INTRODUCTION TO AI

Unit 1

Outline

- Overview
- Definition of AI
- AI and Related Fields
- Brief History of AI
- Applications of AI
- Importance of AI
- Definition of Knowledge and Learning
- Importance of Knowledge and Learning
- Intelligent Agents and it types and performance measures

Overview- Background

- Humans and Mental Capacities
- How we Think?
  - How we Perceive, Understand, Predict and Manipulate a large and complicated world?
- Understand Intelligent Entities
- Build Intelligent Entities

Overview- AI and Its Subfields

- General Purpose Areas
  - Learning
  - Perception
  - Natural Language Processing
  - Common-sense Reasoning
  - Robot Control
- Specific Tasks
  - Games (Chess, Backgammon, Cards, Checkers, Tic-Tac-Toe)
  - Mathematical Theorems (Geometry, Calculus, Logic, Proving properties)
  - Scientific Analysis
  - Medical Analysis
  - Financial Analysis
  - Writing Literatures (Poems)

AI systemizes and automates intellectual tasks.

Definition of AI- What is AI?

- A thought process
- Reasoning
- Fidelity to Human Performance
- Rationality (doing right thing)

Definition of AI- Approaches to AI

- Act Humanly: Turing Test Approach
- Think Humanly: Cognitive Modelling Approach
- Think Rationally: The Laws of Though Approach
- Act Rationally: The Rational Agent Approach

Act Humanly: Turing Test Approach

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- The art of creating machines that perform functions that require intelligence when performed by people.(Kurzwail, 1990)
- The study of how to make computers do things at which, at the moment, people are better.(Rich and Knight, 1991)
- Based on Turing Test (Alan Turing, 1950)
  - Test based on indistinguishability from undeniably intelligent entities (human).
  - The computer passes a test if a human interrogator, after posing some written questions, can't tell whether the responses were made by a human or not.

Act Humanly: Turing Test Approach

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- Capabilities need of the computer for the tests:
  - Natural Language Processing (ability to communicate successfully)
  - Knowledge Representation (store what it knows or hears)
  - Automated Reasoning (use the stored information to answer questions and draw new conclusions)
  - Machine Learning (adapt to new circumstances and to detect and extrapolate patterns)
- And
  - Computer Vision (to perceive objects)
  - Robotics (to manipulate objects and move about)

Think Humanly: Cognitive Modelling Approach

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- The exciting new effort to make computers think… machines with minds, in the full and literal sense. (Haugeland, 1985)
- "The automation of activities that we associate with human thinking, activities such as decision-making, problem solving, learning…"(Bellman, 1978)
- Based on Cognitive Science
  - Cognitive science brings together compute models from AI and experimental techniques from psychology to try to construct precise and testable theories of the workings of the human mind.
  - Needs understanding of how human thinks?
  - Example: General Problem Solver-GPS

Think Rationally: The Laws of Thought Approach

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- The study of mental faculties through the use of computational models. (Charniak and McDermott, 1985)
- The study of the computations that make it possible to perceive, reason and act. (Winston, 1992)
- Based on Rational Thinking (Right Thinking)
  - Irrefutable Reasoning Process
  - Syllogisms providing patterns for argument structures that always yielded correct conclusions
  - Logic: the Laws of thought
  - Logicist tradition within AI hopes to build on such programs to create intelligent systems

Act Rationally: The Rational Agent Approach

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- Computational Intelligence is the study of the design of intelligent agents. (Poole et al., 1998)
- AI… is concerned with intelligent behaviour in artifacts. (Nilsson, 1998)
- Based on Intelligent Agents
  - Agents are the things that act. Computer agents are expected to have other attributes that distinguish them from mere "programs", such as operating under autonomous control, perceiving their environment, persisting over a prolonged time period, adapting to change, and being capable of taking on another's goals.
  - Rational agents are those who act so as to achieve the best outcome or, the best expected outcome when there is uncertainty.

