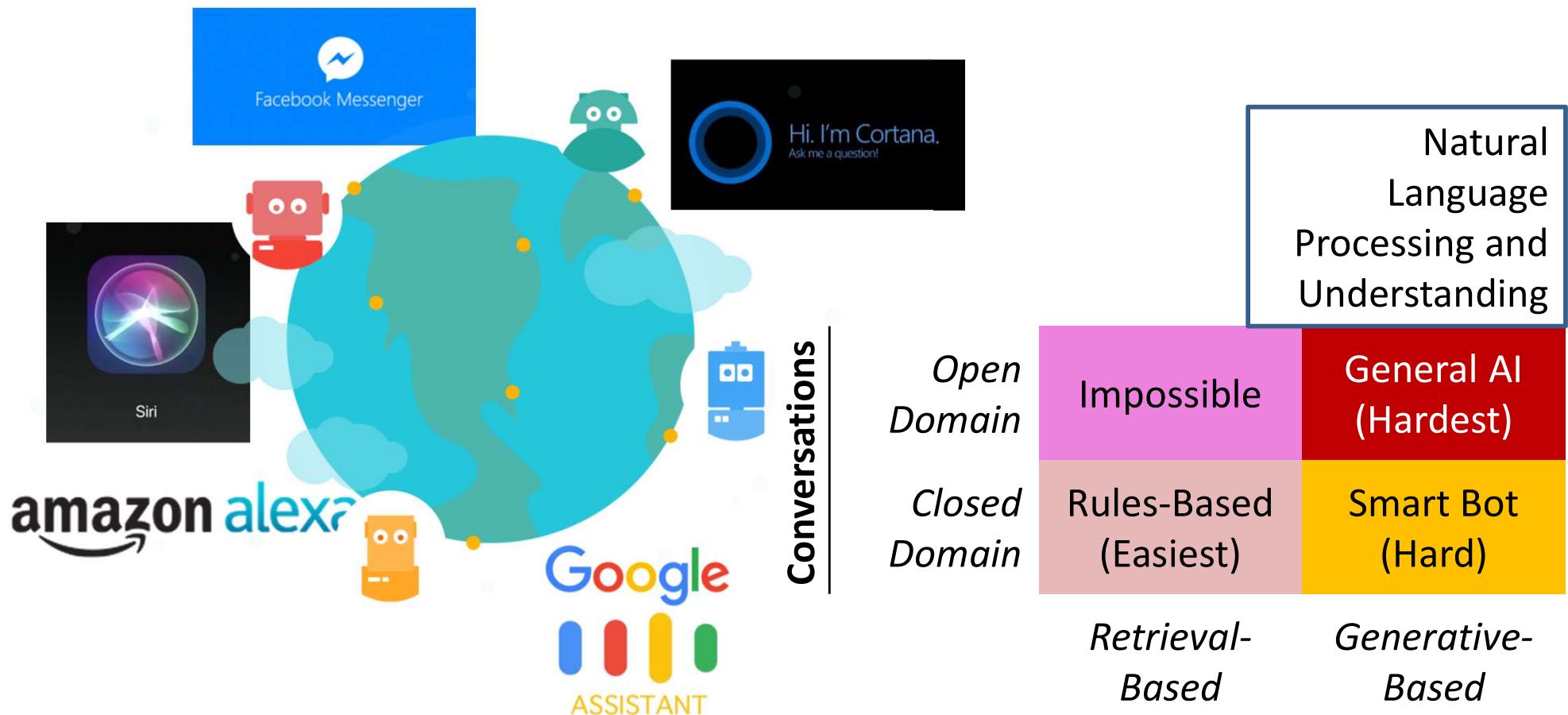
- Convert spoken language to written text and vice versa
- Chatbots, voice control, domotics, readers, ...



# AI – NLP: Watson at Jeopardy



# AI – Natural Language Processing

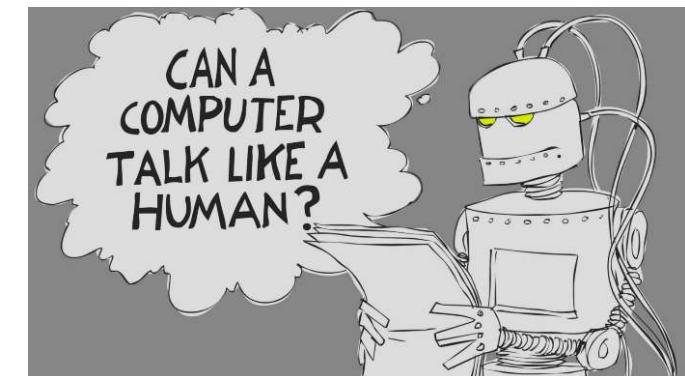
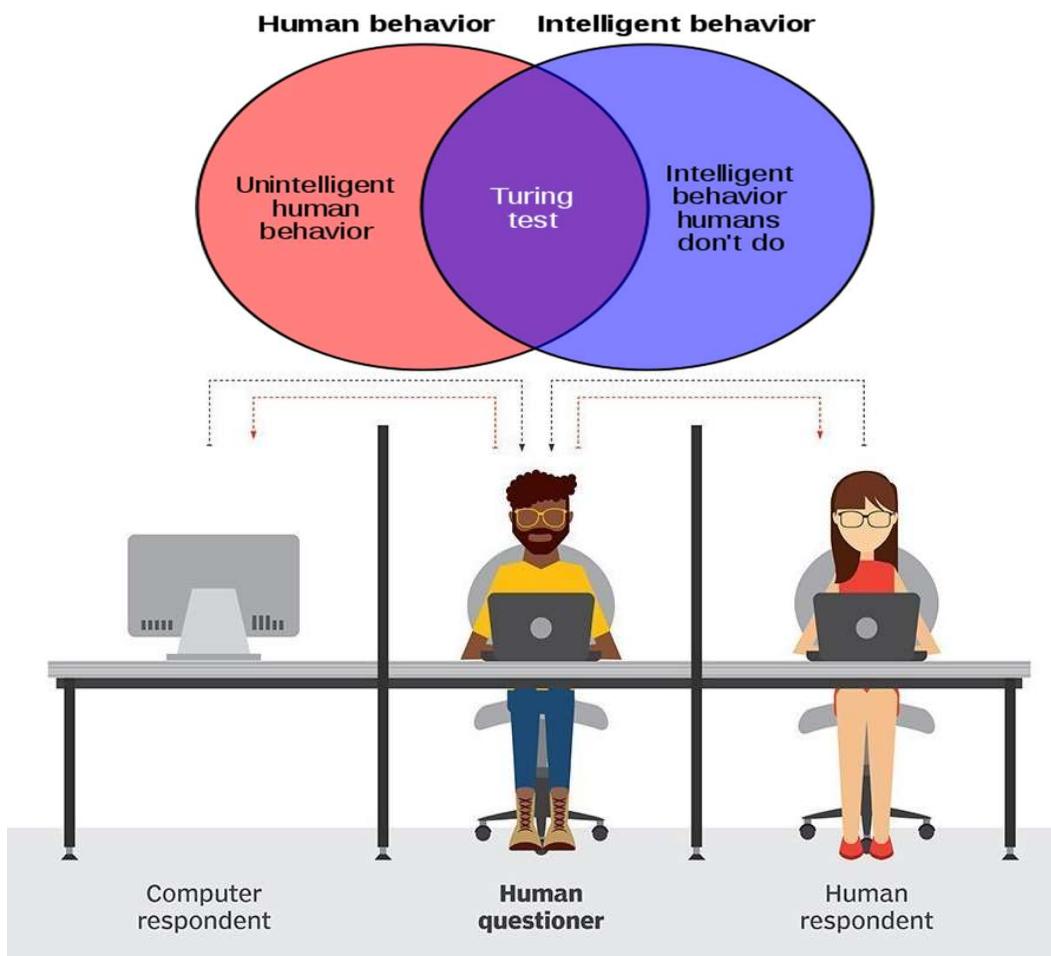


- Without sophisticated NLP capabilities
- Pattern recognition, rule based expression matching, simple machine learning, together with repositories of pre-written sentence templates

**Responses**

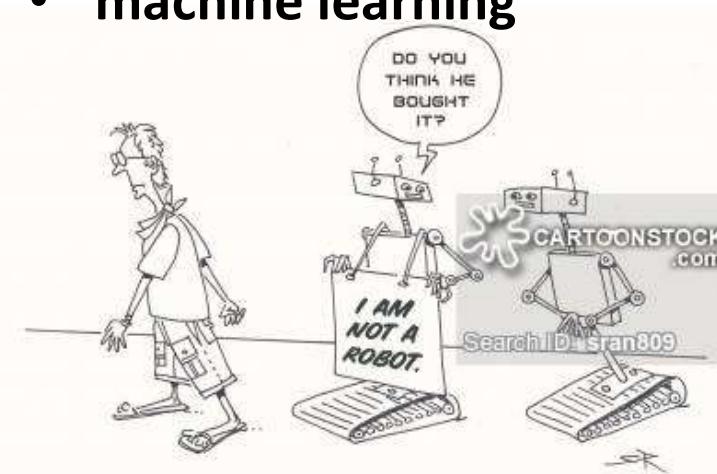
# AI: NLP - Turing Test

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



## Capabilities:

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

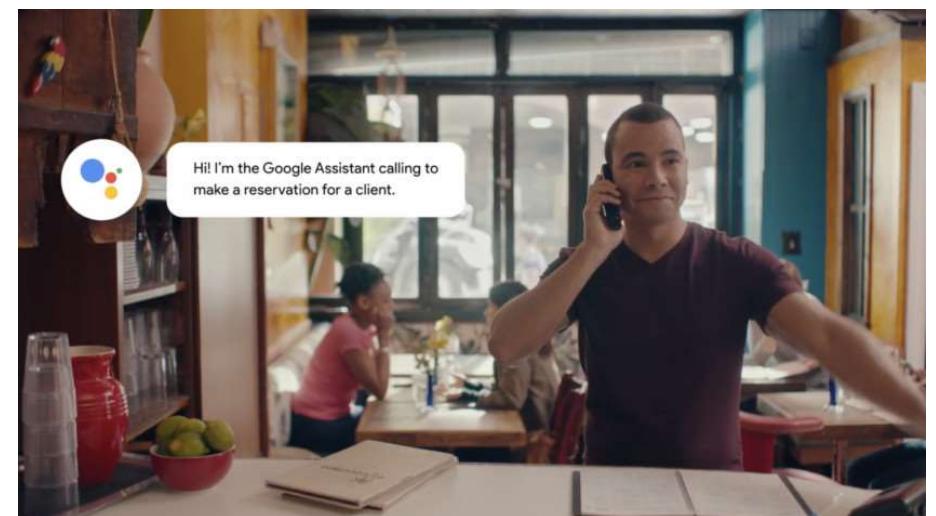
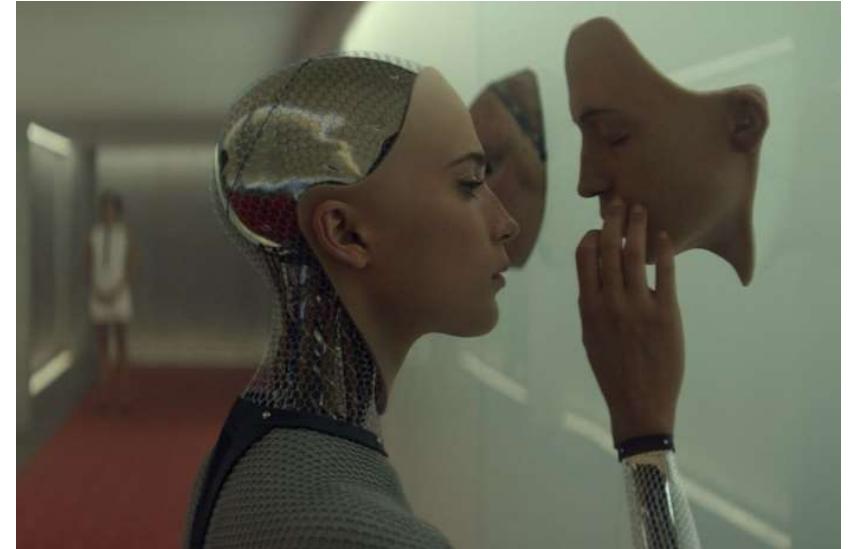


# AI: NLP - Turing Test



# 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**.



# AI - Intelligent Robotics

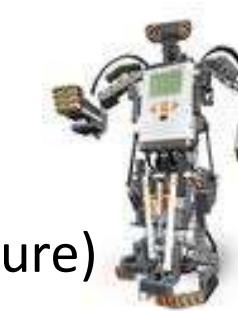
- **Robotics**

- 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 **personal service** 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!**

