TAIWAN TECH National Taiwan University of Science and Technology

Artificial Intelligence Technologies and Business Applications - Course Introduction

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Course Goals

- Introduce AI technologies and their potential business applications.
- Dive into the principles and implementations of a few AI/ML algorithms and tools.

Materials

- Textbook
  - *Artificial intelligence – A modern approach*

    Stuart Russel and Peter Norvig
- Reference book
  - *Data mining: concepts, models, methods and algorithms*, Mehmed Kantardzic
  - *Introduction to machine learning*, Ethem Alpaydin
  - *Web Mining*, Bing Liu
- Examples
  - Java, Typescript, Python

Grading Rules for this course

- Attendance 10%
- Homework 20%
- Mid-term 40%
- Final project 30%

AI – from Fantasy to Reality…

- A Space Odyssey (2001) : HAL (Heuristically programmed Algorithmic computer)
  - Play chess (search)
  - Read lips (image/speech recognition)
  - Engaged in conversation with humans
  - Go mad
- AI (Steven Spielberg): a robotic boy
  - Intelligent as a human being
  - Feel emotions

Definition of Artificial Intelligence

- A branch of computer science that is concerned with the automation of intelligent behavior. (Luger)
- But, a more fundamental problem…
  - What is "intelligence"?
  - Can intelligence be inferred from observable behavior, or does it require evidence of a particular internal mechanism?
  - Can *intelligence* be measured?
  - How is knowledge represented in the nerve tissue of a living being?
  - What is self-awareness?
- It is more concerned with expanding the boundaries of computer science than with defining those borders

What is *Intelligence*?

- *Intelligence* is difficult to define, but could be observed in the real world
- Observe behaviors of the humans
  - Solve problems, use tools, cooperate, communicate, recognize voices/objects, think logically, learn things, be adapted to environments, create art works, invent things…
- Observe behaviors of the other creatures
- Observe mechanisms of the world (non-creatures)

Different Attitudes

- Strong AI
  - By giving a computer program sufficient processing power, and by providing it with enough intelligence, one can create a computer that can literally think and is conscious in the same way that a human is conscious.
  - A computer might have mind …
- Weak AI
  - *Intelligent behavior* can be modeled and used by computers to solve complex problems
  - it is not necessary to mimic human
    - Computers can be do quicker arithmetic operations
  - It is not necessary to imitate birds in order to fly
    - Just because a computer behaves intelligently does not prove that it is actually intelligent in the way that a human is.

Weak AI vs. Strong AI

- Weak AI
  - Artificial intelligence is the study of systems that act in a way that to any observer would appear to be intelligent.
  - Electronic dogs, fishes or dinosaur
- Strong AI
  - Artificial intelligence involves using methods based on the intelligence behavior of humans and other animals to solve complex problems.
  - Try to mimic humans or living organisms

Turing Test

- Alan Turing, *Computing Machinery & Intelligence*, 1950
- An Interrogator
  - Is given access to two individuals – a human and a computer
  - Can ask the two individuals any questions in text mode
  - Is requested to distinguish the computer from the human
- If the interrogator cannot distinguish the computer from the human, then the computer may be assumed to be intelligent.

