CSCI 3230

Fundamentals of Artificial Intelligence

Introduction

Fall 2013

Introduction

Instructor: Prof . K.S. Leung, 梁廣錫

Professor of Computer Science & Engineering

Computer Science and Engineering Department

Rm 917, HSH Bldg

ksleung@cse.cuhk.edu.hk

Tutors: Mr. Antonio Szeto – Rm 1013, HSH

<hyszeto@cse.cuhk.edu.hk>

Mr. Paco WONG Pak Kan – Rm 1013, HSH

<paco@cse.cuhk.edu.hk>

Miss. CAO Qin– Rm 1013, HSH

<qcao@cse.cuhk.edu.hk>

Homepages: Course Materials: (user name:csci3230; p/w: ksleung)

http://www.cse.cuhk.edu.hk/~ksleung/csci3230/

Tutorial Materials:

http://www.cse.cuhk.edu.hk/~csci3230/

Important Points

- Partnership- same goal
- Plagiarism
- Please don't disturb (phone, chat)
- Attendance- try our best
- Break?
- Student-Faculty-Expectations (Web)
- Student-Faculty-Expectations (Lecture)

Objective:

To learn and use AI in a PRACTICAL way.

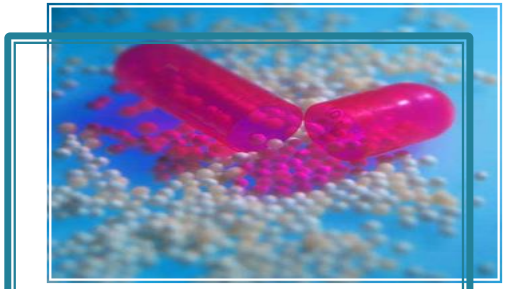
Course:	3 lectures per week (13 weeks) (37 Lectures) 1 tutorial per week: To be finalised Lecture time & places: T7-8 (T.Y. Wong Hall LT) & W5 (Lady Shaw Bldg LT6)
Assessment:	Assignments(15%) Lab (10%) Project (20%) Final Examination (55%) At least 40/100 marks in Final Exam to pass the course
Laboratory & Project:	1. Data Mining and Machine Learning Lab (knowledge acquisition) (SAS, WEKA, Mineset, IBM Intelligent Miner) 2. Neural Network on pattern classification with feature selection (computer marking – resubmit allowed) 1or **2 persons** per team. Specifications to be announced

Assessment

Content	Marks	Remarks
2 Written Assignments	0%	Optional - You can choose to do or submit them or not - Submitted works will be marked
1 Written Assignment	5%	
Lisp Programming Assignment	0%	Optional - 3 Tutorials will still focus on Lisp program - You can choose to do or submit it or not - Submitted works will be marked
Prolog Programming Assignment	10%	
Data Mining Laboratory	10%	Hands-on Lab - During tutorials in Week 10 - You have to attend a face-to-face assessment - Marks will be deducted if assist is needed
Neural Network Project	20%	2 People Project - You are allowed to choose any programming language
Final Examination	55%	At least 40 marks in Final Exam to pass the course

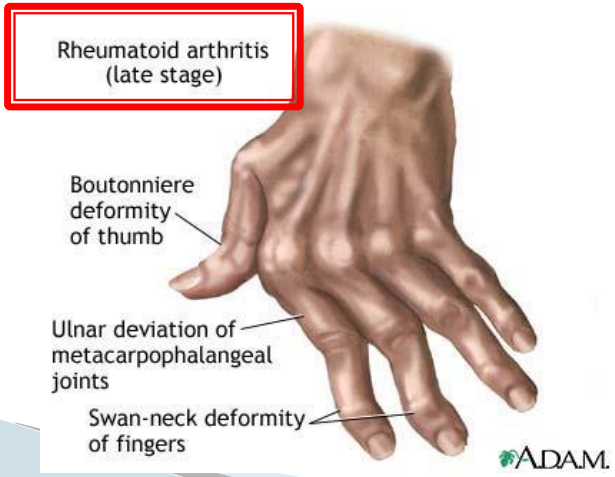
Project: What is Rheumatoid Arthritis (RA)? (類風濕關節炎)

Inflammation (發炎)



No effective therapy

No effective diagnosis



Unknown causes

60,000,000 patients

http://www.geninv.net/category/medicine/
http://trialx.com/curebyte/2011/05/24/what-is-rheumatoid-arthritis
http://www.cosmosmagazine.com/features/online/3445/a-plague-people
http://whymarbella.com/marbella-is-looking-to-host-a-medicine-university/
http://www.onlinemedicinetips.com/disease/y/yeast-infection/Can-Yeast-Infection-Cause-Blisters.html

Neural Network Project

- Title: Genetic Prediction of Rheumatoid arthritis

- The dataset provided
  - represents a set of patient data of :
    - Genetic variants on the genome
      - Single Nucleotide Polymorphism (SNP)
    - Class label shows if a patient has Rheumatoid Arthritis
  - 1600 Samples: 809 cases (with RA), 791 controls (without RA)
  - 30 Attributes (SNPs) + 1 Class label

- Goal: Train a NN to predict the genetic risk of unseen patients.