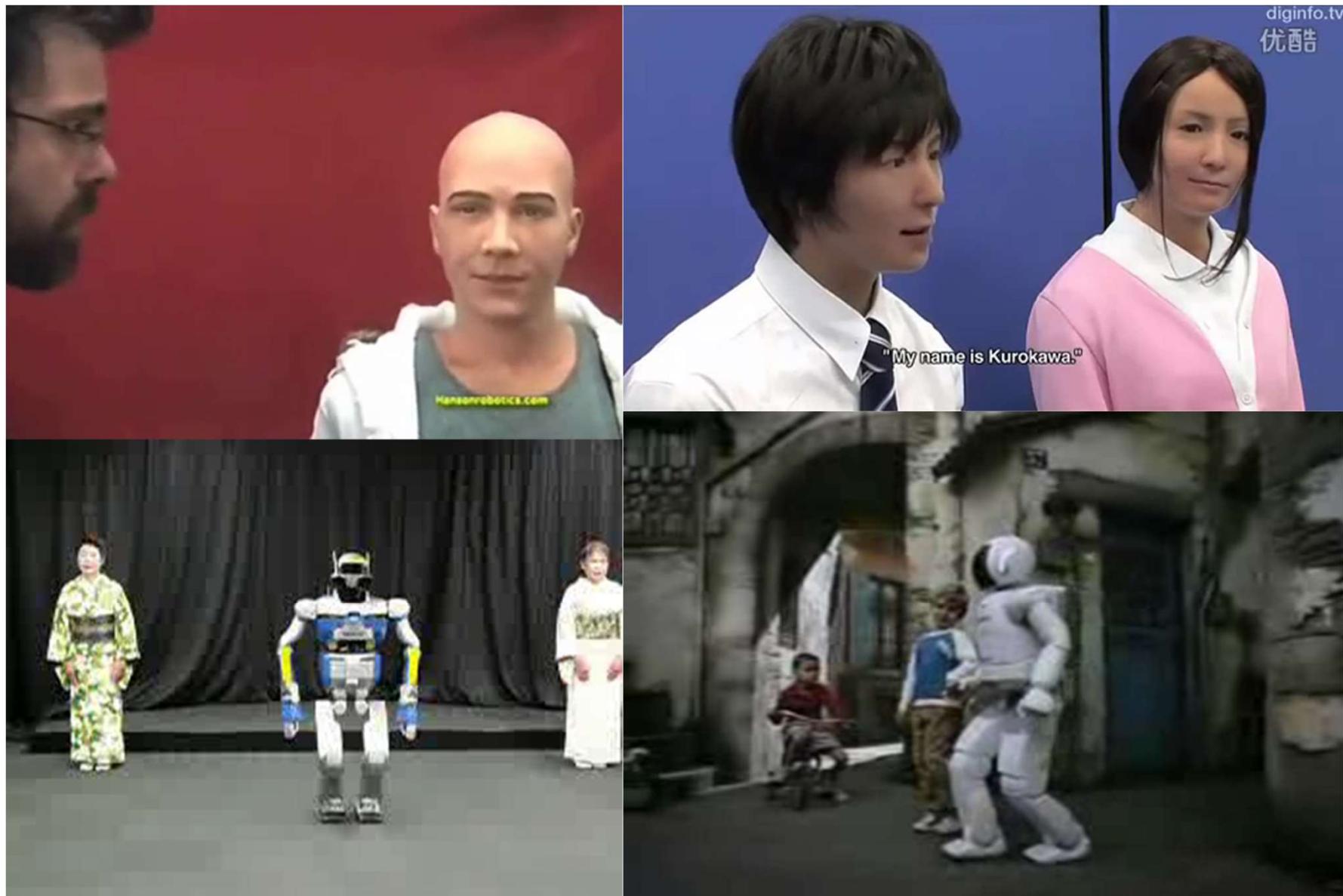


# AI - Robotics

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



# AI - Humanoid Robotics



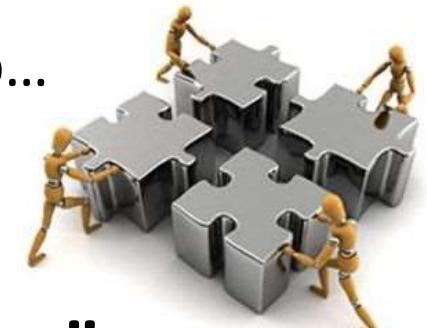
# AI - Robotic Competitions - RoboCup



# 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**



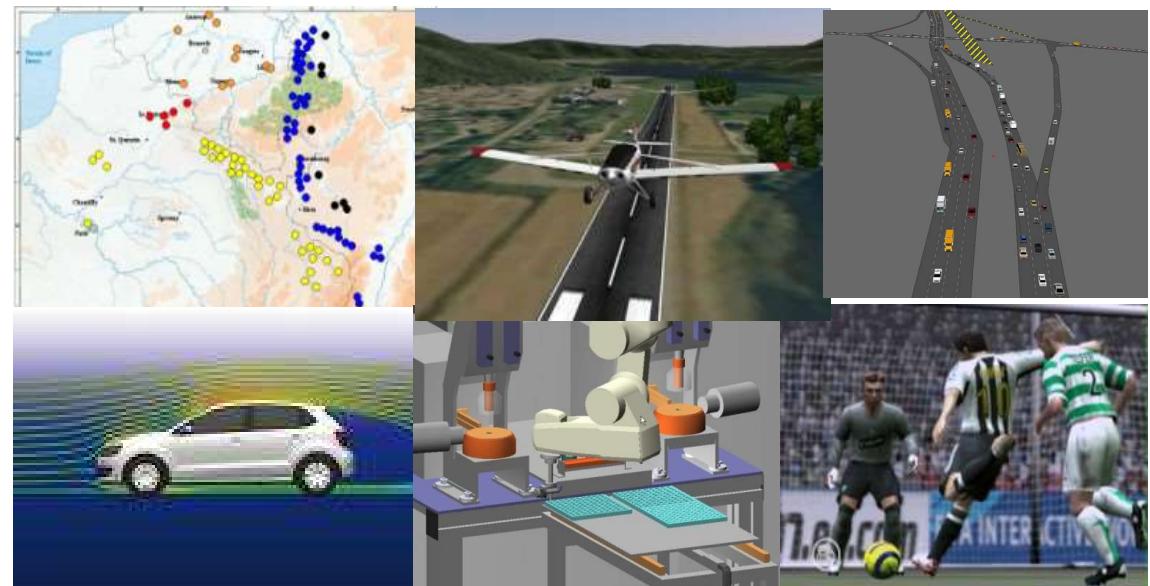
## Coordination : “to work in harmony in a group”

- **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

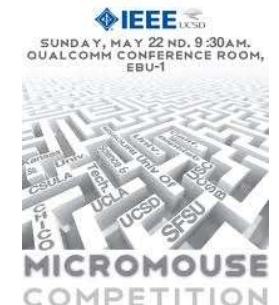
- **Simulation:** Imitation of some real thing, state of affairs, or process, over time, representing certain key characteristics or behaviours of the physical or abstract system
- Applications:
  - Understand system functioning
  - Performance optimization
  - Testing and validation
  - Decision making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



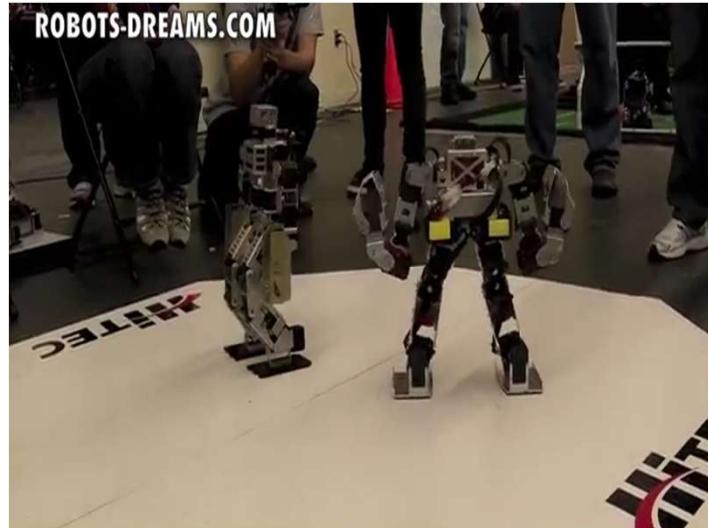
# Robotic Games and Competitions



**ROBOXOTICA**  
Festival für Cocktail-Robotik



# Robotic Competitions - RoboGames



# Robotic Competitions - RoboGames



# Robotic Games and Competitions

## Benefits

- Research inspiration
  - Hard deadline for creating fully functional system
  - Common platform/problem
  - Exchange of research ideas/solutions
  - Continually improving solutions
  - Excitement for students/researchers at all levels
  - Large number of teams/solutions created
  - Encouragement for flexible software/hardware

## Dangers

- Obsession with winning
- Domain dependent/ hacked solutions
  - Cost escalation
  - Difficulty in entering at competitive level
  - Restrictive rules
  - Invalid evaluation conclusions

# Robotic Competitions - RoboCup

**RoboCup**

- Real, Standard, Simulated Robots
- Mini, Small, Medium and Large Robots
- Wheeled, Legged and Humanoid Robots
- **Distinct but interrelated Leagues/Problems**
- Only a Few Research Groups able to develop code that works in more than one league!

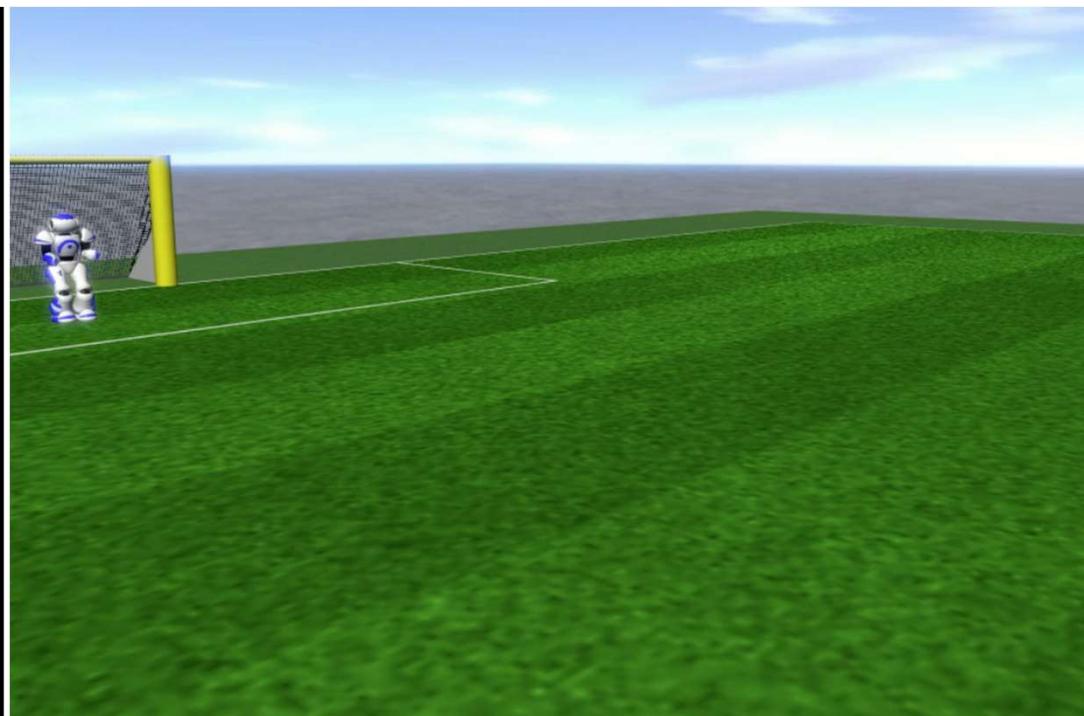
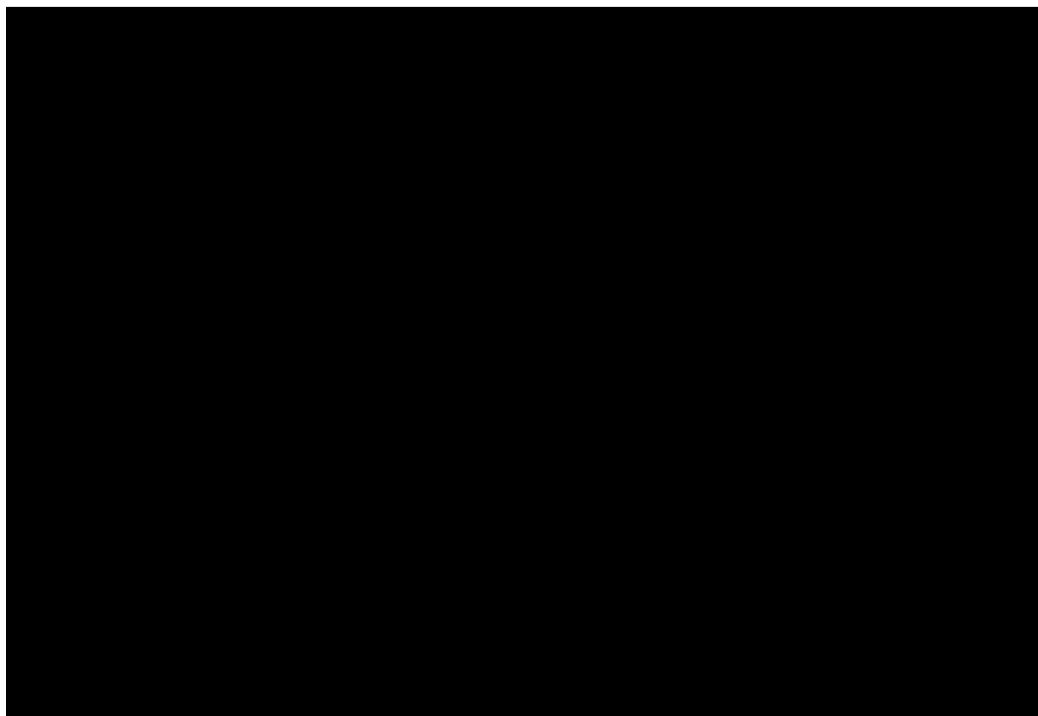
# Learning to Walk with PPO

