

Artificial Intelligence

CS 165A

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Prof. Yu-Xiang Wang

Computer Science

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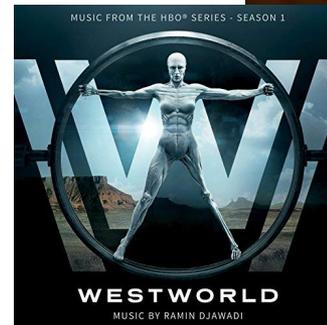
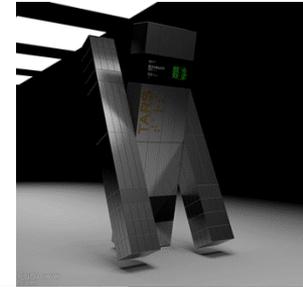
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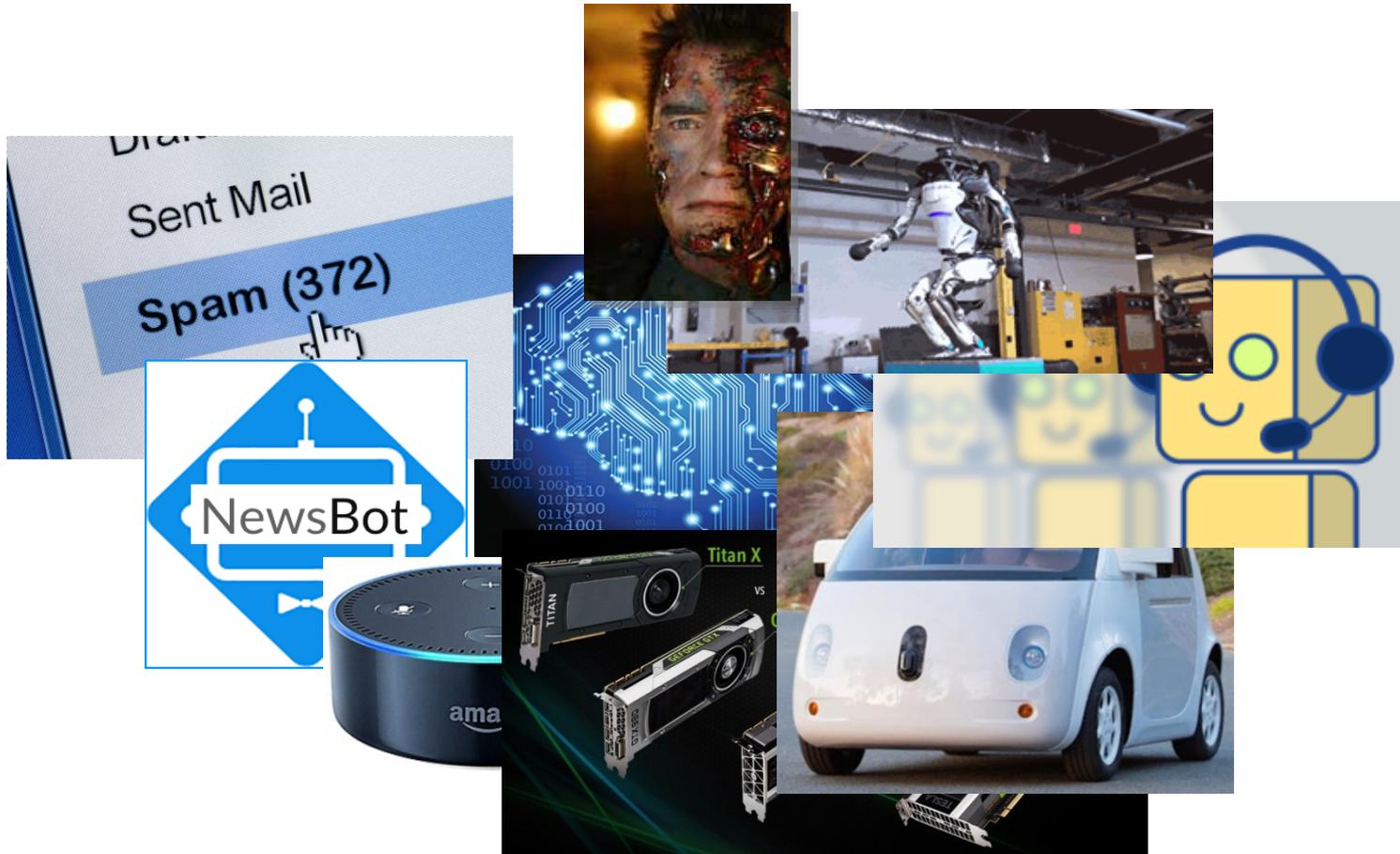


Artificial Intelligence

- AI in the media
 - Popular movies
 - ◆ 2001: A Space Odyssey
 - ◆ Star Wars
 - ◆ The Terminator
 - ◆ The Matrix
 - ◆ Artificial Intelligence: AI
 - ◆ and many ...
 - Popular press, novels
- Often portrayed as
 - A property of evil computers
 - Computers doing impossible things
- Public view
 - Books and movies have inspired many AI researchers
 - Books and movies have raised the public's expectations



Artificial Intelligence



AI Is Transforming The Industries

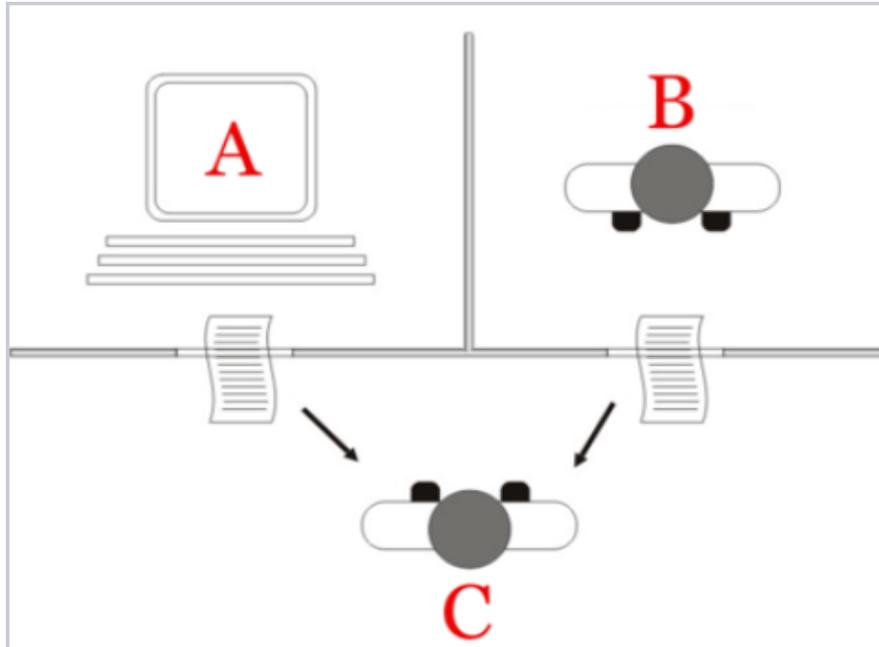
- AI has transformed the IT industry
 - Search Engine
 - Speech Recognition
 - Machine Translation
 - Recommendation

- AI is transforming other industries
 - Transportation
 - Healthcare
 - Finance
 - Insurance, Law, HR, Travel, Media, ...