AI and Related Fields- The Foundations of AI

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- Philosophy (428 B.C. – Present)
  - Drawing conclusions from the rules
  - Mental mind and physical brain
  - Where does knowledge come from?
  - How does knowledge lead to action?
    - Dualism, Materialism, Empiricism, Induction, Logical Positivism, Confirmation Theory
- Mathematics (800 A.D. – Present)
  - What are the formal rules to draw conclusions?
  - What can be computed or manipulated?
  - How do we reason with uncertain information?
    - Algorithms, NP Completeness, Probability, Incompleteness Theorem, Intractability

AI and Related Fields- The Foundations of AI

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- Economics (1776 A.D. – Present)
  - How decisions can be made to maximize payoff?
  - How can something be done when others may not go along?
  - How can this be done when payoff may be far in future?
    - Decision Theory, Game Theory, Operations Research, Satisficing
- Neuroscience (1861 A.D. – Present)
  - How are information processed by the human brain?
    - Neurons
- Psychology (1879 A.D. – Present)
  - How do humans and animals think and act?
    - Behaviourism, Cognitive Psychology, Cognitive Science

AI and Related Fields- The Foundations of AI

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- Computer Engineering (1940 A.D. – Present)
  - How can we build an efficient computer?
- Control theory and Cybernetics (1948 A. D. – Present)
  - How can artifacts operated under their own control?
    - Control Theory, Cybernetics, Objective Function
- Linguistics (1957 A.D. – Present)
  - How does language relate to thought?
    - Computational Linguistics, NLP, Knowledge Representation

Brief History of AI- The Gestation Period (1943-1955)

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- Warren McCulloch and Walter Pitts (1943): 3 Sources (Knowledge of basic physiology and functions of neurons in brain; a formal analysis of propositional logic due to Russell and Whitehead; Turing's theory of computation → proposed model of artificial neurons characterized by on/off logic that could even learn
- Hebbian Learning (1949) by Donald Hebb: demonstration of simple updating rule for modification of the connections strengths between the neurons
- Marvin Minsky and Dean Edmonds (1951): first neural network computer → SNARC (3000 Vacuum Tubes and a pilot mechanism from B-24 bomber to simulate a network of 40 neurons <Von Neumann>
- Alan Turing (1950): "Computing Machinery and Intelligence" (Articulated a complete vision of AI, introducing Turing Test, Machine Learning, Genetic Algorithms, Reinforcement Learning)

Brief History of AI- The Birth (1956)

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- John McCarthy, Marvin Minsky, Claude Shannon and Nathaniel Rochester focused researches on automata theory, neural nets, and intelligence organizing a 2-month workshop (1956)
- Two participants Allen Newell and Herbert Simon presented works on reasoning program named the Logic Theorist that was claimed to think non numerically and prove many theorems but the paper was not recognized by the *Journal of Symbolic Logic*
- But the workshop laid the foundation for AI and the participants of the workshop became the leaders in the field of Artificial Intelligence

Brief History of AI: The Early Period (1952-1969)

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- General Problem Solver – Thinking Humanly Purpose
- Nathaniel Rochester in IBM came with some of the first AI Programs
- Herbert Gelernter (1959) – Geometry Theorem Prover
- Arthur Samuel (1952) – Series of Programs for checkers leading to skilled checker program that could play better than its creator
- John McCarthy (1958) – Contributions
  - Lisp- a high level dominant AI programming language
  - Paper entitled *Programs and Common Sense* described the Advice Taker as a complete AI System- use knowledge to search for solutions to problems
  - AI Lab at Stanford

Brief History of AI: The Early Period (1952-1969)

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- Marvin Minsky (1958) – anti logical outlook
- J. A. Robinson – discovery of Resolution Method
- Cordell Green (1969) – Question answering and planning system
- Minsky's Students focused on study to solve limited problems that seems to require AI and this domain is called microworlds.
- James Slagle (1963) – SAINT program solved closed form calculus integration problems
- Tom Evan (1968) – ANALOGY program solved geometric analogy problems