## Results

Top Sp.:1.5m/s

v1 v2

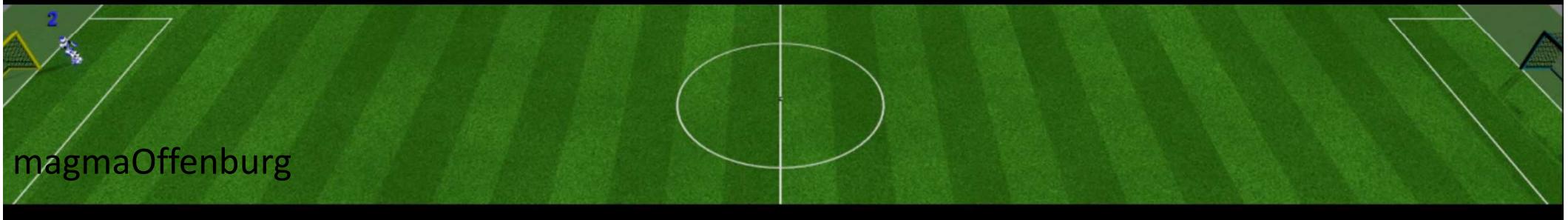
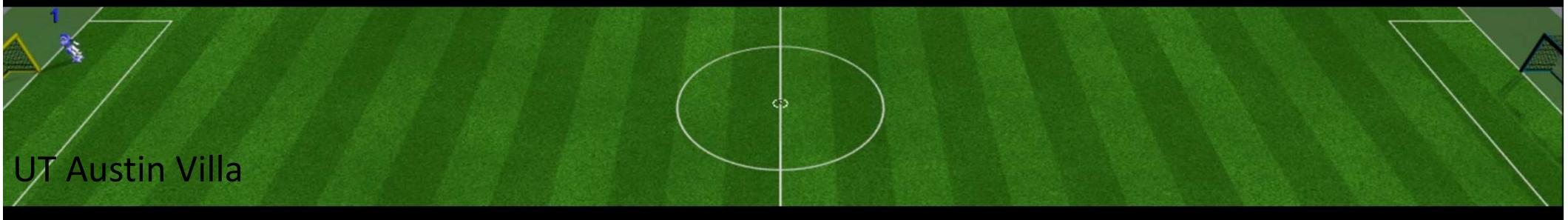
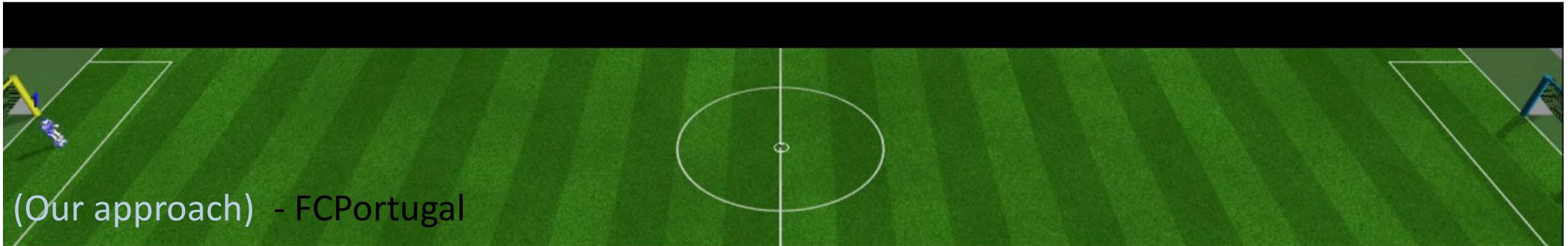
Top Sp.:2.5m/s



# Learning to Walk with PPO



# Learning to Walk with PPO

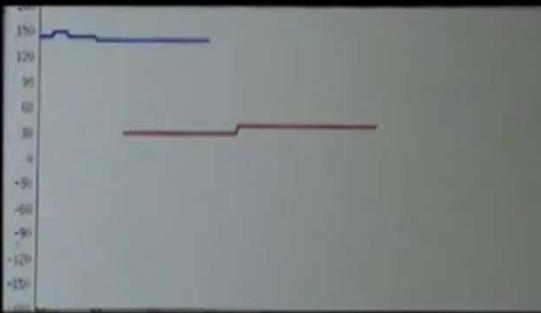


# AI Projects - Intellwheels



# AI Projects - HearBo

Copyright (c) 2012 Honda Research Institute Japan Co., Ltd. All Rights Reserved.



## Sound Localization

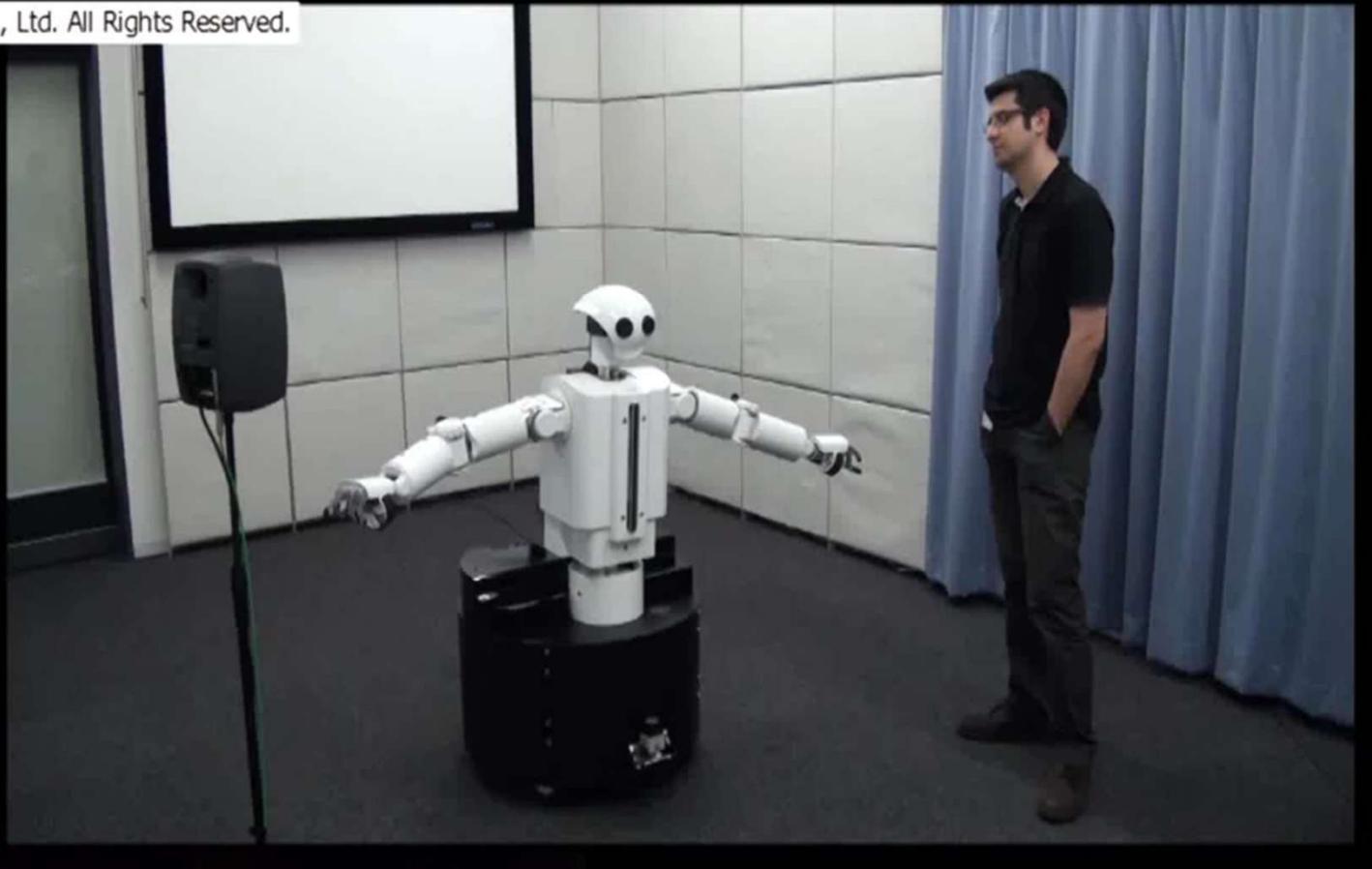
Speech Decision: 0

Maintain Interaction

Music Decision: 0

Maintain Interaction

## Decision/Behavior



## ASR Result

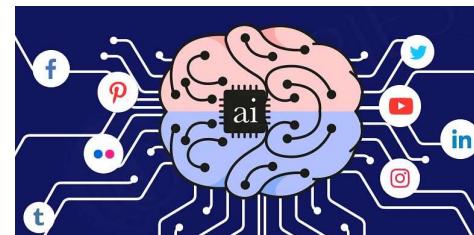
# AI Application Area: Health

- Radiology (X-ray, CT, MRI)
- Dermatology (Image)
- Drug/Treatment Discovery
- Risk Identification in Patients
- Primary Care and Screening
- Health Monitoring/Wearables
- Cognitive and Social Rehabilitation
- Physical Rehabilitation
- Patient Interaction with the Health System
- Health Systems Exchange of Information
- Surgical/Medical Robots
- Efficient Resource Allocation in Health
- ...



# Artificial Intelligence in Digital Media

- Digital Images
- Digital Video
- Digital Audio
- Movie Industry
- Video Games
- Web Pages and Websites
- Social Media
- Digital Data and Databases
- Electronic Documents/Books



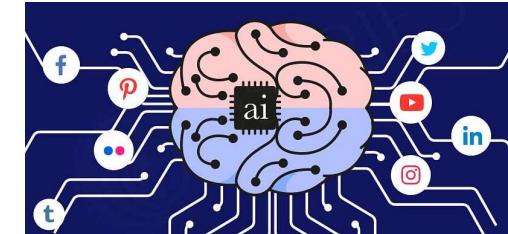
# Artificial Intelligence in Video Games

- Generate responsive, adaptive or intelligent behaviours
- Non-player characters (NPCs) with human-like intelligence
- Improve the game-player experience
- Game Balancing/ Dynamic Difficulty Adjustment
- Movement patterns, in-game events based on player's input
- Pathfinding and decision trees for NPCs actions
- Procedural-content generation
- Text to speech and speech recognition
- AI for automatic level generation
- AI opponents for board/strategic games



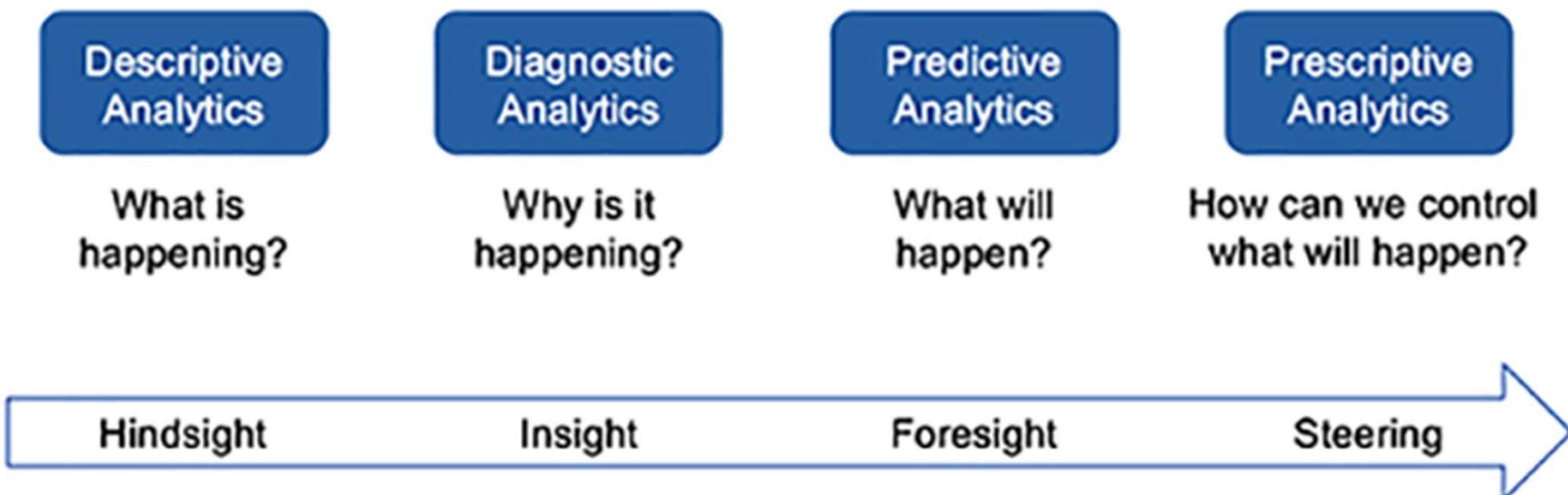
# Artificial Intelligence in Social Media

