Fundamentals of Artificial Intelligence

SEng 9032

Objective of the course

- Understand reasoning, knowledge representation, and learning techniques of *artificial intelligence.*

- Know the fundamentals of artificial intelligence programming techniques in a modern programming language

- Know a variety of ways to represent and retrieve knowledge and Information.

- Consider ideas and issues associated with social, technical, and ethical uses of machines that involve *artificial intelligence*.

Preliminaries Required

- Here are some of the basic prerequisites that will help get started with AI:

  - A strong hold on Mathematics – namely discrete mathematics, Statistics, and probability.

  - A stronghold in understanding and writing algorithms

  - Knowledge of any computer language such as C, C++, Java, Python, prolog, etc.

- *Textbook:*
  - *Russell, S. and P. Norvig (1995) Artificial Intelligence: A Modern Approach Prentice-Hall. Third edition.*

Chapter-One

Introduction to Artificial Intelligence (AI)

Basic Topics in Chapter-One

- Introduction to AI

- Objectives/Goals of AI

- What is AI?

- **Approaches to AI** – Making computer:
  - *Think like a human (Thinking humanly)*
  - *Act like a human (Acting humanly)*
  - *Think rationally (Thinking rationally)*
  - *Act rationally (Acting rationally)*

- Adv & Disadv of AI

- The Foundations of AI

- Application of AI (the State of the Art)

- History of AI

What is AI?

- The intelligence demonstrated by machines is known as *Artificial Intelligence.*

- In today's world, technology is growing very fast, and we are getting in touch with different new technologies day by day.

- Here, one of the booming technologies of computer science is ***Artificial Intelligence*** which is ready to create a new revolution in the world by making intelligent machines.

- Artificial Intelligence is now all around us.

- AI holds a tendency to cause a machine to work as a human.

What is AI?   Cont'd

It is currently working with a variety of subfields, ranging from general to specific, such as

- *self-driving cars,*

- *playing chess,*

- *proving theorems,*

- *playing music, Painting*, etc.

- **Here is Some Example:**

Definition of AI

- **AI** is composed of two words **Artificial** and **Intelligence**,

- where Artificial defines *"man-made,"* and intelligence defines *"thinking power"*, hence AI means *"a man-made thinking power."*

- So, we can define AI as:

  - *"It is a branch of computer science by which we can create intelligent machines which can behave like a human, think like humans, and able to make decisions."* or

  - *i.e.* *An intelligent entity created by humans.*

Definition of AI   Cont'd

- **Intelligence** is the capability of *observing*, *learning*, *remembering* & *reasoning.*

- AI exists when a machine can have human based skills such as ***learning, reasoning, and solving problems.***

- **Note:** *With AI you do not need to pre-program a machine to do some work, despite that you can create a machine with programmed algorithms which can work with own intelligence, and that is the awesomeness of AI.*

Why AI?

Q. What is the importance of AI and why should we learn it?
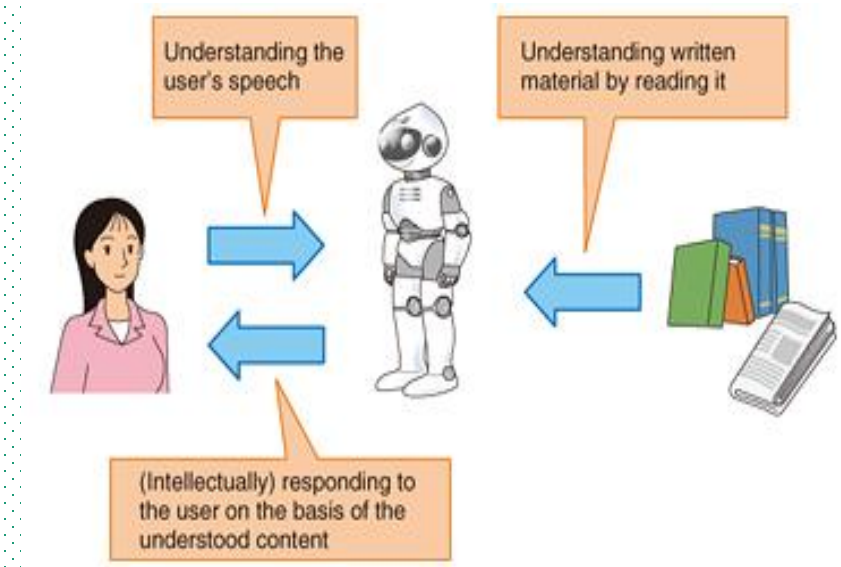
- **The main reason to learn AI**

- **With the help of AI:**

    - *You can create such software or devices which can solve real-world problems very easily and with accuracy such as health issues, marketing, traffic issues, etc.*
    - *You can create your personal virtual Assistant, such as Google Assistant, Siri, etc.*
    - *You can build such Robots which can work in an environment where the survival of humans can be at risk.*
    - *AI opens a path for other new technologies, new devices, and new Opportunities.*

Goals of AI

✓ **Scientific goal**: understand the mechanism behind human intelligence.

