CM 3311 - Artificial Intelligence

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Structure of the Lecture series

- Topic 1 - Foundation of AI (6 hrs)
- Topic 2 – Search (6 hrs)
- Topic 3 - Knowledge Representation (6 hrs)
- Topic 4 – Major areas of AI (4 hrs) – in Topic 1

Reference

- Russell and Norvig (2020), Artificial Intelligence – a Modern Approach, 4th Edition

Topic 1 – Foundation of AI

Foundation of AI

- Introduction
- Nature of Knowledge
- Intelligent machine – a dream or reality?
- Influential areas for AI
- Major Areas of AI
- Turing Test*
- John Searle's argument*
- Four Schools of thought*
- History (study of change) of AI *
- State of the art
- Agent Technology*

Introduction - General

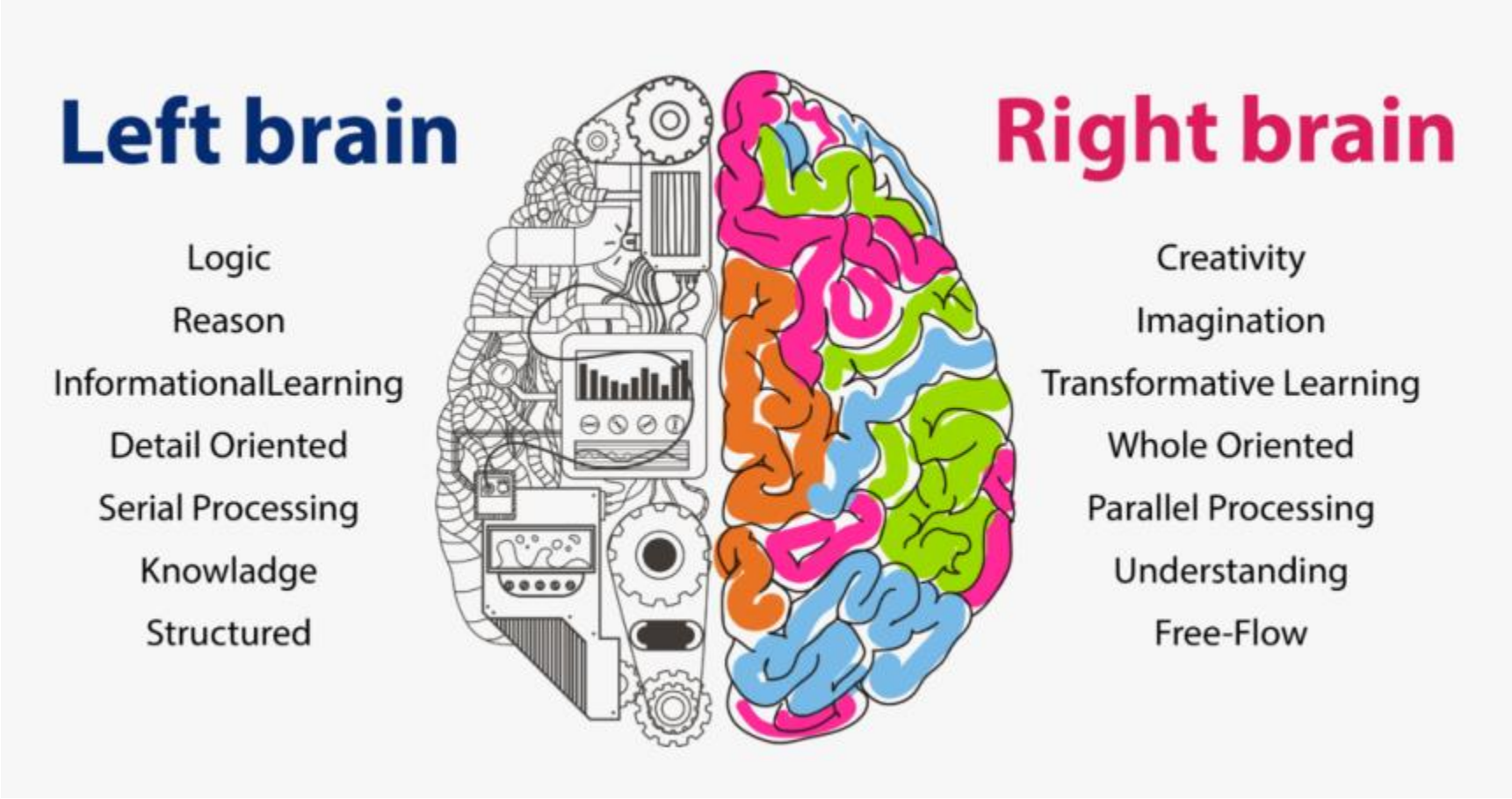
- We are in an era of Intelligent Machines (1950s) බුද්ධිමය යන්ත්‍ර
- Here we model Natural Intelligence into machines
  - understand intelligence and build intelligent machines
- The area of Intelligent Machines is named as
  - Artificial Intelligence (AI) - බුද්ධිමය යාන්ත්‍ර විද්‍යාව (කෘතිම බුද්ධිය)
- AI is Science and Engineering to build intelligent machines
- AI has gone into all sectors of the society
- Nowadays people cannot live without AI
- AI has changed the way people work and live
  - Office, University, Home, market, roads, ……
- AI is the fuel for the 4th industrial revolution
  - 1st steam, 2nd Electricity (current), 3rd Electronics (logic gates), 4th AI algorithms
  - In the modern world, many problems can be solved by programing
- AI has revolutionized academia and industry

Replace, repaired, program

Introduction - Academic

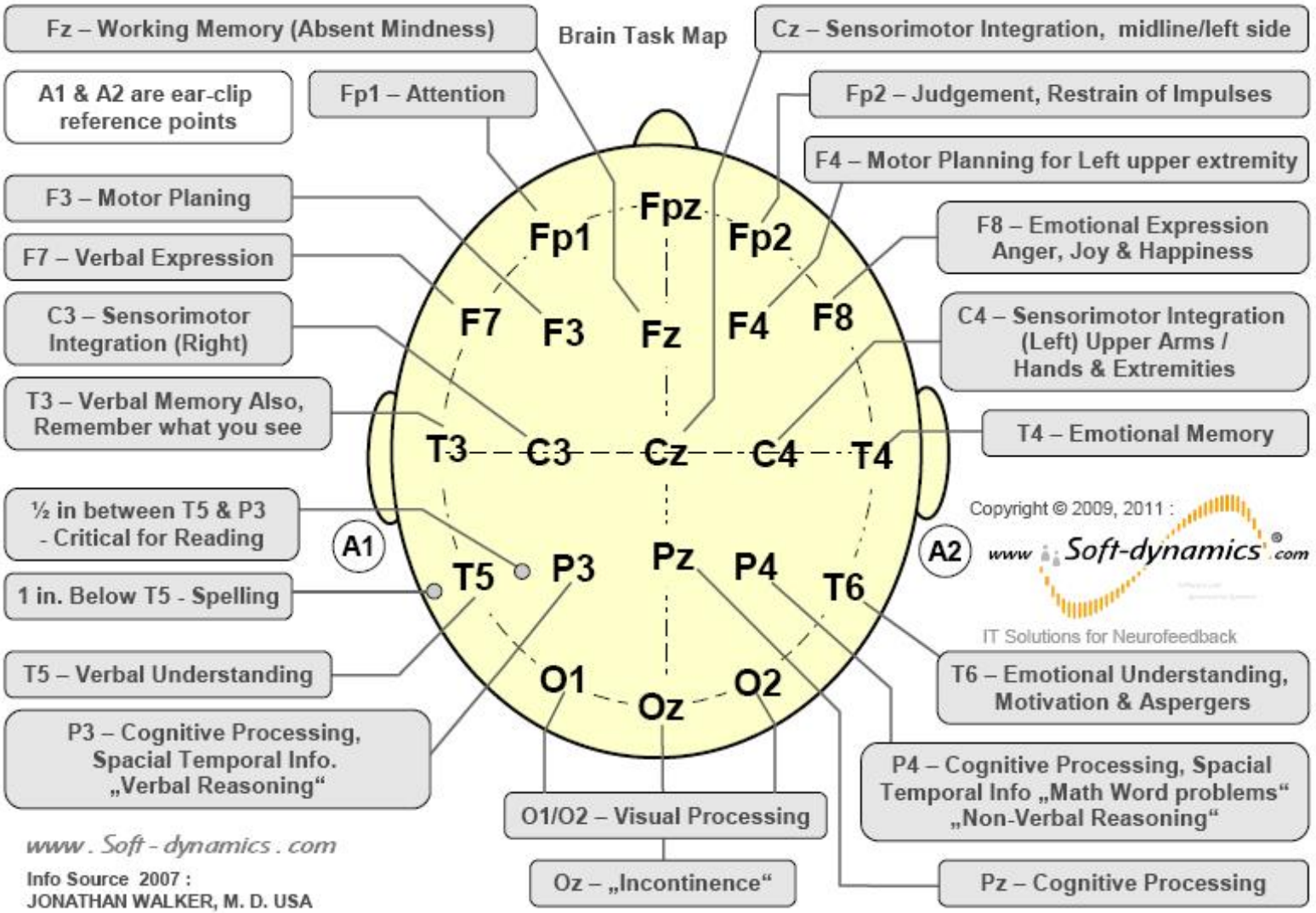
- AI solves problems that could not be solved otherwise
  - Any problem solved by human/animal can also be solved by AI
- Problem-solving needs *Knowledge* and/or *Data*
- AI can model both knowledge and data
- Neuroscience provides a strong basis for AI
  - Logical/analytical-based intelligence (symbolic AI)- Artificial Cognitiv Systems (ACS)
  - Training-based intelligence (non-symbolic AI) – Machine Learning (M
- In 1950s, AI began as modules in Computer Science and evolved as a Bachelor's degrees in AI
- Degree in AI degree encompasses
  - Artificial Intelligence, Computer Science, Mathematics, Statistics