- Social Creation and Management
- Social Insights
- Social Media Advertising
- Image/Face Recognition
- Fake News/Improper Content Recognition
- Personalised User Experience
- Advise Contacts/ Job candidates / Matches
- AI Powered Chatbots
- Social Listening
- Sentiment Analysis
- Improved Influencer strategies
- Increased Security



# AI for the Environment

- **Descriptive:** Interprets historical data to determine what happened
- **Diagnostic:** Determines why something has happened using AI
- **Predictive:** Predicts what will happen in the future based on historical data/patterns, external data and AI techniques
- **Prescriptive:** Predicts multiple outcomes for a given scenario based upon actions taken. Steering the user toward the best possible option



# AI for Land/Agriculture

- Land is under very high pressure
- Soil pollution, population growth, intensive agriculture, etc
- One third of the earth already depleted, contaminated, pesticide poisoning
- Land cover mapping, species classification,
- AI has the power to make agricultural practices safer for the land and the public health
- Machine Learning, Robotics, Simulation, Decision Making, Optimization
- Analyse farm and weather data, automating and optimizing farming processes
- Organic and land friendly crops



# AI for Air/Pollution

- Better monitoring and prediction of Pollution
- Pollution/air quality sources identification
- Reduce harmful emissions on its source
- Intelligent and Green Transportation,  
Autonomous Cars
- Ai may help mitigate health risks and assist in drug development related to pollution
- Autonomous ride shares, dynamic bus routing, intelligent traffic lights
- Smart Sensors, Machine Learning, Robotics, Simulation, Decision Making, Optimization



# AI for Water

- **Healthy Oceans, Lakes and Rivers**
- **Autonomous Garbage collection (plastic) at the oceans**
- **Intelligent ocean farming (fish and shellfish)**
- **Predict emergence events (storms, tsunamis, hurricanes, ...)**
- **Reducing energy costs, optimizing chemical use for treatment, and enabling proactive asset maintenance**
- **Clean, effective, resilient, sustainable, and cost-effective water management**
- **Smart Sensors, Machine Learning, Robotics, Simulation, Decision Making, Optimization**



# AI for Climate Change

- An increasingly variable climate, extreme weather events, rising sea levels, higher global temperatures, and increased ocean acidity threaten human health, infrastructure, and the natural systems we rely on for life itself
- Climate change is one of the biggest challenges facing the planet and It will need strong contribution from AI
- Better climate predictions, Showing the effects of extreme weather, Measuring where carbon is coming from
- Smart Sensors, Machine Learning, Robotics, Simulation, Decision Making, Optimization



# AI for Biodiversity

- Species are going extinct beyond the natural rate by orders of magnitude, driving the decay of key ecosystem services, like pollination, that humans depend upon
- AI is being used to classify animals in real time, to detect people where they shouldn't be, and even to identify and track individual animals and plants throughout their lives
- Environmental decision support systems
- Biodiversity surveillance, tracking, analysis and prediction
- Catastrophe and natural events analysis and prediction
- Machine Learning, Simulation, Decision Making, Optimization



# APPIA



<http://www.appia.pt/>

EVENTOS APPIA ▾ IA EM PORTUGAL ▾ RECURSOS ▾ ACERCA DA APPIA ▾

## Prémio Melhor Tese de Doutoramento em Inteligência Artificial 2019-2020

 2021-03-19  Henrique Lopes Cardoso

A APPIA institui o Prémio para a Melhor Tese de Doutoramento em Inteligência Artificial 2019-2020, com a finalidade de distinguir trabalhos doutoramento de elevado mérito na área da Inteligência Artificial e que tenham sido atribuídos por uma instituição de ensino superior portuguesa durante o ano de 2019 ou 2020.

O prémio tem um [regulamento específico](#), sendo que as candidaturas devem ser efectuadas via preenchimento deste [formulário](#) até à data limite: **28 de Maio de 2021**.

O prémio tem um valor simbólico de 1000 euros, sendo que o candidato (ou seu representante) receberá o certificado do Prémio de Melhor Tese de Doutoramento em Inteligência Artificial 2019-2020 em Setembro de 2021, durante a realização da **20th Conference on Artificial Intelligence (EPIA 2021)**, <http://www.appia.pt/epia2021/>.



Associação Portuguesa Para a Inteligência Artificial

### Categorias

[rede.APPIA] (384)

Documentos (7)

Eventos (151)

Eventos APPIA (84)

EAIA (14)

EPIA (30)

ISSAI (2)

Prémio Doutoramento (7)

Prémios PremEIA (3)

Prémios TLEIA (6)

SDIA (4)

# EPIA 2021

- <http://www.appia.pt/epia2021/>

EPIA 2021

20th EPIA Conference on Artificial Intelligence

September 7-9, 2021

News    Call for Papers    Attending    Important Dates    Program    About

## Welcome to the 20th EPIA Conference

---

The EPIA Conference on Artificial Intelligence is a well-established European conference. The 20th edition of the EPIA conference will take place online in 2021. As in previous editions, this international conference is hosted with the patronage of the Portuguese Association for Artificial Intelligence (APPIA). The purpose of this conference is to promote research in all areas of AI, covering both theoretical/foundational issues and applications, and the scientific exchange among researchers, engineers, and practitioners in related disciplines. The conference is organized in a number of thematic tracks. Accepted papers will be published in a Springer's Lecture Notes in Artificial Intelligence volume.

# EAIA 2021 – EASSS 2021

22nd European Agent Systems Summer School (EASSS 2021)

HOME

IMPORTANT DATES

NEWS

PROGRAM ▾

ATTENDING ▾

ABOUT ▾

Search



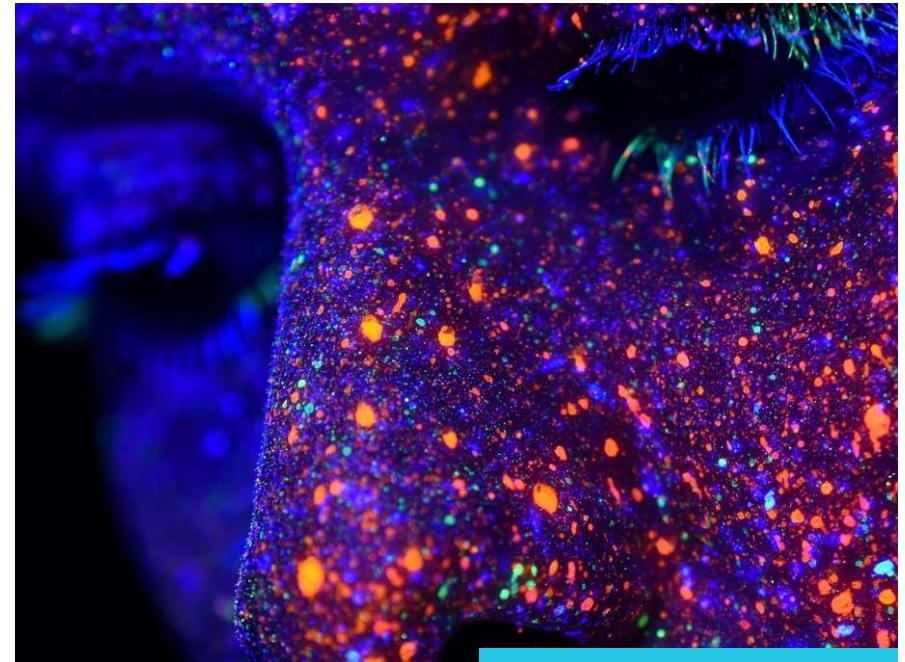
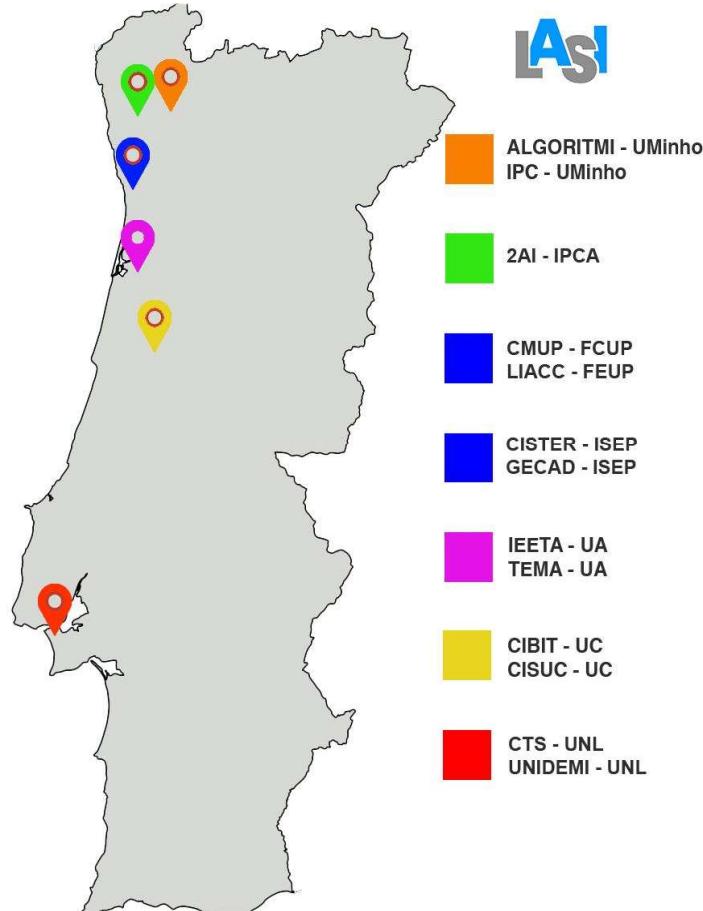
22nd European Agent Systems Summer School (EASSS 2021)

EAIA 2021 -- Advanced School on Artificial Intelligence

JULY 19-23, 2021

<https://paginas.fe.up.pt/~easss2021/>

# LASI - Intelligent Systems Associate Laboratory



LASI

Our vision is to advance edge knowledge in Intelligent Systems to support our society in an innovative, ethical, and sustainable path for the 21<sup>st</sup> century.

430 PhD Researchers, and more than 1000 Researchers from 13 Labs in Portugal

# LIACD – New BSc in AI and DS

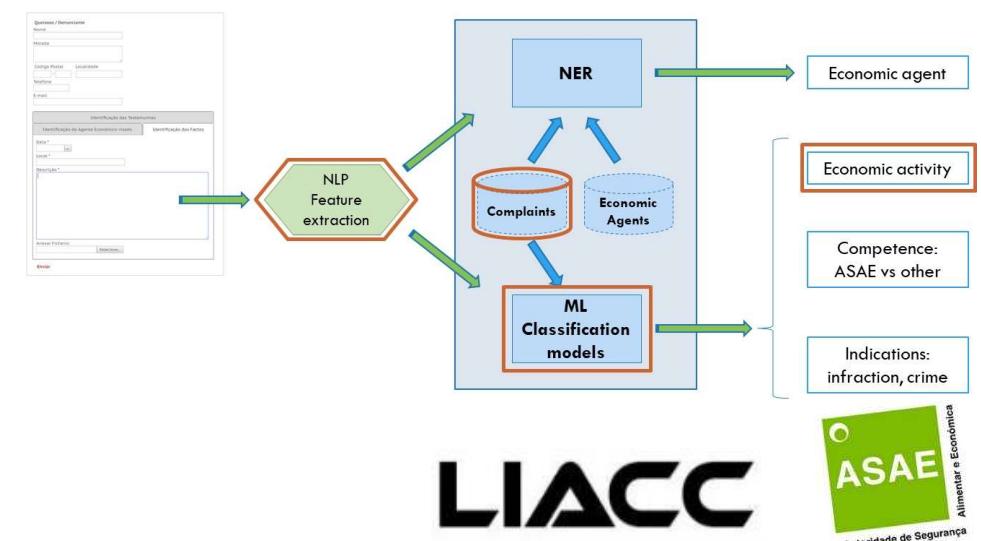
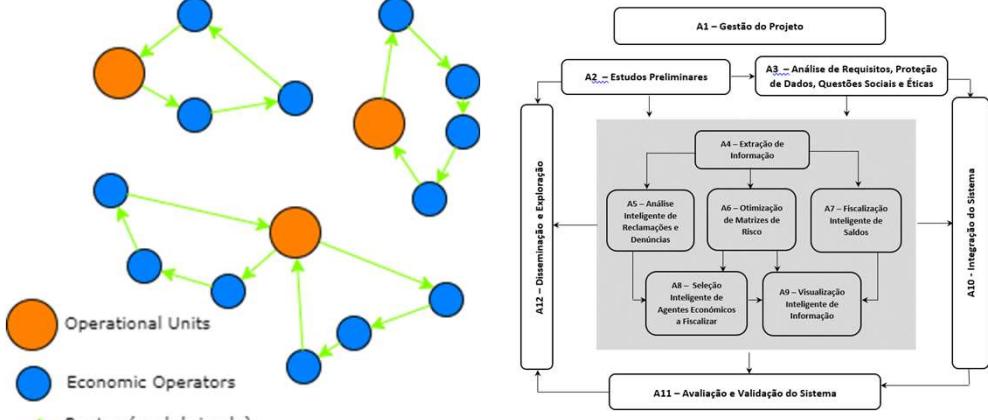
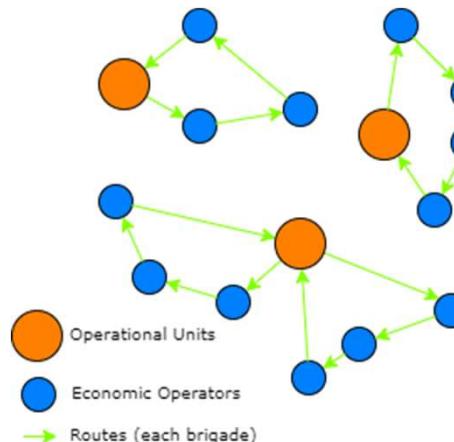


