

Artificial Intelligence/ Inteligência Artificial

Lecture 0: Course Presentation

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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”



IART – Objetivos

- **Caraterizar e distinguir a Inteligência Artificial (IA) e a sua aplicabilidade.**
- **Mostrar como Representar, Adquirir, Manipular e Aplicar Conhecimento usando Sistemas e Algoritmos Computacionais.**
- **Compreender as principais áreas da IA**, incluindo: Agentes Inteligentes e SMA, Métodos de Resolução de Problemas, Otimização e Meta-heurísticas, Engenharia do Conhecimento, Aprendizagem Computacional, Processamento de Linguagem Natural.
- **Desenvolver projetos simples, mas completos, usando técnicas de IA.**

IART – Programa/Syllabus

- I. Introdução à Inteligência Artificial (IA)**
- II. Agentes Inteligentes e Sistemas Multi-Agente (SMA)**
- III. Métodos de Resolução de Problemas**
- IV. Otimização e Meta-heurísticas**
- V. Engenharia do Conhecimento**
- VI. Aprendizagem Computacional**
- VII. Processamento de Linguagem Natural**
- VIII. Tópicos Avançados de Inteligência Artificial**

IART – Programa/Syllabus

I. Introdução à Inteligência Artificial (IA)

- Definição de IA.
- Fundamentos e Âmbito da IA.
- Evolução e Cronologia da IA.
- Problemas e Abordagens da IA e dos Sistemas Inteligentes.
- Aplicações da IA.

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**

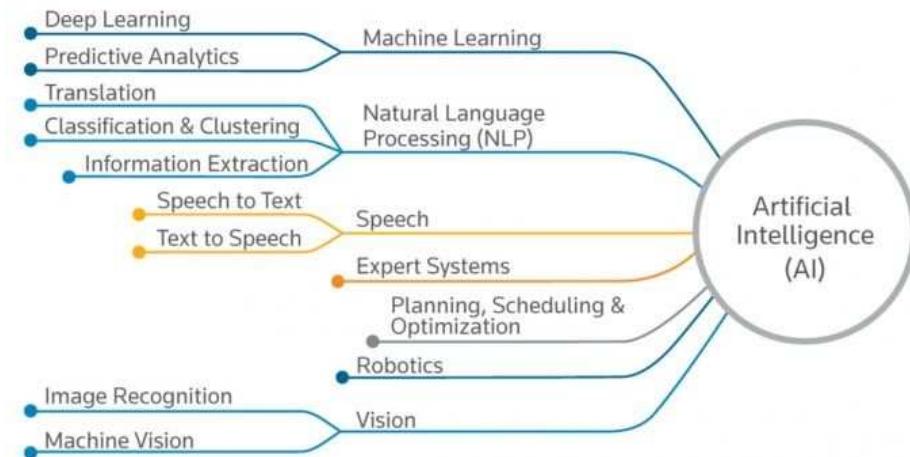
Strong AI or Artificial General Intelligence (AGI) is the intelligence of a machine that could successfully perform **any intellectual task** that a human being can! Science fiction ?



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



Artificial Intelligence Applications

Some AI applications:

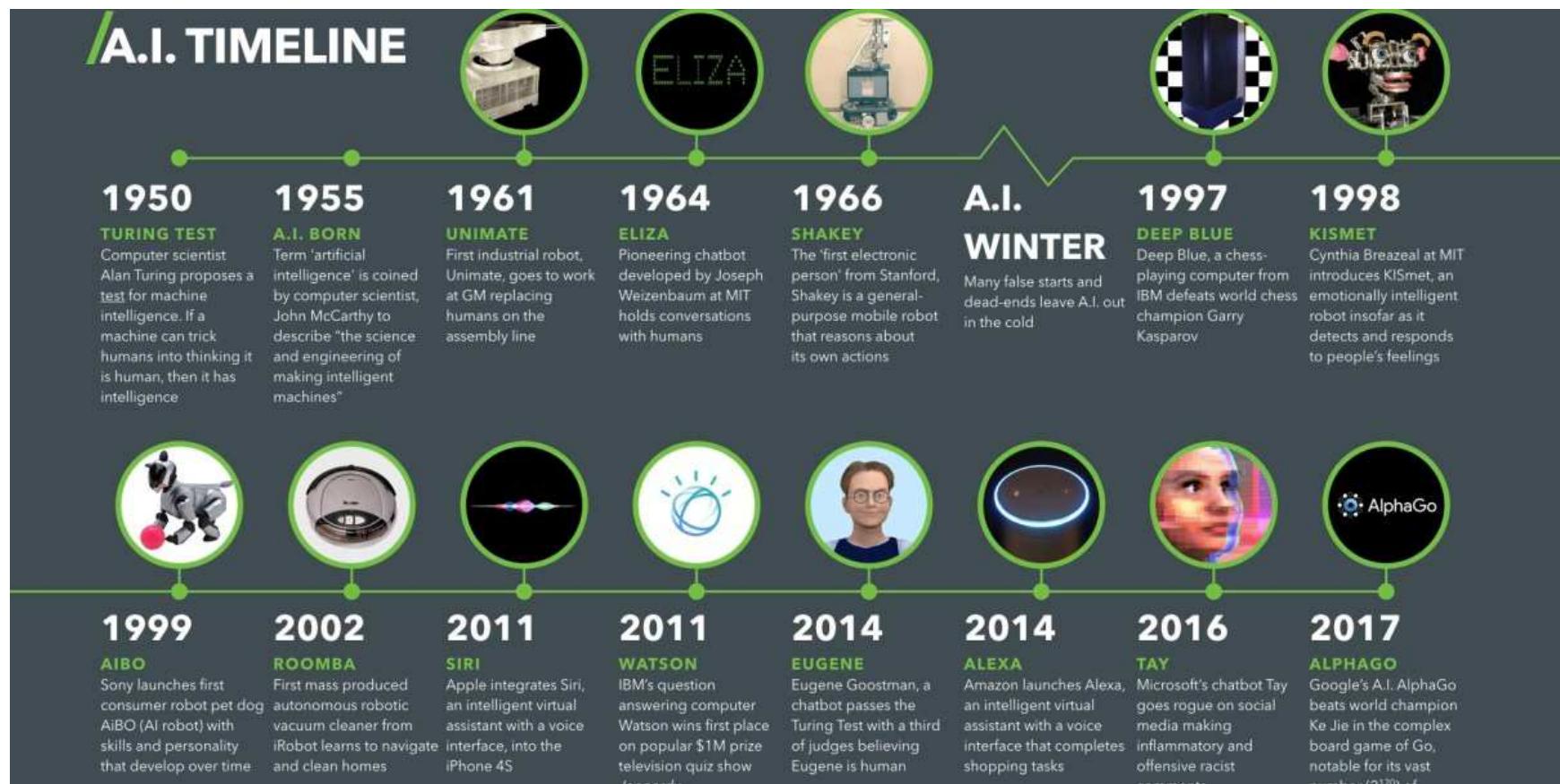
- **AI in Healthcare**
- **AI in Business**
- **AI in Education**
- **AI in Finance**
- **AI in Law**
- **AI in Manufacturing**
- **AI in Games**

AI for Health Application Areas

- 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
- ...



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,
...

IART – Programa/Syllabus

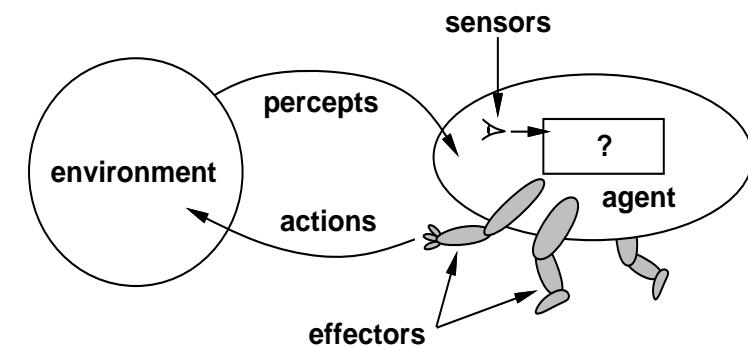
II. Agentes Inteligentes e Sistemas Multi-Agente (SMA)

- Conceito de Agente.
- Ambientes.
- Agentes Reativos, Deliberativos, Baseados em Objetivos, Baseados em Utilidade, com Aprendizagem e BDI.
- Sistemas Multi-Agente: Conceito, Motivação, Arquiteturas, Comunicação, Coordenação.
- Exemplos Práticos de Aplicação.

AI - Autonomous Agents and Multi-Agent Systems

Agent:

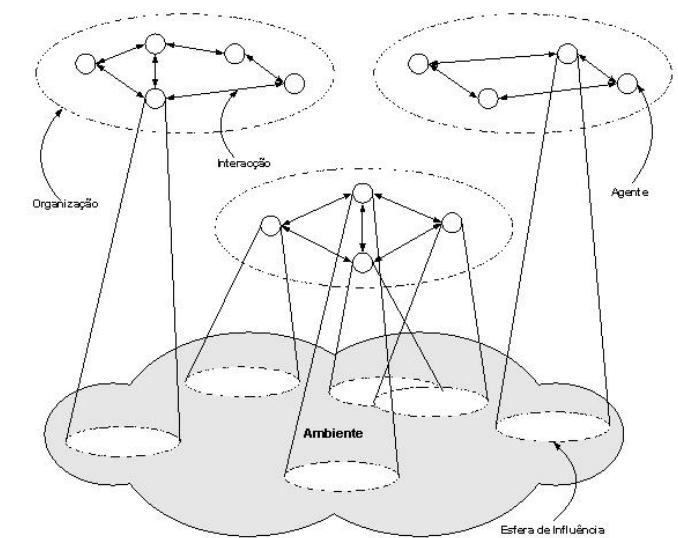
“Computational System, situated in a given **environment**, that has the ability to **perceive** that environment using **sensors** and **act**, in an **autonomous way**, in that environment using its **actuators** to fulfill a given **function**.”



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

Multi-Agent System:

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



AI - Coordination in Multi-Agent Systems

- Agents/Robots don't live alone and have to work in a group...
- **Human-Robot Interaction**
- **Multi-Robot 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



IART – Programa/Syllabus

III. Métodos de Resolução de Problemas

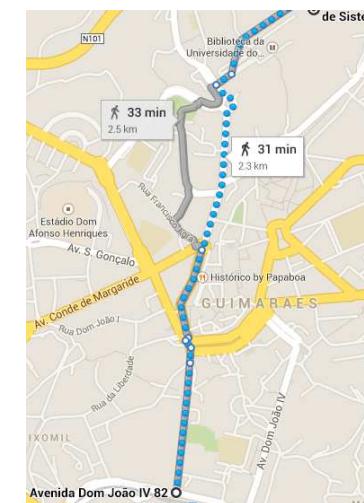
- **Formulação de Problemas.**
- **Espaço de Estados.**
- **Pesquisa Não Informada:** Primeiro em Largura, Primeiro em Profundidade, Custo Uniforme, Aprofundamento Iterativo, Pesquisa Bidirecional.
- **Pesquisa Inteligente:** Pesquisa Gulosa, Algoritmo A*.
- **Pesquisa com Adversários:** Pesquisa em Jogos, Algoritmo Minimax, Cortes Alfa-Beta,
- **Pesquisa com Informação Imperfeita.**
- **Exemplos Práticos de Aplicação.**

IA: Pesquisa de Soluções

Sistemas Inteligentes são a componente decisiva de quase todos os Sistemas de Informação!

