Artificial Intelligence
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Outline

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- Narrow AI vs. General AI
- Superintelligence
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- What is AI Today
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Readings

1. Russell S, Norvig P , Artificial Intelligence : A Modern Approach, Pearson Education.
2. Elaine Rich and Kelvin Knight : Artificial Intelligence, Tata McGraw Hill.
3. Dan W. Patterson : Introduction to Artificial Intelligence and Expert Systems, Prentice Hall of India.
4. Kaushik Saroj, Logic and Prolog Programming, New Age International Publishers.
5. Konar Amit : Artificial Intelligence and Soft Computing, Behavioral and Cognitive Modeling of the Human Brain, CRC Press.

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Introduction

- In recent years, artificial intelligence, or AI, has gained a surge in attention from policy makers, universities, researchers, corporations, media, and the public.
- Driven by advances in big data and computing power, breakthroughs in AI research and technology seem to happen almost daily.
- Expectations, but also fears, are mounting about the transformational power of AI to change society.

“AI is the new electricity. Just as electricity transformed almost everything 100 years ago, today I have a hard time thinking of an industry that I don’t think AI will transform.”

– Andrew Ng,
AI Expert.

Don’t get left in the dark.

Benefits of AI

- Consumers use AI on a daily basis to find their destinations using navigation and ride-sharing apps, as smart home devices or personal assistants, or for streaming services.
- Businesses can use AI to assess risk and define opportunity, cut costs, and boost research and innovation. Cost and effort estimation, Risk estimation of projects can utilize AI as it is done based on historical data.

Industries Currently Using AI

- The self-driving car is probably the best-known use of AI.
- Predictive maintenance is another part of AI, forecasting when maintenance will be needed so that it can be done proactively, leading to tremendous cost savings.
- AI is used in transportation such as for train scheduling and to help Uber drivers navigate routes.
- Smart cities use AI to be more energy efficient, reduce crime and improve safety.

Intelligence

- The capability to form concepts and grasp their significance.
- To judge well, to comprehend well, to reason well
- Reflected in
  - mental and behavioral activities
  - situation specific (acquisition of skills implies behaving in a certain way)

    e.g. Car Driving

Intelligence

- Adaptation to the physical and social environment.
- essential abilities to
  - respond to situations flexibly
  - make sense out of ambiguous or contradictory messages.
  - Find similarity in situations separated by differences.
  - To generate new concepts and new ideas.

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Artificial Intelligence

- AI is the study of how to make computers do things, which at the moment, people do better (Elaine Rich).

  (This definition does not include problems that can not be solved by either computers or people).

- AI is the science of making machines do things that would require intelligence if done by men (Marvin Minsky).
- AI can be defined as a subject dealing with computational models that can think and act rationally, i.e., plan and execute the right task at the right time.(Amit Konar)

Artificial Intelligence

- AI is the branch of computer science concerned with the study and creation of computer systems that exhibit some form of intelligence (Patterson):
  - systems that can learn new concepts and tasks,
  - systems that can draw useful conclusions about the world around us,
  - systems that can understand a natural language or perceive and comprehend a visual scene
  - systems that can perform other types of feats that require human type of intelligence

- Humans try to understand about how to perceive, understand, predict and manipulate

AI tries not just to understand but also to build intelligent entities.

- AI currently encompasses a huge variety of subfields in
  - general-purpose areas such as learning and perception
  - specific tasks such as playing chess, proving mathematical theorems, writing poetry and diagnosing diseases.

- AI systematizes and automates intellectual tasks and is therefore relevant to any sphere of human intellectual activity. In this sense, it is truly a universal field.

- AI is one of the newest sciences. Work started soon after world war II and name itself was coined in 1956. Along with molecular biology, AI is regularly cited as the "**field I would most like to be in**" by scientists in other disciplines.

