CHAPTER : ONE
Introduction to Artificial Intelligence (AI)

Contents

Introduction

- What is intelligence ?

➢ Artificial Intelligence is composed of two words Artificial and Intelligence.

➢ Artificial defines "man-made," and intelligence defines "thinking power", or “the ability to learn and solve problems” hence Artificial Intelligence means "a man-made thinking power."

  – “The capacity to learn and solve problems” (Webster dictionary)
  – The ability to think and act rationally

• Intelligence is the ability of ***observing, learning, remembering*** **and** ***reasoning*** something.

- This course focuses on ***computational intelligence***:
  – Trying to understand the computational principles behind intelligent behavior
- Top languages for AI
  – Python
  – Prolog
  – R
  – Lisp
  – Java

Cont….

- AI is the effort to develop computer based system(intelligent entities) that behave as human.
- It enable computers behave/act like human and emulate the reasoning power of humans
  - in order to do tasks that require human intelligence.

– Which task requires intelligence?
  – Complex arithmetic operations
    – For instance, Solving $2^{20} * 3^{50}$?
  – Every day/Mundane tasks
    – Example, Natural language understanding; face recognition
  – Expert tasks: which require specialists knowledge
    – Example, Medical diagnosis; computer maintenance

AI Foundations/Academic Disciplines important to AI.

- AI is a synergy/cooperation of d/t disciplines

  A. Psychology/Cognitive Science: how do people behave, perceive, process information, represent knowledge.

  - How do humans and animals think and act?
  - Behaviorism, measuring of the percepts (or stimulus) given to an animal and its resulting actions (or response).
  - Cognitive psychology, which views the brain as an information-processing device.
    - ✓ For example, Craik clearly specified the three key steps of designing good knowledge-based agent:-

      (1) The stimulus must be translated into an internal representation,

      (2) The representation is manipulated by cognitive processes to derive new internal representations, and

      (3) These are in turn retranslated back into action.

B. Neuroscience: Neurons as information processing units

- How do brains process information?
- Neuroscience is the study of the nervous system, particularly the brain.

Cont.

C. Philosophy: Logic, methods of reasoning, foundations of learning & rationality.

- Can formal rules be used to draw valid conclusions?
- How does the mind arise from a physical brain?
- Where does knowledge come from?
- How does knowledge lead to action?

D. Mathematics: Formal representation and proof, algorithms, computation, probability.

- What are the formal rules to draw valid conclusions?
- What can be computed?
- How do we reason with uncertain information?

E. Linguistics: knowledge representation, grammar

- How does language relate to thought?
- Natural Language Processing is a hybrid field of modern linguistic and AI.

F. Computer engineering: building fast computers.

- How can we build an efficient computer?
- For artificial intelligence to succeed, we need two things: intelligence and an artifact.
  - ✓ The computer has been the artifact of choice.
- The modern digital electronic computer passed various historical innovations, like:-
  - ✓ Operational Computer
  - ✓ Programmable Computer
  - ✓ Electronic Computer
- AI also owes a debt to the software side of computer science, which has supplied the operating systems, programming languages, and tools needed to write modern programs.

Computers vs. Human Brain

	Supercomputer	Personal Computer	Human Brain
Computational units	10^4 CPUs, 10^{12} transistors	4 CPUs, 10^9 transistors	10^{11} neurons
Storage units	10^{14} bits RAM	10^{11} bits RAM	10^{11} neurons
	10^{15} bits disk	10^{13} bits disk	10^{14} synapses
Cycle time	10^{-9} sec	10^{-9} sec	10^{-3} sec
Operations/sec	10^{15}	10^{10}	10^{17}
Memory updates/sec	10^{14}	10^{10}	10^{14}

- ✓ Figure is a crude comparison of the raw computational resources available to the IBM BLUE GENE supercomputer, a typical personal computer of 2008, and the human brain.
- ✓ The brain's numbers are essentially fixed, whereas the supercomputer's numbers have been increasing by a factor of 10 every 5 years or so, allowing it to achieve rough parity with the brain.
- ✓ The personal computer lags behind on all metrics except cycle time.

- ✓ Brains and digital computers have somewhat different properties.
- ✓ Previous figure shows that computers have a cycle time that is a million times faster than a brain.
- ✓ The brain makes up for that with far more storage and interconnection than even a high-end personal computer, although the largest supercomputers have a capacity that is similar to the brain's.
- ✓ (It should be noted, however, that the brain does not seem to use all of its neurons simultaneously.)
- ✓ Futurists make much of these numbers, pointing to an approaching **singularity** at which computers reach a superhuman level of performance (Vinge, 1993; Kurzweil, 2005), but the raw comparisons are not especially informative.
- ✓ Even with a computer of virtually unlimited capacity, we still would not know how to achieve the brain's level of intelligence.

Different people approach Al with different goals in mind,
Two important questions to ask are:

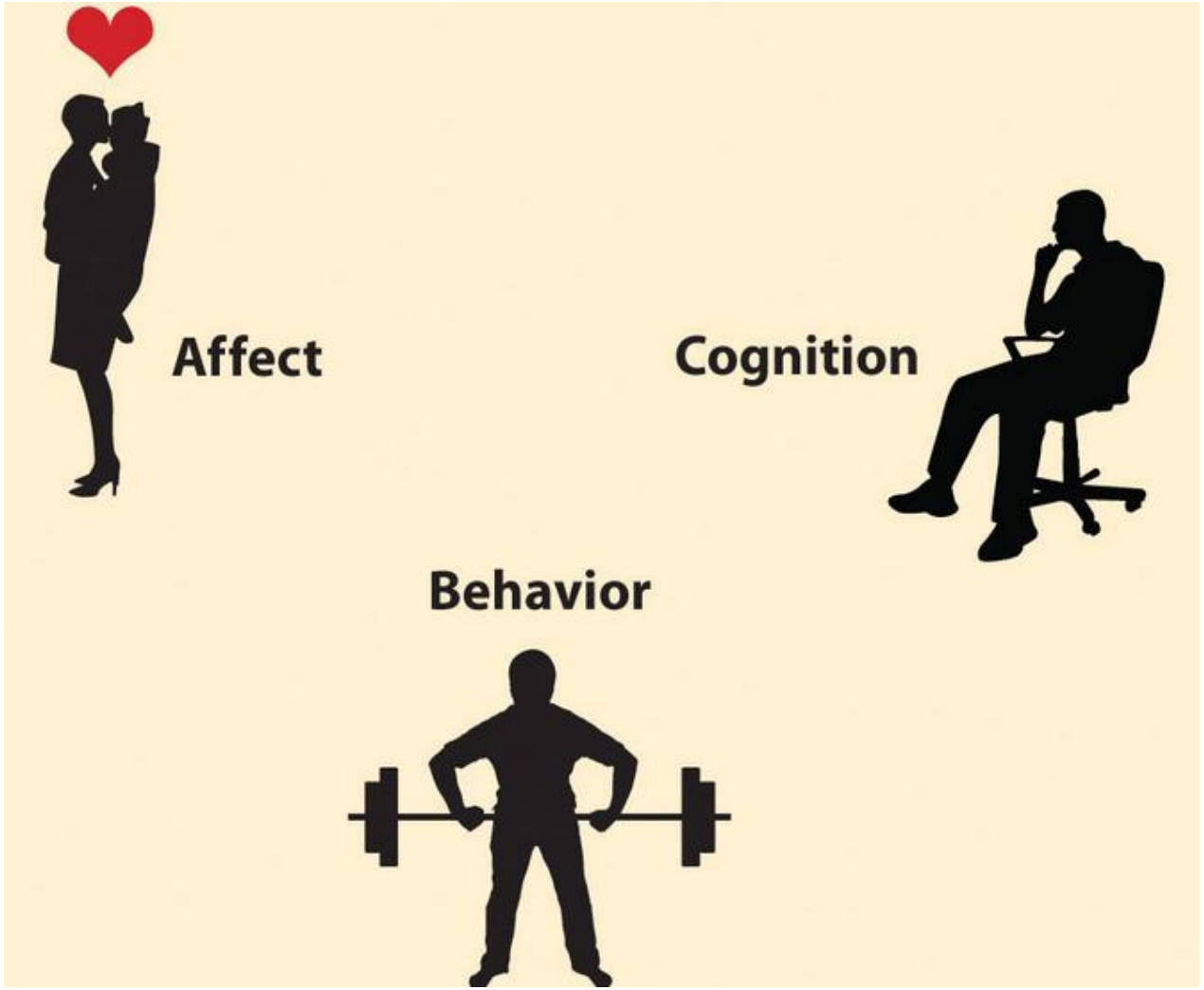
- Are we concerned with thinking or behavior?
- Do we want to model humans or work from an ideal standard?

✓ We adopt the view that intelligence is concerned mainly with rational action.

✓ Ideally, an intelligent agent takes the best possible action in a situation.

✓ We study the problem of building agents that are intelligent in this sense

- we rely on these three basic and interrelated human capacities:
  - Affect (feelings)
  - Behavior (interactions)
  - Cognition (thought)


Affect
Cognition
Behavior

Characteristics of Intelligent system:

- Use vast amount of knowledge
- Learn from experience and adopt to changing environment
- Interact with human using natural language and speech
- Respond in real time
- Tolerate error and ambiguity in communication

Artificial Intelligence vs. KBS

- Knowledge based system is part of Artificial Intelligence
- AI also requires extensive knowledge of the subject at hand.
  - AI program should have knowledge base
  - Knowledge representation is one of the most important and most active areas in AI.
  - AI programs should be learning in nature and update its knowledge accordingly.

What is Knowledge

- Knowledge includes facts about the real world entities and the relationship between them
  - It is an understanding gained through experience
  - Familiarity with the way to perform a task
  - An accumulation of facts, procedural rules, or heuristics
- Characteristics of Knowledge:
  - It is voluminous/big in nature and requires proper structuring.
  - It may be incomplete/partial and imprecise/indefinite.
  - It may keep on changing (dynamic).

Knowledge base

- Knowledge base is used to store facts and rules.
- In order to solve problems, the computer needs an internal model of the world.
  - This model contains, for example, the description of relevant objects and the relations between these objects.
  - All information must be stored in such a way that it is readily accessible.
- Various methods have been used for KR, such as logic, semantic networks, frames, scripts, etc...

Knowledge base systems (KBSs)

- is a computer program that reasons and uses a knowledge base to solve complex problem

- KBS - is a form of artificial intelligence (AI) which captures the **knowledge** of human experts to support decision-making

- Use **inference** to solve problems on a computer.

  Inference- is a conclusion reached on the basis of evidence and reasoning.

  – Ability to make the workings of the human mind understandable and executable on a computer.

Views of AI/Some possible definitions of AI are:-

3

- Four AI Definitions by Russell + Norvig
- AI is found on the premise that:
  - workings of human mind can be explained in terms of computation, and
  - computers can do the right thing given correct premises/properties and reasoning rules to achieve a specified goal.

