Artificial Intelligence
CS 6364

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Section 1
Introduction to AI
Outline

- Definitions
- AI Fields
- Successes and Failures
- Inferences and Entailments
- Computational Effectiveness
- Probabilistic Reasoning
Definition

AI is the study of computations that make it possible to perceive, reason and act. (Winston)

One may say that AI is: computational reasoning

Notice: 1) Definition implies computations, programs, computers (computer science and engineering)

2) Definition implies perception, reasoning, action—which are human qualities

A bad definition is: AI is the study of computers that perform human-like activities.

This includes emotions, feelings, smelling, etc. which are not part of AI (at least not now).
Other definitions of AI

- Systems that think like humans
  - Cognitive modeling approach
- Systems that act like humans
  - Activities that require human intelligence: communicate, reason, learn, plan, etc.
  - Turing test
- Systems that think rationally
  - Activities related to human thinking, arriving to logical conclusions
- Systems that act rationally
  - Activities related to rational human activities, that have a purpose
Some Task Domains of AI

I. Mundane Tasks
   Perception
      - Vision
      - Speech
   Natural Language
      - Understanding
      - Generation
      - Translation
   Planning
   Commonsense reasoning
   Robot control

II. Formal Tasks
    Games
       - Chess, backgammon, etc.
    Mathematics
       - Logic, geometry, calculus

III. Expert Tasks
     Engineering
        - Design
        - Manufacturing planning
     Scientific analysis
     Medical diagnosis
     Financial Analysis
Some successes and Failures of AI

Successes
- Expert systems
  - Nonlinear dynamics
  - Medicine
  - CAD
- Learning from examples
  - Discovering a new star
- Robot control, planning
  - Many robots are built using AI
- Natural Language
  - Information retrieval
  - Translation systems
- AI used in combination with Software Engineering in many applications
- Military applications

Failures
- Most systems are toy systems working in some small domains
- AI did not deliver in 1980’s as it was expected. 5th Generation computers (project that started in Japan and picked up in US failed to build an AI computer—of good quality ⇒ It was an “AI winter”).
Fundamental Hypothesis of AI

Intelligent systems can be constructed from explicit, declarative knowledge bases which in turn are operated on by general, formal reasoning mechanisms.

Thus, of central importance to the field of AI is:
- Knowledge representation and
- Reasoning

Intelligence is knowledge.

AI systems are synonymous of knowledge-based systems.

Leibnitz (1646-1716) wanted to mechanize intelligence. He dreamed of a calculus of ideas, where truth could be determined by manipulating an “alphabet of thoughts” (characteristica universalis). This was supposed to be similar with Newton’s calculus which manipulates numbers to preserve value. Leibnitz’ calculus was supposed to preserve the truth.
Examples of Computational Inferences

An inference is a (reasoning) process that provides new facts unstated in a knowledge base.

Example 1. Consider the sentences
S1: John hit the ball with a bat.
S2: It landed far away.

An inference system would provide first a correct interpretation of these two sentences. One interpretation (most plausible) is that a male named John held a club in his hands, and the club touched with some force a round object, the ball, which then moved through the air and finally fell to the ground due to gravitational force.

To build a machine to provide such interpretations (inferences) for broad English domain is a monumental task.
Examples of Computational Inferences

Example 2. (more modest)
Consider that we are building a KB system to assist in providing a medical treatment. We want to include which patients are allergic to which medications. A simple database (DB) may be:

S1: Ralph is allergic to sulfa.
S2: Trixie is allergic to penicillin.
S3: Alice is allergic to tetracycline, etc.

Simple retrieval operation will tell us whether or not to use a drug in a therapy. However, drugs are related to one another:
S4: All patients allergic to penicillin are also allergic to ampicillin.

From these statements we conclude that:
S5: Trixie is allergic to ampicillin.

This is a new fact not stated in the KB, and cannot be simply retrieved from KB.
The truth of a conclusion is implicit in the truth of the two premises. We say that conclusion is entailed by the premises.
Computing Entailments (Inferences)

⊨ means entails

KB ⊨ α means that α is entailed from the KB.

α is a truth that may be derivable from the KB. We need rules of inference that allow us to extract truth from KB.

The central goal of AI is to build KB systems capable of determining truths about the world implied by the contents of the KB, that is go beyond explicitly stated facts.

Some differences between Databases and KB.

<table>
<thead>
<tr>
<th>DB</th>
<th>KB</th>
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<tr>
<td>- Stores simple facts</td>
<td>- Stores complex facts</td>
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<tr>
<td>- In DB there is no notion of entailment (only complex queries)</td>
<td>- KB deals with incomplete info. There is an inference mechanism that extracts new facts not stated explicitly in KB.</td>
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The field of AI is complex because intelligent behavior is complex. AI systems were built from limited domains. (Examples of systems in limited domains).

It is not possible to expand from limited domains to larger, more general domains by simply adding more facts and rules.

Intelligence is not a linear function. Solutions do not scale up.

Computational effectiveness is how to interconnect many domains to make more complex domains.

For a system to be intelligent, it must be capable of acting within some specified time. The required time is usually imposed by the environment. This is sometimes called computational effectiveness constraint. It is a basic property of intelligent systems.
Computational Effectiveness

- Parallel processing provides speed, and speed helps with computational effectiveness.

  Open question: Can speed (PP) provide intelligence?

- Problems with von Neumann architectures when used in AI—bottleneck. Only an insignificant portion of system’s knowledge participates in processing. Intelligent behavior requires frequent interactions between many pieces of information. Memory cells should not only hold information, but be able to process, and exchange information.
Probabilistic reasoning

- Often, information available is incomplete, vague, or uncertain.

- Probabilistic reasoning uses probabilistic logic where the truth values of sentences are probabilities.
**Monotonic vs Non-monotonic Reasoning**

- In monotonic reasoning new true facts are added to the KB. The KB grows monotonically.

- In non-monotonic reasoning some facts are invalidated in face of new evidence and replaced with other possible contradictory facts. Such reasoning is more realistic, closer to human thinking.