Definitions of AI, organized into four categories

- Systems that think like humans
- Systems that act like humans

- Systems that think rationally
- Systems that act rationally

Systems that act like humans

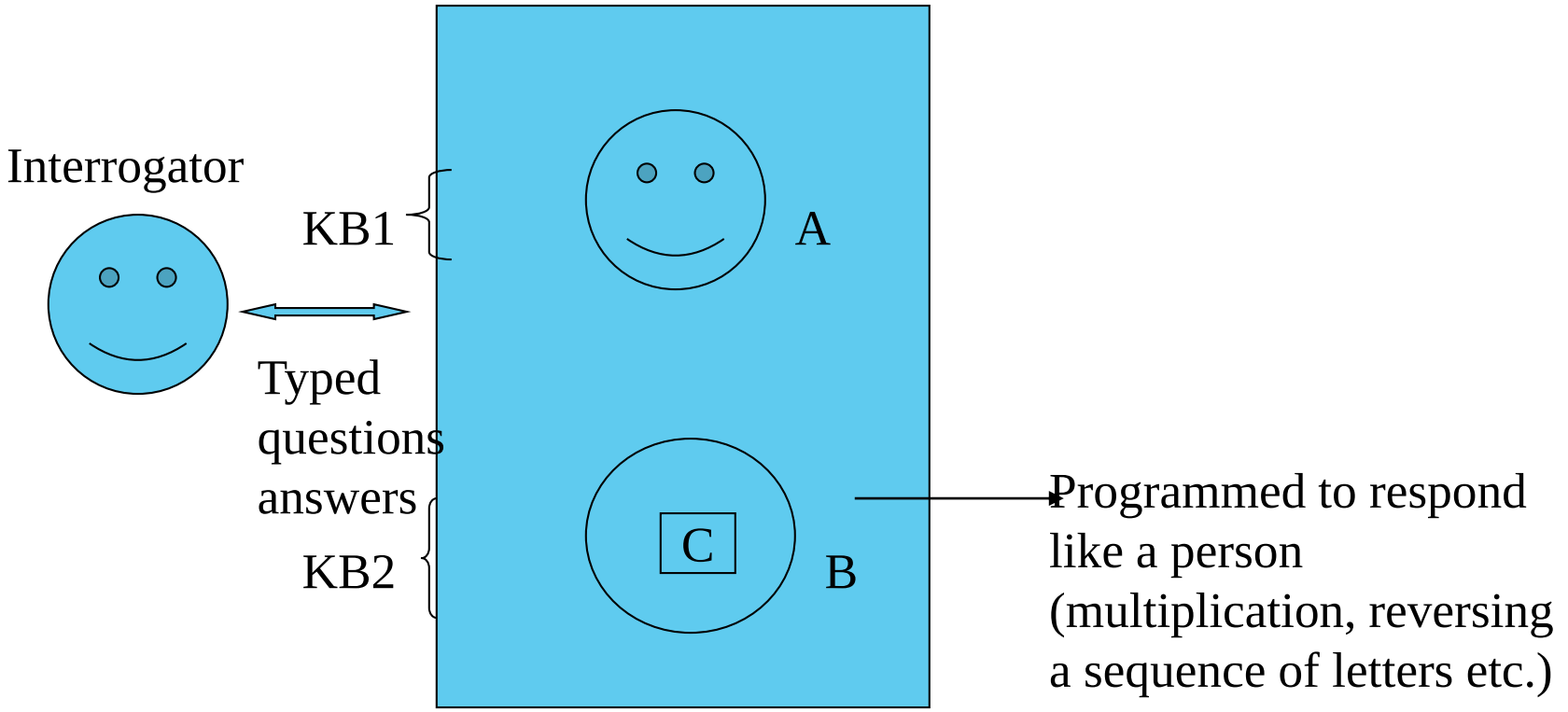
(Turing Test approach)

• The act of creating machines that perform functions that require intelligence when performed by people.(Kurzweil 1990)

• Study of how to make computers do things at which, at the moment people are better(Elaine Rich).

Turing Test

Named after Alan Turing who in 1950 proposed the following method for determining whether the machine can think.



If the interrogator can not distinguish between a computer and a person, the computer passes the Turing test for that problem.