Neuroscience of Intelligence



Two forms of intelligence – analytical/logical-based intelligence, training-based intelligence

Brain Task Map



Introduction - Industry

- Industry is interested in AI due to many reasons
  - AI can give more one solution for problem
  - AI can give level of assurance of a solution
  - AI gives evolvable solution – over time accuracy and efficiency are improved
  - AI can extend the classical solutions (DB, ERP, MIS)
  - AI can make existing solutions intelligent
  - AI gives explanations for solutions
  - AI solutions are cheaper
- AI can give solution for these needs

Introduction - Enthusiasm for AI

- Many intelligent programs have given popularity for the field of AI
  - XCON (1984) – used to configure mini-computers (ACS)
  - DART (1991) – Expert s system execute entire Gulf-war (ACS)
  - Pathfinder (1997) – Rover explores unknown environment (ACS)
  - IBM Deep Blue (1996) – Defeated grandmaster of chess (ACS)
  - Watson (2011) – Answering any question (ACS + ML)
  - AlphaGo (2015) – demonstrated power of training over rules (ML)
  - Self-driving cars (2009) – autonomy in technology (ML)
  - Tesla (2015) – self-driving cars/trucks (ML)
  - Sophia (2016) – Citizenship in Saudi Arabia (ACS+ML)
  - Amazon Alexa – work as a hub for controlling device at home
  - Google Assistant – Answer any question (ML)
  - Neurlink – Chip implanted in the brain
  - ChatGPT – LLM (large language model) – Energetic Idiot
- Future of AI – the gap between man and machine will be reduced

Exercise

- Discuss why AI is different from other technologies, and its major implications.
  - Any technology involves power and control
  - Generally, for all technologies (electricity, vehicles, nuclear power) power is with technology but control is with human
  - But in AI both power and control are built together
- Positive implication - AI can make its own decisions and produce autonomous machines (UAVs, Self-driving cars….)
- Negative implication - Machines may supersede mankind (singularity)

Discussion

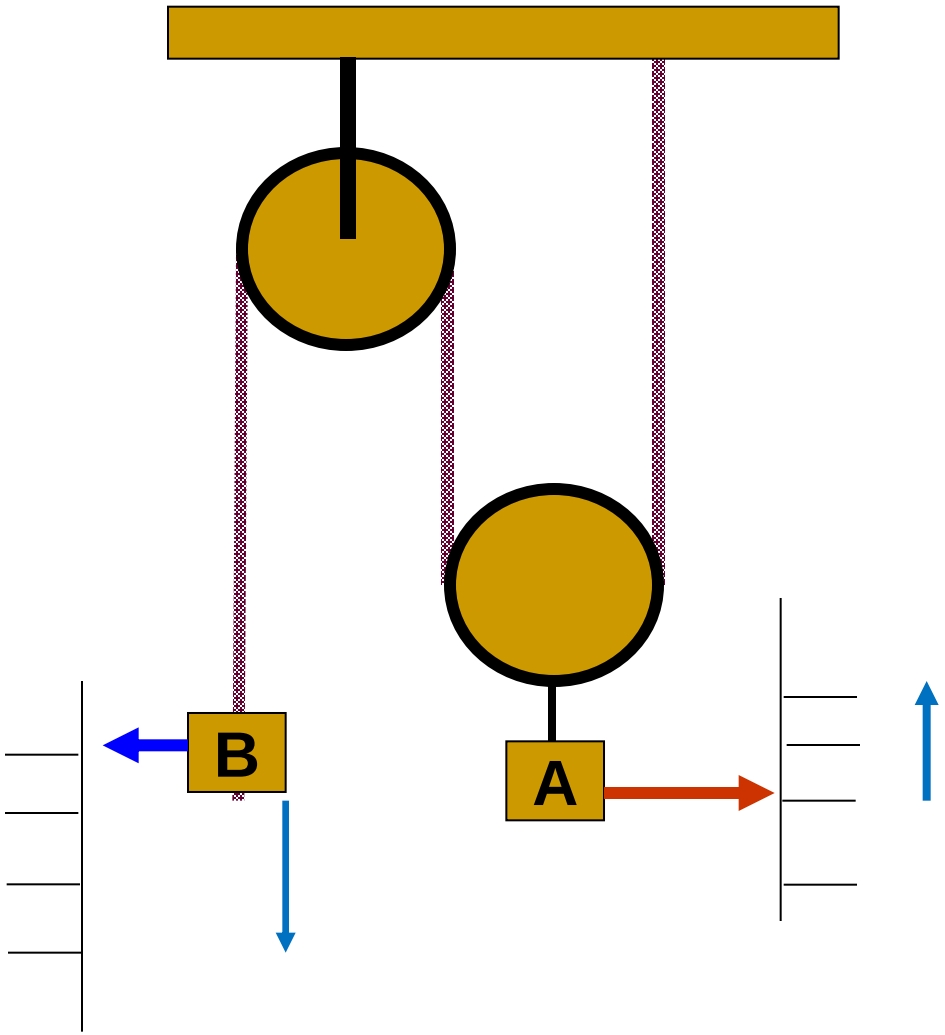
- At present AI have achieved beyond our expectation
  - People made the machine more and more intelligent
  - But we forget to increase intelligent capacity of humans
- People should develop AI solution to increase intelligence (thinking, memory, creativity,) of humans
- See the analogy below
  - Vehicle/Machines/elevators → physical fitness went down
  - People develop machines to improve physical fitness
- We know that doctors say that - If you do not exercise for 30 min every day you will have a heart attack
- Similarly, doctors will also If you do not solve 10 arithmetic problems involving +, *, -, / your lose your math skills

Nature of Knowledge

- Science – Evidence based decisions on experiments
  know-why (can explain)
- Mathematics –measurements, calculations, patterns
- -3*-2 = -6, 98% -3*-2 = 6, 2%
- Engineering – building artifacts with/without science
- Technology – know-how (even without a science), one science contribute to technology for centuries (F=ma, V=IR)
- Formal knowledge – theories/models (S, M, E, T) – left brain
- Informal knowledge – (beliefs, experiences,…)- right brain
- Where is AI? – informal(non-algorithmic)+ formal(algorithmic)
- If people (nature) can do something, so does AI

AI Dream or reality?

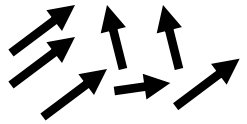
- Discovery of artifacts by mankind
  - Early days to make physical activities easy
  - various tools, wheels, etc.
- Artifact to Make Intellectual activities easy is a quite natural interest
- Ruler, calculator are some examples
- Simple machine using pulley and strings
- Video – Familiarizing with machine intelligence



Simple machine to multiply by 2

Exercise 1

- Identify Intelligence features that are already built into machines.
  - Navigation
  - Grasping
  - Natural Language understanding
  - Vision
  - Hearing
  - Image recognition
  - Remembering
  - …….



