0. Course Details & Introduction

COMP7404
Computational Intelligence and Machine Learning

Dirk Schnieders

Course Staff

- Instructors
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- TA
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    - Consultation hours: Tue 5:00pm - 6:00pm & by appointment

Schedule

#	Date	Venue	Time	Topic*
1	2 Sep	CYP-P4	7pm - 10pm	Course Details / Uninformed Search
2	9 Sep	CYP-P4	7pm - 10pm	Informed Search
3	16 Sep	CYP-P4	7pm - 10pm	Local Search CSP
4	23 Sep	CYP-P4	7pm - 10pm	Markov Decision Process
5	30 Sep	CYP-P4	7pm - 10pm	Reinforcement Learning
6	7 Oct	CYP-P4	7pm - 10pm	Perceptron & Adaline
7	21 Oct	CYP-P4	7pm - 10pm	Logistic Regression, Support Vector Machines, Decision Tree Learning, KNN
8	28 Oct	CYP-P4	7pm - 10pm	Evaluation / Tuning & Ensemble Learning
9	4 Nov	CYP-P4	7pm - 10pm	Presentations
10	11 Nov	CYP-P4	7pm - 10pm	Presentations

Assessment

- Assignments (30 %)
  - A1 (8%): Search (13 Sep - 27 Sep)
  - A2 (8%): Adversarial Search (27 Sep - 11 Oct)
  - A3 (8%): Reinforcement Learning (25 Oct - 8 Nov)
  - A4 (6%): Machine Learning (11 Nov - 25 Nov)
- Group project (20 %)
  - Read and implement machine learning research paper
  - Presentation to class (8 minutes presentation)
  - Max 36 Groups
  - Max 4 students per group
- Final examination (50 %): written, closed book, 2 hours

Prerequisite

- Python programming
  - Students without strong experience may spend a lot of time on assignments
- Basic linear algebra, calculus and statistics

Assessment - Project - Group Selection

- Select your group on Moodle
  - Start: 16 Sep
  - Deadline: 23 Sep 23:59
  - We will randomly assign a group for you if you don’t make a selection by the deadline
- Member swapping
  - Allowed if approved before start of project
    - All group members of both groups must agree

Assessment - Project - Paper Selection

- Read a machine learning paper
- Implement / test the paper
  - TensorFlow 2 / PyTorch on CS GPU Farm
  - Employ own test/training data
  - Make your code available to others
- List of project topics will be made available on 28 Sep
- Topic selection
  - On 7 Oct in-class
    - First come first serve
    - Done by group leader
  - Deadline: 8 Oct 23:59

Plagiarism

- What is Plagiarism ?
  - https://tl.hku.hk/plagiarism/
- If a student commits plagiarism, with evidence after investigation, no matter whether the student concerned admits or not, a penalty will be imposed
- First Attempt: the student shall be warned in writing and receive zero mark for the whole assignment or the whole test; if the student does not agree, s/he can appeal to the Programme Director within a week
- Subsequent Attempt: May impose any of the following penalties: a published reprimand, suspension of study for a period of time, fine, or expulsion from the University
- Both the student who copies and the student who offers his/her work for copying shall be penalized

Course Materials

- Available on Moodle
  - Use the provided materials responsibly
  - For your own research and private study only
  - Don’t distributed to others without the appropriate authorization
    - We do not hold copyright for most materials

References and Acknowledgements

- Textbooks
  - Artificial Intelligence: A Modern Approach, Third Edition, Stuart Russell & Peter Norvig
  - Python Machine Learning (PML), Third Edition Sebastian Raschka & Vahid Mirjalili
  - Introduction to Machine Learning (IML), Third Edition Ethem Alpaydin
- Other Courses
  - CS188, Berkeley
  - Machine Learning Crash Course, Google
  - Machine Learning, Coursera
- Additional references (if any) will be listed on the lecture slides

Tools

- Provided examples and exercises will use the following tools
  - Python 3
  - NumPy
  - SciPy library
  - scikit-learn
  - Matplotlib
  - Pandas
  - Tensorflow
  - Jupyter Notebook
- All of the above can be installed conveniently with Anaconda
  - We recommend to use Google CoLab

Discussion Forum

- If you have questions about course materials, please **use the forum**
  - Answer questions from other students!