Measuring Intelligence: Turing Test

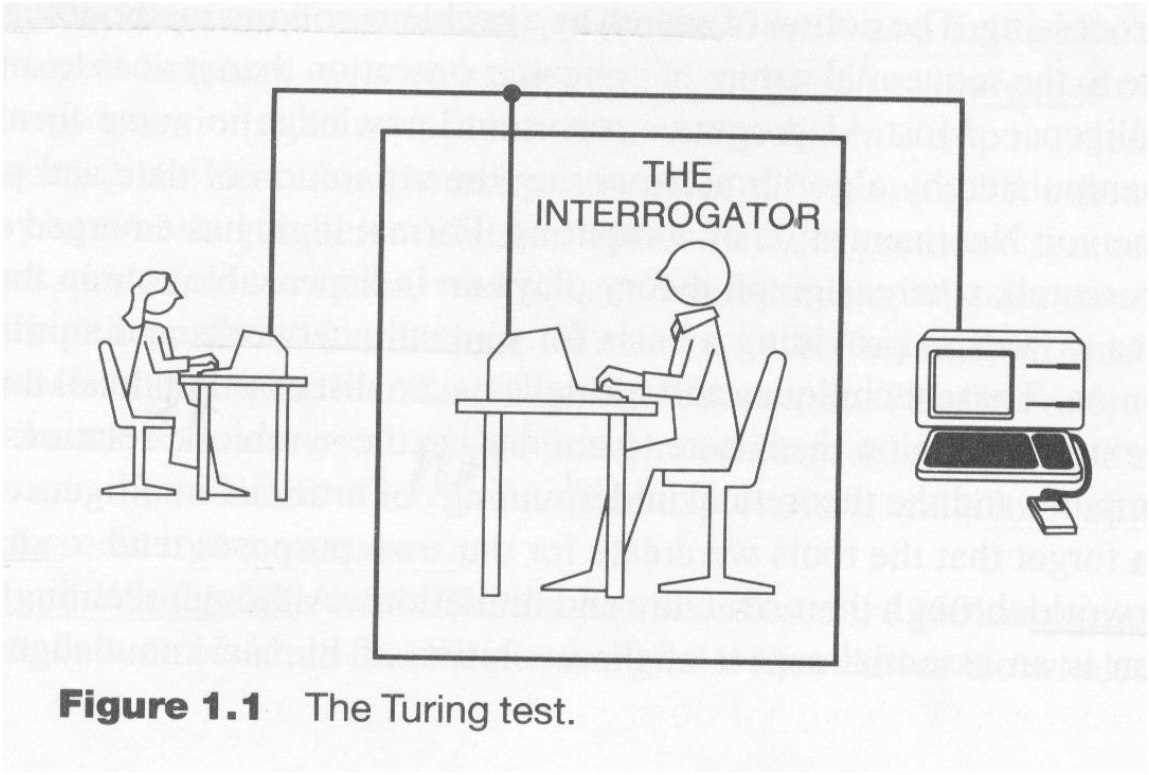


Figure 1.1 The Turing test.

- Can the interrogator tell the difference?
- Use human intelligence as a standard for the machine intelligence

Turing Test

- Giving an objective notion of intelligence
  - The behavior of a known intelligent being in response to a particular set of questions
- Preventing from being sidetracked by confusing & unanswered questions
  - whether the computer uses internal processes
  - whether the machine is conscious of its actions
- Eliminating bias in favor of living organisms over machine intelligence

Turing Test

- No program passed the Turing test yet
- Providing a basis for many schemes used to evaluate modern AI programs
- *Human behaviors* could be as indications of "intelligent" or "good"
- Giving an *operational* definition of "intelligence" (instead of descriptive definition)

Influences of Turing Test

- CAPTCHA
  - Completely Automated Public Turing test to tell Computers and Humans Apart
- Expert system
  - evaluated by human judgment
- Information retrieval
  - Reference answers are set by humans
- Speech synthesis
  - judgment for the quality of synthsized voices
- Spoken dialogue (wizard of Oz)
  - A human pretend to be a machine

AI Pre-History

- Aristotle 384-322 B.C. : Syllogism
  - All men are mortal. Socratis is a man.
    → Socratis is mortal.
- Gottfried Leibniz, late 17th century
  - Developing a formal mathematical language for reasoning
- George Boole, 1815-1864
  - Boolean algebra
- Gottlob Frege, 1879,1884
  - First-Order Predicate Calculus
- Charles Babbage, 1950s
  - Analytic engine – first computer

AI History

- *Artificial Intelligence* was first used by John McCarthy at a conference in Dartmouth College, in Hanover, New Hampshire.
  - John McCarthy invented LISP programming language in 1958
- Newell and Simon (1957)invented the idea of the General Problem Solver (GPS)
  - To solve almost any logical problem
  - Means-ends analysis

AI Development Strategies

- Winter of AI (~ 1980)
- Optimism → Realism (1960~1990)
- Steps
  1. Observe the intelligent behaviors from the world
  2. Induce the abstract and general factors of intelligence from the observations
  3. Develop the models/technologies that can empower the computer to exhibit the capabilities in the aspects individually (e.g. solve problem, learn, plan…)

"Divide and Conquer" strategies

- Define some research issues for realization of machine intelligence
- No longer to create a robot as intelligent as a human, but rather to use algorithms, heuristics, and methodologies based on the ways in which the human brains solves problems. (Weak AI)

