FUNDAMENTALS OF ARTIFICIAL INTELLIGENCE

Lecture 1: Introduction

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EXPECTED LEARNING OUTCOMES

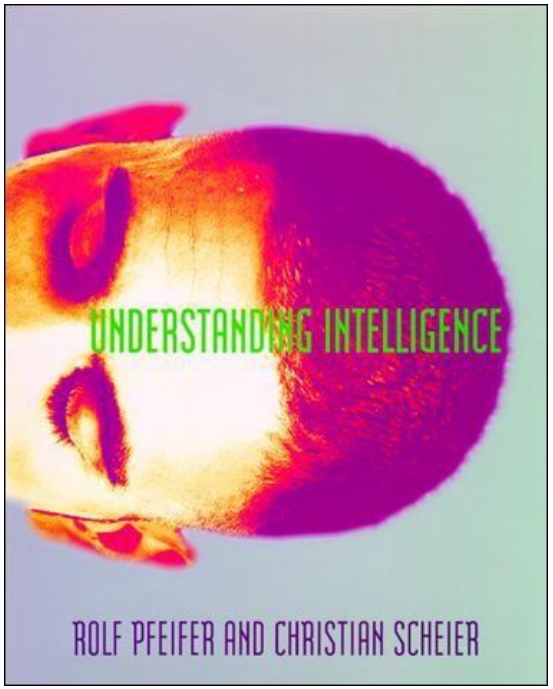
After having completed the course the student will be able to:

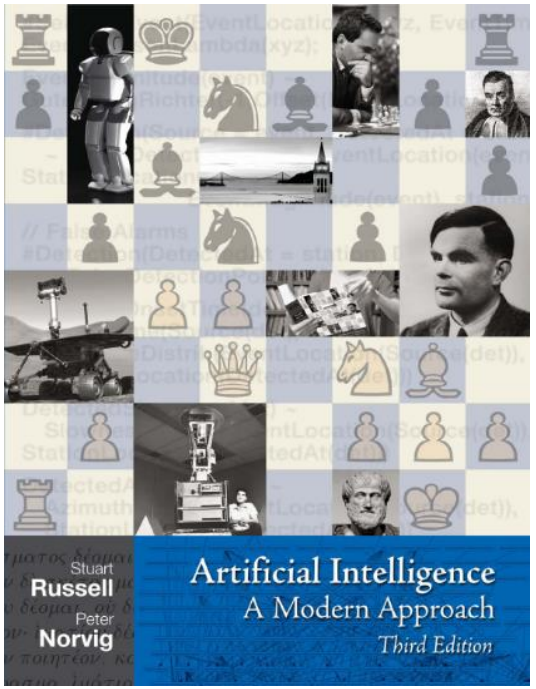
- Give an **overview** of the field **of artificial intelligence**, its background, history, fundamental issues, challenges and main directions
- Interpret and formulate **knowledge representations** in the form of **logic** expressions
- Explain basic concepts, methods and theories for **search**
- Account for **classical planning** of proactive agents
- Describe methods and theories for **reactive agents**, architectures based on subsumption, and potential fields
- Describe the **physical structure of robots**
- Account for different **degrees of autonomy of robots**

CONTINUED …

- Explain concepts, methods and theories of **embodied cognition and situatedness**
- Explain basic concepts, methods and theories of
  - Sensing
  - Neural networks and learning
  - Artificial evolution, genetic algorithms, multiple autonomous agents and swarm intelligence
- Demonstrate the ability to **apply a given subset** of the theories, methods and principles discussed during the course
- Discuss and analyze **social implications of AI** technologies in human societies.

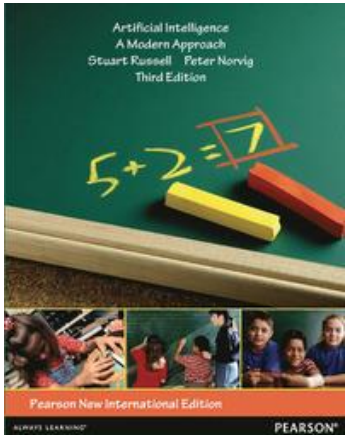
LITERATURE





Plus additional articles/compendia (Cambro).

NOTE! *Pearson New International Edition* of the AI book has slightly different chapter numbering. Chapter 7 and 6 have switched places ("Logical Agents“).



