INTRODUCTION TO AIML

Ami Munshi

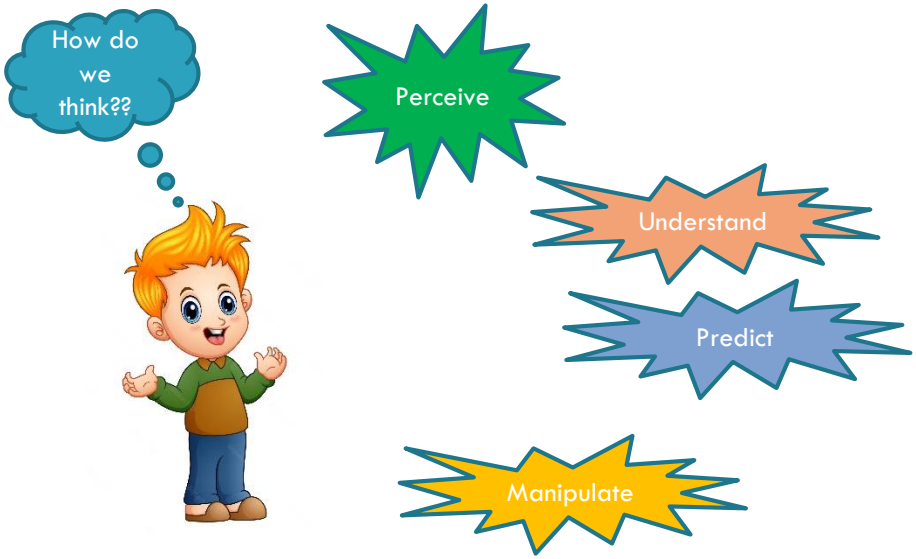
Syllabus

Introduction to Artificial Intelligence Definition, Foundations of AI, Approaches to AI.	**02**

References

- Stuart Russel and Peter Norvig, *Artificial Intelligence: A Modern Approach*, 4th edition, Pearson Education, 2021
- Elaine Rich, Kavin Knight, Shivshankar Nair, Artificial intelligence, 3rd edition, Tata McGraw Hill, 2019

Intelligence



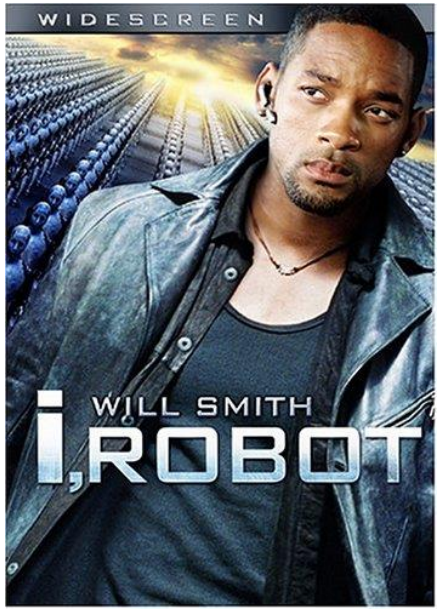
Mere handful of matter can perceive, understand, predict, and manipulate a world far larger and more complicated than itself

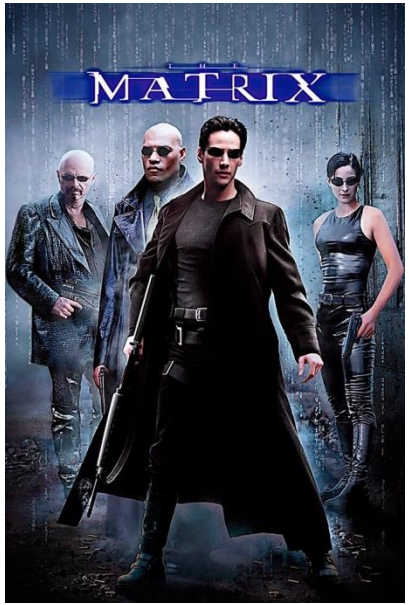
Homo Sapiens- Man the wise

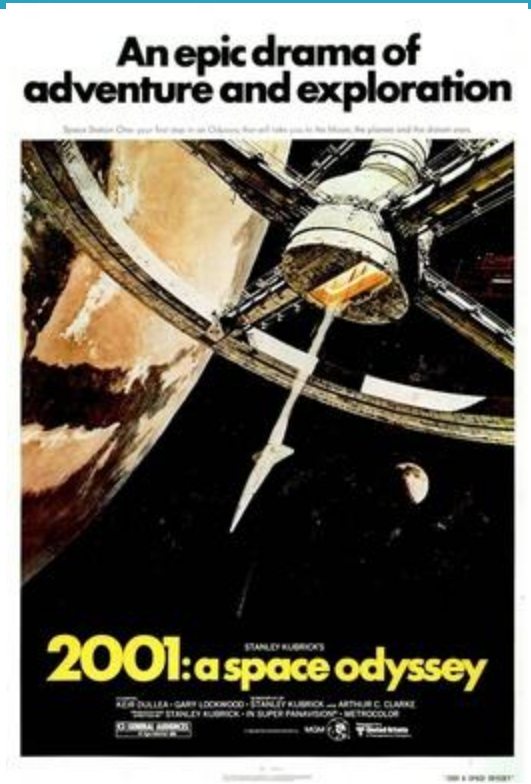
Artificial Intelligence

- It attempts not just to understand but also to *build* intelligent entities
- AI currently encompasses a huge variety of subfields like
  - General field- learning and perception
  - Specific field- playing chess, proving mathematical theorems, writing poetry, driving a car on a crowded street, and diagnosing diseases.
- AI is relevant to any intellectual task
- It is truly a universal field

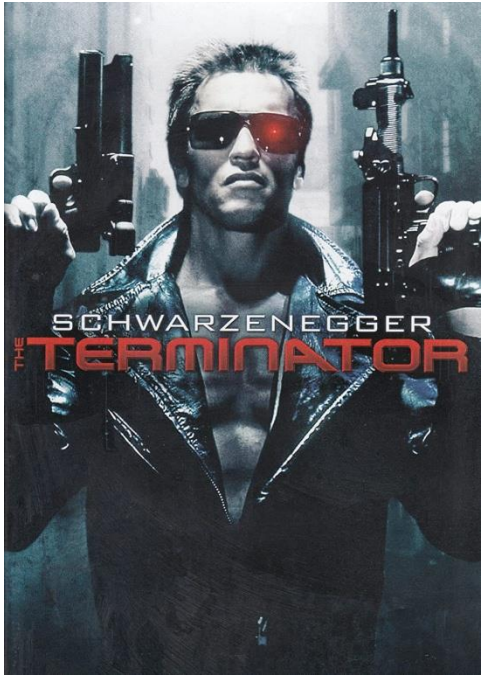
What movies have you seen about AI?