✓ **Engineering goal**: develop concepts and tools for building intelligent agents capable of solving real-world problems. Examples:

- **Knowledge-based systems**: capture expert knowledge and apply them to solve problems in a limited domain.

- **Common sense reasoning systems**: capture and process knowledge that people commonly hold which is not explicitly communicated.

- **Learning systems**: possess the ability to expend their knowledge based on accumulated experience.

Goals of AI

- **Natural language understanding systems.**
  - ✓ *is a branch of AI that uses computer software to understand input in the form of sentences using **text** or **speech.***
  - ✓ *NLU enables human-computer interaction. As shown in the figure below*

  - ✓ *Elements of natural language: e.g.*
    - ○ *Machine translation,*
    - ○ *Information Retrieval,*
    - ○ *Sentiment analysis,*
    - ○ *Information Extraction,*
    - ○ *Question answering*

Understanding the user's speech

Understanding written material by reading it

(Intellectually) responding to the user on the basis of the understood content

Goals of AI   Cont'd

- **Intelligent Robots.**

    - is an intelligent machine with the ability to take action and make choices.

    - Choices to be made by an intelligent robot are connected to the intelligence built into it through machine learning or deep learning.

    - The Robots have predefined commands and responses.

- AI robots are now a common help in sectors such as

- *manufacturing and automobile, their adoption also is increasing across food processing, construction, and distribution.*

Goals of AI   Cont'd

- Building a machine that can perform tasks that requires human intelligence such as:

  o *Playing chess,*

  o *Proving a theorem, e.g look at picture*

  o *Plan some surgical operationson,*

  o *a car in traffic* etc.

- Creating some system which can exhibit intelligent behavior,

  - *Learn new things by itself,*

  - *Demonstrate, explain, and can advise to its user.*

Approaches to AI—Making Computer

Views of AI fall into four categories

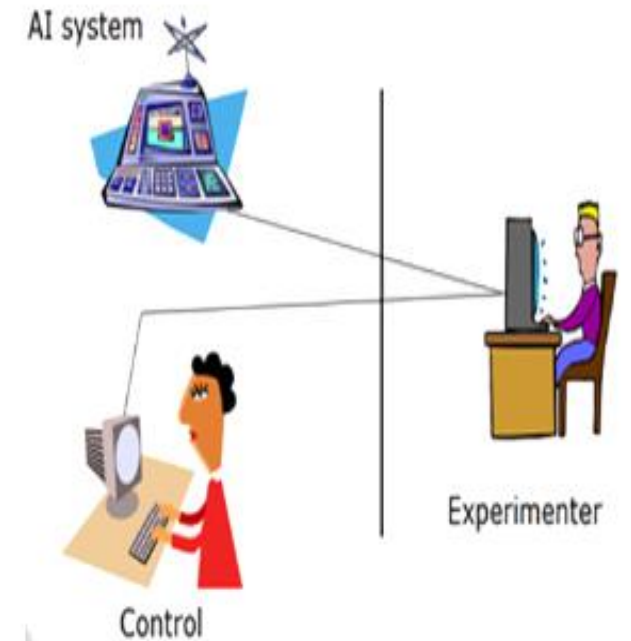| Thinking humanly	Thinking rationally
Acting humanly	Acting rationally

- **Note:**
  - A *human-centered approach* must be an empirical science, involving hypothesis and experimental confirmation.
  - A *rationalist approach* involves a combination of *mathematics* and *engineering*.

Q. How do we measure if AI is acting like a human?

- AI can behave as a human does, how can we be sure it can continue to behave that way?

- We can base the human-likeness of an AI entity with the:

  - *Turing Test Approach*

  - *The Cognitive Modeling Approach*

  - *The Law of Thought Approach*

  - *The Rational Agent Approach*

i. Acting Humanly: Turing Test Approach

- Making a computer act like a human being.