LECTURES

- **Lectures will not cover all content of the course,** but will introduce each topic of the course
  - I'm sorry but you also have to read the books ☺
- A set of readings is given for each lecture (together with the slides) on Canvas
- Some lectures will be **flipped calssroom**
- You are always welcome to ask questions during the lectures
- You are encouraged to send questions or topics via mail, we will bring them up during the lecture

EXAM AND GRADING

- The course is graded using in the following way:
  - U – Fail
  - 3 – Pass
  - 4 – Pass with mark
  - 5 – Pass with distinction
- In order to receive a grade of 3 or higher you must:
  - Pass the exam
  - Complete all obligatory assignments
  - Attend to obligatory parts of the course
- Assignments are only graded with Pass/Fail

COURSE EVALUATION

- Result of last years student evaluation (68/163 respondents):

Good things	Could be improved
The assignments and seminars	Some assignments needs to be improved
Good contents of the course	Short time for ANN assignment. Too long for follow the path
Assignment assistance	Schedule assistance hours earlier

CHANGES TO THIS YEAR

- Everything online due to Covid
  - Note that access to computer labs are restricted. Use your own computer if possible
- Removed one of the seminars and changed the ethics seminar somewhat
- More time for ANN assignment, less for follow the path
- Many lectures reworked
- Most tutoring hours scheduled already now
  - Check the Canvas schedule

ASSIGNMENTS

There are 4 assignments
(3 for BSc cognitive science students, 5DV201)

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ASSIGNMENT 1: FOLLOW THE PATH

- Create a program that controls the robot in a simulated environment such that the robot follows a specified path
- Work in pairs, **demonstrate** your working solution **on Zoom**
- After demonstration, **compare** your results to another group and write a **1 page report** about similarities/differences together
- Demo: 2020-09-16
- Report: 2020-09-17

INTRODUCTION TO MRDS

- There is an online **video introduction** to the virtual robot environment used for the first assignment, MRDS available on Canvas
- The goal is that you should be able to start the environment and move the robot around using the given code
- Make sure to install MRDS and get the demo code working already now!

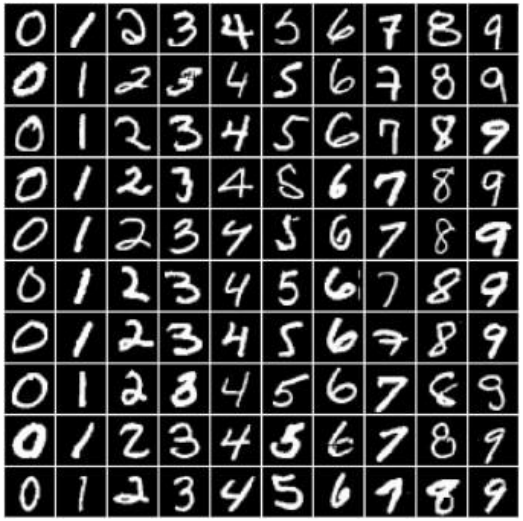
ASSIGNMENT 2: K-NN

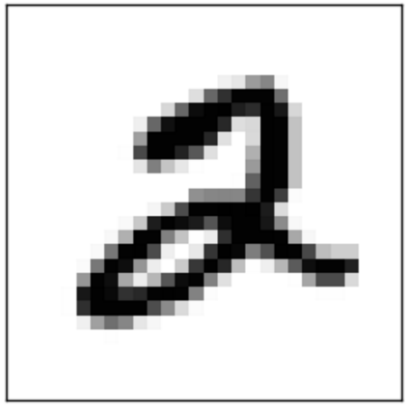
- Investigate how the **k-nearest neighbor-algorithm** works
- Work together in groups of two
- There will be an online **workshop** where we will work on it together (Sept. 21)
- Deadline: 2020-09-28

- Note: not for BSc cognitive science students (5DV201)

ASSIGNMENT 3: NEURAL NETWORK

- Create a simple Artificial Neural Network (perceptron)
- Train the perceptron such that it can classify hand written numbers (from MNIST database)
- BSc cognitive science (5DV201) have a simpler assignment using a pre-implemented network recognizing faces
- Deadline 2020-10-14





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ASSIGNMENT 4: ETHICS OF AI – ROLE-PLAY SESSION

- Scenario: A Facebook-like website wants to revise which news and ads are shown to users
- Task:
  - You **will play the** characters that represent **stakeholder** groups (3 ppl) involved in this transition during the role-play session:
    - users, company representatives, governments
  - **Negotiate with each other** how to revise the news and ads algorithm
  - After the role-play you **hand in a report**, which partly depends on the negotiation.
- Deadlines:
  - Stakeholder group proposal: 16th of October
  - Negotiation (role-play): 19th of October
  - Final report: 21st of October

TIGHT SCHEDULE!!