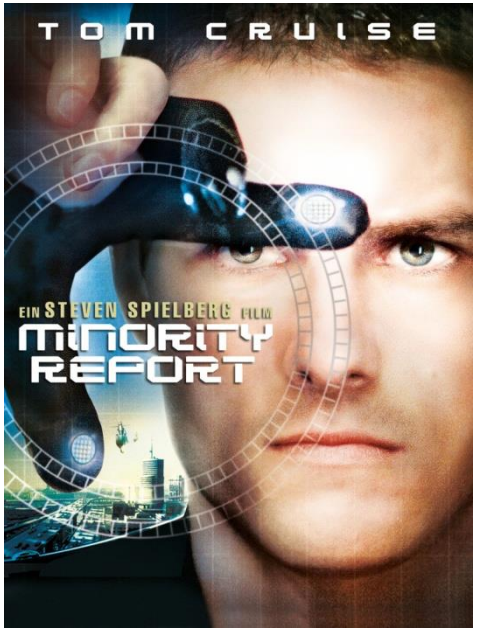






What movies have you seen about AI?





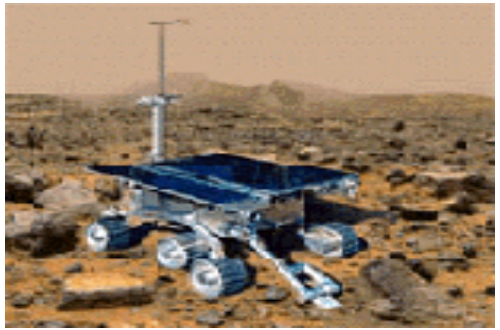
What movies have you seen about AI?

- And many more…

Why the interest in AI?

AI everywhere

Labor



Science

Appliances

Google

YAHOO!

Search engines

Medicine/
Diagnosis

What else?

At present, in what activities humans are better than computers

- Being human
  - Emotions- Express empathy, taking care,
  - Creativity
  - Human touch
  - Ability to dream (dream can become reality)- Innovation
  - Free will (autonomy to think)
  - Flexibility- act according to situation
  - Understand and handle abstract concepts

At present, in what activities computers are better than human

- Computing
  - Speed, accuracy
- Strategizing
  - Analyse all possible solutions and arrive at the most efficient
- Memory
  - Store vast amount of information
  - Retrieving information quickly and accurately
- Processing
  - Accurate and quick processing of information
- Can work without getting tired

Discerning Intelligence

- **Learning:** Having the ability to obtain and process new information.
- **Reasoning:** Being able to manipulate information in various ways.
- **Understanding:** Considering the result of information manipulation.
- **Grasping truths:** Determining the validity of the manipulated information.
- **Seeing relationships:** Divining how validated data interacts with other data.
- **Considering meanings:** Applying truths to particular situations in a manner consistent with their relationship.
- **Separating fact from belief:** Determining whether the data is adequately supported by provable sources that can be demonstrated to be consistently valid.

What is Artificial Intelligence?

- Intelligence Exhibited by machines
- Intelligence is artificial, that is not *real* or *human*
- Mimics cognitive functions such as perceiving, learning and reasoning which are exhibited by humans

Some Definitions of AI

The exciting new effort to make computers think …
machines with minds,
in the full literal sense.

Haugeland, 1985

Some Definitions of AI

The study of how to make computers do things
at which, at the moment,
people are better.

Rich & Knight, 1991

Great Contributors

- **Dartmouth Workshop 1956: the birth of AI**
- Organized by Marvin Minsky, John McCarthy and two senior scientists: Claude Shannon and Nathan Rochester of IBM
- Proposal for the conference included :
  - "every aspect of learning or any other feature of intelligence can be so precisely described that a machine can be made to simulate it"
- McCarthy persuaded the attendees to accept "Artificial Intelligence" as the name of the field

Great Contributors

- Herbet Simon
  - Developed first AI software along with Allen Newell and J.C Shaw in 1956
- John McCarthy
  - Coined the term Artificial Intelligence
  - Developed LISP programming language family
- Alan Turing
  - "*Computing Machinery and Intelligence*"
    - https://doi.org/10.1093/mind/LIX.236.433
    - Proposed a question "Can machine think"
  - Developed Turing Test

Artificial Intelligence Systems Approaches

- Systems that think like humans
  - Model human mind
  - Machine with minds
  - Activities associated with human thinking- decision making, problem solving, learning
- Systems that act like humans
  - Show human behaviour
- Systems that think rationally
  - Draw logical inferences while making decisions
- Systems that act rationally
  - Performing actions that are rational

	Humanly	Rationally
Think	Think Humanly	Think Rationally
Act	Act Humanly	Act Rationally

Thinking humanly

- Science of making machines that think like people
- Cognitive modeling approach
- Need to know actual working of human mind
  - through introspection—trying to catch our own thoughts as they go by
  - through psychological experiments—observing a person in action
  - through brain imaging—observing the brain in action
- With sufficiently precise theory of the mind, it possible to express the theory as a computer program
- Main obstacles??

Acting humanly

- Not worrying about the though process, more importance given to actions taken
- All about the behavior
  - Turing test
- Computer would need to possess the following capabilities
  - natural language processing to enable it to communicate successfully in English
  - knowledge representation to store what it knows or hears
  - automated reasoning to use the stored information to answer questions and to draw new conclusions
  - machine learning to adapt to new circumstances and to detect and extrapolate patterns

Thinking rationally: “Laws of thought approach”

- Thinking rationally-Right thinking
  - Irrefutable reasoning process
- Aristotle
  - codified right thinking
  - his **syllogisms** provided patterns for argument structures
  - that always yielded correct conclusions when given correct premises
- for example
  - “Socrates is a man;
  - all men are mortal;
  - therefore, Socrates is mortal.”
- These laws of thought were supposed to govern the operation of the mind; their study initiated the field called **logic.**

Thinking rationally: "Laws of thought approach"

- Some obstacles to this approach
  - Not easy to take informal knowledge and state it in formal terms as required by logical notations
  - Big difference between solving a problem in theory and in practice
  - Problems with just few dozen facts can exhaust the computational resources

Acting rationally-Rational Agent Approach

- An **agent** is just something that acts
- Computer agents are expected to do more-
  - operate autonomously, perceive their environment, persist over a prolonged time period, adapt to change, and create and pursue goals
- A **rational agent**
  - is one that acts so as to achieve the best outcome or,
  - Maximally achieving predefined goals
  - when there is uncertainty, the best expected outcome
- All the skills needed for the Turing Test also allow an agent to act rationally
- Knowledge representation and reasoning enable agents to reach good decisions
- Rationality is only concerned about the action taken does not matter what is the though process
- Limitations??
  - achieving perfect rationality—always doing the right thing—is not feasible in complicated environments

What can AI system do presently?

What can AI systems do presently?

- Play board games?
- Play ping pong game?
  - https://www.techrepublic.com/videos/ping-pong-playing-robot-proves-ai-driven-machines-can-sense-human-emotion/
- Drive safely along a road
  - https://www.techtarget.com/searchenterpriseai/definition/driverless-car#:~:text=AI%20technologies%20power%20self%2Ddriving,systems%20that%20can%20drive%20autonomously.
- But grocery?
  - https://blog.richardvanhooijdonk.com/en/the-supermarket-of-the-future-is-self-driving-and-run-by-ai/
- Cleaning dishes or folding laundry?

