

IART - Artificial Intelligence

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Artificial Intelligence (AI)

- **Intelligence**

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



- **Artificial Intelligence**

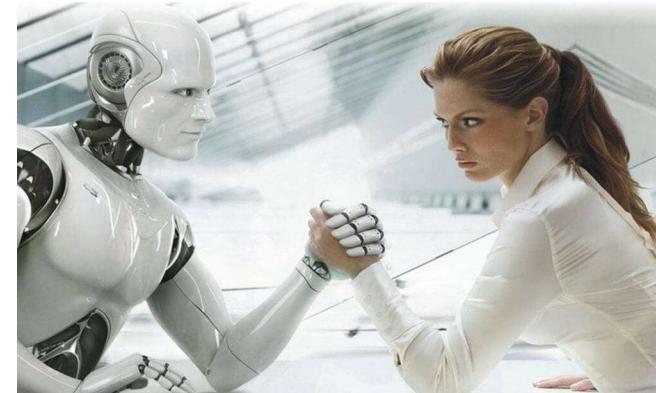
- “Science concerned with building **intelligent machines**, that is, machines that perform tasks that when performed by humans require intelligence”



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**

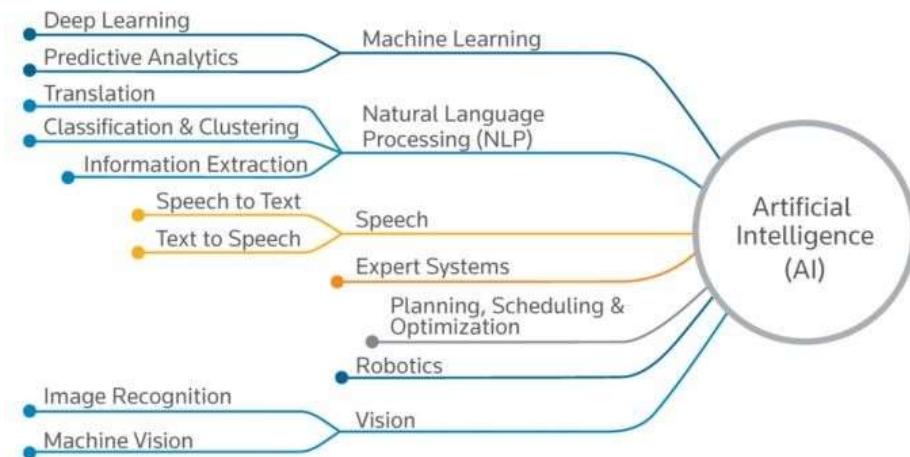
Strong AI or Artificial General Intelligence (AGI) is the intelligence of a machine that could successfully perform **any intellectual task** that a human being can! Science fiction ?



Areas of Artificial Intelligence

Some AI Areas:

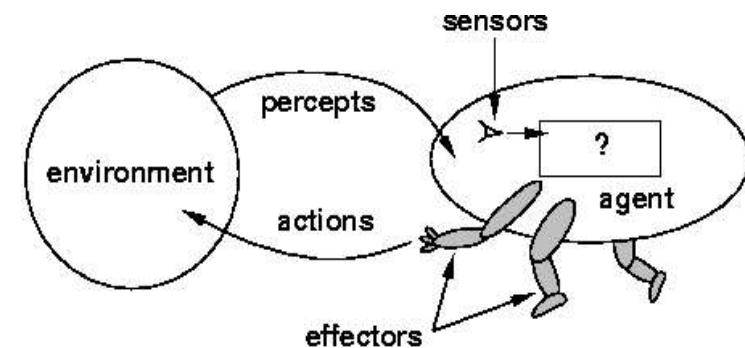
- Knowledge Representation and Reasoning
- Problem Solving
- Planning and Scheduling
- Machine Vision
- Natural Language Processing
- Machine Learning
- Machine Vision
- Intelligent Robotics



AI - Autonomous Agents and Multi-Agent Systems

Agent:

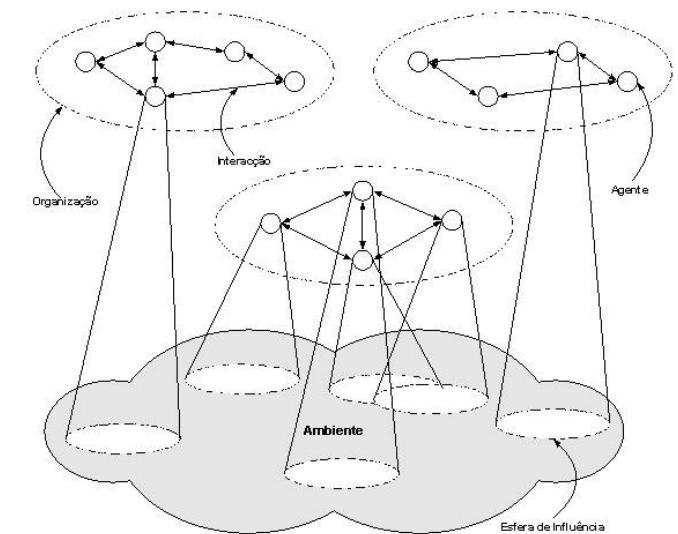
“Computational System, situated in a given **environment**, that has the ability to **perceive** that environment using **sensors** and **act**, in an **autonomous way**, in that environment using its **actuators** to fulfill a given **function**.”



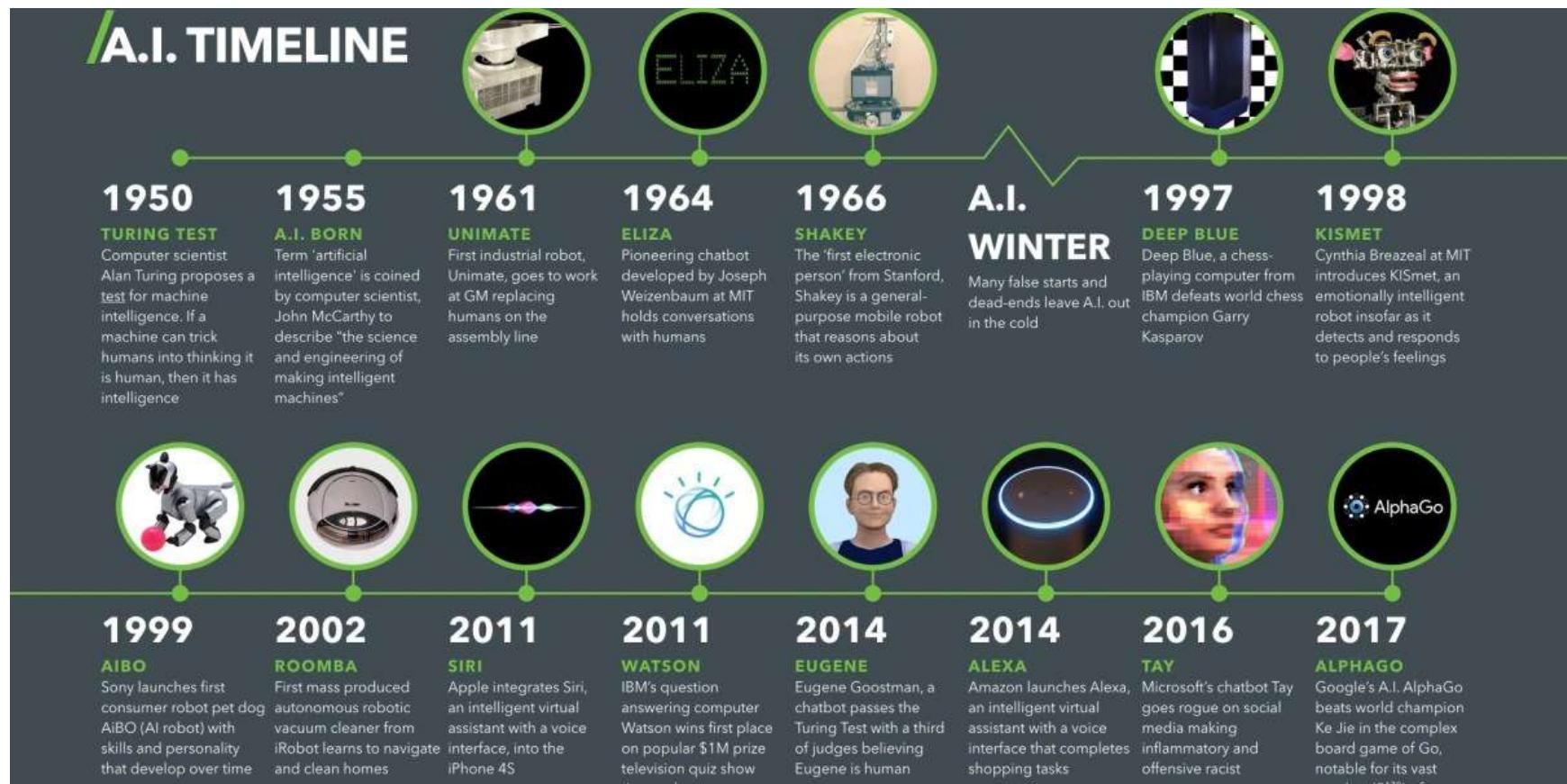
Russel and Norvig, "AI: A Modern Approach", 1995