Prerequisite

- Basic information systems knowledge:
  - Discrete Mathematics
  - Operation Systems
  - C programming
  - Interface writing and
  - File handling, etc
- You must have NI (Natural Intelligence) to learn about AI.
- Most importantly: right attitude!
- New programming skill
  - **Prolog** and **Lisp** in tutorials

Text and References:

"Artificial Intelligence – A Modern Approach"

- Stuart Russell and Peter Norvig
  - Prentice Hall, 2011 (3nd Edition).

"Artificial Intelligence: Foundations of Computational Agents"

- David Poole, Alan Mackworth,
  - Cambridge University Press, 2010. **(Free e-book)**

"Artificial Intelligence"

- George F. Luger
  - Addison-Wesley, 2009(6th Edition).

"Artificial Intelligence"

- Patrick Henry Winston
  - Addison-Wesley, 1992.

Artificial Intelligence – A Guide to Intelligent Systems

- Michael Negnevitsky
  - Addison-Wesley, 2005 (2nd Edition).

More on Course Homepage

Course Outline

- Introduction to AI and Intelligent Agents
- Problem Solving:
  Search Techniques and Game Playing
- Knowledge Representation and Reasoning:
  Logics & Expert Systems
- Learning
- Neural Networks
- Computer Vision
- Revisions

Course Notes

	Chapter	Content
Week 1	1	Introduction
Week 2	2	Intelligent Agents
Week 2	3	Problem Solving and Search
Week 4	4	Informed Search Algorithms
Week 6	6	Game Playing
Week 7	7	Logical Agents
Week 9	8	First Order Logic
Week 10	9	Inference in First Order Logic
Week 11	20	Learning in Neural Networks
⇔		
Week 12	18	Learning from Observation
Week 13	24	Perception

What is AI?

AI is the study of ideas which enable computer to do the things that make people seem intelligent.

--- Winston, 1st ed. 1977

AI is the study of ideas that enable computers to be intelligent.

--- Winston, 2nd ed.1984

AI is the study of weak method. (weak because widely applicable. E.g. generate and test)

--- Allen Newell

AI is equivalent to Programs in AI.

--- Allen Newell

AI is the set of problems we don't yet know how to solve. (?????....)

-- the Cynic's definition

What is AI?

AI is the study of ideas which enable computer to do the things that make people seem intelligent.

--- Winston, 1st ed. 1977

AI is the study of ideas that enable computers to be intelligent.

--- Winston, 2nd ed.1984

AI is the study of weak method. (weak because widely applicable. E.g. generate and test)

--- Allen Newell

AI is equivalent to Programs in AI.

--- Allen Newell

AI is the set of problems we don't yet know how to solve. (Nothing in AI works!)

-- the Cynic's definition

What is AI?