Weak vs Strong AI

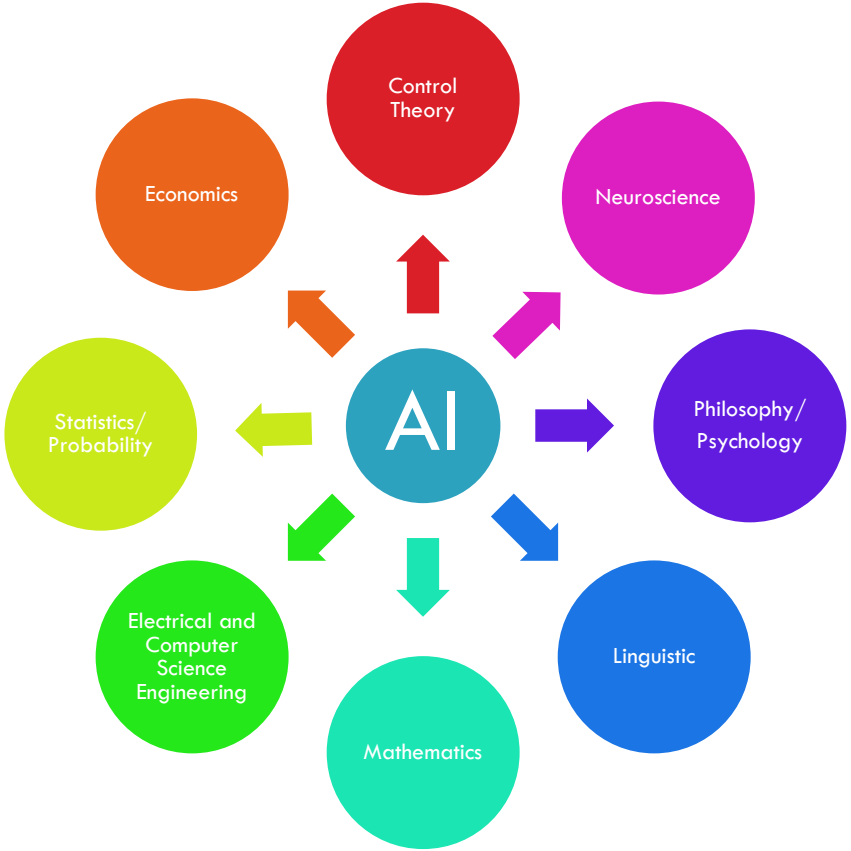
- Weak AI or Narrow AI or Artificial Narrow Intelligence (ANI)
  - Intelligent at completing a specific task
  - AI applied to a specific domain
  - They give human like experience, but it is just a simulation
  - They often have programmed response
  - Examples language translators, virtual assistants, self driving cars, AI powered web searches, recommendation engines, intelligent spam filters
  - Example Siri or Alexa, advanced chess programs
- Strong AI or Artificial General Intelligence (AGI)
  - Exhibits human intelligence
  - It can understand, perceive, think, act, plan, solve problems etc like a human being does
  - They have self awareness
  - They can interact and operate a wide variety of independent and unrelated tasks
  - Can learn new tasks to solve new problems
  - Machines that are indistinguishable from human mind

https://www.ibm.com/cloud/learn/strong-ai

Some world famous AI machines

- IBM Watson
- Google's driverless car
- Sophia, humanoid Robot
- Assistant/chatbot- Alexa, Siri, Google Home
- Honda Asimo- Humanoid Robot

Many disciplines involved



Foundation of AI

- Philosophy
- Mathematics
- Economics
- Neuroscience
- Psychology
- Control Theory
- John McCarthy- coined the term- 1950's

Summary of foundation

- Philosophers
  - Made AI conceivable by considering the ideas that the mind is in some ways like a machine, that it operates on knowledge encoded in some internal language, and that thought can be used to choose what actions to take
- Mathematicians
  - Provided the tools to manipulate statements of logical certainty as well as uncertain, probabilistic statements. They also set the groundwork for understanding computation and reasoning about algorithms
- Economists
  - Formalized the problem of making decisions that maximize the expected outcome to the decision maker
- Neuroscientists
  - Discovered some facts about how the brain works and the ways in which it is similar to and different from computers

Summary

- Psychologists
  - Adopted the idea that humans and animals can be considered information processing machines.
- Linguists
  - Showed that language use fits into this model.
- Computer engineers
  - Provided the ever-more-powerful machines that make AI applications possible.
- Control theory
  - Deals with designing devices that act optimally on the basis of feedback from the environment. Initially, the mathematical tools of control theory were quite different from AI, but the fields are coming closer together.

What can AI do today?

- Robotic vehicles
- Speech recognition
- Autonomous planning and scheduling
- Game playing
- Spam fighting
- Logistic planning
- Machine translation
- Robotics

Turing Test

Turing Test

- Human beings are intelligent
- To be called intelligent,
- a machine must produce responses that are
- indistinguishable from those of a human

Alan Turing

Intelligence

- *Turing Test*: A human communicates with a computer via a teletype.
- If the human can't tell he is talking to a computer or another human, it passes.
  - natural language processing
  - knowledge representation
  - automated reasoning
  - machine learning
- Add vision and robotics to get the total Turing test.

What does it mean if a computer passes the Turing Test?

- Can the computer think?
- Does the computer have a mind in exactly the same sense that you and I have minds?

Consider what might be involved in building a "smart" computer….

- What are the "components" that might be useful?
  - Fast hardware?
  - Foolproof software?
  - Chess-playing at grandmaster level?
  - Speech interaction?
    - speech synthesis
    - speech recognition
    - speech understanding
  - Image recognition and understanding ?
  - Learning?
  - Planning and decision-making?

Can we build hardware as complex as the brain?

- How complicated is our brain?
  - a neuron, or nerve cell, is the basic information processing unit
  - estimated to be on the order of 10^{12} neurons in a human brain
  - cycle time: 10^{-3} seconds (1 millisecond)

- How complex can we make computers?
  - 10^6 or more transistors per CPU
  - supercomputer: hundreds of CPUs, 10^9 bits of RAM
  - cycle times: order of 10^{-8} seconds

- Conclusion
  - **YES**: in the near future we can have computers with as many basic processing elements as our brain, but with
    - far fewer interconnections (wires or synapses) than the brain
    - much faster updates than the brain
  - **but** building hardware is very different from making a computer behave like a brain!

Can Computers Talk?

