(CT-17001) Artificial Intelligence

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Unit I : Introduction: What is AI, History, AI problems, Production Systems, Problem characteristics, Intelligent Agents, Agent Architecture, AI Application (E-Commerce, & Medicine), AI Representation, Properties of internal representation, Future scope of AI , Issues in design of search algorithms. [6 Hrs]

Unit II : Heuristic search techniques: Heuristic search, Hill Climbing, Best first search, mean and end analysis, Constraint Satisfaction, A* and AO* Algorithm, Knowledge Representation: Basic concepts, Knowledge representation Paradigms, Propositional Logic, Inference Rules in Propositional Logic, Knowledge representation using Predicate logic, Predicate Calculus,Predicate and arguments, ISA hierarchy, Frame notation, Resolution, Natural Deduction [6 Hrs]

Unit III : Logic Programming: Introduction, Logic, Logic Programming, Forward and Backward reasoning, forward and Backward chaining rules. Knowledge representation using non monotonic logic: TMS (Truth maintenance system), statistical and probabilistic reasoning, fuzzy logic, structure knowledge representation, semantic net, Frames, Script, Conceptual dependency. [6 Hrs]

(CT-17001) Artificial Intelligence

Unit IV : Learning: What is Learning, Types of Learning (Rote, Direct instruction Analogy, Induction, Deduction) Planning: Block world, strips, Implementation using goal stack, Non linear planning with goal stacks, Hierarchical planning, Least commitment strategy. [6 Hrs]

Unit V : Advance AI Topics: Game playing: Min-max search procedure, Alpha beta cutoffs, waiting for Quiescence, Secondary search, Natural Language Processing: Introduction, Steps in NLP, Syntactic Processing, ATN, RTN, Semantic analysis, Discourse & Pragmatic Processing. Perception and Action: Perception, Action, Robot Architecture [8 Hrs]

Unit VI : Neural Networks and Expert systems: Introduction to neural networks and perception-qualitative Analysis, Neural net architecture and applications, Utilization and functionality, architecture of expert system, knowledge representation, two case studies on expert systems. [8 Hrs]

(CT-17001) Artificial Intelligence

1. Artificial Intelligence by Kevin Knight and Elaine Rich

2. Artificial Intelligence: A Modern Approach by Stuart Russell and Peter Norvig

Course Learning Outcomes

- **Knowledge and understanding**

You should have a knowledge and understanding of the basic concepts of Artificial Intelligence including Search, Game Playing, Knowledge-based System (KBS) (including Uncertainty), Planning and Machine Learning.

- **Intellectual skills**

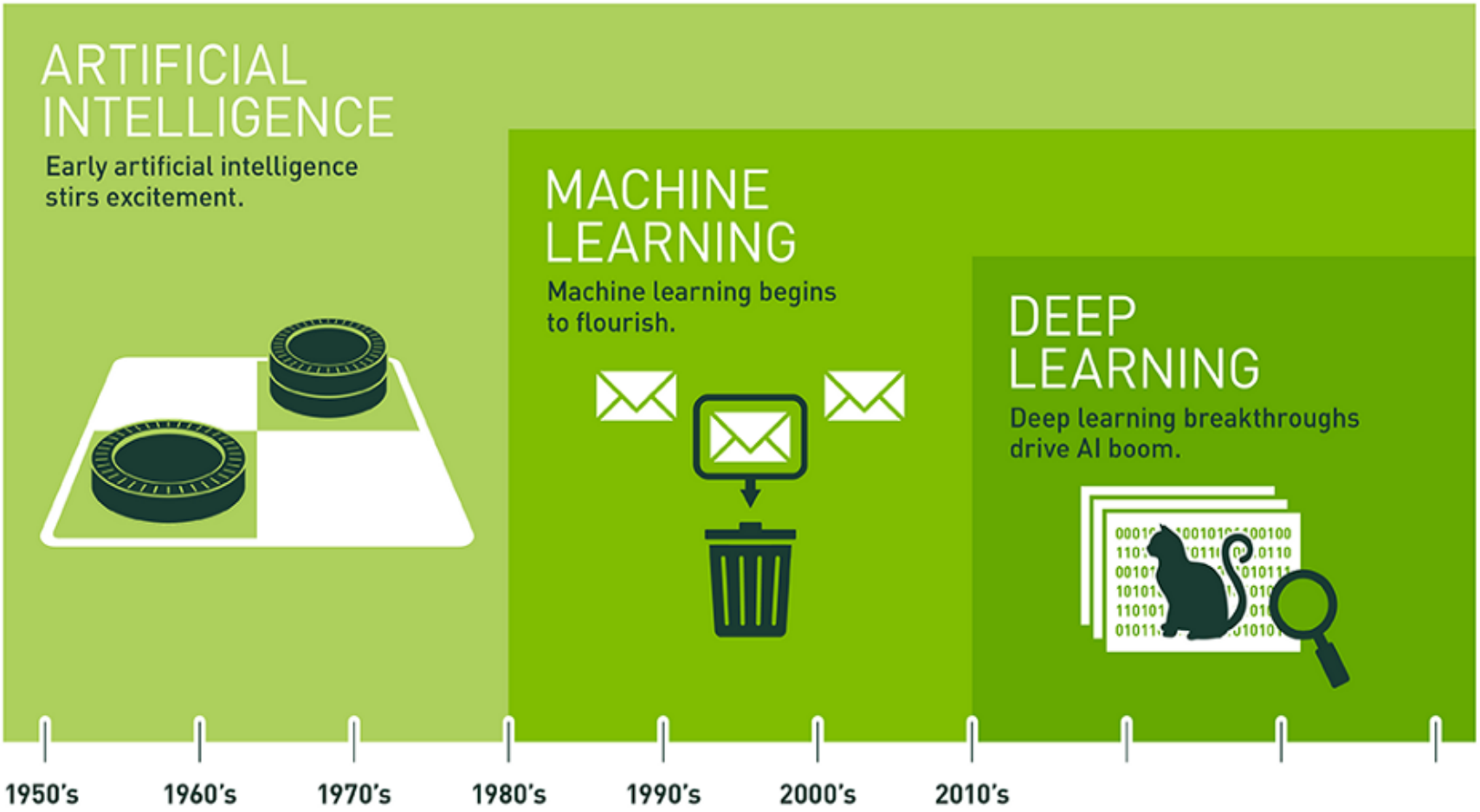
You should be able to use this knowledge and understanding of appropriate principles and guidelines to synthesize solutions to tasks in AI and to critically evaluate alternatives.