Deep Blue beat G. Kasparov in 1997

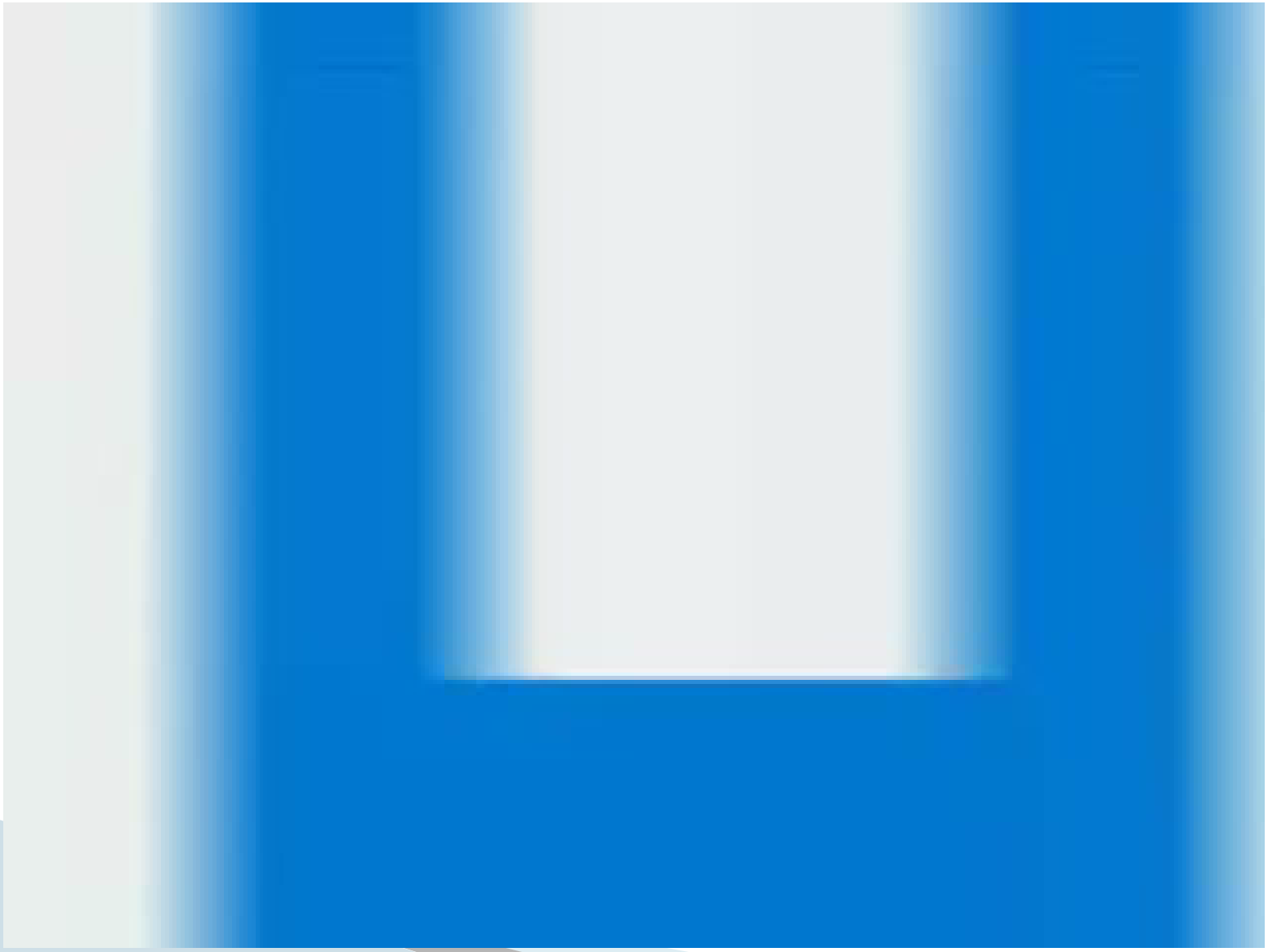
Robot shows how to solve Rubik's Cube

What is AI?

Deep Blue beat G. Kasparov in 1997 [YouTube]

What is AI?

Robot shows how to solve Rubik's Cube [YouTube]



What is AI? (cont'd)

Thinking Humanly	Thinking Rationally
Acting Humanly	Acting Rationally

"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)	"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)
"The art of creating machines that perform functions that require intelligence when performed by people" (Kurzweil, 1990) "The study of how to make computers do things at which, at the moment, people are better" (Rich and Knight, 1991)	"A field of study that seeks to explain and emulate intelligent behavior in terms of computational processes" (Schalkoff, 1990) "The branch of computer science that is concerned with the automation of intelligent behavior" (Luger and Stubblefield, 1993)

- AI is the branch of CS concerning the automation of intelligent behavior.
- AI is the collection of problems and methodologies studied by AI researchers.

Using the definitions in the previous figure, we can broadly classify them into 4 streams:

- Thinks like a human: the cognitive modeling approach (Top Left)
  - Need a model of human thinking. Fuzzy Logic?
  - The interdisciplinary field of Cognitive science brings together computer models from AI and experimental techniques from psychology to construct precise and testable theories of the workings of the human mind.
  - Cognition: Act of knowing, consciousness and judgment of the things (認知)
  - Consciousness: knowing one's existence (意識,自覺); chimpanzees?
- Acts like a human: the Turing test approach (BL)
  - The computer need to possess the following capabilities:
    - Natural language processing
    - Knowledge representation
    - Automated reasoning
    - Machine learning
  - To pass the Turing test, the computer also needs: computer vision, robotics

Using the definitions in the previous figure, we can broadly classify them into 4 streams:

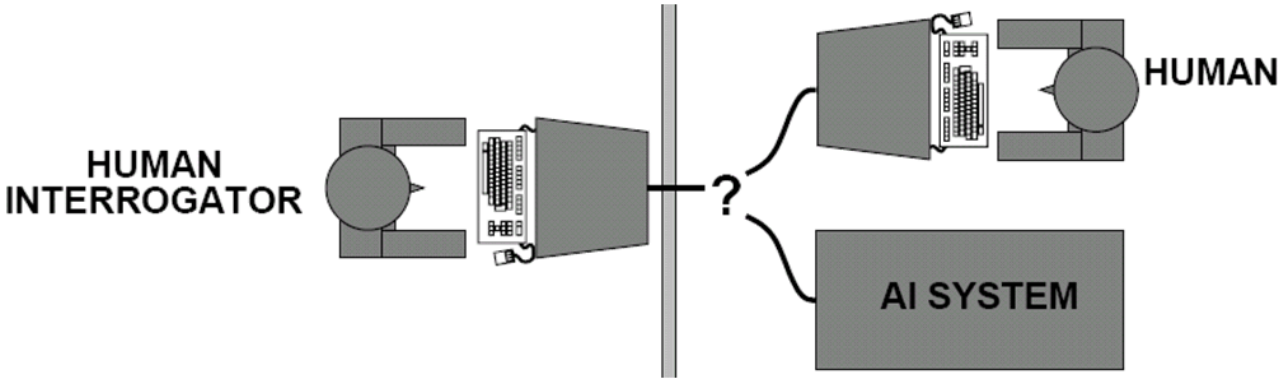
- Thinks rationally: the law of thought approach (TR)
  - The laws of logical inferences supposed to govern the operation of the mind, and this initiated the field of Logic.
  - Mathematical logics and philosophical logics.
- Act rationally: the rational agent approach (BR)
  - An Agent acting to achieve its goals given its beliefs.