- This is known as “speech synthesis”
  - translate text to phonetic form
    - e.g., “fictitious” -> fik-tish-es
  - use pronunciation rules to map phonemes to actual sound
    - e.g., “tish” -> sequence of basic audio sounds

- Difficulties
  - sounds made by this “lookup” approach sound unnatural
  - sounds are not independent
    - e.g., “act” and “action”
    - modern systems (e.g., at AT&T) can handle this pretty well
  - a harder problem is emphasis, emotion, etc
    - humans understand what they are saying
    - machines don’t: so they sound unnatural

- Conclusion: NO, for complete sentences, but YES for individual words

Can Computers Recognize Speech?

- Speech Recognition:
  - mapping sounds from a microphone into a list of words.
  - Hard problem: noise, more than one person talking, occlusion, speech variability,..
  - Even if we recognize each word, we may not understand its meaning.
- Recognizing single words from a small vocabulary
  - systems can do this with high accuracy (order of 99%)
  - e.g., directory inquiries
    - limited vocabulary (area codes, city names)
    - computer tries to recognize you first, if unsuccessful hands you over to a human operator
    - saves millions of dollars a year for the phone companies

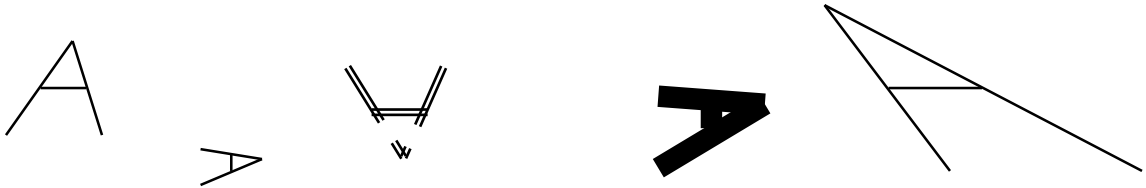
Can Computers Learn and Adapt ?

- Learning and Adaptation
  - consider a computer learning to drive on the freeway
  - we could code lots of rules about what to do
    - systems like this are under development (e.g., Daimler Benz)
    - e.g., RALPH at CMU
      - in mid 90's it drove 98% of the way from Pittsburgh to San Diego without any human assistance
  - **machine learning** allows computers to learn to do things without explicit programming
- Conclusion: YES, computers can learn and adapt, when presented with information in the appropriate way

Can Computers “see”?

- Recognition v. Understanding (like Speech)
  - Recognition and Understanding of Objects in a scene
    - look around this room
    - you can effortlessly recognize objects
    - human brain can map 2d visual image to 3d “map”

- Why is visual recognition a hard problem?



- Conclusion: mostly NO: computers can only “see” certain types of objects under limited circumstances: but YES for certain constrained problems (e.g., face recognition)

Can Computers plan and make decisions?

- Intelligence
  - involves solving problems and making decisions and plans
  - e.g., you want to visit your cousin in Delhi
    - you need to decide on dates, flights
    - you need to get to the airport, etc
    - involves a sequence of decisions, plans, and actions
- What makes planning hard?
  - the world is not predictable:
    - your flight is canceled
    - there are a potentially huge number of details
    - do you consider all flights? all dates?
      - no: commonsense constrains your solutions
  - AI systems are only successful in constrained planning problems

Conclusion: NO, real-world planning and decision-making is still beyond the capabilities of modern computers

exception: very well-defined, constrained problems: mission planning for satellites.

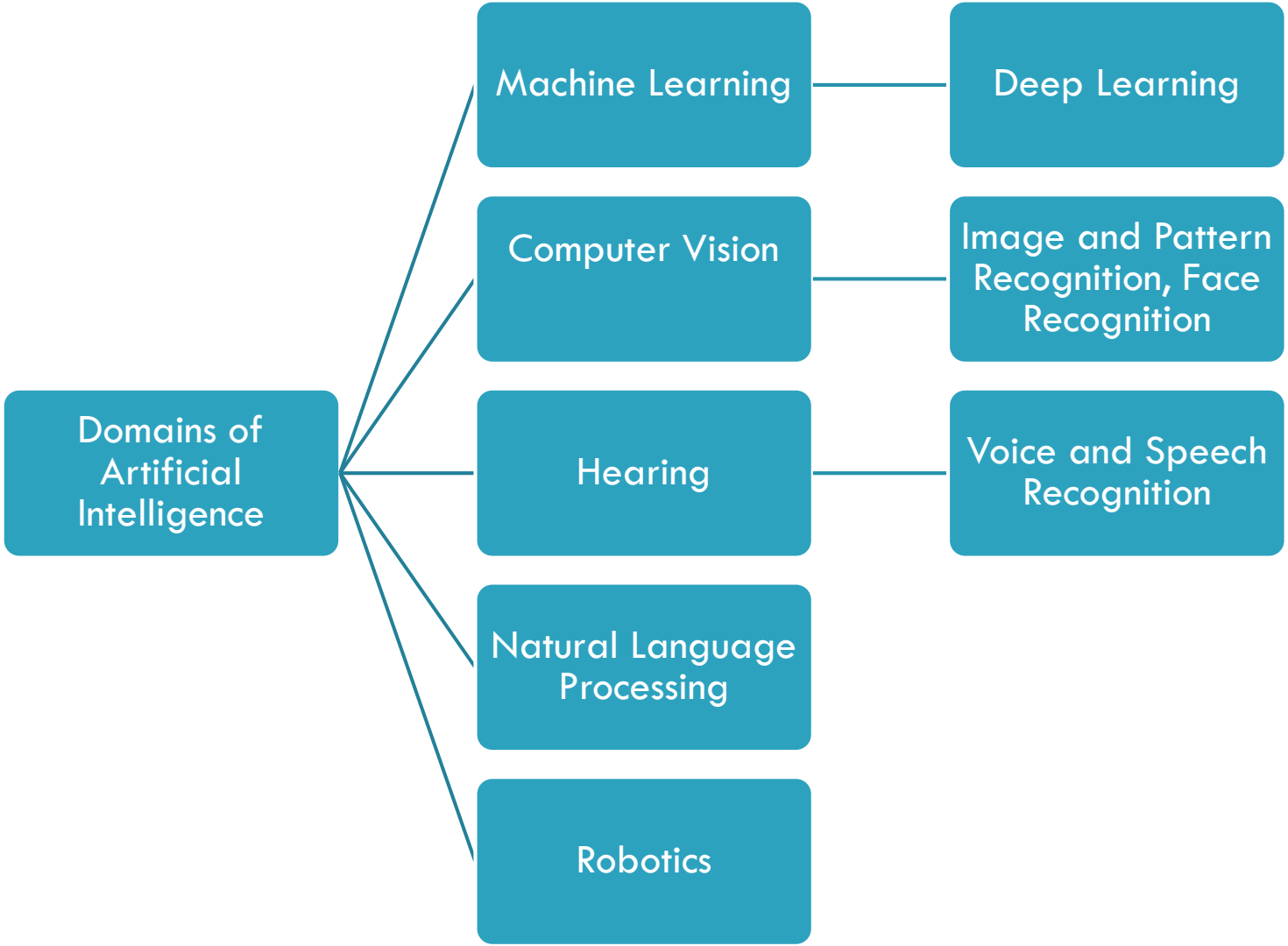
Applications of AI

Does AI have applications?