U.PORTO  
FC  
FACULDADE DE CIÉNCIAS  
UNIVERSIDADE DO PORTO

U.PORTO  
FEUP  
FACULDADE DE ENGENHARIA  
UNIVERSIDADE DO PORTO

# IA.SAE - Artificial Intelligence for Food and Economic Safety

- ASAE Databases, AI and ML
- Georeferencing of 3M Economic Agents
- Intelligent Analysis of Complaints for Classification & Prioritization
- Flexible and Intelligent Risk Analysis
- Optimized Selection of Economic Agents to Inspect
- Flexible generation of Inspection Routes
- Disruption Management
- Intelligent Visualization/KPIs
- Functional prototype



LIACC

# *Complaints Analysis Using Natural Language Processing*

Entidades ▾ Densidades Fiscalizações ▾ Denúncias ▾ Dashboards ▾ Vídeos Ajuda [www.BANDICAM.com](#)

(admin) Utilizador Teste2 - Unidade UO2 [Logout](#)

**Homepage**

Utilize o navegador **Chrome** para uma melhor experiência, particularmente nas *fiscalizações* e *Nova Entidade*.

Esta aplicação foi criada com o intuito de atingir dois objectivos:

# *Selection of Economic Agents and Generation of Inspection Routes*

The screenshot shows a web application interface. At the top, there is a blue header bar with the following navigation items: Entidades ▾, Densidades, Fiscalizações ▾, Denúncias ▾, Dashboards ▾, Videos, and Ajuda. On the right side of the header, it shows the user information (ester) Ester Esteves - Unidade UO3 and a Logout button. Below the header, there is a large image of a police officer wearing a vest with 'ASAE' and 'POLÍCIA' on it, and a badge that reads 'AGÊNCIA DE SEGURANÇA ALIMENTAR E ECONÔMICA' and 'ÓRGÃO POLÍCIA CRIMINAL FISCALIZAÇÃO'. A white dropdown menu is open over the image, containing two options: 'Nova fiscalização' and 'Consultar fiscalização'. The main content area below the image contains the text: 'Homepage'. At the bottom left, there is some descriptive text about the application's objectives and a small note about JavaScript.

Entidades ▾ Densidades Fiscalizações ▾ Denúncias ▾ Dashboards ▾ Videos Ajuda

(ester) Ester Esteves - Unidade UO3 Logout

Nova fiscalização  
Consultar fiscalização

ASAE  
POLÍCIA

AGÊNCIA DE SEGURANÇA ALIMENTAR E ECONÔMICA  
ÓRGÃO POLÍCIA CRIMINAL  
FISCALIZAÇÃO

Homepage

Esta aplicação foi criada com o intuito de atingir dois objectivos:

- Exploração da informação disponível;
- Como uma base de teste, experimentação e visualização dos diferentes módulos: classificação, geocodificação, duplicação, rotas de fiscalização, ...

javascript:void(0)

# *Intelligent Information and KPIs Visualization*



## Homepage

Utilize o navegador **Chrome** para uma melhor experiência, particularmente nas *fiscalizações* e *Nova Entidade*.

Esta aplicação foi criada com o intuito de atingir dois objectivos:

# IA.SAE - Artificial Intelligence for Food and Economic Safety



- **Effective decision support**, based on **Artificial Intelligence** techniques
- Provide **ASAE specialists** with additional means to increase their efficiency
- **Sensitize economic agents** to the importance of **law enforcement**
- **Increase in national food and economic security**
- **Increased consumer confidence**



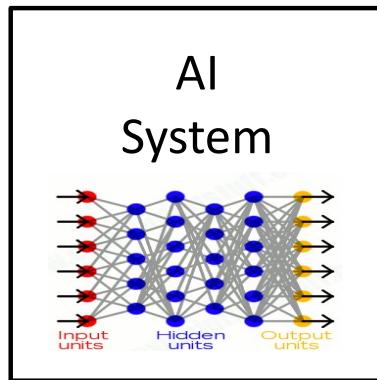
*Artificial Intelligence and  
Computer Science Laboratory of  
the University of Porto*



*Portuguese Food and  
Economic Security  
Authority*



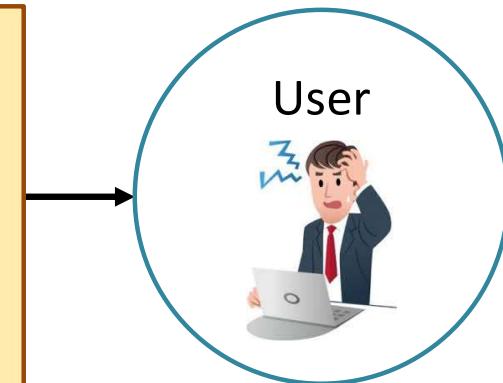
# Explainable Artificial Intelligence - XAI



The central box contains four images illustrating various AI applications:

- QA - Watson**: A photograph of the Jeopardy! game show set. Watson is competing against Ken Jennings and Brad Rutter. The screen shows scores of \$200, \$4,000, and \$600, along with categories like "Maxwell's silver hammer" and "FRANK SINATRA".
- Games - AlphaGo**: A photograph of a Go board with black and white stones, illustrating the AI system's success in the complex board game.
- Decision-Making**: A photograph of a person in military or scientific attire sitting at a desk with multiple computer monitors displaying data and maps, representing AI in decision-making scenarios.
- Robot Operations**: A photograph of two soldiers operating a robotic arm or vehicle in an outdoor setting.

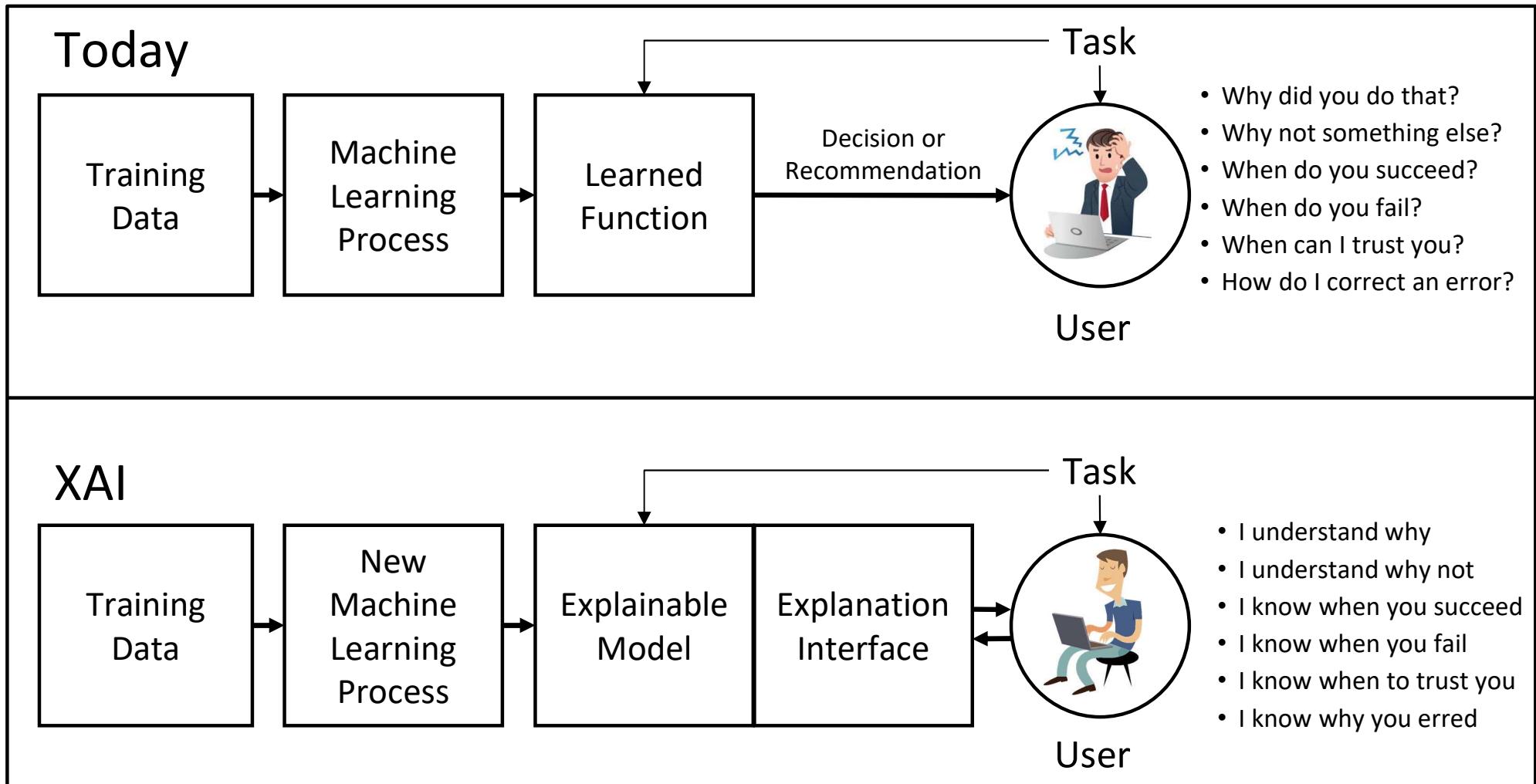
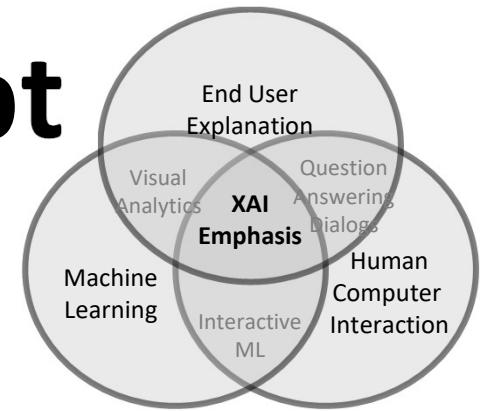
- New age of AI applications
- Machine learning is the core technology
- Machine learning models are black-box, non-intuitive, and difficult for people to understand
- AI effectiveness limited by the machine's inability to explain its decisions and actions to users
- Explainable AI will be essential for users to understand, trust, and use AI



- Why did you do that?
- Why not something else?
- When do you succeed?
- When do you fail?
- When can I trust you?
- How do I correct an error?