Exemplo: Problema de Rotas/Caminhos e GPS

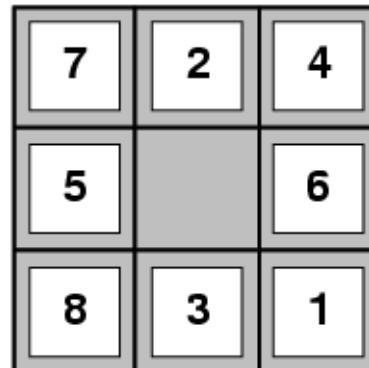
- **Encontrar o melhor caminho** de um ponto a outro (aplicações: GPS, google maps, redes de computadores, planeamento militar, viagens aéreas)
- **Visitar cada ponto pelo menos uma vez** num dado espaço (Ex: Caixeiro viajante visitar cada cidade exatamente uma vez, encontrar o caminho mais curto, sistemas de distribuição, companhias aéreas)



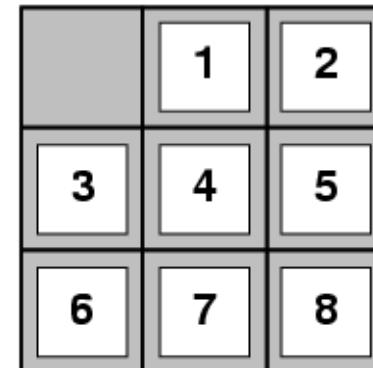
IA – Formulação de Problemas

- **Estados, Operadores, Teste Objetivo, Custo da Solução**

- Estados: Especifica a posição de cada uma das peças e do espaço vazio (várias representações são possíveis)
- Estado inicial: Representado na figura
- Operadores - sucessores: gera os estados válidos que resultam da execução. São as quatro ações (mover espaço vazio para esquerda, direita, cima ou abaixo)
- Teste de objetivo: Verifica se o estado corresponde à configuração objetivo (representado na figura)
- Custo da solução: Cada passo custa 1, sendo o custo da solução o número de passos para resolver o problema

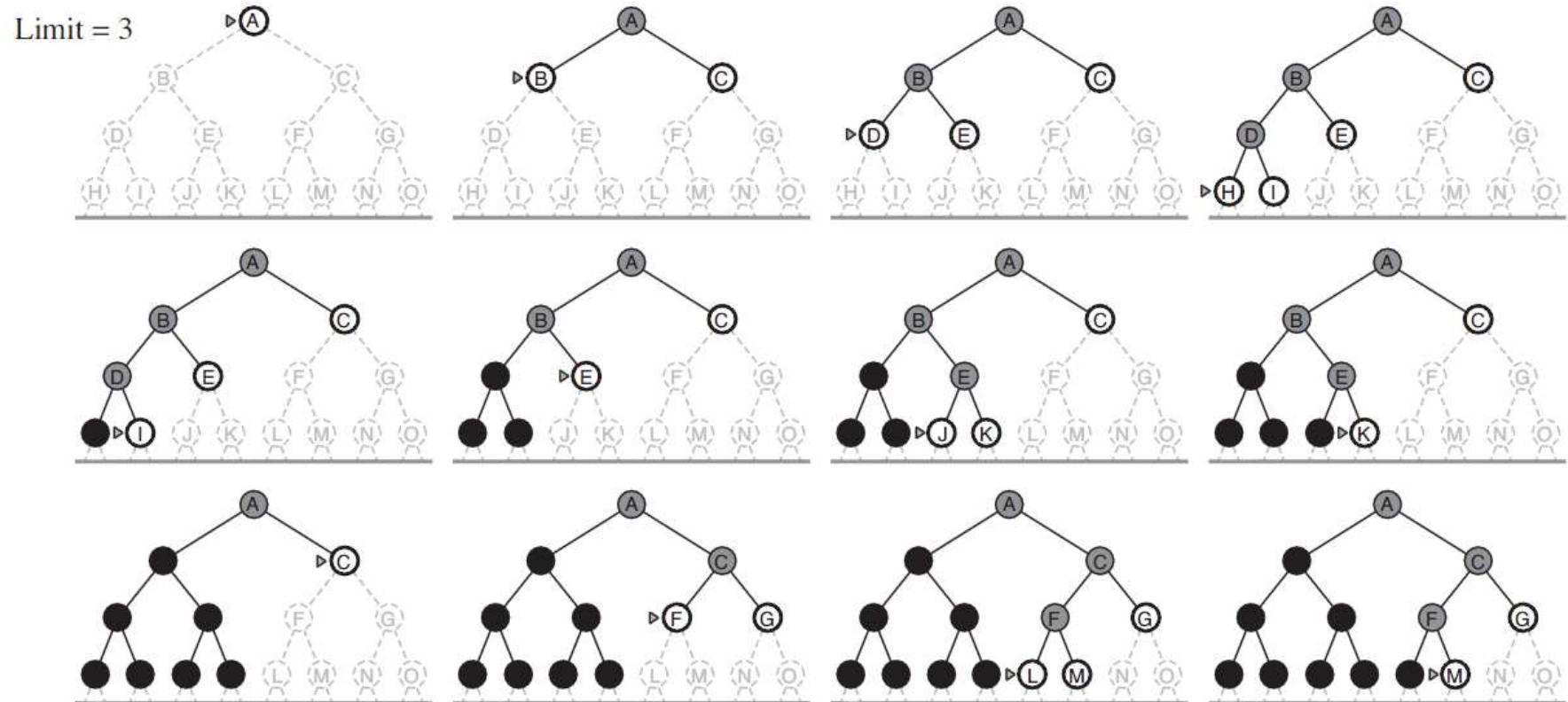


Start State

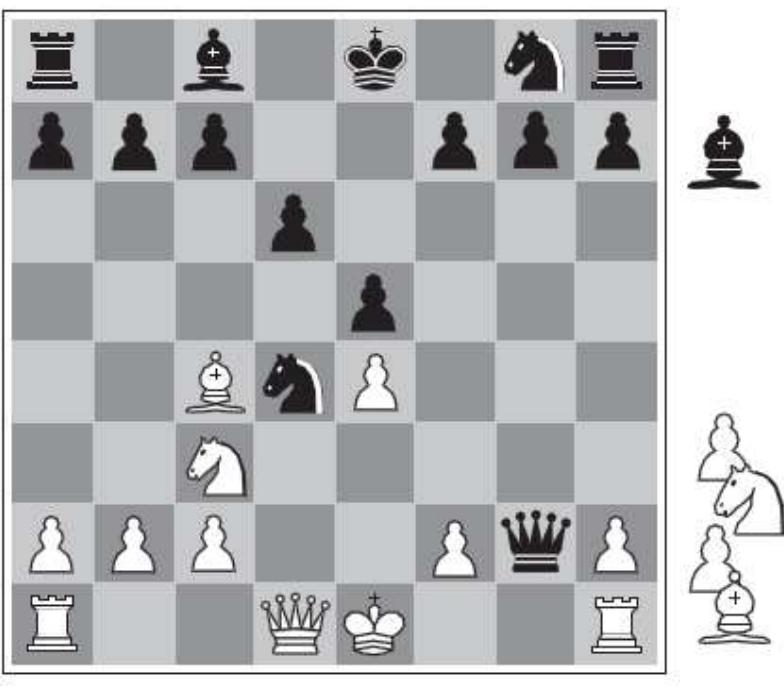


Goal State

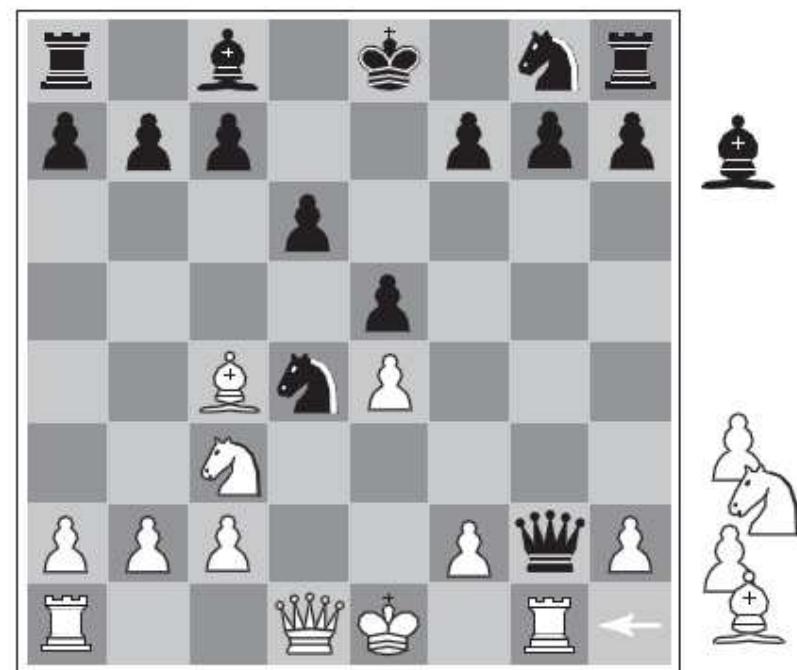
IA: Métodos de Pesquisa



IA: Algoritmo Minimax



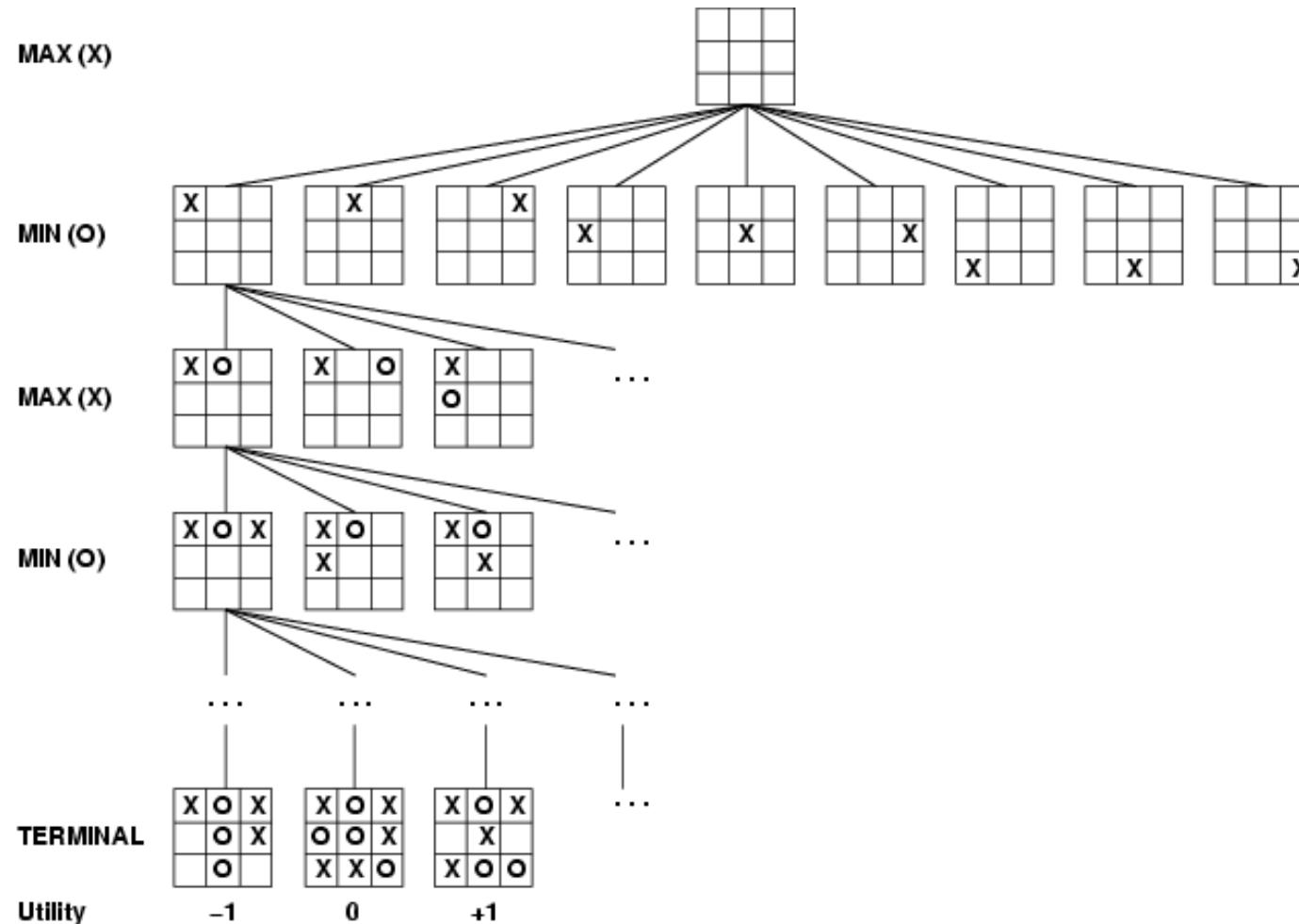
(a) White to move



(b) White to move

IA: Pesquisa com Adversários/Jogos

- Jogo do Galo utilizando Minimax



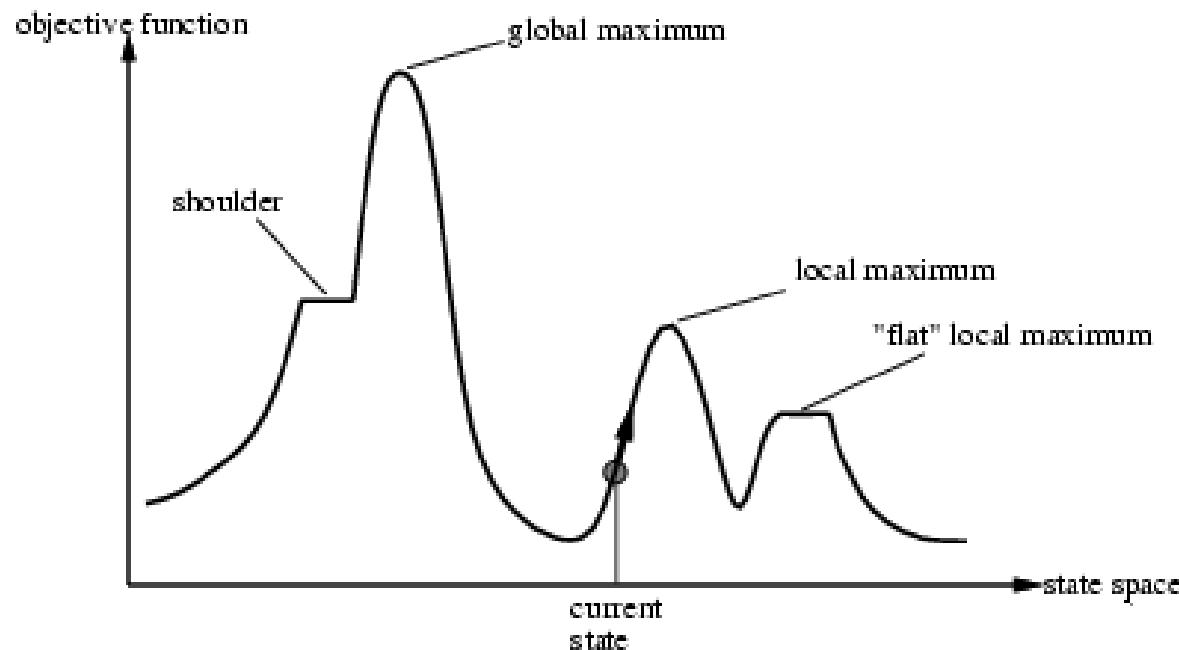
IART – Programa/Syllabus

IV. Otimização e Meta-heurísticas

- Formulação de Problemas de Decisão/Optimização.
- Algoritmos “Hill-Climbing”, Arrefecimento Simulado, Pesquisa Tabu, “Ant Colony”.
- Algoritmos Genéticos e Computação Evolucionária.
- Exemplos Práticos de Aplicação.