- **Practical skills**

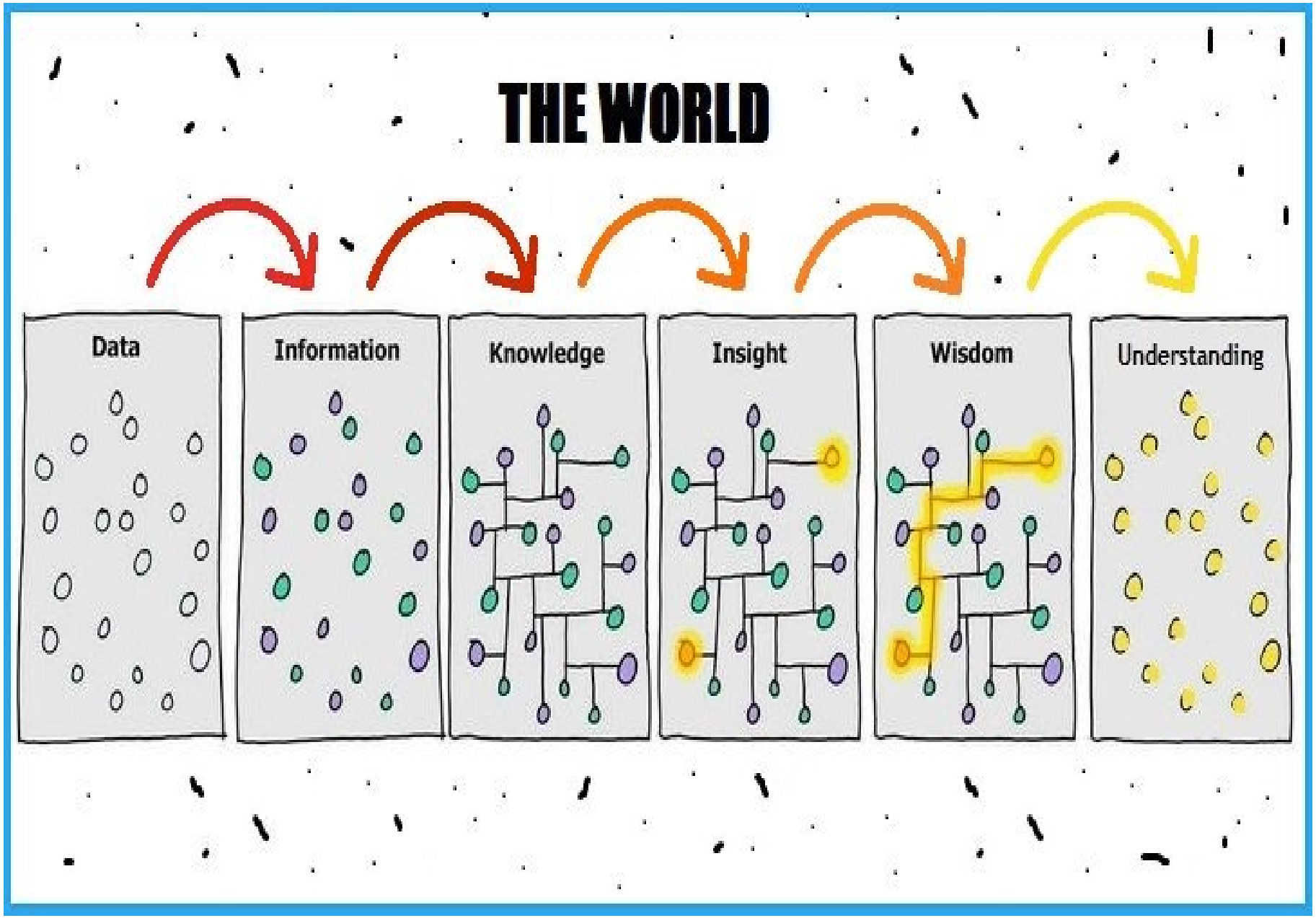
You should be able to use a well known language (Python) and to construct simple AI systems.