Artificial Intelligence

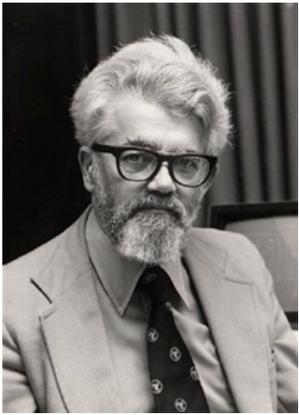


□ Turing Test



The "standard interpretation" of the Turing Test, in which player C, the interrogator, is given the task of trying to determine which player – A or B – is a computer and which is a human. The interrogator is limited to using the responses to written questions to make the determination. (wiki)

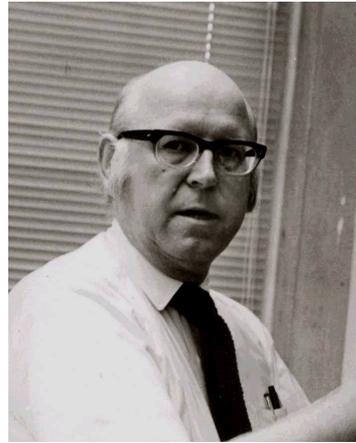
□ Artificial Intelligence is an ultimate dream of computer science



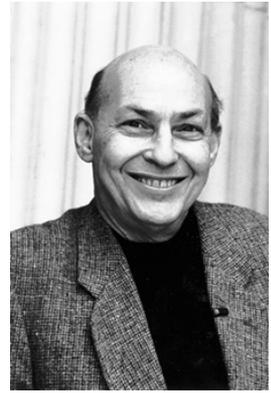
John McCarthy



Herb Simon



Allen Newell



Marvin Minsky

Seminal event for AI as a field, in 1956:

The **Dartmouth Summer Research Conference on Artificial Intelligence**

“We propose that a 2 month, 10 man study of artificial intelligence be carried out during the summer of 1956 at Dartmouth College in Hanover, New Hampshire. The study is to proceed on the basis of **the conjecture that every aspect of learning or any other feature of intelligence can in principle be so precisely described that a machine can be made to simulate it.** An attempt will be made to find how to make machines use language, form abstractions and concepts, solve kinds of problems now reserved for humans, and improve themselves. We think that a significant advance can be made in one or more of these problems if a carefully selected group of scientists work on it together for a summer.”

Over-Confidence

Herbert Simon (1957)

It is not my aim to surprise or shock you - but the simplest way I can summarize is to say that there are now in the world machines that think, that learn and that create, ... More precisely: within 10 years a computer would be **chess champion**, and an important new **mathematical theorem** would be proved by a computer.

Both of these milestones have now been achieved by computers, but each happened much later, more than **10** years:

1. Four color theorem proven in 1976 by Kenneth Appel and Wolfgang Haken
2. Deep Blue *chess* computer *defeated* Kasparov in 1997

History

- 1956: The **Dartmouth Summer Research Conference on Artificial Intelligence**, Seminal event for AI as a field
- 1976: **Four color theorem** was proven by Kenneth Appel and Wolfgang Haken
- 1997: Deep Blue **chess** computer *defeated* Kasparov (10^{50})
 - “Saying Deep Blue doesn’t really think about chess is like saying an airplane doesn’t really fly because it doesn’t flap its wings.”
 - Drew McDermott
- 2016, **AlphaGo** beat a 9-dan professional (Lee Sedol) (10^{170})
- Since 2012, we saw breakthroughs in **Speech Recognition, Image Recognition, Machine Translation, Autonomous Car**, etc.

DARPA Grand Challenge (2004, 2005)

“DARPA intends to conduct a challenge of autonomous ground vehicles between Los Angeles and Las Vegas in March of 2004 (Mojave Desert). A cash award of **\$1 million** will be granted to the team that fields the first vehicle to complete the designated route within a specified time limit.”