Adapted from [Gunning, 2016]

# Explainable AI Concept



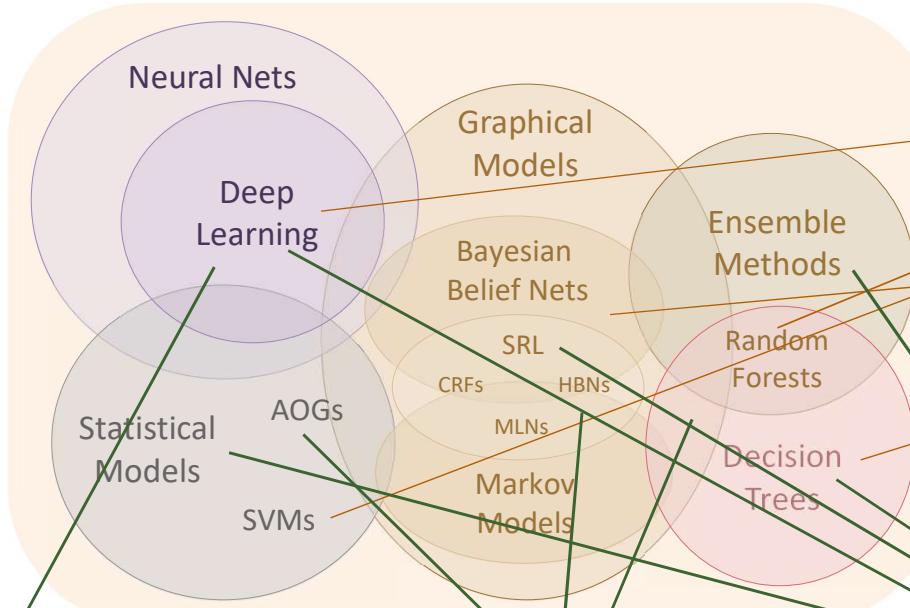
Adapted from [Gunning, 2016]

# Explainable AI/ML Models

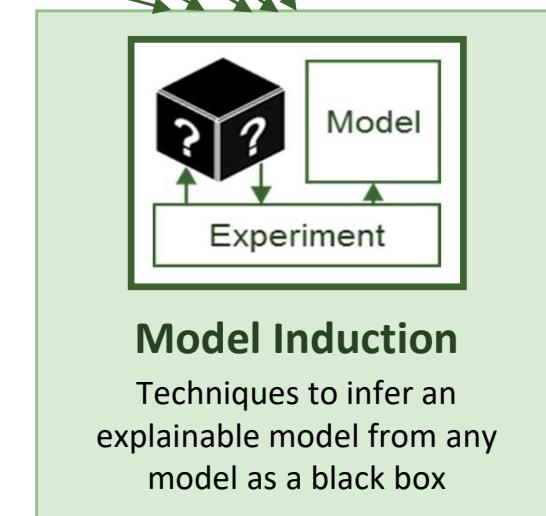
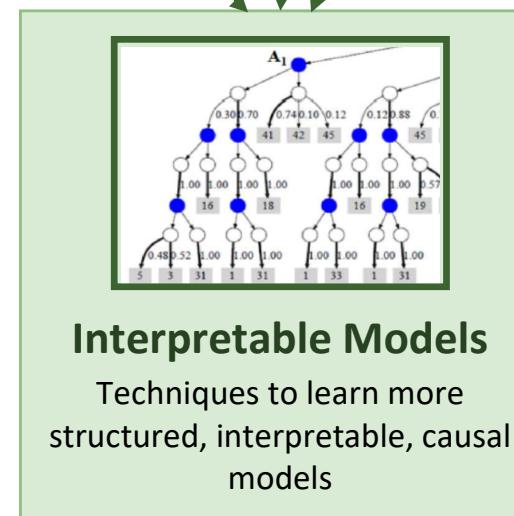
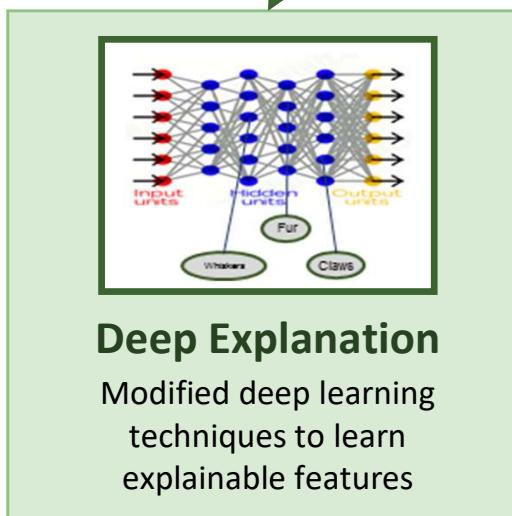
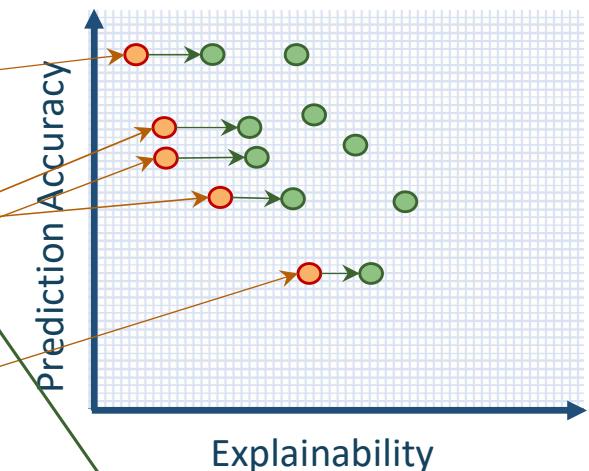
## XAI Approach

Create machine learning techniques that produce more explainable models, while maintaining a high-level of learning performance

## Learning Techniques (today->tomorrow)



## Explainability (Today ->Tomorrow)



Adapted from [Gunning, 2016]

# Ethics in Artificial Intelligence

- **Ethics of artificial intelligence**

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

- **“Robot Ethics”**

Refers to the **morality of how humans design, construct, use and treat robots** and other artificially intelligent beings.

It considers both how artificially intelligent beings may be used to **harm humans** and how they may be used to **benefit humans**.

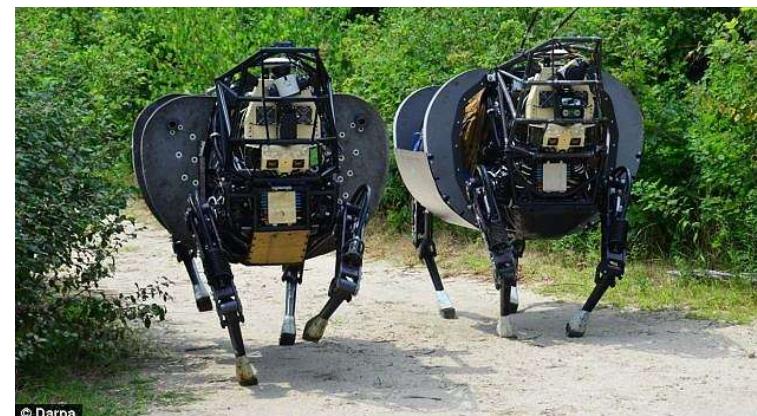
- **"Robot Rights"**

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

These could include the **right to life and liberty, freedom of thought and expression and 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. LAWs 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**



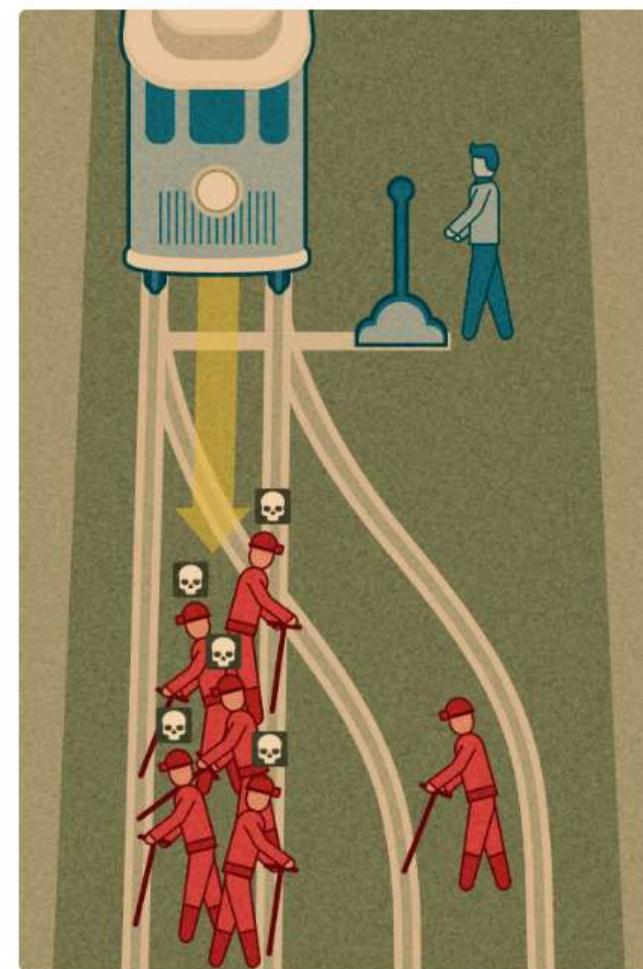
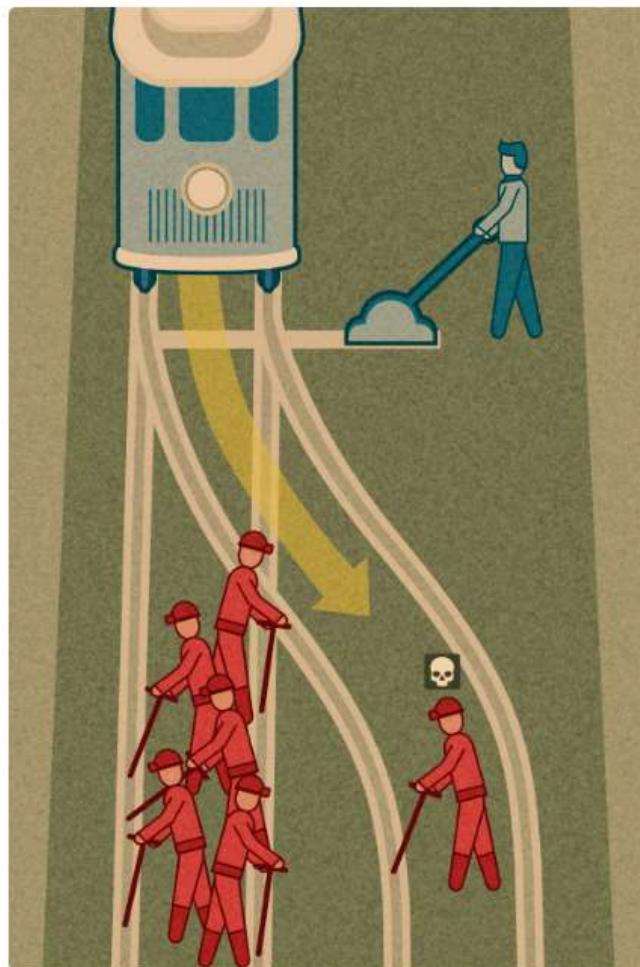
# Asimov's Robotic Laws

- 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



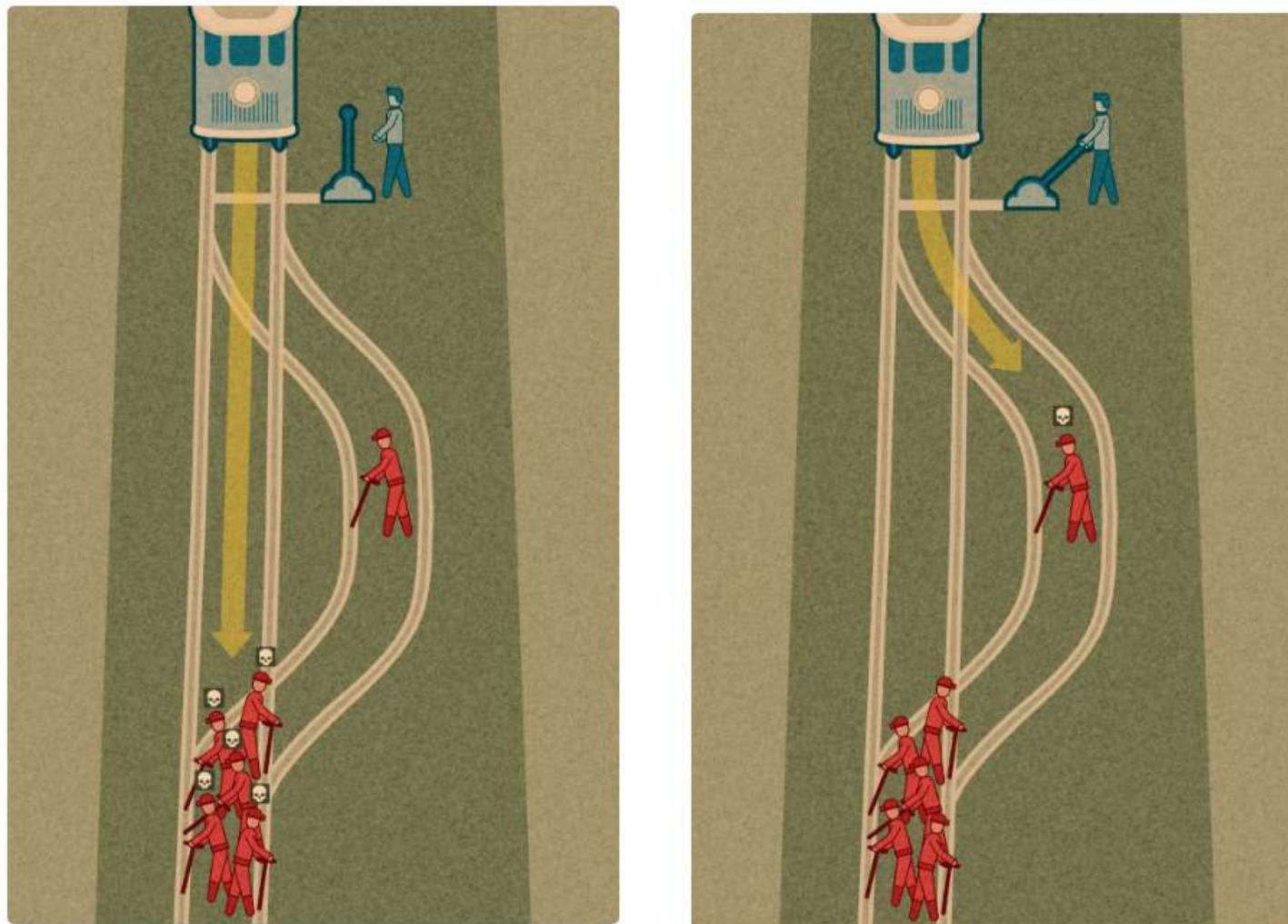
# Moral Machine (1)

What should the man in blue do?