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

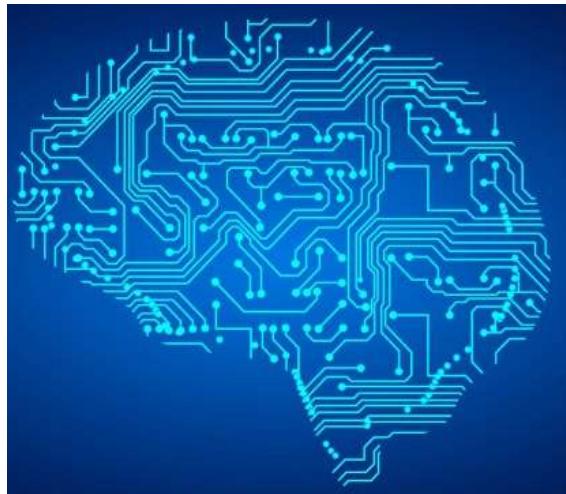


Real Artificial Intelligence

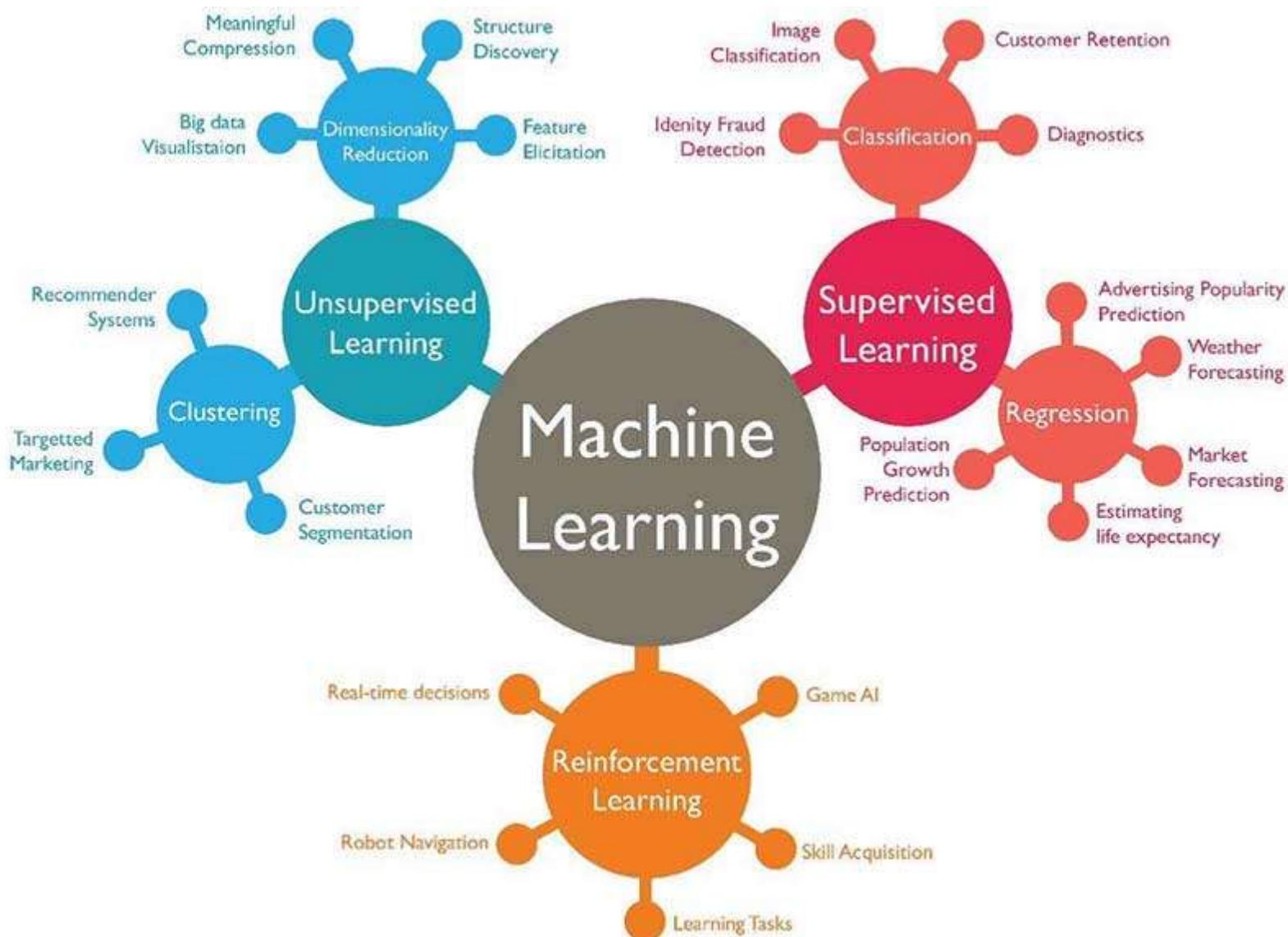
- A very serious science and with incredible developments each year!
- General-purpose AI like the robots of science fiction is still incredibly hard!
- Human brain appears to have lots of special and general functions, integrated in some amazing way that we really do not understand (yet)
- Special-purpose 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