Terrain between LA and Las Vegas

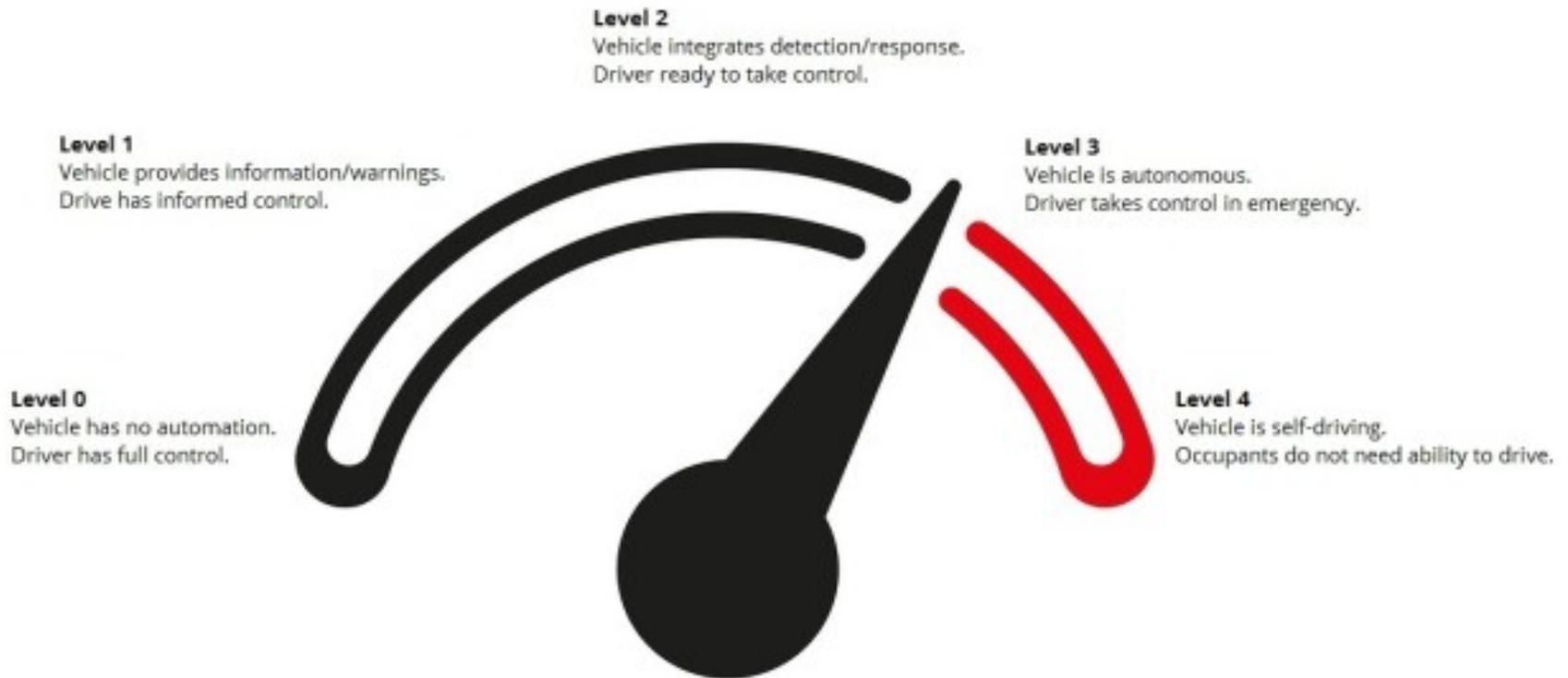






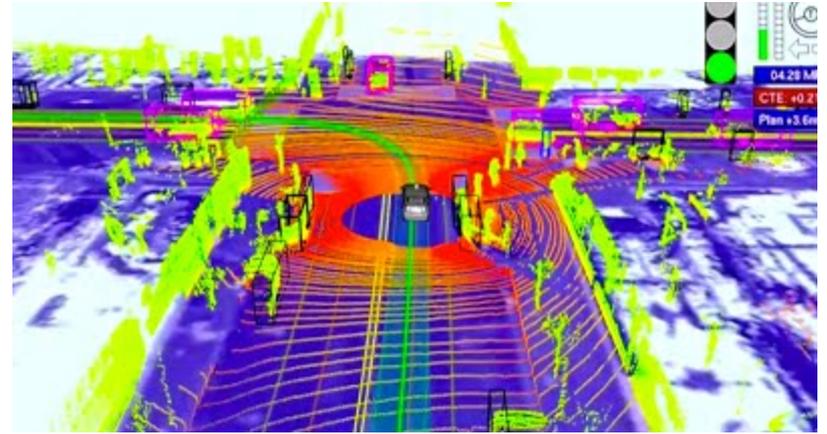
Autonomous Vehicles

The National Highway Traffic Safety Administration's 5 Levels of Automation



Autonomous Vehicles

- LIDAR based: Starting with Google => Waymo



\$75,000 LIDAR (Light Detection and Ranging) sensor is cut to \$7500, Jan 2017

- Pure vision based: Tesla autopilot, etc.
- Now all the major auto car companies are working on autonomous vehicles.

Advanced Driver Assistance Systems

- **Mobileye** developed vision-based advanced driver assistance systems (ADAS) providing warnings for collision prevention and mitigation.
- forward collision warning
- lane keeping
- pedestrian detection
- traffic sign recognition
- adaptive highbeam



MobileEye EyeQ2 chip

Robots

- Honda/Asimo
- Boston Dynamics
- BigDog (2010), Cheetah, WildCat and Atlas (Boston Dynamics) joined Google's growing robot menagerie.
- Google acquired other seven robot companies, wants big role in Robotics
- December 29, 2015, BigDog Robot Shelved by Marines Due to Noise Problem
- Atlas: <https://www.youtube.com/watch?v=vjSohj-IcIc>
- Google Sold Boston Dynamics to Softbank
- Why Google Wants to Sell Its Robots: Reality Is Hard

(Deep) Question Answering

- IBM Watson / Jeopardy!
- Apple Siri
 - The application uses a natural language user interface to answer questions, make recommendations, and perform actions by delegating requests to a set of Web services.
- Amazon Echo / Google Home
 - Associate the natural language user interface with a speaker.
- Google demo of restaurant reservation
 - <https://www.youtube.com/watch?v=eHvyKWS5QzE>
 - (updated link, now working)

Question Answering

Apple Siri

- “Hey Siri, what’s the best sushi place in town?”
- “Find videos I took at Iva’s birthday party”
- “What movies are playing today?”
- “Wake me up at 7 AM tomorrow”

Google Search

- “Who was U.S. President when the Angels won the World Series?”
- But, “Who was the UK prime minister when the Angels won the World Series?”

Can Computers Understand?

- **They ate the pie with ice cream.**
- **They ate the pie with rhubarb.**
- **They ate the pie with paper plates.**
- **They ate the pie with cold milk.**
- **They ate the pie with friends.**
- **They ate the pie with dinner.**
- **They ate the pie with enthusiasm.**
- **They ate the pie with spoons.**
- **They ate the pie with napkins.**

Why Are They Concerned?

- Why are Stephen Hawking, Elon Musk, and Bill Gates concerned about Artificial Intelligence?



Were We Concerned?



Usain Bolt: Men's 100M (9.58s)



Tesla Model S P100D does 0-60 in 2.5 Seconds

But, the reason we were not concerned about is the reason we are concerned about now.

Concerns

- Elon Musk: artificial intelligence is our biggest existential threat

<http://www.theguardian.com/technology/2014/oct/27/elon-musk-artificial-intelligence-ai-biggest-existential-threat>

“I think we should be very careful about artificial intelligence. If I had to guess at what our biggest existential threat is, it’s probably that. So we need to be very careful,” said Musk.

- Stephen Hawking: warns artificial intelligence could end mankind, <http://www.bbc.com/news/technology-30290540>

“Humans, who are limited by slow biological evolution, couldn’t compete and would be superseded”

“We are in the middle of a new industrial revolution.” --- Bernhard Schölkopf

- First two revolutions: our ability to harness energies
 - Coal / Fossil fuel
 - Electricity
- Third revolution our ability to harness information
 - Digital revolution from 1950s.
 - Big Data revolution, most recently, AI revolution
- Fundamental societal changes
 - Job loss
 - Addiction, polarization
 - Privacy, fairness
 - Synthesize voice, face of any one
 - AI Weapons?



Goals of AI

- Scientific

- To understand the principles and mechanisms that account for intelligent action

To create models and mechanisms of intelligent action

- Engineering

- To design intelligent systems that can survive and operate in the real world and solve problems of considerable scientific difficulty at high levels of competence

To understand and build intelligent systems

Intelligent systems

- An intelligent system is characterized as one that can:
 - Exhibit adaptive, goal-oriented behavior
 - Learn from experience
 - Use vast amounts of knowledge
 - Exhibit self-awareness
 - Interact with humans using language and speech
 - Tolerate error and ambiguity in communication
 - Respond in real-time

What AI people study

- Logic
- Knowledge representation
- Search
- Reasoning/inference
- Planning
- Probabilistic reasoning
- Machine learning
- Speech recognition
- Machine Translation
- Natural language processing
- Computer vision
- Pattern recognition
- Intelligent agents
- Robotics
- Neural networks
- Data mining
- Expert systems

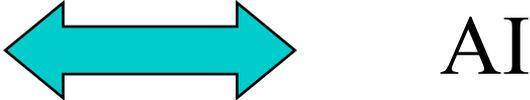
... and more...

What AI people (and programs) do

- Prove theorems
- Emulate/model human cognitive abilities
- (Attempt to) solve exponentially hard problems
- Build expert systems for diagnostic tasks (e.g, medical diagnosis, error analysis)
- Build robots
- Build machine vision systems for industrial tasks, surveillance, consumer apps, etc.
- Create speech recognition and understanding systems for various domains
- Process text to {understand, summarize, correct, respond, etc. }
- Create data mining systems to process very large amounts of information (e.g., bioinformatics)
- Build intelligent agents to look and act in socially useful ways
- Develop computer games
- Big Data Analytics

... and more...