- **Transferable Skills**

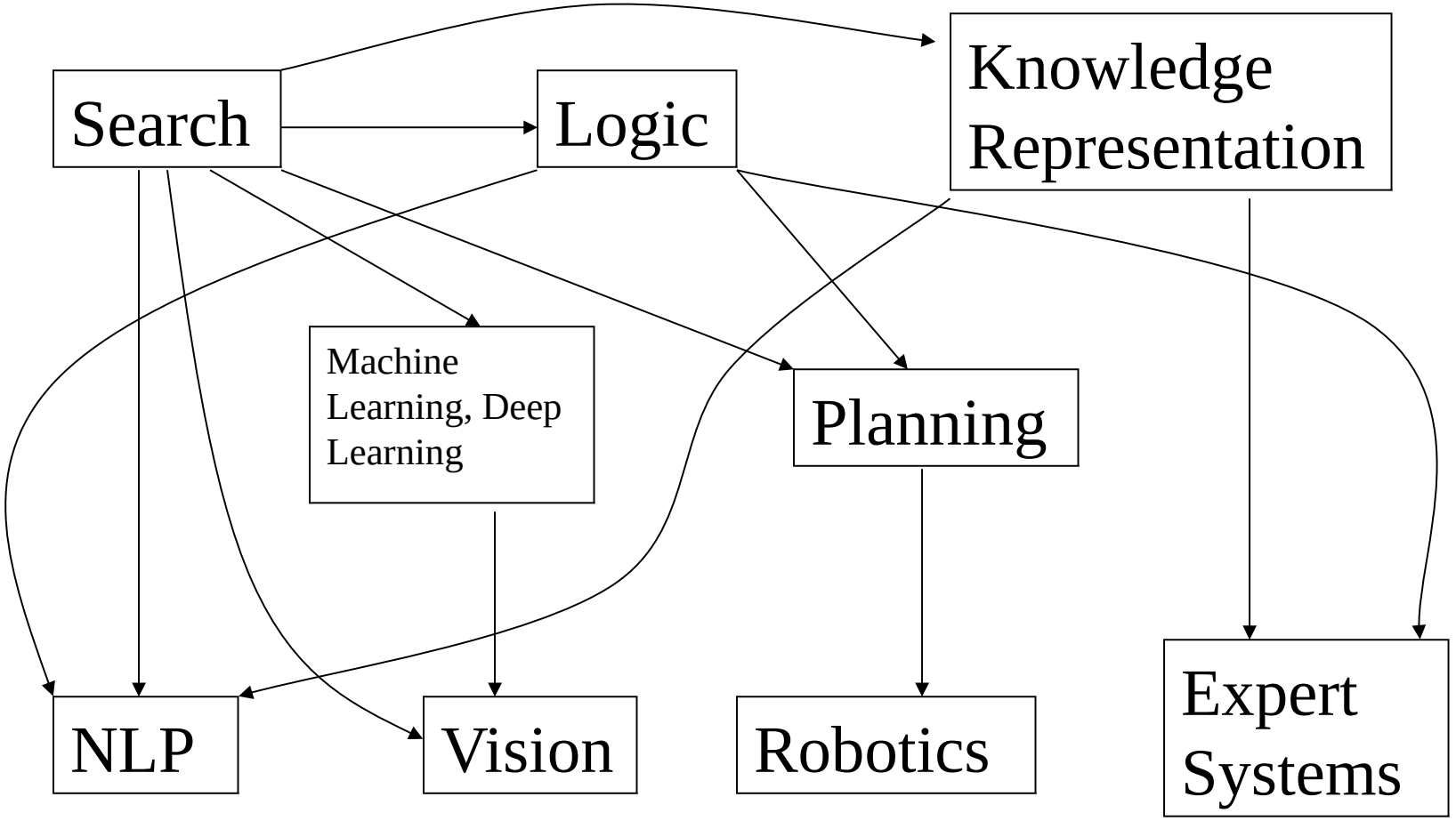
You should be able to solve problems and evaluate outcomes and alternatives.



Since an early flush of optimism in the 1950s, smaller subsets of artificial intelligence – first machine learning, then deep learning, a subset of machine learning – have created ever larger disruptions.


THE WORLD
Data
Information
Knowledge
Insight
Wisdom
Understanding

Areas of AI and Some Dependencies



What is Artificial Intelligence ?

- making computers that think?
- the automation of activities we associate with human thinking, like decision making, learning ... ?
- the art of creating machines that perform functions that require intelligence when performed by people ?
- the study of mental faculties through the use of computational models ?

What is Artificial Intelligence ?

- the study of computations that make it possible to perceive, reason and act ?
- a field of study that seeks to explain and emulate intelligent behaviour in terms of computational processes ?
- a branch of computer science that is concerned with the automation of intelligent behaviour ?
- anything in Computing Science that we don't yet know how to do properly ? (!)