- Very tight deadlines for the assignments
- Make sure to follow the planning on Canvas
- Make sure to check the schedule often as it might change

CHEATING AND PLAGIARISM

- Read this document so that you are familiar with the rules about cheating!
- **You are not allowed to copy** code or text from other students or the internet.
  - It is allowed to discuss your solutions as long as you don't copy from each other
- Be sure to reference any information that you used
- The university takes this seriously and several students are warned or suspended every year

TUTORING

- You can get help through the **discussion forum on Canvas**
  - Write there for help (or check previous answers for tips)
  - There is a also thread for finding a partner for the assignments
- We will have scheduled **tutoring through Zoom**
  - On Tutoring Queue (https://webapps.cs.umu.se/tutorqueue) write your zoom link and a tutor will connect when available
  - Look at the schedule on Canvas (normally Mon + Thu 10-12)
- Mail: 5dv124ht20-handl@cs.umu.se (reaches all teachers on the course)
  - Better to use discussion forum and tutoring hours if possible.

INTRODUCTION TO AI

Readings:
Russel and Norvig Ch. 1

Pfeifer and Scheier Ch. 1

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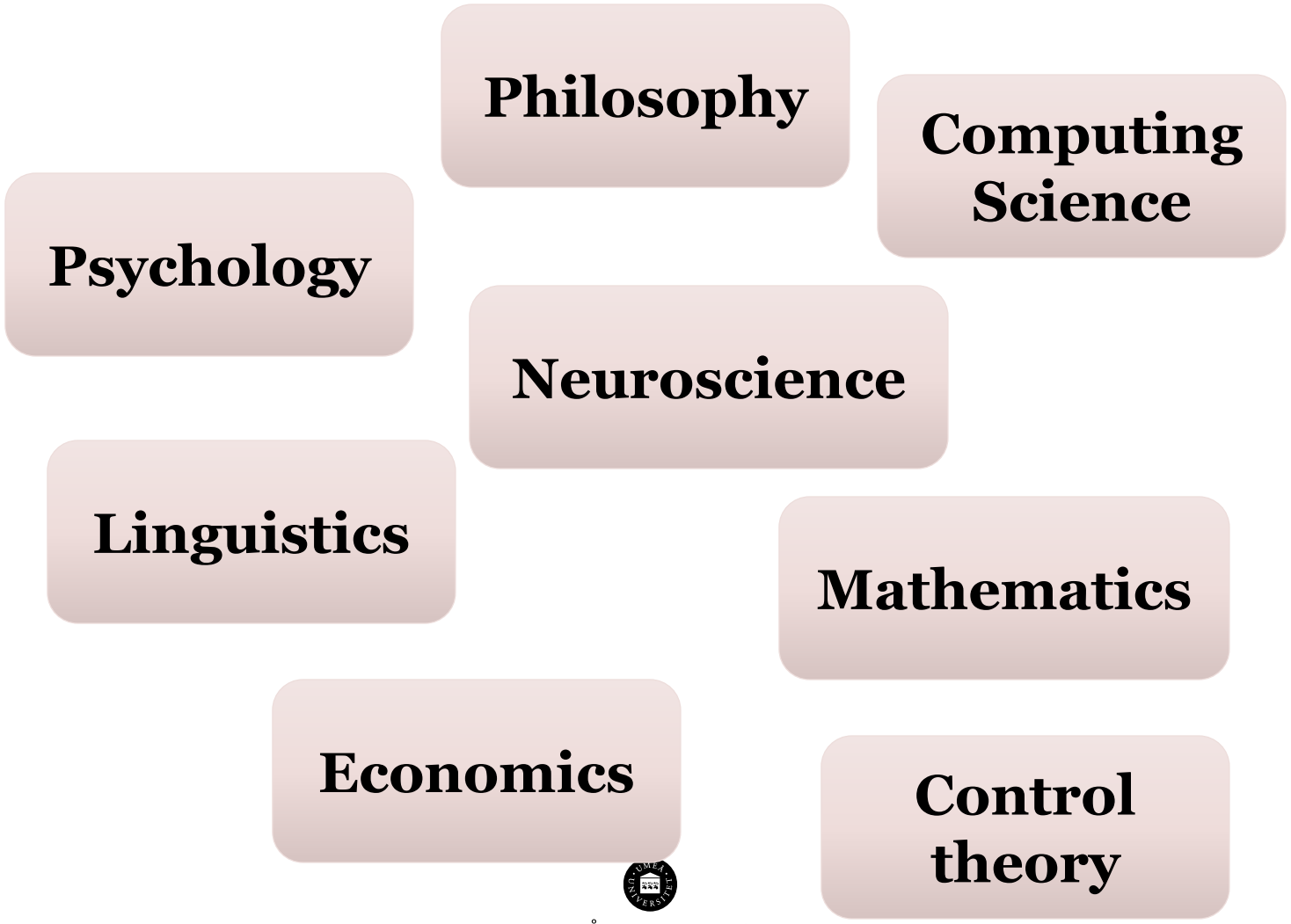
ARTIFICIAL INTELLIGENCE