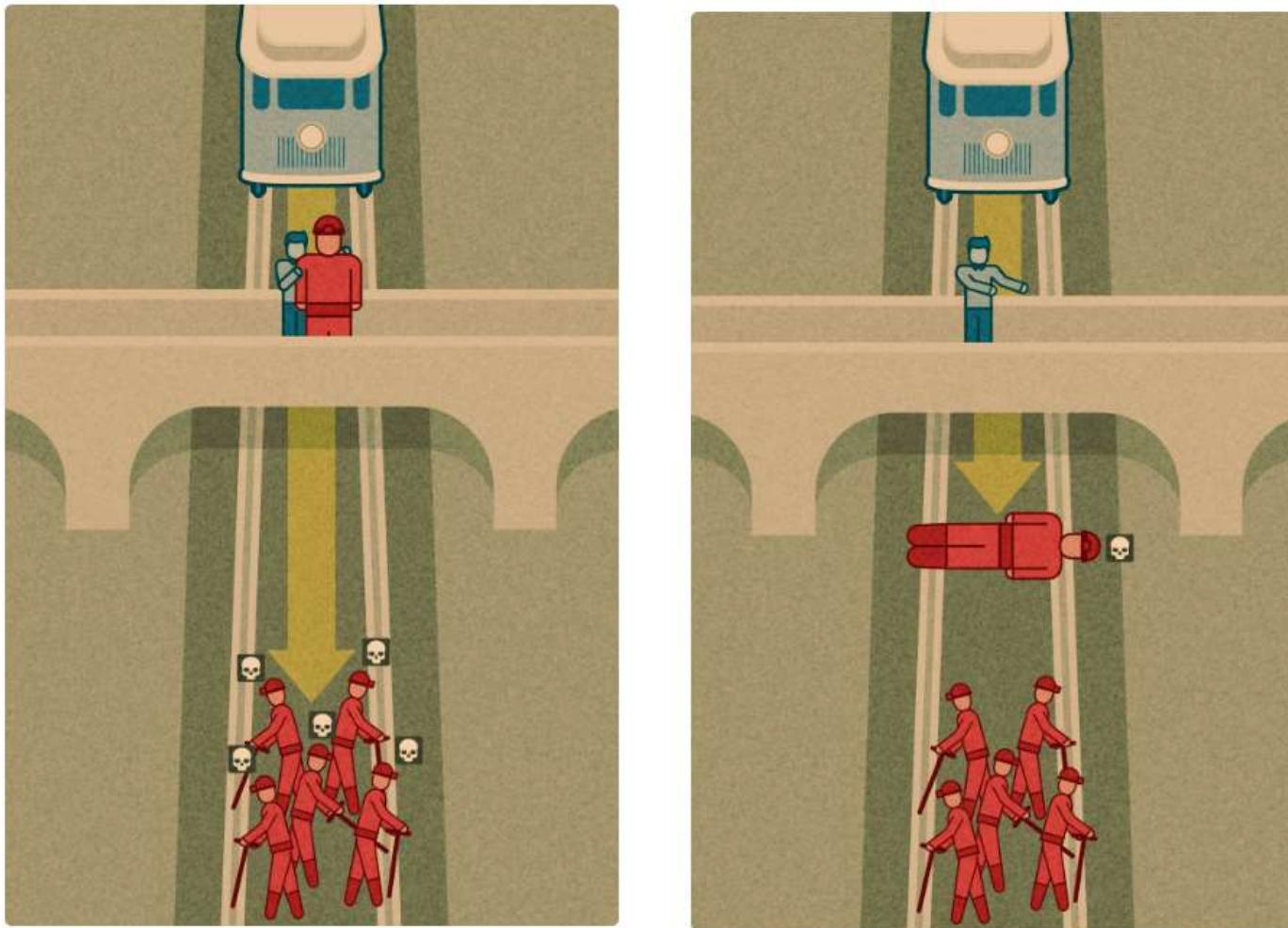
# Moral Machine (2)

What should the man in blue do?



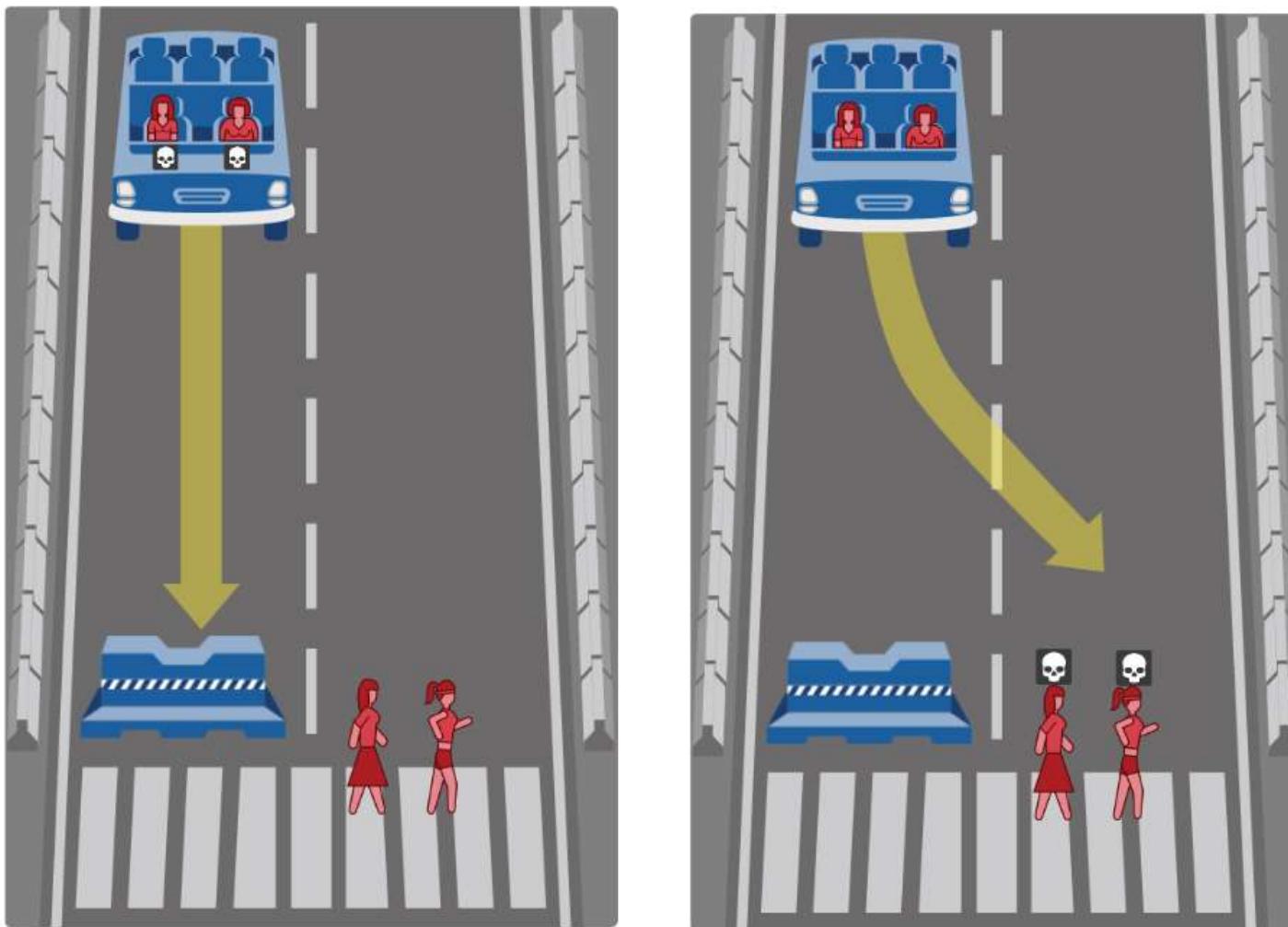
# Moral Machine (3)

What should the man in blue do?

