50.021 Artificial Intelligence

Instructors:
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V1 Course was prepared with great efforts of MIT Profs Leslie Pack-Kaelbing and Tomas Lozano-Perez

- About the Alex:
  - German Diplom in pure Math (~ M. Sc.)
  - Ph.D. in computer science – TU Berlin, Klaus-Robert Mueller
  - from Berlin, Germany

What skills you need for this course?

- Python programming
- Probability and statistics
- Linear algebra
- Being able to compute a derivative
  - Knowledge of machine learning never hurts
  - It is not a course on cute robots or go playing (is that important?)
- The will to pre-read external materials BEFORE class (often external links provided)
- Not giving up with installation problems – windows causes pains when taken with scientific software? consider ubuntu in a virtual machine as a fallback!

- Consider to drop if any of these is a horror for you or you feel particularly week in those

How to get 12 credits:

- Submit programming parts that are assigned as homework (dynamical decision in class) and submit other homeworks – 35%
  - Late submission penalties: 1d – 8%, 2d – 20%, 3d – 30%, 3 free late submissions of max 3 days
  - Homework submission is monday 4pm
  - Handing in by edimension
- Quizzes (Thusdays, weeks: wk 4,8,12) – 30%
- Final Exam – 30%, not intended to make students die – Term 8
- Class participation – 5%

Software

- Install: python, numpy, scipy, matplotlib, h5py
- two of the three: pytorch, mxnet, tensorflow

- Later more packages

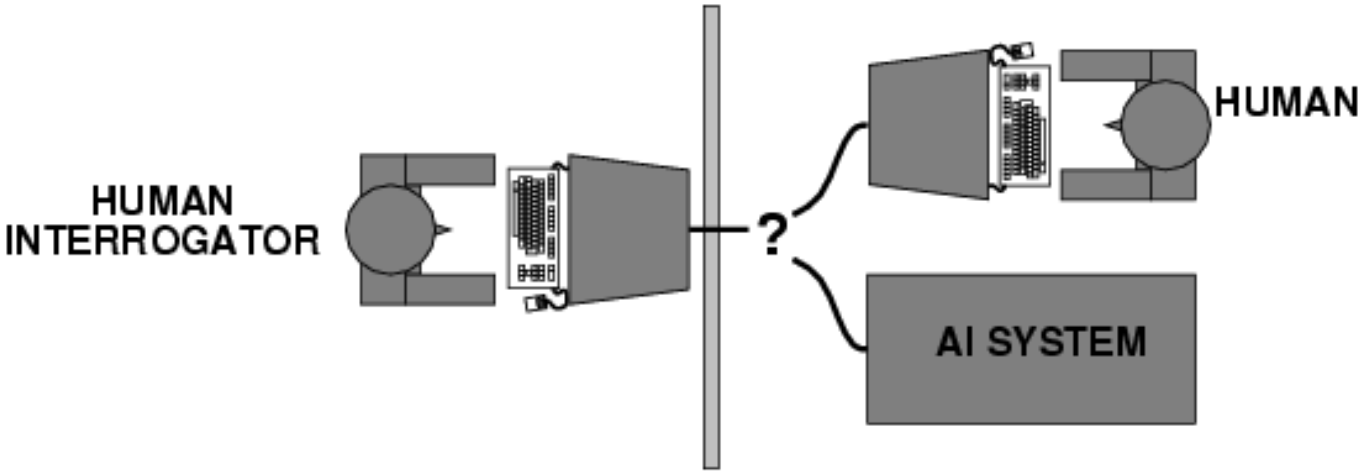
- The next slides are copied from different locations (Chuck Dyer, U Wisconsin Madison; U Berkeley, U Stanford)
- What questions one can have to AI ?
- Why are you here?

Today

- Some Definition(s) of AI
- Applications of AI

What is AI ? One answer: The Turing Test

- A. Turing, “Computing machinery and intelligence,” 1950
- Can machines think? Can we tell if a conversation is by a machine and not a human?
- In the test, an interrogator converses with a man and a machine via a text-based channel. If the interrogator fails to guess which one is the machine, then the machine is said to have passed the Turing test.



- Suggested major components of AI: natural language processing, learning, learned knowledge rep., reasoning,
- The beauty of the Turing test is its simplicity – it is a test of behavior, not of the internals of the machine. It doesn’t care whether the machine is using logical methods or neural networks.
- The underlying definition: AI = act like a human

Different Approaches to AI

- Philosophy, ethics, religion
  - What is intelligence?
- Cognitive science, neuroscience, psychology, linguistics
  - Understand natural forms of intelligence
  - Learn principles of intelligent behavior
- Engineering
  - Can we build intelligent devices and systems?
  - Autonomous and semi-autonomous systems for replicating human capabilities, enhancing human capabilities, improving performance, etc.