IA: Pesquisa Subida da Colina (Hill-Climbing Search)

- Problema: Dependendo do estado inicial pode ficar “preso” num mínimo local!



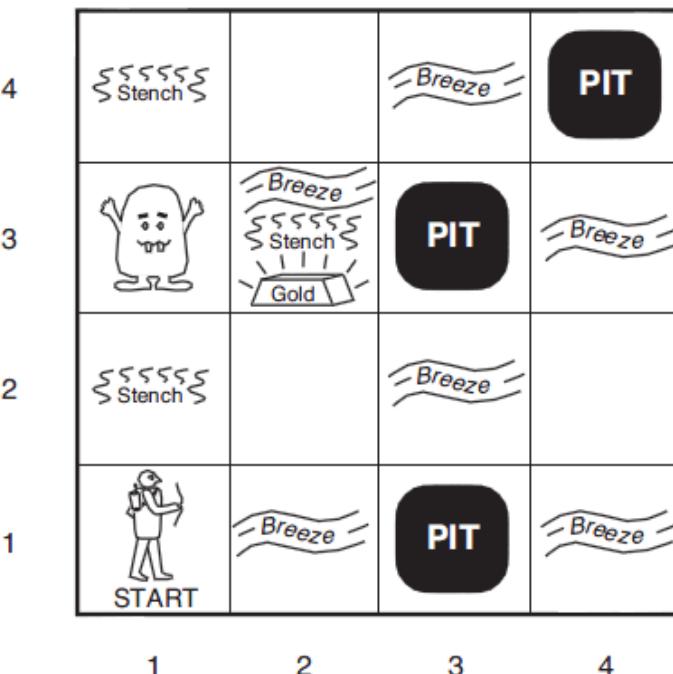
IART – Programa/Syllabus

V. Engenharia do Conhecimento

- Representação do Conhecimento e Raciocínio
- Lógica Proposicional e Lógica de Predicados.
- Redes Semânticas, “Frames”, Regras e Ontologias.
- Programação em Lógica e Programação com Restrições.
- Raciocínio com Conhecimento Incerto.
- Sistemas Baseados em Conhecimento e Sistemas Periciais: Motor de Inferência, Geração de Explicações, Sistemas Genéricos (“Shells”).
- Exemplos Práticos de Aplicação.

IA: Rep. Conhecimento - Mundo do Wumpus

- Perceções: Cheiro, Brisa, Brilho
- Ações: Virar à Direita, Virar à Esquerda, Frente, Agarrar, Largar, Disparar
- Objetivos: Apanhar o Ouro e regressar ao início sem entrar em nenhum quadrado com buraco ou Wumpus
- Ambiente:
 - Quadrados junto ao Wumpus têm cheiro
 - Quadrados junto aos buracos têm brisa
 - Quadrados com Ouro têm brilho
 - Agarrar pega no Ouro se ele estiver no mesmo quadrado
 - Largar deixa o Ouro no quadrado atual
 - Disparar mata o Wumpus se estivermos virados para ele
 - Disparar usa a única seta



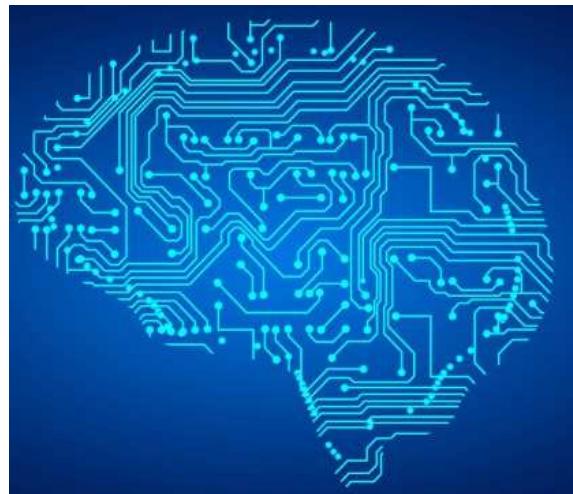
IART – Programa/Syllabus

VI. Aprendizagem Computacional

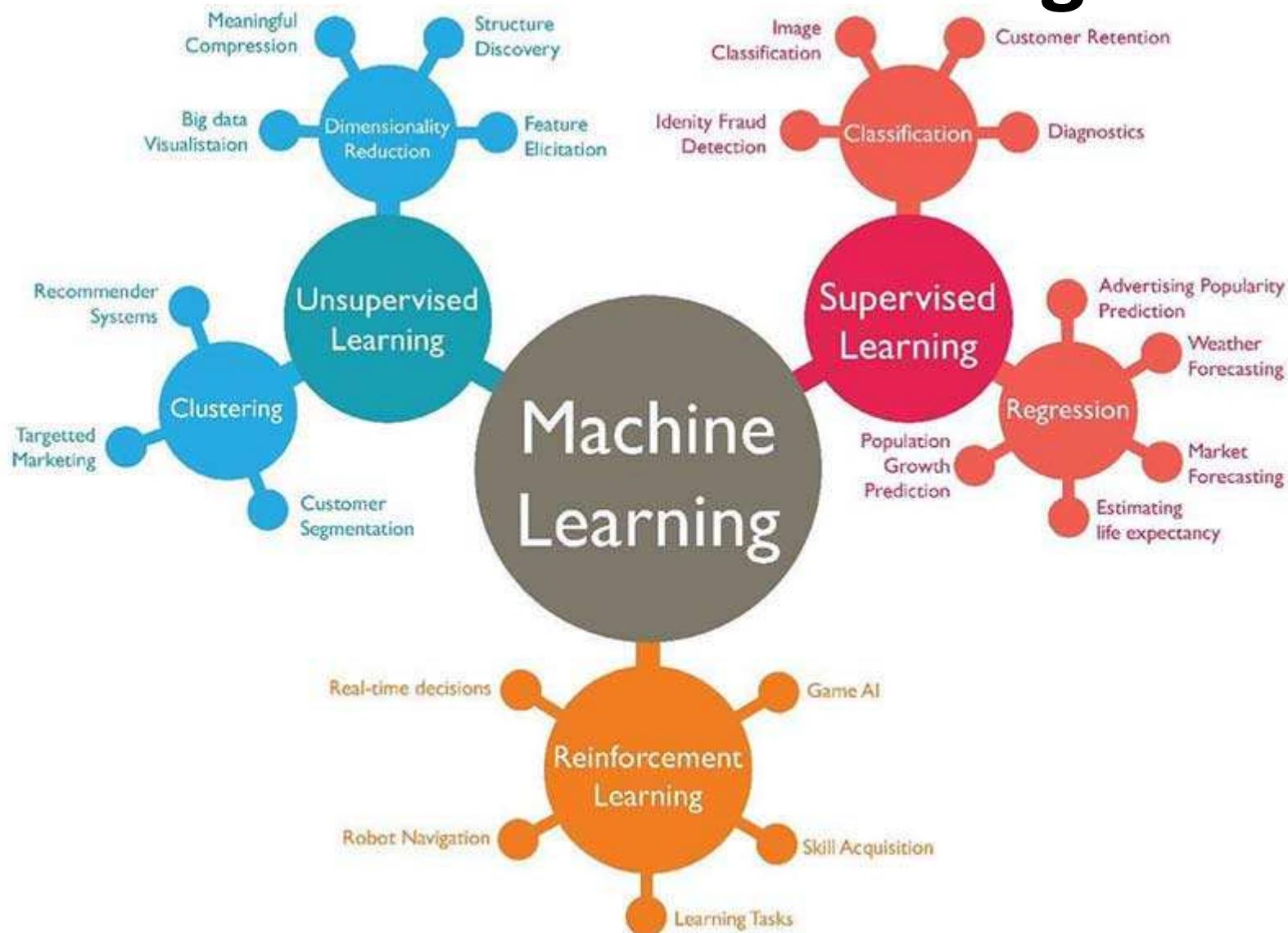
- **Tipos de Aprendizagem.**
- **Aprendizagem de conceitos, por exemplo, por analogia, baseada em explicações.**
- **Aprendizagem Indutiva: Algoritmos ID3 e C4.5.**
- **Redes Neuronais Artificiais: Princípios básicos e algoritmos fundamentais.**
- **Máquinas de Vetores de Suporte (“Support Vector Machines”).**
- **Aprendizagem por Reforço.**
- **Aprendizagem em Profundidade (“Deep Learning”).**
- **Exemplo Práticos de Aplicação.**

AI - Machine Learning

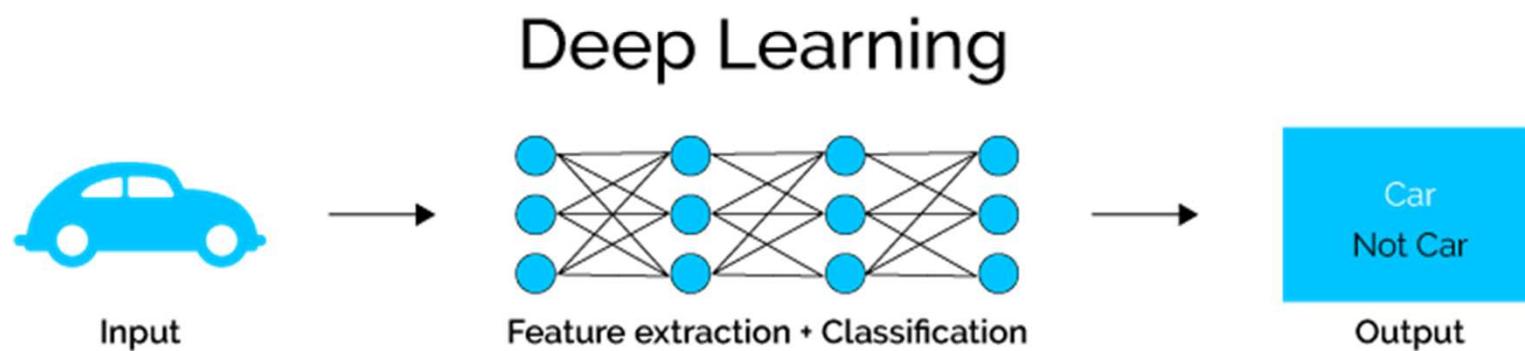
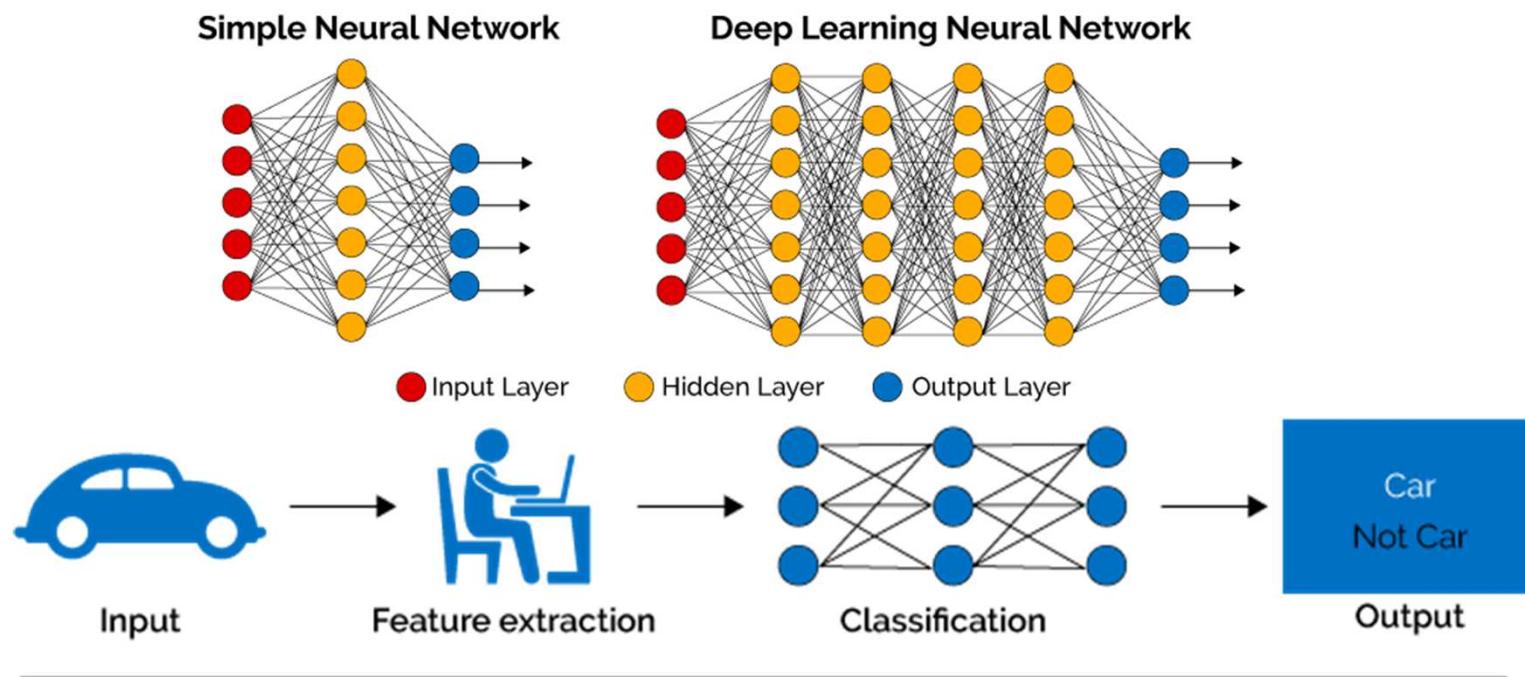
- **Machine learning** is a field of artificial intelligence that gives computer systems the ability to "learn" (e.g., progressively improve performance on a specific task) from data/results of their actions, without being explicitly programmed