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10/09/2024

- Now we have machines with biological brains (Rat Brains demo)
- We also have brains with machines (AI Chip)
  - Neuralink
- We are heading to an era where we experience man-machine coexistence

Foundation of AI – Influential areas

- Intelligence is topic of many areas
- Philosophy (428BC) – talks of change/way of thinking, mind/matter, life/death, intelligence/knowledge, real/simulation, machine/human,
- Mathematics and Statistics (800) – Formalizing (using symbols, F-ma), Reasoning: Turing, McCarthy, Minsky, Babbage, George Boole, Add Lovelace
- Economics (1776-)- Effective use of resources/profit
- Neuroscience (1861-) – help to identify two major forms of intelligence
- Psychology (1887-) – behavior of the brain (Metal health –ELIZA, 1964
- Computer Science – to program intelligence (algorithms, data structures, programming-Turing, compilers)
- Computer engineering (1940-) – build the machine to run programs
- Control theory and Cybernetics (1984-) – controlling(Robots)/networking
- Linguistics (1957-) – Theory of languages, NLP
- Education, Physics, Biology, Medicine – the model of intelligence
- Engineering (Mechanical/Electrical/Electronics) - design of artifacts

Exercises

- Identify, which philosophical concepts are relevant to AI
  - Think, intelligence, machine, human, knowledge, simulations
- Discusses the influence of Computer Science and Computer Engineering for AI
  - to program intelligence
  - machine to run the program
  - As a result, AI has become a Software exercise)

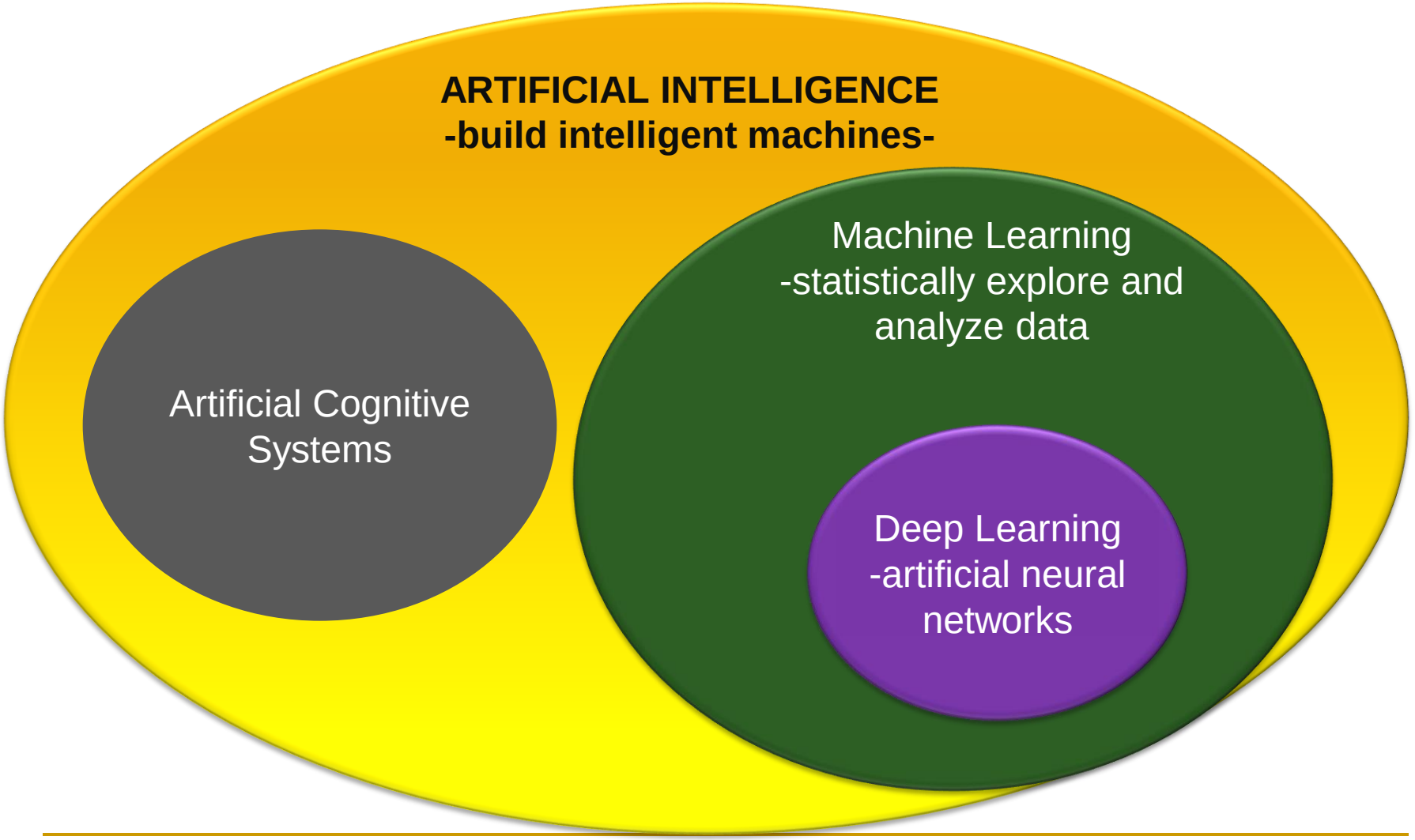
Exercise ..

- Discuss some contributions from AI back to CS
  - ANN → Parallel computing
  - MAS → Distributed computing
- What is the area which has influenced the field of Machine Learning
  - ML implements the intelligent feature of learning which come under education