- **Turing (1950)** "Computing machinery and intelligence":

    - "Can machine behave intelligently?"

    - *Operational test for intelligent behavior: the Imitation Game.*

- **Turing Test:** Operational test for intelligent behavior.
    - Suggested major components of AI:
        - ✓ *knowledge, reasoning, language understanding, learning.*

ii. Thinking Humanly: Cognitive Modeling Approach

- Making a computer think like a human being.

- **Requires** scientific theories of **internal activities of the brain.**

- This approach tries to build an AI model-based on Human Cognition.

- To distill the essence of the human mind, there are 3 approaches:

  - *Introspection: observing our thoughts, and building a model based on that.*

  - *Psychological Experiments: conducting experiments on humans and observing their behavior.*

  - *Brain Imaging: Using MRI (**Magnetic Resonance Imaging**) to observe how the brain functions in different scenarios and replicating that through code.*

iii. Thinking Rationally: Law of Thought Approach

- **Making a computer think rationally**

- **AI thinking rationally** means thinking rightly
  - For example if something is true that should be true or that must be true or it can not be false

- **A system is rational** if it **thinks the right thing through correct reasoning.**

- **Aristotle**: provided the correct arguments/ thought structures that always **gave correct conclusions given correct premises**.

  - *"Abebe is a man; all men are mortal; therefore Abebe is mortal"*
  - *"All men have brains, All humans have brains therefore all human are men"*
  - These Laws of thought **governed the operation of the mind** and **initiated the field of Logic** to determine computer's reasoning.

iii. Thinking Rationally: Law of Thought Approach ...

Problem:

- **There is some main problems to implement this approach:**

- This approach needed 100% knowledge

- Not all intelligent behavior is determined by logical deliberation (e.g. *taking your hand out of a fire*)

- *It is n*ot easy to take informal knowledge.

- *Also formal logic in unable to handle uncertain knowledge.*

iv. Acting Rationally: Rational agent Approach

- Making a computer act rationally

- Rational behavior: **doing "the right thing".**

  - "The right thing": that which is **expected to maximize goal achievement**, given the available information.

- Doesn't necessarily involve thinking – e.g., blinking reflex – but thinking should be in the service of rational action.

- **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).

The Foundations of AI

- **AI-**is not just a part of computer science even though it's so vast and requires lots of other factors which can contribute to it.

- To create the AI first we should know how *intelligence is composed:*

- so **Intelligence** is an intangible part of our brain which is a combination of:

  - *Reasoning, learning, problem-solving, perception, language understanding, etc.*
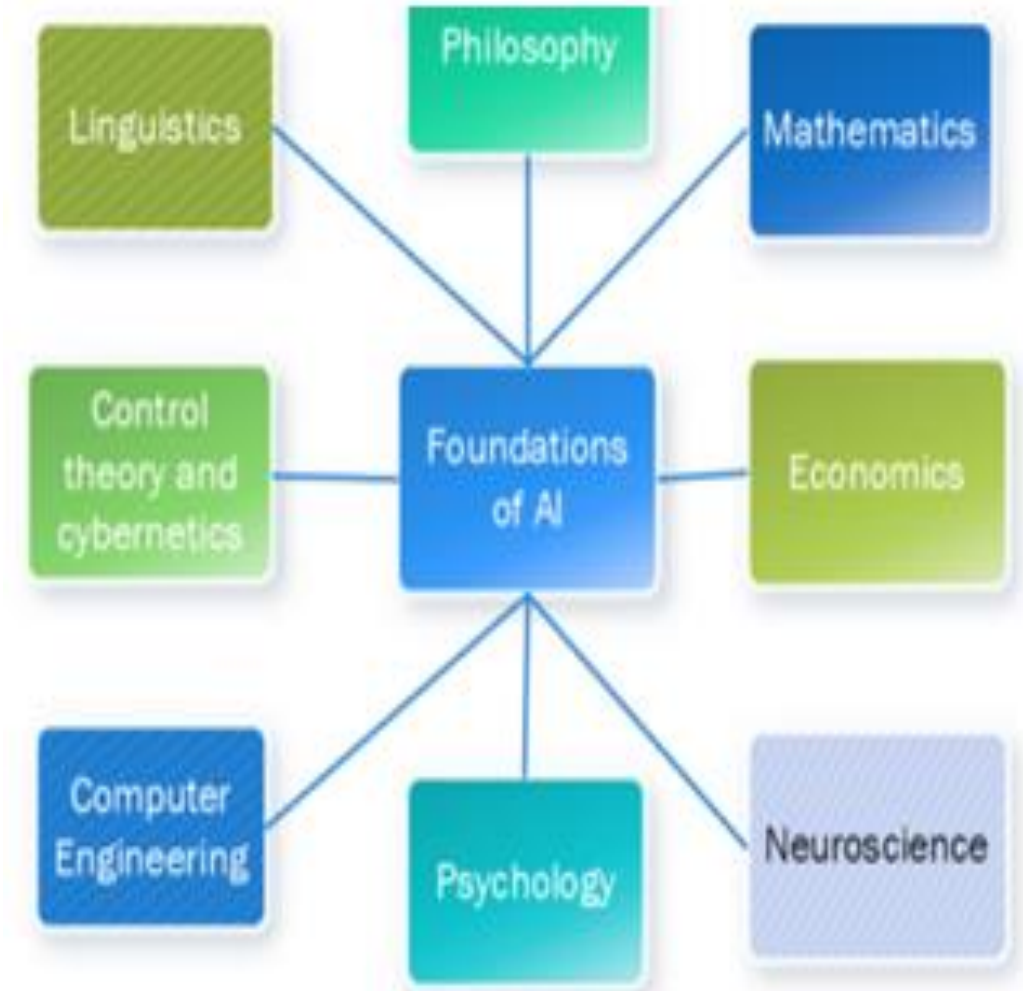
Foundations of AI   Cont'd