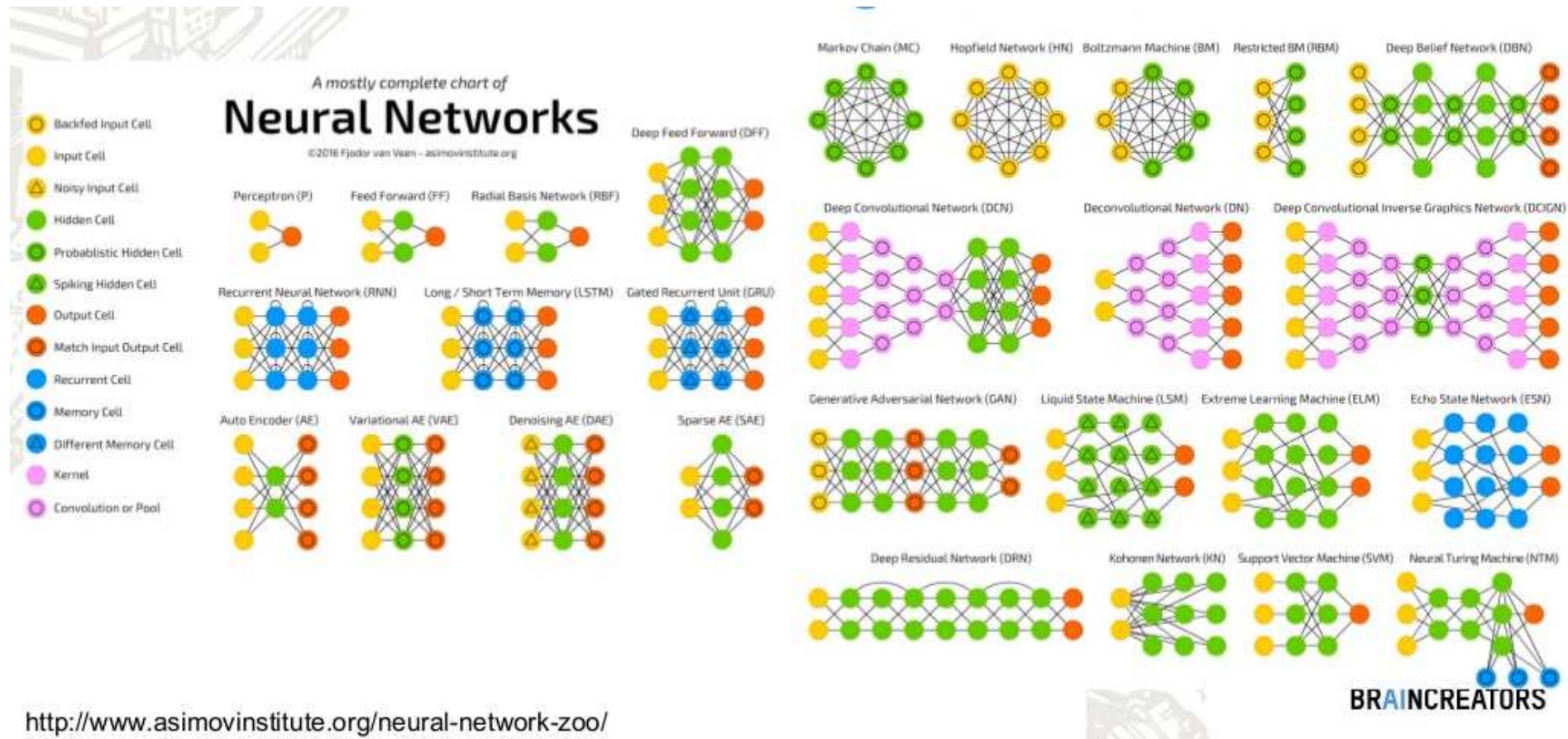
AI - Machine Learning



AI - Deep Learning



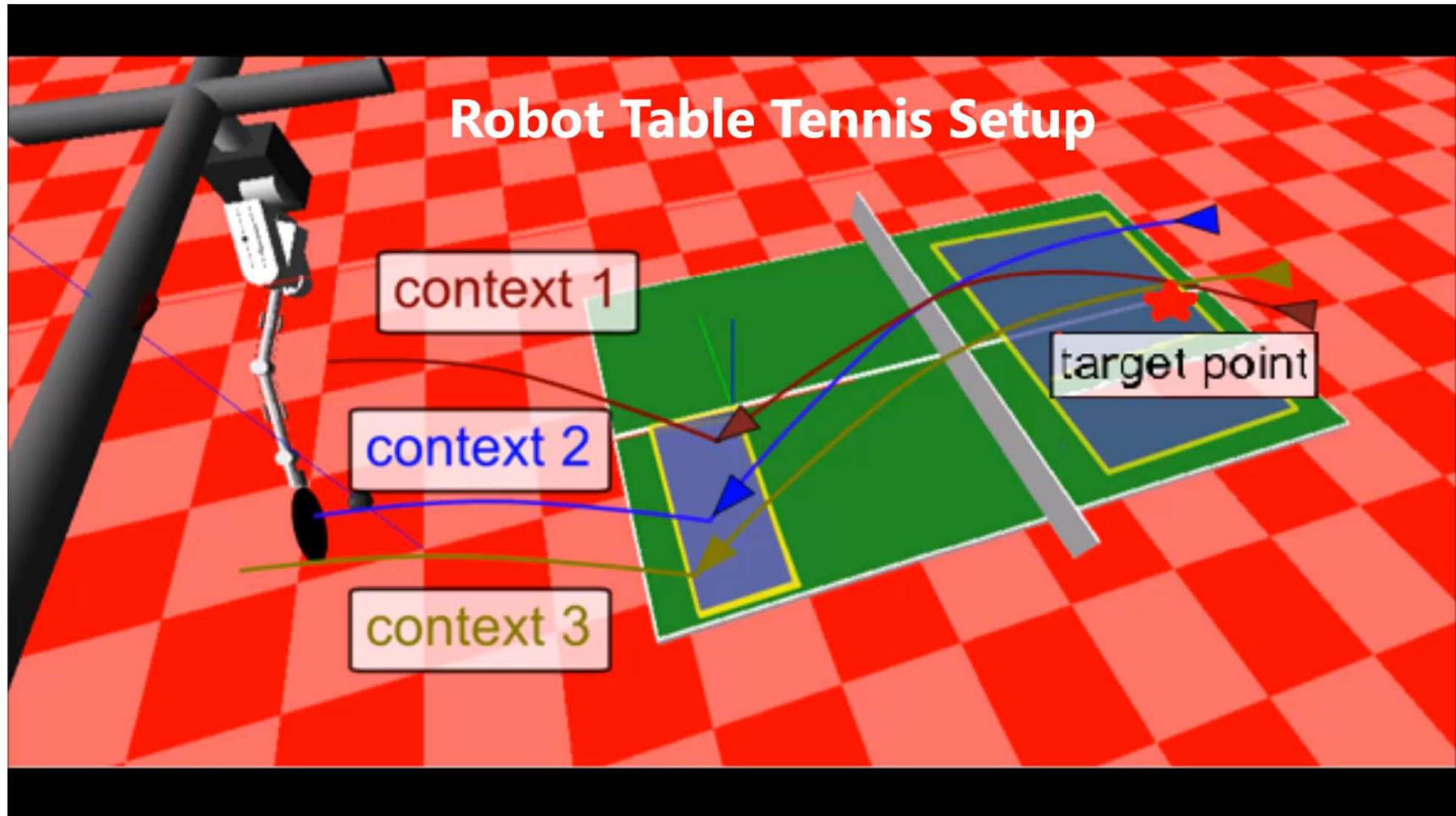
Neural Networks Endless Configurations



Artificial Intelligence: Machine Learning



AI: ML – Learning Table Tennis



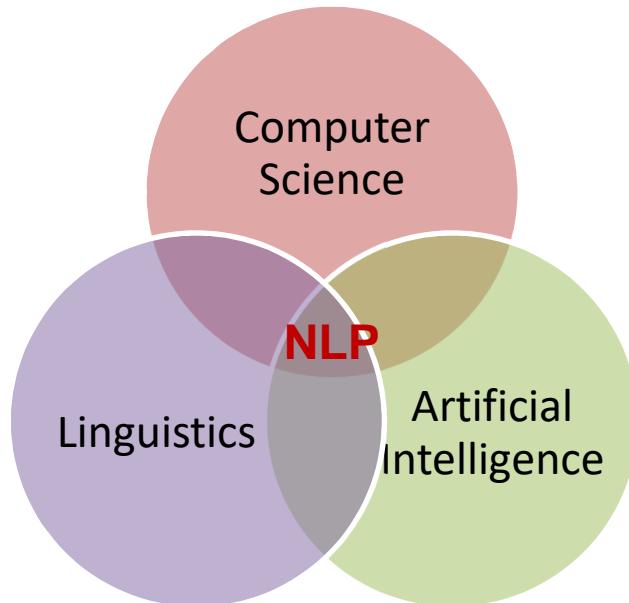
IART – Programa/Syllabus

VII. Processamento de Linguagem Natural

- Níveis de Processamento.
- Análises Sintática e Semântica.
- ATN, Gramáticas Semânticas e Gramáticas de Caso.
- Aproximação Clássica e uso da Lógica.
- Gramáticas com Cláusulas Definidas. Gramáticas de Extraposição.
- Abordagem Estatística.
- Mineração de Texto (“Text Mining”).
- Exemplo Práticos de Aplicação.