AI - Machine Learning



Programming vs Machine Learning

Traditional Programming



Machine Learning

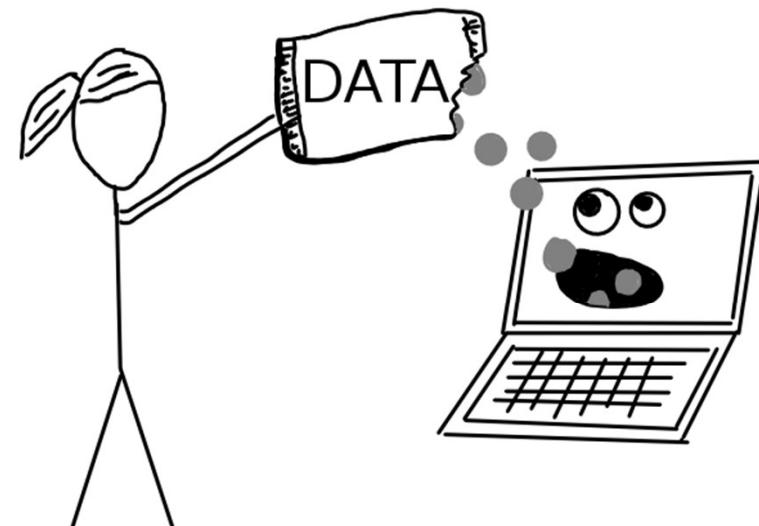


Machine Learning

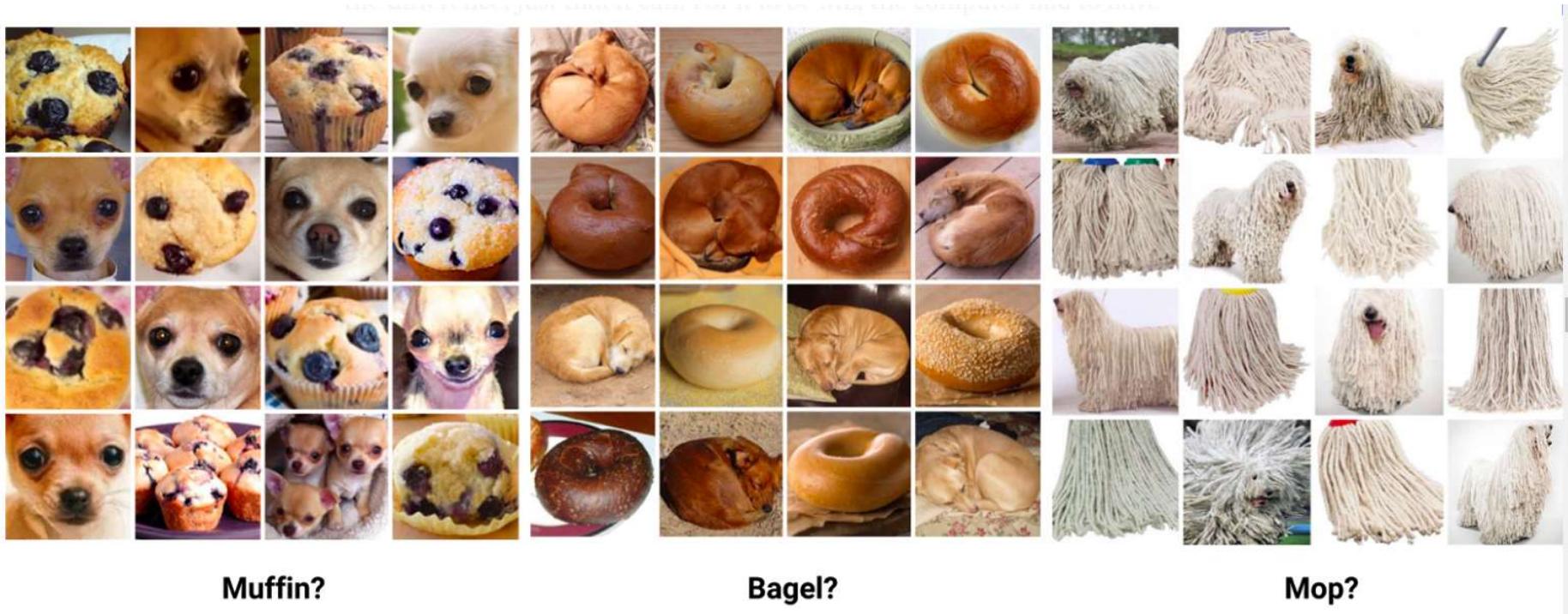
Without Machine Learning



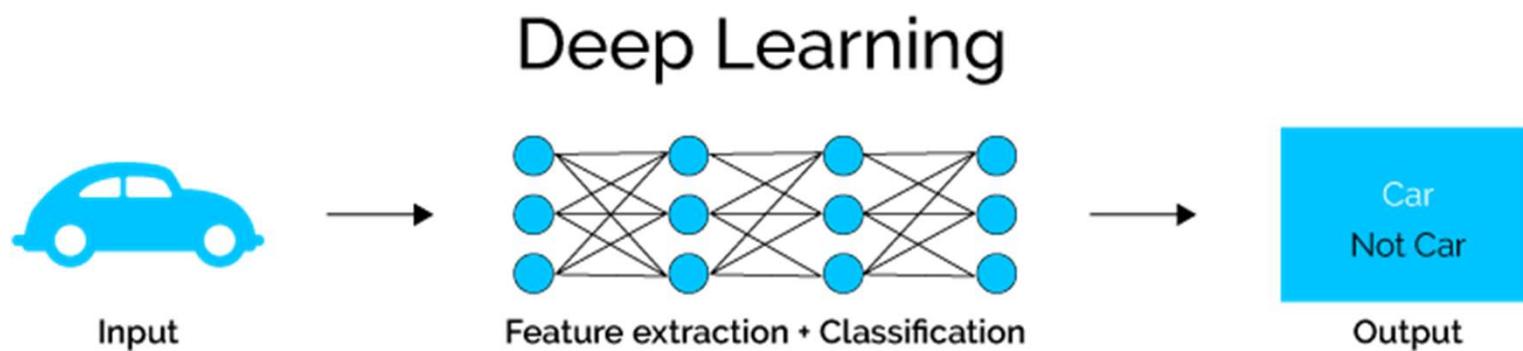
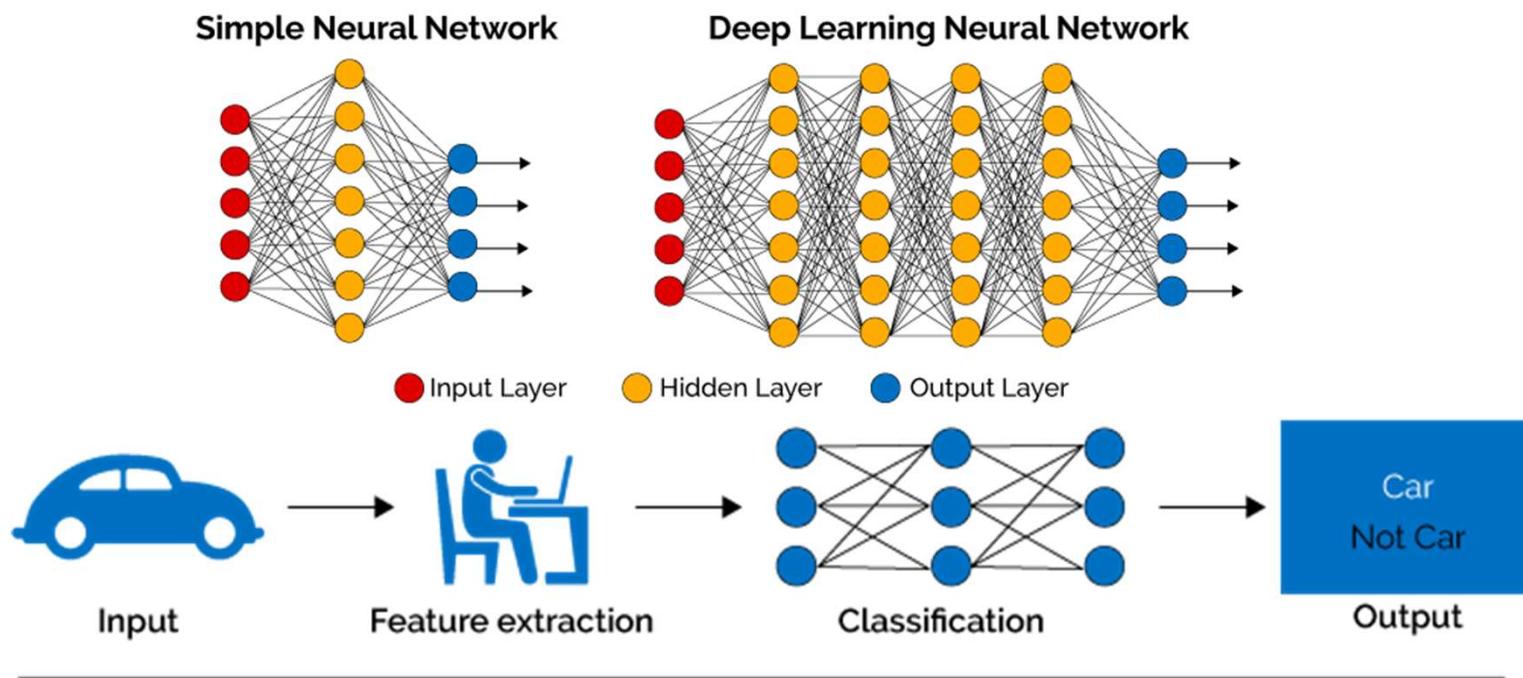
With Machine Learning