Philosophy (428 $B . C$ **.-present)-**

Theories of reasoning and learning

–Can formal rules be used to draw valid conclusions?

–How does the mental mind arise from a physical brain?

–Where does knowledge come from?

–How does knowledge lead to action?

• **Mathematics (800 - present-**

• Theories of logic probability, decision making, and computation

– What are the formal rules to draw valid conclusions?

– What can be computed?

– How do we reason with uncertain information?

- **Economics (1776 - present)**

  - How should we make decisions so as to maximize payoff?

  - How should we do this when others may not go along?

  - How should we do this when the payoff may be far in the future?

Foundations of AI Cont'd

Computer engineering (1940-present)

- How can we build an efficient computer?

- How build powerful machine to makes AI possible E.g. Self driving car

Neuroscience (1861-present)

- How do brains process information?
- How human brain and computer are similar?

Psychology (1879-present)

- How do humans and animals think and act?
- Where does knowledge comes from?

Control theory and Cybernetics (1948-present)

- How can artifacts operate under their own control?

Linguistics (1957-present)

- How does language relate to thought?

Advantages of AI

- **High Accuracy with less errors:**
  - *AI machines or systems are prone to less errors and high accuracy as it takes decisions as per pre-experience or information.*

- **High-Speed:**
  - *AI systems can be of very high-speed and fast-decision making, because of that AI systems can beat a chess champion in the Chess game.*

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

- **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.*

Advantages of AI   Cont'd

- **Digital Assistant:**

    - *AI can be very useful to provide digital assistance to the users such as AI technology is currently used by various E-commerce websites to show products as per customer requirements.*

- **Useful as a public utility:** *such as:*

    - *a self-driving car that can make our journey safer and hassle-free,*

    - *facial recognition for security purposes,*

    - *Natural language processing to communicate with the human in human language, etc.*

Disadvantages of AI

High Cost:

- The hardware and software requirement of AI is very costly as it requires lots of maintenance to meet current world requirements.

Can't think out of the box:

- Even though we are making smarter machines with AI, but still they cannot work out of the box, as the robot will only do the work for which they are trained, or programmed.

Disadvantages of AI   Cont'd

- **No feelings and Emotions:**
  - AI machines can be outstanding performers, but still, it does not have feeling so they cannot make any kind of emotional attachment with human.