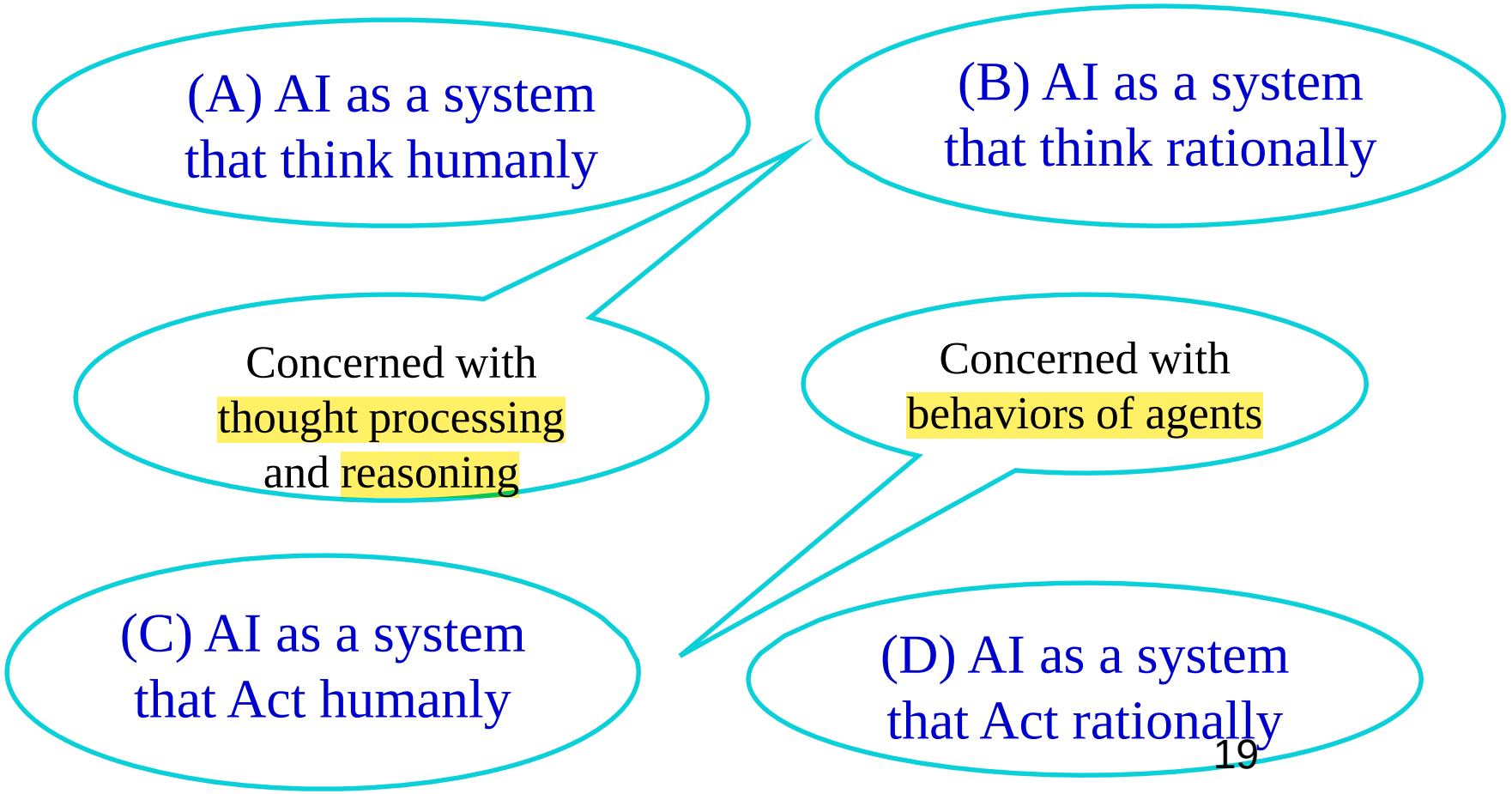
Views of AI fall into four categories:

Thinking humanly	Thinking rationally
Acting humanly	Acting rationally

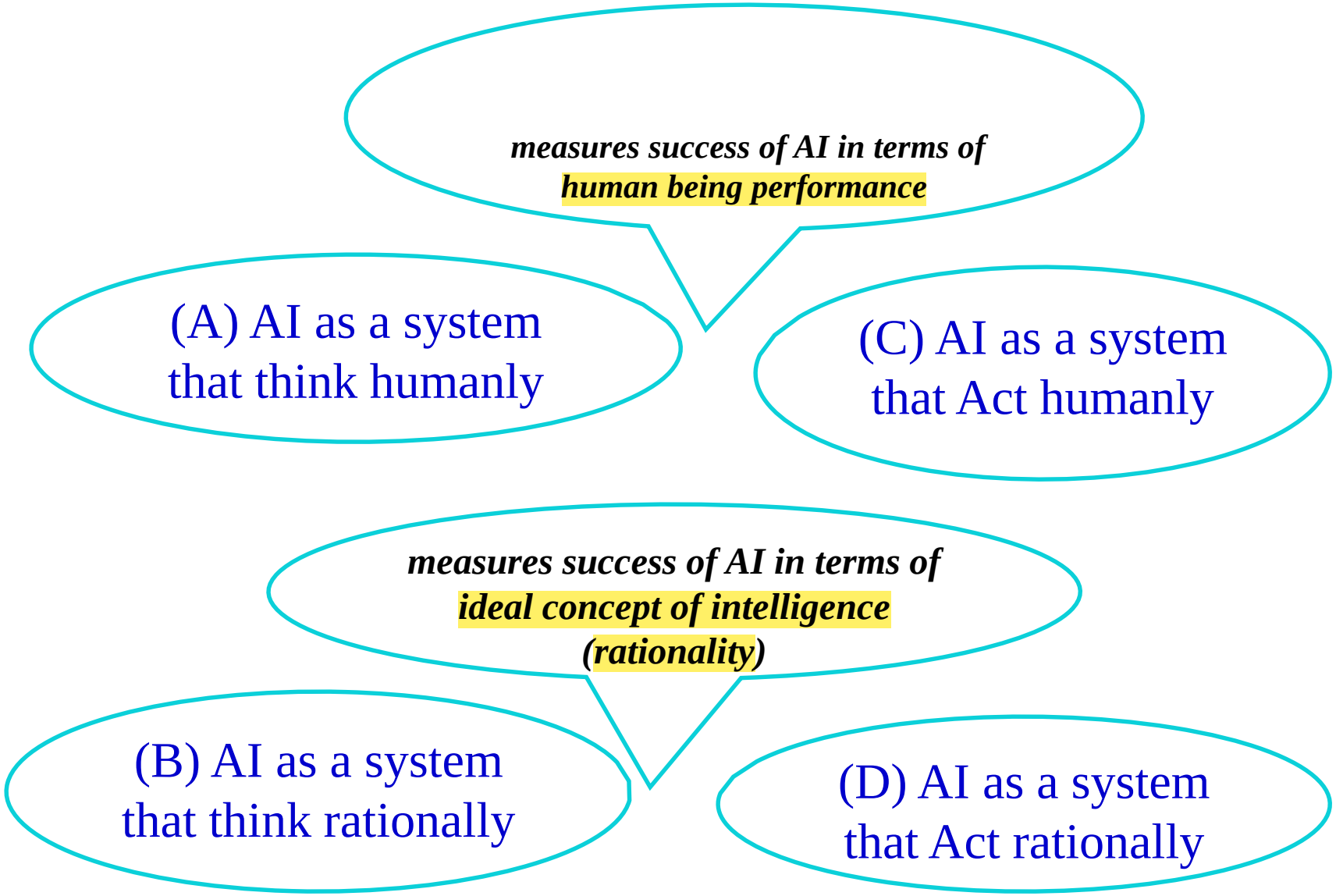
Views of defining AI

What is AI ?

Different scholars define AI differently



Views of defining AI



I. Thinking humanly: The Cognitive Modeling

- Cognitive Science
  - ✓ The brain as an information processing machine.
  - ✓ Requires scientific theories of how the brain works
- How to understand cognition as a computational process?
  - ✓ Introspection, try to think about how we think
  - ✓ Predict and test behavior of human subjects
  - ✓ Image the brain, examine neurological data

- Reasons like humans do
  - Programs that behave like humans
  - Is concerned with modeling human thinking processes
- Requires understanding of the internal activities of the brain
  - see how humans behave in certain situations and see if you could make computers behave in that same way.
  - **Protocol analysis** (think aloud) can help in understanding how human beings solve a given problem

Example. write a program that plays chess.

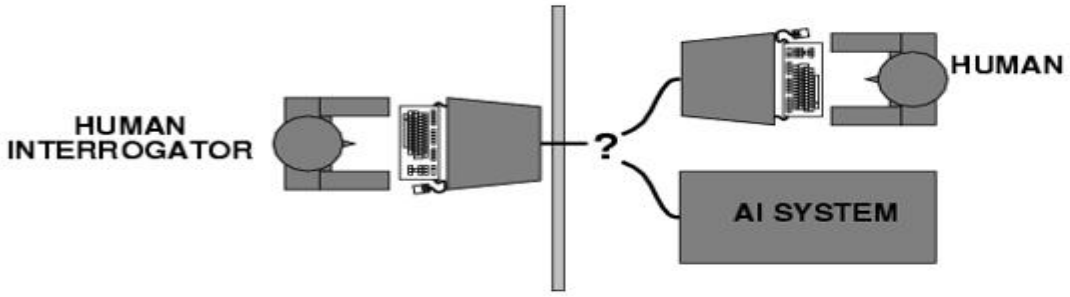
- Instead of making the best possible chess-playing program, you would make one that play chess like people do.

II. Acting humanly: The Turing Test

Can machines act like human do? Can machines behave intelligently?

- Acting like humans requires AI programs to interact with people

- Turing Test:
- What capabilities would a computer need to have to pass the Turing Test?
  - ✓ Natural Language Processing
  - ✓ Knowledge Representation
  - ✓ Automated Reasoning
  - ✓ Machine Learning



- ***Turing Test Criticisms***
  - ✓ There are some potential problems with the Turing Test, for example:-
    - Some human behavior is not intelligent
    - Some intelligent behavior may not be human
    - Human observers may be easy to fool.
    - The *"Chinese Room Argument"*, that is one may simulate intelligence without having true intelligence
  - ✓ Is passing the Turing test a good scientific goal?

III. Thinking Rationally: The Laws of Thought

- Idealized or "right" way of thinking.
- **Logic**
  - ✓ Patterns of argument that always yield correct conclusions when supplied with correct premises

    "Socrates is a man;

    All men are mortal;

    Therefore Socrates is mortal."
- Beginning with Aristotle, philosophers and mathematicians have attempted to formalize the rules of logical thought.

Logical Approach to AI

- ✓ Describe problem in formal logical notation and apply general deduction procedures to solve it.
- ✓ Problems with the logical approach are:-
  - Computational complexity of finding the solution.
  - Describing real-world problems and knowledge in logical notation.
  - A lot of intelligent or “rational” behavior has nothing to do with logic.

IV. Acting rationally: The rational agent

- A rational agent is one that acts to achieve the best outcome.
  - ✓ Goals are application-dependent and are expressed in terms of the utility of outcomes.
  - ✓ Being rational means maximizing your expected utility.
- This definition of rationality only concerns the decisions/actions that are made, not the cognitive process behind them.

•Central to our approach to AI

- **Doing the right thing** so as to achieve one's goal, given one's beliefs.
  - **AI** is the study and construction of rational agents (an agent that perceives and acts)
- Rational action requires the ability to represent knowledge and reason with it so as to reach good decision.
  - Learning for better understanding of how the world works

The State of The Art

- Robotic Vehicles
- Speech Recognition
- Autonomous Planning and Scheduling
- Game Playing
- Spam Fighting
- Fraud Detection
- Robotics
- Machine Translation
- Vision
- Drones
- Medical diagnosis

4

What do we get from using AI technology instead of previous reactive technology?

Following are some main advantages of Artificial Intelligence:

A. High Accuracy with fewer errors as it made decisions as pre-experience or information.

B. High-Speed: AI systems can be of very high-speed and fast-decision making

C. High reliability: AI machines are highly reliable and can perform the same action multiple times with high accuracy.

D. **Useful for risky areas:** AI machines can be helpful in situations such as defusing a bomb, exploring the ocean floor, where to employ a human can be risky.

E. Digital Assistant: AI technology is currently used by various E-commerce websites to show the products as per customer requirements.

F. Useful as a public utility: Such as a self driving car ,facial/message recognition for security purposes, Natural language processing (for search engines, for spelling checker etc.