Thinking Humanly	**Thinking Rationally**
Cognitive science approach. Try to model how humans actually thinks. *General Problem Solver (GPS)*	"Think" using logic. Rule based
Acting Humanly	**Acting Rationally**
Passing the *Turing test*. Could pass as a human "make computers do things that humans, at the moment, are better at"	Rational agents: always act to achieve the best outcome.

Russell & Norvig (2010), p. 2

THE FIELDS OF AI



WHAT DO WE STUDY

- **Intelligence**
- Thought
- **Reasoning**
- **Rationality**
- **Learning**
- **Memory**
- **Representation**
- Consciousness
- Attention
- Creativity
- **Behavior**
- **Emergence**
- **Robotics**
- **Sensing**

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THE BIRTH OF AI

- The Dartmouth Conference, 1956
  - John McCharthy
  - Marvin Minsky
  - Allen Newell
  - Herbert Simon
- Symposium of Information Theory, MIT, 1956
  - Allen Newell (computer science)
  - Herbert Simon (political science)
  - George Miller (psychology)
  - Noam Chomsky (linguistics)
  - Jerome Bruner, Jacqueline Goodnow and George Austin (psychology)
- Also the birth of Cognitive Science as we know it

DEFINING INTELLIGENCE

1. Ability to carry out abstract thinking
2. Ability to think rationally
3. Ability to act rationally
4. Playing chess
5. Scoring high at an IQ-test
6. Knowing a lot of stuff
7. Ability to learn and adjust oneself to the environment
8. A biological mechanism by which the effects of a complexity of stimuli are brought together and given a somewhat unified effect in behavior
9. The capacity to learn or profit from experience

Given some behavior – say of a human, an elephant, an ant, or a robot – that we find interesting in some way, how does this behavior come about?

(Phfeifer and Scheier, 2001)

DIVERSITY-COMPLIANCE TRADE-OFF

Almost all notions of intelligence introduce a trade-off between *doing what you know* and *doing something new*. This tradeoff has many names and we will run into several of them during this course.

- **Psychology:** Assimilation – Accommodation
- **Adaptivity:** Conservative – Innovative
- **Learning theory:** Flexibility – Stability
- **Reinforcement:** Exploration – Exploitation
- **Evolution:** Mutation – Inheritance

HOW TO STUDY INTELLIGENCE

Reductionism

- Break down the problem into manageable pieces
- Study each part separately
- Put them together and understand the whole
- Typically a *top-down* perspective

Holism

- Argues that we can not break down the system into parts without loosing important properties of the system that does not exists in any of the parts alone
  - These properties are called *emergent*
- Studies simple but complete systems
- Typically a *bottom-up* perspective

ANALYTIC APPROACH

- Typically reductionistic
  - Break the system of analysis into parts and analyze each part
- Primary methods of all empirical sciences

- A hypothesis of how the system works is created
- Experiments are designed to test the hypothesis
- Experiments are performed and data is gathered
- Results are analyzed

THE ANALYTIC APPROACH IN AI

Example: Explain how a car works

1. Start by observing the behavior of the car
    1. Measure how quickly it accelerates, turns, breaks, etc…
2. Try to come up with an explanation for the observed behavior
    1. Based on the explanation, come up with a number of testable hypotheses
3. Design an experiment that can falsify the hypotheses
4. Run the experiments and analyze the results

The car can of course be replaced with a human, animal etc…

THE SYNTHETIC APPROACH

- *Understanding by building*
- Modeling
  - Build a model of the biological system
    - The model should replicate some aspects of the natural system
  - Use the model in order to predict the results of traditional experiments
  - Use the model to perform experiments that can not be performed on the natural system

- AI and Cognitive Science is to the large part synthetic
- The synthetic and analytic approaches are complementary, not contradictory!