Perspectives on AI / Disciplines involved

- AI functions as a channel of ideas between computing and other fields, ideas that in fact have profoundly changed those fields
 - Logic
 - Mathematics
 - Statistics
 - Philosophy
 - Psychology
 - Linguistics
 - Neuroscience
 - Cognitive science
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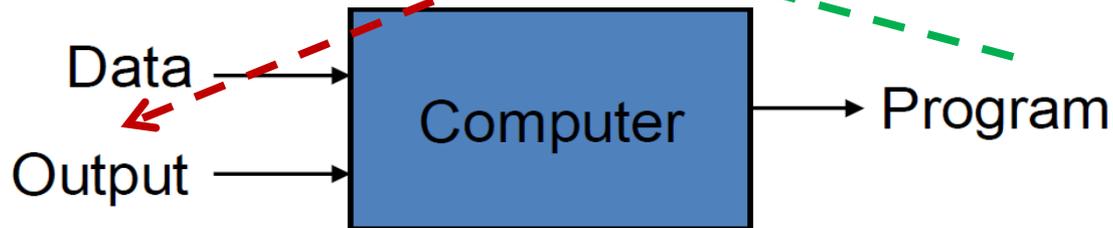
Core Area: Machine Learning

Machine learning is a field of computer science that gives computers the ability to learn without being explicitly programmed

Traditional Programming

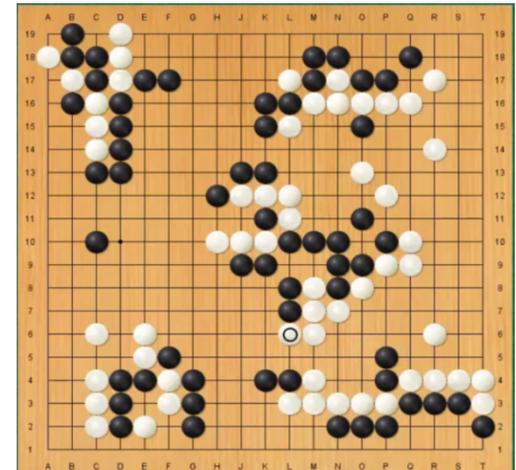
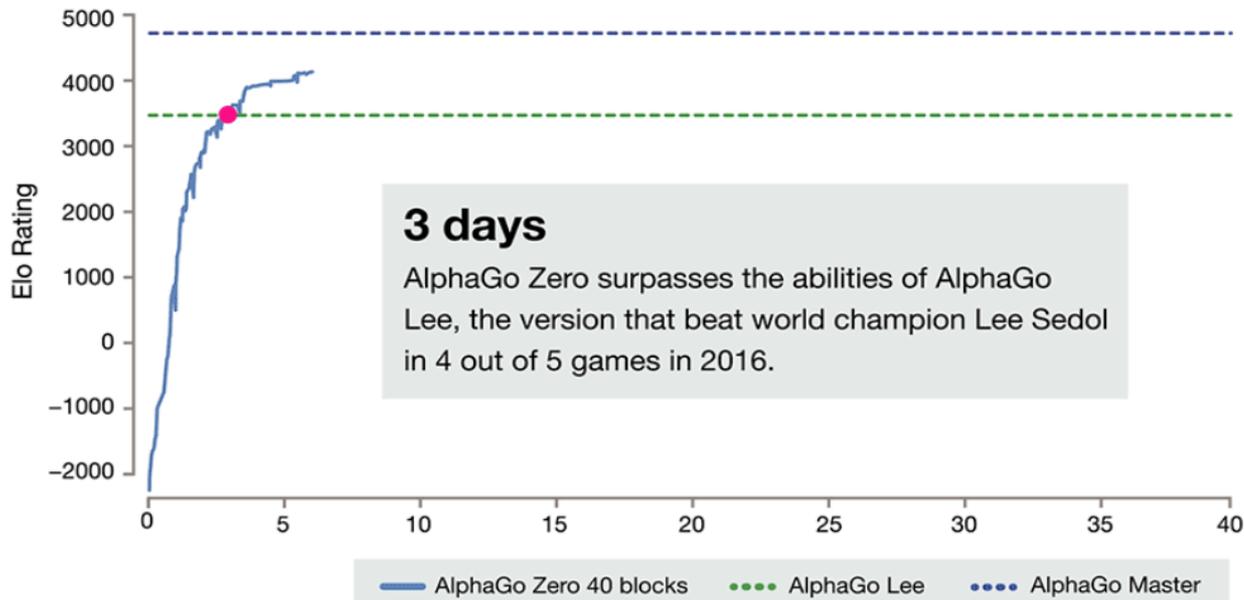


Machine Learning



AlphaGo

- AlphaGo: trained on thousands of professional games to learn how to play Go.
- AlphaGo Zero skips this step and learns to play simply by playing games against itself, starting from completely random