- **Increase dependency on machines:**
  - With the increment of technology, people are getting more dependent on devices, and hence they are losing their mental capabilities.
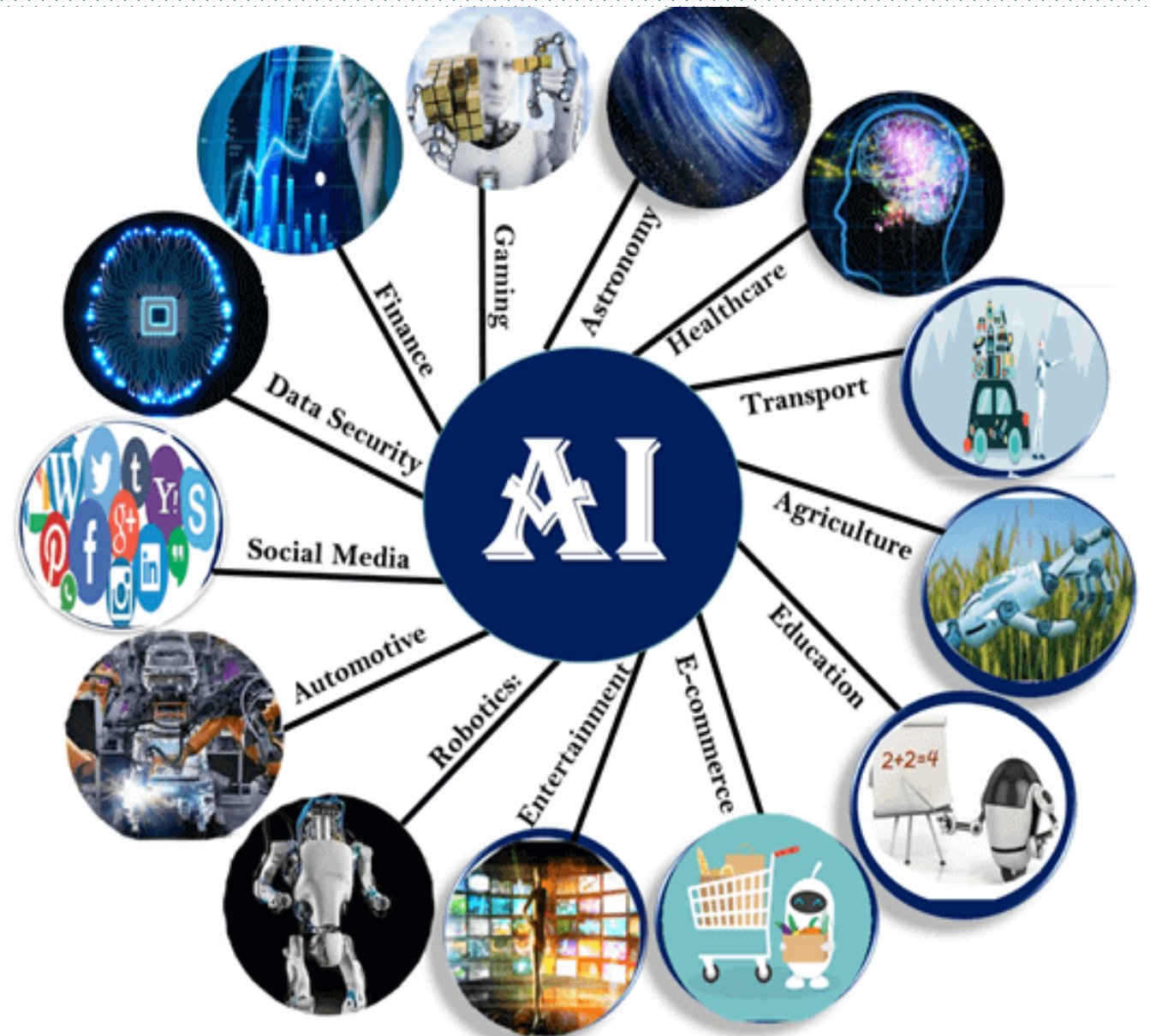
- **No Original Creativity:**
- As humans are so creative and can imagine some new ideas but still AI machines cannot beat this power of human intelligence and cannot be creative and imaginative.
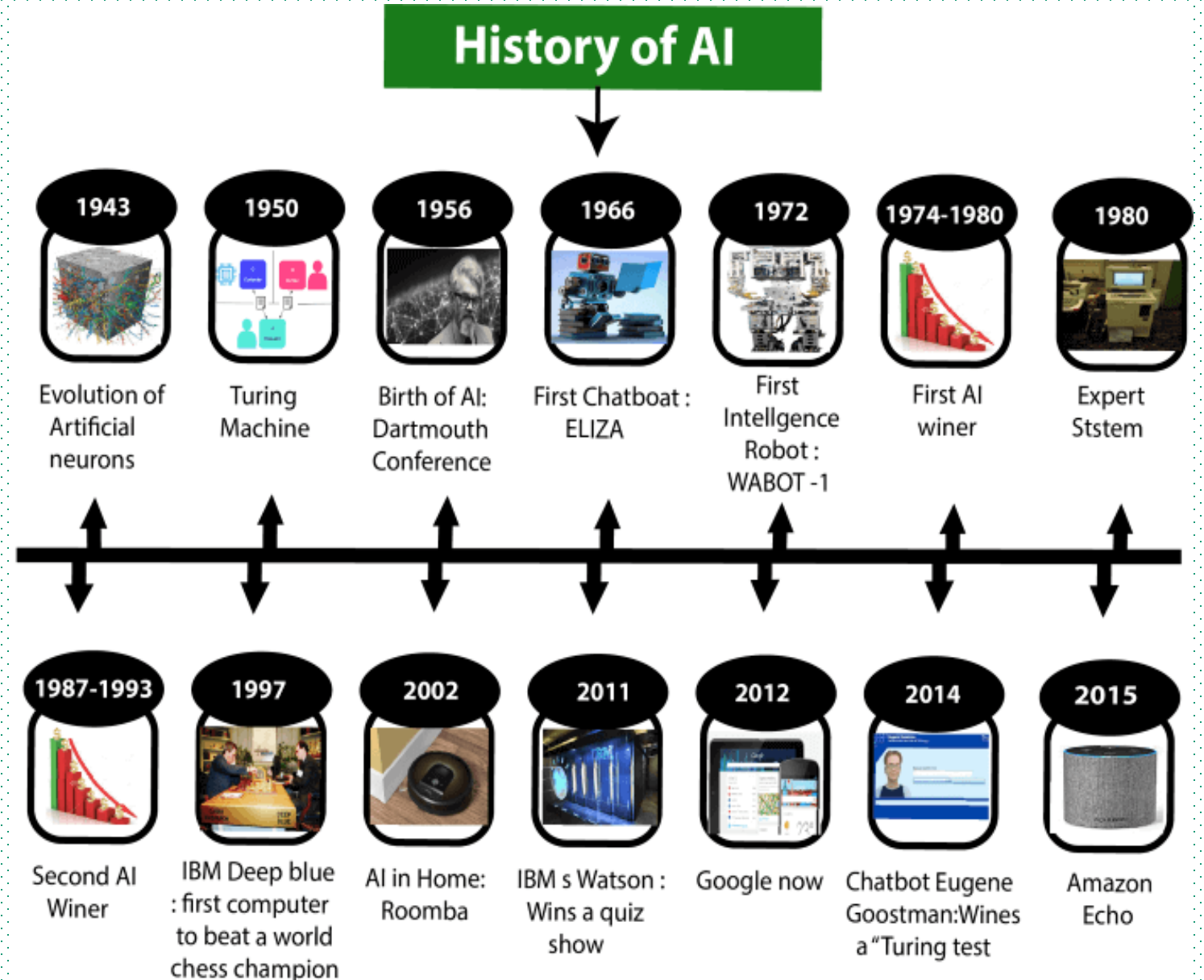
Application of AI