One set of definitions of AI

Discipline that systematizes and automates intellectual tasks to create machines that:

Think like humans	Think rationally
Act like humans	Act rationally

Think like humans - cognitive neuroscience: analysis of processes in the brain

Usefulness?

Limitations?

Act like humans: imitate human behaviour

Usefulness?

Limitations?

- Think rationally

  Rational thinking: what are correct thoughts/ how to draw conclusions? Logical thoughts?
- Schools of Logic
- Limitations:
  - Formulating problems in terms of logic can be very difficult, error-prone (forgetting to encode some logical conditions bcs we find them obvious)
  - True or False, no gray zones?

- Act rationally

  Rational behavior: do the right thing
- Always make the best decision given what is available (knowledge, time, resources)
- Usefulness: optimize a defined criterion
- Limitations: how to define a function/criterion measuring better or worse?

  “ criterion/function = cost efficiency?”

  – Where can it be useful? What are possible risks?

- Act rationally

  Rational behavior: do the right thing

- Always make the best decision given what is available (knowledge, time, resources)
- Usefulness: optimize a criterion

  chess – find best move, maze – find shortest path, route planning – find fastest/cheapest route,

- Limitations: how to define a function measuring better or worse?

  “AI Hospital / elderly home – criterion/function = cost efficiency?”

  - Function optimization is merciless, ethics play no role per se

Where do you think that AI brought much profit so far?

Maybe?

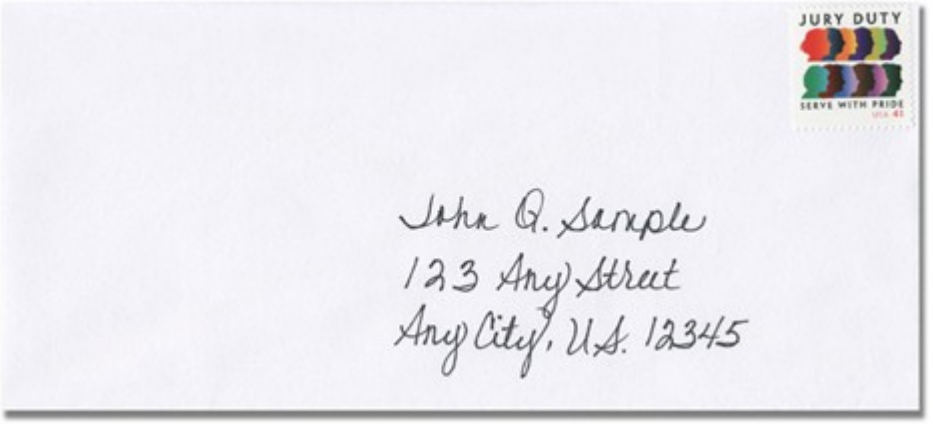
- Logistics planning – for wars :(

- Dynamic Analysis and Replanning Tool
  - From https://en.wikipedia.org/wiki/Dynamic_Analysis_and_Replanning_Tool
  - Introduced in 1991, DART had by 1995 offset the monetary equivalent of all funds DARPA had channeled into AI research for the previous 30 years combined.
  - Directly following its launch, DART solved several logistical nightmares, saving the military millions of dollars.[2] Military planners were aware of the tremendous obstacles facing moving military assets from bases in Europe to prepared bases in Saudi Arabia, in preparation for Desert Storm.[5] DART quickly proved its value by improving upon existing plans of the U.S. military. What surprised many observers was DART's ability to adapt plans rapidly in a crisis environment.[3]
  -

- Wars bring dead

Maybe?

- Handwriting Recognition
  - Used for automatically sorting letters



  - First practical systems in late nineties
  - Saved several hundred million dollars

Maybe?

- Automatic trader systems in earlier times deployed in Fund Companies?

In what area do you think AI will have the most important societal
impact?

- **A new White House report explains the economical impacts of AI**
- **Millions of Americans may lose their jobs over the next few years, it warns**
- **Less-educated workers will be hit the hardest, which increases wealth inequality**
- **But AI will increase productivity resulting in higher wages and fewer work hours**
- **AI will also create new jobs for those who have been replaced by robots**

By STACY LIBERATORE FOR DAILYMAIL.COM
PUBLISHED: 19:43 BST, 27 December 2016 | **UPDATED:** 15:50 BST, 28 December 2016

The increase of artificial intelligence will likely leave millions of Americans unemployed in coming years, reveals a new report from the White House.