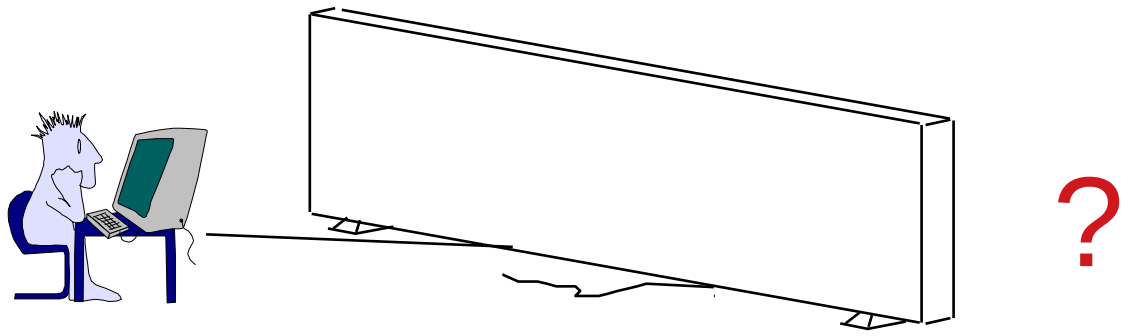
What is Artificial Intelligence ?

	HUMAN	RATIONAL
THOUGHT	Systems that think like humans	Systems that think rationally
BEHAVIOUR	Systems that act like humans	Systems that act rationally

Systems that act like humans

- “The art of creating machines that perform functions that require intelligence when performed by people.” (Kurzweil)
- “The study of how to make computers do things at which, at the moment, people are better.” (Rich and Knight)

Systems that act like humans: Turing Test



- You enter a room which has a computer terminal. You have a fixed period of time to type what you want into the terminal, and study the replies. At the other end of the line is either a human being or a computer system.
- If it is a computer system, and at the end of the period you cannot reliably determine whether it is a system or a human, then the system is deemed to be intelligent.

Systems that act like humans

- The Turing Test approach
  - a human questioner cannot tell if
    there is a computer or a human answering his question, via teletype (remote communication)
  - The computer must behave intelligently
- Intelligent behavior
  - to achieve human-level performance in all cognitive tasks

Systems that act like humans

- These cognitive tasks include:
  - *Natural language processing*
    - for communication with human
  - *Knowledge representation*
    - to store information effectively & efficiently
  - *Automated reasoning*
    - to retrieve & answer questions using the stored information
  - *Machine learning*
    - to adapt to new circumstances

The Total Turing Test

- Includes two more issues:
  - *Computer vision*
    - to perceive objects (seeing)
  - *Robotics*
    - to move objects (acting)

What is Artificial Intelligence ?

	HUMAN	RATIONAL
THOUGHT	**Systems that think like humans**	**Systems that think rationally**
BEHAVIOUR	**Systems that act like humans**	**Systems that act rationally**

Systems that think like humans: cognitive modeling

- Humans as observed from ‘inside’
- How do we know how humans think?
  - Introspection vs. psychological experiments
- Cognitive Science
- “The exciting new effort to make computers think … machines with *minds* in the full and literal sense” (Haugeland)
- “[The automation of] activities that we associate with human thinking, activities such as decision-making, problem solving, learning …” (Bellman)

What is Artificial Intelligence ?

	HUMAN	RATIONAL
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Systems that think rationally "laws of thought"

- Humans are not always ‘rational’
- Rational - defined in terms of logic?
- Logic can’t express everything (e.g. uncertainty)
- Logical approach is often not feasible in terms of computation time (needs ‘guidance’)
- “The study of mental faculties through the use of computational models” (Charniak and McDermott)
- “The study of the computations that make it possible to perceive, reason, and act” (Winston)

What is Artificial Intelligence ?

	HUMAN	RATIONAL
THOUGHT	Systems that think like humans	Systems that think rationally
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Systems that act rationally: "Rational agent"

- Rational behavior: doing the right thing
- The right thing: that which is expected to maximize goal achievement, given the available information
- Giving answers to questions is 'acting'.
- I don't care whether a system:
  - replicates human thought processes
  - makes the same decisions as humans
  - uses purely logical reasoning

Systems that act rationally

- Logic only *part* of a rational agent, not *all* of rationality
  - Sometimes logic cannot reason a correct conclusion
  - At this moment, some *specific (in domain) human knowledge* or information is used
- Thus, it covers more generally different situations of problems
  - Compensate the incorrectly reasoned conclusion

Systems that act rationally

- Study AI as rational agent –

2 advantages:

  - It is more general than using logic only
    - Because: LOGIC + Domain knowledge
  - It allows extension of the approach with more scientific methodologies

Rational agents

- An agent is an entity that perceives and acts
- This course is about designing rational agents
- Abstractly, an agent is a function from percept histories to actions:

$$[f: P^* \longrightarrow A]$$

- For any given class of environments and tasks, we seek the agent (or class of agents) with the best performance
- Caveat: computational limitations make perfect rationality unachievable
  - ✉ design best program for given machine resources

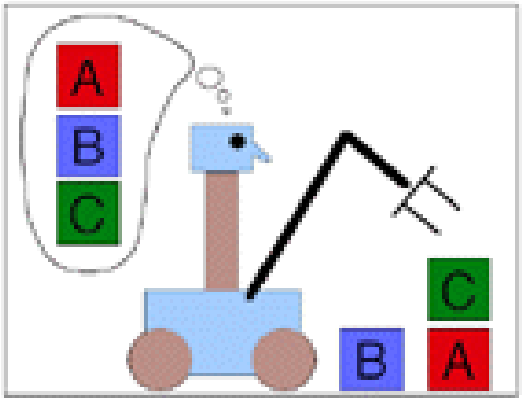
- Artificial
- Produced by human art or effort, rather than originating naturally.
- Intelligence
- is the ability to acquire knowledge and use it [Pigford and Baur]
- **So AI was defined as:**
  - AI is the study of ideas that enable computers to be intelligent.
  - AI is the part of computer science concerned with design of computer systems that exhibit human intelligence(From the Concise Oxford Dictionary)

From the above two definitions, we can see that AI has two major roles:

- Study the intelligent part concerned with humans.
- Represent those actions using computers.