<https://deepmind.com/blog/alphago-zero-learning-scratch/>

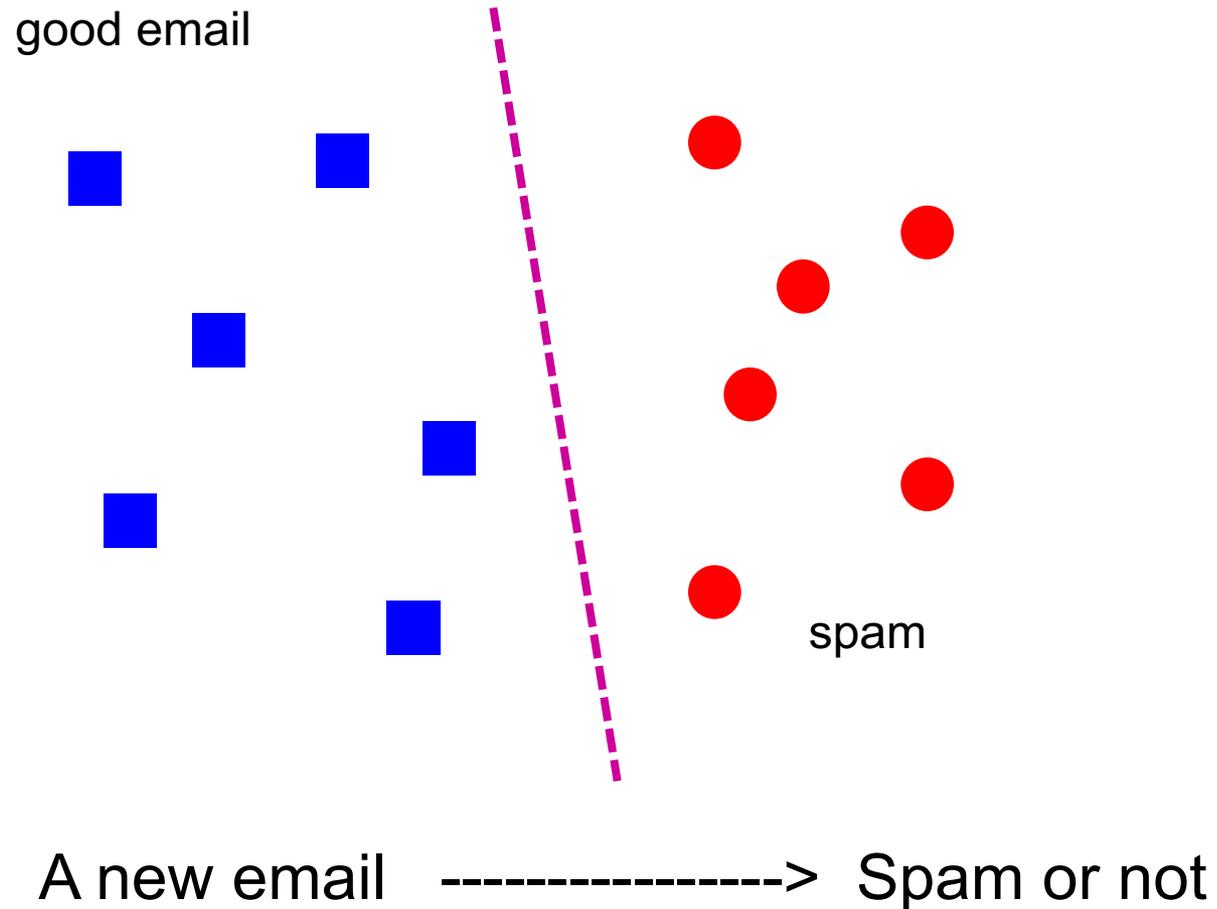
Autonomous Vehicles

- How to drive 10 billion miles in an autonomous vehicle?
Simulation!



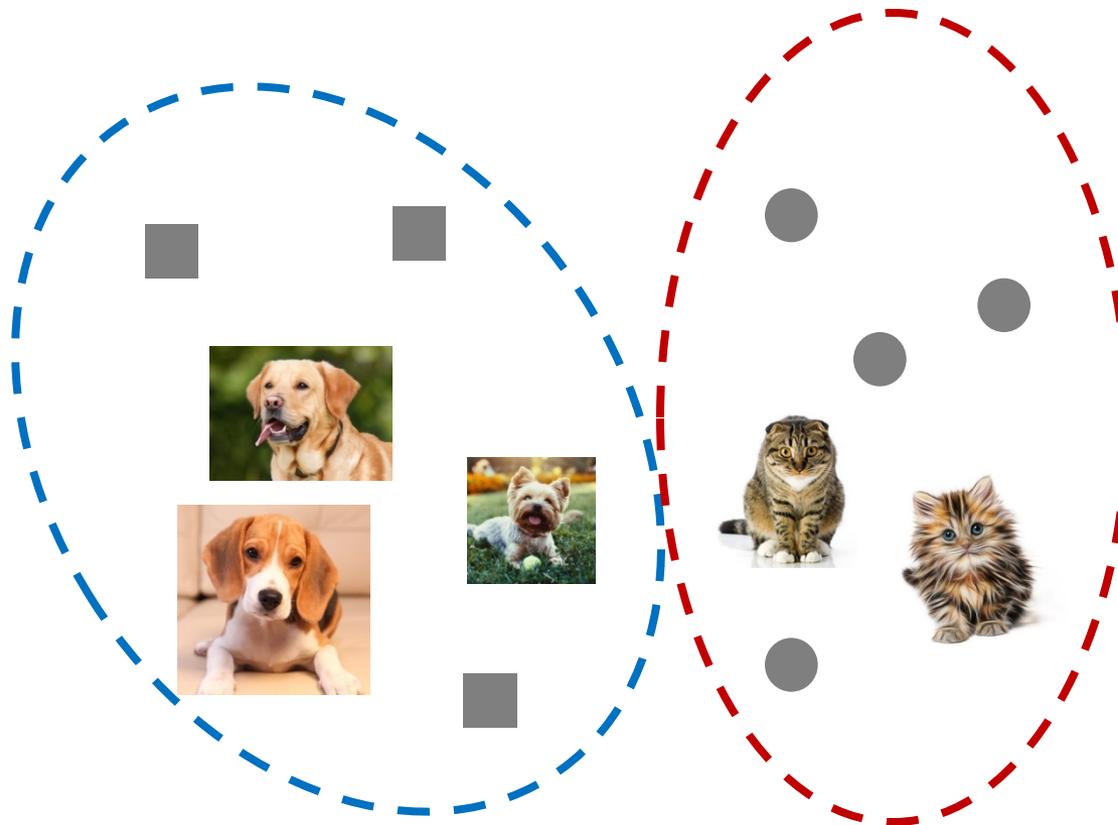
Two Typical Problems in Machine Learning

Supervised Learning (Classification)



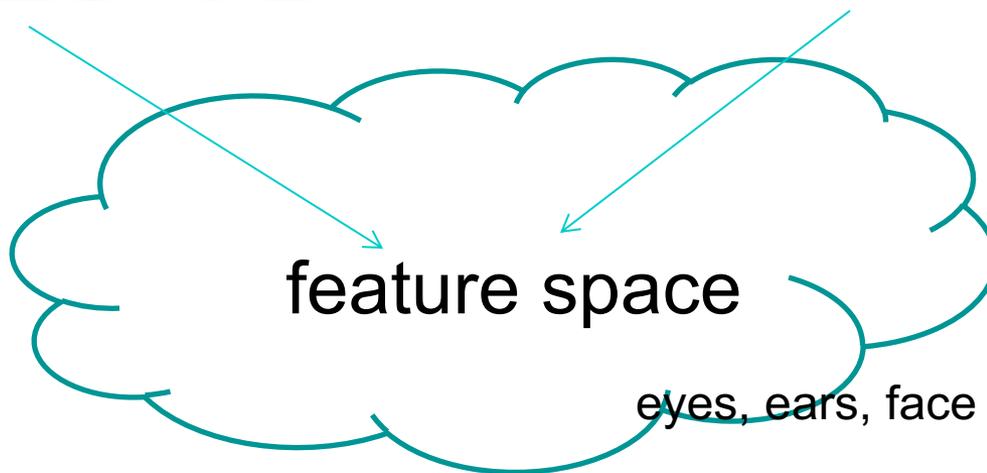
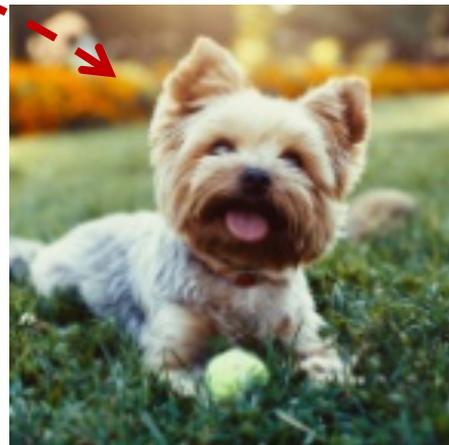
Two Typical Problems in ML (cont.)