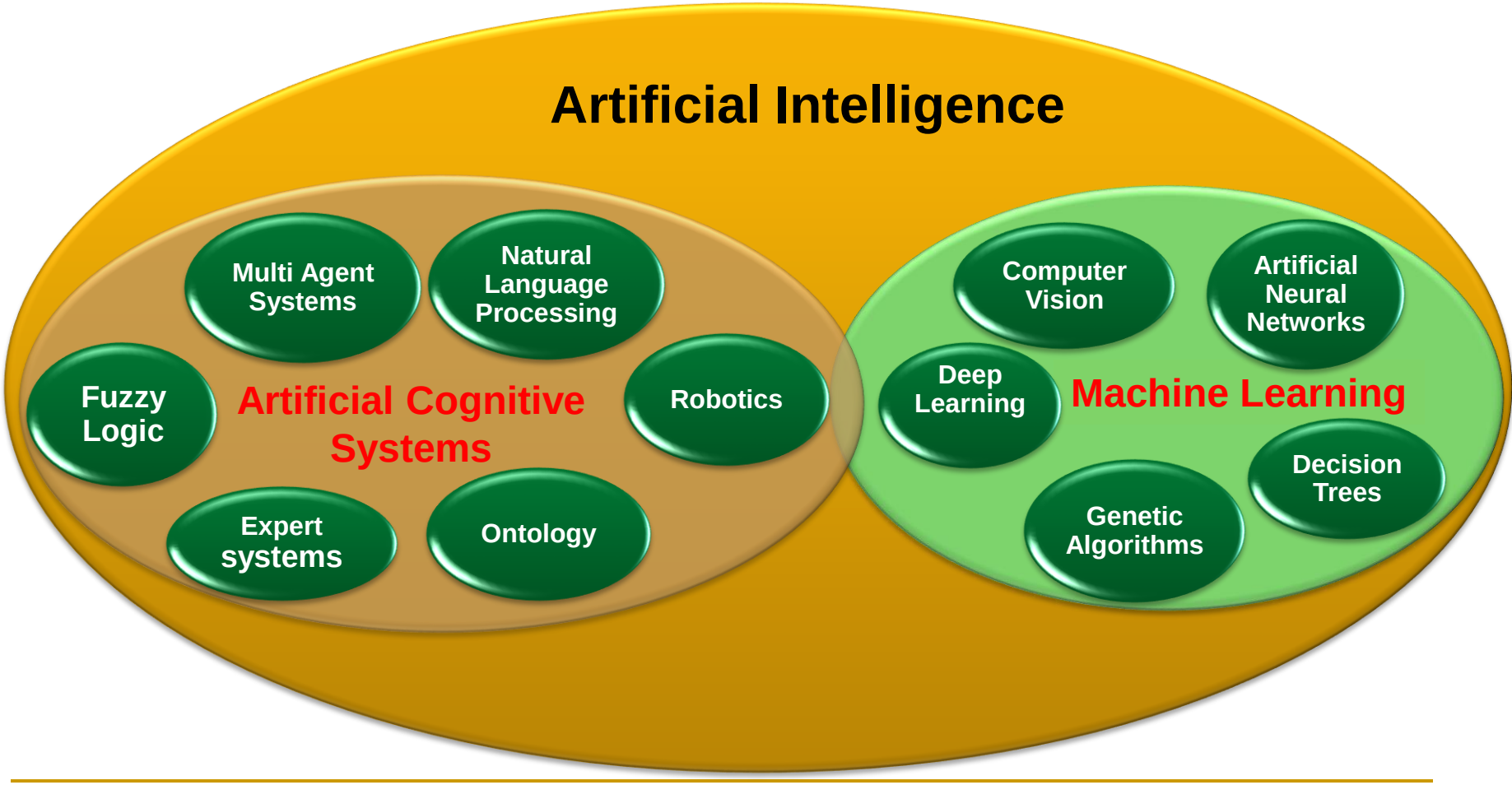
Major Areas of AI

- All AI technologies can be classified under two broad areas: symbolic-AI, non-symbolic AI
- Artificial Cognitive systems (symbolic-AI) – Knowledge, theory, rules, logic, algorithmic, procedures,
  - Expert Systems
  - Natural Language processing
  - Multi Agents Systems
  - Game playing
  - Fuzzy Logic
  - Ontology …….
- Machine Learning (Non-symbolic AI) – Data, experience, non-algorithmic, commonsense,
  - Artificial Neural Networks (CNN, RNN, RL)
  - Genetic Algorithms
  - Robotics
  - Computer Vision

AI, Machine Learning, Deep Learning



Major Areas of AI



Exercise

- Discuss why Natural Language Processing, Robotics, and Game Playing can be considered under both ACS and ML.
  - Language processing can be done by knowing grammar/theories as well by practice

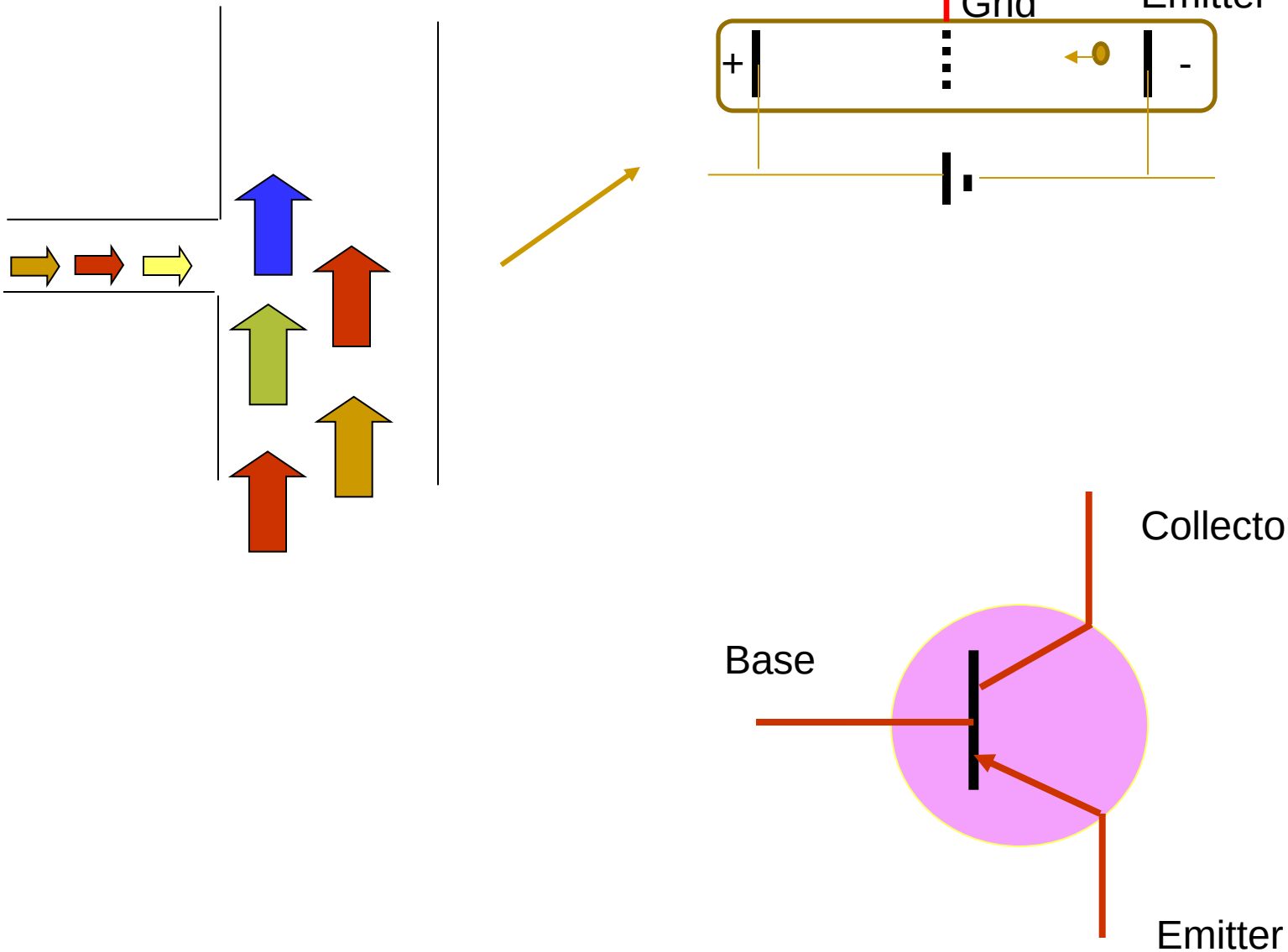
Inspiration for the development of Artifacts

Nature

Artifact


SriLankan

Learn by knowing theories
practicing


+/-
Collector
Grid
Emitter
+
-
Collector
Base
Emitter

Expert Systems

- Fault diagnosis in circuits
- Travel advisory systems
- Student counselling
- Legal advisory systems

Domain specific knowledge

Problem solving knowledge

- A model of problem-solving by human experts
- Why do two doctors in the same field give different diagnoses?
- ES is the champion of ACS which uses rules Logic, algorithms, etc. This does not mean experts do not have training-based knowledge

Get the insight into how a medical doctor (expert) examining a patient

- Doctor dominates asking questions
- Provide solutions
- Give explanations for solutions
- Give alternative solution
- Know the certainty of solutions
- Can handle incomplete information by
  - asking question, assume, ignore

Evolution

Reptiles (breathing, blood circulation, food digestion)
Mammals (hangry, react, ……)
Humans (think)

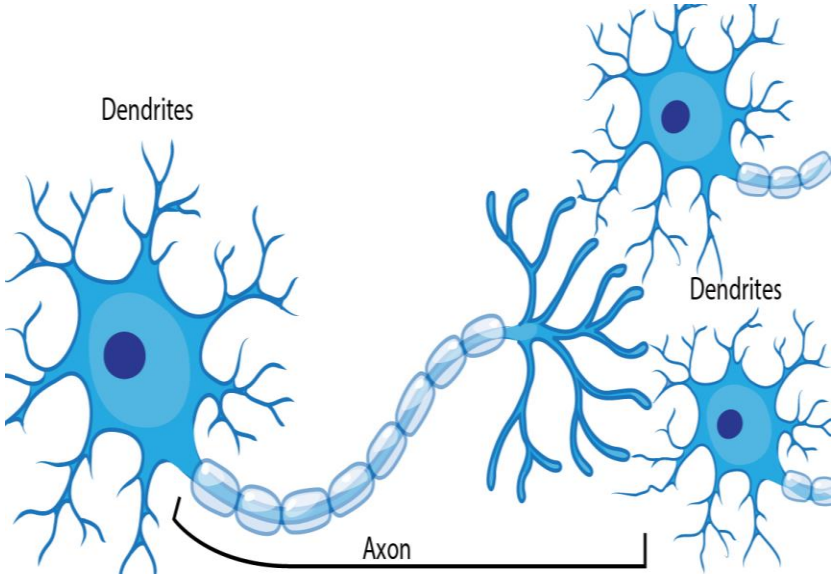
Intelligence – Thinking

Education is not for flooding the students' minds with facts, but training the minds to think