CAPTCHA

Completely **A**utomated **P**ublic **T**uring test to tell **C**omputers and **H**umans **A**part

Computer would need to provide the following capabilities (Various Disciplines of AI)

- NLP to enable it to communicate successfully in English
- KR to store about 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
- Computer Vision to perceive objects
- Robotics to manipulate objects and move about.

Systems that think like humans (The Cognitive Modeling approach)

- “ The exciting new efforts to make computers think… machines with minds, in full and literal sense.” (Haugeland,1985)
- “[The automation of] activities that we associate with human being, activities such as decision-making, problem solving, learning…(Bellman,1978)

How humans think

One can understand actual working of Human mind

- through introspection - try to catch your own thoughts as they go by
- through psychological experiments - observing the person in action
- through brain imaging – observing the brain in action

Once we have a precise theory of mind, it becomes possible to express the theory as a computer program

The interdisciplinary field of **cognitive science** brings together computer models from AI and experimental techniques from psychology to try to construct precise and testable theories of the working of human mind.

Thinking rationally (The Law of Thought approach)

• “The study of mental faculties through use of computational models.” (Charniak and McDermott,1985)

•The study of the computations that make it possible to perceive, reason and act.” (Winston, 1992)

These law of thought approach were supposed to govern the operation of mind; their study initiated the field called **logic**.

Acting rationally (The Rational Agent approach)

- Doing the right thing under the given circumstances.

- "Computational Intelligence is the study of intelligent agents." (Poole et al, 1998)

- AI is concerned with intelligent behavior in artifacts."(Nilson 1998.)

An **agent** is just something that acts (agent comes from the Latin word agere, to do).

Attributes that distinguish agents from programs

- operating under autonomous control
- perceiving their environment
- persisting over a prolonged time period
- adapting to change
- being capable of taking another's goal

A **rational agent** is one that acts so as to achieve the best outcome or, when there is uncertainty, the best expected outcome.

•In law of thought approach to AI, emphasis is on correct inferences. Making correct inference is sometimes a part of being a rational agent because one way to act rationally is to reason logically to the conclusion that a given action will achieve one's goals and then to act on that conclusion.

On the other hand, correct inference is not all of rationality, because there are often situations where there is no provably correct thing to do, yet something must be done.

•All the skills needed for the Turing test are there to allow rational actions. Thus we need the ability to represent knowledge and reason with it because this enables us to reach decisions in a wide variety of situations.

Advantages of study of AI as rational agent approach

•It is more general than law of thought approach as correct inference is just one of the several possible ways to achieve rationality.

•It is more amenable to scientific developments than the approaches based on human behavior or human thought because the standard of rationality is clearly defined and completely general. Human behavior on the other hand is well adapted for one scientific environment.

Hence We will follow the rational agent approach to AI.

•Perfect rationality- always doing the right thing

•Limited rationality - acting appropriately when there is not enough time to do all the computations one might like

Foundations - Mathematics

- More formal logical methods
  - Boolean logic (Boole, 1847)
- Analysis of limits to what can be computed
  - Intractability (1965) – time required to solve problem scales exponentially with the size of problem instance
  - NP-complete (1971) – Formal classification of problems as intractable
- Uncertainty
  - The basis for most modern approaches to AI
  - Uncertainty can still be used in logical analyses

Foundations - Neuroscience

- How do brains work?
  - Early studies (1824) relied on injured and abnormal people to understand what parts of brain work
  - More recent studies use accurate sensors to correlate brain activity to human thought
    - By monitoring individual neurons, monkeys can now control a computer mouse using thought alone
  - Moore's law states computers will have as many gates as humans have neurons in 2020
  - How close are we to having a mechanical brain?
    - Parallel computation, remapping, interconnections, binary vs. gradient

Foundations – Control Theory

- Machines can modify their behavior in response to the environment (sense / action loop)
  - Water-flow regulator (250 B.C.E), steam engine governor, thermostat
- The theory of stable feedback systems (1894)
  - Build systems that transition from initial state to goal state with minimum energy
  - In 1950, control theory could only describe linear systems and AI largely rose as a response to this shortcoming