Unsupervised Learning (Clustering)

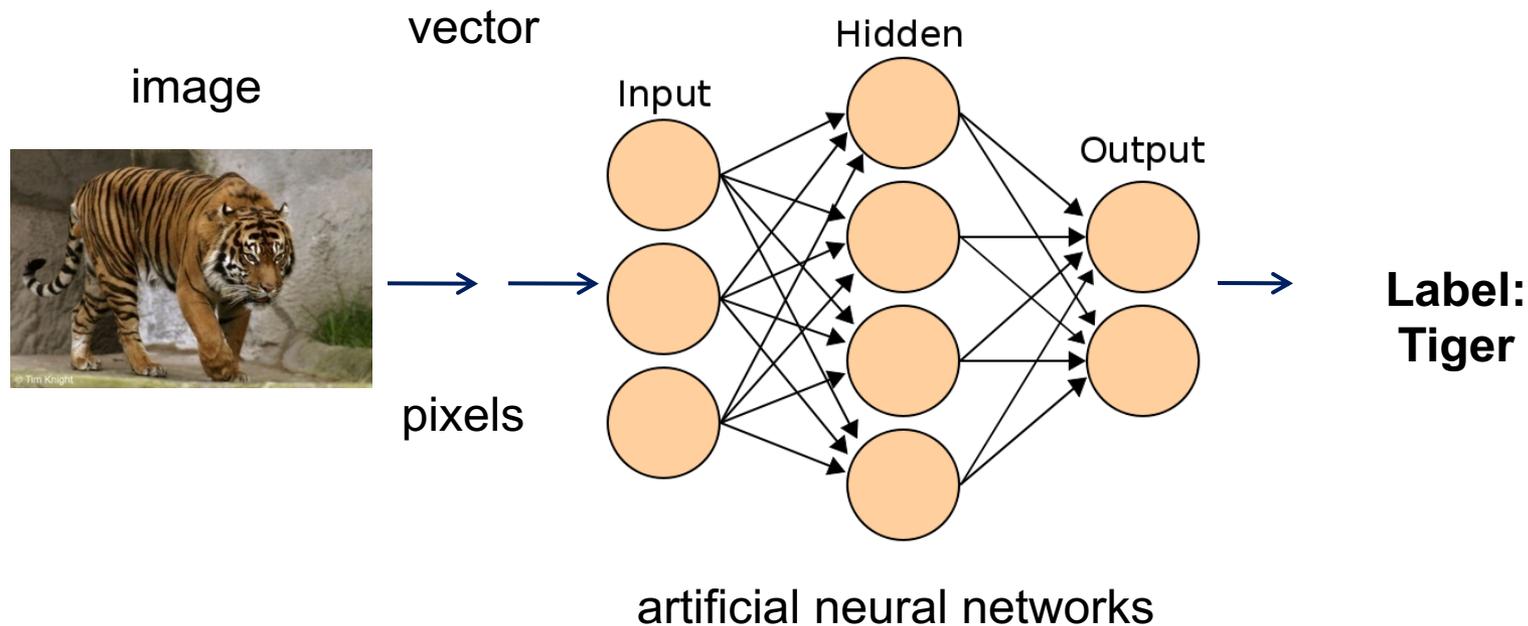


A Representation Problem

Pixel Comparison?



What Does Deep Learning Offer?



- One engine good for both representation and classification
- One engine good for classification, clustering, and regression

Deep CNN

Convolutional neural nets

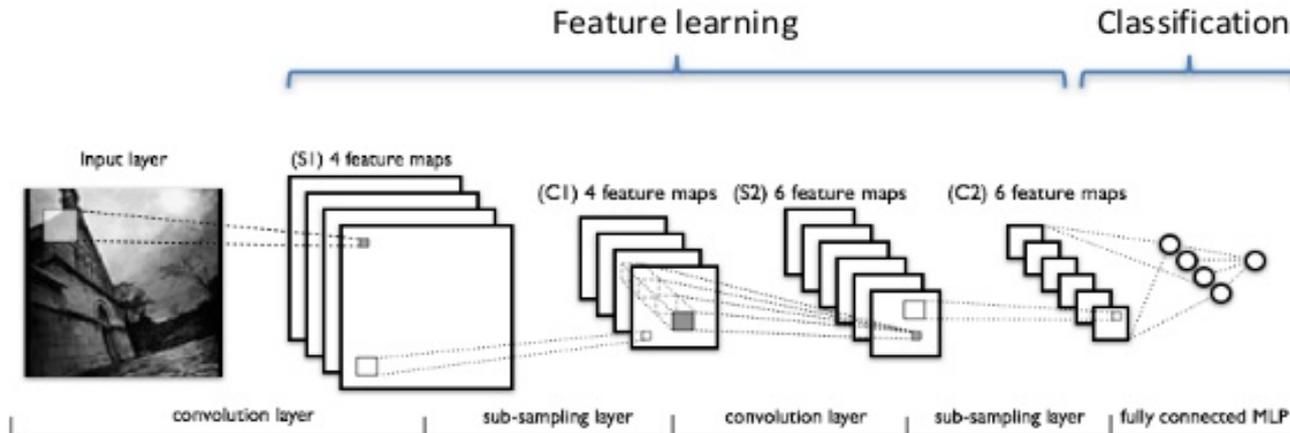


Image credit: <http://deeplearning.net/tutorial/lenet.html>

With Neural Networks and Deep Learning

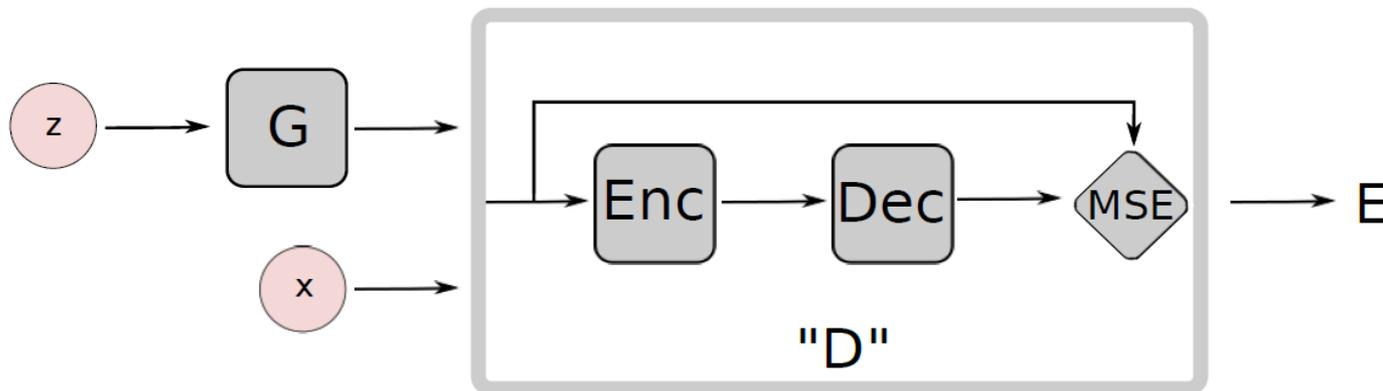
- Unified (simpler) structure => general artificial intelligence
- One engine good for both representation and classification
- Good for both classification and clustering
- It really works for some long-standing difficult problems
- It has breakthroughs, starting at **Speech recognition (2012)** => **image recognition** => **machine translation** => **natural language processing**