Intelligence of Creatures

- Apes/Monkeys can …
  - Use tool to get banana
  - Buy coke from vending machine
- Dolphins can…
  - Understand "language" & communicate with human
  - Hunt for sardines through cooperation
- Dogs can …
  - Recognize its master and his voice
  - Do a few jobs
  - Read
- Parrots can …
  - Do arithmetic

Intelligence of Creatures

- Pigs
  - talk (Korea)
- Ants can …
  - Find their way home
  - Communicate with one other
  - Manage complicated society
- Trees can …
  - Grow and do not collapse
  - Adapt itself to the environment (cactus)
- Migrant birds can …
  - Identify their direction

Intelligence in Non-Creatures

- Examples
  - Blood
  - Heartbeat
  - Virus
  - Rain
- Is *intelligence* relevant to thinking?
  - These examples show that intelligent behavior does not necessarily to come from *thinking rationally* with knowledge or information consciously …
  - e.g. the ghosts in Pac-Man game

Factors of Intelligence

- Problem Solving
- Knowledge Representation
- Reasoning
- Planning
- Learning
- Communicating
- Moving
- Perceiving
- Creating

Research Fields

- Problem Solving
  - search , optimization, evolutionary computation
  - game playing, adversarial problem
- Reasoning
  - theorem proving, automatic reasoning, expert systems
  - fuzzy logic, probabilistic reasoning
  - ontology, knowledge representation, semantic network
- Planning
  - robotics, scheduling
- Learning
  - Induction, clustering, summarization
  - Classification, regression, prediction

Research Fields

- Communication
  - natural language processing, machine translation
  - dialogue systems, chat bot
  - information retrieval, multimedia retrieval
  - knowledge processing, question answering system
- Perception
  - speech recognition, machine vision, context awareness
- Creation
  - evolutionary computation, automatic composition
  - synthesis of speech, music, image, video,…

Automatic Reasoning

- Logic programming (Prolog/Lisp)
- Probabilistic reasoning
- Expert System / Fuzzy logic
- Theorem Proving

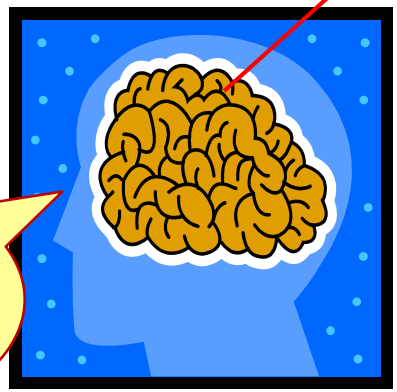
knowledge base

Rules:

if diastolic pressure (舒張壓) 80~89
AND
systolic pressure (收縮壓) 130~139
then pre-HBP
if DP >90, SP >140
then 1st stage HBP…

Facts:

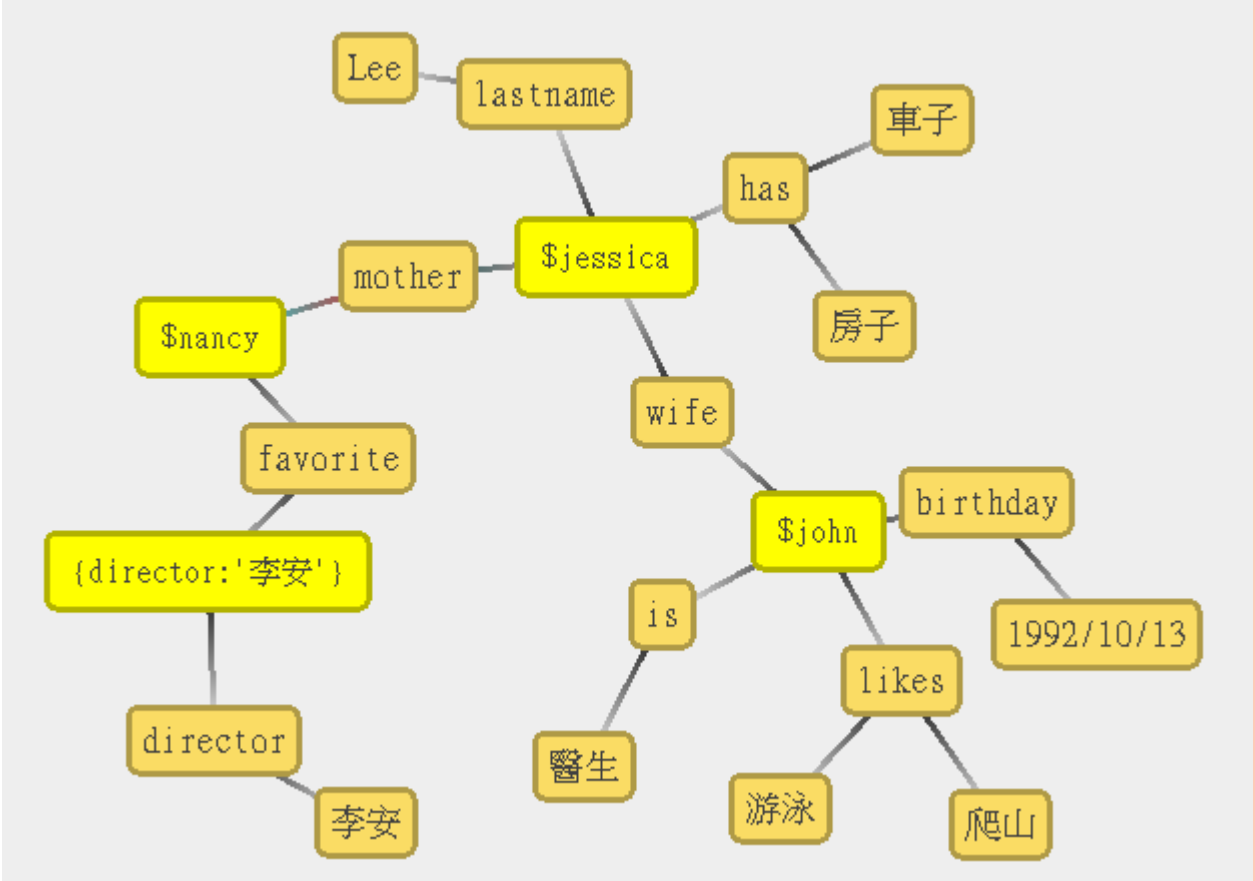
DBP=90,SBP=148 → ???



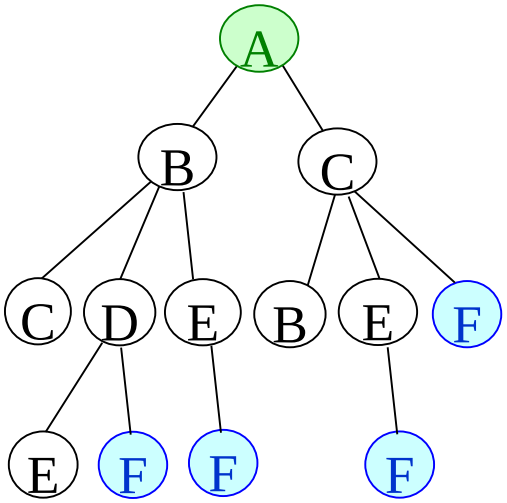
Disgnosis: high blood pressure

Knowledge Representation

- Who is Jessica?
- Who among my friends likes to swim?
- What is the relationship between Jessica and John?