The less educated working class will likely be greatly affected by the technology, which in turn creates a greater divide of wealth inequality throughout the nation.

However, the report suggests AI could improve the country's productivity growth, which would result in higher wages and fewer work hours – concluding that the US economy needs more AI, not less.

Scroll down for videos

http://pwc.blogs.com/press_room/2017/03/up-to-30-of-existing-uk-jobs-could-be-impacted-by-automation-by-early-2030s-but-this-should-be-offse.html

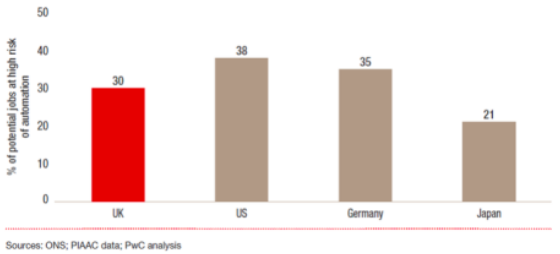
Up to 30% of existing UK jobs could be impacted by automation by early 2030s, but this should be offset by job gains elsewhere in economy

Published at 00:01 AM on 24 March 2017

- Up to around 30% of existing UK jobs are susceptible to automation from robotics and Artificial Intelligence (AI) by the early 2030s, but in many cases the nature of jobs will change rather than disappear
- This is lower than the US at 38% and Germany at 35%, but higher than Japan at 21%
- The likelihood of automation appears highest in sectors such as transport, manufacturing, and wholesale and retail, and lower in education, health and social work
- Male workers could be at greater potential risk of job automation than women, but education is the key differentiating factor for individual workers
- Automation will also boost productivity and wealth, leading to offsetting additional job gains elsewhere in the economy - but income inequality may rise
- Economic, legal and regulatory constraints may restrict the pace and extent of increases in automation in practice

Up to around 30% of existing UK jobs could face automation over the next 15 years, but new AI-related technologies will also boost productivity and generate additional jobs elsewhere in the economy, according to new analysis by PwC in its latest *UK Economic Outlook* report. This involves looking in detail at the task composition of jobs in different industry sectors and occupations, using machine learning techniques to model the potential impact of AI in the future based on OECD data.

The study estimates that the UK (30%) has a lower proportion of existing jobs at potential high risk of automation than the US (38%) and Germany (35%), but more than Japan (21%).



Sources: ONS; PIAAC data; PwC analysis

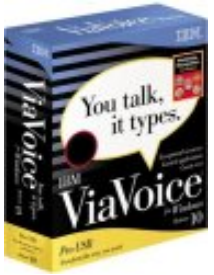
PwC's analysis finds the likely impact of automation varies significantly across industry sectors: transportation and storage (56%), manufacturing (46%) and wholesale and retail trade (44%) have the highest proportion of jobs facing potential high risks of automation among the larger sectors. Education and health and social work are estimated to face

Some Successful AI Applications

1. Machine translation
2. News aggregation and summarization
3. Speech recognition
4. Song recognition
5. Face recognition
6. Image recognition
7. Question answering
8. Chess playing, Go playing
9. Logistics planning
10. Handwriting recognition
11. Driverless cars
12. Traffic prediction systems

Speech Recognition

- “speak your card number” (tiny vocabulary, high accuracy needed)
- call routing, airline reservations: “how can I help you?” (large vocab, low accuracy)
- dictation (large vocab, high accuracy)



IBM
ViaVoice

Nuance Dragon
NaturallySpeaking

- Hidden Markov Models, heuristic search, …
- Is not about understanding sentences (chatbots!)

Machine Translation

- Here need to understand the meaning,
- not just match audio to words
- Google translate – statistical models

Virtual Assistants

• Apple’s Siri, Google Now, Microsoft Cortana, Amazon Echo, and other virtual assistants are also becomingreal.

• A large part of this is due to the dramatic improvements in speech recognition in the last seven years(thanks to deep neural networks).

