Artificial Intelligence

cs4701

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• What is the field of AI?
  – AI is a branch of computer science that is concerned with the automation of intelligent behavior.
  – AI is the science of making machines do things that would require intelligence if done by peoples (Minsky)
• What is human intelligence?
  – Intelligence is the ability to form plans to achieve goals by interacting with the information-rich environment.
• Is intelligent behavior the same for a computer and a human?
Turing test

“A computer can be considered smart only when a human interviewer conversing with both an unseen human being and an unseen computer cannot determine which is which.” – Alan Turing
History of AI has deep roots

• 4th cent. BC: Aristotle studied mind and thought, defined formal logic
• 14-16th cent. Renaissance’s idea that all natural or artificial processes could be mathematically analyzed and understood
• 18th cent.: Descartes emphasizes the distinction between mind and body/brain
• 19th cent.: advances in science and understanding nature made the idea of creating artificial life seem plausible
  – Shelley’s Frankenstein raises moral and ethical question of the whole idea of AI creation
• 19-20th cent.: advances in logical formalism: Boole’s algebra, Frege’s predicate calculus
• 20th cent.: first computers for numeric calculations!!
• 1956 – birth of AI within Computer Science: John McCarthy and Marvin Minsky organized the Dartmouth Conference
AI played a key role in the development of new programming paradigms:

- **LISP**: quick search of data within a list. First language with untyped data
- **Prolog**: inferences based on First Order Logic. Prolog uses list structures but each structure represents an inference rule, constituted of a conclusion and a set of conditions.

List processing
Logical programming
}\[
\text{Symbolic processing}
\]

Neural nets is an example of non-symbolic AI
Examples of Symbolic Processing

• Understanding English
  What Universities are based in the city of New York?

• Reasoning based on general principles
  If the patient is male, then the patient cannot be pregnant

• Symbolic mathematics
  \[ Y = M \times X + B: \text{find derivative of } Y \text{ with respect to } X \]
Support for symbolic programming

• Symbol structures are often represented by lists. Lists consist of symbols and other lists (LISP)
  (friends jim (joe mary anne))

• Manipulating symbol structures often involves pattern matching (Prolog)
  (friends jim X),
  where X is a variable matching any list
  match X to (joe mary anne)
Pattern recognition and matching

When program makes observations of some kind, it is often programmed to compare what it sees with a pattern. For examples, a vision program may try to match a pattern of eyes and a nose in a scene in order to find a face.
Why study pattern matching

- One of the problems when trying to make intelligent systems is that computers are fundamentally stupid and inflexible. To a computer, things are either true or false.
- Anything we can do to make a program more flexible is a big advantage.
- Pattern matching allows us to do this, and ask whether a list matches a general structure.
- We use the pattern matcher by using the matches operator. `[a b c d]` matches `[a b c d]` => ** <true>
Two major issues of symbolic AI

• How to translate the real world into an accurate, adequate symbolic description (speech understanding, vision)
• How to perform reasoning on the above data
Expert systems

A class of computer programs intended to serve as consultants for decision making. These programs use a collection of facts, rules of thumb, and other knowledge about a limited field to help make inferences in the field. They differ substantially from conventional computer programs in their goals may have no algorithmic solution, and they must make inferences based on incomplete or uncertain information.
Motivation
for creation of systems that could imitate a work of an expert in some domain

- Knowledge is a scarce resource
- Knowledge is power and thus has its price
- Training, internship, and experience takes time and is expensive
- Expert systems could reduce the cost of training, synthesis, design, control, diagnostics, . .
- Expert systems make knowledge available to a wider audience and improve performance.
- Expert systems can improve safety of human workers by assisting in environments that may be hazardous to humans.
- It is possible that an expert system that synthesizes the knowledge of many experts could perform in ways that no single expert can.
- The expertise can be codified in permanent form, unlike human experts who may retire, quit, die, etc.
Expert Systems

• Expert system is a computer system that simulates the routine reasoning of a human expert with advanced knowledge in a particular area (chemistry, medicine)
• Domain-dependent knowledge base created by experts
• Reasoning about input data according to the built-in knowledge
  – Context trigger (when should rule be used)
  – Condition (if X ...)
  – Conclusion (… then Y)
  – Having some input match condition (input) -- conclusion (output) rule
Rule-based expert systems should contain, at the very least, the **three** components:

- **Data-base**: domain-specific facts and heuristics associated with the problem.
- **Knowledge-base**: relevant common knowledge, historical information, statistical data engineering coefficients, etc.
- **Inference engine**: a reasoning system that acts upon the domain-specific knowledge, general data base and problem-specific input from the user
How an expert system works:

Expert system tests whether the pattern part (set of effects) matches the database. If yes – output the disease or several possible diseases with some probabilities.
Weaknesses of expert systems

- Brittle of unforeseen data
- Cannot learn from experience
- Hard to maintain (add/delete/modify rules)
- Knowledge acquisition bottleneck (only experts can populate knowledge-base)
- Cannot handle incomplete or probabilistic data
NLP as a branch of AI

• Natural language is not possible to completely formalize:
  – lexicon can never be complete
  – though it is possible to create a list of the major syntactic rules, it is impossible to enumerate all possible exceptions
  – very hard to represent semantics

• A lot of methods used in NLP are language-dependant
Example of a dialogue

A: What is the complement of the John F. Kennedy?
B: 2500

A: The New Jersey?
B: 2200

In order to answer the first question B must know that the John F. Kennedy is a navy ship and that in this context complement refers to the crew, and thus A probably wants to know how large the crew is. To answer the second B needs to know first that it is a question and second that it is basically the same question as the first with a different subject. Thus even a short conversation requires considerable knowledge to understand.
ELIZA

• Joseph Weizenbaum, 1966
• Eliza simulates a dialogue between a user and a computer program (Eliza itself) on a pre-defined subject
• The user can increasingly improve the quality of the conversation Eliza produces, like Eliza in Bernard Shaw’s Pygmalion
ELIZA's architecture

- Very simple. She/it gives one of four types of response, in a readline loop. The loop is:
  
  ```
  REPEAT
  - get input from user
  - generate a response
  - print it
  ENDREPEAT
  ```

- The four types of response are:
  - syntactic pattern matching
  - keywords
  - memory
  - default

- [http://www-ai.ijs.si/eliza/eliza.html](http://www-ai.ijs.si/eliza/eliza.html)
Some rules in Eliza

- (X me Y) → (X you Y)
- (I remember X) → (Why do you remember X just now?)
- (My {family-member} is Y) → (Who else in your family is Y?)
- (X {family-member} Y) → (Tell me more about your family)
- There should a rule with empty left side which is used when no other rules can be matched:
  - Very interesting. Please, go on.
- If two or more rules can be matched then the rule should be chosen at random
- Think of your own rules :)

- Very interesting. Please, go on.
More on Eliza

• Does Eliza produce an imitation of an intelligent dialogue
• Does Eliza understand language, at least structure of the sentence, syntax
• Do you think Eliza has any representation of the world knowledge
• Does Eliza pass Turing test
What program can pass Turing test

- Expert system
- Eliza
- Any other program you know