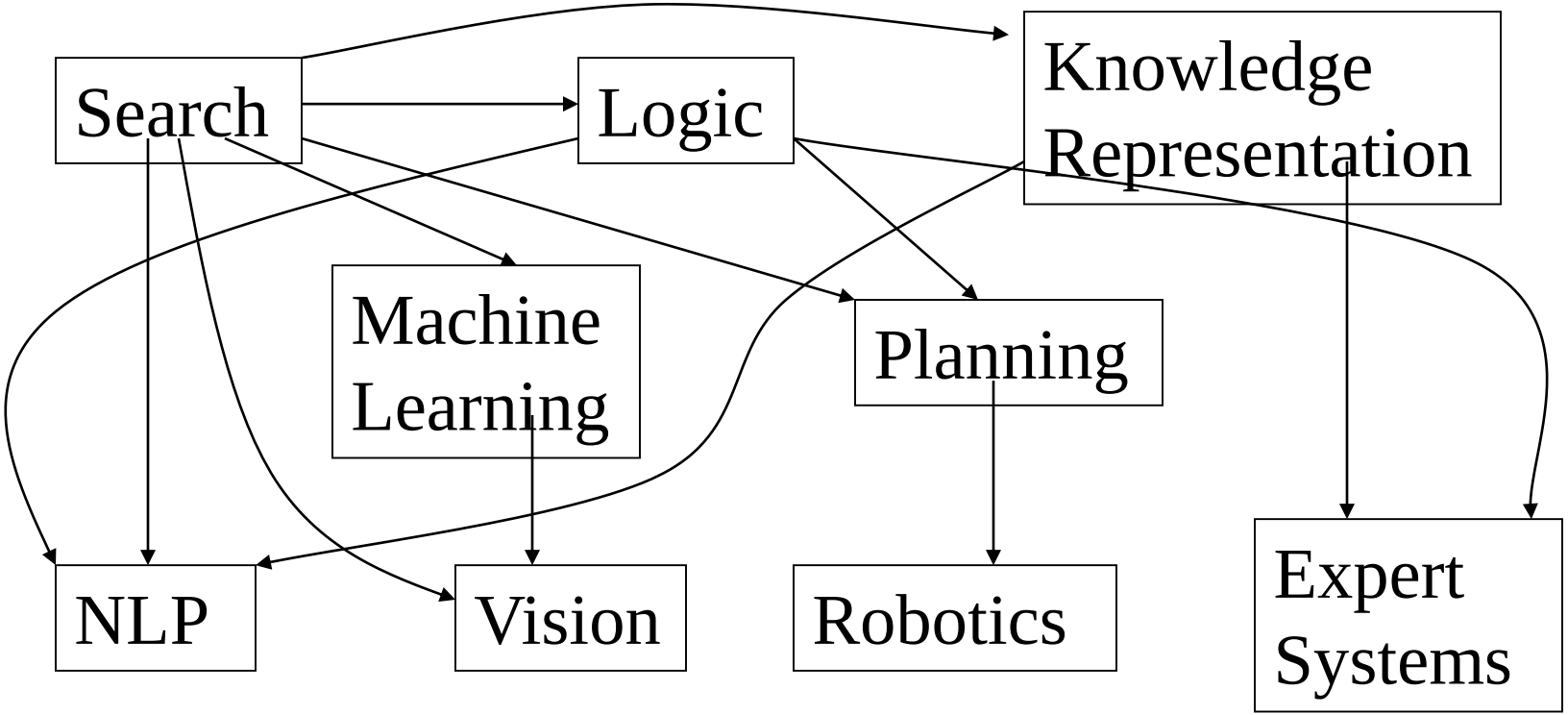
- Autonomous planning and scheduling of tasks aboard a spacecraft
- Beating Gary Kasparov in a chess match
- Steering a driver-less car
- Understanding language
- Robotic assistants in surgery
- Monitoring trade in the stock market to see if insider trading is going on

Intelligent Systems in Your Everyday Life

- Post Office
  - automatic address recognition and sorting of mail
- Banks
  - automatic check readers, signature verification systems
  - automated loan application classification
- Telephone Companies
  - automatic voice recognition for directory inquiries
  - automatic fraud detection,
  - classification of phone numbers into groups
- Credit Card Companies
  - automated fraud detection, automated screening of applications
- Computer Companies
  - automated diagnosis for help-desk applications


Domains of Artificial Intelligence
Machine Learning
Deep Learning
Computer Vision
Image and Pattern Recognition, Face Recognition
Hearing
Voice and Speech Recognition
Natural Language Processing
Robotics

Areas of AI and Some Dependencies



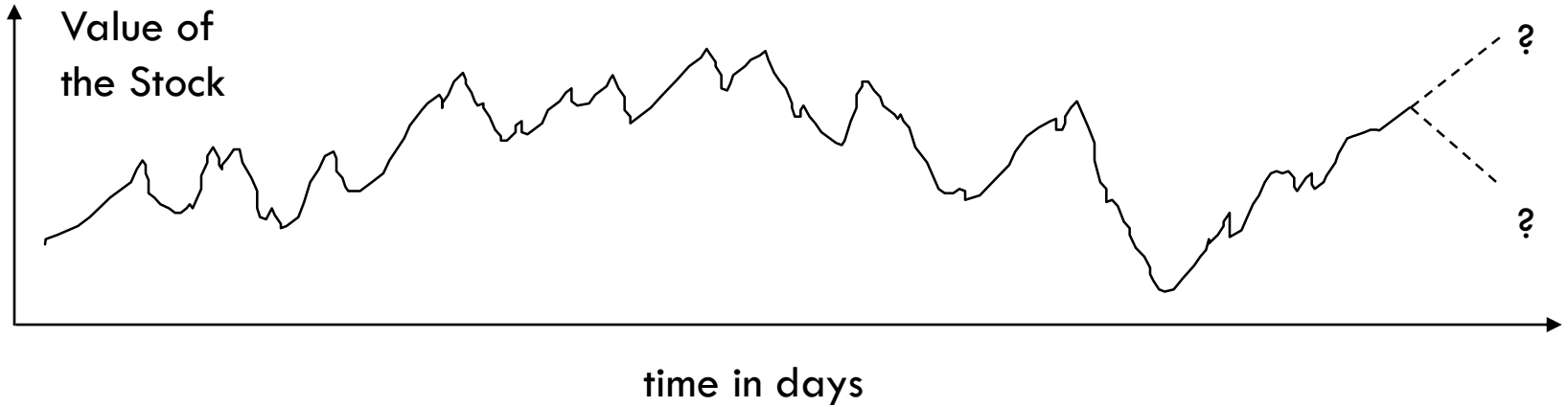
Some applications used extensively

Image Recognition	Speech Recognition	Language Translation
Sentiment Analysis	Split Testing or A/B Testing	Product Analytics

AI Applications: Identification Technologies

- ID cards
  - e.g., ATM cards
  - can be a nuisance and security risk:
    - cards can be lost, stolen, passwords forgotten, etc
- Biometric Identification
  - walk up to a locked door
    - camera
    - fingerprint device
    - microphone
  - computer uses your biometric signature for identification
    - face, eyes, fingerprints, voice pattern

AI Applications: Predicting the Stock Market



- The Prediction Problem
  - given the past, predict the future
  - very difficult problem!
  - we can use learning algorithms to learn a predictive model from historical data
  - such models are routinely used by banks and financial traders to manage portfolios worth millions of dollars

AI-Applications: Machine Translation

- Language problems in international business
  - e.g., at a meeting of Japanese, Korean, Vietnamese and Swedish investors, no common language
  - or: you are shipping your software manuals to 127 countries
  - solution; hire translators to translate
  - would be much cheaper if a machine could do this!