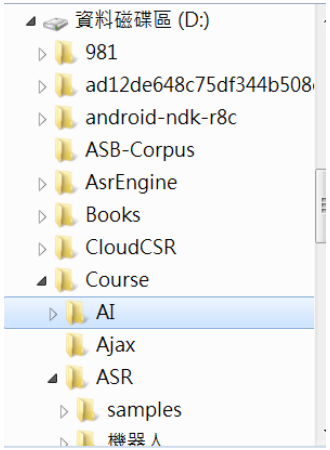


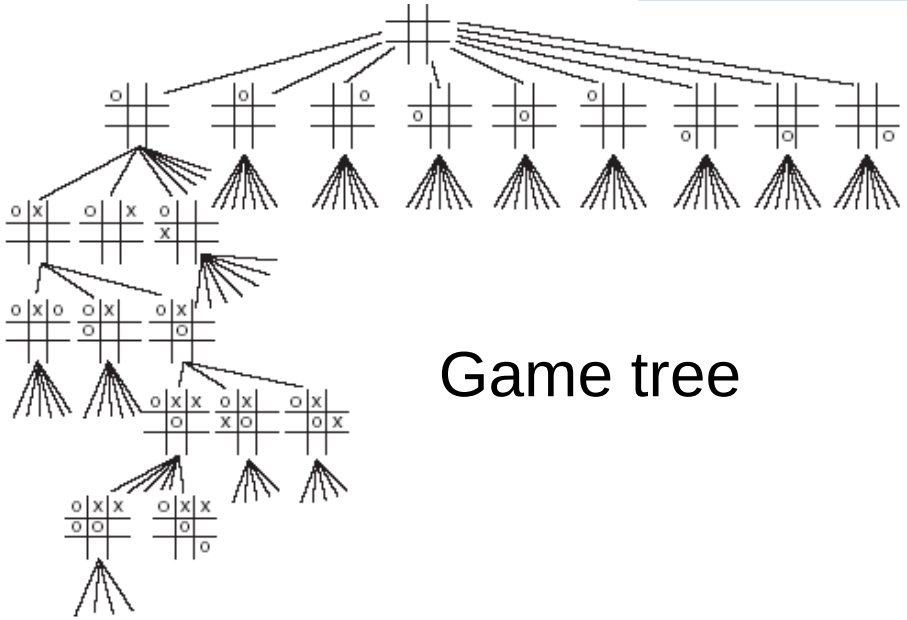
Search Tree



Path finding

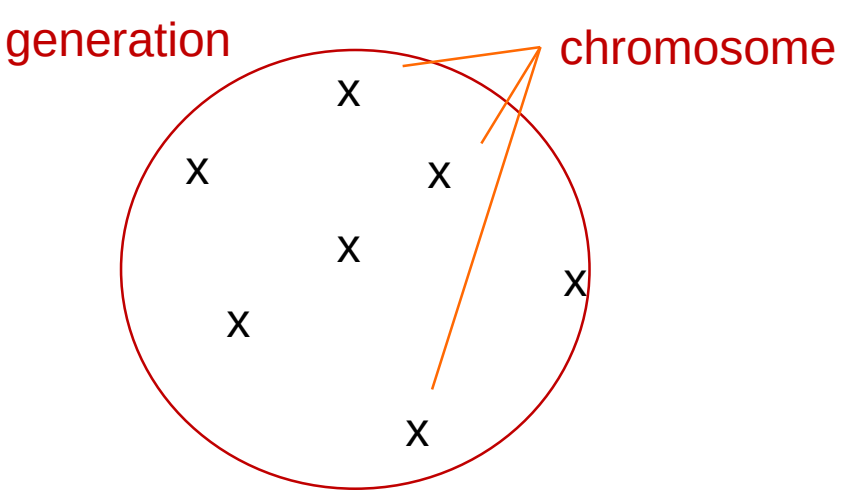
directory

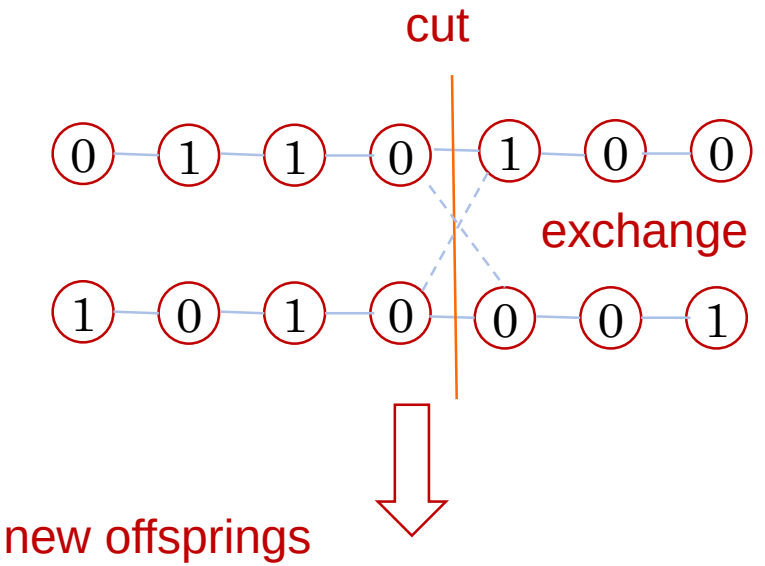




Game tree

Genetic Algorithm





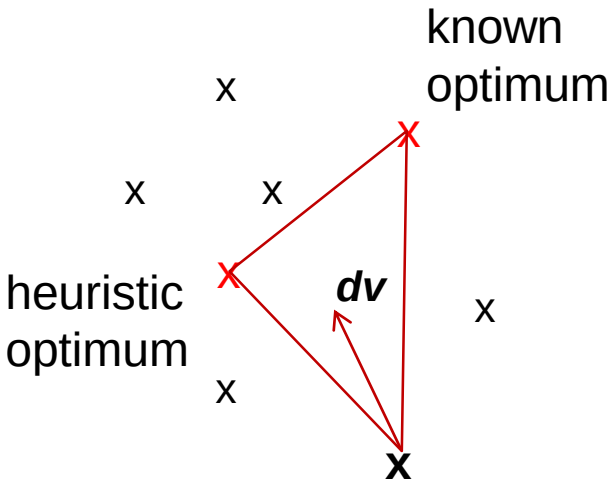
- Create new generation
  - fitness function
  - selection/exchange/mutation
- Search , optimization, creation

Ant Colony Optimization

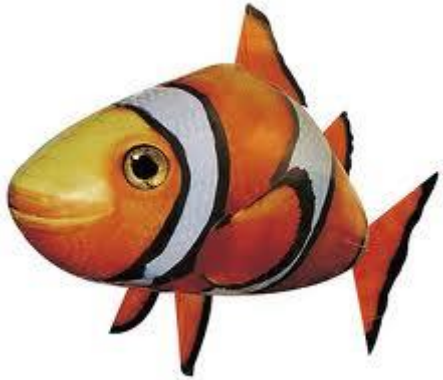
- How do ants find/move foods ?
  - every ant has simple behavior, but a group of ants may find shortest path!