How do we know we have achieved that?

Act like human

Turing Test?: (Alan Turing, 1950)

- To provide a satisfactory operational definition of intelligence.
- Intelligent behavior as the ability to achieve human-level performance in all cognitive tasks, sufficient to fool interrogator.
- The computer with AI behavior should be interrogated by a human via a teletype, and passes the test if the interrogator cannot tell if there is a computer or a human at the other end.



Problem: *Turing test is not reproducible, constructive, or amenable to mathematical analysis*

How do we know we have achieved that?

Think like human

IQ test? Other tests? EQ? ELIZA?

- Do these tests adequately defined intelligence?
- How to measure one's inside?
- Imaging that your task today is to design a machine that will mimic a human being, what type of system will you like to construct?
  - An ideal friend?
  - A homework generator?

Foundations of AI

- Philosophy (428 BC–present)
  - e.g. dualism (matter & spirit); mind=soul, materialism = mind obeys physical law, induction
- Mathematics (800 BC – present)
  - e.g. formal logics, algorithm, intractability = exponential time to solve, complexity and decision theories, probability, Markov models, NP completeness…
- Economics (1766 – present)
  - e.g. utility and decision theory, game theory, operations research, satisficing (good enough solution)
- Neuroscience(1861 – present)
  - study of the nerve system & brain
- Psychology(1879–present)
  - e.g. behaviorism, cognitive science
- Computer Engineering(1940 – present)
- Control theory & Cybernetics (1948 – present)
- Linguistics (1957 – presents)

History of AI

- The gestation孕育 of AI (1943–1956), simple NN, logic, Turing test
- The birth of AI (1956 –) CMU, MIT, IBM
- Early en'thusiasm, great expectations (1952 – 1969): 1958 High level AI language–Lisp, successful in micro–worlds (limited domains)

See Figs. 1.2-1.4

- A dose of reality (1966–1974), ELIZA, NP–complete, world knowledge
- Knowledge–based system: the key to power? (1969 – 1979) expert systems, certainty, fuzziness, frames (OO), knowledge engineering
- AI becomes an industry (1980 (few millions) – 1988 (US$2 billion))
- The return of neural networks (1986 –)
- AI becomes a science (1987 –) merging with other fields (see p.18) e.g. hidden Markov models (speech technology), Data mining, probabilistic reasoning, Bayesian network.

Potted history of AI

1943	McCulloch & Pitts: Boolean circuit model of brain
1950	Turing's "Computing Machinery and Intelligence"
1952–69	Look, Ma, no hands!
1950s	Early AI programs, including Samuel's checkers program, Newell & Simon's Logic Theorist, Gelernter's Geometry Engine
1956	Dartmouth meeting: "Artificial Intelligence" adopted
1965	Robinson's complete algorithm for logical reasoning
1966–74	AI discovers computational complexity Neural network research almost disappears
1969–79	Early development of knowledge-based systems
1980–88	Expert systems industry booms
1988–93	Expert systems industry busts: "AI Winter"
1985–95	Neural Network return to popularity
1988–	Resurgence of probability; general increase in technical depth "Nouvelle AI": ALife, GAs, soft computing
1995–	Agents and agents everywhere…