THE SYNTHETIC APPROACH IN AI

Example: Explain how a car works

1. Start by observing the construction of the car
    1. Study how the engine works, how the suspension and wheels are constructed…
2. Try to come up with a model that matches observations
3. Implement the model
    1. Physical model (robot) or simulated in a computer
4. Run the model and compare the results with the observed behavior of the car
5. Make predictions of which results we should expect if we do some new experiment using a real car

The car can of course be replaced with a human, animal etc…

INFORMATION PROCESSING VIEW

- The brain is viewed as a computer
  - The brain receives input from our senses
  - The inputs are processed, producing mental representations
  - Based on the internal mental state, an intention or plan is generated
  - Finally, actions are executed, producing an output
- Also known as **Sense – Think – Act**
- This is a metaphor, we do not mean that the brain internally works as a computer
- This view is important for cognitive psychology and cognitive science in general

HISTORY OF AI

Examples of applications

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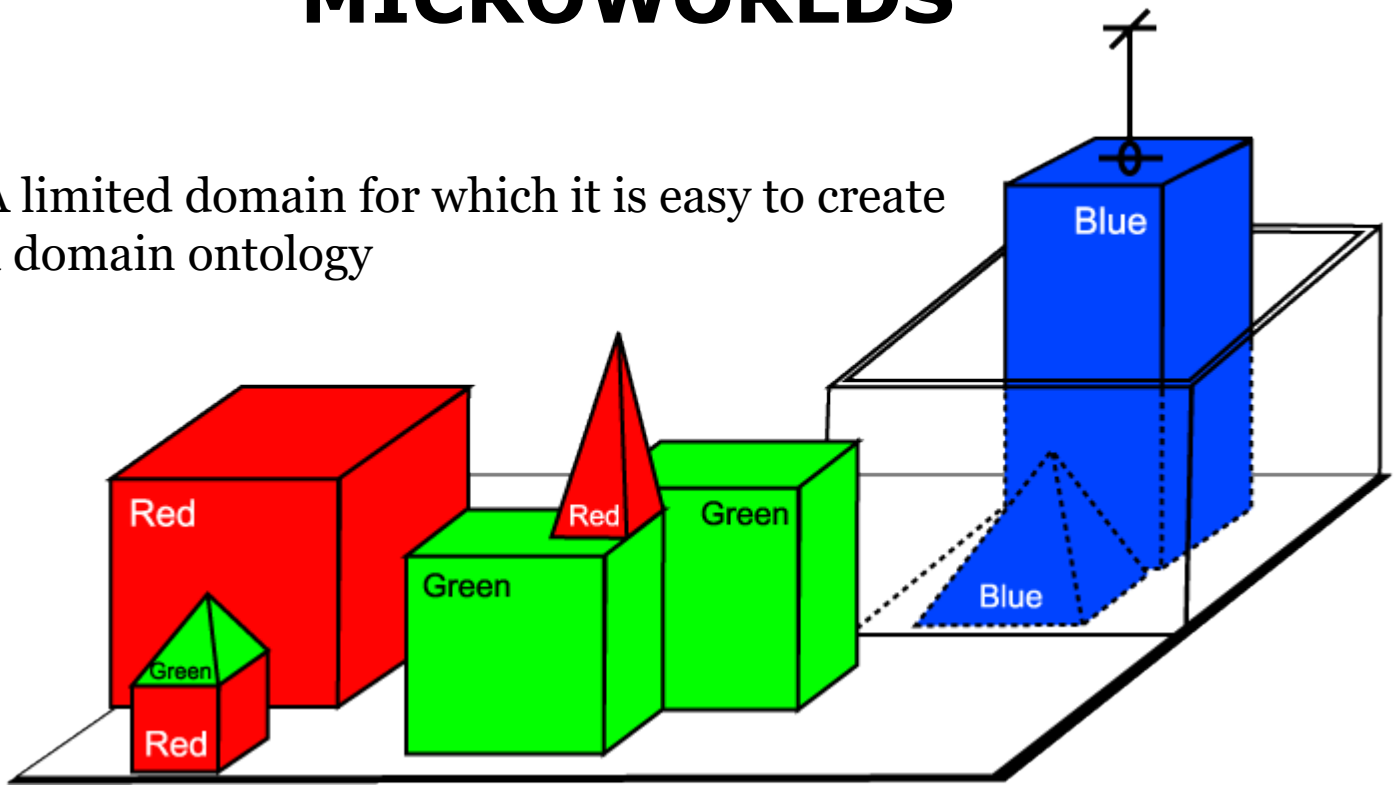
GENERAL PROBLEM SOLVER (GPS)