Q & A

Introduction

Intelligence

- We call ourselves Homo sapiens
  - Latin: Wise Man
  - Intelligence is important to us
- For thousands of years, we have tried to understand how we humans think
- Intelligence is most widely studied in humans, but has also been observed in animals and in plants

Artificial Intelligence

- AI goes further than just understanding intelligence
  - It attempts to build intelligent entities
- Is AI science, or is it engineering?
  - AI's science goal
    - To understand the principles and mechanism that account for intelligent action
  - AI's engineering goal
    - To design intelligent artifacts that can survive and operate in the physical world and solve problems of considerable scientific difficulty at high levels of competence

Goal of AI

- Should we create machines that …

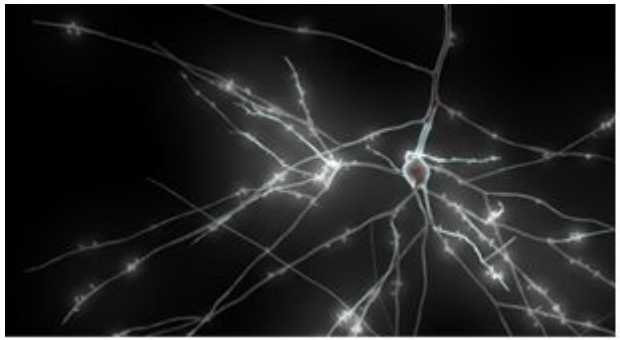
A. Think Humanly
B. Act Humanly
C. Think Rationally
D. Act Rationally

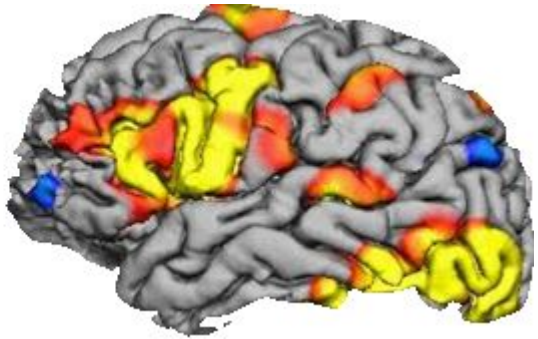
A. Think Humanly

- Researchers find out how we think by
  - Introspection
  - Psychological experiments
  - Brain imaging
- Cognitive science constructs precise and testable theories of the human mind
  - E.g., express a theory as a computer program and compare input-output behaviors to a human
  - If there is a match, some of the programs mechanism could also be operating in humans

A. Think Humanly

- The human brain is one of the great mysteries of science
  - How does our brain process information?
- The brain consists of nerve cells (aka neurons) and the collection of these simple cells leads to thought, action and consciousness
- The recent development of functional magnetic resonance imaging (fMRI) provides neuroscientists with details of brain activities





A. Think Humanly

- Brains and digital computers have somewhat different properties
- A crude comparison of the raw computational resources

	Supercomputer	Personal Computer	Human Brain
Computational units	10^6 GPUs + CPUs	8 CPU cores	10^6 columns
	10^{15} transistors	10^{10} transistors	10^{11} neurons
Storage units	10^{16} bytes RAM	10^{10} bytes RAM	10^{11} neurons
	10^{17} bytes disk	10^{12} bytes disk	10^{14} synapses
Cycle time	10^{-9} sec	10^{-9} sec	10^{-3} sec
Operations/sec	10^{18}	10^{10}	10^{17}

- Would we be able to achieve the brain's level of intelligence with a computer of unlimited capacity?

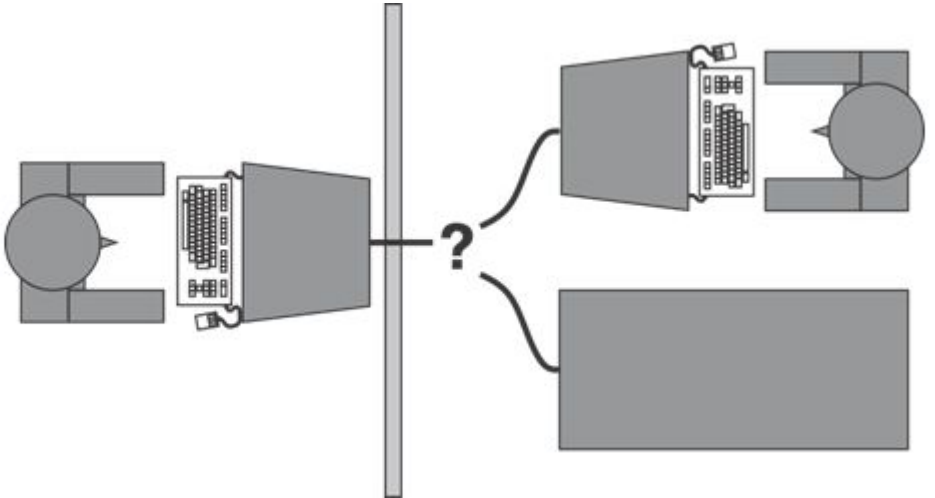
Should we create machines that ...