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

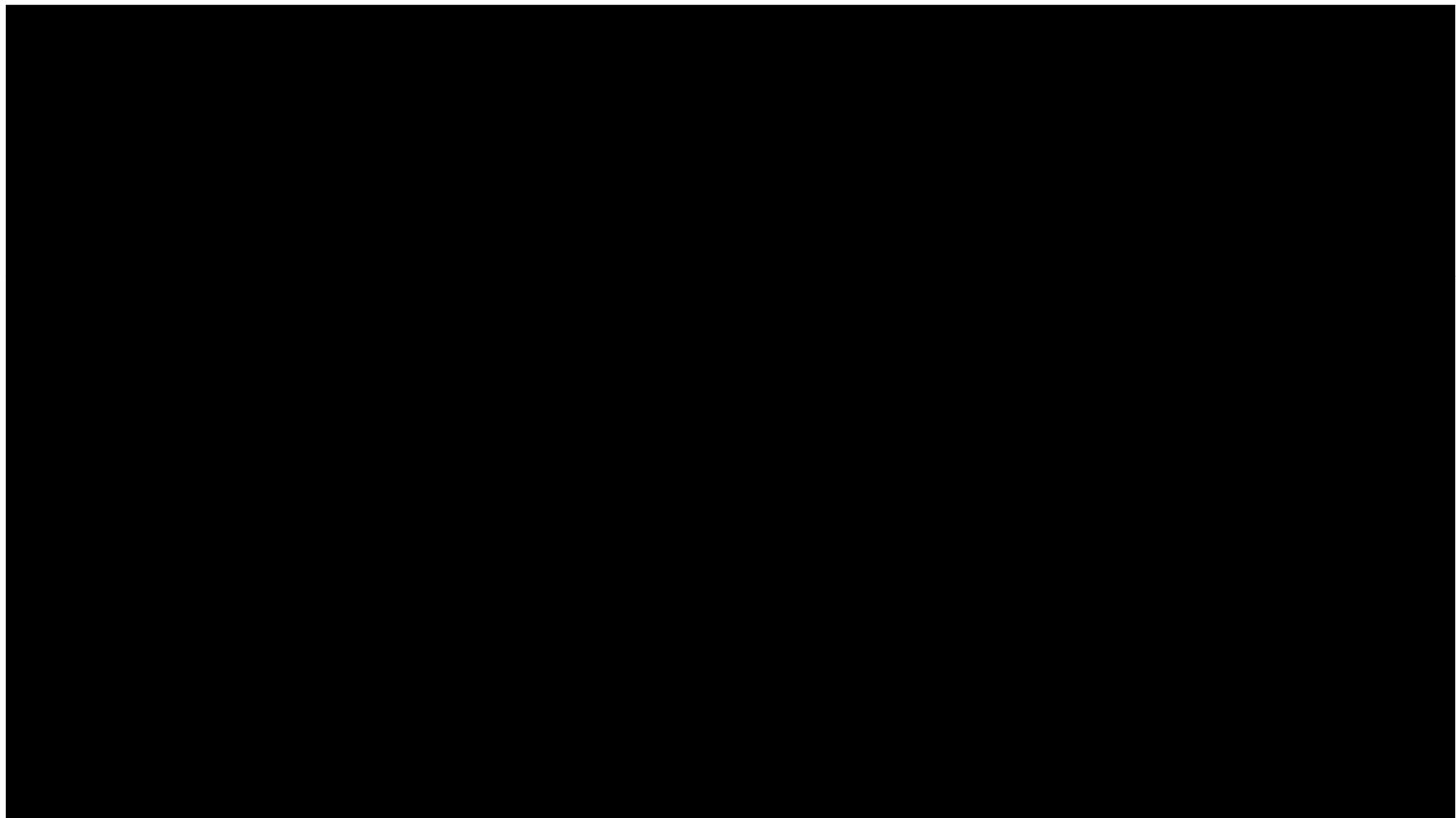


- **Speech-to-text/text-to-speech**

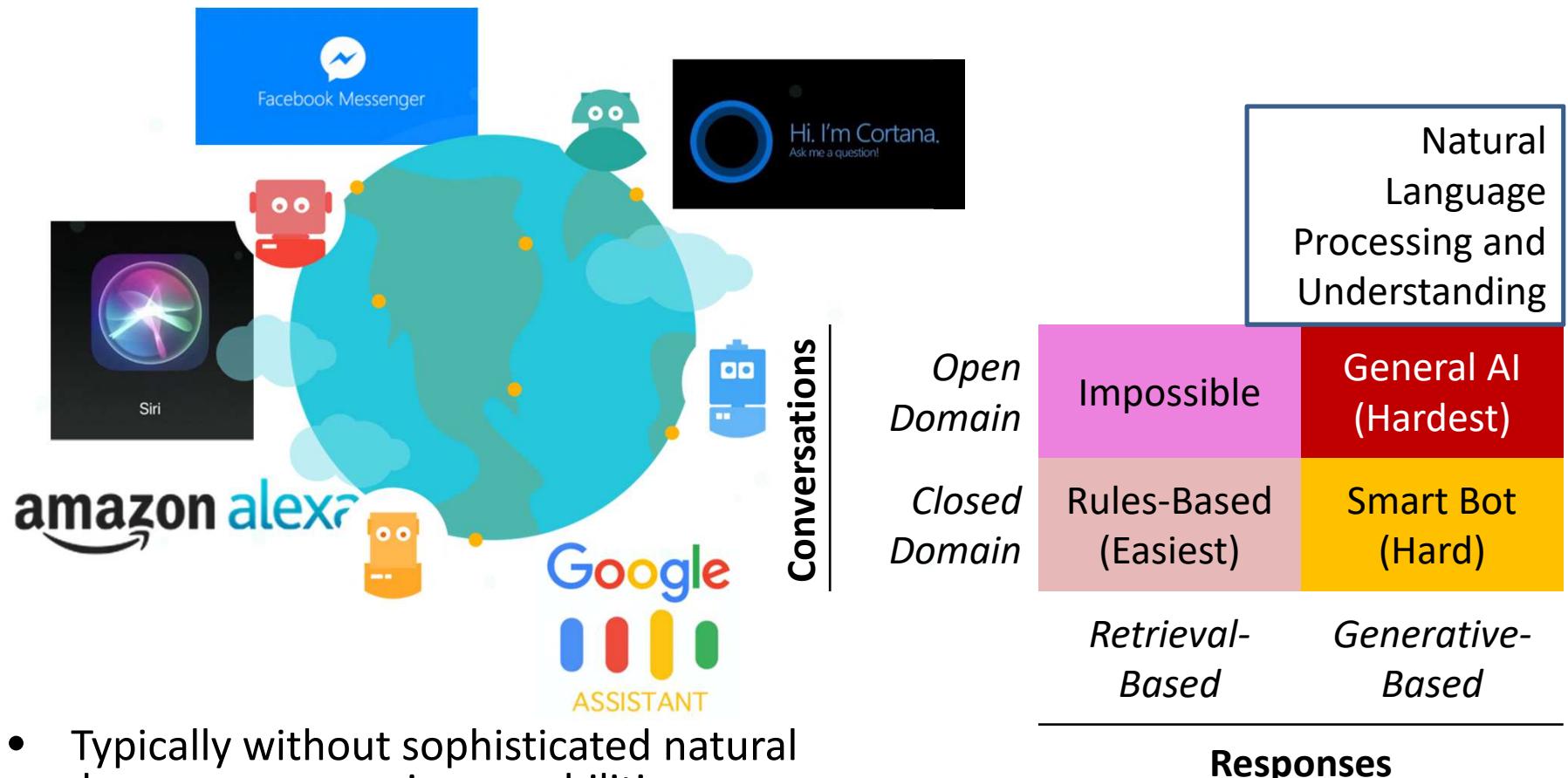
- Convert spoken language to written text and vice versa
- Chatbots, voice control, domotics, readers, ...



AI – NLP: Watson at Jeopardy



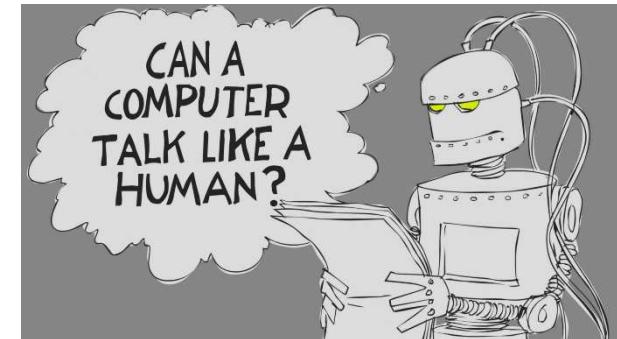
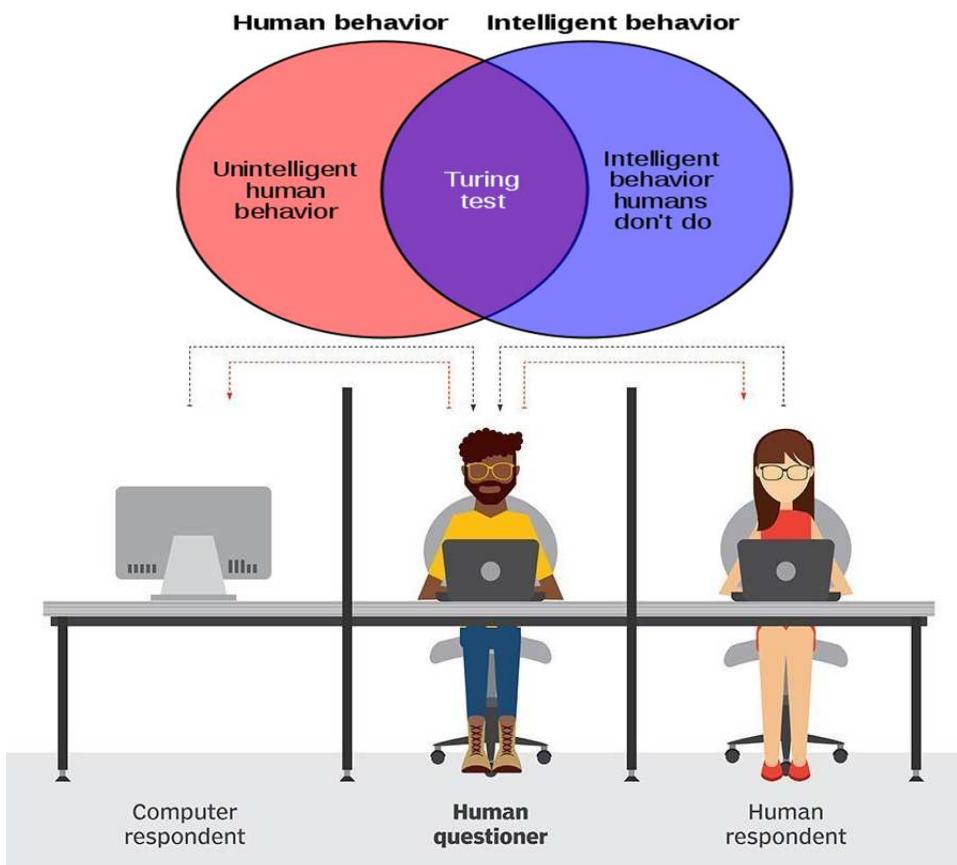
AI – NLP: ChatBots Hype



- Typically without sophisticated natural language processing capabilities
- Pattern recognition, rule based expression matching, simple machine learning, together with repositories of pre-written sentence templates

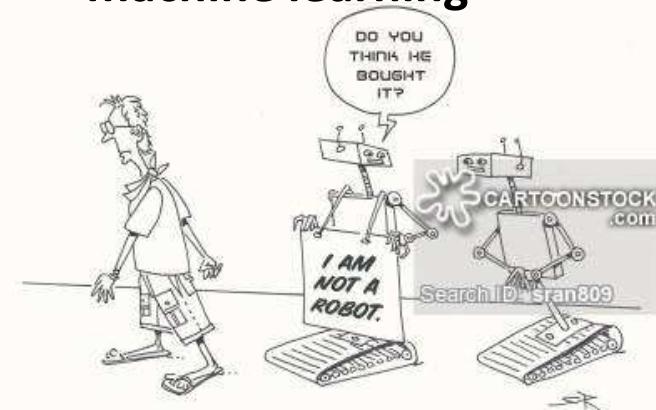
AI: NLP - Turing Test

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



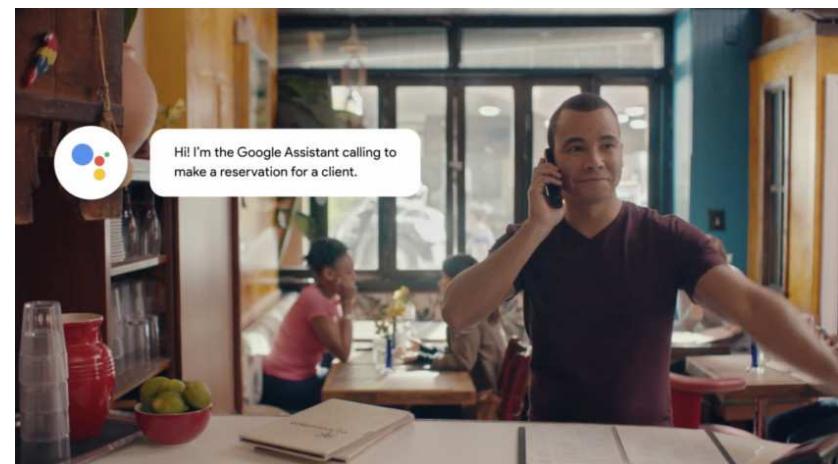
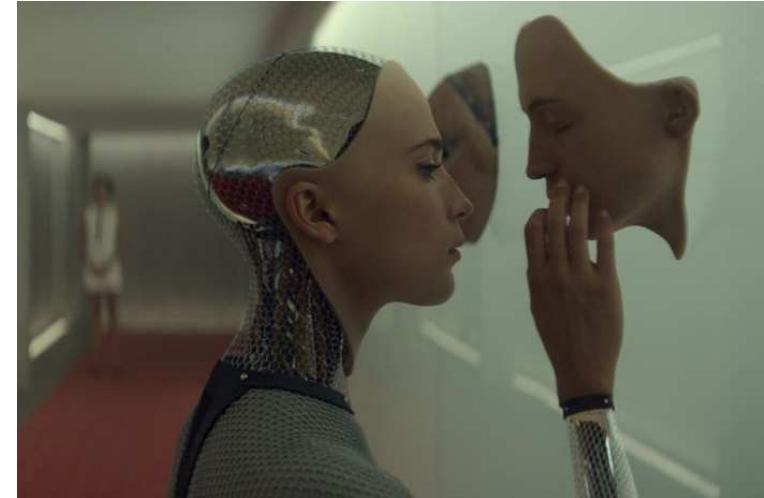
Capabilities:

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



AI: NLP – 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: NLP - Turing Test



IART – Programa/Syllabus

VIII. Tópicos Avançados de Inteligência Artificial

- Perceção/Visão, Comunicação, Interação, Planeamento, Escalonamento, Robótica, Simulação Inteligente.
 - IA fraca e IA forte. O Futuro da IA. Problemas “Hard”.
 - IA e a Sociedade.
 - IA Explicável/Transparente
-
- Aplicações de Inteligência Artificial e Sistemas Inteligentes.