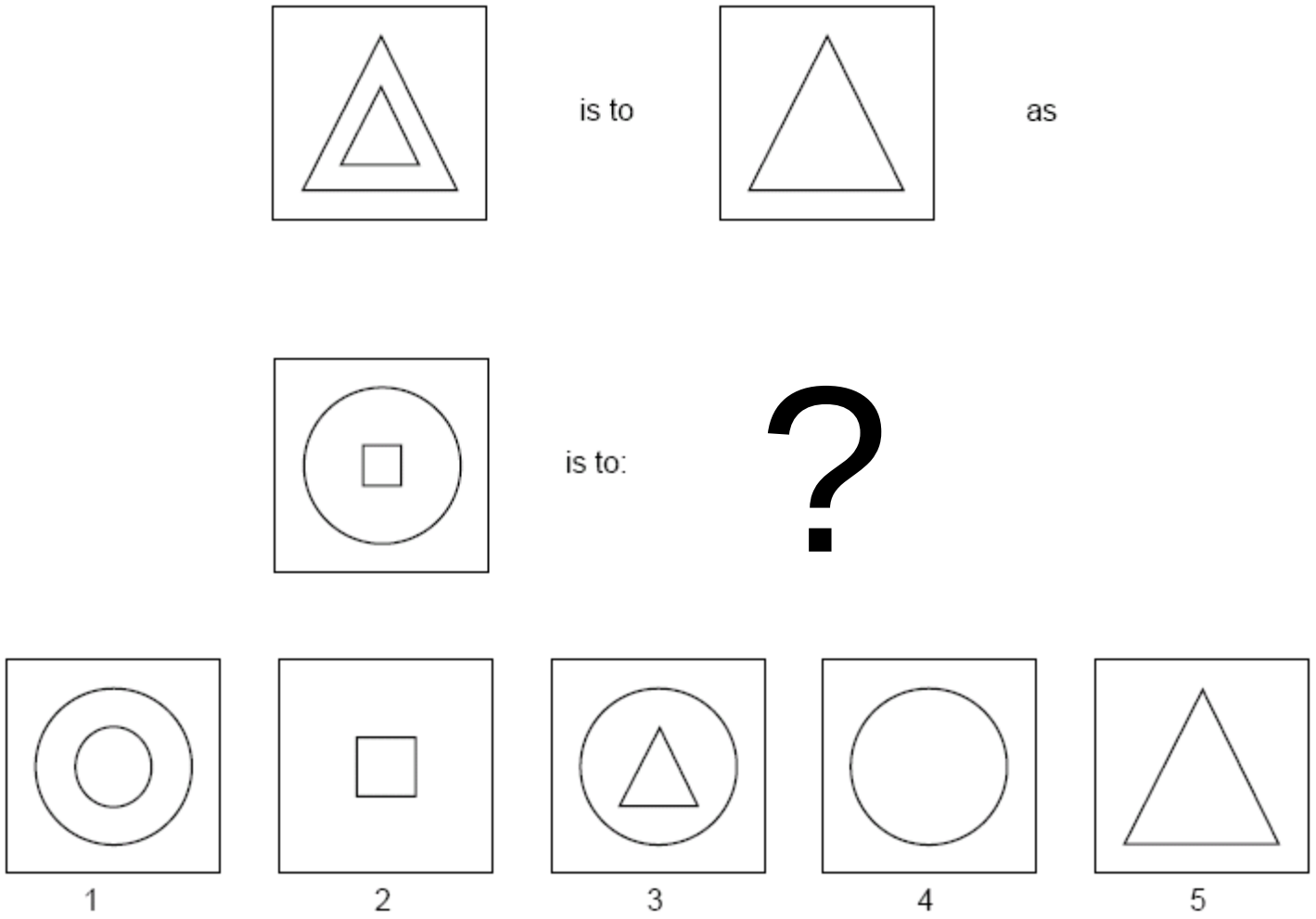


Fig. 1.2 An example problem solved by Evan's ANALOGY program

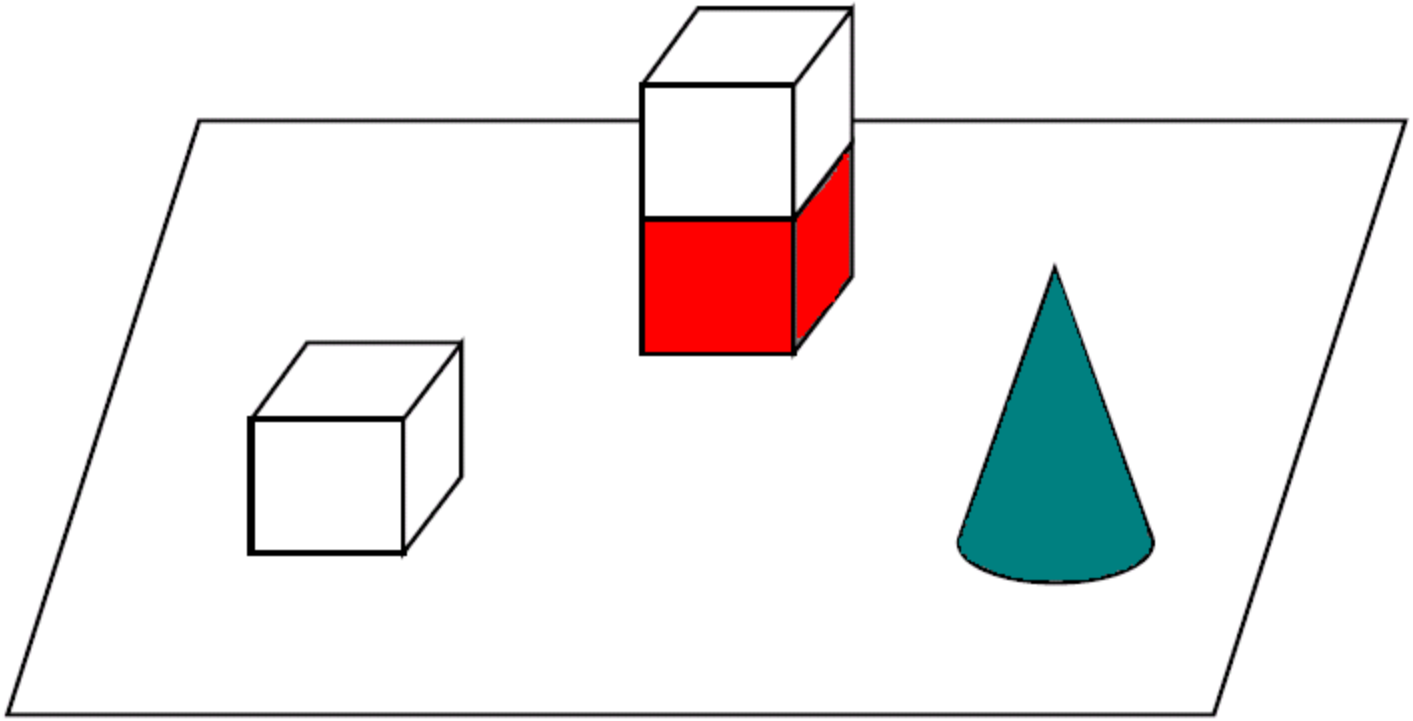


Fig. 1.3 A scene from the blocks world. A task for a robot: “Pick up a big red block” (robotic action, reasoning with changes and natural language processing)
//How would you do it? (path planning)