Machine Learning

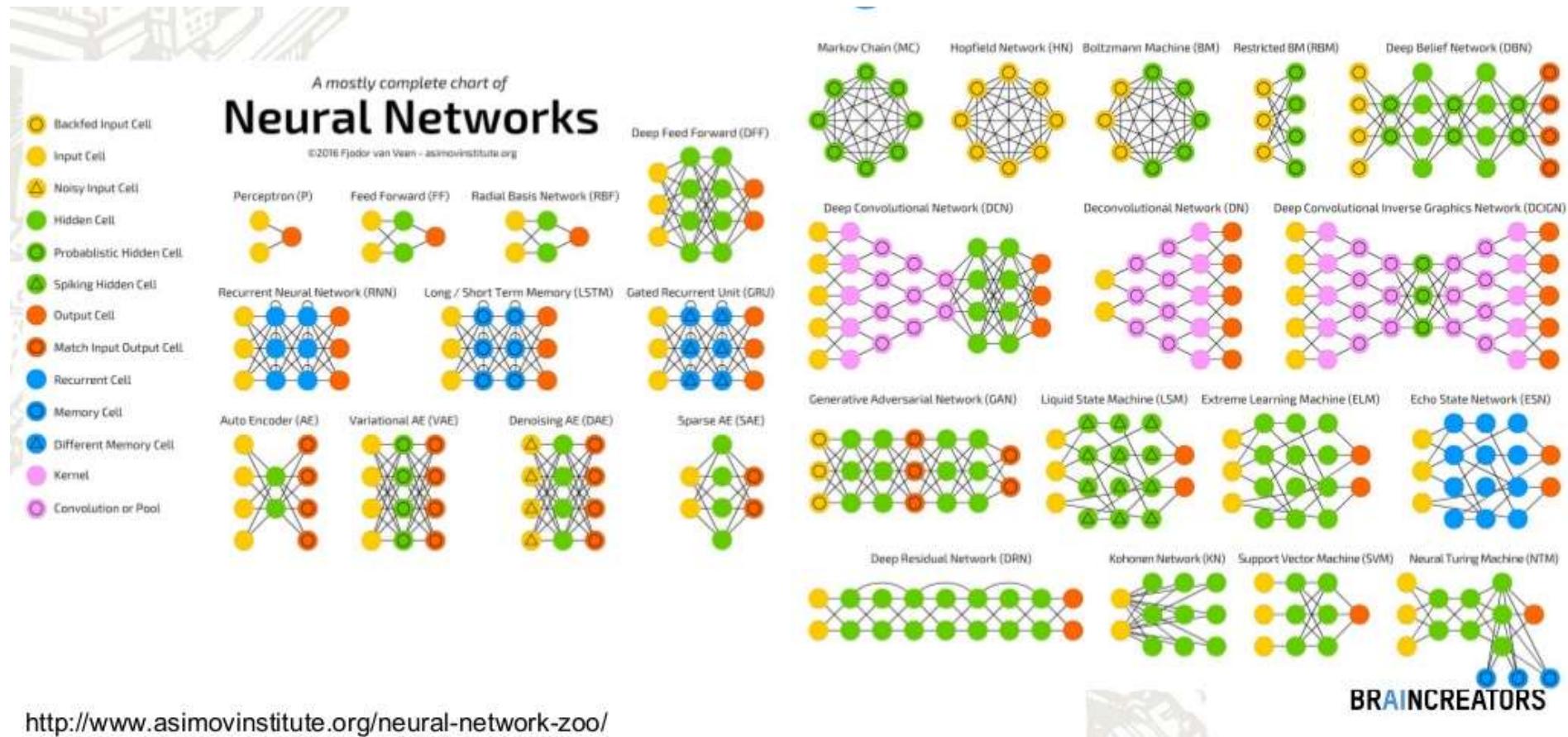


AI - Deep Learning



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

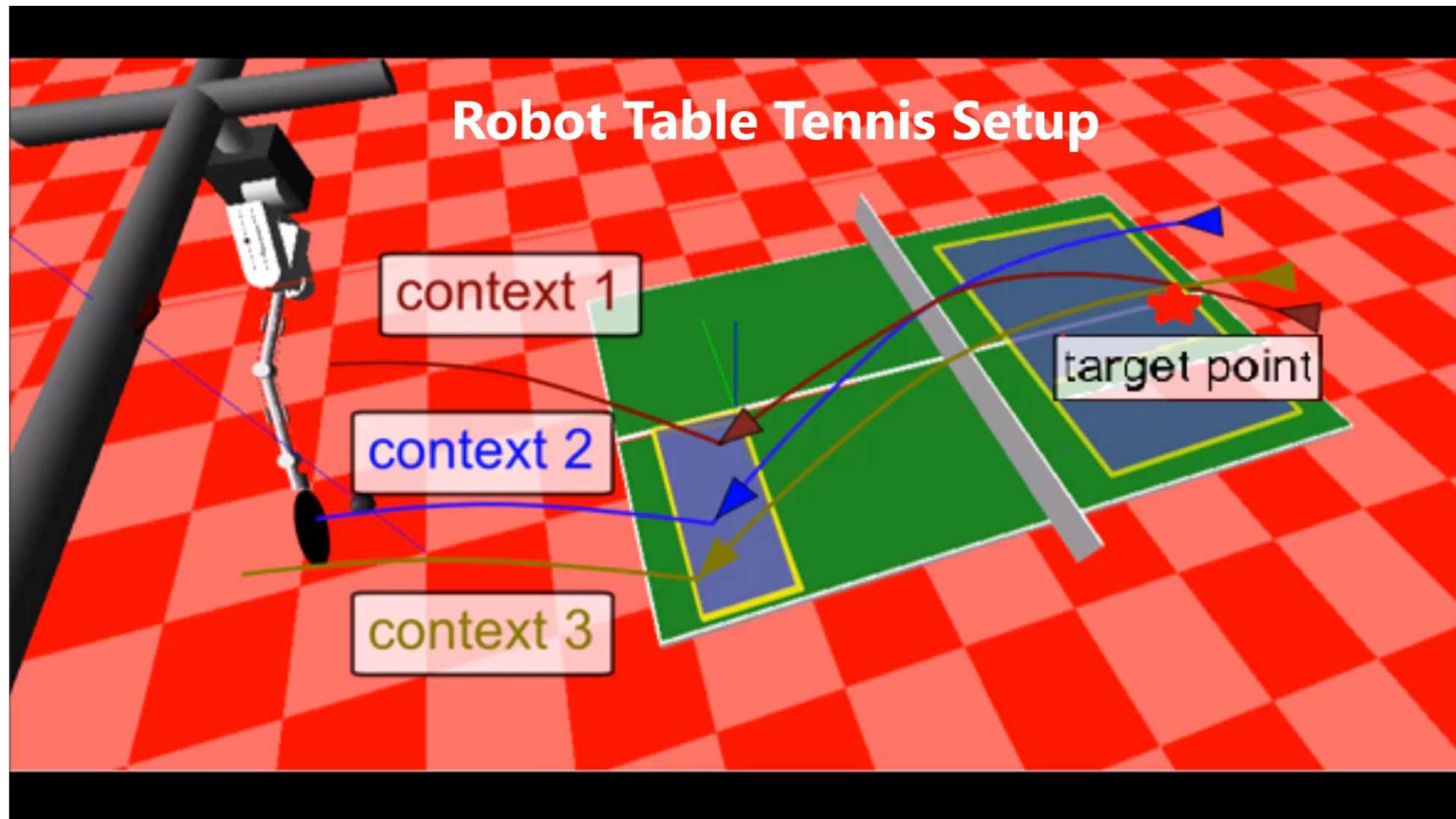
Neural Networks Endless Configurations



Artificial Intelligence: Machine Learning

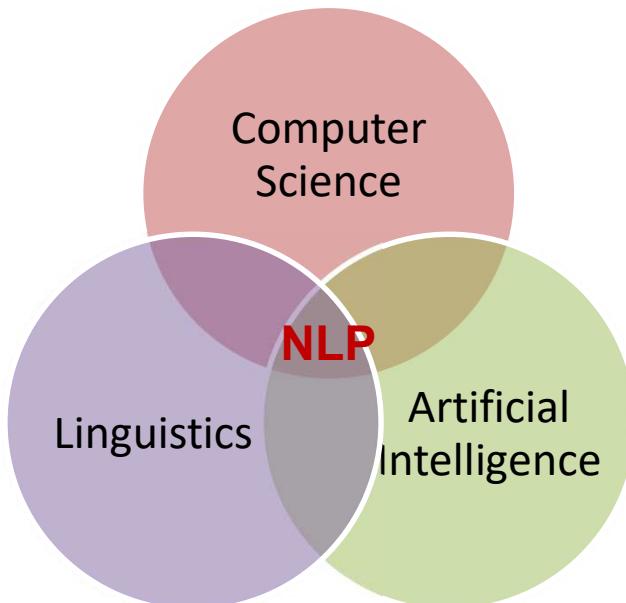


AI: ML – Learning Table Tennis



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**

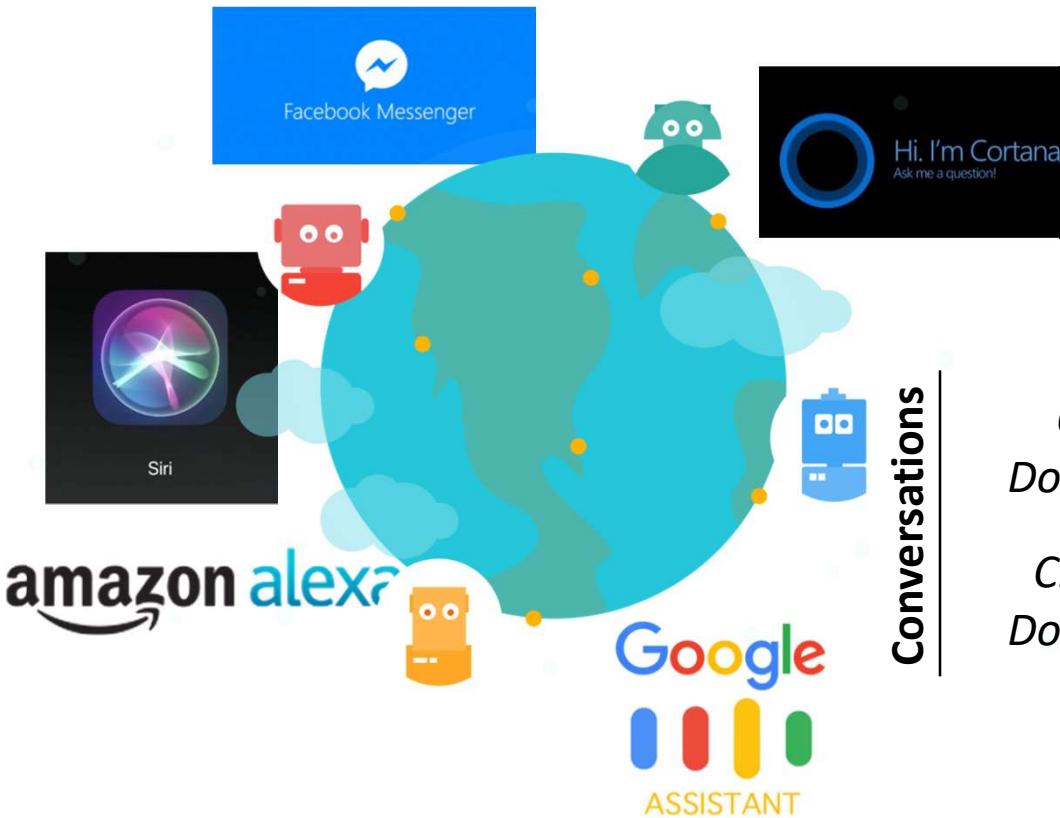
- Convert spoken language to written text and vice versa
- Chatbots, voice control, domotics, readers, ...



AI – NLP: Watson at Jeopardy



AI – Natural Language Processing

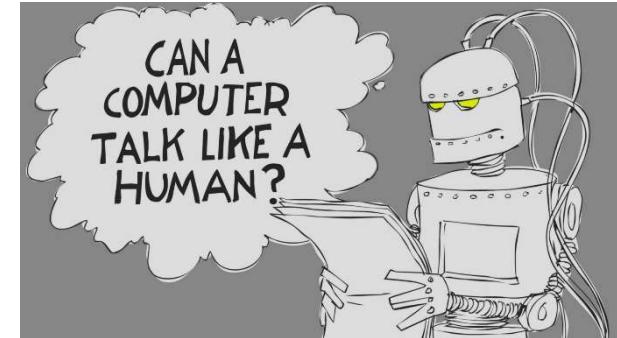
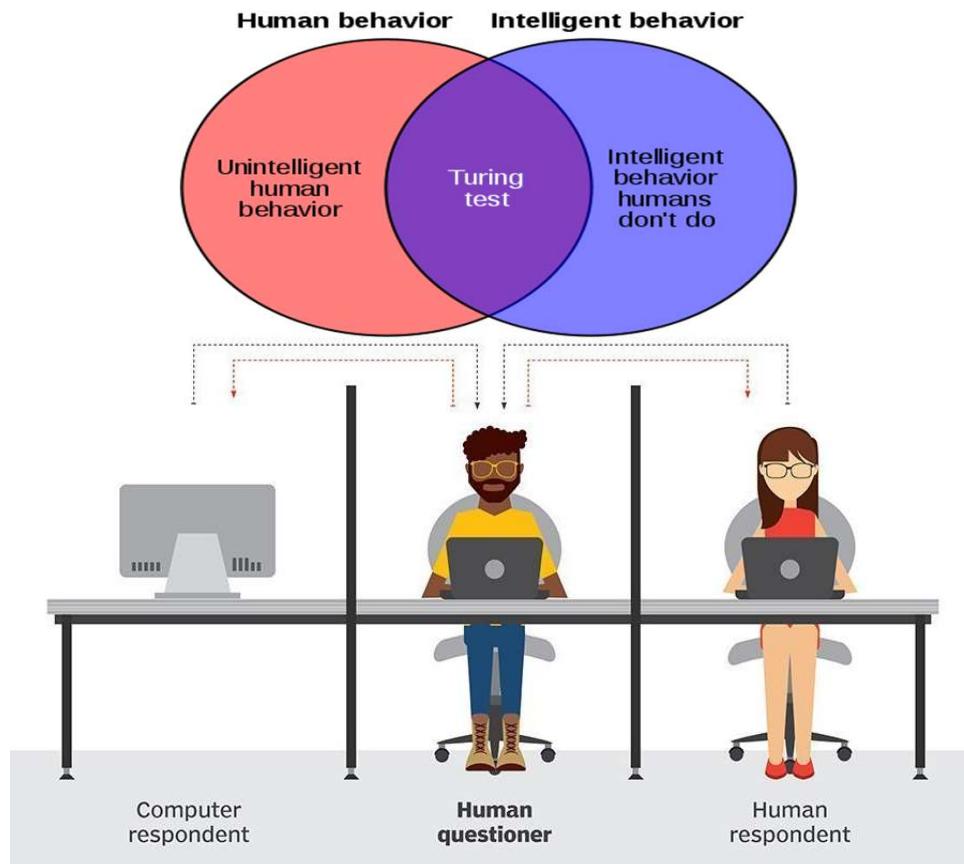


Natural Language Processing and Understanding	
Open Domain	Impossible
Closed Domain	Rules-Based (Easiest)
Retrieval-Based	Generative-Based