Foundations - Linguistics

- Speech demonstrates so much of human intelligence
  - Analysis of human language reveals thought taking place in ways not understood in other settings
    - Children can create sentences they have never heard before
    - Language and thought are believed to be tightly intertwined

The birth of AI (1943 – 1956)

- Warren McCulloch & Walter Pitts (1943): ANN with on-off neurons
  - Neurons triggered by sufficient #neighbors
  - Showed that any computable function computable with some network like this
  - Logical connectives implementable this way
  - Donald Hebb's 1949 learning rule
- Turing & Shannon chess programs, 1950s
- *SNARC*, first ANN computer, Minsky & Edmonds, 1951

The birth of AI (1943 – 1956)

- John McCarthy, who is the Father of Artificial Intelligence coined the term Artificial Intelligence in 1955 and he proposed this term in the famous Dartmouth conference in 1956.
- Alan Newell & Herbert Simon created the “first **artificial intelligence** program” Which was named as "**Logic Theorist**". This program had proved 38 of 52 Mathematics theorems, and find new and more elegant proofs for some theorems.

Early enthusiasm (1952 – 1969)

- 1956 Dartmouth conference

  John McCarthy (Lisp);

  Marvin Minsky (first neural network machine);

  Alan Newell and Herbert Simon (GPS);

- Emphasis on intelligent general problem solving

  Goal Stack Planning (means-ends analysis);

  Lisp (AI programming language);

  Resolution by John Robinson (basis for automatic theorem proving);

  heuristic search (A*, AO*, game tree search)

Emphasis on knowledge (1966 – 1974)

- domain specific knowledge is the key to overcome existing difficulties
- knowledge representation (KR) paradigms
- declarative vs. procedural representation

Knowledge-based systems (1969 – 1979)

- *DENDRAL*: molecule structure identification [Feigenbaum et al.]
  - Knowledge intensive
- *MYCIN*: medical diagnosis [Feigenbaum, Buchanan, Shortliffe]
  - 450 rules; knowledge from experts; no domain theory
  - Better than junior doctors
  - Certainty factors
- *PROSPECTOR*: drilling site choice [Duda et al]
- Domain knowledge in NLP
- Knowledge representation: logic, frames...

AI became an industry (1980 – 1988)

Wide applications in various domains and commercially available tools

- *R1*: first successful commercial expert system, configured computer systems at DEC; saved 40M$/year
- 1988: DEC had 40 expert systems
- 1981: Japan's 5th generation project to create computers using massively parallel computing and logic programming
- Software tools for expert systems: Carnegie Group, Inference Corporation, Intellicorp, Teknowledge
- LISP-specific hardware: LISP Machines Inc, TI(Texas Instruments), Symbolics, Xerox

Return of ANNs (1986-)

- Mid-1980s, different research groups reinvented backpropagation (originally from 1969)
- Disillusionment on expert systems
- Fear of AI winter (**AI winter** is a period of reduced funding and interest in artificial intelligence research)

Current trends (1990 – present)

- Real-world applications rather than toy domains
- distributed AI and intelligent software agents
- resurgence of natural computation - neural networks and emergence of genetic algorithms – many applications
- dominance of machine learning and deep learning

Two Views of AI Goal

- AI is about duplicating what the (human) brain DOES
  - Cognitive Science

- AI is about duplicating what the (human) brain SHOULD do
  - Rationality (doing things logically)

Weak AI vs. Strong AI

- Weak AI - describes "simulated" thinking., i.e., a system which appears to behave intelligently, but doesn't have any kind of consciousness about what it's doing and why. For example, a chatbot.
- Strong AI - describes "actual" thinking., i.e., thinking and acting intelligently as a human with a conscious, subjective mind.

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Narrow AI vs. General AI

- Narrow AI - AI that is limited to a single task or a set number of tasks.

- General AI - AI which can be used to complete a wide range of tasks in a wide range of environments.

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Superintelligence

- Superintelligence - general and strong AI at the point at which it surpasses human intelligence, if it ever does.

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Cool Stuff in AI

- Game playing agents
- Machine learning
- Speech
- Language
- Vision
- Data Mining
- Web agents ……..