A. Think Humanly
B. Act Humanly
C. Think Rationally
D. Act Rationally

B. Act Humanly

- The Turing Test (aka Imitation Game) was designed to provide a definition of intelligence
- A computer passes the test if a human interrogator, after posing some questions, cannot tell whether the response come from a human or a computer

Human interrogator

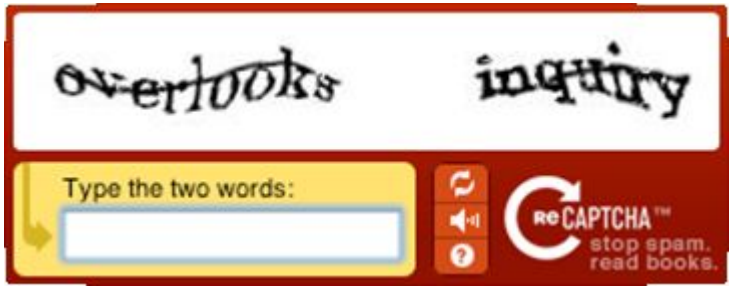


B. Act Humanly

- The underlying principles of intelligence are more important than to duplicate an exemplar
- Consider another field: Artificial Flight
  - The Wright brothers succeeded because they stopped imitating birds and started using wind tunnels and learn about aerodynamics
  - It was not their goal to make “machines that fly so exactly like pigeons that they can fool even other pigeons”

B. Act Humanly

- A reverse Turing test is a Turing test in which the objective or roles between computers and humans have been reversed. Interrogator is a computer. Interrogatee is a human.
  - Example: CAPTCHA
    - It is program that can generate and grade tests that
      - most humans can pass, but
      - current computer programs cannot pass



C. Think Rationally

- What are the laws that guide and underlie our thinking?
- Greek schools developed various forms of logic
  - Notation and rules of derivation for thoughts
  - Example: Socrates is a man; all men are mortal; therefore, Socrates is mortal
- By 1965, programs existed that could (in principle) solve any solvable problem described in logic notation
- Problems with this approach
  - How to take informal knowledge and state it in formal terms? How about uncertainty?

D. Act Rationally

- Act so as to achieve the best outcome or, when there is uncertainty, the best expected outcome
- Advantages over the other approaches
  - More general than the laws of thought approach because correct inference is just one of several possible mechanisms for achieving rationality
  - The standard of rationality is mathematically well defined. Human behavior, on the other hand, is well adapted only for one specific environment
- In this course we will focus on the general principles of rational agents and how to build them
  - An agent is something that perceives and acts

Rational Agent

- This course is about designing rational agents
- For any given class of environments and tasks, we seek the agent (or class of agents) with the best performance
  - Computational limitations make perfect rationality unachievable
  - Design best program for given machine resources

Machine Learning

- An agent is learning if it improves its performance on future tasks
- Why would we want an agent to learn? If the design of an agent can be improved, why not design the agent with that improvement to begin with?
  - Cannot anticipate all possible situations
  - Cannot anticipate all changes over time
  - Don’t know how to program some solutions

History of AI

History of AI - Turing Award Winners

- Marvin Minsky (1969)
- John McCarthy (1971)
- Edward Feigenbaum and Raj Reddy (1994)
- Judea Pearl (2011)
- Yoshua Bengio, Geoffrey Hinton, and Yann LeCun (2019)

History of AI - Milestones

- Inception (1943 - 1956)
- Early Enthusiasm (1952 - 1969)
- A dose of reality (1966 - 1973)
- Expert systems (1969 - 1986)
- Return of NN (1986 - present)
- Probabilistic reasoning (1987 - present)
- Big data (2001 - present)
- Deep Learning (2011 - present)

The State of the Art

- Publications
  - AI papers increased 20 fold between 2010 to 2019 to 20,000 a year
- Conferences
  - Attendance of NeurIPS increased 800% since 2012 to 13,500
- Industry
  - AI startups in the US increased 20 fold to over 800 from 2010 to 2019
- Internationalization
  - China publishes more AI papers per year then US and about as many as Europe
  - In citation weighted impact, US is ahead by 50% vs. China

The State of the Art

- Vision
  - Error rates for object detection improved from 28% to less than 2%
- Speed
  - Training time for image recognition dropped by a factor of 100 in last 2 years
  - Amount of computing power used in top AI applications is doubling every few month
- Humans vs. AI
  - AI is better in chess, go, pojer, pac-man, jeopardy!, object detection, speech recognition in limited domain, chinese-to-english in restricted domain, Quake III, Dota 2, StarCraft II, many Atari games, Skin cancer detection, prostate cancer detection, protein folding, ...

Benefits of AI

First solve AI, then use AI to solve everything else.

Demis Hassabis, Google DeepMind

Risks of AI

- Lethal autonomous weapons
- Surveillance
- Biased decision making
- Impact on employment
- Safety-critical applications
- Cybersecurity

Risks of AI - Superhuman AI

- Most experts agree that we will eventually be able to create a superhuman AI
  - An intelligence that far surpases human ability

Risks of AI - The Gorilla Problem

- About seven million years ago, a now-extinct primate evolved
  - one branch led to gorillas
  - another to humans
- Today the gorillas are probably not too happy about the human branch
  - They have no control over their future

Risks of AI - The Gorilla Problem

- If the gorilla problem is the result of developing AI then we should stop working on it
- If superhuman AI were a black box from outer space, we should be careful in opening the box
  - But it is not, **we** design the AI systems
  - If AI does end up taking control, it would be a design failure
- We need to understand the source of potential failure
  - Philosophical foundations of AI
  - Maybe the most important area of AI research