CSC384

Introduction to Artificial Intelligence

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Part I

Notes

CHAPTER

INTRODUCTION TO ARTIFICIAL INTELLIGENCE 1

1.1 Artificial Intelligence (AI)

Artificial Intelligence is a branch of computer science utilizing *computational* ideas and examining how we can achieve *intelligent* behavior through computation.

1.1.1 Intelligence

The ability to apply knowledge to manipulate one's environment or to think abstractly as measured by objective criteria (such as tests)

— *Merriam-Webster Dictionary*

Human features that are considered intelligent includes the ability to learn, understand, reason, plan, communicate, and perceive. For example, a human can learn to play a game, understand the rules of the game, reason about the best moves to make, plan a sequence of moves, communicate with other players, and perceive the state of the game.

1.1.2 The Turing Test

The Turing Test is a test of a machine's ability to exhibit intelligent behavior equivalent to, or indistinguishable from, that of a human. The test was introduced by Alan Turing in his 1950 paper, *Computing Machinery and Intelligence*, while working at the University of Manchester [1]. Turing proposed that a human evaluator would judge natural language conversations between a human and a machine designed to generate human-like responses. The evaluator would be aware that one of the two partners in conversation is a machine, and all participants would be separated from one another. The conversation would be limited to a text-only channel such as a computer keyboard and screen so that the result would not be dependent on the machine's ability to render words as speech. If the evaluator cannot reliably tell the machine from the human, the machine is said to have passed the test. The test does not check the ability to give the correct answer to questions; it checks how closely the answer resembles typical human answers. The conversation is limited to a single topic chosen by the examiner.

- Turing provided some very persuasive arguments that a system passing the Turing test is *intelligent*.
  - We can only really say it *behaves* like a human
  - **No guarantee** that it *thinks* like a human
- The Turing test does not provide much traction on the question of **how to build** an intelligent system.

Why not just simulate human's brain?

- Brains are very good at making rational decisions, but **not perfect**.
- Brains **aren't as modular** as software, so hard to reverse engineer!
- Computers and Humans have quite **different abilities**.
  - *Memory* and *simulation* are key to decision making.
  - *Perceptual tasks* (vision, sound, etc.) are effectively accomplished by architectures related to the way the brain works (deep neural networks).

1.1.3 Computational Intelligence

Artificial Intelligence tries to understand and model *intelligence* as a **computational process**. Thus we try to construct systems whose **computation** achieves or approximates the desired notion of intelligence.

Other areas interested in the study of intelligence lie in other areas or study, e.g., cognitive science which focuses on human intelligence. Such areas are very related, but their central focus tends to be different.

1.2 Rationality

Formally, we can define an **agent** as something that **perceives** and **acts** in an *environment*. An agent can be a *human*, a *robot*, or a *software agent*.

A **rational agent** is one that acts so as to achieve the best outcome or, when there is uncertainty, the best expected outcome. Rationality is distinct from omniscience (knowing everything) and omnipotence (being able to do anything). Rationality maximizes **expected utility**, which is the sum of the utility of each possible outcome of an action weighted by its probability of occurring.

Rationality is measured by the *outcome*, not the *action* itself. It is a precise *mathematical* notion of of what it means to do *the right thing* in any particular circumstance. Provides

- A **precise mechanism** for analyzing and understanding the properties of this ideal behaviour we are trying to achieve.
- A **precise benchmark** against which we can measure the behaviour the systems we build.

Trying/Expectation

Rational action is not always equal to rational decision.

1. We often don't have **full control** or **knowledge** of the world we are interacting with.
2. We usually don't know **precisely** what the **effects** of our actions will be.

In some contexts we can *simplify* the computational task by assuming that we do have full knowledge/control.

1.3 Subareas of AI

A common misconception is to equate AI with Machine Learning. But AI is much more than that. This course will not focus on Machine Learning, but rather on the other subareas of AI. What we cover is not an exhaustive list of all subareas of AI, but rather a starting point for further exploration.

- **Perception**: vision, speech understanding, etc.
- **Machine Learning**, **Neural Networks**
- **Robotics**
- **Natural Language Processing**
- **Reasoning and Decision Making**
    - **Symbolic Knowledge Representation**
    - **Reasoning** (logical, probabilistic)
    - **Decision Making** (search, planning, decision theory)

1.3.1 Further Courses in AI

- Perception: vision, speech understanding, etc.
    - CSC487H1 "Computational Vision"
    - CSC420H1 "Introduction to Image Understanding"
- Machine Learning, Neural networks
    - CSC311H "Introduction to Machine Learning"
    - CSC412H "Probabilistic Learning and Reasoning"

- CSC413H1 “Neural Networks and Deep Learning”

- Robotics
  - Engineering courses
- Natural language processing
  - CSC401H1 “Natural Language Computing”
  - CSC485H1 “Computational Linguistics”
- Reasoning and decision making
  - CSC486H1 “Knowledge Representation and Reasoning”

1.4 A Brief History of AI

- 1940-1950: Early days
  - 1943: McCulloch & Pitts: Boolean circuit model of brain
  - 1950: Turing’s “Computing Machinery and Intelligence”
- 1950—70: Excitement: Look, Ma, no hands!
  - 1950s: Early AI programs, including Samuel’s checkers program, Newell & Simon’s Logic Theorist, Gelernter’s Geometry Engine
  - 1956: Dartmouth meeting: “Artificial Intelligence” adopted
  - 1965: Robinson’s complete algorithm for logical reasoning
- 1970—Early 2000: Knowledge-based approaches
  - 1969—79: Early development of knowledge-based systems
  - 1980—88: Expert systems industry booms
  - 1988—93: Expert systems industry busts: “AI Winter”
  - 1997: IBM’s Deep Blue beats chess grandmaster Garry Kasparov
- Early 2000— present: Statistical approaches
  - Resurgence of probability, focus on uncertainty
  - Agents and learning systems... “AI Spring”
  - 2007: DARPA Urban Challenge – CMU autonomous vehicle drives 55 miles in an urban environment while adhering to traffic hazards and traffic laws.
  - 2016: AlphaGo beats 9-Dan pro Go player Lee Sedol
  - 2017: AlphaGo Zero – learns by playing with itself
  - 2022: Large Language Models (LLM) Chat Generative Pre-trained Transformer, which has been fueled by advances in Neural Net architecture and access to big data.

There are many **unsolved** problems yet...including lots of **legal/ethical** ones.

CHAPTER 2

SEARCH

CHAPTER

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GAME TREE SEARCH

CHAPTER

CONSTRAINT SATISFACTION PROBLEMS 4

CHAPTER

5 REPRESENTING AND REASONING UNDER UNCERTAINTY

CHAPTER

SYMBOLIC KNOWLEDGE REPRESENTATION AND REASONING

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Part II

Appendices

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