Useful Stuff

- Medical Diagnosis
- Fraud Detection
- Object Identification
- Space Shuttle Scheduling
- Information Retrieval ….

AI Techniques

- Rule-based
- Fuzzy Logic
- Neural Networks
- Genetic Algorithms
- Machine Learning
- Deep Learning

Characteristics of AI systems

- learn new concepts and tasks,
- reason and draw useful conclusions about the world around us,
- understand a natural language or perceive and comprehend a visual scene,
- plan sequences of actions to complete a goal,
- offer advice based on rules and situations,

- remember complicated interrelated facts, and draw conclusions from them (inference),
- look through cameras and see what's there (vision), to move themselves and objects around in the real world (robotics),
- may not necessarily imitate human senses and thought processes but indeed, in performing some tasks differently, they may actually exceed human abilities,
- capable of performing intelligent tasks effectively and efficiently,
- performing tasks that require high levels of intelligence,

UNDERSTANDING OF AI

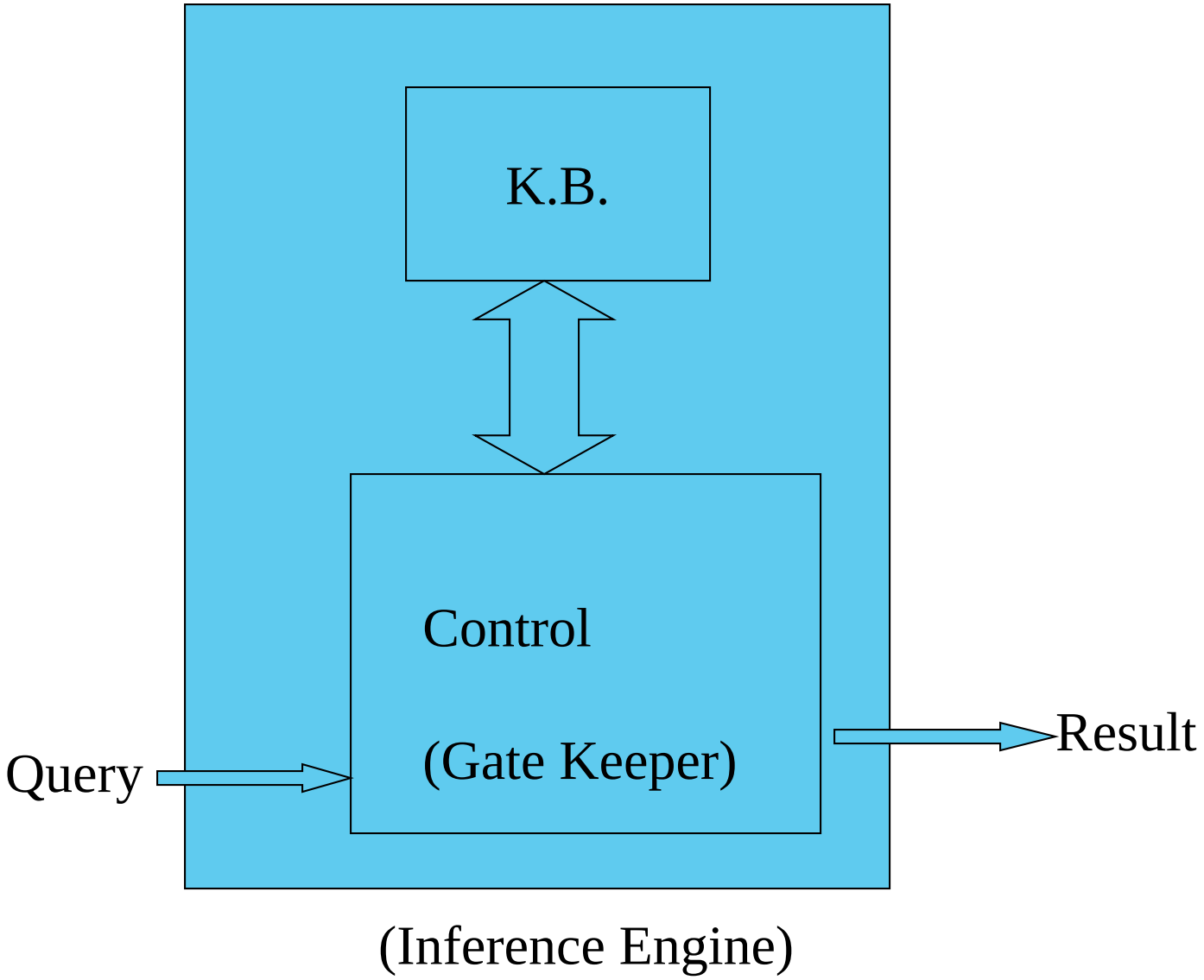
- AI techniques and ideas seem to be harder to understand than most things in computer science.
- Artificial intelligence shows best on complex problems for which general principles don't help much, though there are a few useful general principles.
- It often means, nonnumeric ways of solving problems, since people can't handle numbers well.
- Nonnumeric ways are generally "common sense" ways, not necessarily the best ones.

