CSC384: Intro to Artificial Intelligence

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- Office Hours: TBA (watch Web page), by appt.

Artificial Intelligence (AI)
- What is AI?
- What is intelligence?
- What features/abilities do humans (animals? animate objects?) have that you think are indicative or characteristic of intelligence?
- abstract concepts, mathematics, language, problem solving, logical reasoning, emotions, morality, ability to learn/adapt, etc...

Some Definitions (Russell + Norvig, 1995)

- The exciting new effort to have computers that think... machines with minds in the full and literal sense [Haugeland 85]
- [The automation of] activities that we associate with human thinking, such as decision making, problem solving, learning [Bellman 78]
- The art of creating machines that perform functions that require intelligence when performed by a human [Kuczweil 90]
- The study of how to make computers do things at which, at the moment, people are better [Rich&Kight 91]
- The study of mental faculties through the use of computational models [Chamia & McDermott 86]
- The study of computations that make it possible to perceive, reason and act [Winston 92]
- A field of study that seeks to explain and emulate intelligent behavior in terms of computational processes [Schalkoff 90]
- The branch of computer science that is concerned with the automation of intelligent behavior [Luger&Stubblefeld93]

Computational Intelligence
- Notice the term systems in each box
  * most AI researchers build systems to do these things
  * computational theories or models of intelligence (and systems that implement them) our goal
  * computational, not “artificial”, intelligence
- But it still comes down to intelligence: what is it?
- Our defns break down as follows:
  * Two in terms of thinking, two acting
  * Two in terms of what humans do, two rationality
- Consider relative advantages of each

Aside on Rationality
- What is rationality?
  * A precise mathematical notion of what it means to do the right thing in any particular circumstance (see Ch.10.4 of our text)
  * If you find yourself in a situation where you have several courses of action, choose one that’s best for you: one that has the best chance of achieving your goals (or furthering your interests)… balancing short and long term objectives
- Does this sound selfish? Where do these interests come from?
Agency

- We’ll focus on acting rationally
  - which has implications for thinking/reasoning
- Our aim is to build agents, either:
  - with their own goals
  - or that act on behalf of someone (a “user”)
- An agent is an entity that that exists in an environment and acts on that environment based on its perceptions environment
- An intelligent agent acts to further its own interests (or those of a user)

Agent Schematic (I)

- Thermostat, ROSI, Web browser, Craig, you, software agent, etc.

Agent Schematic (II)

- First diagram is misleading
  - ROSI knew you were a student before interacting with you, and remembers stuff too!

Monitoring Intensive-Care Patients

The “alarm” network
37 variables, 509 parameters (instead of ~2^20)

ALVINN

- Pomerleau, et al. NAVLAB Group (CMU)

NAVLAB
Autoclass (Cheeseman et al.)

Other Examples
- credit card fraud detection
- printer diagnostics, help in Windows, spam filters
- medical diagnosis, teleoperated/micro surgery
- information retrieval, Google
- TAC
- Cobot
- scheduling, logistics, etc.
- aircraft, pipeline inspection
- speech understanding, generation, translation
- Mars rover, DS1
- and, of course, cool robots (let’s go to video)

Degrees of Intelligencen
- Range of circumstances in which agent can act
- E.g., a software agent
  - gets Web page you type in
  - does URL completion of unambiguous match
  - does URL completion of most frequent/likely match
  - completes URL based on context (time, history, etc.)
  - notices trends and prefetches Web pages, clips, etc.
  - downloads new music, makes new playlist for gym
  - buys your clothes at Eddie Bauer online
  - charges it to stolen credit card… just kidding
  - schedules car for tune ups, plans your trip to Italy this summer, makes a fortune daytrading, etc…

Degrees on Intelligence
- A rational agent’s degree of intelligence might be characterized by
  1. ability to act rationally in a *variety of circumstances*
  2. ability to *adopt complex goals* and balance their achievement
  3. ability to *adapt to new circumstances*

Agent Properties (Wooldridge, Jennings)
- **Autonomy:** needs no direct intervention to perform duties
- **Reactivity:** perceives its environment and reacts appropriately to it
- **Proactivity:** exhibits goal-directed behavior
- **Sociability:** interacts with other agents

Areas of AI
- Perception: vision, speech understanding, etc.
- Robotics
- Natural language understanding
- Reasoning and decision making (our focus)
  - Knowledge representation
  - Reasoning *(logical, probabilistic)*
  - Decision making *(search, planning, decision theory)*
  - Machine Learning
Topics We’ll Cover