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!**

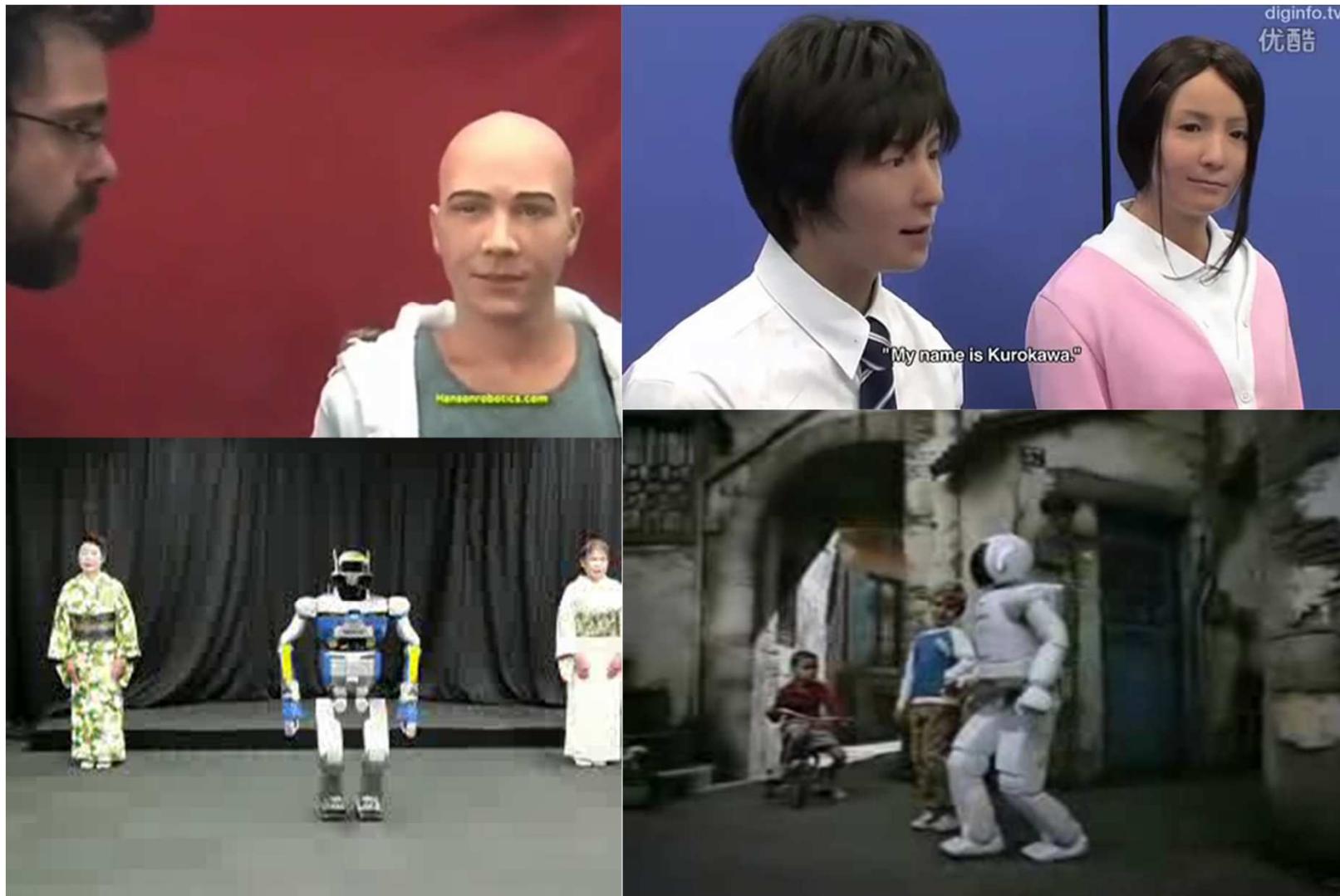


AI - Robotics

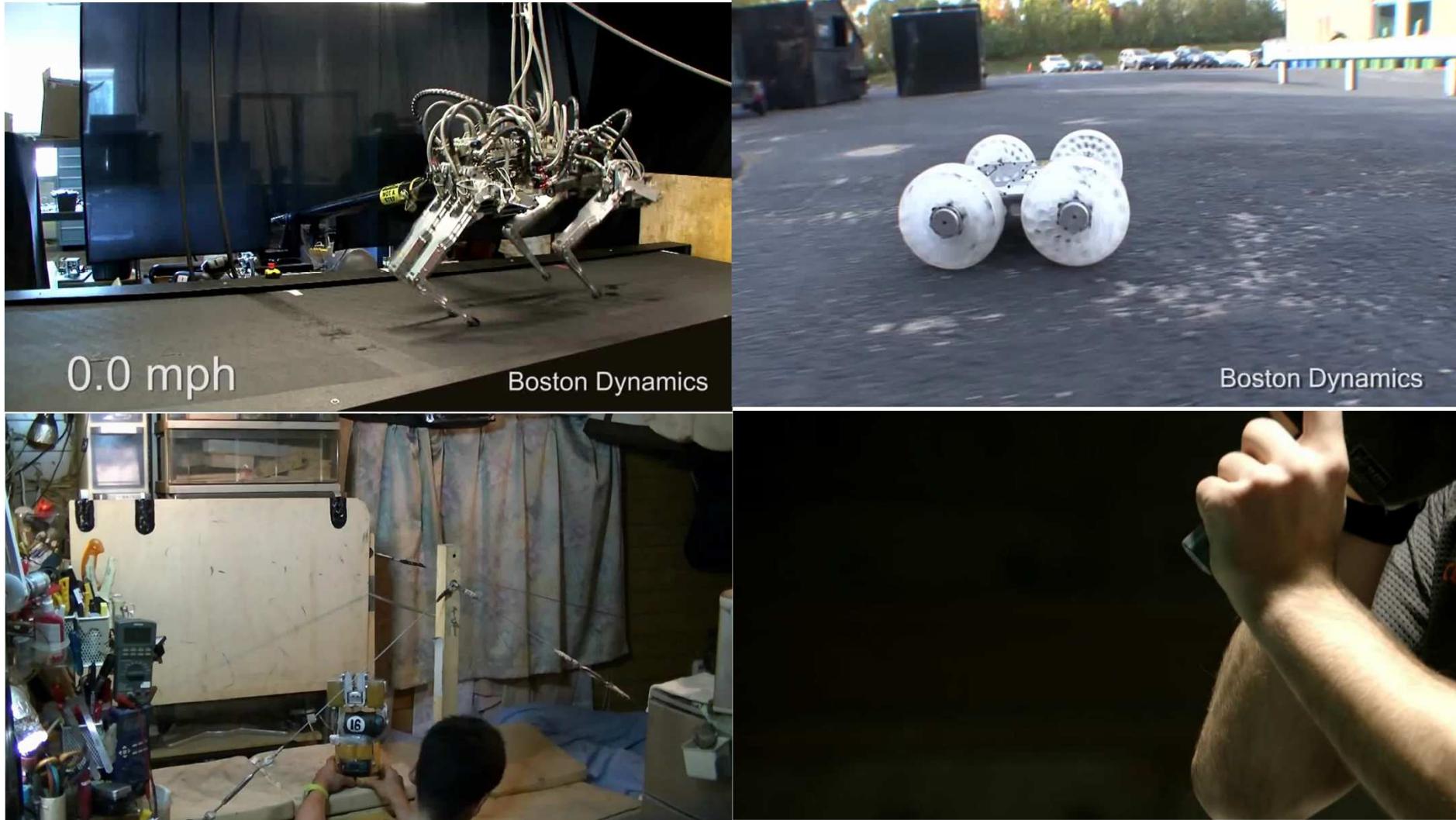
- Autonomous driving car (Google)
- Service, mars explor., medical robotics (Motorman, Miimo, Roomba, Oz, Asimo, Nao)
- Exoskeleton (exoAtlete)
- Ambient Assisted Living
- Drones & Delivery (PT ConnectRobotics)
- Military, Assistive, Eldery, ...
- Education, entertainment, ...



AI - Humanoid Robotics



AI - Sports' Robotics



AI - Robotic Competitions - RoboCup



Artificial Intelligence: Robotics



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. 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**



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



AI in Government

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



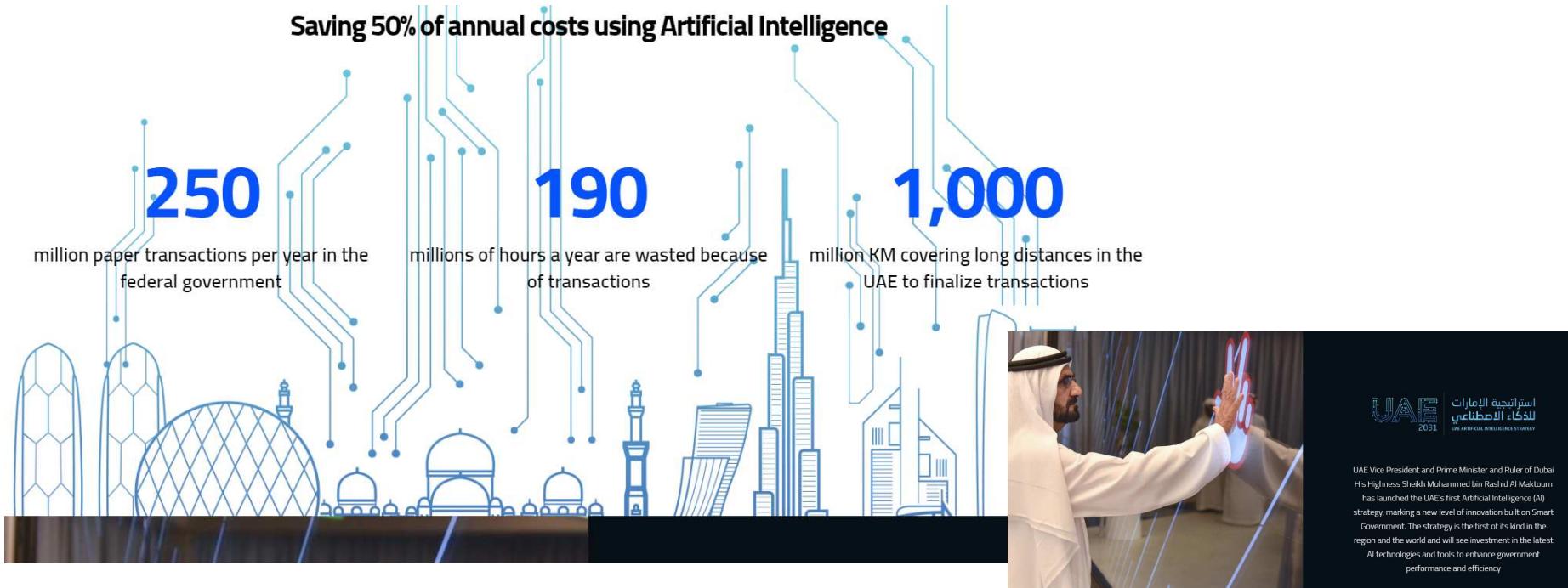
العربية Other languages Accessibility Help Register