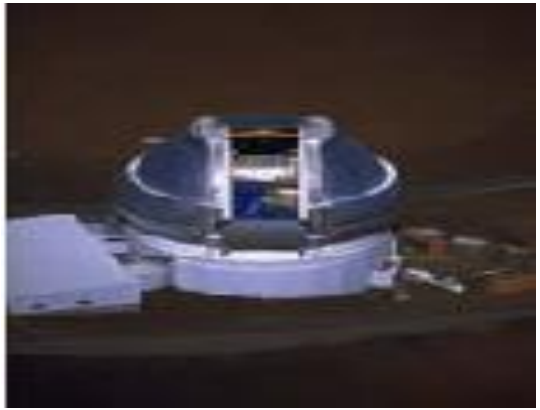
- Nonetheless....
  - commercial systems can do alot of the work very well (e.g.,restricted vocabularies in software documentation)
  - algorithms which combine dictionaries, grammar models, etc.
  - see for example babelfish.altavista.com

AI Applications

- Autonomous Planning & Scheduling:
  - Autonomous rovers.

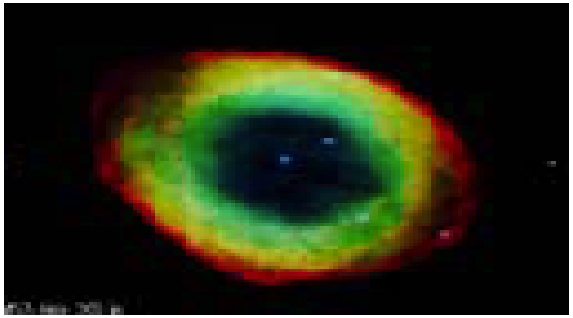
AI Applications

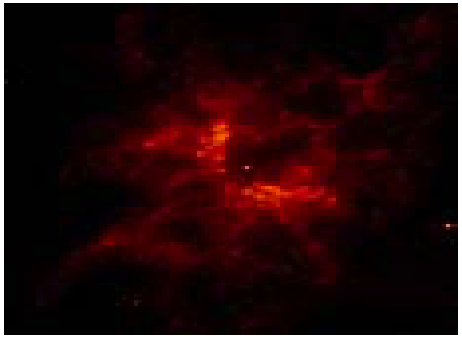
- Autonomous Planning & Scheduling:
  - Telescope scheduling



AI Applications

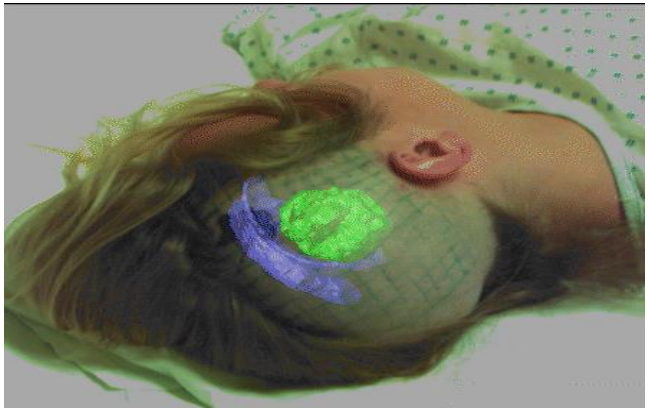
- Autonomous Planning & Scheduling:
  - Analysis of data:

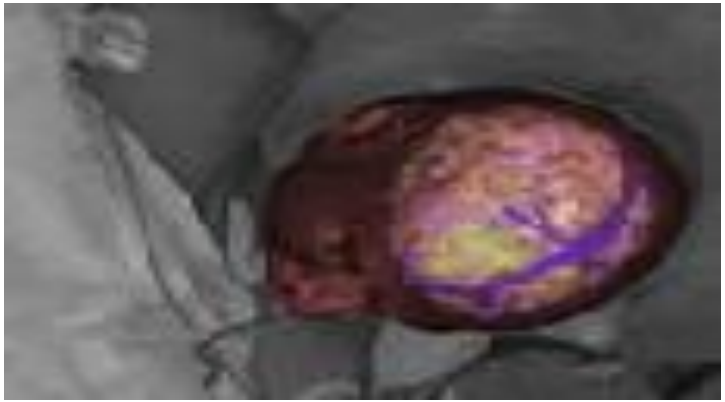




AI Applications

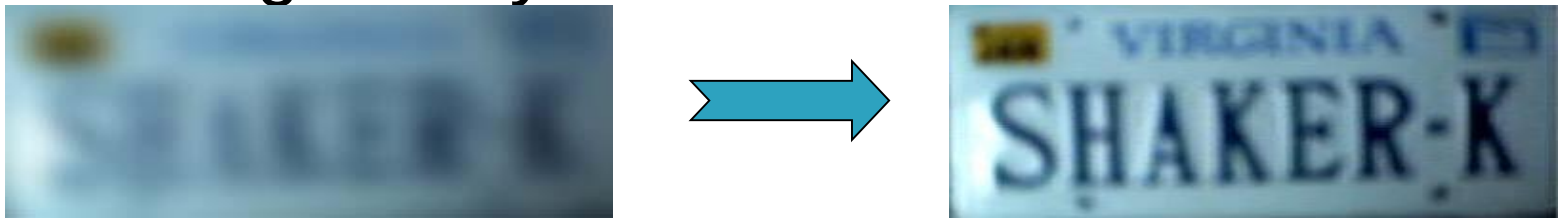
- **Medicine:**
  - Image guided surgery