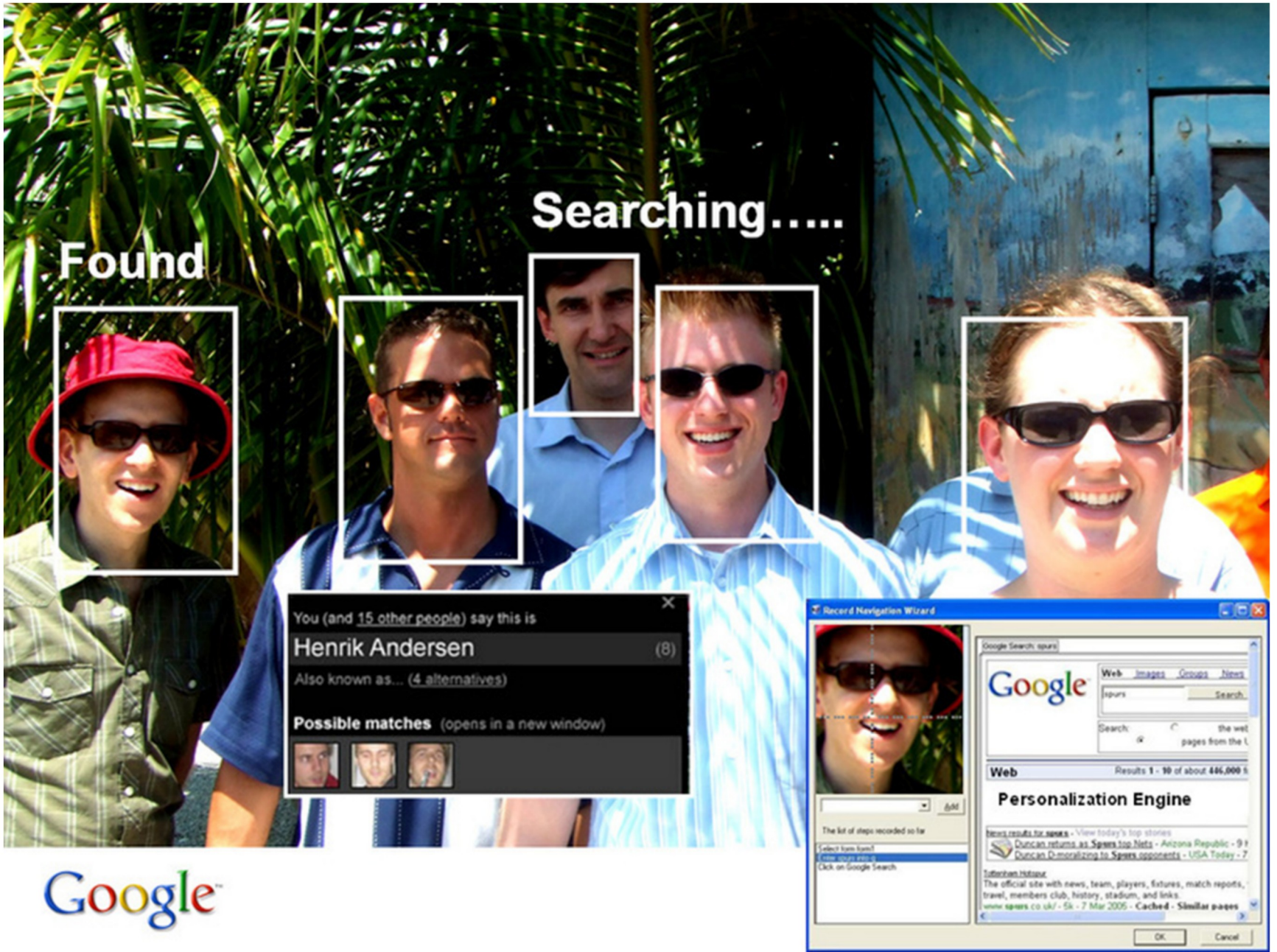
• However, speech recognition is only one part of the story; the other is understanding the text, which is a much harder problem. Current systems don’t handle much more than simple utterances and actions (e.g.,setting an alarm, sending a text, etc.), but the area of natural language understanding is growing rapidly

Game Playing: Go

Google AlphaGo beat Korean grandmaster Lee Sedol 4 games to 1 in 2016

Is that really impactful?

Face Recognition: Autotagging Photos in Facebook, Flickr, Picasa, iPhoto, …



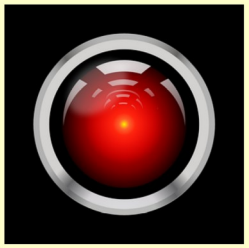
Google

Common key elements to solving all these?