- Why may a group of ants achieve this?
  - every ant moves randomly
  - an ant leaves pheromones on the trail when it finds foods and move back the nest
  - other ants follow the trail with more pheromones
  - Pheromones on longer trail vaporizes faster
- Idea: mimic the behaviors of ants!

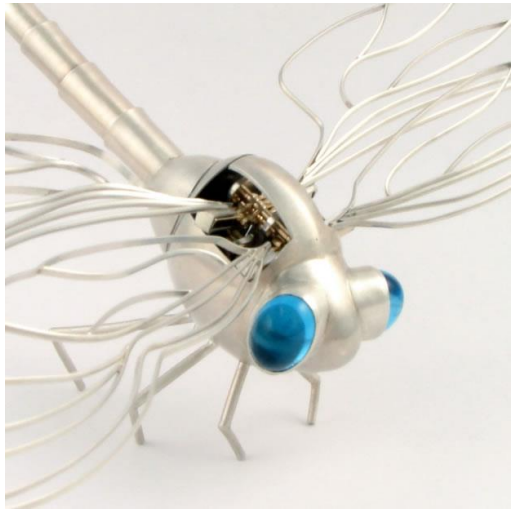
Particle Swarm Optimization

- Observing the behaviors of
  - flock of birds or school of fishes
  - A fish finds food → probably more foods nearby
  - every fish moves towards the site