Any problem is a matter of not being able to think

New knowledge + Past knowledge +Thinking → Understanding

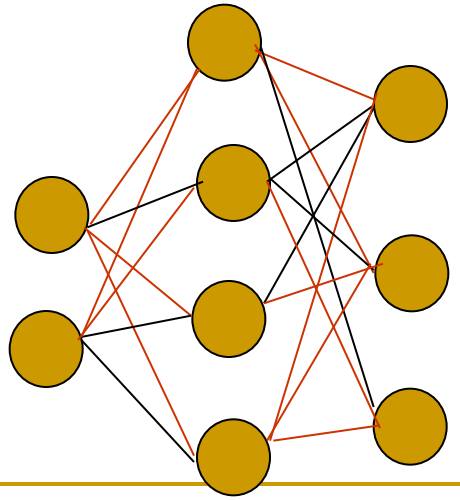
Thinking again and again → create memories

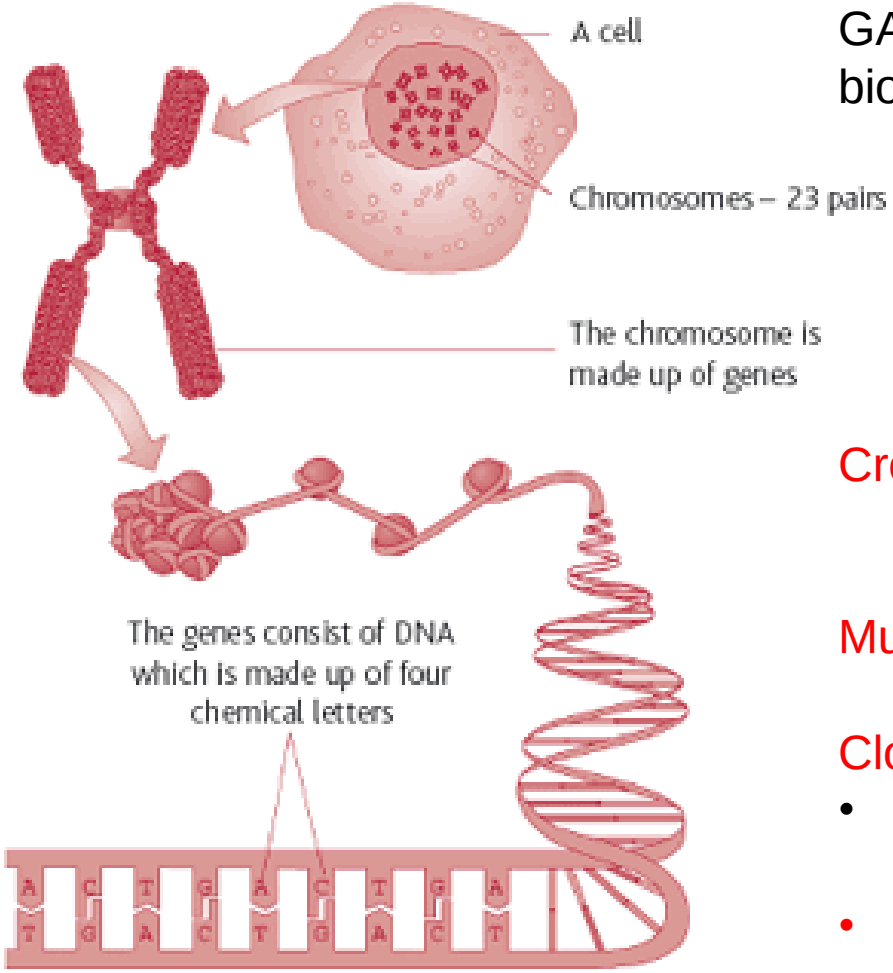


- ANN implement learning feature of right brain
- ANN can Learn from non-algorithmic data with noisy, incomplete, partial data (handwriting, distorted images, unclear images
- Signature recognition, Weather forecasting, self-driving vehicles, face recognition, gaming
- When ANN is trained for a certain purpose, it cannot be used for another purpose
- ANN is the champion of ML
- Limitations – ANN cannot explain solutions, requiring large amounts of data require regular training

Artificial Neural Networks

- Model of the human brain with neurons (100billion)





Genetic Algorithm

GA a model of Chromosome and genes in biological systems

Bread	Dhal	Tea	f=250
Rice	Fish	Milk	f= 350
Shoppers	Sambol	coffee	f= 300

Cross-over

Bread and Rice swap get two new menu (solutions with similar features)

Mutation Fish invert as Chicken giving new menu

Rice Chicken Milk

Cloning copying all the time

- Mutation followed by cross-over generate solutions that accommodate a change
- A fitness function is used to evaluate a chromosome
- After generation chromosome with the highest frequency determine the solution
- GA can start with no data, but random values for genes subject to satisfying fitness function

Machine with human/animal like appearance
Using Legs you can travel anywhere

Initially, Robotics came under the ACS
Nowadays, they can also be developed as ML
Boston dynamics

Robotics

A model of problem-solving by teamwork

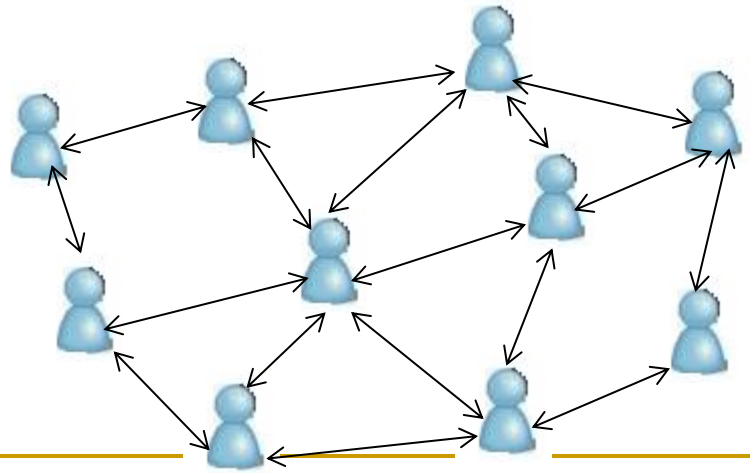
- This is shown in ant, fish, bats colonies, etc.
- Problem-solving by message passing rather than algorithms

Buying pair of shoes – search on the internet

F1 – Bata, F2-DSI,F3 – DSI cheep,
F2 – DSI durable, F1-Bata on sales,
F4 – Bata at Ratmalana,

- Better quality solutions in shorter time due to views of many members
- Any problem (without data/knowledge) can be solved by MAS technology
  - Because whenever we cannot solve a problem (covid) we form a group, initiate discussions to get a solution.

MAS can be developed as a rule-based ACS



Multi Agent Systems

Fuzzy Logic

- World is full of situations where a conclusion does not fall into one end but a set of acceptable values in between
  - Thermostat: when 18C is required, the AC accepts 17.7 to 18.4
  - Automatic focusing: object is at 4m, camera accepts 3.9 or 4.2
  - Washing machine: 5kg selected, work for weights between 4.8 to 5.5
  - Salt into a curry: 5ml required, can accept
- FL can be primarily implemented as ACS solutions
- Nowadays, there are also ML-based FL solutions

Natural Language Processing

- NLP models the intelligent feature of communication
- Languages are the devices for communication
- Humanity has become more intelligent than other species due to communication using symbolic languages
- It includes
  - Understanding
  - Dealing with incomplete/noisy sentences
  - Translation among languages such as
  - Generating/synthesizing answer
  - There are 10 balls in box A and 12 balls in box B. Saman has taken 3 balls from A and kept two with him; the remainder is added to A. Find how many balls are now in A.
- Such NLP systems can be implemented as ACS and ML solutions (ChatGPT)

Exercise

- Explain why NLP could be implemented as ACS (left) and ML (right) solutions
  - Because humans can use rules/grammar manifested in the left brain and/or right brain to train language skills
- What are other areas in AI that have been developed as ACS and ML solutions?