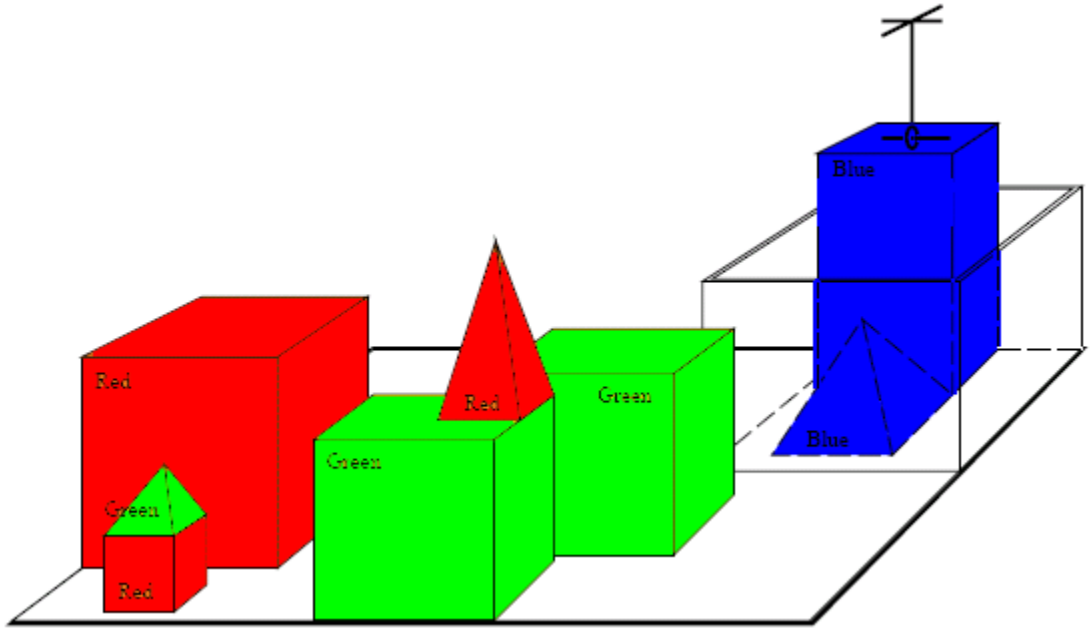


Fig. 1.4 A scene from the blocks world. A task for a robot: “Find a block which is taller than the one you are holding and put it in the box” (robotic action - path planning, vision, reasoning with changes and natural language processing)

Back

State of the Art

- Autonomous planning & scheduling
  - NASA's Remote Agent: on-board autonomous plan & control for spacecraft operation (2000)
- Game playing
  - Chess (IBM Deep Blue, 97, beaten international grandmasters), Blue gene; "Go"?
- Language/speech understanding
  - Automated travel agent
  - Solve crossword puzzles better than most humans
- Knowledge-based systems
  - JPL Marvel Voyage Diagnostic system (saved the spacecraft near Neptune)海王星
- Logistic planning: deploys 50,000 vehicles, cargo & people

State of the Art

- Autonomous control & vision
  - 2007,CMU's BOSS can follow traffic rules, avoid pedestrians and vehicles
  - Automated driving, 2850 miles – 98% of the time –CMU
- Discover and prove a new mathematical theorem
- Write an intentionally funny story
- Expert Systems: Give competent legal advice in a specialized area of law; medical diagnosis
- Translate spoken English into spoken Swedish in real time; Arabic to English (trained from 2 trillion words)
- Perform a complex surgical operation
- Auto circuit design, drug discovery, bio-knowledge discovery
- Big Data Analytics, gigabytes, tera-, peta-, exa- (10^{18})

Intelligent activity, in either human or machine, is achieved through the use of:

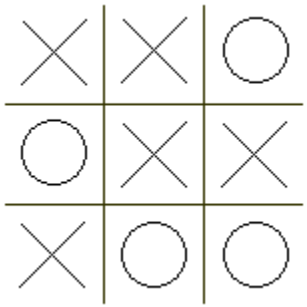
- Symbol patterns to represent significant aspects of a problem domain.