Impact

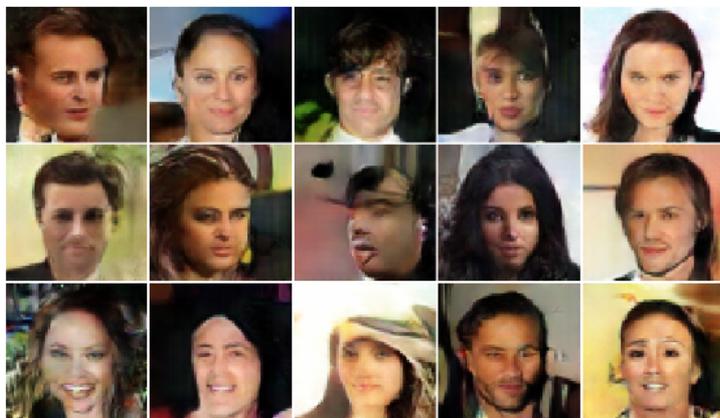
- Lower down the technical barrier in many subareas of AI

- Disrupting the IT industry: Many techniques developed before 2012 are obsolete
 - Speech Recognition: IBM Viavoice => Google Voice
 - Hardware: Intel CPU => NVidia GPU, Google TPU
 - Autonomous Cars: Hertz=>Uber=>Google Waymo
 - Information Search:
 - Keyword based => Vector based
 - Web Pages => Knowledge graph
 - IBM Watson and Lucidworks have to change

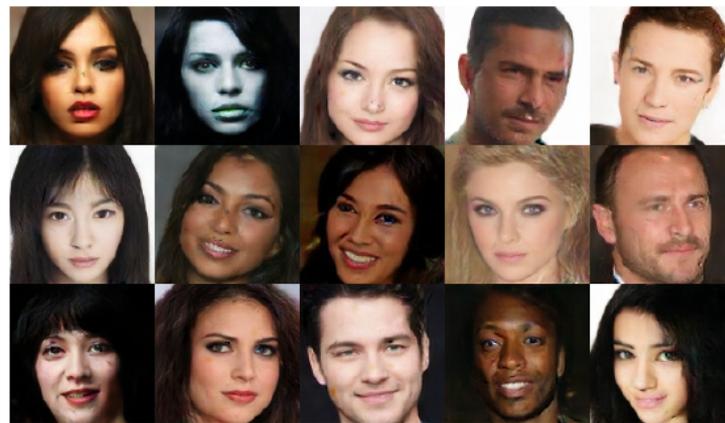
Generative Adversarial Network (Goodfellow 2014)



EBGAN architecture with an auto-encoder discriminator (Zhao, et al 2016)

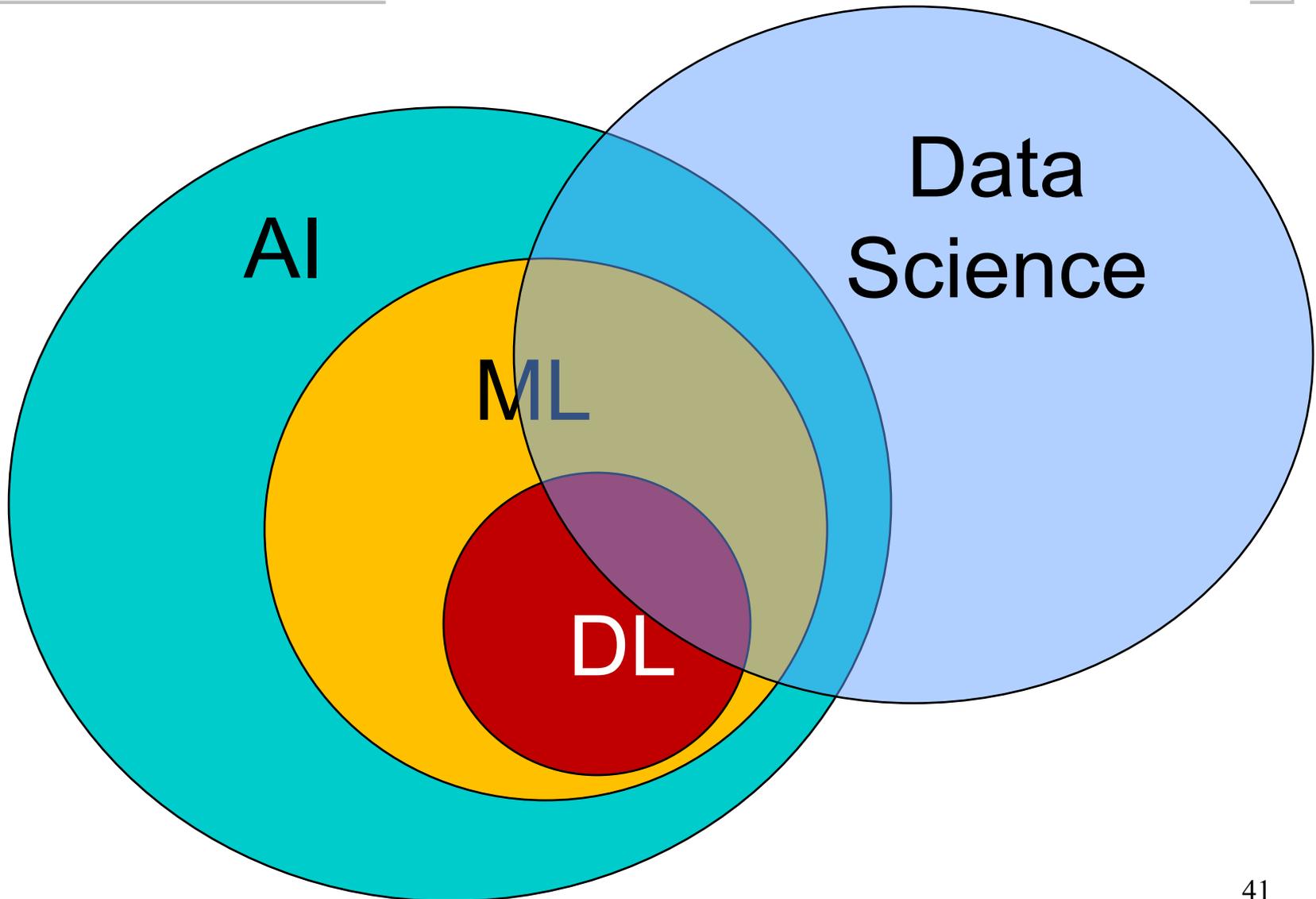


EBGAN (Zhao et al, 2016)



BEGAN (Berthelot et al, 2017)

AI, Machine Learning, Deep Learning, Data Science



Is it all just hype?

'AI IS THE NEW ELECTRICITY'



“Just as electricity transformed almost everything 100 years ago, today I actually have a hard time thinking of an industry that I don't think AI will transform in the next several years.”

Andrew Ng
Former chief scientist at Baidu, Co-founder at Coursera

CBINSIGHTS source: <https://www.gsb.stanford.edu/insights/andrew-ng-why-ai-new-electricity> www.cbinsights.com 7

“For those debating ML hype, getting a ticket to a ML conference is now more challenging than a Taylor Swift conference or a Hamilton showing.”