Gamming

- Gaming is an intelligent activity requiring thinking or training
  - It includes perceiving many options at a given state and deciding the best option
- This can be done by knowing rules (ACS), or having training (ML)
- ACS (Deep Blue) and ML (AlphaGo)
- First time in history, a machine (Deep Blue) defeated a human expert

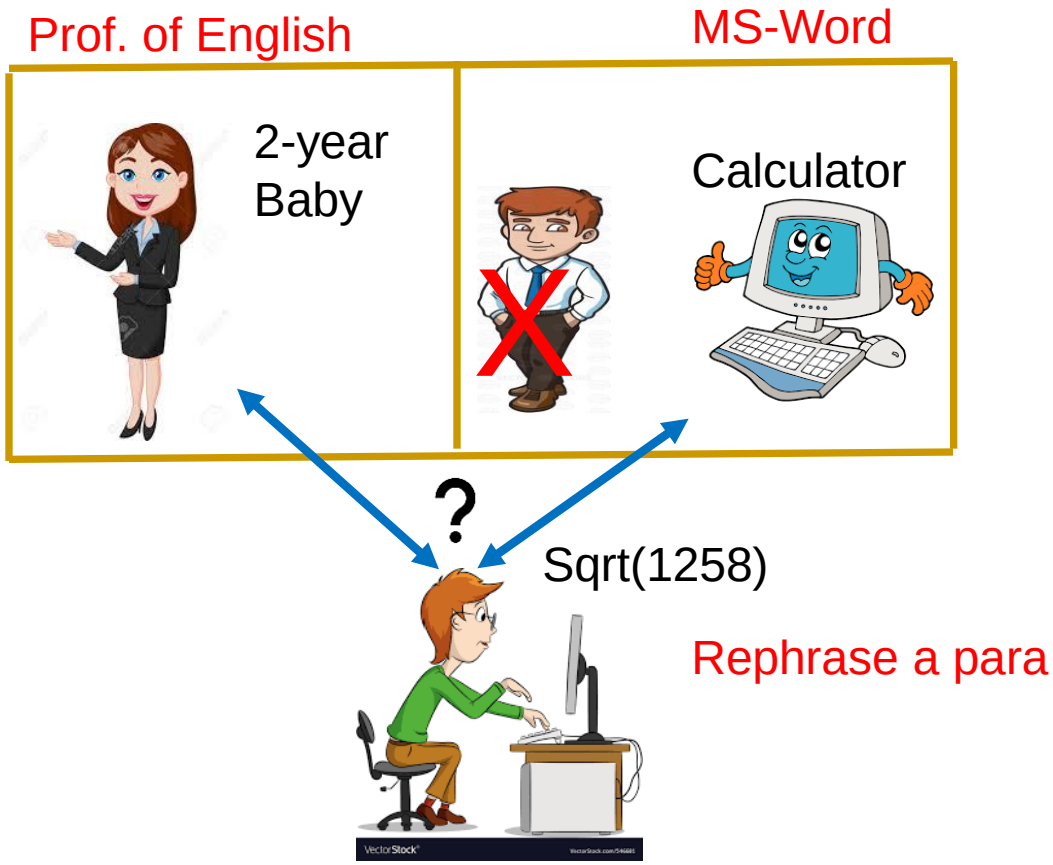
Homework

- Identify
  - major universities in the world, which lead the field of AI
  - major universities offering BSc Hons in AI
  - major AI companies in the world
- Compile a 20 min video on developments in AI

Turing Test

- At this point, it is required to find a way to determine whether a machine is intelligent
- For this purpose, Turing proposed the Turing Test
- A man and a woman communicate with an interrogator without seeing each other
- Man is replaced with a machine without knowing the interrogator and he continues questioning
- If interrogator cannot notice a difference between answers provided by the woman and the machine, then Woman and Machine are equally intelligent
  - If the machine fools the interrogator, then machine is intelligent

The Turing Test



Implications –Turing Test

Benefits of note-taking
remember
Thinking
Wring in exam
points, speed

- Intelligence is comparative phenomena
- Can be used to prove that a machine is intelligent, or machine is not intelligent
- Based on questions being asked with whom the machine is compared we can prove whether a machine is intelligent or not intelligent

Technological limitations for TT

- Standard TT is limited to keyboard inputs
- We should be able to ask questions based on voice, images, motions, colour, etc.
- Some concerns are
  - Knowledge representation to store knowledge
  - Automated reasoning to store knowledge answer questions and to draw conclusion
  - Machine learning to adapt to new scenarios and to detect and extrapolate patterns
- All these limitations are now addressed in AI programs like: Chatbots, ChatGPT, Watson

Total Turing Test

- New technology required
  - Natural language processing
  - Image processing/motion detection
  - Computer vision
- Loebner Prize
  - The **Loebner Prize** is an annual Turing Test completed for the best AI software
  - Find Loebner prize award-winning AI programs 2024, 2023, 2022?

Exercise

- To claim a program to be intelligent, should it pass the TT?
  - Any program implementing intelligent features like learning, problem-solving, etc. is intelligent. However, passing the TT is an additional qualification. Before 1992, many intelligence programs were there, …
- Can a calculator be considered an intelligent machine? Justify your answer (TT).
  - Yes –
  - No - .
- Can you consider Abacus as an intelligent machine?
  - No, because it cannot do calculation on its own, but ……
- Do you consider a computer as an intelligent machine?

Exercise

- Prove that auto-gear cars are intelligent
  - At the correct speed change the gear, which is done by a human when driving

Homework

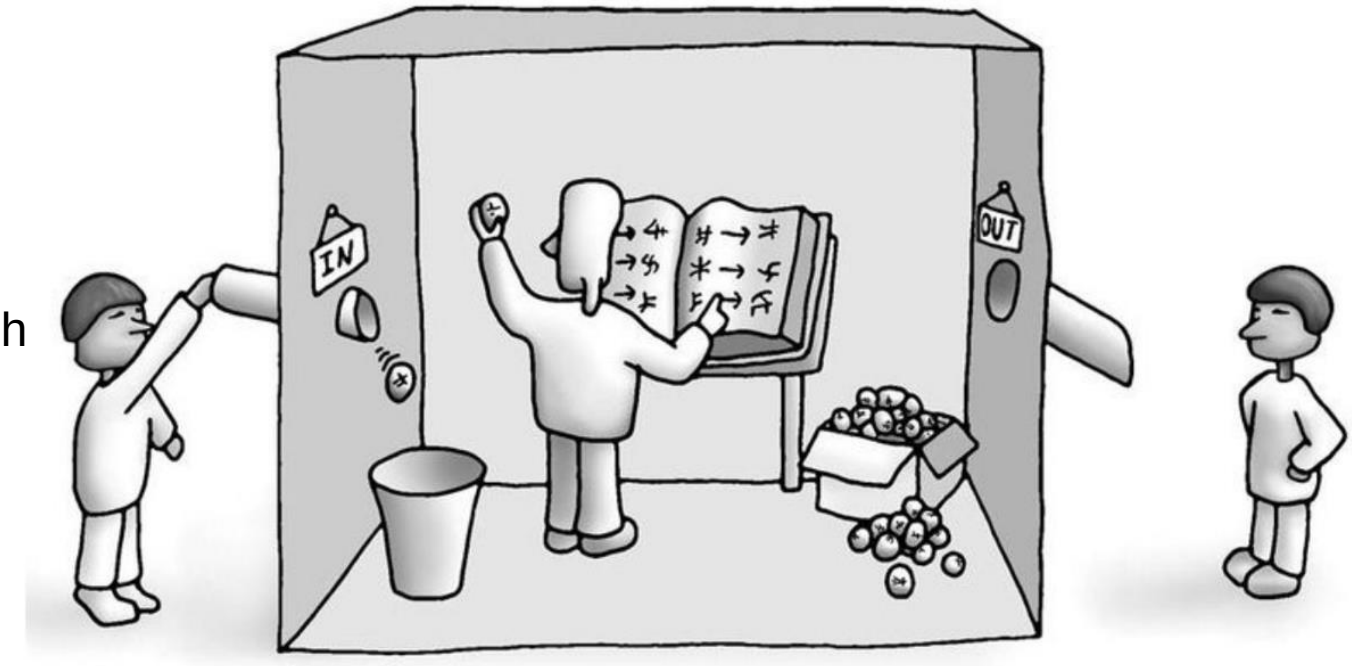
- Do Internet search about **Loebner Prize** annual Turing Test completion
- Identify name of the programs which have won the **Loebner Prize** during last five years.