Three key steps of a knowledge-based agent (Craik, 1943):

- 1. the stimulus (= sensor inputs) must be translated into an internal representation
- 2.the representation is manipulated by cognitive processes to derive new internal representations
- 3.these in turn are translated into actions/ decisions

- “agent”



  - Perception – cognition – action
  - Sensor inputs – processing – decision

Autonomous Robots

- Key questions in mobile robotics
  - **What is around me?**
  - **Where am I ?**
  - **Where am I going ?**
  - **How do I get there ?**
- Alternatively, these questions correspond to
  - **Sensor Interpretation**: what objects are in the vicinity?
  - **Position and Localization**: find your own position on a map (given or built autonomously) and position on road
  - **Map building**: how to integrate sensor information and your own movement?
  - **Path planning**: decide the actions to perform for reaching a target position

Cleaning Robots

- iRobot Roomba robot for vacuuming floors

Roomba demo

Harvesting Human Intelligence:

Anti-AI: CAPTCHA

CAPTCHA

- Yahoo!

- Google

CAPTCHA

- Yahoo!

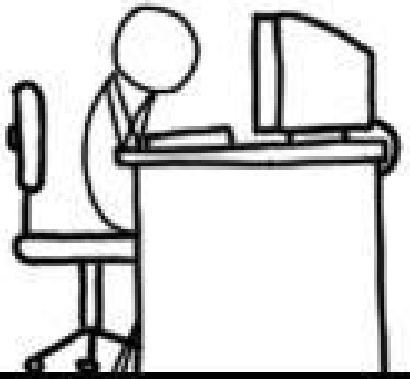
- Google

To prove that you're not a bot, please enter the characters you see in the picture below.

Submit

...

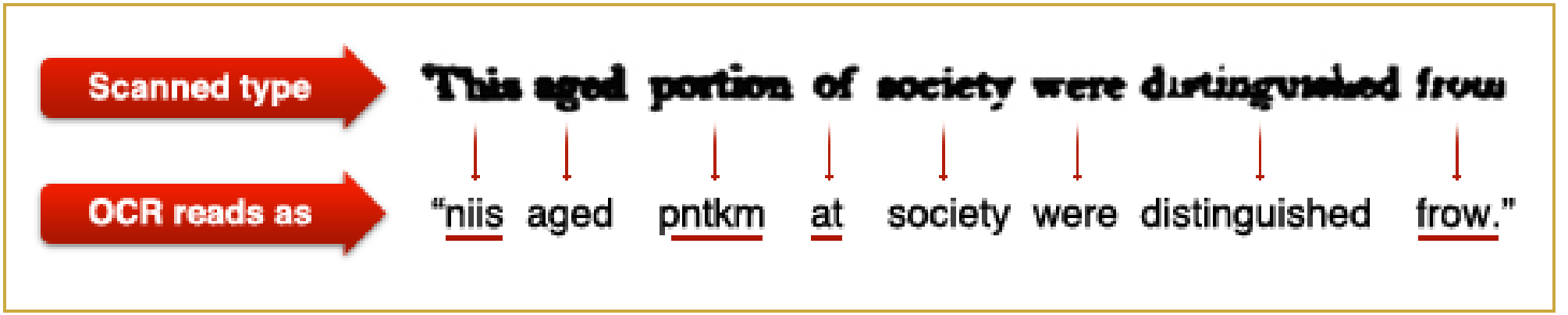
WELL, THAT SETTLES IT. I GUESS I ALWAYS HAD MY SUSPICIONS...