Goals of AI

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



The Foundation of AI

- ***Philosophy***
  - At that time, the study of human intelligence began with no formal expression
  - Initiate the idea of mind as a machine and its internal operations

The Foundation of AI

- **Mathematics** formalizes the three main area of AI: *computation*, *logic*, and *probability*
  - Computation leads to analysis of the problems that can be computed
    - *complexity theory*
  - Probability contributes the "*degree of belief*" to handle *uncertainty* in AI
  - *Decision theory* combines *probability theory* and *utility theory* (bias)

The Foundation of AI

- **Psychology**
  - How do humans think and act?
  - The study of human reasoning and acting
  - Provides reasoning models for AI
  - Strengthen the ideas
    - humans and other animals can be considered as information processing machines

The Foundation of AI

- **Computer Engineering**
  - How to build an efficient computer?
  - Provides the artifact that makes AI application possible
  - The power of computer makes computation of large and difficult problems more easily
  - AI has also contributed its own work to computer science, including: time-sharing, the linked list data type, OOP, etc.

The Foundation of AI

- **Control theory and Cybernetics**
  - How can artifacts operate under their own control?
  - The artifacts adjust their actions
    - To do better for the environment over time
    - Based on an objective function and feedback from the environment
  - Not limited only to linear systems but also other problems
    - as language, vision, and planning, etc.

The Foundation of AI

- **Linguistics**
  - For understanding natural languages
    - different approaches has been adopted from the linguistic work
  - Formal languages
  - Syntactic and semantic analysis
  - Knowledge representation

The main topics in AI

Artificial intelligence can be considered under a number of headings:

- Search (includes Game Playing).
- Representing Knowledge and Reasoning with it.
- Planning.
- Learning.
- Natural language processing.
- Expert Systems.
- Interacting with the Environment
  (e.g. Vision, Speech recognition, Robotics)

Some Advantages of Artificial Intelligence

- more powerful and more useful computers
- new and improved interfaces
- solving new problems
- better handling of information
- relieves information overload
- conversion of information into knowledge

The Disadvantages

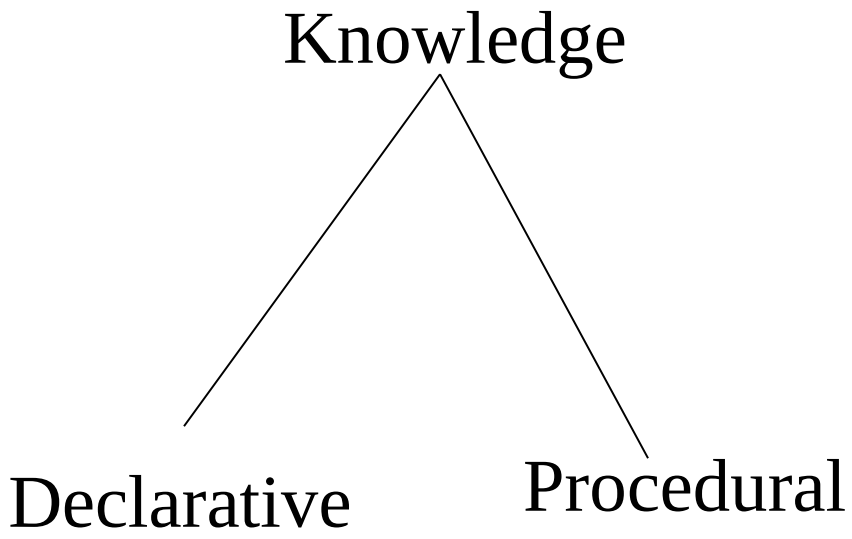
- increased costs
- difficulty with software development - slow and expensive
- few experienced programmers
- few practical products have reached the market as yet.

Search

- *Search* is the fundamental technique of AI.
  - Possible answers, decisions or courses of action are structured into an abstract space, which we then search.
- Search is either "blind" or “informed":
  - blind
    - we move through the space without worrying about what is coming next, but recognising the answer if we see it
  - informed
    - we guess what is ahead, and use that information to decide where to look next.
- We may want to search for the first answer that satisfies our goal, or we may want to keep searching until we find the best answer.

Knowledge Representation & Reasoning

- The second most important concept in AI
- If we are going to act rationally in our environment, then we must have some way of describing that environment and drawing inferences from that representation.
  - how do we describe what we know about the world ?
  - how do we describe it *concisely* ?
  - how do we describe it so that we can get hold of the right piece of knowledge when we need it ?
  - how do we generate new pieces of knowledge ?
  - how do we deal with *uncertain* knowledge ?



- Declarative knowledge deals with factoid questions (what is the capital of India? Etc.)
- Procedural knowledge deals with “How”
- Procedural knowledge can be embedded in declarative knowledge

Planning

Given a set of goals, construct a sequence of actions that achieves those goals:

- often very large search space
- but most parts of the world are independent of most other parts
- often start with goals and connect them to actions
- no necessary connection between order of planning and order of execution
- what happens if the world changes as we execute the plan and/or our actions don’t produce the expected results?