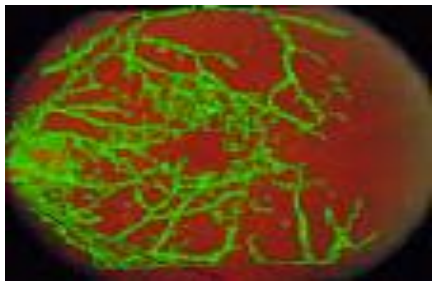


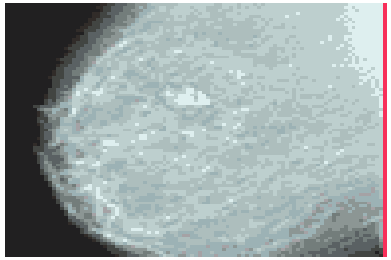


AI Applications

- **Medicine:**
  - Image analysis and enhancement







AI Applications

- **Transportation:**
  - **Autonomous vehicle control:**

AI Applications

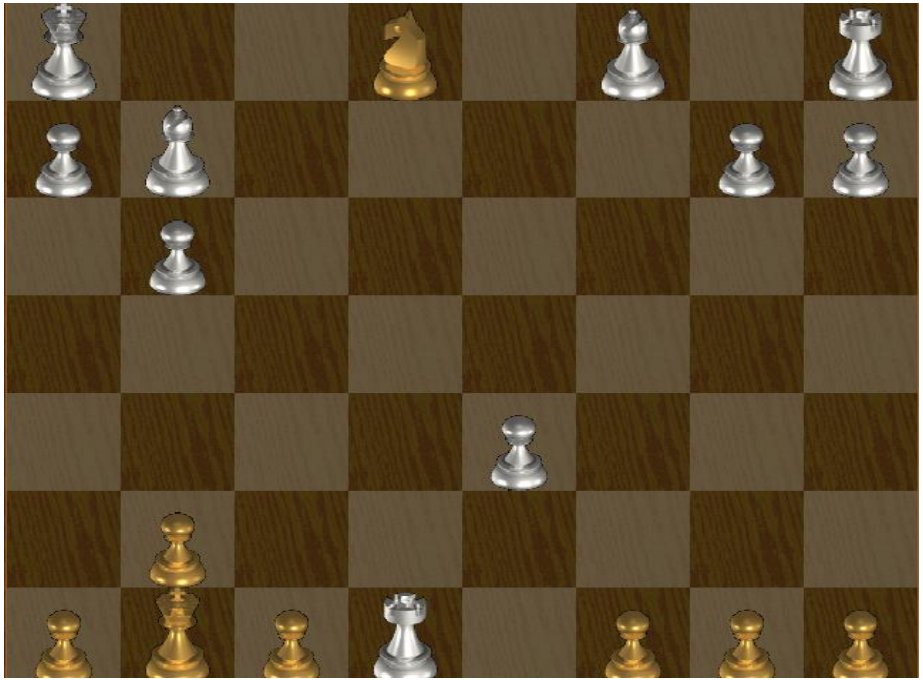
- **Transportation:**
  - **Pedestrian detection:**

AI Applications

Games:

AI Applications

- **Games:**



AI Applications

- **Robotic toys:**

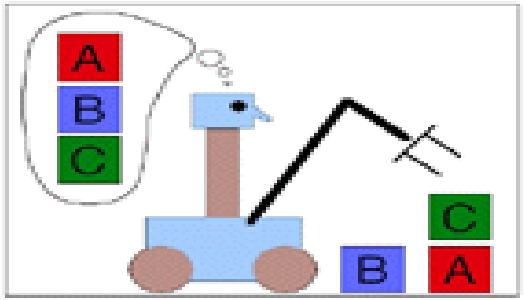
AI Applications

Other application areas:

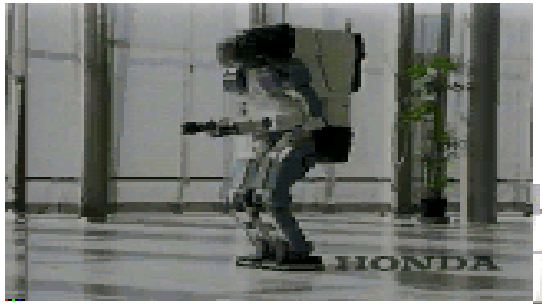
- **Bioinformatics:**
  - Gene expression data analysis
  - Prediction of protein structure
- **Text classification, document sortin**g:
  - Web pages, e-mails
  - Articles in the news
- **Video, image classification**
- **Music composition, picture drawing**
- **Natural Language Processing** .
- **Perception.**

Goals of AI

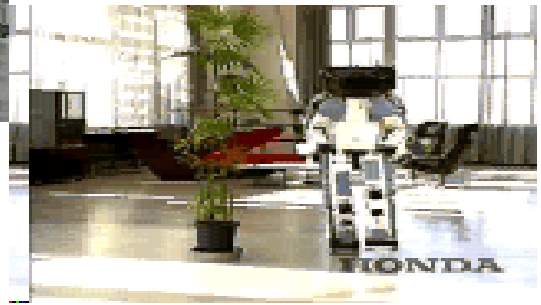
- To make computers more useful by letting them take over dangerous or tedious tasks from human
- Understand principles of human intelligence