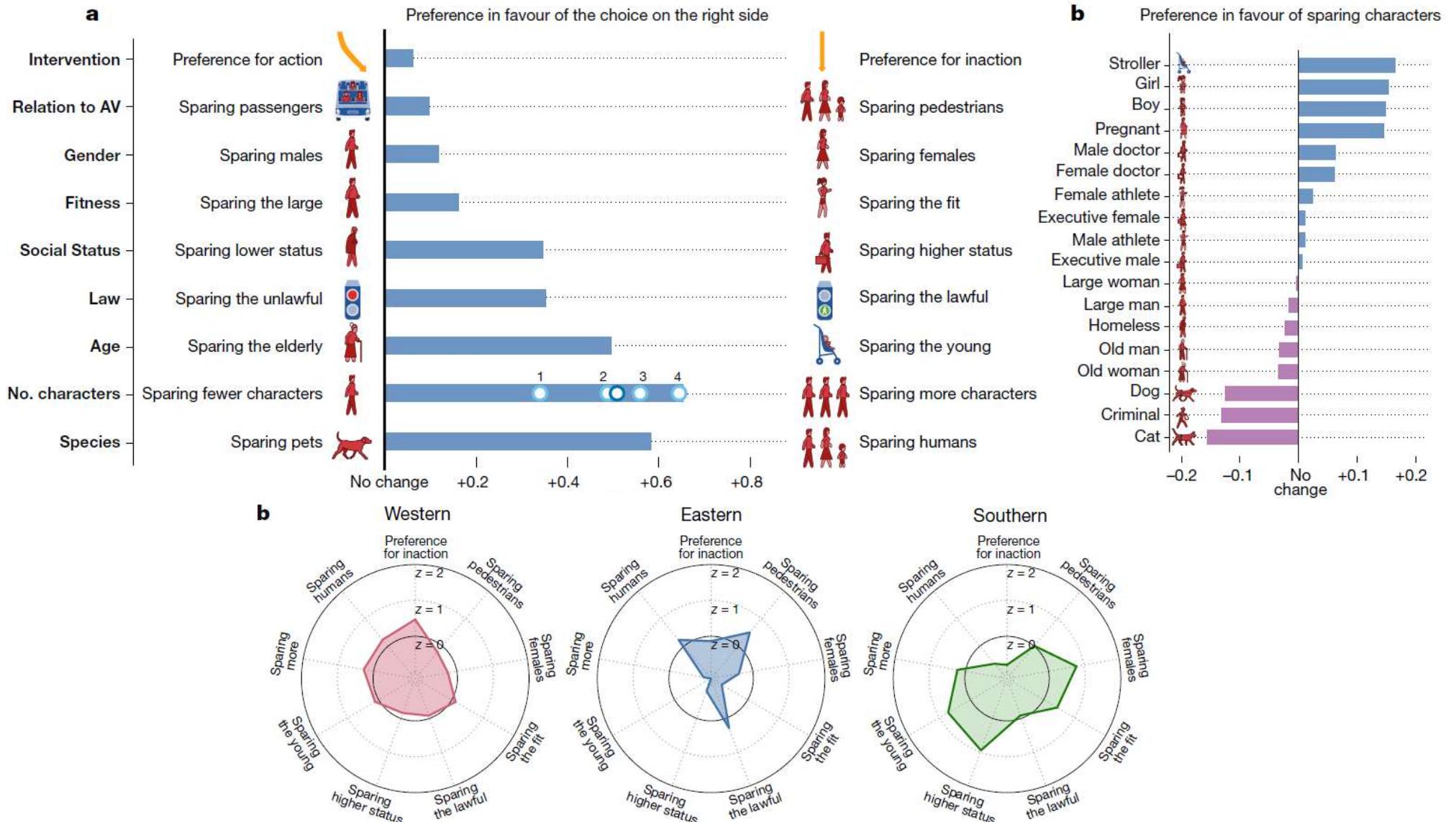


# Moral Machine (4)

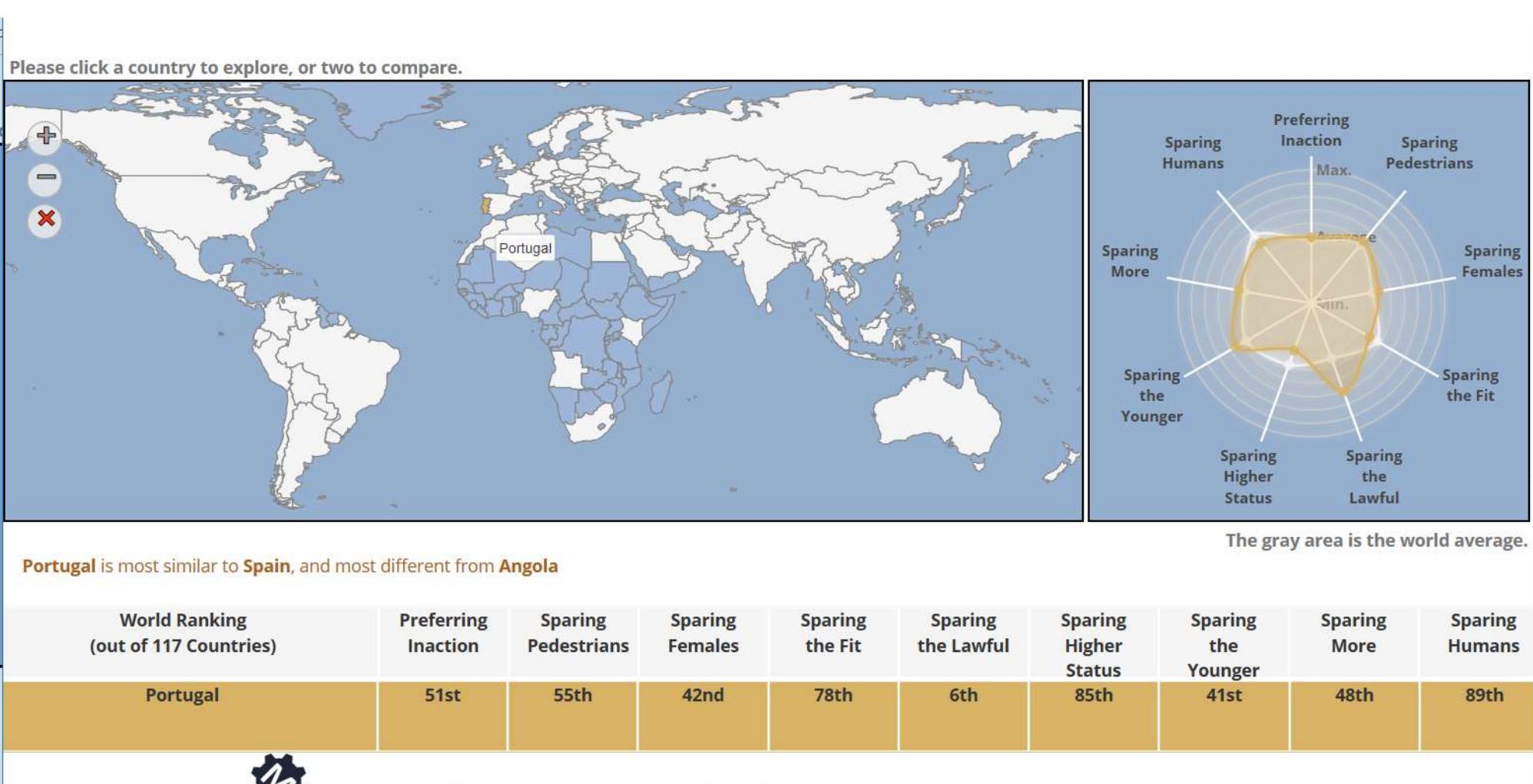
What should the self-driving car do?



# Moral Machine – Results (1)



# Moral Machine – Results (2)



# AI in Government

- UAE Ministry of Artificial Intelligence - <http://www.uaeai.ae/en/>

The screenshot shows the official portal of the UAE Government, Government.ae. The page features the UAE coat of arms and the text "Government.ae" with "The Official Portal of the UAE Government". Navigation links include "Home", "Information and service", "العربية" (Arabic), "Other languages", "Accessibility", "Help", and "Register". A main text block states that in October 2017, the UAE Government launched the "UAE Strategy for Artificial Intelligence (AI)". It aims to achieve the objectives of UAE Centennial 2071, boost government performance, use an integrated smart digital system, and make the UAE the first in AI investments. Below this, a breadcrumb navigation shows "About the UAE > Strategies, initiatives and awards > Federal governments' strategies and plans > UAE Strategy for Artificial Intelligence". A large graphic titled "Saving 50% of annual costs using Artificial Intelligence" highlights three key figures: 250 million paper transactions per year, 190 millions of hours wasted, and 1,000 million KM covered by long-distance travel. The graphic is set against a background of stylized UAE landmarks and circuit board patterns. On the right, a photo of UAE Vice President and Prime Minister Sheikh Mohammed bin Rashid Al Maktoum interacting with a digital screen is shown, along with the UAE Artificial Intelligence Strategy logo and a summary of the strategy's goals.

In October 2017, the UAE Government launched '[UAE Strategy for Artificial Intelligence \(AI\)](#)'. This marks the post-mobile government phase which will rely on various future services, sectors and infrastructure projects. The strategy is first of its kind in the region and the world and it aims to:

- achieve the objectives of UAE Centennial 2071
- boost government performance at all levels
- use an integrated smart digital system that can overcome challenges and provide quick efficient solutions
- make the UAE the first in the field of AI investments in various sectors

About the UAE > Strategies, initiatives and awards > Federal governments' strategies and plans > UAE Strategy for Artificial Intelligence

**Saving 50% of annual costs using Artificial Intelligence**

**250** million paper transactions per year in the federal government

**190** millions of hours a year are wasted because of transactions

**1,000** million KM covering long distances in the UAE to finalize transactions

UAE Vice President and Prime Minister and Ruler of Dubai His Highness Sheikh Mohammed bin Rashid Al Maktoum has launched the UAE's first Artificial Intelligence (AI) strategy, marking a new level of innovation built on Smart Government. The strategy is the first of its kind in the region and the world and will see investment in the latest AI technologies and tools to enhance government performance and efficiency

# Artificial Intelligence – The Future

- **Super Artificial Intelligence**

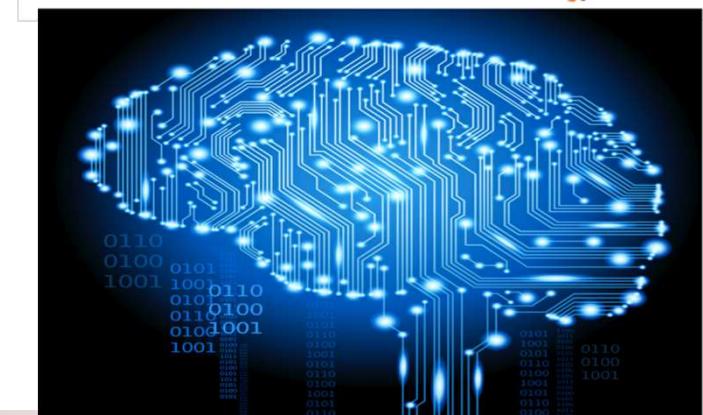
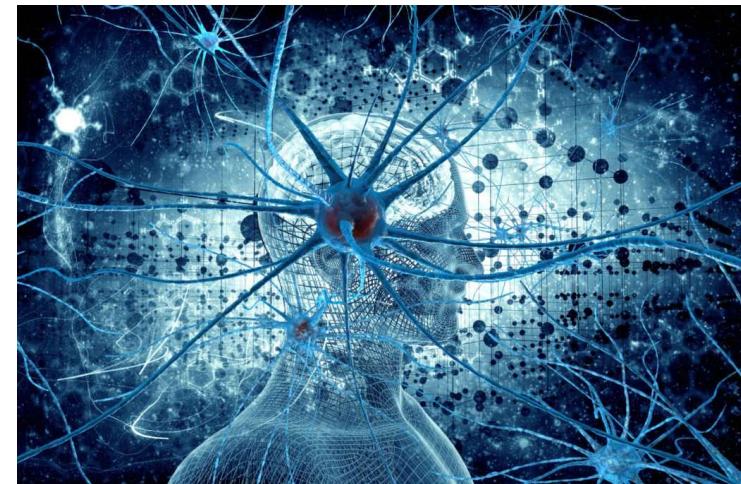
Hypothetical agent that possesses **intelligence far surpassing that of the brightest and most gifted human minds**

- **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!**



# **Detailed Program**

- I. Introduction to Artificial Intelligence (AI)**
- II. Intelligent Agents and Multi-Agent Systems**
- III. Problem Solving Methods**
- IV. Optimization and Metaheuristics**
- V. Knowledge Engineering**
- VI. Machine Learning**
- VII. Natural Language Processing**
- VIII. Advanced Topics in Artificial Intelligence**

# Detailed Program

- **I. Introduction to Artificial Intelligence (AI)**  
Definition of AI. Fundamentals, Scope, Evolution and Chronology of AI. Problems and Approaches of AI and Intelligent Systems. AI Applications.
- **II. Intelligent Agents and Multi-Agent Systems**  
The Concept of Agent. Environments. Agent Architectures: Reactive, Deliberative, Goal-Based, Utility Based, Learning and BDI. Multi-Agent Systems. Practical Examples of Application.
- **III. Problem Solving Methods**  
Problem Formulation. State Space. Search Strategy. Uninformed Search: Breadth First, Depth First, Uniform Cost, Iterative Deepening, Bidirectional Research. Intelligent Search: Greedy Search, A\* Algorithm. Search with Adversaries: Game Search, Minimax Algorithm, Alpha-Beta Cuts, Search with Imperfect Information. Practical Examples of Application.

# Detailed Program

- **IV. Optimization and Metaheuristics**

Formulation of Decision/Optimization Problems. Combinatorial Optimization Problems. Metaheuristics. Hill-Climbing, Simulated Annealing, Tabu Search, "Ant Colony". Genetic Algorithms and Evolutionary Computation. Constraint Satisfaction. Practical Examples of Application.

- **V. Knowledge Engineering**

Knowledge Representation and Reasoning. Propositional and Predicate Logic. Semantic Networks, Frames, Rules, and Ontologies. Logic Programming and Constraints. Reasoning with Uncertain Knowledge. Knowledge-Based Systems. Practical Examples of Application.

- **VI. Machine Learning**

Types of Machine Learning. Unsupervised Learning. Supervised Learning. Decision Trees. Artificial Neural Networks. Support Vector Machines. Reinforcement Learning. Q-Learning, SARSA, SAC and PPO Algorithms. Deep Learning. Practical Application Examples.

# Detailed Program

- **VII. Natural Language Processing**

Processing Levels. Syntactic and Semantic Analysis. Classical Approach. Definite Clauses Grammars. Statistical Approach. Text Mining. Machine Learning in NLP. Deep Learning in NLP. Practical Application Examples.

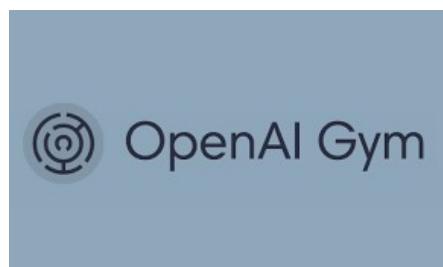
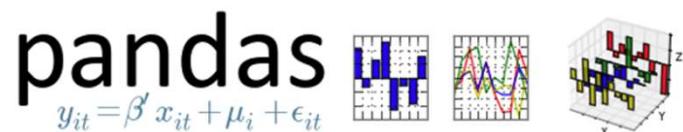
- **VIII. Advanced Topics in Artificial Intelligence**

Interaction, Planning and Scheduling, AI for Games, Intelligent Simulation, Social Intelligence. Cloud AI. The Future of AI. IA and the Society. Beneficial IA. Explainable AI. Machine Ethics. Weak and Strong IA. Super Intelligence. The Singularity.

# Some Useful Tools



IP[y]: IPython  
Interactive Computing



# IART – Classes Operation/Methodology

- **Theoretical Classes (Monday 9-11)**
  - Interactive Exhibition of AI Subjects
  - Exercises Proposal and Solving
  - Evaluations (Kahoots)
- **Practical Classes (8 practical classes per week on Tuesday and Wednesday morning):**
  - Exercises Proposal and Solving
  - Monitoring of Practical Work
  - Evaluation of Practical Assignments/Work

# IART – Evaluation

- **Two Mini-Exams: 40%**
  - Mini-Exams, 1h30m, with consultation, with practical exercises to be performed at Moodle
- **Practical Assignments: 50%**
  - Assignment 1: 25% (groups of 3 students)  
(Problem Solving or Adversarial Games or Optimization)  
(Presentation, Code and Demo)
  - Assignment 2: 25% (groups of 3 students)  
(Supervised Learning or Reinforcement Learning or Natural Language Processing)  
(Presentation, Code and Demo)
- **Class Participation: 10%**
  - Kahoots/Activities at Moodle (best 6 out of around 12 Kahoots)

# Bibliografia/Bibliography

- Bibliography
  - Stuart Russell, Peter Norvig, [Artificial intelligence: A Modern Approach, 3<sup>rd</sup> Edition.](#)
- Complementary Bibliography
  - David Poole, Alan Mackworth, [Artificial Intelligence: Foundations of Computational Agents, 2<sup>nd</sup> edition](#)
  - Stuart Russell, Peter Norvig; Artificial intelligence: A Modern Approach, 4<sup>th</sup> Edition
  - Richard Sutton, Andrew Barto: Reinforcement Learning - An Introduction, 2<sup>nd</sup> edition

# Conclusions

- IART Course is an Introduction to Artificial Intelligence and its main areas and applications
- Two practical assignments that will allow the students to explore various areas of AI
- Program includes:
  - Intelligent Agents and MAS, Problem Solving Methods, Optimization and Meta-heuristics, Knowledge Engineering, Machine Learning: Supervised/ Unsupervised/ Reinforcement, Natural Language Processing and Advanced AI Topics
- AI has a great present and above all future impact on industry, services and public administration

# IART - Artificial Intelligence

**Luís Paulo Reis**

[lpreis@fe.up.pt](mailto:lpreis@fe.up.pt)

Director of LIACC – Artificial Intelligence and Computer Science Lab., UPorto  
Associate Professor at Faculty of Engineering of the University of Porto  
President of APPIA – Portuguese Association for Artificial Intelligence

