COSC 3P71: Artificial Intelligence

Instructor: Dr. Beatrice Ombuki-Berman
Department of Computer Science

What is this course about?

- *Introductory* course in Artificial Intelligence
  Fundamental principles and technology, algorithms
  Applications: practical uses of AI
  Philosophy: what is Intelligence ?

- *(see outline)*
  - by the time you are finished ……
  - have fun with AI☺

Course Information

- Evaluation:

Coursework	approx. amount	approx %
assignments	3	40 %
project/term paper	1	20 %
Term exam		35 %
Participation		5%

- Late policy for assignments/Marking
- you need a minimum of 40% on the final exam to pass the course
- Programming language

Course Information

- Course materials:
  - Text: *Artificial Intelligence – A modern Approach* 3rd.ed., Stuart Russell and Peter Norvig, Prentice hall, 2010.
  - Assigned Readings
  - Lectures
  - Tutorials
  - samples midterms/exams
  - Supplementary/alternate reading material will be provided from time to time.
  - Please send me interesting AI-related web sites to add to course page

Course Information

- Course web site:
  - http://www.cosc.brocku.ca/Offerings/3P71/
  - Check this web site often
  - Updates related to assignments, reminders etc will be posted here as needed

Plagiarism

- Don't be tempted
  - Just don't do it
  - See COSC policy for the meaning of plagiarism

Course Objective I

- Do a broad overview of AI
- Develop a good understanding of various major topics in AI
- Develop the skills to build intelligent applications

Course Objective II

- Provide a good foundation for a number of COSC AI courses including:
- COSC 4P76 Machine learning
- COSC 4P78 Robotics
- COSC 4P80 Artificial Neural Networks
- COSC 4P87 Reasoning under uncertainty
- COSC 4P79 Expert Systems – to be replaced
- COSC 4P90: Project Course (if AI topic)
- COSC 5P71 Genetic Programming
- COSC 5P73 Computer Vision
- COSC 5P74 Evolutionary Computation

Potential Topics:

- What is AI ? Intelligent Agents and environment
- Problem solving & search
- Heuristics & games trees
- Logic, knowledge representation & reasoning
- Evolutionary Computation: Genetic algorithms, artificial life
- Swarm intelligence
- Machine learning
- Artificial neural networks
- Expert systems: an intro
- Reinforcement learning
- Philosophy & AI
- Planning, Decision making
- Possible invited talks

What is AI ?

(Ch.01)

- Artificial Intelligence (AI) is the study of computations that make it possible to perceive, reason, act rationally, behave, learn

  - differs from mainstream comp sci on its emphasis on perception, reasoning, action - *human-like behavior*

  - AI differs by building intelligent entities as well as understand them
    - emphasis on problems that normally require human intelligence to solve
    - However, doesn't mean that we need to literally simulate humans.

    - One of newest fields in science & engineering
    - AI name coined in 1956

Goals of AI

- goals of AI:
  - **engineering**: solve real-world problems using knowledge and reasoning
    - one perspective:AI is concerned with higher-levels of software design and implementation
    - develop concepts, theory and practice of building intelligent entities
  - **scientific**: use computers as a platform for studying intelligence itself
    - scientists design theories hypothesizing aspects of intelligence then they can implement these theories on a computer
    - this permits them to see theory weaknesses, performance

AI

- **Intelligence is studied from many perspectives**
  - **hardcore AI**: computer scientists creating theories and programs to solve previously-mentioned goals
  - **cognitive scientists**: similar to AI and psych schools, except they want to implement human models of intelligence on the computer (i.e. simulate neurology behind vision)
  - **psychology**: psychologists interested in human intelligence
  - **Other AI links**: Philosophy

philosophy & psychology also concerned with intelligence

i.e., tries to understand how seeing, learning, remembering, and reasoning could or should be done.

AI

- **AI itself has somewhat splintered over the years; due to maturation and sophistication of these fields**
  - computer vision: concerned with giving computers sight (to see and analyze)
  - theorem proving and symbolic computation
  - logic programming
  - natural language understanding
  - robotics
  - data mining
  - machine learning
  - neural networks
  - evolutionary computation
  - evolutionary robotics
  - swarm intelligence….

AI

- AI is an active, evolving field
  - Many international journals, conferences

- An interesting phenomenon:
  As soon as a problem in Artificial Intelligence becomes solved, it then leaves AI to be part of computer science.

  this has happened to: Chess playing, logic programming, some pattern recognition problems, mathematics problem solving, object-oriented programming, and others

  perhaps people connote AI with a level of mystery

AI

- Advantages of implementing theories of intelligence on a computer?
  1. problem solving <---> computation
     - tractability & complexity
     - programming languages: command, applicative, functional
     - hierarchical approaches
  2. computers force precision
     - computer programs must be unambiguously specified
     - computer execution is rigorous
  3. computational measurements
     - permit empirical analyses
  4. computers as guinea pigs
     - ethics of experimenting with living creatures (but.....)