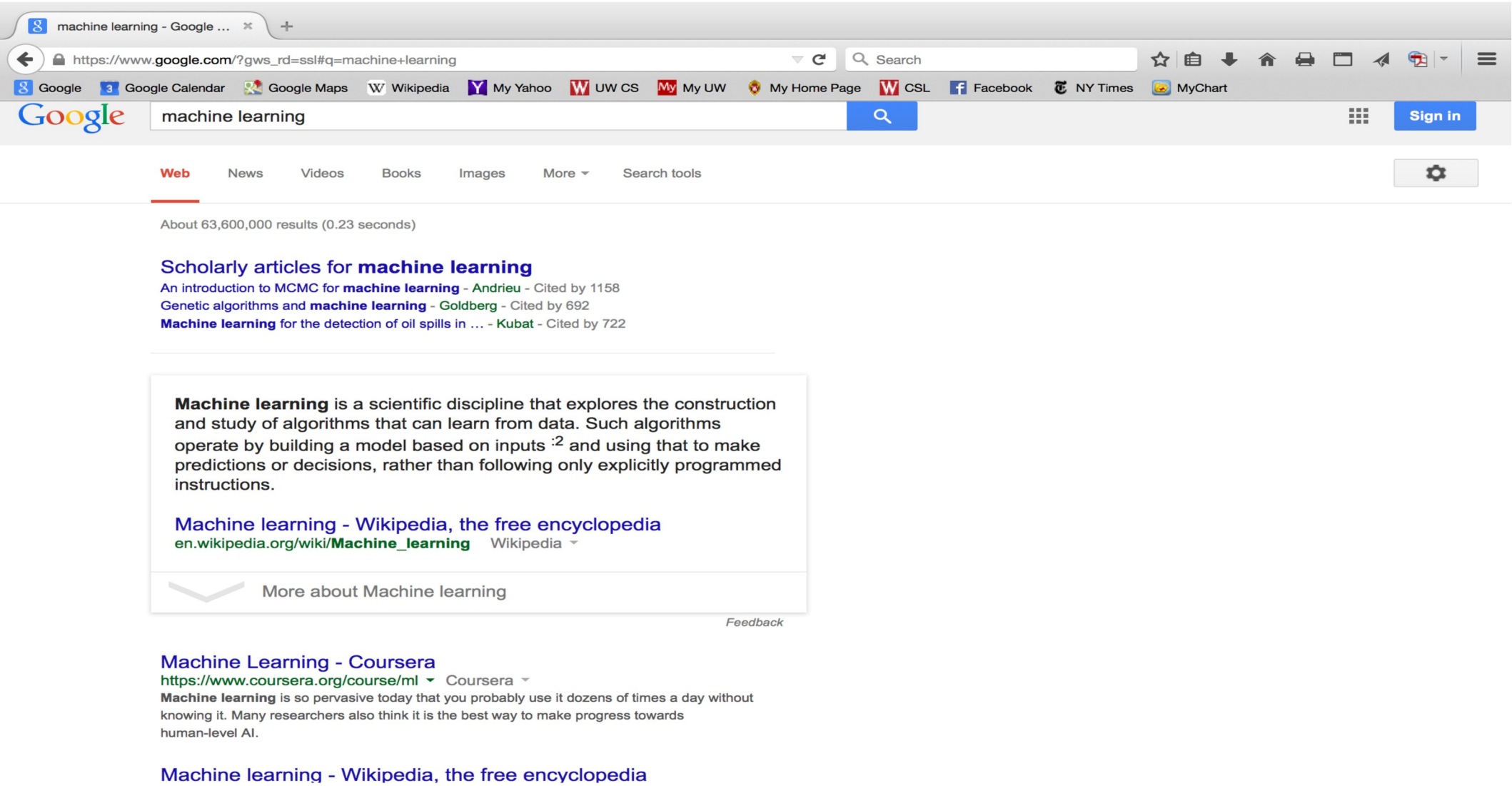
4/27/07 MIKE & STEPH ADAMS

reCAPTCHA

- reCAPTCHA is a free service that improves the process of digitizing books by having humans decipher words that are not automatically recognized