Some of the disadvantages of AI are:

A. High Cost: The hardware and software requirement of AI is very costly as it requires lots of resource to meet current world requirements.

B. Can't think out of the box: Even we are making smarter machines with AI, but still they cannot work out of the box, as the robot will only do that work for which they are **trained**, or programmed.

C. No feelings and emotions: AI machines can be an outstanding performer, but still it does not have the feeling so it cannot make any kind of emotional attachment with humans, and may sometime be **harmful** for users if the proper care is not taken.

D. Increase dependence on machines: With the increment of technology, people are getting more dependent on devices and hence they are losing their mental capabilities.

E. No Original Creativity: As humans are so creative and can imagine some new ideas but still AI machines cannot beat this power of human intelligence and cannot be creative and imaginative.

History of AI

- Artificial Intelligence is not a new word and not a new technology for researchers.
- This technology is much older than you would imagine.
- Even there are the myths of Mechanical men in Ancient Greek and Egyptian Myths.
- The following are some milestones in the history of AI which define the journey from the AI generation to till date development (see Figure *3.3*).

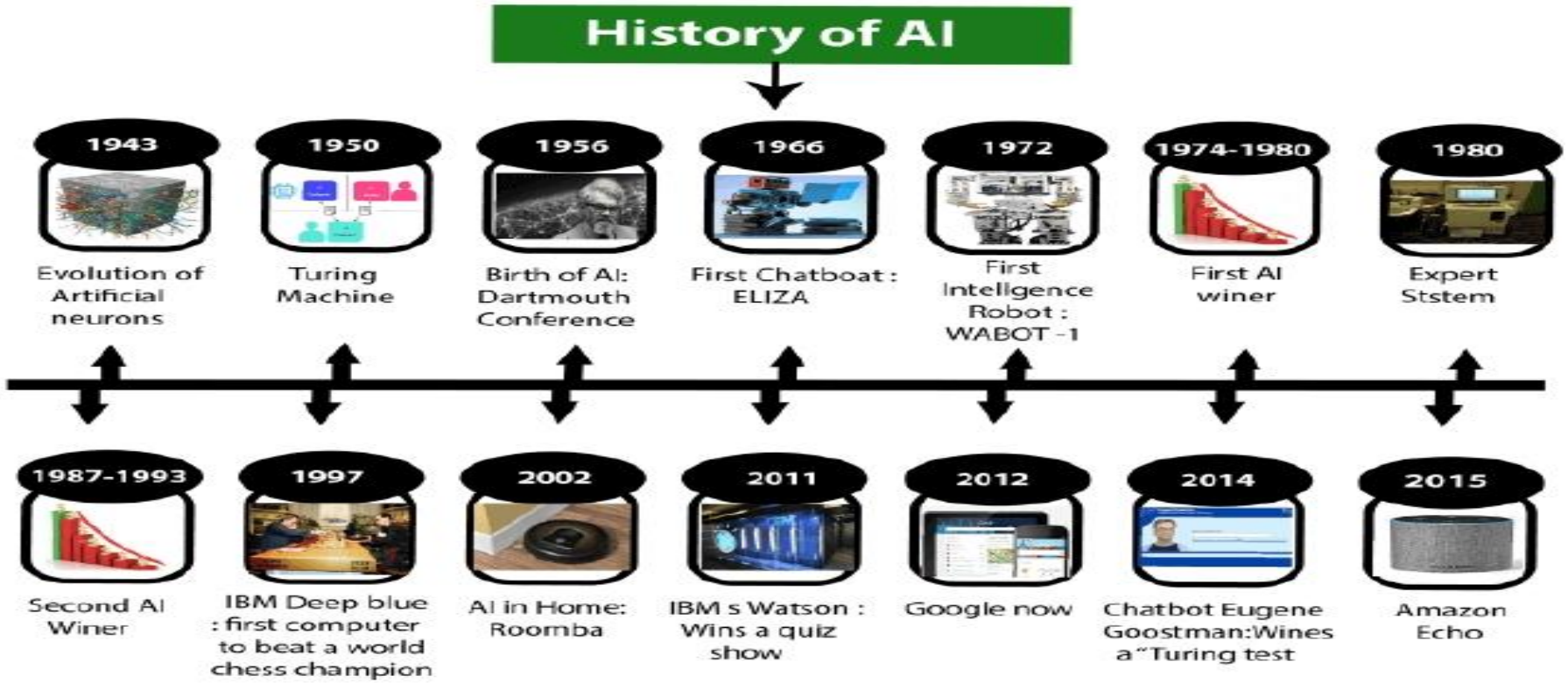


Figure 3.3 History of Artificial Intelligence (AI)

A. Maturation of Artificial Intelligence (1943-1952)

- **The year 1943**: Warren McCulloch and Walter pits are **proposed a model of artificial neurons**.
- **The year 1949**: Donald Hebb modifying the **connection strength between neurons.** His rule is now called Hebbian learning.
- **The year 1950**: Alan Turing proposed a test can check the machine's ability to exhibit intelligent behavior **equivalent to human intelligence**, called a **Turing test**.

B. The birth of Artificial Intelligence (1952-1956)

- **The year 1955**: An Allen Newell and Herbert A. Simon created the **"first artificial intelligence program"** Which was named "Logic Theorist".
- **The year 1956**: John McCarthy ,AI coined as an academic field. At that time high-level computer languages such as **FORTRAN, LISP, or COBOL** were invented.

C. The golden years-Early enthusiasm (1956-1974)

➢ **The year 1966**: Joseph Weizenbaum created the **first chatbot** in 1966, which was named as **ELIZA**.

➢ **The year 1972**: The first intelligent **humanoid robot** was built in Japan which was named **WABOT-1**.

D. The first AI winter (1974-1980)

➢ AI winter refers to the time period where computer scientists dealt with a severe **shortage of funding** from the **government** for **AI researches**.

➢ During AI winters, an interest in publicity/promotion on artificial intelligence was decreased.

E. A boom of AI (1980-1987)

➢ **The year 1980**: AI came back with "**Expert System**". Expert systems were programmed that emulate the decision-making ability of a human expert.