- Artificial intelligence is also difficult to understand by its content.
- Boundaries of AI are not well defined.
- Often it means the advanced software engineering, sophisticated software techniques for hard problems that can't be solved in any easy way.
- AI programs - like people - are usually not perfect, and even make mistakes.
- Understanding of AI also requires an understanding of related terms such as intelligence, knowledge, reasoning, thought, cognition, learning, and a number of other computer related terms.

Components of AI Program

- AI techniques must be independent of the problem domain as far as possible.
- AI program should have
  - knowledge base,
  - navigational capability which contains control strategy,
  - inferencing.

A.I. Program



Control (Gate Keeper) explores the knowledge and draws the inference.

Knowledge Base

- AI programs should be learning in nature and update its knowledge accordingly.
- Knowledge base consists of facts and rules.
- Characteristics of Knowledge:
  - It is voluminous in nature and requires proper structuring.
  - It may be incomplete and imprecise.
  - It may keep on changing (dynamic).
  - new facts might emerge

    * soil on Mars means evidence of life

    * absence of ozone layer means no evidence of life

However, an AI technique which is a method that exploits knowledge and attempts

•to capture generalization as far as possible
- helps to conserve storage
- enhances clarity
- one may need exception handling

•to have flexibility of representation
- for modification
- for extensibility of approach

- Control strategy
  - determines the rule to be applied
  - some heuristics (thumb rule) may be applied
- Inferencing
  - requires search through knowledge base and derive new knowledge

Sub-areas

- Natural language understanding,
- Computer vision,
- Understanding spoken utterances,
- Intelligent tutoring systems,
- Robotics,
- Machine translation systems,
- Expert problem solving,
- Neural networks
- Deep learning,
- AI tools etc

Applications

- **Business :** Financial strategies, give advice
- **Engineering:** check design, offer suggestions to create new page
- **Manufacturing:** Assembly, inspection & maintenance
- **Mining:** used when conditions are dangerous
- **Hospital :** monitoring, diagnosing & prescribing
- **Education :** In teaching
- **Household :** Advice on cooking, shopping etc.
- **Farming :** prune trees & selectively harvest mixed crops.