Some example successes of AI

- AI is producing commercial successes
- AI is also solving problems that have been too complex to solve cheaply, or at all
- the need for more sophisticated software that can adapt, make decisions, learn,... means that AI will continue to be an important area of computer science

Examples of AI Application Systems

Game Playing

- TDGammon, the world champion backgammon player, built by Gerry Tesauro of IBM research
  - Perception: keyboard input
  - **Reason**: reinforcement learning
  - Actuation: graphical output shows dice and movement of piece
- Deep Blue chess program beat world champion Gary Kasparov
  - Perception: input symptoms and test results
  - **Reason**: Bayesian networks, Monte-Carlo simulations
  - Actuation: output diagnoses and further test suggestions

Natural Language Understanding

- **AI translators** – spoken to and prints what one wants in foreign languages : e.g., Arabic to English
- Advanced systems can answer

  questions based on the information in the text and produce useful summaries

- **Natural language understanding**(spell checkers, grammar checkers)

- Examples of successes

  English conversation

  - START system: a natural language question answering system

Object-oriented programming

- Marvin Minsky: grandfather of AI

Inventions: neural networks, frame-based reasoning

- Frames are an early form of object-orientation
  - A type of knowledge representation
  - Inheritance
- –Could be argued that frames are a precursor to object-orientation in modern day languages

Of course, current languages have large pedigree.

Machine learning

–By taking raw data, programs can simplify & generalize it

–In addition programs can:

- adapt to situations
- acquire knowledge and improve performance with skills
- make decisions based on acquired knowledge

-e.g.. In medical diagnosis: Quinlan's ID3: simplified several thousand medical cases (*look-up* Quinlan's ID3 …)

-Another practical example: credit card risk analysis

- **solving difficult analyses problems**
  - E.g., KAM system: simulated differential equations, and then analyzed the plot using computer vision methods
  - related are Mathematica, Maple systems, which derive from early work in AI problem solving and symbolic computation

Invention and discovery

- AI technologies are being used to design and improve things such as electrical circuits, machine engineering, computers, bridges, buildings, **…**

Discovery

- In geology
  - the **Prospector expert system** has a knowledge base of geological expertise
  - after analyzing a map, it hypothesized the existence of a rare and valuable mineral
  - an actual deposit was discovered; this showed the commercial viability of expert systems

Expert systems

- Diagnostic Systems
  - **Pathfinder**, a medical diagnosis system (suggests tests and makes diagnosis) developed by Heckerman and other Microsoft research
  - **MYCIN** system for diagnosing bacterial infections of the blood and suggesting treatments
- Financial decision making
  - banks, credit card companies, mortgage companies use AI to systems to detect fraud and expedite financial transactions.
  - Financial expert systems is a hot area!
- Classification Systems
  - Information put into one of a fixed set of categories using several sources of information e.g., financial decision making systems, NASA probes

Robotics

- Robotics becoming increasing important in various areas like: games,

  to handle hazardous conditions, and to do tedious jobs among other things, e.g., deploy robots to handle hazardous materials in warzone areas, clear explosives, and identify snipers locations

- ***E.g***
  - automated cars, ping pong player
  - mining, construction, agriculture
  - garbage collection

- **Xavier, a mail delivery robot developed at CMU**
  - –Perception: vision, sonar, web interface
  - –**Reason**: A*, Bayes classification
  - –Actuation: wheeled robotic actuation

- **Spam fighting**
  - E.g., use learning algorithms to classify billions of messages as spam
  - Spammers are continuously updating their techniques: a static programmed approach insufficient
    - Solution: use learning

Logistics planning

- Scheduling and Planning
  - Automated scheduling for manufacturing
  - DARPA's DART system used in Desert Storm and Desert Shield operations to plan logistics of people and supplies, that involved up to 50,000 vehicles, cargo, and people
  - Air traffic control systems e.g., Airline rerouting contingency planner
  - **Autonomous planning and scheduling**: NASA's on-board autonomous planning program controlled the scheduling of operations for a spacecraft

More examples of AI Applications

- Supervisory systems (controls elevators, power)
- Speech recognition: e.g. can have entire conversation guided by an automated speech recognition and dialog management system.
- Handwriting recognition (US postal service zip code readers)
- Automated theorem proving (4-color theorem, algebra etc)
  - use inference methods to prove new theorems
- Web search Engines
- Proverb solves crossword puzzles better than most humans

Measure of AI success

- criteria to measure success by:
  - –is the task clearly defined?
  - –is there an implementation? If not, why?
  - –is the implementation ad hoc, or are there principles underlying it?
  - –does the application solve a real problem? does it open up new opportunities?
  - –Industry: will the application generate money?