➢ In the Year 1980, the first national conference of the American Association of Artificial Intelligence was held at Stanford University.

F. The second AI winter (1987-1993)

➢ The duration between the years 1987 to 1993 was the second AI Winter duration.

➢ Again, **Investors and government stopped in funding for AI research** due to high cost but not efficient results.

➢ The expert system such as XCON was very cost-effective.

➢ (**XCON** /Expert configure ,automatically selecting the computer **system** components based on the customer's requirements

- Examples are: MYCIN: It could identify various **bacteria** that could cause **acute infections**.
- DENDRAL: Used for chemical analysis to predict molecular structure.
- PXDES: Used to **predict** the degree and type of **lung cancer**.

G. The emergence/rise of intelligent agents (1993-2011)

➢ **The year 1997**: In the year 1997, IBM Deep Blue beats world chess champion, Gary Kasparov, and became the first computer to beat a world chess champion.

➢ **The year 2002**: for the first time, AI entered the **home** in the form of **Roomba**, a **vacuum cleaner**.

➢ **The year 2006**: AI came into the Business world until the year 2006. Companies like **Facebook, Twitter, and Netflix** also started using AI.

H. Deep learning, big data and artificial general intelligence (2011-present)

➢ **The year 2011**: In the year 2011, IBM's Watson won jeopardy, a **quiz** show, where it had to solve complex questions as well as challenges.

Watson had proved that it could understand natural language and can solve tricky questions quickly.

➢ **The year 2012**: Google has launched an Android app feature "**Google now**", which was able to provide information to the user as a **prediction**.

➢ **The year 2014**: In the year 2014, **Chatbot** "Eugene Goostman" won a competition in the infamous "**Turing test.**"

➢ **The year 2018**: The "Project Debater" from IBM debated on complex topics with two master debaters and also performed extremely well.

- ✓ Nowadays companies like Google, Facebook, IBM, and **Amazon** are working with AI and creating amazing devices.
- ✓ The future of Artificial Intelligence is inspiring and will come with high intelligence.

How to make computers act like humans?

The following sub-fields are emerged

- **Natural Language processing** (enable computers communicate in human language, English, Amharic, ..)
- **Knowledge representation** (schemes to store information, both facts and inferences, before and during interrogation/interview/questioning)
- **Automated reasoning** (use stored information to answer questions and to draw new conclusions)
- **Machine learning** (adapt to new circumstances/conditions and accumulate/collect knowledge)
- **Computer vision** (recognize/identify objects based on patterns/designs in the same way as the human visual system does)
- **Robotics** (produce mechanical device capable of controlled motion; which enable computers to see, hear & take actions)

- Is AI equals human intelligence? Can we create a KBS called mind?

Types of AI

- Artificial Intelligence can be divided into two categorization which are based on capabilities and based on functionally of AI.

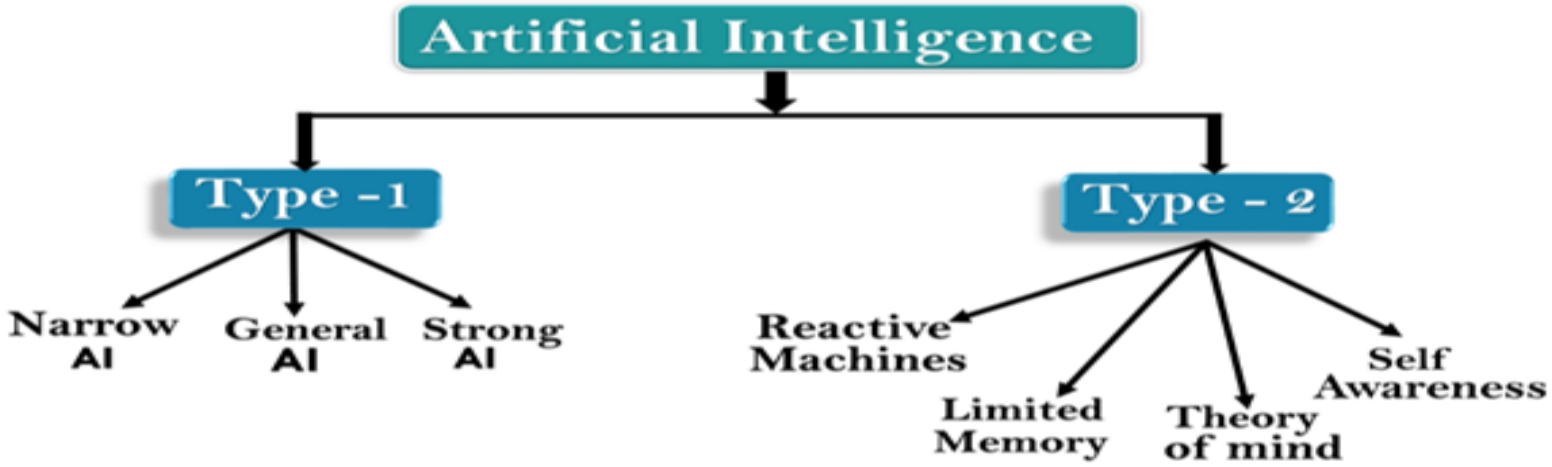


Figure types of Artificial Intelligence (AI)

A. **Based on Capabilities**

1. ***Weak AI or Narrow AI:*** is a type of AI which is able to perform a dedicated task with intelligence.

- Narrow AI , it is only trained for one specific task.
- Some Examples of Narrow AI are Google translate, playing chess, self-driving cars, speech recognition, and image recognition.

2. General AI: is a type of intelligence that could perform any intellectual task with efficiency like a human.

- The idea behind the general AI to make such a system that could be smarter and think like a human on its own.
- Currently, there is no such system exists which could come under general AI and can perform any task as perfect as a human.
- The worldwide researchers are now focused on developing machines with General AI.
- As systems with general AI **are still under research**, and it will take lots of effort and time to develop such systems.