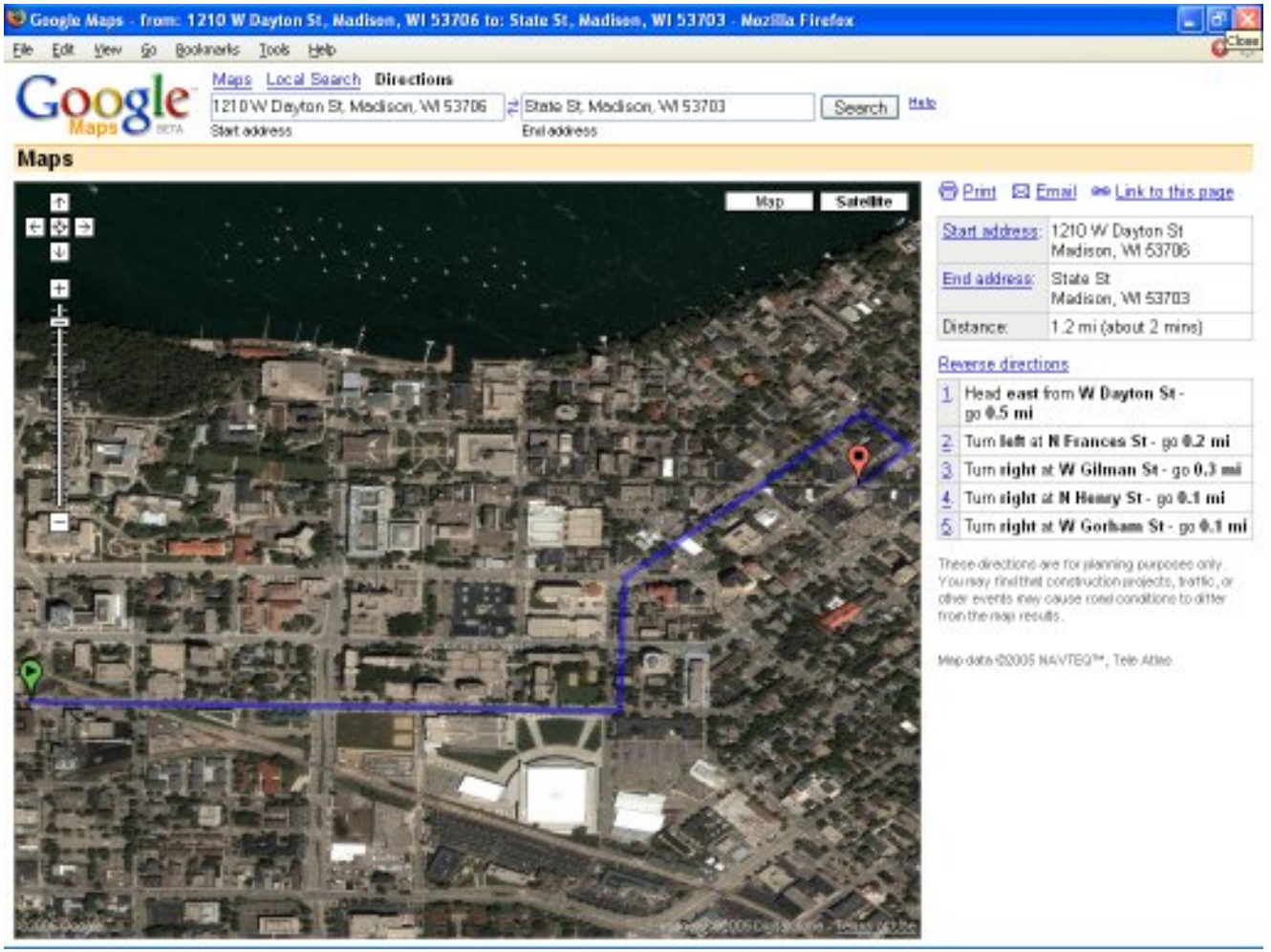
Web Page Ranking



- Google PageRank uses Machine Learning

Navigation

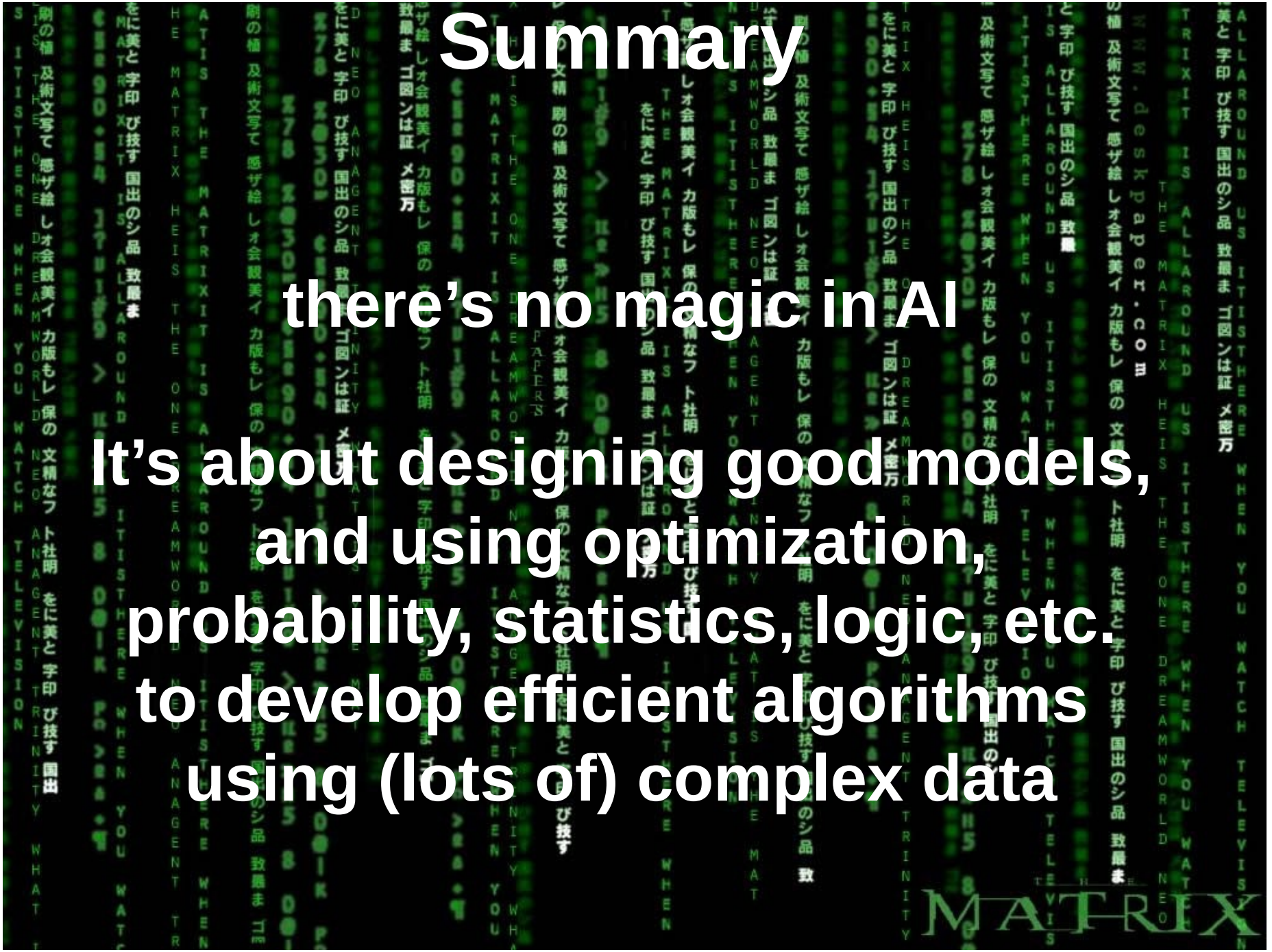
- Goggle Maps, Bing Maps, MapQuest
- FedEx, UPS to plan package delivery