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

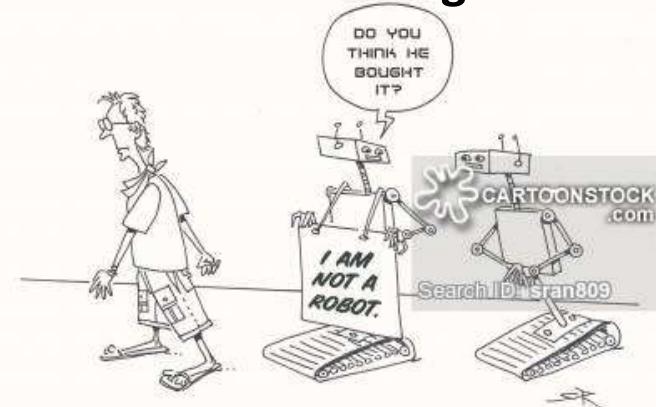
AI: NLP - Turing Test

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



Capabilities:

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

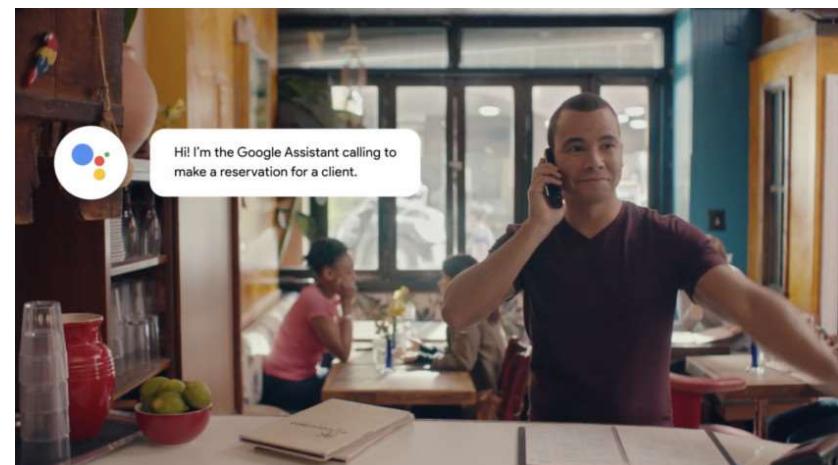
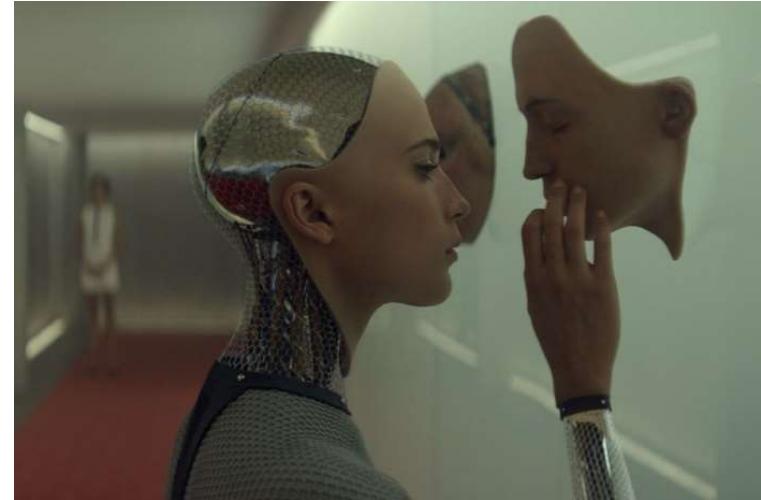


AI: NLP - Turing Test



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

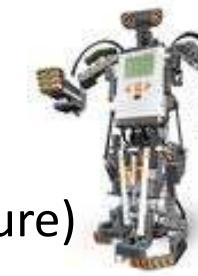
- **Robotics**

- 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!

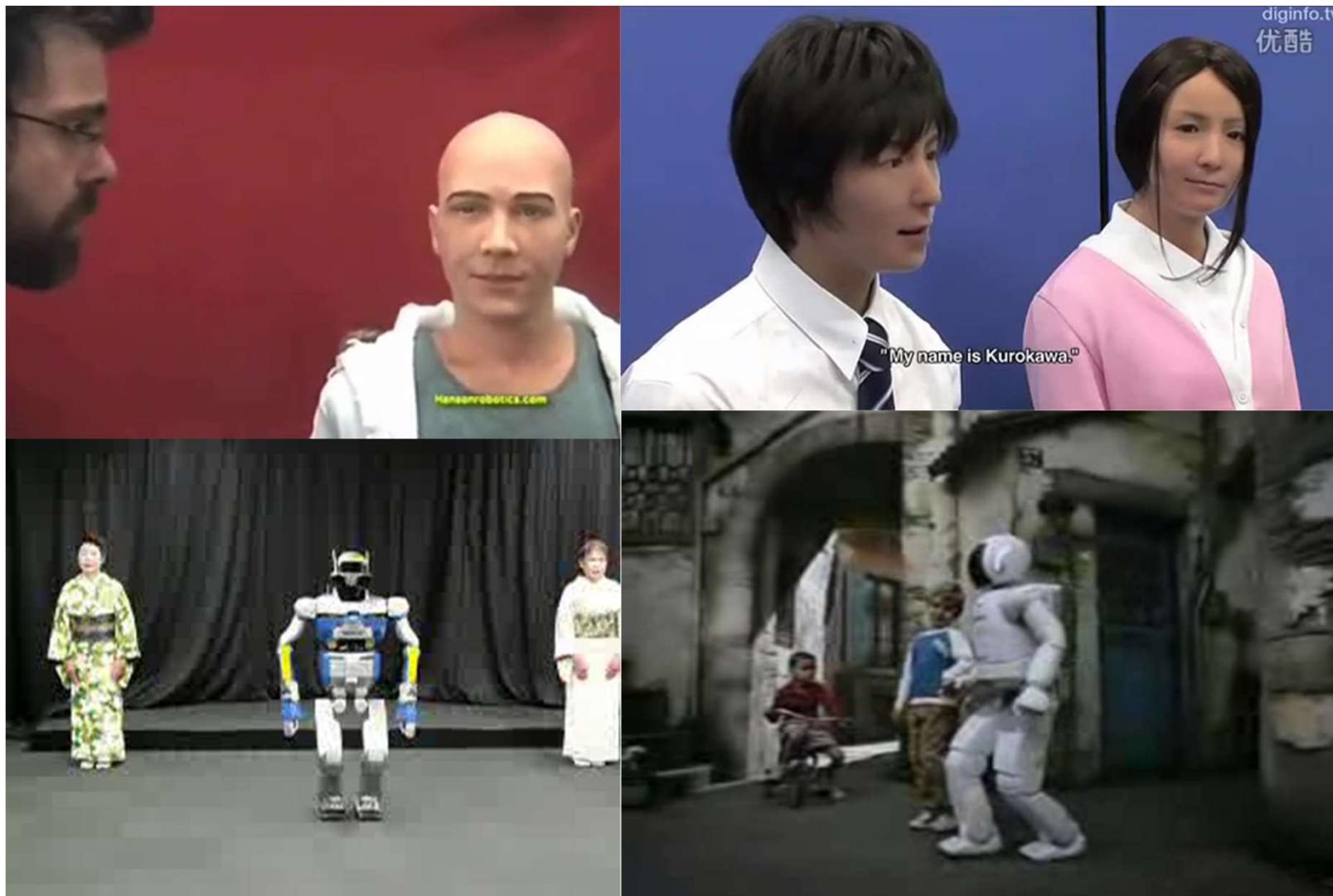


AI - Robotics

- 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**



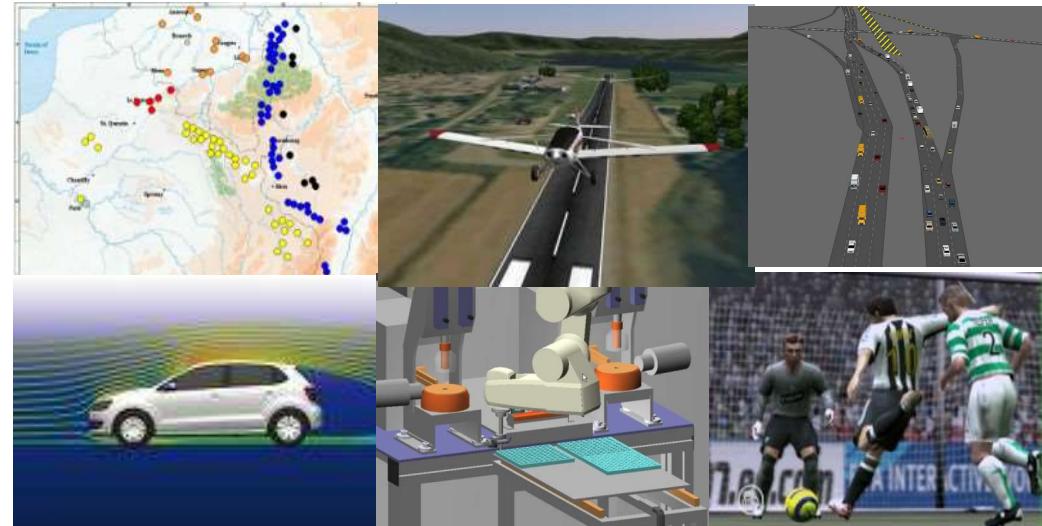
Coordination : “to work in harmony in a group”

- **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

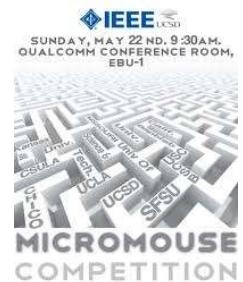
- **Simulation:** Imitation of some real thing, state of affairs, or process, over time, representing certain key characteristics or behaviours of the physical or abstract system
- Applications:
 - Understand system functioning
 - Performance optimization
 - Testing and validation
 - Decision making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



