

CSC384: Intro to Artificial Intelligence

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1

Artificial Intelligence (AI)

- What is AI?
- What is intelligence?
- What features/abilities do humans (animals?) have that you think are indicative or characteristic of intelligence?

Webster says: a. the capacity to acquire and apply knowledge. b. the faculty of thought and reason. ...

- *abstract concepts, mathematics, language, problem solving, logical reasoning, emotions, morality, ability to learn/adapt, etc...*

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2

Some Definitions (Russell+Norvig,1995)

The exciting new effort to make computers that think... machines with minds in the full and literal sense [Haugeland 85]	The study of mental faculties through the use of computational models [Charniak & McDermott 85]
[The automation of] activities that we associate with human thinking, such as decision making, problem solving, learning [Bellman 78]	The study of computations that make it possible to perceive, reason and act [Winston 92]
The art of creating machines that perform functions that require intelligence when performed by a human [Kurzweil 90]	A field of study that seeks to explain and emulate intelligent behavior in terms of computational processes [Schalkoff 90]
The study of how to make computers do things at which, at the moment, people are better [Rich & Knight 91]	The branch of computer science that is concerned with the automation of intelligent behavior [Luger & Stubblefield 93]

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3

Some Definitions (Russell+Norvig,1995)

Systems that think like humans	Systems that think rationally
Systems that act like humans	Systems that act rationally

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4

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 defn. breaks down as follows:
 - Two in terms of **thinking**, two **acting**
 - Two in terms of **what humans do**, two **rationality**
- Consider relative advantages of each

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5

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?

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6

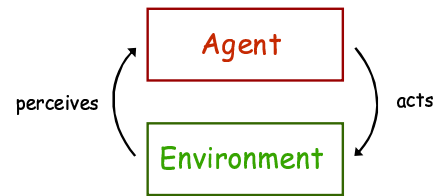
Agency

- 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)

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7

Agent Schematic (I)

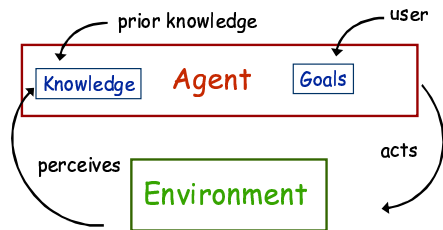


- Thermostat, ROSI, Web browser, Craig, you, software agent, etc.

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8

Agent Schematic (II)



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

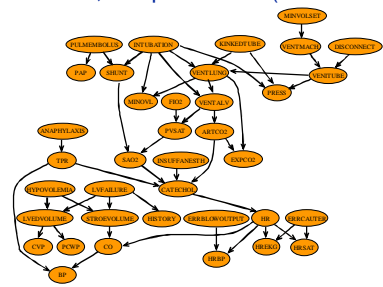
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9

Monitoring Intensive-Care Patients

The “alarm” network

37 variables, 509 parameters (instead of $\sim 2^{52}$)



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10

ALVINN

- Pomerleau, et al. NAVLAB Group (CMU)



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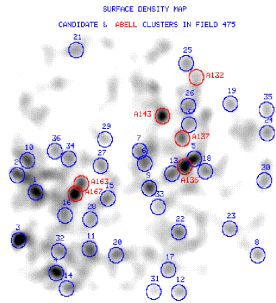
11

NAVLAB

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12

Autoclass (Cheeseman et al.)



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13

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)

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14

Degrees of Intelligence

- 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...

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15

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*

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16

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

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17

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

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18

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

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19

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

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20

General Lecture Announcements

- Last time
 - nothing
- Today (rest of class)
 - RRSs and DCL
- Readings:
 - Today □ : 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

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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

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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

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23

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)

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24

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, airflight 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.

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25

Assumptions

(2) **DK**: Agent's knowledge is *positive* and *definite*

- no imprecise or negative knowledge
- OK: *home(craig, toronto)*
- not OK: *home(craig, toronto) OR home(craig, halifax)*
- not OK: *NOT home(craig, sherbrooke)*
- definiteness not the same as completeness

(3) **SE**: Agent's environment is static

- this is only temporary (once we get to problem solving, planning, decision making, we'll relax this)

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26

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 fctn and pred symbol has a specific arity (number of arguments)

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27

DCL Formally

- A **term** is either:
 - a variable
 - a constant
 - an expression of the form $f(t_1, \dots, t_k)$ where (a) f is a function symbol; (b) k is its arity; (c) each t_i is a term
- An **atom** is an
 - expression of the form $p(t_1, \dots, t_k)$ where (a) p is a predicate symbol; (b) k is its arity; (c) each t_i is a term
- Note: if p takes zero args, we write " p ", not " $p()$ "
if f takes zero args, it is a constant

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28

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(hotel7) cost(hotel7)
- Atoms denote facts that can be true or 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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29

DCL Formally

- A **body** is $a_1 \& a_2 \& \dots \& a_n$ where each a_i is an atom
 - a *conjunction* of atoms (denotes that *each* is true)
- A **rule** is $a \leftarrow \langle \text{body} \rangle$ where a is an atom
- A **fact** is $a.$ where a is an atom
 - note the period
 - it's a rule with an empty body
- A **definite clause** is a fact or a rule
- A **knowledge base (KB)** is a set of definite clauses

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30

Example Clauses

```
happy(client17) <- 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 & offerTravelMug(C).
```

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

... ..