COMP 424: Artificial Intelligence

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Notes from Jackie Cheung's Winter 2018 lectures and slides (which are based on slides by Joelle Pineau).

Contents

1 Introduction to AI 01/08/18

Class website. Material will be posted on myCourses.

Some of the relevant terms we'll be hearing in this course

- Planning
- Reasoning
- Search (very important)
- Modeling
- Learning (big part that we will address during the second half of the semester)
- Decision-making
- Perception

- Language
- Knowledge

Course Topics

- Search
- Game playing
- Logical reasoning
- Classical planning
- Probabilistic reasoning
- Learning probabilistic models

- Post midterm:
- Reasoning with utilities
- Sequential reasoning and decision-making
- Learning complex sequential decisions
- Applications

1.1 Biological Intelligence

Before we talk about artificial intelligence, let's talk about biological intelligence.

Sensory processing used to perceive things

- Visual cortex
- Auditory cortex
- Somatosensory cortex

Motor cortex then used to act on things

Cognitive functions

- Memory
- Reasoning
- Executive control
- Learning
- Language

Biological intelligence is a mix of general-purpose and special-purpose algorithms.

General-purpose

- Memory formation, updating, retrieval
- Learning new tasks

Special-purpose

- Recognizing visual patterns
- Recognizing sounds
- Learning language

All are integrated seamlessly and we are not always aware of what is going on.

1.2 Artificial Intelligence

What is AI? There are several answers.

- Modeling human cognition using computers
- Studying problems that others can't solve, i.e. some complex optimization problems like scheduling and minimizing conflicts. Perhaps this is too hard to solve for people with pen and paper.
- Game playing, machine learning, data mining, speech recognition, computer vision, web agents, robots
- Medical diagnosis, fraud detection, genome analysis, object identification, space shuttle scheduling, information retrieval

Solving AI may be the solution to all problems, as we would just write an AI to solve it.

Working definition Developing models and algorithms that can produce rational behaviors in response to incoming stimulus and information.

Mapping to human intelligence We can map human intelligence to certain aspects of AI.

- Visual cortex relates to computer vision
- Auditory cortex, signal/speech processing
- Somatosensory cortex, haptics
- Motor cortex, robotics
- Memory, knowledge representation
- Reasoning, search/inference
- Executive control, planning/decision-making
- Learning, model learning
- Language, language understanding

Will not be focusing on the sensory part in this course, mainly the core cognitive functions.

Different Goals of AI

- Thinking like a human
- Thinking rationally
- Acting like a human
- Acting rationally (the focus of this course, as we may note with the working definition)

We don't have good answers on how to model thinking, so it is very hard to model the first two points. People have proposed several models, like a logic based model, but others disagree. It is not easy to observe people thinking, but it is easy to observe people's actions. Acting humanly would be nice, but it has several problems.

Acting Human It's hard to define acting human but also perhaps we may not always want to act like a human.

Alan Turing made the **Turing test** with a human judge and one human and one AI agent on the other side. The goal is for the judge to not be able to tell which one is the human and which one isn't. It is still not very easy to evaluate AI systems to determine whether or not they "act human" or not. Also, people may make different judgments for the same thing, i.e. it can be shown in a positive way and the person might decide differently in comparison to it being shown in a negative way, yet the choice is still numerically the same.

Acting Rationally It's about doing the "right" thing, although this has to be decided by the creator. Essentially, the AI must maximize goal achievement with its available information and resources. Doesn't always require thinking, but often does.
The AI agent does actions influencing the world and then gets information from its task and environment (perception). Might perceive before acting. In two player games, the AI thinks based on what the opponent played. But what if we exploit that and play based off what the opponent will play if we play some move.

Rational Agents This course is about making rational agents. Agents perceive and act. Our goal is to learn a function that maps percept histories to actions.

$$f : P^h \to A$$

Might not always act the same way based off the percept history, i.e. a game may want to implement some randomness. This function does not mean the agent is deterministic. A rational agent implements this function to maximize performance (measured by goal achievement, resource consumption and more).
We have resource constraints (like time, space, energy, bandwidth) that make perfect rationality impossible. So instead our objective is to find the best function for given information and resources.

1.3 History of AI

- ENIAC was the first super-computer created in 1946
- Early work done in 50s, perceptron and agent that can play checkers
- Dartmouth Conference in 1956 to propose studying AI

Early Ambitions Make programs with similar intelligence as people, such that they can prove theorems, play chess and have a conversation. Logical reasoning was heavily used and learning was important. Didn't want a system that can only do one thing, like play checkers, wanted a very general purpose machine, but did not workout. Since people were too optimistic about AI, it lead to many disappointments and the field grew slower.

Recently More math heavy, lots of probability theory, decision theory and statistics. Aimed for specific problems instead of general problems. Some may argue that this helps in the short term, but not the long term. More and more people are thinking about how we can go back to thinking about putting all the sub-fields together, like how AI originally was aiming for. AI is now a collection of sub-fields.

Chess Playing (1997) Perception consists of advanced features of the board, each spot on the board and how certain positions are better than others. Actions consist of making a move, there are concrete actions in chess, valid and invalid moves. Reasoning, searching for a move and evaluating possible board positions, what kind of state it will leave you in. Computer resources are important, the more resources you have, the more you can look ahead.

Poker Playing (2008) Perception consists of the features of game and the actions consist of moves.

Jeopardy (2011) Jeopardy is about trivia, sometimes worded in a convoluted way so some rational thinking is required. Perception would be clue you get and the category, action would be deciding whether or not you hit the buzzer and what your response is. Reasoning would be searching through database of knowledge, looking for relevant information.

Atari (2015) Learning, gets a signal that signifies whether or not the action the machine is performing is good or not and the agent will tend to do things that are better.

Self-Play for Go (2017) Original version of AlphaGo learned by original plays by human experts and additional training reinforcements to get good, but this version just played by itself and got good, did not need to look at human games or need human help.

So we have seen great results in AI, but games are much more constrained than other things, such as natural language processing, the amount of actions may be infinite, say if we don't bound the length of the sentence, while in games there are only a finite number of actions. There is also no good reward/good behavior, like there is in games (i.e. you're winning). In some ways, our AI systems are better than us (i.e. games), but in many other ways they aren't, some of the domains we want to apply AI to are much more complex.

Stock Market AI agents are now much more involved in the stock market, they tell us when to trade given the rates and the news. Perception consists of rates and news, actions are trades and reasoning is putting all this information together. These automated trading agents are so quick now that it actually matters how close they are to the stock/server.

Medical Diagnosis (1992) Perception: symptoms, test results, actions: suggest tests, make diagnosis, reasoning: bayesian inference, machine learning, Monte-Carlo. Might have to make decisions with missing information, what's the best choice?

City Driving (2014) Google cars, almost no accidents.

Amazon Echo (2016) Consumer-grade AI for less than $200 US that is useful to us.

AI and the Web There is a lot of information available on the web in order for agents to learn, like search engines and social networking websites. So many interactions that we must now use large data processing algorithms.