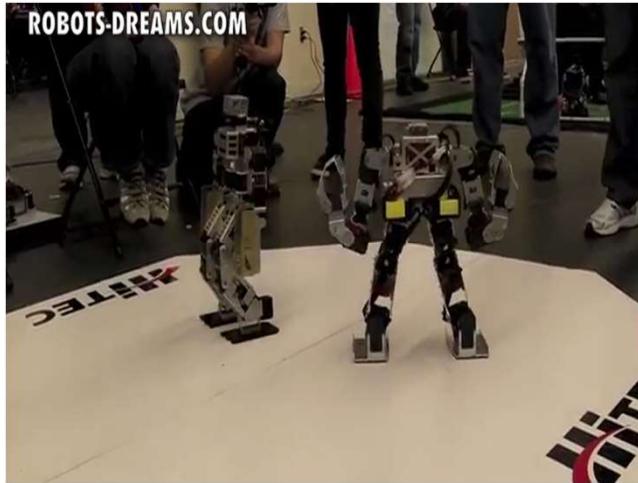
Robotic Games and Competitions



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



AI Projects - Intellwheels



AI Projects - HearBo

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Sound Localization

Speech Decision: 0
Maintain Interaction

Music Decision: 0
Maintain Interaction

Decision/Behavior

ASR Result

IA.SAE – AI for Food and Economic Safety



The screenshot shows a web browser window for 'localhost/index.php' version 'rev_2.12'. The header includes a logo, user information '(ester) Ester Esteves - Unidade UO3', and a 'Logout' button. The main menu has items like 'Entidades', 'Densidades', 'Fiscalizações', 'Denúncias', 'Dashboards', 'Videos', and 'Ajuda'. A dropdown menu over a photo of a police officer's arm features 'Nova fiscalização' and 'Consultar fiscalização'. The photo shows a person in a dark uniform with 'ASAE POLÍCIA' on the sleeve and a gold badge with 'ÓRGÃO DE SEGURANÇA ALIMENTAR E ECONOMICA' and 'POLÍCIA CRIMINAL'.

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, ...

javscript:void(0)

Escreva aqui para procurar

10:43 10/12/2019

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**.

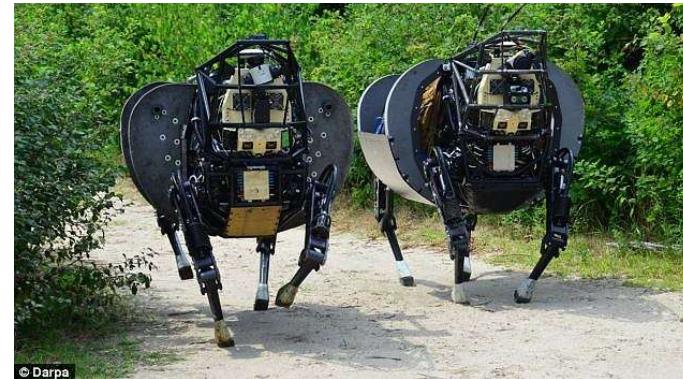
- **"Robot Rights"**

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**



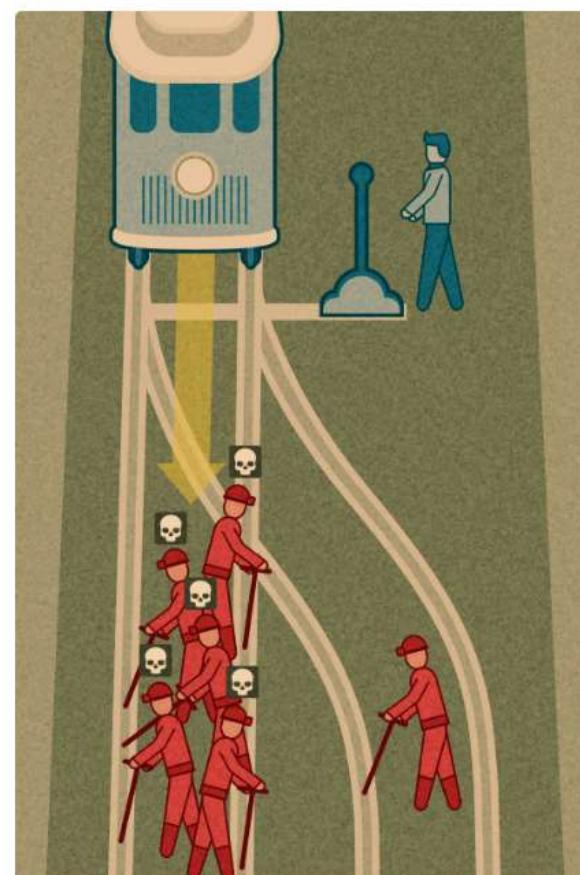
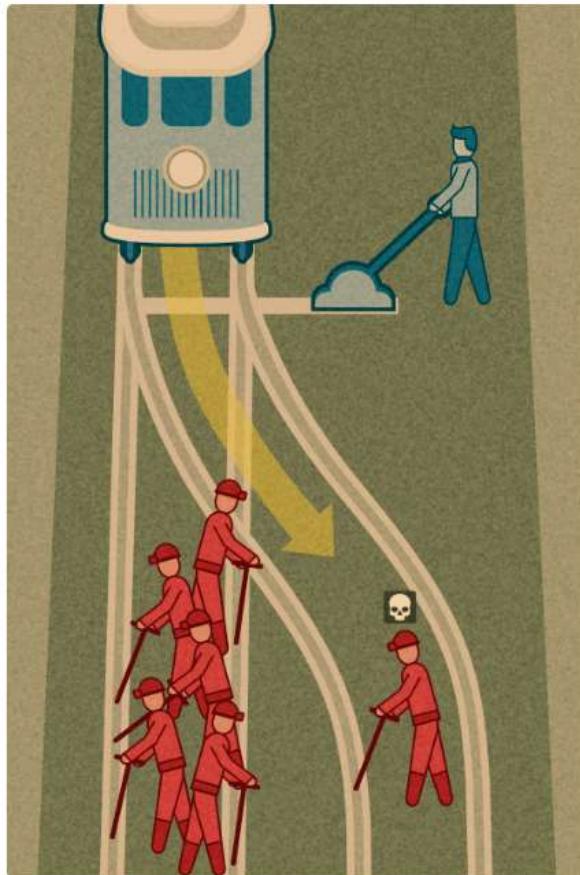
Asimov's Robotic Laws

- 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



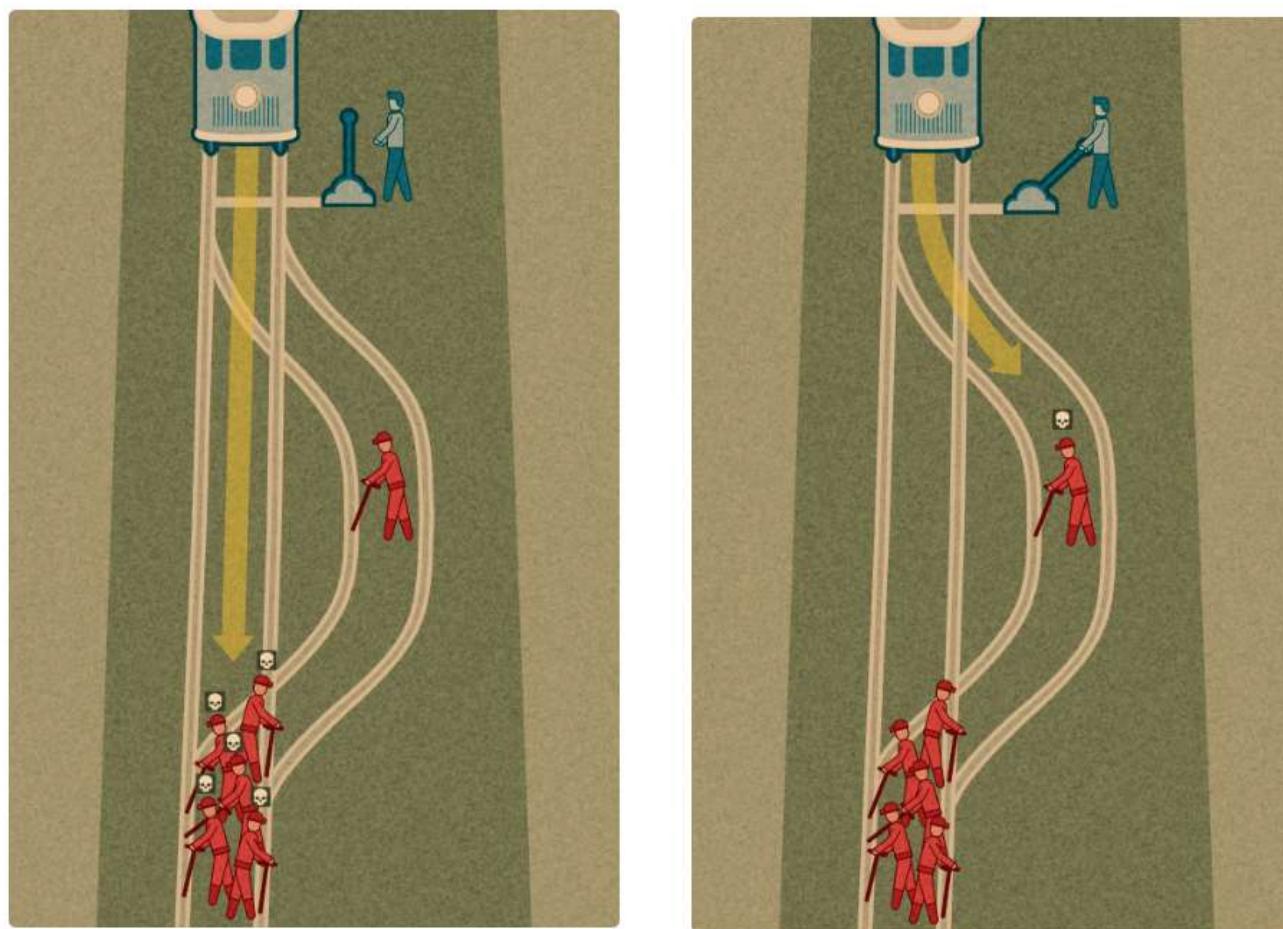
Moral Machine (1)

What should the man in blue do?