John Searle's argument

- John Searles argues that we are intelligent only if we are aware (conscious) of what we do. Based on that Searle argues machines are not aware of what they do, therefore machines are not intelligent.
- A person who knows neither English nor Chinese is kept in a room with a huge book containing the Chinese translation for any given English phrase, in adjacent pages
- Yet a person can find the correct translation just by manipulating symbols, without being aware of what the symbols mean
- John Searles says that the person who does translation is not intelligent, because he just do the symbolic manipulation, without knowing (consciousness) what the symbols mean.
- ~~Computers also doe symbolic manipulation, without being~~ conscious, therefore computers cannot be intelligent

John Searle's Argument .....

English



Chinese

Implications – Chinese room argument

- Machine can never be intelligent; therefore, the field of AI is impossible.
- Note that we are also not aware all what we do
  - So humans are also not intelligent at least some time.
- Can aircraft fly? Yes, Can submarines swim? No. They are matter of words.
- Searle (Intelligent machines cannot be developed) and Turing have two different views on intelligent machines.

- Which of TT or JS arguments has a positive impact on the development of AI?

Four schools of thought

- **Acting humanly**
  - AI attempts to build machines that behave like humans as stated in TT – DART, Deep Blue
- **Thinking humanly**
  - AI attempts to build machines that think like humans
  - Many activities requiring thinking (playing games - Deep Blue, problem-solving/GPS, theorem proving) are already built into machines
- **Thinking Rationally**
  - AI attempts to build logic-based machines, that think logicall
- **Acting rationally**
  - ~~AI attempts to build a machine which can~~ do the right thing
  - Now AI solutions: ChatGPT, Robots,

- Nowadays, intelligence is recognized as not necessarily behaving like a human (monkey?), thinking like a human (have to pay?), thinking logically (damage), but doing the right thing (breaking window).

- Blind woman and boy.

Exercise

- There is a humanoid robot that looks after a baby when parents have gone to work. Identify two instances and actions where you claim that the robot comes under acting rationally.

- A snake is entering to the room –
  - Attend the baby first….

Definition for AI

- The art of creating machines that perform functions that require intelligence when performed by people (Kurzweil, 1990) -AH
- The study of how to make computers do things at which, at the moment, people are better (Rich & Knight, 1991) – AH
- The exciting new effort to make computers think ……machines with minds, in the full and literal sense (Haugeland, 1985) - TH
- Automation of activities that we associate with human thinking, activities such as decision making , problem solving, learning (Bellman, 1978) -TH

Definition for AI….

- The study of mental faculties through the use of computational models (Charniak and McDermott, 1985)
- The study of computations that make it possible to perceive, reason and act (Winston, 1992)
- Computational Intelligence is the study of the design of intelligent agents (Poole et al, 1998)
- AI is concerned with the intelliegt behaviour in artifacts (Nilsson, 1998)

History (how change happens) of AI

- **The Gestation of AI (1943-1955)**
  - After World War 2 lots of enthusiasm to discover knowledge
  - In 1936, Turing presented the idea of computability
  - Turing's paper on Computing Machinery and Intelligence (1950)
  - Turing also built the Bombe machine to attack Enigma (1943)
  - Curiosity about intelligent machines
  - In 1943, McCulloch & Pitts - mathematical model of the human brain (ANN)
  - In 1948 transistor was invented, and the digital computer was born
  - In the 1950s, John McCarthy and Minsky completed their Ph.D. in Mathematics Department at Princeton, in intelligent machines
  - After PhD, McCarthy joined CMU, and Minsky joined MIT

- **The birth of AI (1956)**
  - Dartmouth conference (10 attendees) – proposal for distinct subject areas for intelligent machines by McCarthy (CMU).
  - McCarthy coined the name Artificial Intelligence (AI)
  - AI strives to understand natural intelligence and construct intelligent machines
  - Understanding AI by breaking it into two words as Artificial and Intelligence is wrong
  - To understand feature NaCl, we cannot consider features of Na and Cl.
  - McCarthy joined MIT and had a conflict with Minsky
    - McCarthy - Intelligent is logic-based
    - Minsky - intelligent is anti-logic based as well
  - Most AI initiatives were funded US-defense Ministry under the DARPA
    - Findings were military secrets

- **Early enthusiasm (1952-1969)**
  - Early AI systems were very much algorithmic/rule/logic-based
    - General Problem solver (CMU)
    - Game playing (CMU, IBM)
    - Theorem provers (IBM)
  - In the Early 1960s, Minsky Criticized ANN saying it was useless
  - People gave up ANN research for nearly 25 years
  - Knowing Searching is an intelligent task, the Search is recognized as the 1st approach to modeling intelligence
  - During this period, the understanding of intelligence is minimal. This is true even for today

History of AI….

- **Knowledge Based systems (1969-1979)**
  - People realize knowledge is the main ingredient of intelligence
  - Knowledge is everywhere: learning, books, papers, theories,
  - Modelling knowledge instead of intelligence (Allen Newell, CMU)
  - Then Knowledge modeling becomes the 2nd approach to AI
  - Many knowledge-intensive AI programs were developed
  - Natural Language Processing (NLP) (ELIZA – chatbot by MIT 1964)
    - http://psych.fullerton.edu/mbirnbaum/psych101/Eliza.htm
  - Natural Language understanding - SHRDLU (MIT 1968)
  - Birth of Expert systems: DENDRAL, MYCIN (Stanford, CMU)
  - Minsky (1975) proposed Frames as a method to model knowledge

Homework

- Compile a video by studying chronology of AI

History of AI….

- **AI becomes an industry (1980-present)**
  - XCON (1987) Expert systems by DEC (CMU)
  - XCON could configure a computer in a few minutes with 100% accuracy
  - Because of XCON, DEC earns billions of dollars
  - Return of ANN (1986) with Backpropagation algorithm
  - Turning point in the new area of Machine Learning
  - This period is called AI Winter 1988 (No funding for AI)
  - Nowadays, the Industry is full of AI companies (OpenAI, Google, Apple, IBM, ……)

History of AI…

- **AI becomes a science (1990s-)**
  - For 35 years AI has worked as a non-science
  - So, AI theories could not be proven by experiments
  - During this period AI was pushed forward by constructing intelligent programs using engineering
  - After 1990, AI used the scientific method to develop theories
    - Making hypothesis
    - Setting Experiments
    - Statistical analysis of results
  - Science draws conclusions based large number of experimental evidence
  - When AI becomes a Science, people start to trust AI

History of AI…

- **Emergence of Intelligent Agent (1995-)**
  - Agent is an entity works for a master (Knightriders, File, ….)
  - A new approach to design and build AI software
    - Coding the software as Agents (like objects)
  - Allen Newell (CMU), Laird, Rosenbloom, proposed the first known complete Agent architecture (1987)
  - A new approach to realizing Artificial Intelligence is recognized as building intelligent agents

Exercise

- Discuss why AI took such a long time to win industry recognition and popularity among the public.
  - Initial AI funding was for military weapons/secrets
  - There was no war to test AI-based weapons
  - Since, no results, findings were reduced
  - AI was not a science initially
  - People were
    - afraid of AI since AI builds power and control together into the technology itself.
    - Unaware of AI development due to military intervention
  - How suddenly AI become popular
    - Gulf War, DART

The state of the Art

- Autonomous control: ALVINN (Autonomous Land Vehicle in a Neural Network) computer vision system (by NAVLAB of (CMU) to steer the car to keep it following a lane (1989)
- Autonomous planning and scheduling
  - NASA has developed several remote agent programs for on-board autonomous planning …. (Jonsson, et al 2000)
- Robotic Vehicles (driverless vehicles)
  - First Driverless robotic car STANLEY by CMU (2005)
  - Tesla, Google self-driving

The state of the Art….

- Game playing
  - IBM Deep Blue (1997) defeated the chess grandmaster. As a result, IBM's stock increased by $18 billion.
    - Deep Blue could visualize multiple steps ahead beyond human capacity
    - Note Deep Blue is rule/logic-based
- Logistic Planning Expert System (DART) by DARPA (US Defense Ministry) logistic planning during Gulf War (1992)
  - DART could handle more than 50000 entities of tri-forces, weapons, vehicles, civilians, ambulances, medicine, water,
  - DARPA recovered all investments for AI research for 30 years from this DART expert system

The state of the Art…

- Robotics: Modern day we have robots from the nanoscale, office use, domestic use, to huge spacecraft.