– Kaggle CTO Ben Hamner



NIPS @NipsConference · 4m

#NIPS2018 The main conference sold out in 11 minutes 38 seconds

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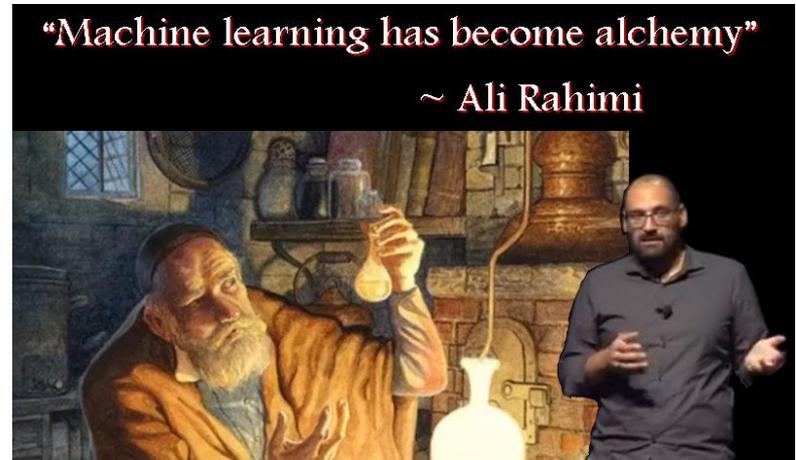
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Is it all just hype?

- AI research is supported by rigorous mathematical foundation.
 - Although... there's caveat.
 - Theory is always a bit behind.

- AI Researchers know the limitations of their algorithms
 - (although.... sometimes it's easy to go over the top)



Regardless, it is an exciting time!

- The field of AI is gathering the top talent from CS, Stats, Math, Physics, Engineering, Business like never before!
 - 70% PhD applicants to UCSB CS want to specialize in AI / ML!
- We are training **the first generation of Da Vinci-like engineers / researchers** in large scale
 - Who can swiftly leverage multiple branches of mathematics
 - Understand computing / computer systems / top coder
 - Understand statistics / causality / data savvy
 - Borrow ideas from neural science / biological world.

Goals of this course

- To teach you some ideas of AI
- To introduce you to a set of key techniques and algorithms from AI
- To get you thinking about how AI can be applied to a variety of real problems
- To help you understand what's hard in AI
- To be grounded despite the hype
- **It is not about vision, natural language processing, machine learning, AlphaGo,...it is an entry level course**

The schedule of this course

Week	Topic	
	Introduction and Course Overview	
1	AI Problem Solving and Intelligent Agents	
	Machine Learning	Machine Learning
2	Machine Learning	
	Probabilistic Graphical Models	Probabilistic Reasoning
3	Probabilistic Graphical Models	
	Search: Problem solving with search	Search
4	Search: Search algorithms	
	Search: Minimax search and game playing	
5	Midterm Review	
	Midterm	
6	RL: Intro, bandits	Reinforcement Learning
	RL: Contextual Bandits	
7	RL: Markov Decision Processes	
	RL: TD Learning	
8	RL: Deep RL, AlphaGo	
	Logic: Propositional Logic	Logic
9	Logic: First order Logic	
	Responsible AI	
10	Review session	
11	Final Exam. 12:00 PM - 3:00 PM	

It will be tough and time-consuming to many!

- You need to use math:
 - Calculus, Linear Algebra, Probabilities.
 - Know how to do complexity analysis in Big O notation.
- You need to be able to code:
 - Mainly in Python (numpy, scipy)
 - Data structures: trees, graphs, hashtables, sparse matrices, etc...
- Homework assignments will be about things that complement the materials in the lectures.
 - That will help you gain deeper understanding of the topics.
- Formal prerequisite:
 - CS20, CS50, CS130A, PSTATS 120A.

It will be “worth it”.

- Like Jedi training.
 - The information can be presented to you, but you can only learn if you are actively looking and thinking.
 - I learn a lot more from doing homeworks on my own than just from the lectures.
- We (your instructor, TAs and peers) are ready to help you!
 - Discussion sessions on Friday, Office hours, Piazza

Useful resources

- Appendix A in the AIMA book.
- Chapter 2, Chapter 17-18 of the D2L book: <http://d2l.ai/>
- Linear Algebra Review by Zico Kolter
 - http://www.cs.cmu.edu/~zkolter/course/linalg/linalg_notes.pdf
 - Videos: <http://www.cs.cmu.edu/~zkolter/course/linalg/index.html>
- Probability and Statistics by Rob Hall
 - http://www.cs.cmu.edu/~aarti/Class/10701/recitation/prob_review.pdf
- Linear algebra + Statistics videos by Aaditya Ramdas
 - https://www.youtube.com/channel/UC7gOYDYEgXG1yIH_rc2LgOw/playlists

UCSB CS AI Sequence: 165A and 165B

165A. Artificial Intelligence

Introduction to the field of artificial intelligence, which seeks to understand and build intelligent computational systems. Topics include intelligent agents, problem solving and heuristic search, knowledge representation and reasoning, uncertainty, probabilistic modelling and inference, planning and reinforcement learning.

165B. Machine Learning

The course covers the most important techniques of machine learning (ML) and includes discussions of: well-posed learning problems; artificial neural networks; concept learning and general to specific ordering; decision tree learning; genetic algorithms; learning sets of rules; Bayesian learning; analytical learning; and combining inductive and analytical learning. The course integrates these approaches to learning with fundamental aspects of machine intelligence (MI), including search, knowledge representation and reasoning, and applications.

UCSB CS Advanced AI courses

- CS190I: Introduction to Natural Language Processing
- CS181: Introduction to Computer Vision
- More to come
- Please check graduate courses too

- CS292A: Convex Optimization: Gradient Methods and Online Learning
 - My course for Fall 2020 (the 2019 version available on my website)

- CS292K: “Deep Learning” by Xifeng Yan

Course information

- Web sites
 - <http://www.cs.ucsb.edu/~yuxiangw/classes/CS165A-2020winter/>
 - ◆ Announcements, syllabus, schedule, lecture notes, assignments, related links
- Discussion on Piazza:
piazza.com/ucsb/winter2020/cs165a
- Homework submission on Gradescope
 - Come to the lectures for the sign-up code!
- Textbook
 - Stuart Russell and Peter Norvig, Artificial Intelligence: A Modern Approach, Prentice Hall, Third Edition, 2010
 - Other reference books will be referred to. (e.g., Sutton and Barto will be our main text for the RL part of the class)

Workload and Grade

- 4 Homework Assignments, 2 Exams
- 60% Homework assignments
15% Midterm exam
25% Final exam
- x% bonus points:
 - For solving bonus questions in homeworks
 - For class participation
- **Late Policy: No late submission allowed.**

Office Hours

- Instructor Office Hour: Thursday 2:00-3:00pm, HFH 2121
- TA1: Boyuan Feng, Office Hour: Monday 3:00-4:00pm, HFH-1138 (CSIL).
- TA2: Jianyu Xu, Office Hour: Wednesday 1:00-2:00 pm, Trailer 936.
- TA3: Sonia Hashim, Office Hour: Thursday 5:00-6:00pm, Trailer 936.
- **Ask your questions on Piazza!**

How to Maximize Your Learning

- Read textbook chapter (or other resources) before class
- Attend lectures and study the slides
- Read related chapters before the class
- **All of the old slides from 2019 are online.**

- Do your own “homework”, self-study
- Ask your peers
- No last minute work

This Week

- Next lecture: Finish overview, start machine learning.
- Homework 1 will be released on Thursday midnight.
- Discussion class on Friday is a refresher on linear algebra and probability.