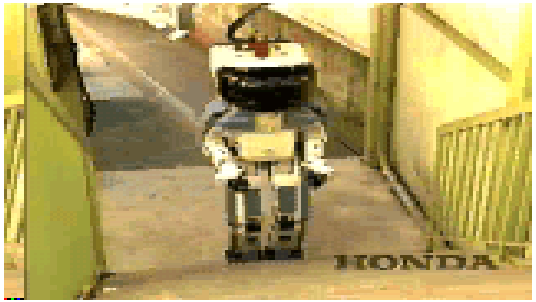
Honda Humanoid Robot



Walk

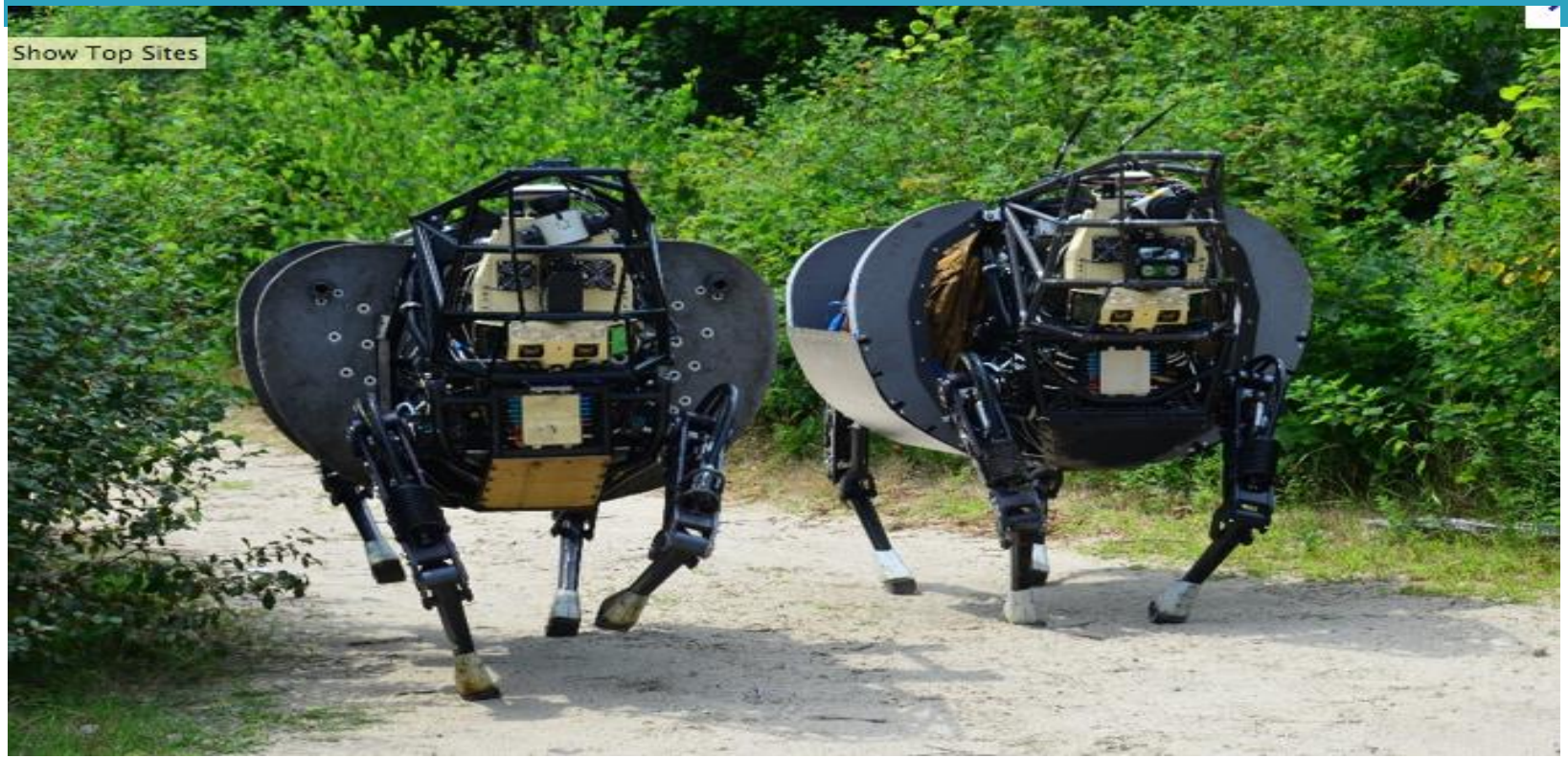


Turn



Stairs

Military robots

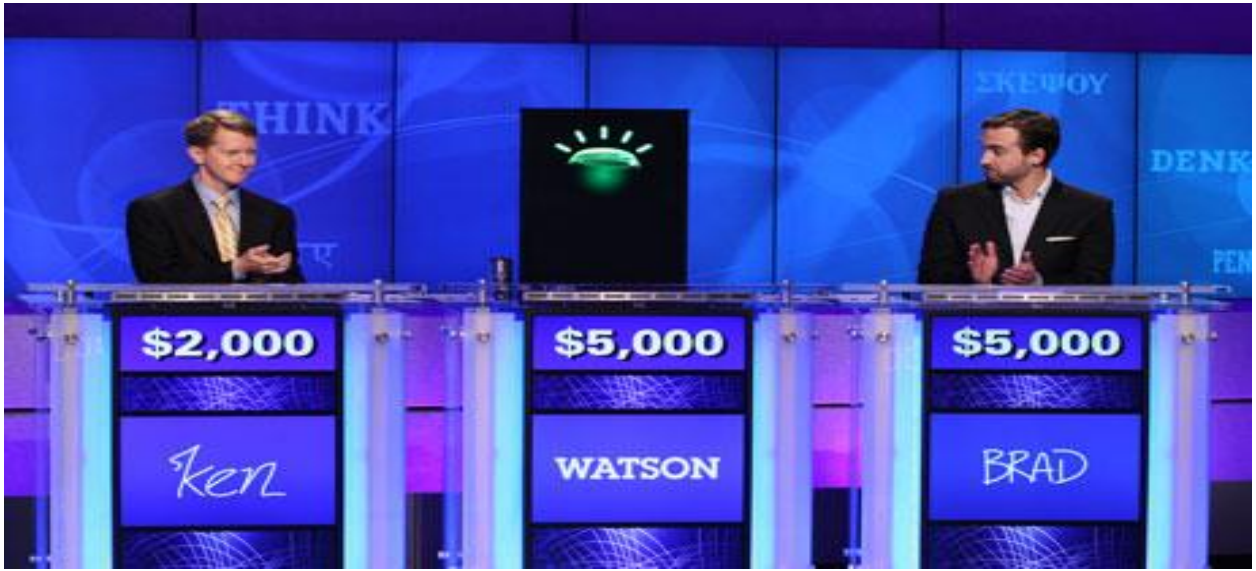


Robocup

www.robocup.org

Dee

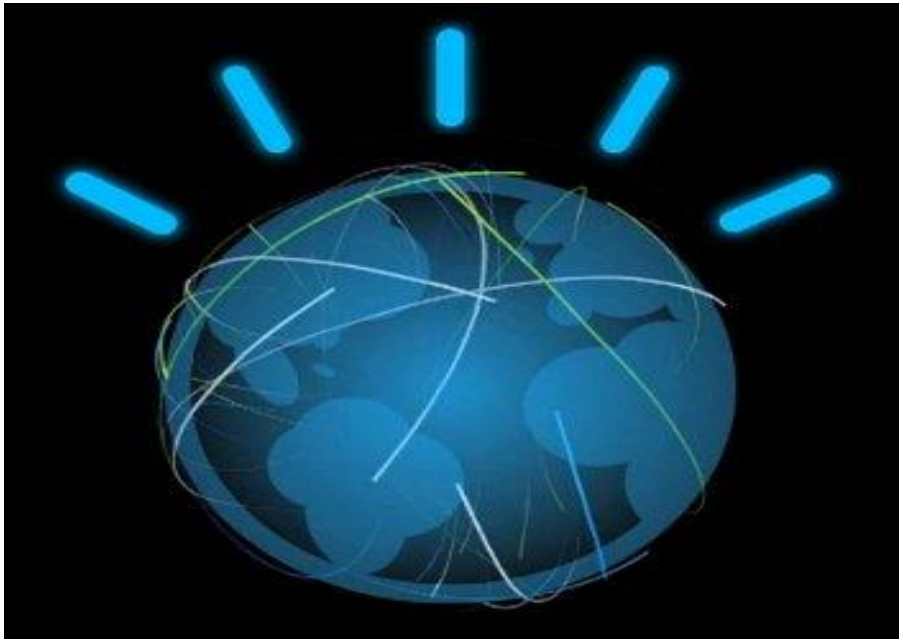
Watson



- “The goal is to have computers start to interact in natural human terms across a range of applications and processes, understanding the questions that humans ask and providing answers that humans can understand and justify” - IBM

Watson

- IBM's Artificial Intelligence computer system
- Capable of answering questions in natural language
- Competed against champions on Jeopardy and won



Applications of deep learning

Example 4

Early detection of cancer tumour and prediction of survival

Applications of deep learning

Example 5
Robotics

Applications of deep learning

Example 6

Autonomous driving cars

Thank you