Learning

- If a system is going to act truly appropriately, then it must be able to change its actions in the light of experience:
  - how do we generate new facts from old ?
  - how do we generate new concepts ?
  - how do we learn to distinguish different situations in new environments ?

Interacting with the Environment

- In order to enable intelligent behaviour, we will have to interact with our environment.
- Properly intelligent systems may be expected to:
  - accept sensory input
    - vision, sound, …
  - interact with humans
    - understand language, recognise speech, generate text, speech and graphics, …
  - modify the environment
    - robotics

History of AI

- AI has a long history
  - Ancient Greece
    - Aristotle
  - Historical Figures Contributed
    - Ramon Lull
    - Al Khowarazmi
    - Leonardo da Vinci
    - David Hume
    - George Boole
    - Charles Babbage
    - John von Neuman
  - As old as electronic computers themselves (1940)

History of AI

- Origins
  - The Dartmouth conference: 1956
    - John McCarthy (Stanford)
    - Marvin Minsky (MIT)
    - Herbert Simon (CMU)
    - Allen Newell (CMU)
    - Arthur Samuel (IBM)
- The Turing Test (1950)
- COMPUTING MACHINERY AND INTELLIGENCE
- https://academic.oup.com/mind/article/LIX/236/433/986238
- "Machines who Think" By Pamela McCorckindale
- https://www.youtube.com/watch?v=i6rnzk8VU24&t=24s

- Early period - 1950’s & 60’s
  - Game playing
    - brute force (calculate your way out)
  - Theorem proving
    - symbol manipulation
  - Biological models
    - neural nets
- Symbolic application period - 70’s
  - Early expert systems, use of knowledge
- Commercial period - 80’s
  - boom in knowledge/ rule bases

- 90’s and New Millenium
- Real-world applications, modelling, better evidence, use of theory, ...?
- Topics: data mining, formal models, GA’s, fuzzy logic, agents, neural nets, autonomous systems
- Applications
  - visual recognition of traffic
  - medical diagnosis
  - directory enquiries
  - power plant control
  - Autonomous cars

Fashions in AI

Progress goes in stages, following funding booms and crises: Some examples:

1. Machine translation of languages

    1950's to 1966 - Syntactic translators

    1966 - all US funding cancelled

    1980 - commercial translators available

2. Neural Networks

    1943 - first AI work by McCulloch & Pitts

    1950's & 60's - Minsky's book on "Perceptrons" stops nearly all work on nets

    1986 - rediscovery of solutions leads to massive growth in neural nets research

The UK had its own funding freeze in 1973 when the Lighthill report reduced AI work severely -Lesson: Don't claim too much for your discipline!!!!

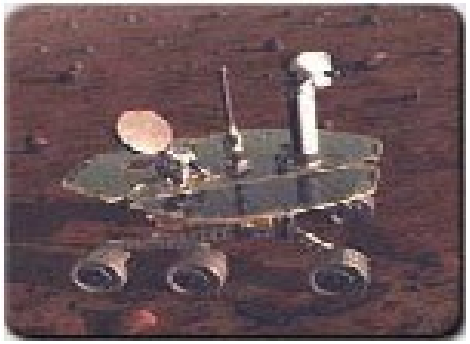
Look for similar stop/go effects in fields like Machine Learning and Deep Learning.

Symbolic and Sub-symbolic AI

- Symbolic AI is concerned with describing and manipulating our knowledge of the world as explicit symbols, where these symbols have clear relationships to entities in the real world.
- Sub-symbolic AI (e.g. neural-nets) is more concerned with obtaining the correct response to an input stimulus without ‘looking inside the box’ to see if parts of the mechanism can be associated with discrete real world objects.
- This course is concerned with symbolic AI.