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

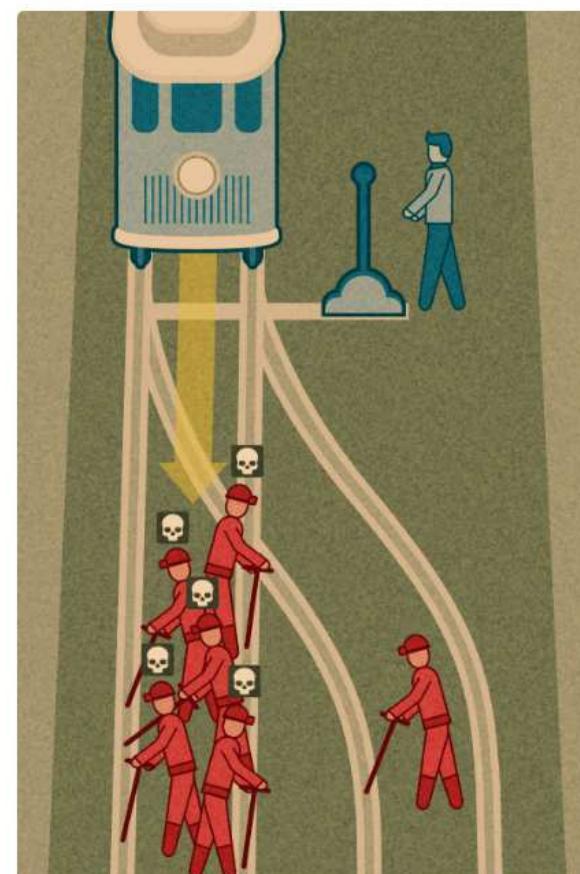
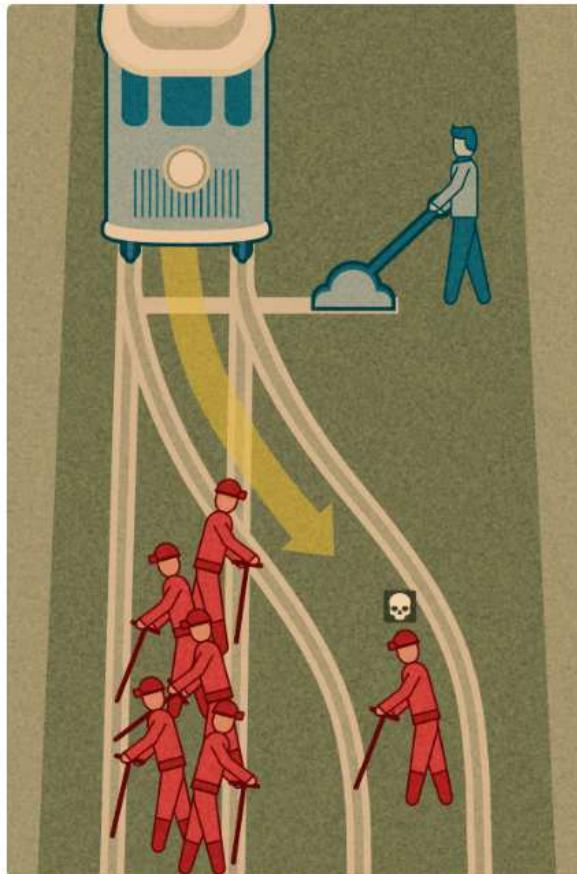
Home Information and service

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



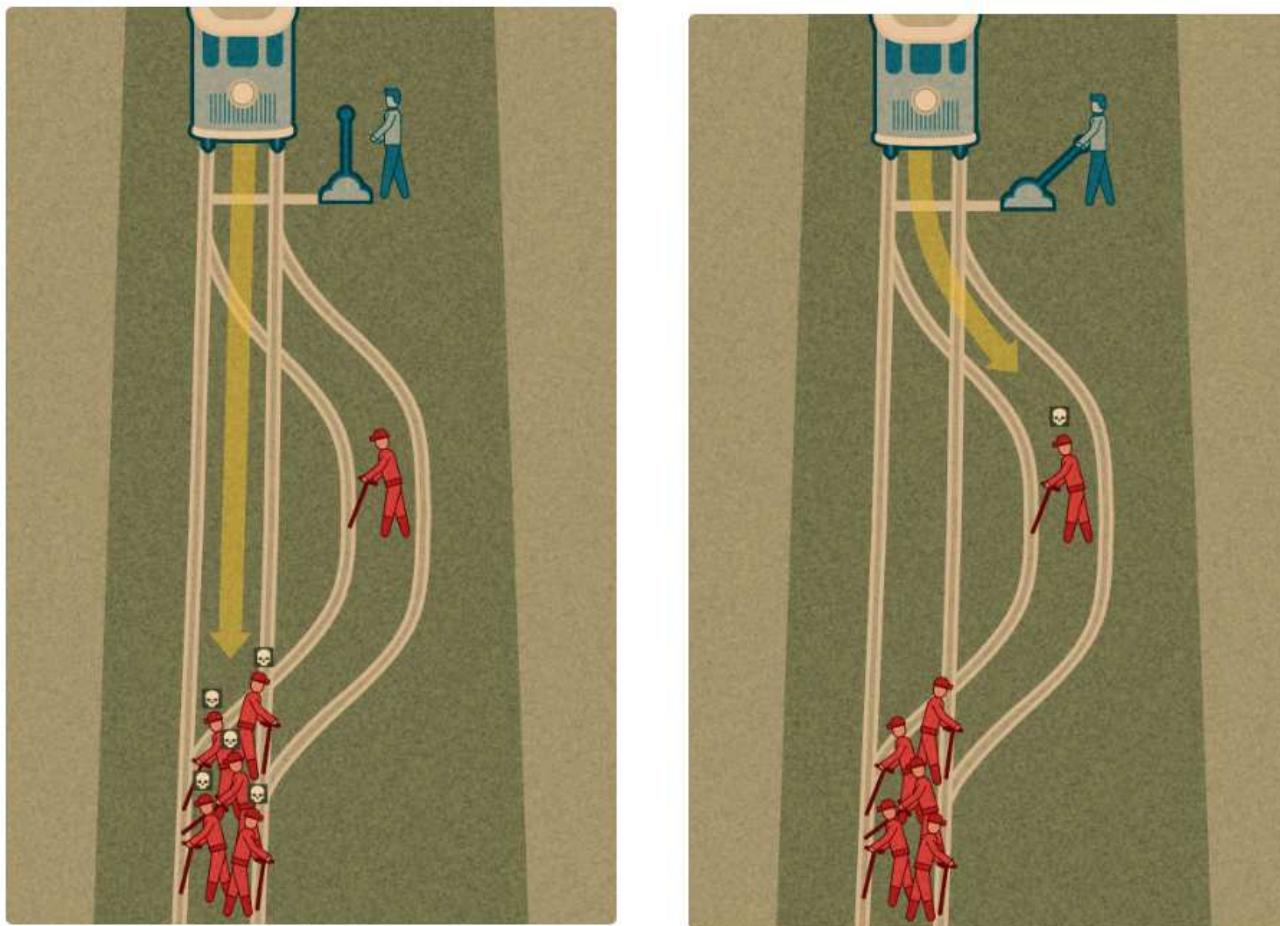
Moral Machine (1)

What should the man in blue do?



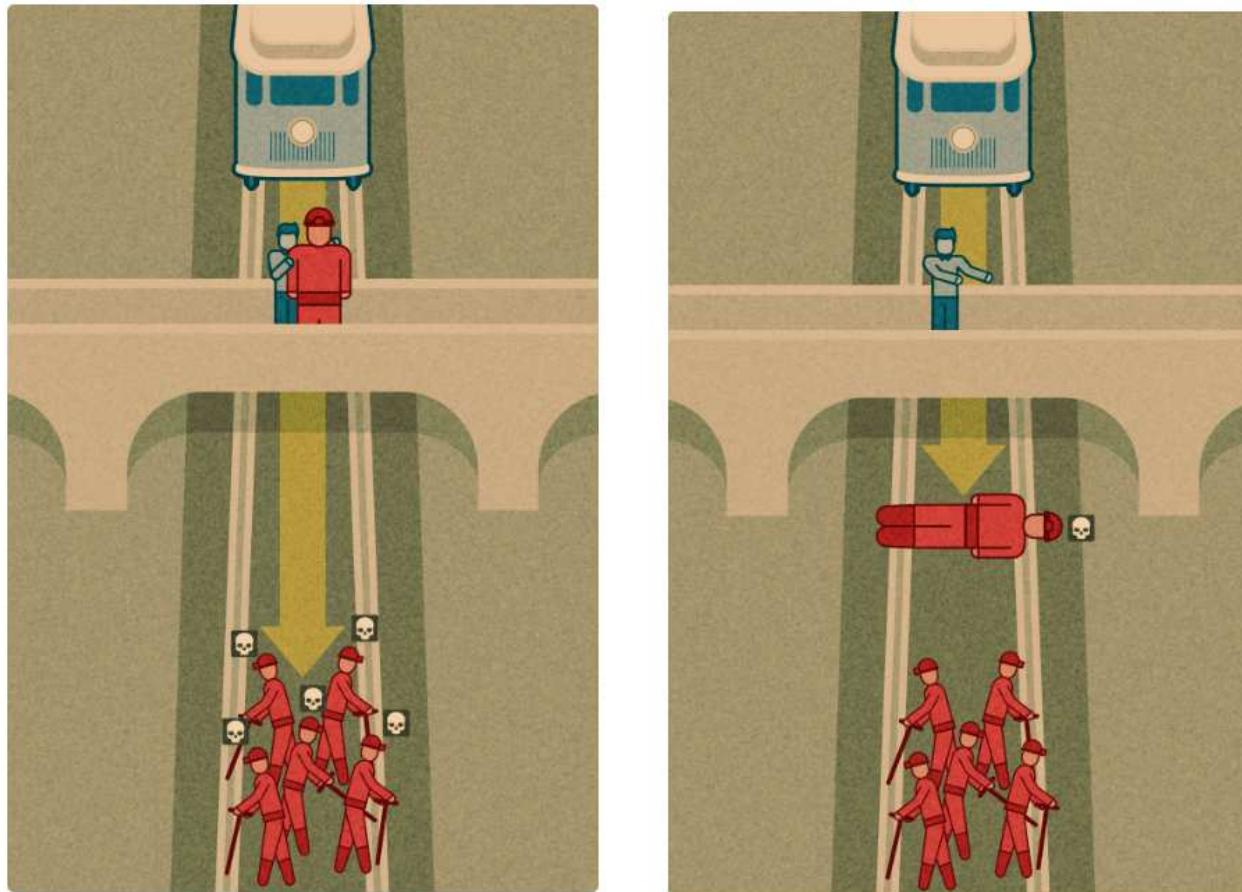
Moral Machine (2)

What should the man in blue do?



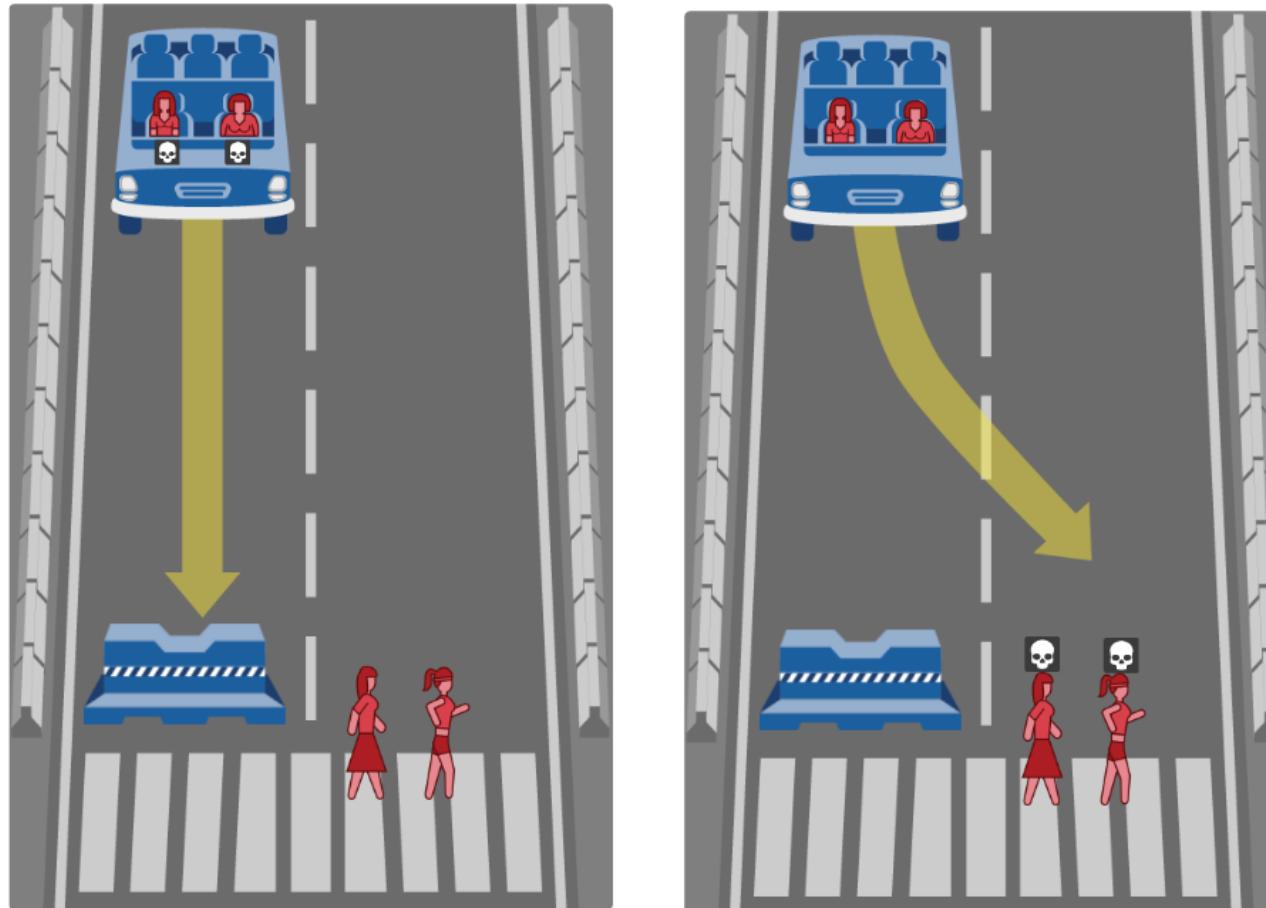
Moral Machine (3)

What should the man in blue do?

