

CSCI 599: Deep Learning and its Applications

Lecture 1

Spring 2019
Joseph J. Lim

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Welcome to CSCI 599!

This class will teach you
one of the most exciting developments in
Machine Learning, Computer Vision, NLP, Robotics,
Other AI related fields
in the last decade!

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Welcome to CSCI 599!

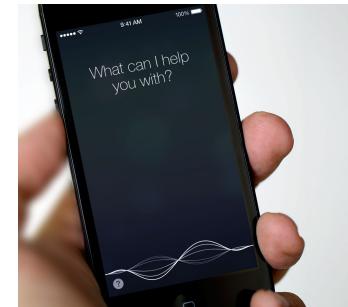
For today, we need your attendance checked.

Please check in with TAs after the class.

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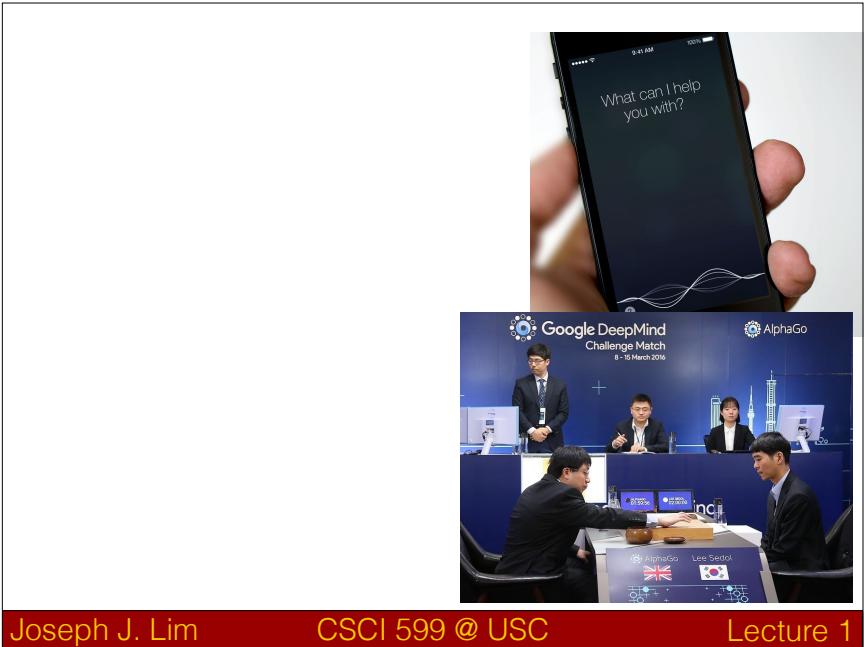
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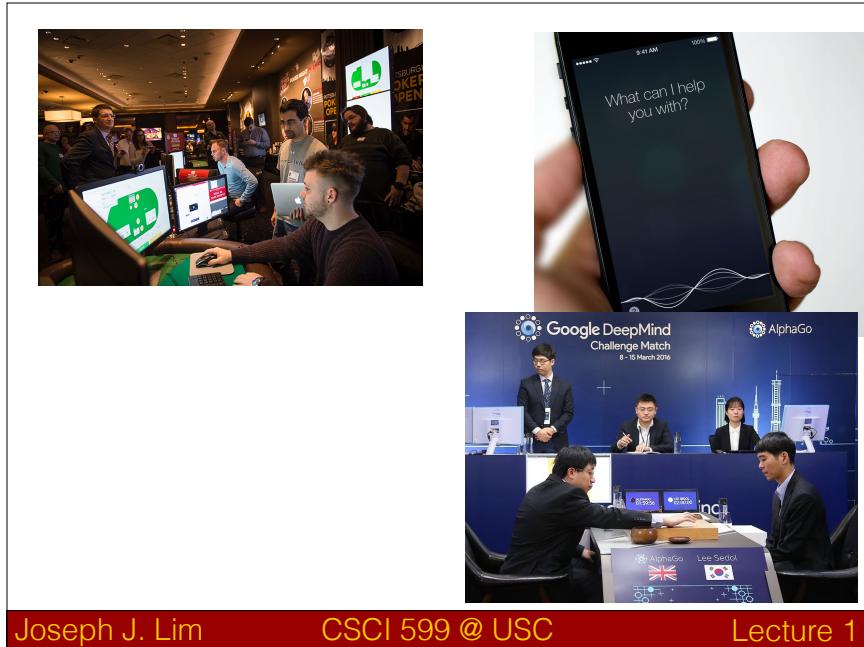
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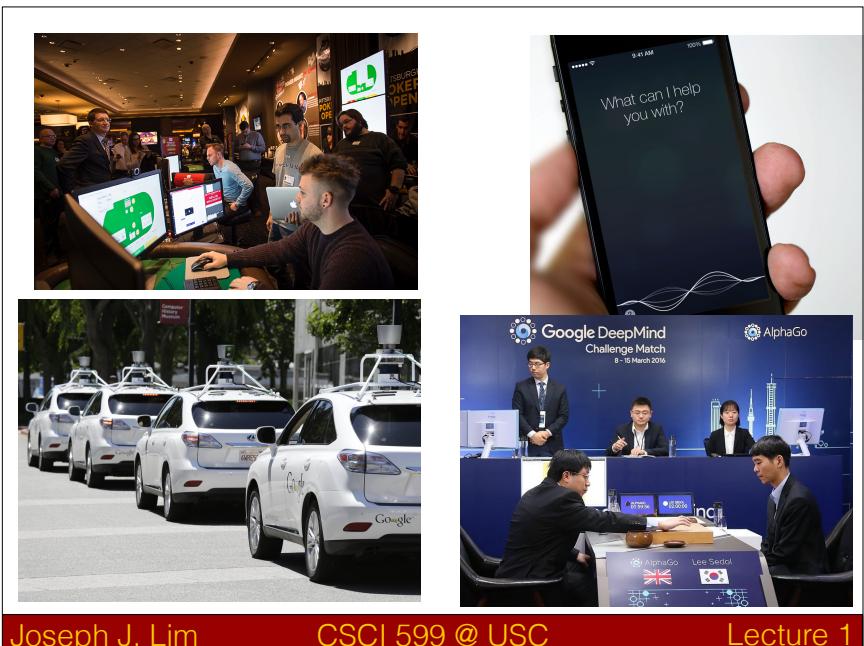
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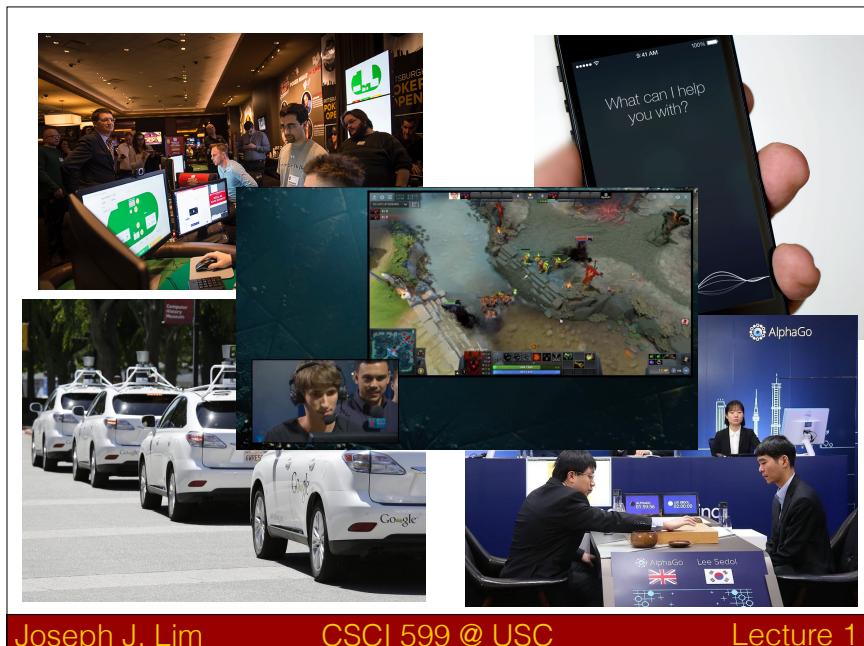
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Disclaimer