3. Super AI: is a level of Intelligence of Systems at which machines could surpass human intelligence, and can perform any task **better than** a human with cognitive properties.

- Some key characteristics of strong AI include capability include the ability to think, to reason solve the puzzle, make judgments, plan, learn, and communicate on its own.

B. Based on the functionality

1. Reactive Machines

- Purely reactive machines are the most basic types of Artificial Intelligence.
- Such AI systems **do not store memories** or past experiences for future actions.
- These machines only focus on current scenarios and react on it as per possible best action.
- IBM's Deep Blue system is an example of reactive machines.
- Google's AlphaGo is also an example of reactive machines

2. Limited Memory

- Limited memory machines **can store past experiences** or some data for a short period of time.
- These machines can use stored data for a limited time period only.
- Self-driving cars are one of the best examples of Limited Memory systems.
- These cars can store the recent speed of nearby cars, the distance of other cars, speed limits, and other information to navigate the road.

3. Theory of Mind

- Theory of Mind AI should understand **human emotions**, people, beliefs, and be able to interact socially **like humans**.
- This type of AI machines is still not developed, but researchers are making lots of efforts and improvement for developing such AI machines.

4. Self-Awareness

- Self-awareness AI is the **future of Artificial** Intelligence.
- These machines will be super intelligent and will have **their own consciousness**, sentiments, and self-awareness.
- These machines will be **smarter than the human** mind.
- Self-Awareness AI does not exist in reality still and it is a hypothetical concept.

Applications of AI

- AI used to solve complex problems in efficient way in multiple industries, such as Healthcare, entertainment, finance, education, etc.
- AI is making our daily life more comfortable and faster.

A. AI in agriculture:- Agriculture is an area that requires various resources, labor, money, and time for the best result.

- ✓ Now a day's agriculture is becoming digital, and AI is emerging in this field.
  - For example agriculture robotics, crop monitoring, and predictive analysis.

B. AI in Healthcare: In the last, five to ten years, AI becoming more advantageous for the healthcare industry and going to have a significant impact on this industry to make a better and faster diagnosis than humans.

C. AI in education:

- ✓ AI can automate grading so that the tutor can have more time to teach.
- ✓ AI chatbot can communicate with students as a teaching assistant.
- ✓ AI in the future can be work as a personal virtual tutor for students, which will be accessible easily at any time and any place.

D. AI in Finance and E-commerce

- ✓ AI and finance industries are the best matches for each other.
- ✓ AI is providing a competitive edge to the e-commerce industry, and it is becoming more demanding in the e-commerce business. AI is helping shoppers to discover associated products with recommended size, color, or even brand.

E. AI in Gaming

- ✓ AI can be used for gaming purposes.
- ✓ The AI machines can play strategic games like chess, where the machine needs to think of a large number of possible places.

F. . AI in Data Security

- ✓ AI can be used to make your data more safe and secure.
- ✓ Some examples such as AEG bot, AI2 Platform, are used to determine software bugs and cyber-attacks in a better way.

G. AI in Social Media

- ✓ Social Media sites such as Facebook, Twitter, and Snapchat contain billions of user profiles, which need to be stored and managed in a very efficient way.

H. AI in Travel &Transport

- ✓ AI is capable of doing various travel related works such as from making travel arrangements to suggesting the hotels, flights, and best routes to the customers.

I. AI in the Automotive Industry

- ✓ Various Industries are currently working for developing self-driven cars which can make your journey more safe and secure.

J. AI in Robotics:

- ✓ Humanoid Robots are the best examples for AI in robotics, recently the intelligent Humanoid robot named Erica and Sophia has been developed which can talk and behave like humans.

K. AI in Entertainment

- ✓ We are currently using some AI-based applications in our daily life with some entertainment services such as Netflix or Amazon.

Sample AI application with hands activity

A. Commuting

- ✓ Google's AI-Powered Predictions
- ✓ Ridesharing Apps Like Uber and Lyft
- ✓ Commercial Flights Use an AI Autopilot

B. Email

- ✓ Spam Filters
- ✓ Smart Email Categorization

C. Social Networking

- ✓ Facebook - When you upload photos to Facebook, the service automatically highlights faces and suggests friends tag.
- ✓ Pinterest - Pinterest uses computer vision, an application of AI where computers are taught to "see," in order to automatically identify objects in images (or "pins") and then recommend visually similar pins.
- ✓ Instagram -Uses machine learning to identify the contextual meaning of emoji, which have been steadily replacing slang (for instance, a laughing emoji could replace "lol")
- ✓ Snapchat - Snapchat introduced facial filters, called Lenses, in 2015.
- ✓ These filters track facial movements, allowing users to add animated effects or digital masks that adjust when their faces moved.

D. Online Shopping

- ✓ Search - Your Amazon searches (“ironing board”, “pizza stone”, “Android charger”, etc.) quickly return a list of the most relevant products related to your search
- ✓ Recommendations - You see recommendations for products you’re interested in as “customers who viewed this item also viewed.

E. Mobile Use

- ➢ Voice-to-Text - By pressing a button or saying a particular phrase (“Ok Google”, for example), you can start speaking and your phone converts the audio into text.
- ➢ Smart Personal Assistants - Now that voice-to-text technology is accurate enough to rely on for basic conversation, it has become the control interface for a new generation of smart personal assistants.
- ➢ Siri and Google Now (now succeeded by the more sophisticated Google Assistant),
- ➢ Alexa, an AI-powered personal assistant that accepts voice commands to create to-do lists, order items online, set reminders, and answer questions (via internet searches)
- ➢ Echo (and later, Dot) smart speakers that allow you to integrate Alexa into your living room and use voice commands to ask natural language questions, play music, order pizza, hail an Uber, and integrate with smart home devices.
- ➢ Microsoft has followed suit with Cortana, its own AI assistant that comes pre-loaded on Windows computers and Microsoft smartphones.

AI Successes

- **Deep Blue** defeated the leading world chess champion Garry Kasparov in 1997.