Artificial Lives

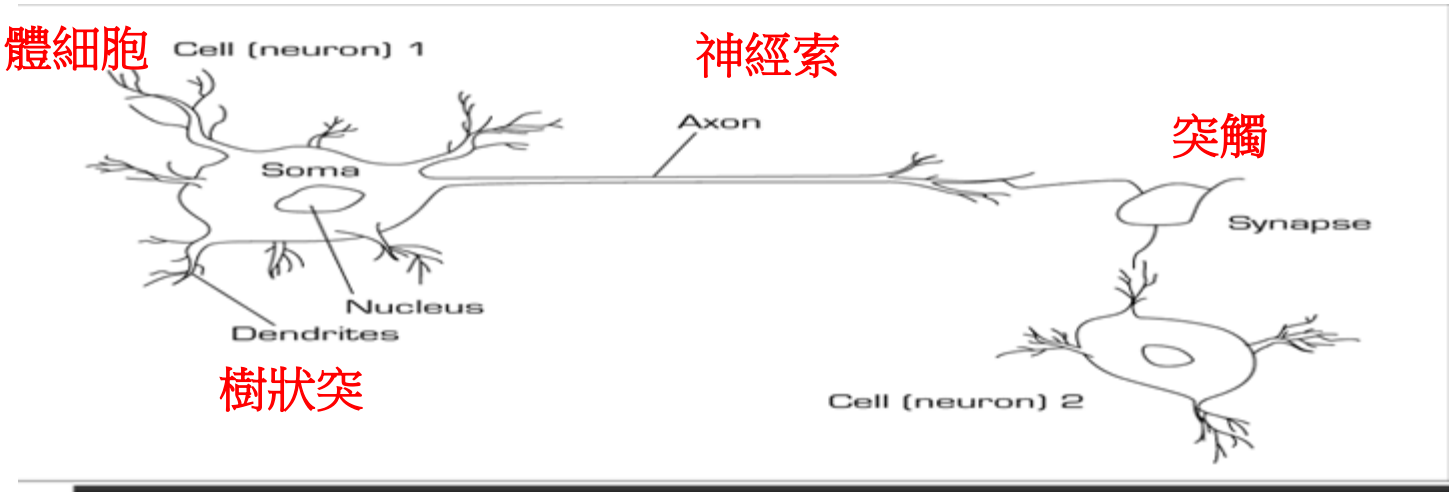




Symbolic AI

- A branch of AI
  - makes computers *think rationally*
  - Logic programming languages: LISP, PROLOG
  - Declarative syntax (instead of procedural)
- Facts
  - made_from(cheese, milk).contains(milk, calcium).
- Rules
  - contains(X, Y):- made_from(X, Z), contains(Z, Y).
- After input the facts and rules into the knowledge base, the computer can answer such queries as
  - contains(cheese, calcium). → yes
    (does cheese contain calcium?)
  - contains(X, calcium) → X=milk. X=cheese.
    (what contains calcium?)

Artificial Neural Network

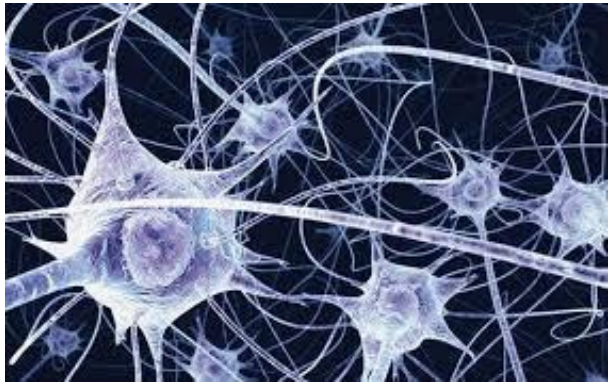


- Human intelligence is

  reliable, error tolerant, flexible, adaptable
- # of neurons: 50 ~ 150 billions
  - function of a single neuron is simple, but a lot of them may provide complicated functions
  - think/judge/memorize/recognize/compute…

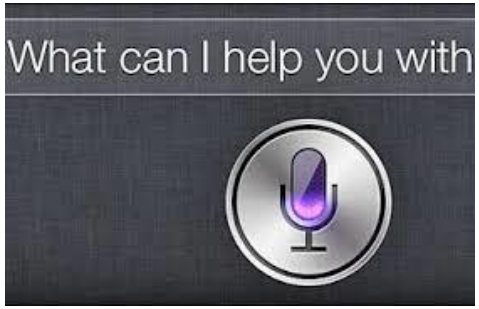
Wonderful Brain

- Memorize, associate
- infer, calculate
- parse, recognize, judge
- induce, plan, learn
- communicate
- cooperate
- art/knowledge creation