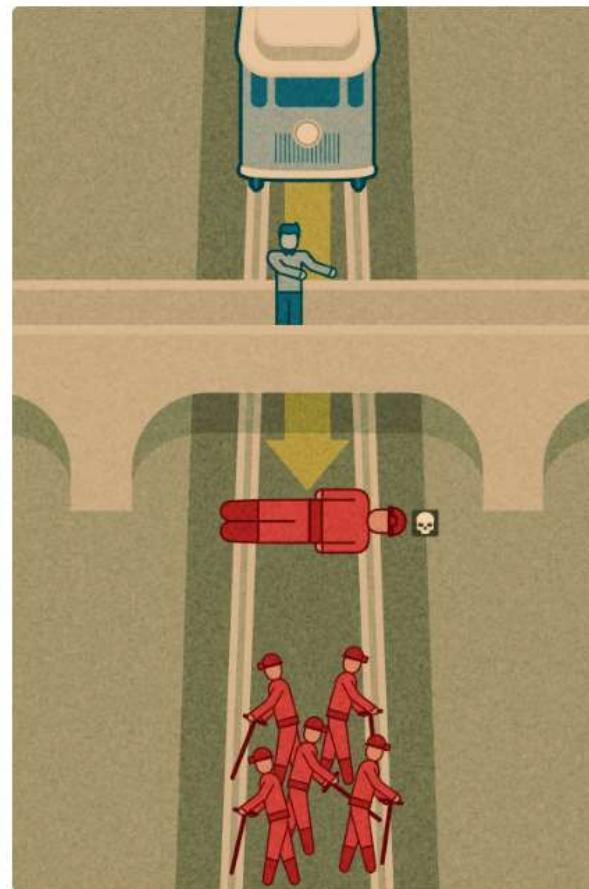
Moral Machine (2)

What should the man in blue do?



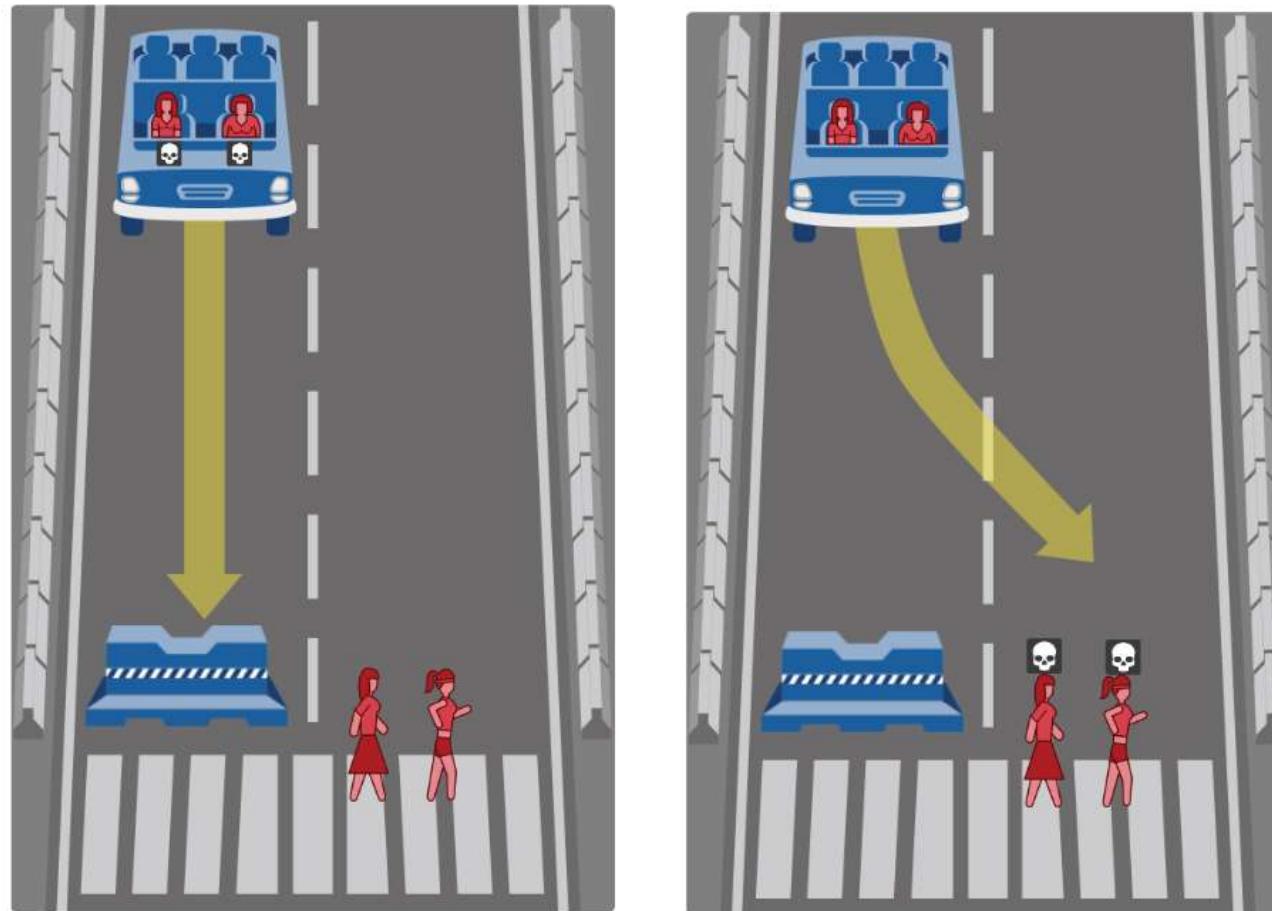
Moral Machine (3)

What should the man in blue do?

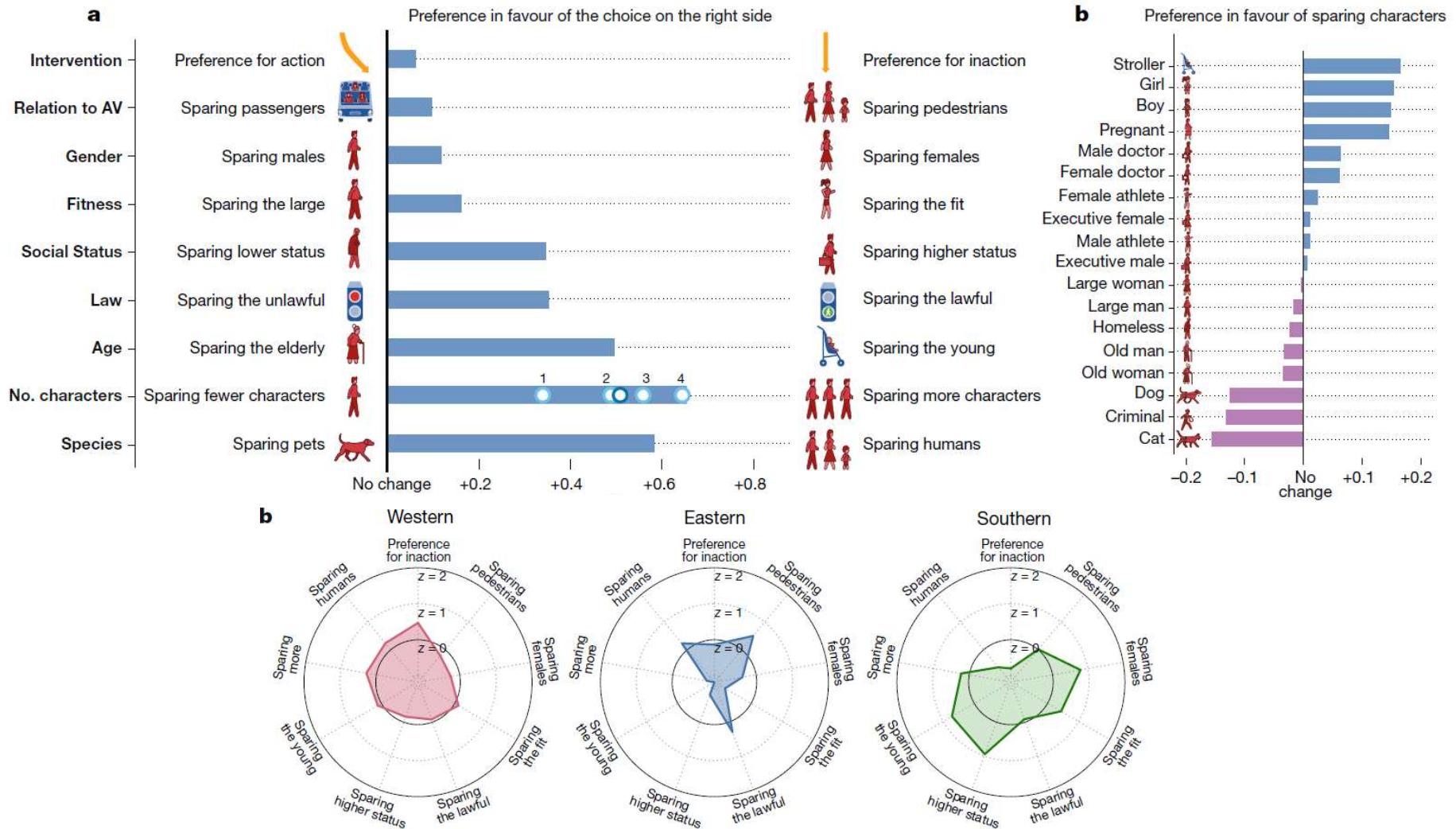


Moral Machine (4)