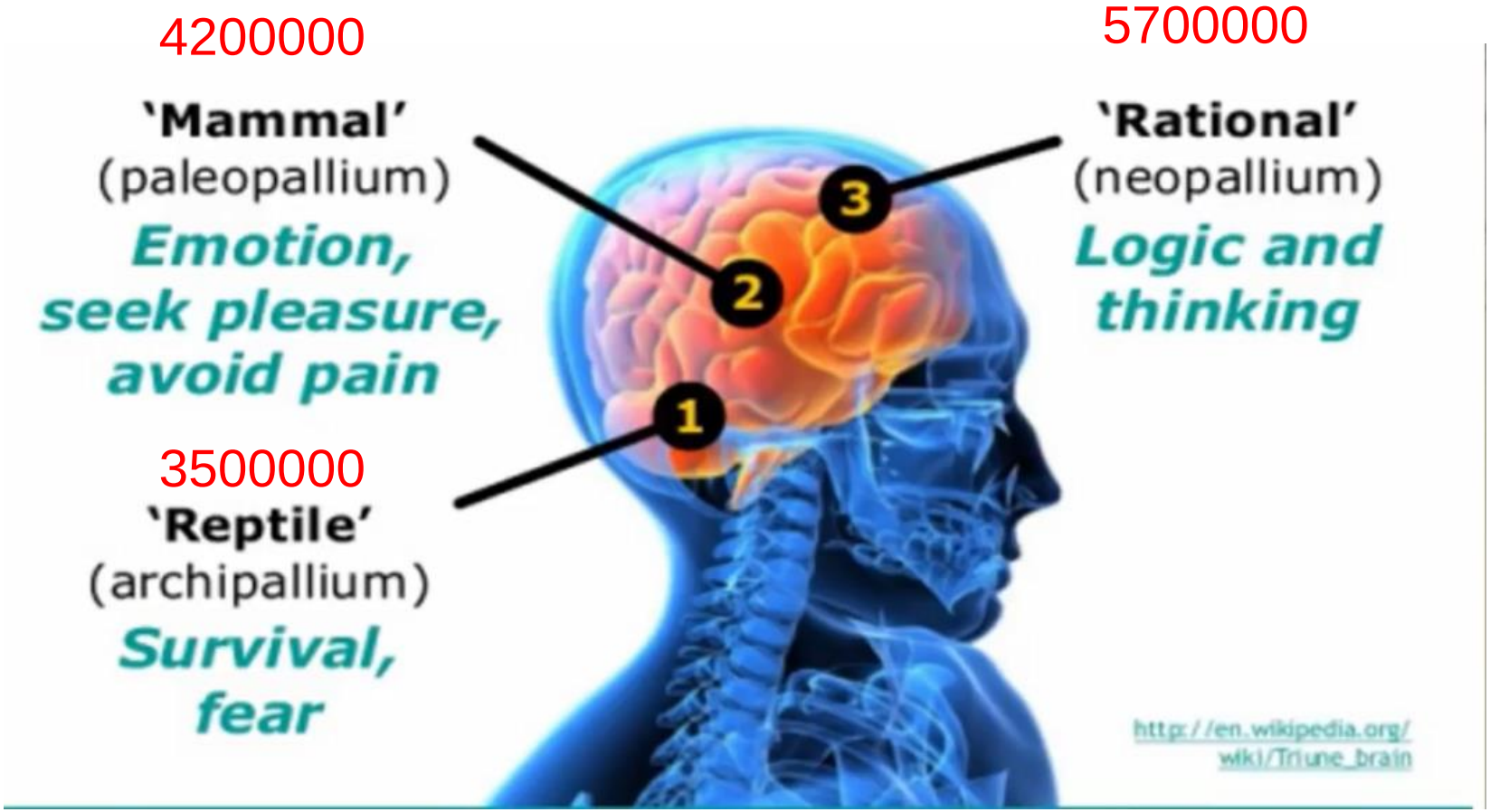
- Language understanding and problem-solving: PROVERB (1999) solves crossword puzzles (better than most humans) using a large database of past puzzles, information sources of dictionaries, online databases, movies, etc.

- **Latest developments:** AlphaGo, Watson, Sophia, ChatGPT, Boston Dynamics

Exercise

- Do an Internet Search and identify AI techniques that are involved in Watson, Sophia, AlphaGo, ChatGPT
- Which Machine Learning or Cognitive Systems have been more influential before 1990?
- Why cognitive system was popular in early AI system
  - Knowledge was identified as the ingredient of intelligence
- Why ML was popular in the recent past?
- Due to the increase of data ……

Evolution of Sri Lankan brain



Emerging Trends in AI

- Agent technology: Agent-based modeling
- Influence of Neuroscience: brain-machine interfacing, EEG technology,
  - man-machine coexistence - iRobot
  - Machine with biological brains – Terminator, Rat brain
  - Brains with AI chips – Neuralink
- Mind uploading
  - Capture EEG when a mind does some tasks, and develop an ANN (digital copy of the brain)
  - Use the ANN to stimulate another brain to activate areas related to the task
- Muscle memory: neurons are in all organs
  - Activating robot arms/legs, etc. by EMG signals

Emerging Trends in AI

- Machines with biological brains - Kevin
- Brains with AI chips – Elon Musk
- Reducing the gap between man and machine
- This leads to man-machine coexistence (iRobot)
- Singularity (machines supersedes human)
  - There are initiatives to attack singularity
  - Human-centered AI (use of human intervention in decision-making)
  - Explainable Ai (addressing explainability in ML)
  - Responsible AI (social, ethical, legal, accountability, …)

Agent Technology – an inspiration

- Massive systems (solar system, brain, body, sun, office, family, societies) are governed by computing taking place at the minute levels
  - Atoms (H ↔ He - Sun)
  - Molecules ($2C_8H_{18}(l) + 25O_2(g) \rightarrow 16CO_2(g) + 18H_2O(g)$ - vehicles)
  - Cells (Glucose molecule + oxygen - Body)
  - Ants (collect food, search for food, storing food)
  - Bees
  - Virus/bacteria/fungers
- This means any huge system can be modeled by tiny entities, we called them Agents
- A tiny entity does only a few smaller tasks.
- This is closer to writing programs as classes/objects

Understanding Agent

- You say to the travel agent:
  - "I want go to a conference in the UK"
- Then a Travel Agent does
  - Flight booking
  - Hotel reservation
  - Taxi booking
  - Conference registration
- Agent does not ask much from you, but he knows what to d
- Agent may get support from the agent next to him
- Agent switch to another client once a client is finished
- How can we develop agent-like software?
- Note: Agents can also be developed as objects

Exercise

- Although Agents can be coded using Object-Oriented concepts, why Agents cannot be considered as Objects.
  - The agent needs to be so small. It does not have its own knowledge-based but access to knowledge. The agent is mainly an entity that can execute but has no storage.

Some characteristics of Agents

- To understand the features of Agents, imagine how a dog works as an agent.
- Situatedness (works in a specific environment)
  - A dog is bound to one house
- Work for a master (Agent listen only to master)
  - A dog listens only to the master
- Autonomous (initiate, execute, terminate with no instruction)
  - When somebody enters the premises dog gets up, barks, stop
- Consume less resources (less CPU/memory)
  - No special food, live outside the home

Some characteristics of Agents

- Adaptivity (adjustable to situation)
  - Once a dog knows the visitor is a friend, dog will also be friendly….
- Reactive (suspend the current work and give priority to the master)
  - When a dog chases a person, but the master talks to the dog, then
- Proactive (work without instructions)
  - From time to time dog walks around the garden, making territory,

Some characteristics of Agents

- Learning (to improve their performance)
  - dog becomes friendly with a visitor after some time.
- Able to move
  - Dog can walk within the limit of house and garden
- Sociability (interact, communicate, cooperate with other agents)

Exercise 6

- Consider tasks performed by a security officer at the main gate of the university, discuss some selected features, with examples, of the Agents technology.
  - Situatedness –
  - Autonomy -
  - Adaptability -
  - Consume less resources -
  - Sociability -