- Search

- Autonomous driving
  - potentially saves much money
  - What are potential disadvantages when used for example for truck driving?

Mobile eye demo: https://www.youtube.com/watch?v=dhEgD6ZFlQE


Summary
there’s no magic in AI
It’s about designing good models,
and using optimization,
probability, statistics, logic, etc.
to develop efficient algorithms
using (lots of) complex data
MATRIX

In this course

- Quick intro to machine learning – since it is no prerequisite to this course!!
- Some aspects of deep learning (neural nets, convolutional neural nets, some aspects of gradient optimization, a bit python programming)
- Probabilistic graphical models – a way to express probabilities between multiple variables
- Search, constraint satisfaction problems – given a map find a coloring, such that all neighboring territories have different colord
  - No logic, little planning, no games

- Uh, thats so low compared to all these nice examples

Textbooks?

- Not following any single textbook closely (too wild bunch of topics)
- Neural networks:

  http://neuralnetworksanddeeplearning.com/

  Michael Nielsen

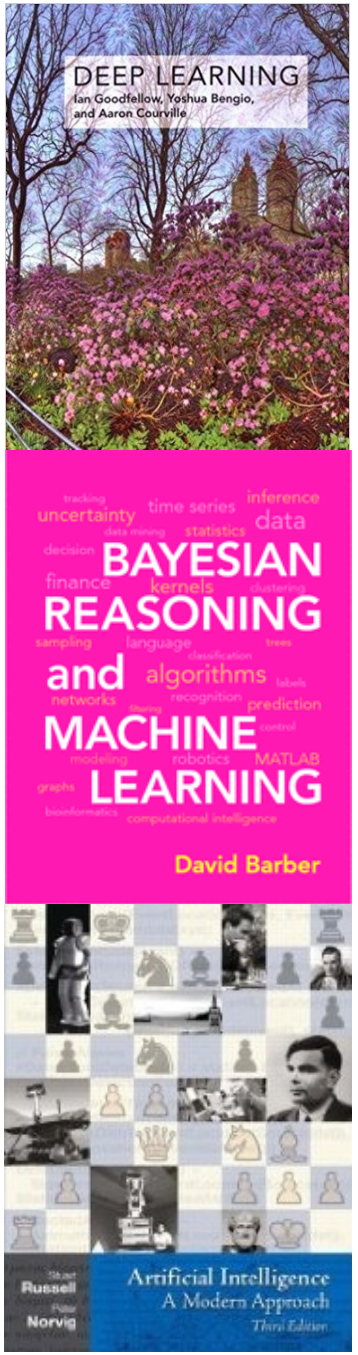
  http://www.deeplearningbook.org/

  Ian Goodfellow, Bengio, Aaron Courville
- Probabilistic graphical models:
  http://www.cs.ucl.ac.uk/staff/d.barber/brml/

  David Barber
- Search, Planning, CSPs:

Artificial Intelligence: *A Modern Approach*,

Russell, Norvig



Next class

- Check out in edimension the review on gaussians