What is AI ?

- Views of AI fall into four categories:

systems that think like humans	**systems that think rationally**
systems that act like humans	**systems that act rationally**

Russell & Norvig advocates "acting rationally"

Acting humanly: Turing Test

- A.M Turing (1950) "Computing machinery and intelligence":
  "Can machines think?" "Can machines behave intelligently?"

. Proposes the Imitation game (Turing test) as a test for intelligent behavior:

If a machine can't be told apart from a human in a conversation over a teletype, then that's good enough.

- The Turing Test: a suggested experiment for evaluating whether a system is intelligent. Q. can machines think?
  - Turing restated: can a computer system fool a human into believing the system is human?

- Predicted that by 2000, a machine might have a 30% chance of fooling a lay person for 5 minutes

Note: Turing test

- Programming a computer to pass the test would need:
- Natural language processing
- Knowledge representation: store what it knows/hears
- Automated reasoning: use stored information to answer questions/draw conclusions
- Machine learning: to adapt to new situations, and to detect and make extrapolations
- For total turing test a computer would also need
- Computer vision: to perceive objects
- Robotics: to manipulate objects and move about

Thinking humanly: cognitive modeling

- 1960s "cognitive revolution": information-processing psychology

- Requires scientific theories of internal activities of the brain
- --How to validate? Requires

  1) Predicting and testing behavior of human subjects

  or 2) Direct identification from neurological data

Both approaches (roughly, Cognitive Science and Cognitive Neuroscience)・

- are now distinct from AI

Thinking rationally: "laws of thought"

- Aristotle: what are correct arguments/thought processes?
- Several Greek schools developed various forms of *logic*: *notation* and *rules of derivation* for thoughts; may or may not have proceeded to the idea of mechanization
- Direct line through mathematics and philosophy to modern AI
- Problems:
  - 1. **Not all intelligent behavior is mediated by logical deliberation**
  - **2. What is the purpose of thinking? What thoughts should I have?**

Acting rationally: rational agent

- Rational behavior: doing the right thing
- The right thing: that which is expected to maximize goal achievement, given the available information
- Doesn't necessarily involve thinking -e.g., blinking reflex -but thinking should be in the service of rational action

Rational agent

- An agent is an entity that perceives and acts
- This course is about designing rational agents
- Abstractly, an agent is a function from percept histories to actions:
  [*f*: P* A]
- For any given class of environments and tasks, we seek the agent (or class of agents) with the best performance
- Caveat: computational limitations make perfect rationality unachievable
  - > design best program for given machine resources

Other Definitions of AI

- AI is the design of flexible programs that respond productively in situations that were not specifically anticipated by the designer (Dean, Allen & Aloimonos).

- AI is the construction of computations that perceive, reason, and act effectively in uncertain environments. In this definition, the psychological aspects of AI are perception, reason, and action, and the "construction of computations" encompasses the computer science aspect of AI (Winston).

AI intro:Summary

- AI can help us solve difficult, real-world problems, creating new opportunities in business, engineering, and many other application areas
- View the topics being presented in this course as an instance of one particular problem requiring intelligence
- View the solutions to these topics as examples of aspects of intelligence.
- If you are not convinced that the solutions to this topics are really intelligent (but merely computer science), then by all means, think of these solutions as new software/programming technologies.
- Ask yourself what constitutes intelligence. Compare how you solve a problem, verses how the computational technique does it.

  ---> identify the similarities and differences

Reading Assignment

- Chapter 1: course text
- See summary on history on following slides

AI prehistory

- Philosophy — Logic, methods of reasoning, mind as physical system, foundations of learning, language, rationality
- Mathematics — Formal representation and proof algorithms, computation, (un)decidability,(in)tractability,probability
- Economics — utility, decision theory
- Neuroscience — physical substrate for mental activity
- Psychology — phenomena of perception and motor control, experimental techniques
- Computer engineering — building fast computers
- Control theory — design systems that maximize an objective function over time
- Linguistics — knowledge representation, grammar

Abridged history of AI

- 1943 — McCulloch & Pitts: Boolean circuit model of brain
- 1950 — Turing's "Computing Machinery and Intelligence"
- 1956 — Dartmouth meeting: "Artificial Intelligence" adopted
- 1950s — Early AI programs, including Samuel's checkers program, Newell & Simon's Logic Theorist, Gelernter's Geometry Engine

Abridged history of AI (2)

- 1965 Robinson's complete algorithm for logical reasoning
- 1966-73 AI discovers computational complexity Neural network research almost disappears
- 1969-79 Early development of knowledge-based systems
- 1980-- AI becomes an industry
- 1986-- Neural networks return to popularity
- 1987-- AI becomes a science
- 1995-- The emergence of intelligent agents