Brief History of AI: The Early Period (1952-1969)

- Daniel Bobrow (1967) – STUDENT program solved algebra problems
- David Huffman (1971) – The vision project
  David Waltz (1975) – The vision and constraint propagation
  Patrik Winston (1970) – The learning theory
  Terry Winoguard (1972) – The natural language understanding program
  Scott Fahlman (1974) – The planner
- → Block World – Rearrange the blocks using robot hand
- McCulloch and Pitts – Neural Network
- Bernie Widrow (1962) – Adalines
- Frank Rosenblatt (1962) – Perceptron and Perceptron Convergence theorem

Brief History of AI: Reality Dawns (1966-1973)

- Problems were faced while realization of AI Projects:
  - The most early programs contained little or no knowledge in their subject matter; success was merely based on simple syntactic manipulation
  - Intractability of many of the problems; microworlds were comparatively less complicated than real world problems
  - Fundamental limitations on the basic structures being used to generate intelligent behaviour → Limitations of existing neural network methods identified
- AI failed to convince the funding agencies as the expectations were not matched

Brief History of AI: Knowledge Based Systems (1969-1979)

- Problem Solving in prior period was based on weak methods → those try to string together the elementary reasoning steps to find complete solutions from a general purpose context
- Alternative was suggested → domain specific knowledge that allows larger reasoning steps and can be easily used to handle typically occurring cases of narrow area of expertise
- Development of knowledge based Systems
- Buchanan et al. (1969) – The DENDRAL Program that solve the problem of inferring molecular structure from the information provided by mass spectrometer

Brief History of AI: Knowledge Based Systems (1969-1979)

- Heuristic Programming Project to identify where could Expert Systems be used
- MYCIN Program → used 450 rules to diagnose blood infections
  - Performed better than junior doctors
- Roger Schank and his students developed a series of programs related to AI and Linguistics
- Development of Successful Rule based Expert Systems
- Minsky (1975) developed idea of frames → that adopted structured approach to assemble facts about particular object and event types and arrange them into a large taxonomy hierarchy analogous to a biological taxonomy

Brief History of AI: AI as an Industry (1980-Present)

- R1 (1986) → first successful commercial expert system by DEC
  - Helps to configure orders for new computers
  - Saved $40 million for DEC
- DEC (1988), developed 40 Expert Systems
- Du Pont, 100 in use and 500 in pipeline
- 1981, Japan announced "Fifth Generation" Computers which were intelligent and US based company MCC also announced similar computer → Could not came to reality
- AI Winter in the future due to unrealistic promises that were not delivered

Brief History of AI: Return of Neural Networks (1986-Present)

- Neural networks return to popularity
- Major advances in machine learning algorithms and applications
- Reinvention of back-propagation learning algorithm in mid 1980s
  - Concept of Parallel Distributed Processing
- Connectionist models of intelligent systems were seen which focused on unjustifiability of symbolic manipulation in decision making

Brief History of AI: AI as a Science (1987-Present)

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- AI focuses on scientific study
- Integration of learning, reasoning, knowledge representation in AI
- AI methods used in vision, language, data mining, etc.
- Bayesian networks as a knowledge representation framework
- Hidden Markov Models based on mathematical theory and training theories
- Emergence of Intelligent Agents

Brief History of AI: Success Stories

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- Deep Blue defeated the reigning world chess champion Garry Kasparov in 1997
- AI program proved a mathematical conjecture (Robbins conjecture) unsolved for decades
- During the 1991 Gulf War, US forces deployed an AI logistics planning and scheduling program that involved up to 50,000 vehicles, cargo, and people
- NASA's on-board autonomous planning program controlled the scheduling of operations for a spacecraft
- Proverb solves crossword puzzles better than most humans
- Robot driving: DARPA grand challenge 2003-2007
- 2006: face recognition software available in consumer cameras