- Presented by Herbert Simon and Allan Newell in 1957
- In principle, GPS can solve any formalized problem
- The problem is specified as a set of rules
- GPS will search for a solution
  - GPS searches using a heuristic called Means-Ends Analysis
- Used to prove theorems, geometric problems, chess problems, and similar
- Could not solve many real world problems due to combinatorial explosion
  - I.e., the program worked in principle but required enormous time to solve large problems

MICROWORLDS

- A limited domain for which it is easy to create a domain ontology



SHRDLU, written by Terry Winograd of MIT, 1972

EXPERT SYSTEMS

Example: Mycin (1972)

- Often said to be the first real knowledge based AI system (expert system)
- It was a medical decision support system
- Like the micro-world systems, it performs in a limited domain
- Knowledge is represented as rules:

RULE543

IF:

1) The infection which requires therapy is meningitis,

2) Only circumstantial evidence is available for this case,

3) The type of the infection is bacterial,

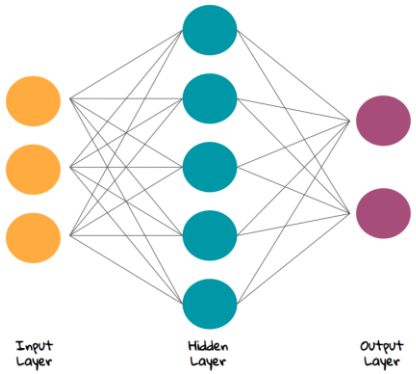
4) The patient is receiving corticosteroids,

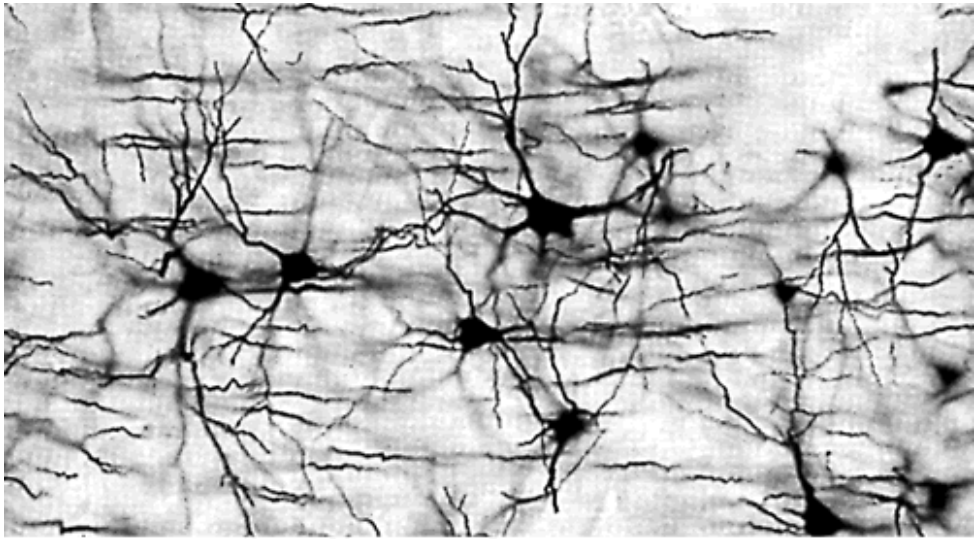
THEN:

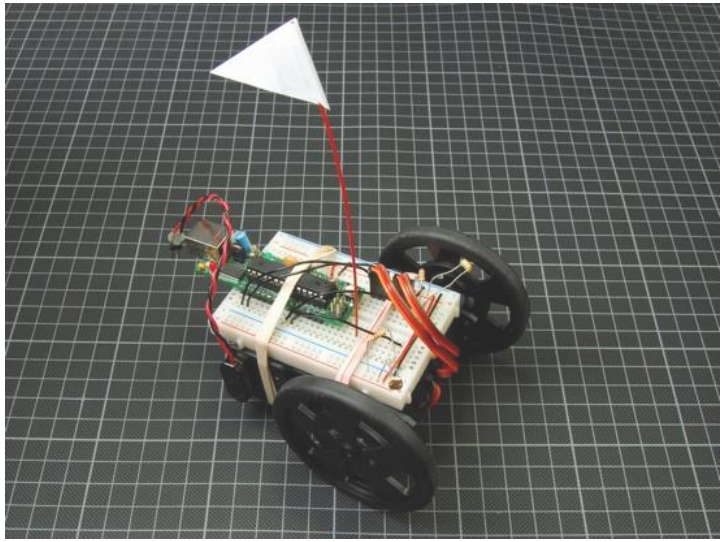
There is evidence that the organisms which might be causing the infection are e.coli (.4), klebsiella-pneumoniae (.2), or pseudomonas-aeruginos

THE GREAT 80-IES

- The return of Artificial Neural Networks
  - *Birth of connectionism*
- Robots that can act in the real world!
  - *Elephant's don't play chess!* – Brooks (1990)







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THE REALISTIC 90-IES

- AI becomes less of an art and more like a science
- Mathematics and statistics is emphasized
  - Hidden Markov Model (e.g. for speech recognition)
  - Kalman filter (filter out noisy sensor data)
- The complete agent – autonomous, embodied, situated
  - Need too tie isolated subfields together
  - Reasoning systems must handle uncertainty
- Artificial General Intelligence (AIG)
  - Attempt to construct human-like AI
  - Reaction against microworlds and domain-specific approaches

2000 UNTIL TODAY

- AI becomes an industry
  - AI technologies are applied for everyday use
- Scale it up!
  - Really large datasets
- “Super computers” (cloud computing / clusters)
- Robotics
- Mobile technologies
  - More sensors
- Deep Learning !

STATE OF THE ART

- When it starts working we stop calling it AI
  - Unlocking the phone using face recognition
  - Autopilot or airplanes
  - GPS navigator / Google Maps telling us how to drive
  - Spam detection algorithms
  - Netflix recommendation algorithms
  - Automatic recognition of what's in photos (e.g. search for a picture of a cat on a beach)
- Big datasets needed!
- Google has released an AI Hub
  - Use (/buy) ready made/trained models

STATE OF THE ART

- Machine learning
- Natural language processing (NLP)
  - Machine translation
  - Speech recognition
  - Chat bots
- Robotics
  - Autonomous cars
  - Robot vacuum cleaners / lawn mowers
  - Agriculture robots (harvesting/weeding/plowing/…)
- Game playing
- Generating fake videos

MAIN CHALLENGES

- Explainability – Technical challenge
- Algorithmic bias – Technical/societal challenge
- Transparency in usage - Societal/political/legal challenge
- Applications - Societal/political/legal challenge

FUTURE OF AI?


AI is enjoying significant hype and investment
Buzz, impact & pervasiveness
A.I. "Winters"
Many are betting on this outcome
A.I. gains scary effectiveness and pervasiveness
Excitement fades, certain applications benefit hugely
?
Bubble bursts, next A.I. winter arrives
1975
1990
2017

CURRENT MAJOR EFFORTS IN AI

- WASP - Wallenberg AI, Autonomous Systems and Software Program
  - Sweden's largest individual research program ever
    - Many researchers @umu involved
  - Vision: **excellent research and competence in AI**,
- AI4EU - seeks to develop a **European AI ecosystem**,
  - Establish an **Ethics** Observatory - Virginia Dignum (cs@umu)
  - Create an open **AI platform**
- AI Competence for Sweden – **increasing AI competence in Sweden** by developing courses for students and industry
  - UMU one of 7 universities participating
- AI@UMU: https://www.umu.se/en/research/features-and-news/artificial-intelligence/

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THINGS TO DO AS SOON AS POSSIBLE !

- **Form groups** (of two) for Assignment 1
  - See the assignment specification on the course web for more information
  - Use the discussion forum on Canvas to find a partner if needed
- Install MRDS on your computer and make sure the demo code works for you
  - Look at the instruction video on Canvas
- Remember to **register for the course** (through the student web)