  (symbolic vs. numeric) ?which more powerful
- Operations on these patterns to generate potential solutions to problems. E.g. If apple is red, then it is ripe.
- Search to select a solution from among these possibilities. E.g. Inference, tree searching

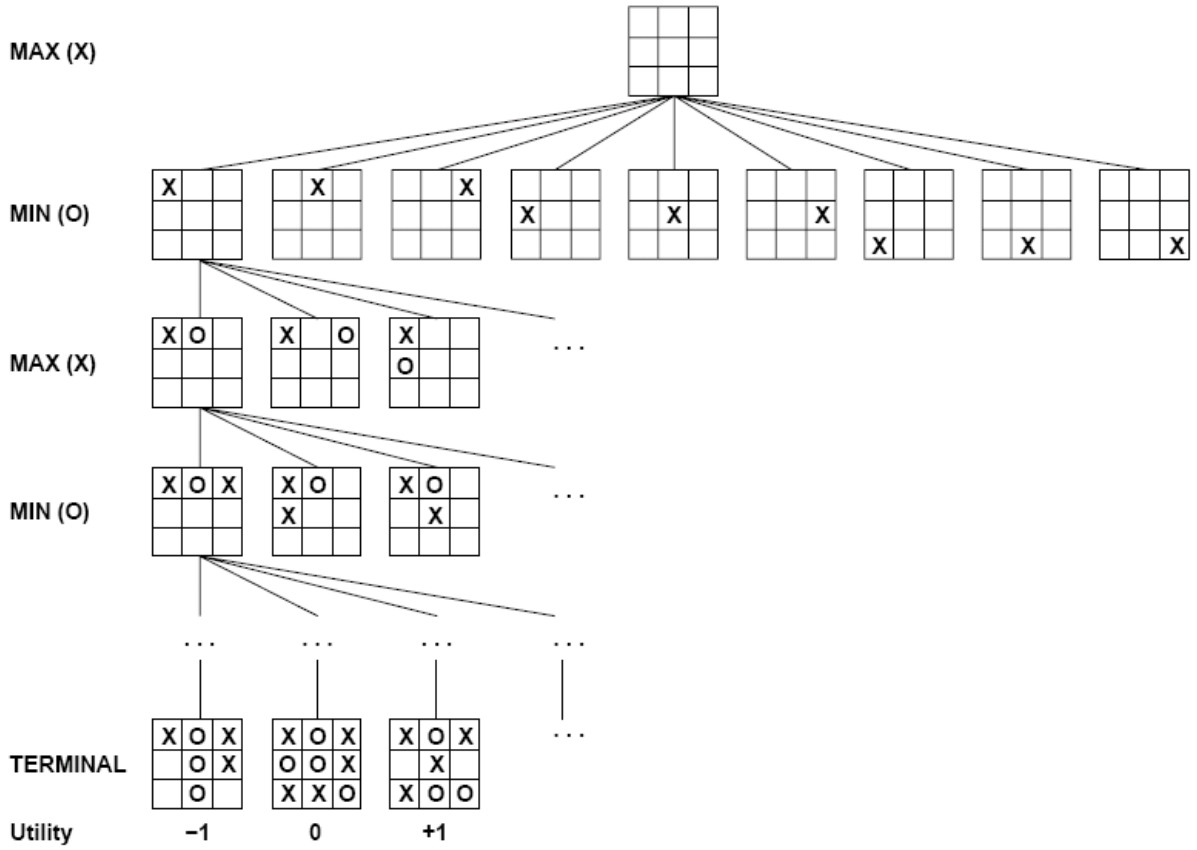
Problem Space, knowledge engineering

Iterate:

- Define the problem precisely (specifications: initial & final states) – I/O; Objective, constraints
- Analysis of the problem
- Represent the task knowledge (modeling)
- Choose the best problem-solving technique(s)
- Defining the Problem as a State Space Search
- E.g. Tic-Tac-Toe
- See next page



Game tree (2-player, deterministic, turns)



A (partial) search tree for the game of Tic-Tac-Toe.
Top node – initial state.
Utilities assigned by the rules of the game to the terminal states.

Slide from Chap 6, p8

Why study AI?

- To model and understand human intelligence
  - Neurobiology, philosophy, psychology, cognitive science, sociology, etc.
- To produce smart programs
  - Engineering, computing science, intelligent information systems, etc.

Supplementary materials

Sensory perception

- Tactile (touching)
- Visual
- Olfactory (smelling)
- ‘Auditory (hearing)
- Gastronome (tasting)
- Motor Action (o/p)
- Robotics (o/p)
- Speech Synthesis (o/p)

inputs

?which is more difficult to implement in AI

Board Categories

AI & Education
Analogical Reasoning
Approximate Reasoning
Automated Deduction
Case-Based Reasoning
Cellular Automata
Classification and Clustering
Cognitive Modeling
Cognitive Science
Logic Programming
Logic-based AI
Machine Discovery
Machine Learning
Model Language Processing
Neural Networks
Non-monotonic Reasoning
Philosophy of AI
Planning

Board Categories

Connectionism
Cybernetics and Systems
Decision Theory and AI
Distributed AI
Emotion
Expert Systems
Fuzzy Logic
Genetic Algorithms
Integrated AI Architecture
Intelligent Tutoring
Knowledge Representation
Probabilistic Reasoning
Production Systems
Qualitative Physics
Reasoning Under Uncertainty
Search
Symbolic Math
Temporal Reasoning
Theorem Proving
Virtual Reality
Vision
Robotics