Applications of AI

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- Autonomous Planning and Scheduling
- Game Playing
- Autonomous Control
- Diagnosis
- Logistics Planning
- Robotics
- Language understanding and Problem Solving

Importance of AI

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- Create a never-ending thought process and collective that could solve our problems
- Thinking of every possible solution
- With artificial intelligence, we could build computers, upon thousands of computers, that could all work in unison to solve our great and most dire problems

Definition of Knowledge and Learning

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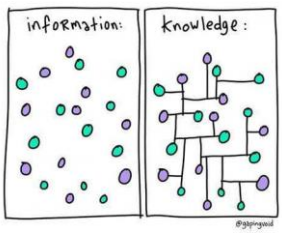
- Knowledge is the justified true belief
  - Data → Information → Knowledge
- **Learning** is the process of acquiring new or modifying and reinforcing the existing knowledge, behaviours, skills, or values through the synthesis and manipulation of information
- Machine Learning → embedding the learning ability into the machine or computers



Importance of Knowledge and Learning

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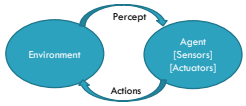
- For Understanding the Environment
- For Updating the Knowledge base
- For Problem Solving
- For Decision Making
- For Building Intelligent Systems

Black-Box Model of Agent

- An agent is anything that can be viewed as perceiving its environment through sensors and acting upon that environment through actuators.

Agent	Human	Machine
Sensors	Eyes, ears, other organs	Cameras, IR finder
Actuators	Hands, legs mouth, other body parts	Various motors for actuators



Agent = architecture + programme

Agent

- Rational Agent
  - Striving to do the right thing based on what it perceive and the action it can perform
  - Performance Measure: An objective Criterion for success of an agent's behaviour.

Ex: Vacuum Cleaner : - amount of dirt cleaned, amount of time consumed, amount of electricity consumed, amount of noise generated, etc.

Intelligent Agent : Self Driving Car:

PEAS(Performance, Environment, Actuator, Sensors)

P: Safe, Fast, Legal, comfortable trip, maximize profit

E: Road, Other Traffics, Pedestrians, Customers

A: Steering Wheels, accelerator, brake, signal, horn

S: Cameras, Sonar, Speedometer, GPS, Odometer, Engine sensors, keyboard

Agent

Types of Environment

- **Fully observable (vs. partially observable):** An agent's sensors give it access to the complete state of the environment at each point in time.
- **Deterministic (vs. stochastic):** The next state of the environment is completely determined by the current state and the action executed by the agent. (If the environment is deterministic except for the actions of other agents, then the environment is strategic)
- **Episodic (vs. sequential):** The agent's experience is divided into atomic "episodes" (each episode consists of the agent perceiving and then performing a single action), and the choice of action in each episode depends only on the episode itself.
- **Static (vs. dynamic):** The environment is unchanged while an agent is deliberating. (The environment is semi-dynamic if the environment itself does not change with the passage of time but the agent's performance score does)
- **Discrete (vs. continuous):** A limited number of distinct, clearly defined percepts and actions.
- **Single agent (vs. multi-agent):** An agent operating by itself in an environment.

Task Environment	Observable	Agents	Deterministic	Episodic	Static	Discrete
Crossword puzzle	Fully	Single	Deterministic	Sequential	Static	Discrete
Chess with a clock	Fully	Multi	Deterministic	Sequential	Semi	Discrete
Poker	Partially	Multi	Stochastic	Sequential	Static	Discrete
Backgammon	Fully	Multi	Stochastic	Sequential	Static	Discrete
Taxi driving	Partially	Multi	Stochastic	Sequential	Dynamic	Continuous
Medical diagnosis	Partially	Single	Stochastic	Sequential	Dynamic	Continuous
Image analysis	Fully	Single	Deterministic	Episodic	Semi	Continuous
Part-picking robot	Partially	Single	Stochastic	Episodic	Dynamic	Continuous
Refinery controller	Partially	Single	Stochastic	Sequential	Dynamic	Continuous
Interactive English tutor	Partially	Multi	Stochastic	Sequential	Dynamic	Discrete