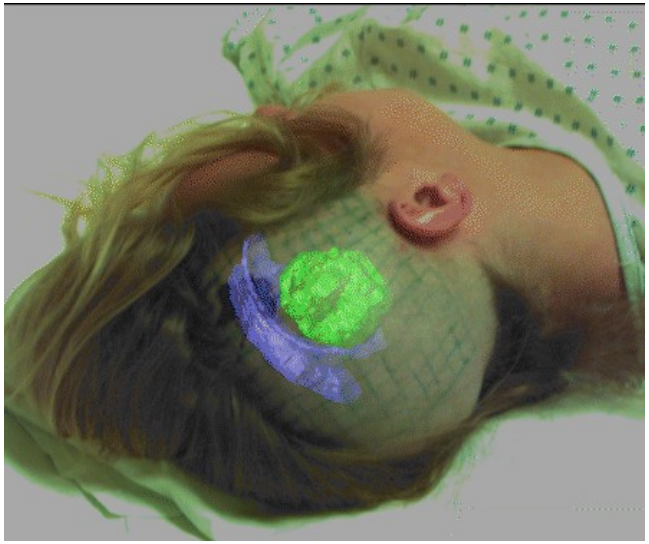
AI Applications

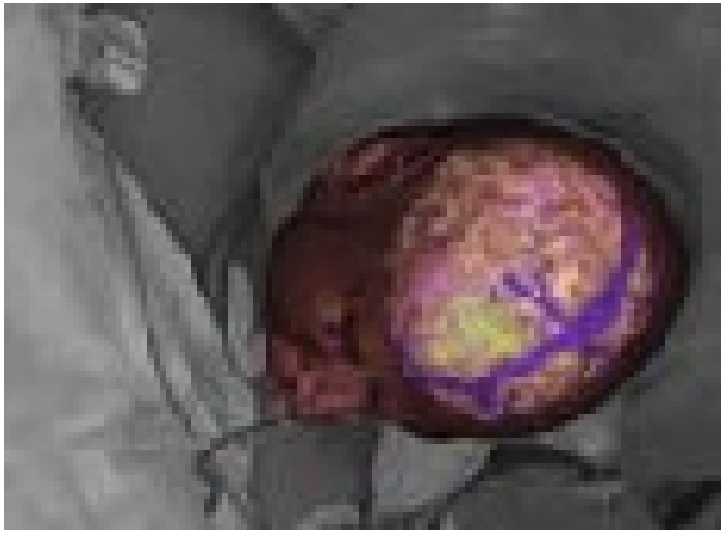
- Autonomous Planning & Scheduling:



AI Applications

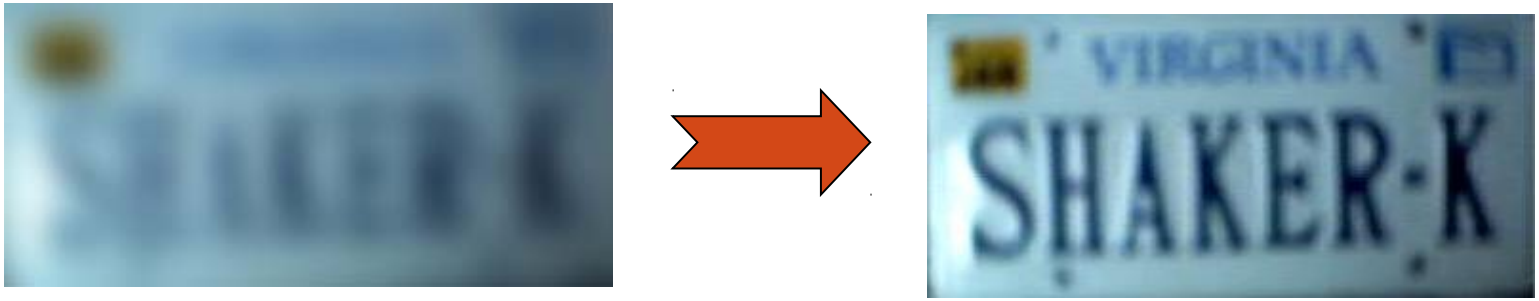
- **Medicine**:
  - Image guided surgery