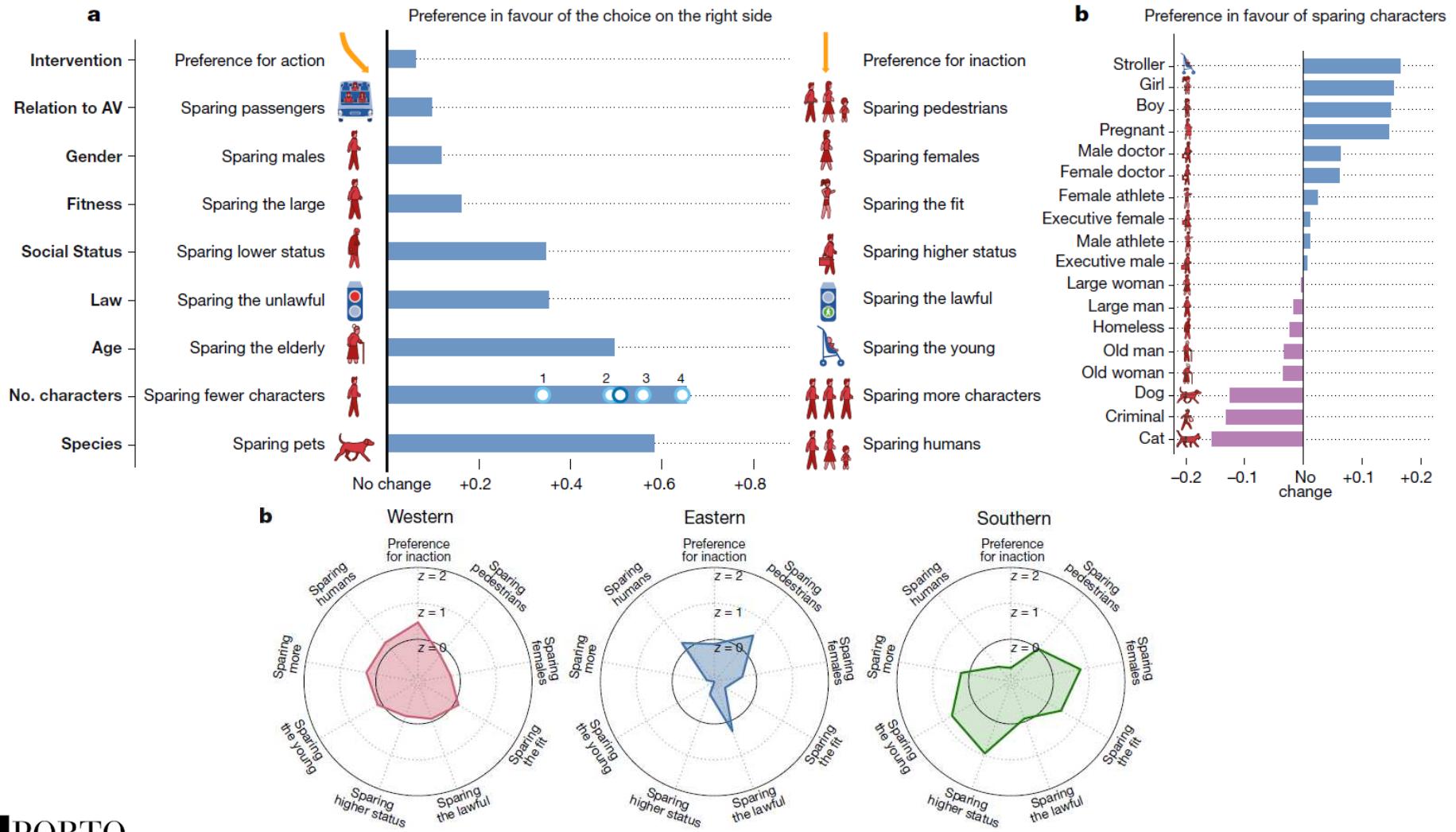


Moral Machine (4)

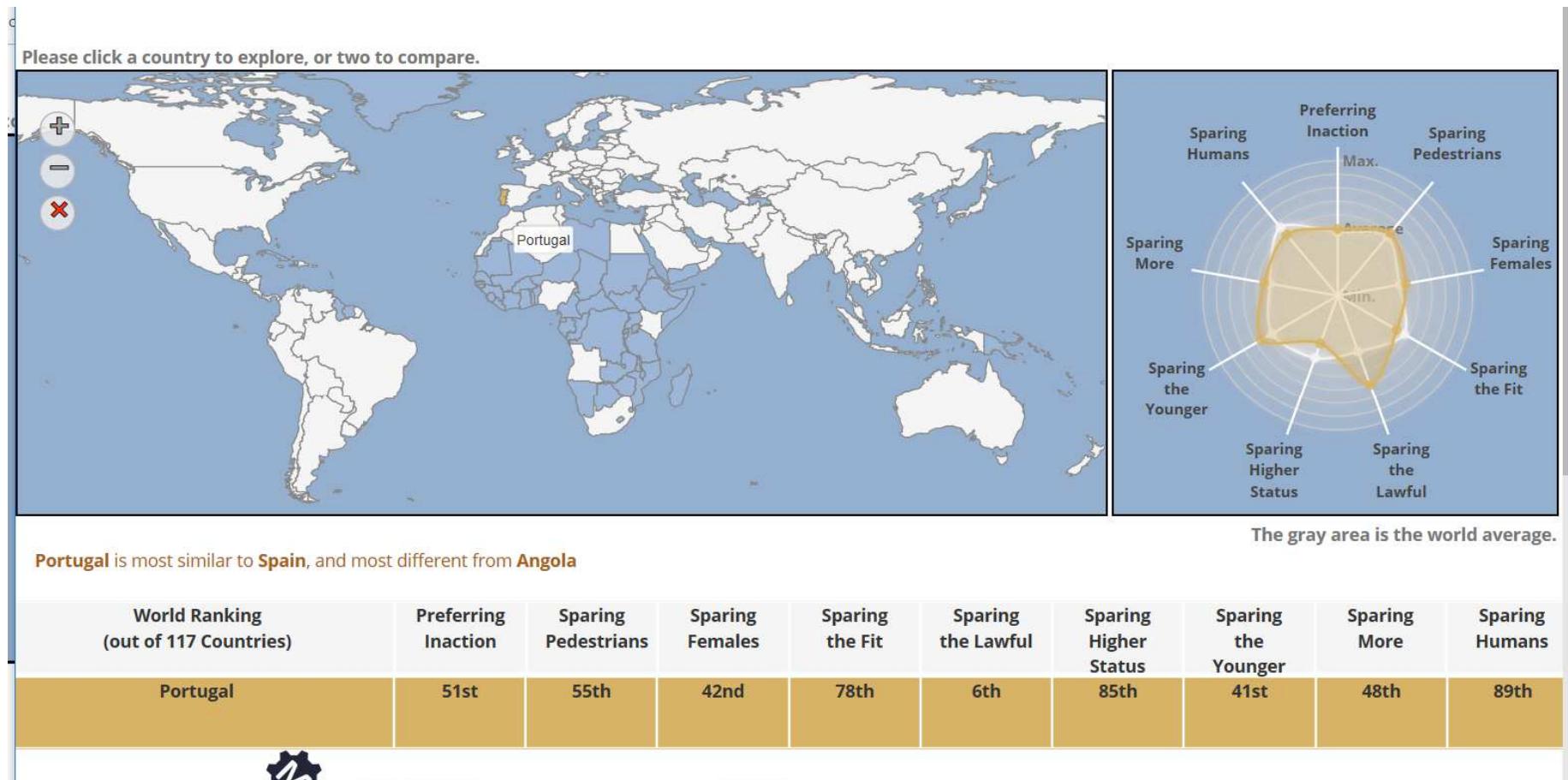
What should the self-driving car do?



Moral Machine – Results (1)



Moral Machine – Results (2)



Artificial Intelligence – The Future

- **Super Artificial Intelligence**

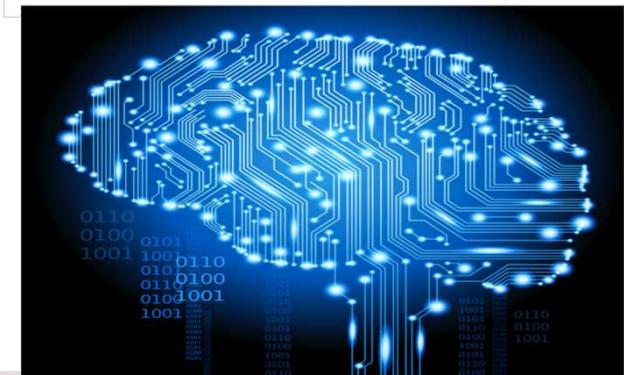
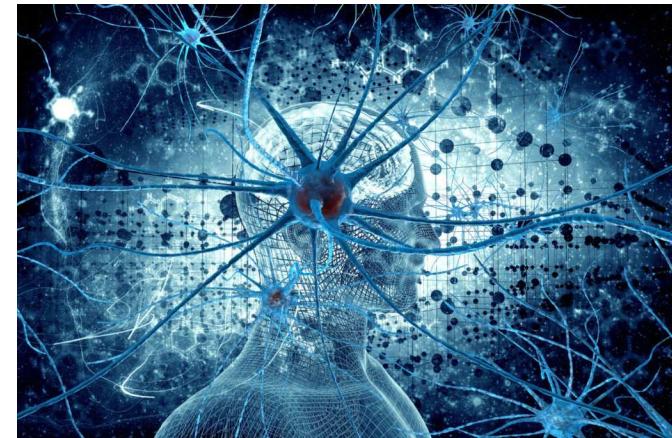
Hypothetical agent that possesses **intelligence far surpassing that of the brightest** and most gifted **human minds**

- **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!**



Resultados da Aprendizagem (I)

- Compreender os fundamentos da Inteligência Artificial e dos Sistemas Inteligentes, o que os caracteriza e distingue, qual a sua aplicabilidade e onde os encontramos no nosso quotidiano.
- Compreender a noção de Agente computacional e de Sistema Multi-Agente e ser capaz de projetar e implementar Agentes e Sistemas Multi-Agente para resolver diferentes problemas.
- Aprender métodos e algoritmos heurísticos e sistemáticos de Resolução de Problemas, com e sem Adversários, utilizando o Conhecimento na resolução de problemas complexos.
- Aprender métodos de Representação do Conhecimento Impreciso e Raciocínio utilizando diferentes formalismos.

Resultados da Aprendizagem (II)

- Compreender como desenvolver interfaces em Linguagem Natural e Motores de inferência para Sistemas baseados em conhecimento
- Conhecer algoritmos de aprendizagem aplicando diferentes paradigmas (supervisionado, não supervisionado, por reforço, em profundidade/"Deep Learning", etc.)
- Compreender tópicos avançados em Inteligência Artificial e ser capaz de formular uma visão sobre o futuro da IA e as suas aplicações práticas agora e no futuro.
- Ser Capaz de implementar pequenos projetos, simples mas completos de Inteligência Artificial.

Lecturing Team



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IART – Funcionamento das Aulas

- **Aulas Teóricas:**
 - Exposição da Matéria
 - Avaliações (kahoots)
- **Aulas Teórico-Práticas:**
 - Exposição da Matéria
 - Exercícios e Resolução
 - Avaliações (Kahoots)
- **Aulas Práticas:**
 - Exercícios e Resolução
 - Acompanhamento dos Trabalhos Práticos
 - Avaliações (Trabalhos Práticos)

IART – Avaliação/Evaluation

- **2 Minitestes / Exame Recurso: 50%**
 - Minitestes/Exames com Consulta de cariz Prático realizados no Moodle
- **Participação nas Aulas/Trabalhos Práticos: 50%**
 - Trabalho 1: 40%
(Apresentação, Código e Demo)
 - Trabalho 2: 40%
(Apresentação, Código e Demo)
 - Kahoots/Atividades Moodle: 20%
(5 de 10 Kahoots)

Bibliografia

- Bibliografia Obrigatória
 - Stuart Russell, Peter Norvig; [Artificial intelligence.](#)
- Bibliografia Complementar
 - Ernesto Costa e Anabela Simões; [Inteligência artificial.](#)
 - Bratko, Ivan; [Prolog programming for artificial intelligence](#)
 - J. Ross Quinlan; [Programs for Machine Learning](#)
 - Elaine Rich, Kevin Knight; [Artificial intelligence.](#)
 - Pedro Domingos; [The Master Algorithm: How the Quest for the Ultimate Learning Machine Will Remake Our World](#)

Conclusões

- Disciplina é uma Introdução à Inteligência Artificial e às suas principais áreas e aplicações
- Dois trabalhos práticos que permitem explorar várias áreas de IA
- Programa inclui: Agentes Inteligentes e SMA, Métodos de Resolução de Problemas, Otimização e Meta-heurísticas, Engenharia do Conhecimento, Aprendizagem Computacional, Processamento de Linguagem Natural e Tópicos Avançados de IA
- IA com grande impacto presente e sobretudo futuro na indústria e administração pública
- Aproximadamente 50% das dissertações de mestrado em curso no MIEIC são em IA

Artificial Intelligence/ Inteligência Artificial

Lecture 0: Course Presentation

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