- **Agent Programme:** Takes the current percept as input from the sensors and return an action to the actuators.

```
function TABLE-DRIVEN-AGENT(percept) returns an action
  persistent: percepts, a sequence, initially empty
              table, a table of actions, indexed by percept sequences, initially fully specified

  append percept to the end of percepts
  action ← LOOKUP(percepts, table)
  return action
```

The TABLE-DRIVEN-AGENT program is invoked for each new percept and returns an action each time. It retains the complete percept sequence in memory

Agent

Four basic types in order of increasing generality:

- Simple reflex agents
- Model-based reflex agents
- Goal-based agents
- Utility-based agents
- Learning Agent (on your own)

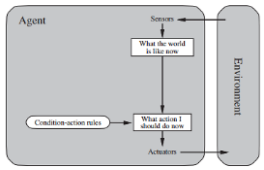
Agents: Simple Reflex Agent

These agents select actions on the basis of the *current* percept, ignoring the rest of the percept history

Ex: Vacuum Cleaner : its decision is based only on the current location and on whether that location contains dirt

```
function REFLEX-VACUUM-AGENT([location,status]) returns an action
  if status = Dirty then return Suck
  else if location = A then return Right
  else if location = B then return Left
```

Agent: Simple Reflex Agent



condition–action-rule

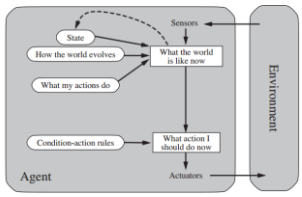
if *car-in-front-is-braking* **then** *initiate-braking*

Limited intelligence

Agent: Model Based Agent

- The most effective way to handle partial observability is for the agent to *keep track of the part of the world it can't see now*. By maintaining Internal State
- how the world works:???

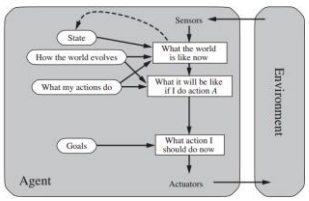
Agents: Model Based Agent



Agent: Goal Based Agent

- Knowing something about the current state of the environment is not always enough to decide what to do. For example, at a road junction, the taxi can turn left, turn right, or go straight on.
- The agent needs some sort of **goal** information that describes situations that are desirable

Agents: Goal Based Agent



It keeps track of the world state as well as a set of goals it is trying to achieve, and chooses an action that will (eventually) lead to the achievement of its goals.

Searching and Planning is mandatory

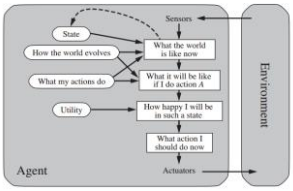
"What will happen if I do such-and-such?" and "Will that make me happy?

Agents: Utility Based Agent

- Goals alone are not enough to generate high-quality behavior in most environments. For example, many action sequences will get the taxi to its destination (thereby achieving the goal) but some are quicker, safer, more reliable, or cheaper than others.
- Goal Achieved or not????

Happy or Unhappy

Agent: Utility Based Agents



It uses a model of the world, along with a utility function that measures its preferences among states of the world. Then it chooses the action that leads to the best expected utility, where expected utility is computed by averaging over all possible outcome states, weighted by the probability of the outcome

Agents: Learning Agents

- On your own…

References

- Russell, S. and Norvig, P., 2011, Artificial Intelligence: A Modern Approach, Pearson, India.
- Rich, E. and Knight, K., 2004, Artificial Intelligence, Tata McGraw hill, India.

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Thank You

Any Queries?

One Day Machine will be Intelligent. What about Man?