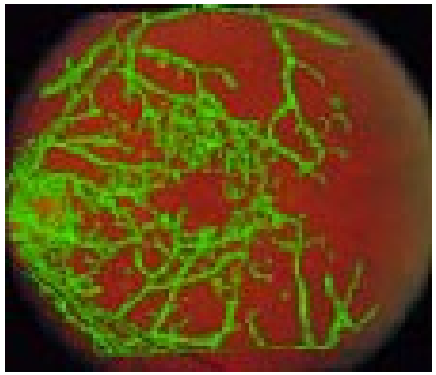


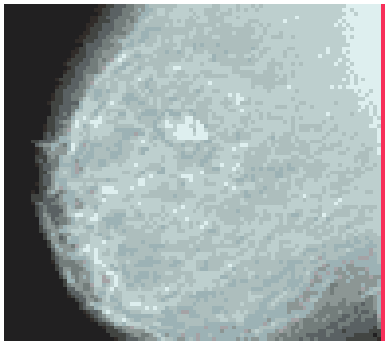


AI Applications

- Image analysis and enhancement





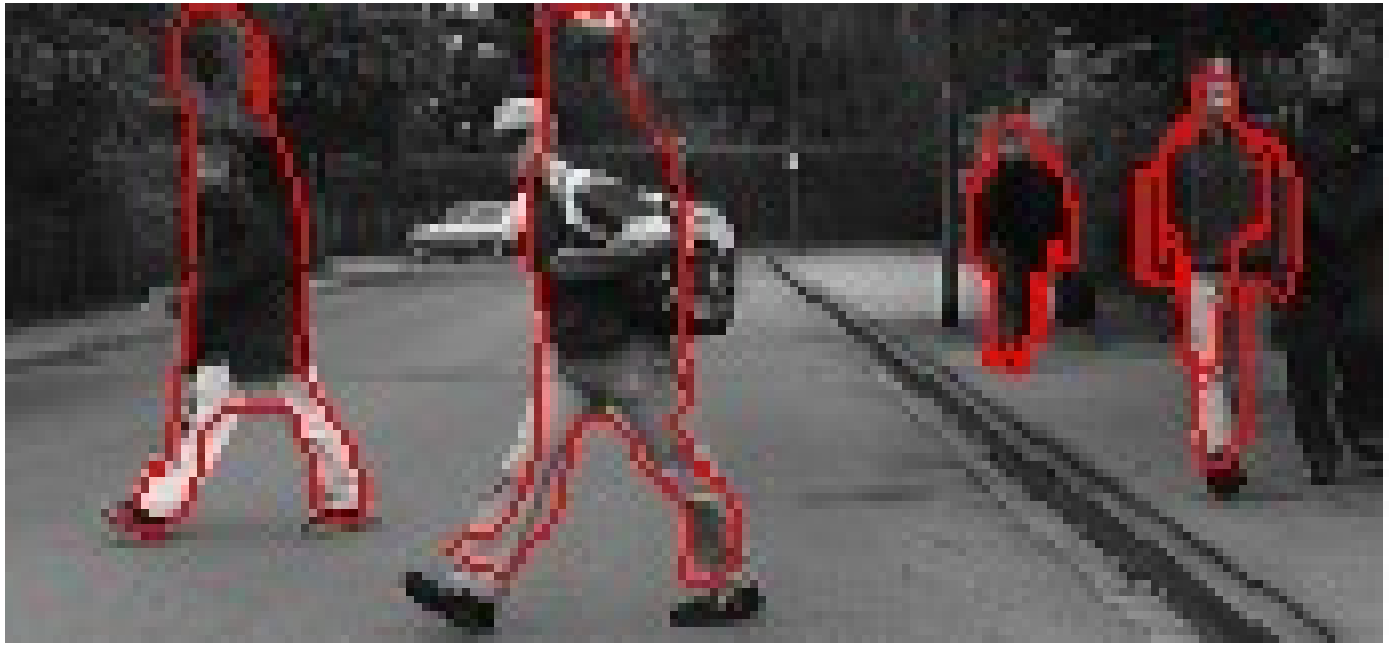


AI Applications

- **Autonomous vehicle:**

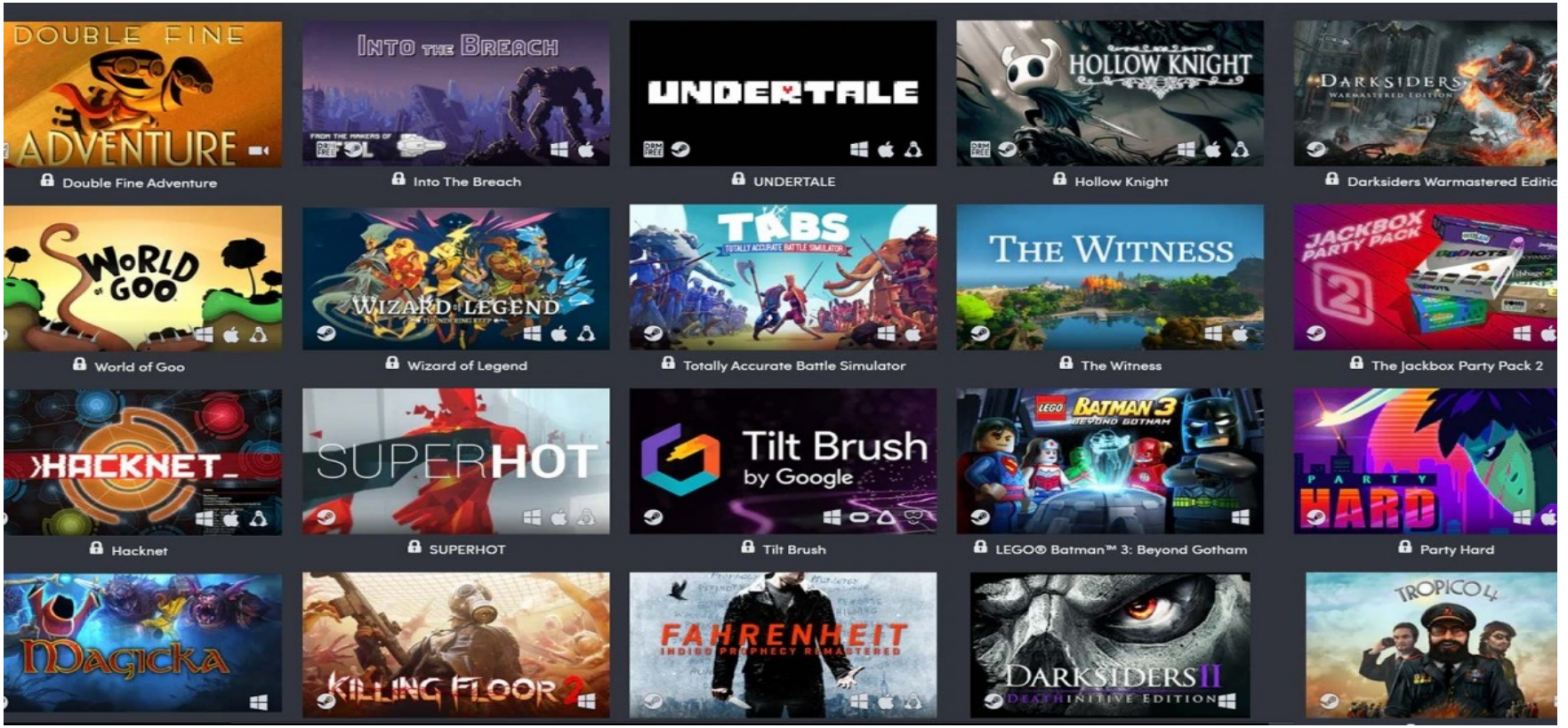
AI Applications

- **Pedestrian detection:**



AI Applications

Games:



AI Applications

- **Robotics**:

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**