Some application areas

Expert System	Games: Chess, Backgammon, Go, etc.
Engineering	Mathematics
Scientific Analysis	Geometry
Medical Diagnosis	Logic
Financial Analysis	Integral Calculus
Formal Tasks	Proving Properties of Programs

Questions:

- Assumptions, Strategies, Architecture, Verification
- What are our underlying assumptions about intelligence?
- What kinds of techniques will be useful for solving AI Problems?
- At what level of detail, if at all, are we trying to model human intelligence?
- How will we know when we have succeed in building an intelligent program
- Representation, Storage (Retrieval), Indexing (Matching)

Questions:

- Should a computer offer medical treatments?
- Should expert systems replace unskilled/skilled workers in societies' infrastructure?
- How about a computer psychiatrist?
- When are computer based problem solvers acceptable within out society?
- What is so hard about understanding language?
- How can computers be taught to handle ambiguous language or other difficult problem solving situations?
- How can computer vision systems identify relevant features in a complex visual scene?

AI Terminology and Short Definitions

- Strong AI:
  - Claim that computers can be made to actually think, just like human beings do. More precisely, the claim that there exists a class of computer programs, such that any implementation of such a program is really thinking.
- Weak AI:
  - Claim that computers are important tools in the modeling and simulation of human activity.
- Case-based Reasoning:
  - Technique whereby “cases” similar to the current problem are retrieved and their “solutions” modified to work on the current problem.
- Nonlinear Planning:
  - A planning paradigm which does not enforce a total (linear) ordering on the components of a plan.

AI Terminology and Short Definitions

- Admissibility:
  - An admissible search algorithm is one that is guaranteed to find an optimal path from the start node to a goal node, if one exists. In A* search, an admissible heuristic is one that never overestimates the distance remaining from the current node to the goal.
- Fuzzy Logic:
  - In Fuzzy Logic, truth values are real values in the closed interval [0..1]. The definitions of the Boolean operators are extended to fit this continuous domain. By avoiding discrete truth-values, Fuzzy Logic avoids some of the problems inherent in either-or judgments and yields natural interpretations of utterances like “very hot”. Fuzzy Logic has applications in control theory.

AI Terminology and Short Definitions

- Verification:
  - The process of confirming that an implemented model works as intended.
- Validation:
  - The process of confirming that one's model uses measurable inputs and produces output that can be used to make decisions about the real world.

AI-related Newsgroups

comp.ai	Artificial Intelligence
comp.ai.edu	AI and Education
comp.ai.fuzzy	Fuzzy Logic. Archived on the Aptronix FuzzyNet and TIL mail-servers (see [4-1]).
comp.ai.genetic	Genetic Algorithms
comp.ai.neural-nets	Neural Nets
comp.ai.nat-lang	Natural Language Processing (unmoderated)
comp.ai.nlang-know-rep	Natural Language and Knowledge Representation (Moderated).
comp.robotics	Robotics. Archived at the anonymous ftp site wilma.cs.brown.edu:pub/comp.robotics/. Read the files AuthorIndex and SubjectIndex first.
comp.theory.cell-automata	Cellular Automata
comp.theory.self-org-sys	Self-Organizing Systems
comp.simulation	Simulation
comp.speech	Speech related research including recognition and synthesis. Archived at the anonymous ftp site svr-ftp.eng.cam.ac.uk[129.169.24.20] in the directory comp.speech/archive/. Other useful information is archived in comp.speech/info/.
sci.lang	Linguistics
sci.math.symbolic	Symbolic Math

AI-related Newsgroups

sci.cognitive	Cognitive Science
comp.ai.philosophy	Philosophical Foundations of AI
comp.ai.shells	Expert System Shells
comp.ai.vision	Vision Research
sci.virtual-worlds	Virtual Reality. Also available through the bi-directional gateway. VIRTU-L on LISTSERVUIUCVMD.BITNET or LISTSERVVMD.CSO.UIUC.EDU
comp.lang.lisp	Common Lisp
comp.lang.clos	Common Lisp Object System
comp.object	Object Oriented Programming
comp.object.logic	Integrating Object-Oriented and Logic Paradigms
comp.lang.scheme	Scheme
comp.lang.lisp.mcl	Macintosh Common Lisp
comp.lang.lisp.franz	Franz Lisp
comp.lang.lisp.x	XLisp
comp.lang.prolog	Prolog and Logic Programming
comp.lang.pop	POPLOG integrated programming language & environment for Lisp, Prolog, ML and Pop11
comp.lang.smalltalk	Smalltalk
comp.lang.ml	Standard ML

AI-related Newsgroups

International Usenet AI news

aicom mcvax!swivax!otten@uunet.uu.net

German AI newsgroups:

de.sci.ki
de.sci.ki.announce
de.sci.ki.mod-ki
de.sci.ki.discussion

Of the above newsgroups the following have FAQ postings:

comp.ai, comp.ai.fuzzy, comp.ai.genetic, comp.robotics, comp.speech, comp.neural-nets, comp.lang.lisp, comp.lang.scheme, comp.lang.clos, comp.lang.prolog