IBM's Deep Blue

World Champion Garry Kasparov

- **Deep Blue** was a chess-playing computer developed by IBM
- First computer chess-playing system to win a chess match against a ruling world champion under regular time controls.

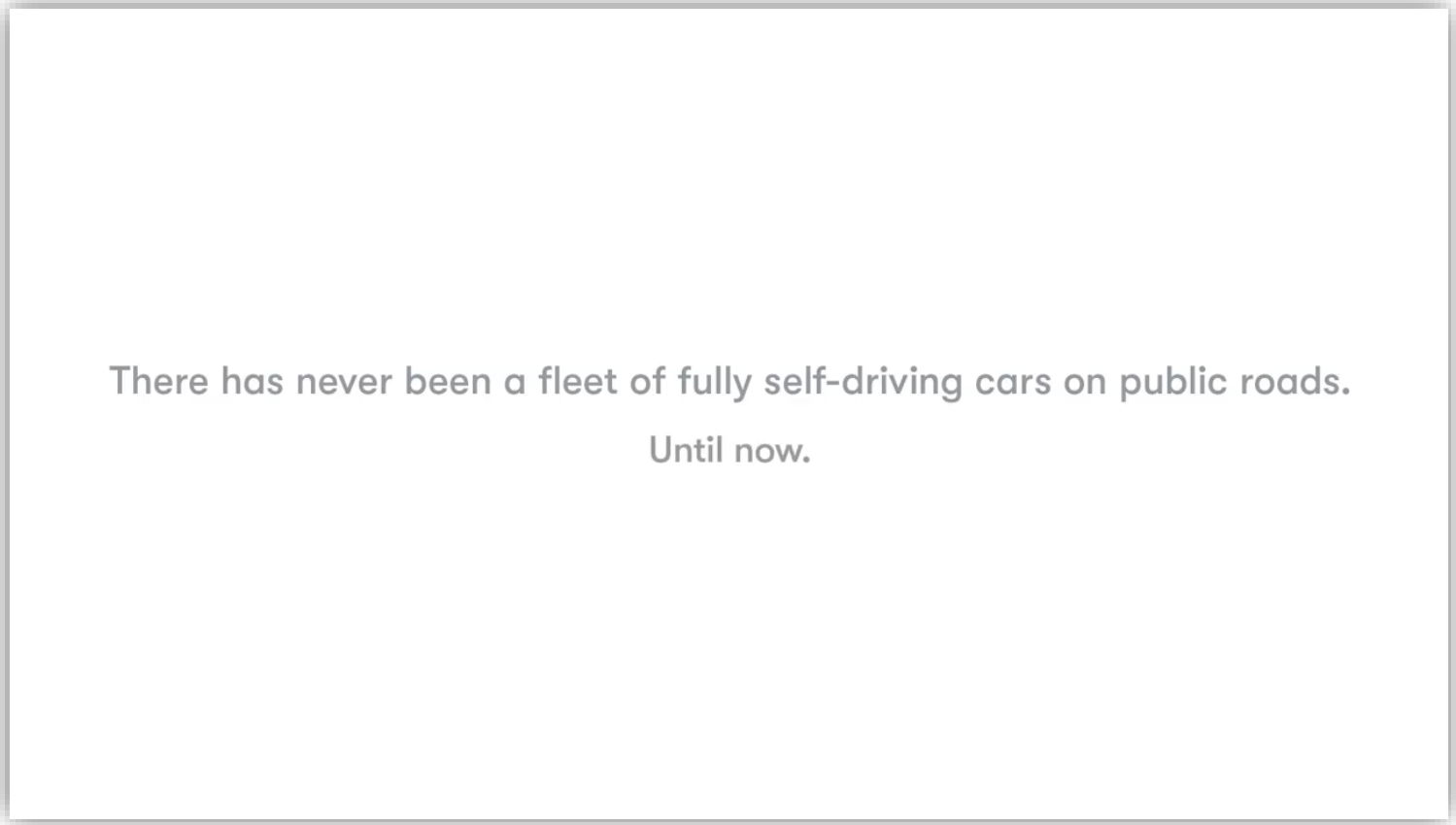
Cont.

- Watson - The computer system was initially developed to answer questions on the quiz show Jeopardy.

- In 2011, the Watson computer system competed on Jeopardy! against legendary champions Brad Rutter and Ken Jennings winning the first place prize of $1 million.

Sophia - From Hanson Robotics - 2016

Google Self Driving Cars



World's first AI presenter unveiled in China - (9-11-2018)
The World’s First AI News Anchor

Cont..

- Games: chess, checkers, poker, etc.
- Physical skills: driving a car, driving a motorcycle, flying a plane or helicopter, playing soccer, vacuuming, etc.
- Art: painting, composing music, performing music, etc.
- Language: machine translation, speech recognition, character recognition, etc.
- Vision: face recognition, face detection, motion tracking, etc.
- Commerce and industry: page rank for searching, fraud detection, stock market investing, etc.

Challenges Ahead

- Note that the examples we discussed so far all involve quite specific tasks.
- The systems lack a level of generality and adaptability. They can't easily (if at all) switch context.
- Key issue:
  - knowledge acquisition/ achievment bottleneck
  - Lack of general common sense knowledge.
  - Big data

Some extra discussion points

1) Discuss one of the following concepts.
   i. Knowledge based system:
      - What is KBS?
      - KBS vs. ES vs. AI
      - Knowledge acquisition, knowledge modeling and knowledge representation (semantic networks, frame, production system, ontology)
   ii. Reasoning:
      - What is reasoning, Case based reasoning, probabilistic reasoning, fuzzy reasoning, rule-based reasoning
   iii. Learning:
      - What is Machine learning? Support Vector Machine, Hidden Markov Model, Bayesian Belief Network

2) Explain the following areas of AI and how they work ?
   i. Natural Language Processing
   ii. Natural Language Generation
   iii. Speech Recognition, Speech synthesis, Speaker Identification
   iv. Optical Character Recognition (OCR),Writer identification, Face recognition
   v. Computer vision and robotics