- This course is taught for the 2nd time @ USC. This course is 599, and thus an **experimental** course.
- The syllabus, course policy, and grading details **may change** over the semester (**check website!**)
- If you prefer a well-structured course, this is **not** a course for you, and I encourage you to take the course next year.
- It will be fun but challenging!

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Should be **already** familiar with Machine Learning

Do you know the following..?

- Probability and Statistical Learning
 - Density function, loss function, cross-validation

Should be **already** familiar with Machine Learning

Do you know the following..?

- Probability and Statistical Learning
 - Density function, loss function, cross-validation
- Supervised Learning
 - Nearest Neighbor, Kernels, Random Forest

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Should be **already** familiar with Machine Learning

Do you know the following..?

- Probability and Statistical Learning
 - Density function, loss function, cross-validation
- Supervised Learning
 - Nearest Neighbor, Kernels, Random Forest
- Unsupervised Learning
 - Clustering, PCA, SVD

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Should be **already** familiar with Machine Learning

- If not, please take other ML courses first!
 - For example, CSCI 567: Machine Learning

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Today's agenda

- A brief introduction to Deep Learning
- Survey
- CSCI 599 overview

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Today's agenda

- A brief introduction to Deep Learning
- Survey
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Deep Learning is impacting everywhere

- Machine Learning
- Computer Vision
- Natural Language Processing
- Robotics
- Medical Application
- Graphics
- Finance
- and many more

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Art Creation



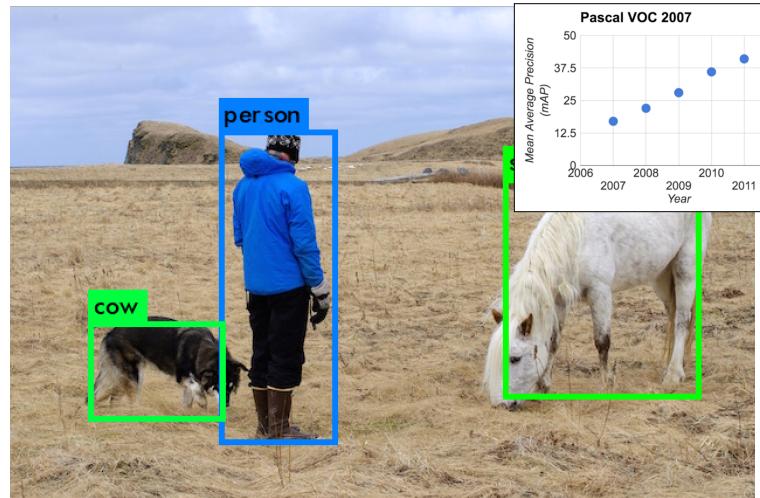
Elgammal, Ahmed, et. al. CAN: Creative Adversarial Networks, Generating "Art" by Learning About Styles and Deviating from Style Norms. arXiv 2016.

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Object Detection



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Object Detection in Video



J. Redmon and A. Farhadi. YOLO9000: Better, Faster, Stronger. CVPR 2017.

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Semantic Segmentation



K. He, et. al. Mask R-CNN. arXiv 2017.

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3D Pose for Furniture



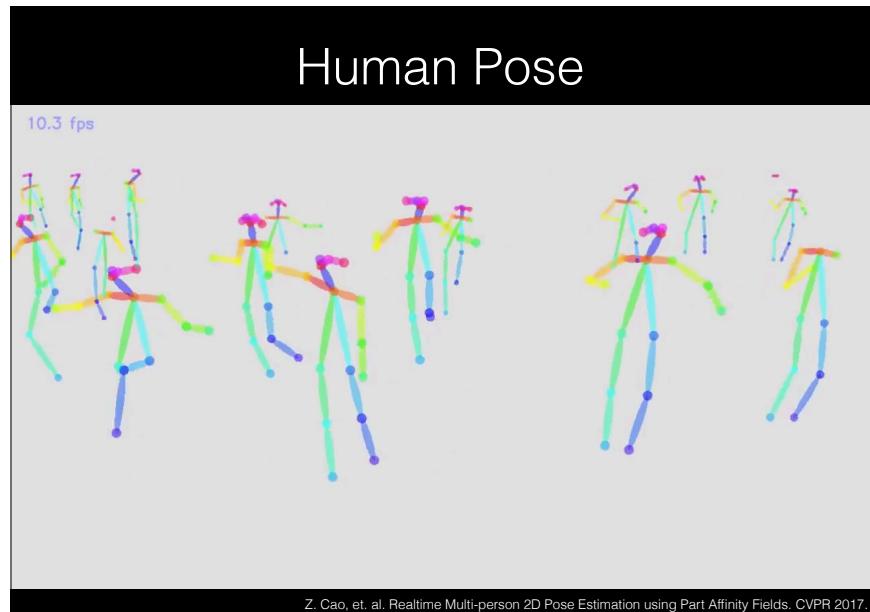
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J. Lim, et. al. Parsing IKEA Objects: Fine Pose Estimation. ICCV 2013.

Human Pose



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Z. Cao, et. al. Realtime Multi-person 2D Pose Estimation using Part Affinity Fields. CVPR 2017.