- AI is making our daily life more comfortable and fast.

- AI has various applications in today's society.

- Some sectors are:

(Group Assignment #1)

The History of AI

- AI is not a new word and not a new technology for researchers.

- Following are defines the journey from the AI generation to till date development.

The History of AI

- **(1943 - 1955)** - **The gestation of artificial intelligence.**

- *1943: McCulloch & Pitts: Boolean circuit model of the brain.*

- *1949: Hebbian Learning: demonstrated a simple updating rule for modifying the connection strengths between neurons.*

- *1950: Turing's "Computing Machinery and Intelligence".*

- **(1958)** - **LISP invented.**

  - LISP stands for <u>L</u>ist <u>P</u>rocessing.

  -The most common AI programming language.

- **(1960's)** - AI Discovers Computational Complexity

The History of AI

- **(1966 - 1973)** - **A dose of reality.**
  - AI discovers computational complexity.
  - **Neural network** research almost **disappears**.

- **(1969 - 1979)** - Early development of knowledge-based systems (expert systems). **The key to power?**

- **(1980 - present)** - AI becomes an industry.

- **(1986 - present)** - Neural networks return to popularity.

- **(1987 - present)** - AI becomes a science.

- **(1995 - present)** - The emergence of intelligent agents.

Chapter One: Exercise

Q#1. Is AI a science, or is it engineering? Or neither or both? Explain.

Q2#. Why would evolution tend to result in systems that act rationally? What goals are such systems designed to achieve?

Q#3. "Surely computers cannot be intelligent—they can do only what their programmers tell them." Is the latter statement true, and does it imply the former?

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The End of Chapter- One!