- What we’ll cover in this class
  - logical knowledge representation and reasoning
  - problem solving; graph-based search (AI-style)
  - game tree search
  - planning
  - probabilistic reasoning
  - Bayesian networks
  - utility theory
  - decision making under uncertainty
- Lots of other advanced AI courses in other areas

Organization

- Check Web page!
  - lots of info will be found there, including lecture slides, references, announcements, etc.
  - Newsgroup important! -- ut.cdf.csc384h
- Text: *Computational Intelligence, A Logical Approach*; Poole, Mackworth, Goebel
- Classes: Keep up with the readings!
  - see Web page for schedule, readings, and slides
- Tutorials: Thursday 6PM (just before class)
  - sections to be assigned; see Web page
- Five assignments, two midterms, one exam
  - 35% / 20% / 45% / approximate dates on Web pg

General Lecture Announcements

- Last time
  - nothing
- Today (rest of class)
  - RRSs and DCL
- Readings:
  - Today II : Ch.1, Ch.2.1-2.4;
  - Next week: Ch.2.5, 2.6, 2.7 (excl. SLD/top-down proofs)
- Announcements:
  - See me immediately if you don’t have prereqs
  - Course Accounts created, see Web page
  - See Web page for tutorial section assignment

Logical KR and Reasoning

- We start with a specific way of doing logical KR and logical reasoning
  - since FOL and definite clauses (Prolog) familiar: fast
- Representation and Reasoning Systems (RRS)
  - how do we represent knowledge about the world in a computer/agent
  - how can the agent reason with (draw conclusions from) that knowledge
  - initial focus on static environments (no uncertainty)
  - we’ll take a formal, logical approach

RRSs require three components

- Specification:
  - provides firm, formal foundations for sentences we use to express knowledge
  - the meaning of those sentences (what facts do they correspond to)
  - how we draw conclusions (derive new facts) from the initial set of facts (e.g., answer questions)
- Implementation:
  - how we implement the spec. on a computer (later…)
- Representational Methodology:
  - how we use the system to represent specific types of knowledge
  - some ways more natural, compact, efficient

Specifications

- Specifications require three components
- (Logical) Representation Language:
  - syntax used to express sentences (knowledge)
- Semantics:
  - method for determining the meaning of sentences
- Proof Procedures:
  - how to answer questions, derive new facts
- Our language: Definite Clause Language (DCL)
  - subset of FOL (no disjunction, negation; tricks later)
  - forms the basis of logic programming (e.g., Prolog)
  - restrictive, but very powerful (will do all we need)
Assumptions

- Assumptions: we'll start with (some justify DCL)
  
  (1) IR: Agent's world usefully described in terms of individuals and relations (properties) of them
  
  - Example: Computer travel agent domain
    - Individuals: clients, destinations, hotels, airlight segments, airlines, prices, dates, ...
    - Properties: cost (hotel/segment), reliability (airline), rating (hotel), satisfied (client), carrier (segment),...
    - Relations: desirable (dest'n for client on date); available (hotel, date); location (hotel, city), etc.

DCL Formally

- Defined structurally (familiar from FOL)
- We'll use Prolog-like notation
  
  - A constant is a (lowercase) symbol
    - begins with lowercase letter, or a number
  
  - A function symbol is a (lc) symbol
  
  - A predicate symbol is a (lc) symbol
  
  - A variable is a (uppercase) symbol
    
    Each func and pred symbol has a specific arity (number of arguments)

Intuitions

- Terms denote individuals; constants denote individuals; functions build up ind's out of others
  
  - bill dick jane father(jane) father(father(jane))
  
  - X father(X) hotel7 rating(hotel77) cost(hotel7)

- Atoms denote facts that can be true of false about the world
  
  - father_of(jane, bill) female(jane) system_down
  
  - satisfied(client15) satisfied(C)
  
  - desires(client15, rome, week29) desires(X,Y,Z)
  
  - rating(hotel7, 4) cost(hotel7, 125)

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Example Clauses

happy(client7) <- desires(client17,rome,week29) &
    available(hotel7, week29) & location(hotel7, rome)
    & rating(hotel7) > 4.

happy(C) <- desires(C, Dest, Date) & available(H, Date)
    & location(H, Dest) & rating(Hotel7) = R
    & minQuality(C) = R.

happy(C) <- desires(C, Dest, Date) & available(H, Date)
    & location(H, Dest) & rating(Hotel7) > R
    & minQuality(C) = R & offerTravelMugC.

desires(client17, rome, week29)
desires(client17, rome, week29)
location(hotel7, rome)