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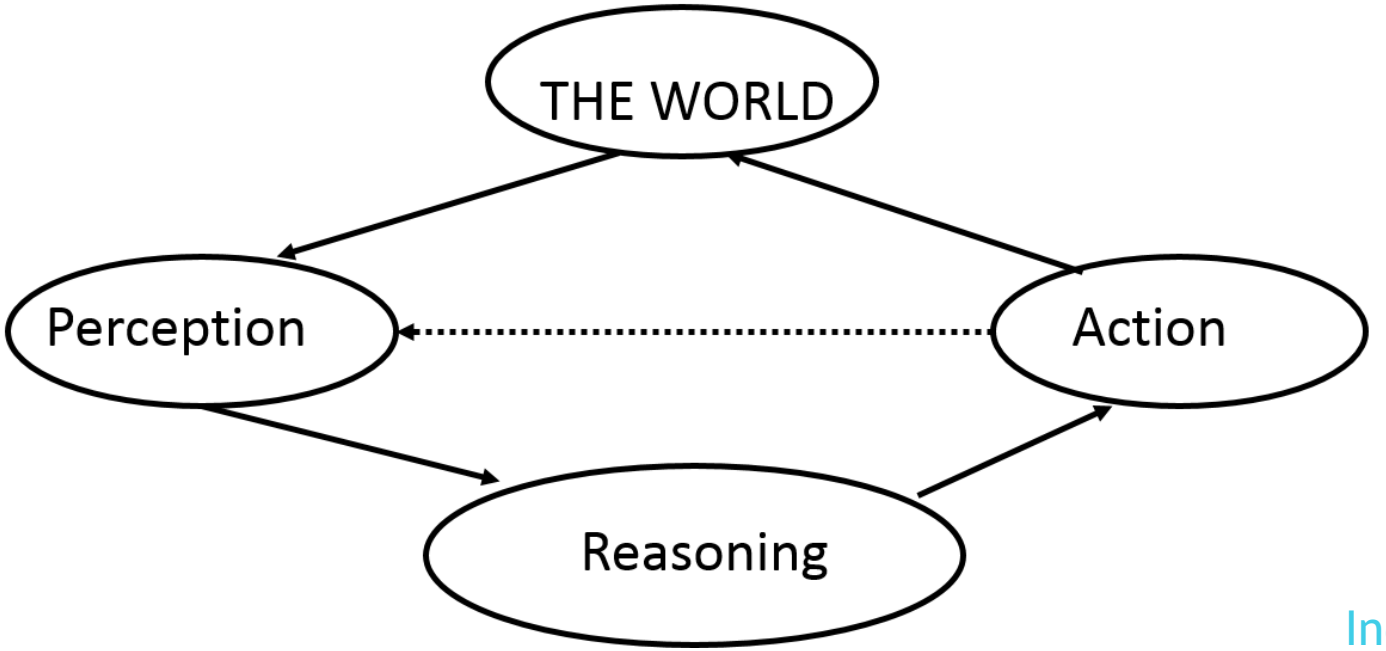
What is AI today

- Three typical components of AI Systems



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Recent AI

Recent AI is about designing good models and applications

using

- probability theory
- optimization
- decision theory
- statistics
- logic (fuzzy, modal, temporal)

to develop

- efficient algorithms using (lots of complex) data

PhD research in AI by my group

- Harmeet Kaur, *Trust based decentralized recommender systems (*2007).
- Sudeep Marwaha, *Temporal extension to ontologies for semantic web enabled systems (2008).*
- Suruchi Chawla, *Information Retrieval using Information Scent and Agents* (2011).
- Ravish Sharma, *Recommending Solutions for Complex Systems based on Ant Colony Metaphor* (2012).
- Anjali Thukral, *Retrieving and Organizing Web Resources Semantically for Informal e-Mentoring (2013).*
- Roli Bansal, *Computationally Intelligent Watermarking for Securing Fingerprint Images (2013).*

PhD research in AI by my group

- Richa Sharma, *Adaptive Content Sequencing Incorporating Social Opinion in an e-Learning Environment (2013).*
- Aakanksha Vats, *Mobile Process Groups based Trustworthy Coordination in Ad-hoc Network (2014).*
- Bhavna Gupta, *Trust-based Multiagent Service Recommender System (2014).*
- Vashisth, Pooja. T*rust and Argumentation based Recommender Systems* (2014).
- Sumit Agrawal, *Context-Aware Trust Based Mobile Recommender System (2014).*
- Anjali Gautam, *Matrix Factorization Based Recommender System for Large-Scale Data* (2018).

PhD research in AI by my group

- Vinita Jindal, Traffic Signals and Route Optimization for Congestion Control in Vehicular Ad-hoc Networks (2018).
- Veenu. Bhasin, Feature Selection Based Multi-Class Image Steganalysis Using Soft Computing Techniques (2018).
- Richa, *Cross Domain Context-aware Recommender System using Trust and Distrust (2019).*
- Chhavi Sharma, *Community Detection Based Recommender Systems (2019).*

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