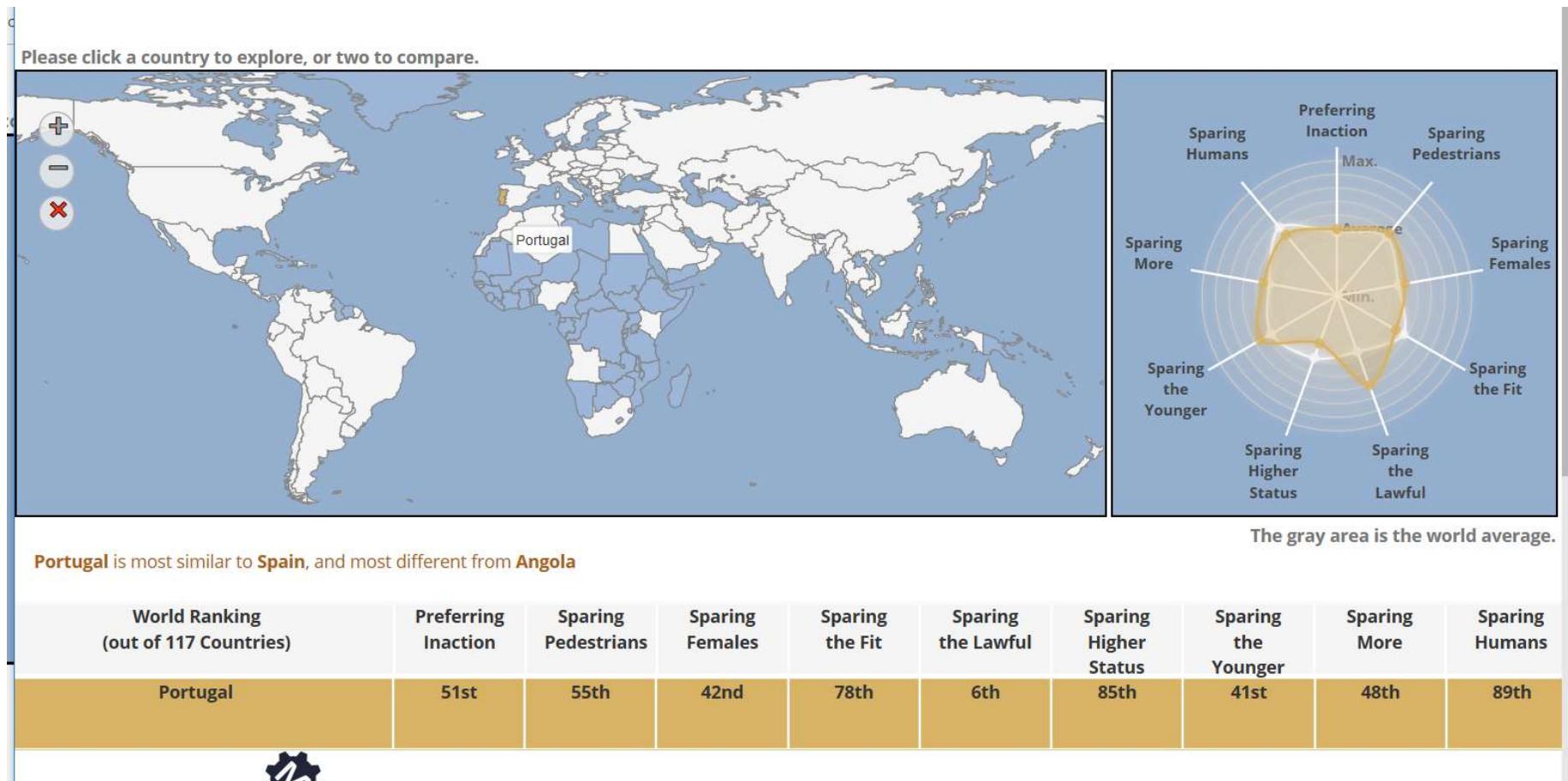
What should the self-driving car do?



Moral Machine – Results (1)



Moral Machine – Results (2)



AI in Government

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



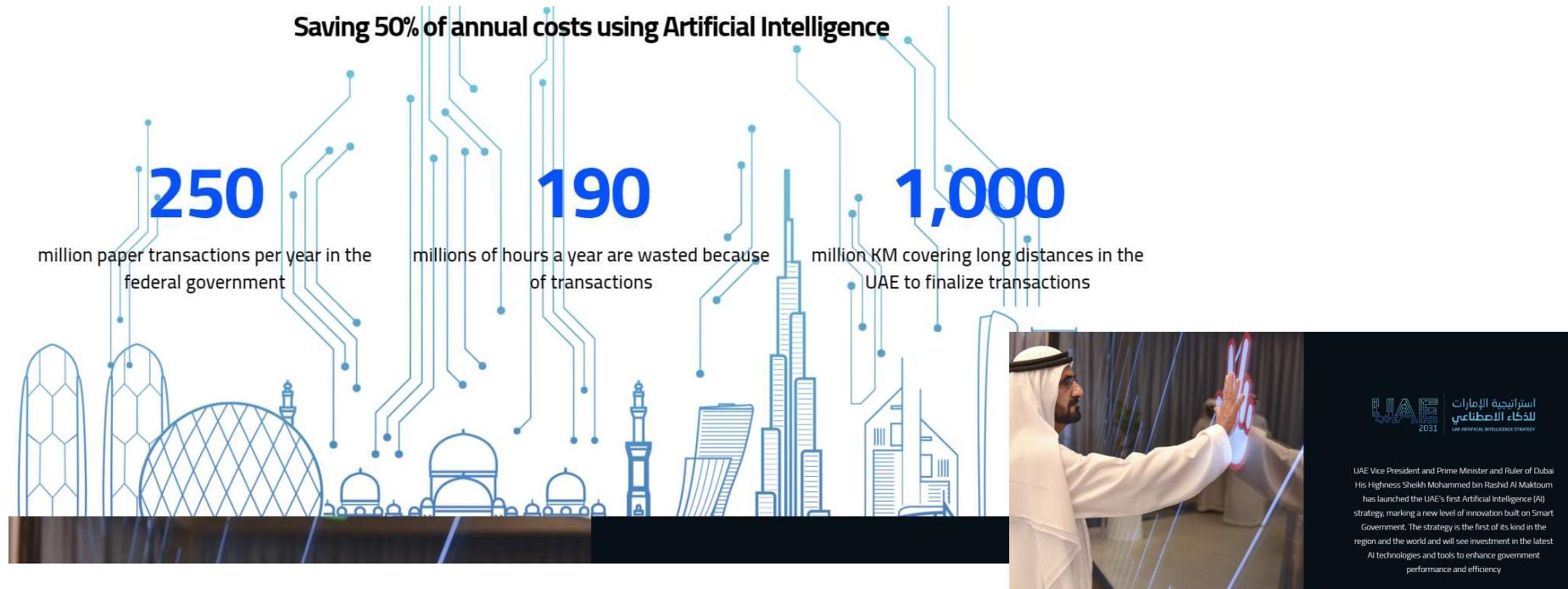
العربية Other languages Accessibility Help Register

Home Information and service

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



Artificial Intelligence – The Future

- **Super Artificial Intelligence**

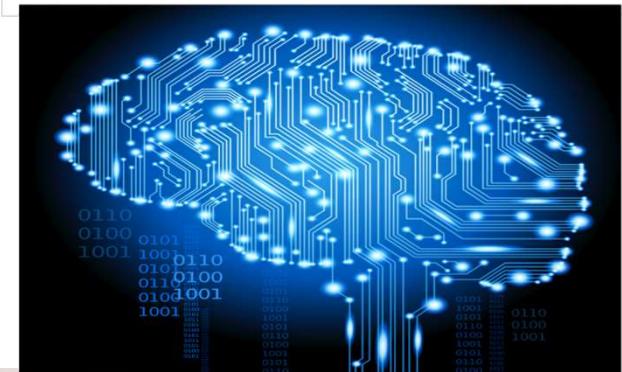
Hypothetical agent that possesses **intelligence far surpassing that of the brightest** and most gifted **human minds**

- **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**

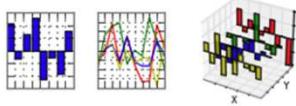
Interaction, Planning and Scheduling, AI for Games, Intelligent Simulation, Social Intelligence. Cloud AI. The Future of AI. IA and the Society. Beneficial IA. Explainable AI. Machine Ethics. Weak and Strong IA. Super Intelligence. The Singularity.

Some Useful Tools



IP[y]: IPython
Interactive Computing

pandas
 $y_{it} = \beta' x_{it} + \mu_i + \epsilon_{it}$



IART – Classes Operation/Methodology

- **Theoretical Classes (first two hours of Theo Classes):**
 - Interactive Exhibition of AI Subjects
 - Evaluations (Kahoots)
- **Theoretical/Practical Classes (last hour of Theo Classes):**
 - Interactive Exhibition of AI Subjects
 - Exercises Proposal and Solving
 - Evaluations (Kahoots)
- **Practical Classes (8 practical classes per week):**
 - 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 10 Kahoots)

Bibliografia/Bibliography

- Bibliografia Obrigatória
 - Stuart Russell, Peter Norvig, [Artificial intelligence: A Modern Approach, 3rd Edition.](#)
- Bibliografia Complementar
 - David Poole, Alan Mackworth, [Artificial Intelligence: Foundations of Computational Agents, 2nd edition](#)
 - Stuart Russell, Peter Norvig; Artificial intelligence: A Modern Approach, 4th Edition
 - Richard Sutton, Andrew Barto: Reinforcement Learning - An Introduction, 2nd edition
 - Ernesto Costa e Anabela Simões; [Inteligência artificial: Fundamentos e Aplicações.](#)

Conclusions

- IART-AI 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
- Approximately 50% of the master's dissertations at MIEIC course are related to AI

IART - Artificial Intelligence

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