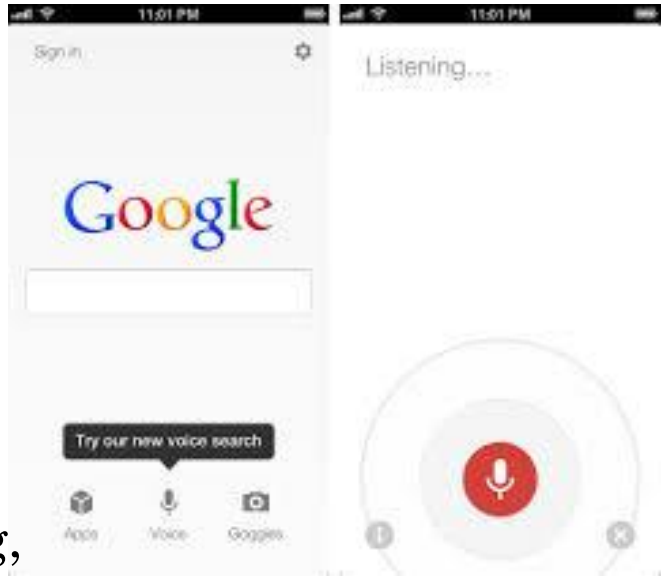
Milestones of AI

- May 11, 1997 – IBM Deep Blue,
  - Defeat world champion of chess
- Since 1997 – Robotcup of soccer
- 2011 - IBM Watson: Question answering
- Since 2011 - Apple/Google/Amazon voice interaction
- 9 May 2012 – Google Auto pilot



Voice Assistant

- Apple Siri
  - Apple TV, Apple watch
- Google, Amazon
- Voice command, controlling home appliances, playing music/video, calling Uber, buying tickets, making, booking, querying information



- 蔡依林的新專輯
- NBA的總冠軍是哪一隊
- 有沒有這附近的餐廳
- 最近的加油站在哪裡

Go

- AlphaGo (by Deep mind)
  - Defeat the smartest professional player
  - Deep learning approach & game trees
- Go Game
  - Regarded to be an extremely difficult AI task
  - Highly complex and abstract
  - Similar to commercial behaviors
    - Benefits vs investments
    - Vague & uncertain
    - Live / dead
    - *Ko* with high uncertainty

Deep learning

- May learn automatically high-level and multi-levels concepts/features from raw texts, sounds, images or objects
- Gains breakthroughs on performance from the advancements of computer hardware and software
  - Complicated computations may be handled with distributed and parallel processing
  - Graphic process unit
- May achieve the performance compatible with or superior to the performance of human beings on speech recognition, image classification and natural language processing

Technology Breakthroughs

- AlphaGo
- ChatGPT / LLM
- Image Synthesis (MdJourney)
- Video Synthesis (Sora)

- How
  - Transformer / Diffusion Model
  - Large model trained with
    - high computational power
    - Huge resources
  - Reinforcement learning (with human involved)

Impacts of AI

- Explore the boundary of intelligence & inspire innovations
  - Definition of intelligence and extend the boundary
- Applicable tools and algorithms
  - Statistical learning、Search、Optimization、Evolutionary computation
- Joint disciplined research
  - Speech recognition/synthesis, machine vision, robot…
- Intelligent information systems
  - Ubiquitous

Impacts of AI

- Inspire many research directions
- Joint contributions from various areas
  - Philosophy, linguistics, cognitive psychology, neural science, biology, computer science, engineering, …

Topics covered in this course

- Problem solving
  - State space search
- Adversarial search
  - Game tree & min-max algorithm
- Local search
  - Genetic algorithm
  - Simulated annealing
- Learning
  - Bayesian network
  - Classification and regression tree
  - Gaussian mixture model (GMM)
  - Regression

Topics covered in this course

- Clustering
- Artificial Neural Network
- Deep Learning
  - CNN, RNN, GAN
  - Encoder decoder model
  - Transformer
- Feature processing
  - Vector space: PCA, LSA
  - Probability model: PLSA
  - Machine learning: Restricted Boltzman Machine(RBM), AutoEncoder, word2vec
- Word Embedding & knowledge graph embedding
- Natural language processing

Relevant Background Knowledges

- Calculus
  - Chain rule, gradient descent, convergence, optimization
- Data structure / Programming
- Probability/Statistics
  - Random variables, Bayesian theory, distributions
  - Statistical models, Markov model, multi-variate analysis
  - Detection/estimation, EM
- Linear Algebra
  - Vector space, basis, decomposition, similarity, distance
  - Covariance, diagonalization, eigen decomposition, matrix factorization
- Signal and Systems / Digital Signal Processing
  - convolution, down sampling/up sampling, filtering