Image to Caption



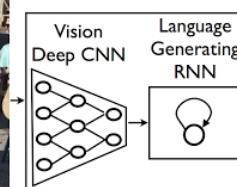
From <https://research.googleblog.com/2014/11/a-picture-is-worth-thousand-coherent.html>

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Image to Caption



A group of people shopping at an outdoor market.
There are many vegetables at the fruit stand.

From <https://research.googleblog.com/2014/11/a-picture-is-worth-thousand-coherent.html>

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Caption to image

Caption

the flower shown has yellow anther red pistil and bright red petals

this flower has petals that are yellow, white and purple and has dark lines

the petals on this flower are white with a yellow center

Caption to image

Caption

the flower shown has yellow anther red pistil and bright red petals



this flower has petals that are yellow, white and purple and has dark lines



the petals on this flower are white with a yellow center



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Reed, Scott, et. al. Generative Adversarial Text to Image Synthesis. ICML 2016.

Visual Question Answering (VQA)



Who is holding the kite?

Submit

Visual Question Answering (VQA)



Who is holding the kite?

Submit

Predicted top-5 answers with confidence:

| | |
|-------|---------|
| man | 39.354% |
| woman | 17.493% |
| girl | 14.672% |
| child | 7.824% |
| boy | 6.156% |

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From <http://www.visualqa.org/>

From <http://www.visualqa.org/>

Machine Translation

Korean English Chinese (Simplified)

CS599 will be a fun class! CS599는 재미있는 수업이 될 것입니다!

26/5000 Suggest an edit

Korean Spanish Chinese (Simplified)

CS599 será una clase divertida! CS599将是一个有趣的课!

Suggest an edit

German Spanish Chinese (Simplified)

CS599 sera une classe amusante! CS599 wird eine lustige Klasse!

Suggest an edit

Google Translate

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How AI detectives are cracking open the black box of deep learning

By Paul Voosen | Jul. 4, 2017 | 2017

Jason Yosinski sits at a small glass bar at Uber's San Francisco, California, headquarters, pondering the need for ethical interpretation. An AI research scientist, Yosinski is performing a kind of brain surgery on a neural network that has been trained to recognize faces in images. He is one of many members involved in cracking self-driving Uber cars. Yosinski's program is a deep neural network, with an architecture that allows it to identify faces in images. The program is trained to recognize faces in images, he says. "It's a black box."

This particular network is trained to identify faces, Yosinski reveals. Could it recognize Yosinski as Jason? As an adult? Or a child? And could it recognize his face in different sizes, different colors, different angles, as he speaks?—to what is prompting its response? Two photofinishes pop up and float across the screen. In one, Yosinski is a small child; in another, he is a middle-aged man. "It's a black box," he says. "It tends to different size faces, different color faces."

No one trained this network to identify faces, Yosinski reveals. In its training images, "I learned how to identify faces in images, but I don't know what it means," he says. "It's a black box." Yosinski's program is trained to identify faces in images. "It's a black box," he says. "But I don't quite understand them. And every year, this gap is going to get a bit larger."

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How AI detectives are cracking open the black box of deep learning

By Paul Voosen | Juillet 4, 2017 | 2017

Jason Yosinski s'assied à un petit comptoir en verre à l'entreprise Uber de San Francisco, Californie, réfléchissant à la nécessité d'une interprétation éthique. Un scientifique de recherche en intelligence artificielle, Yosinski effectue une sorte de chirurgie cérébrale sur un réseau de neurones qui a été entraîné à reconnaître les visages dans les images. Il est l'un des nombreux membres impliqués dans la déconstruction des voitures autonomes Uber. Yosinski's programme est un réseau de neurones profond, avec une architecture qui lui permet de reconnaître les visages dans les images. Il a été entraîné à reconnaître les visages dans les images, il dit. "C'est une boîte noire."

Ce programme particulier est entraîné à reconnaître les visages, Yosinski révèle. Peut-il reconnaître Yosinski comme Jason? Comme un adulte? Ou comme un enfant? Peut-il reconnaître son visage sous différentes tailles, différentes couleurs, différentes angles, lorsque vous parlez?—à quoi réagit-il alors? Deux photos finales apparaissent et flottent à l'écran. Dans une, Yosinski est un petit enfant; dans l'autre, il est un homme d'âge moyen. "C'est une boîte noire," il dit. "Il tend à reconnaître les visages sous différentes tailles, différentes couleurs."

Personne n'a entraîné ce programme pour reconnaître les visages, Yosinski révèle. Dans ses images d'entraînement, "J'ai appris à reconnaître les visages dans les images, mais je ne sais pas exactement ce que cela signifie," il dit. "C'est une boîte noire." Le programme d'Yosinski est entraîné à reconnaître les visages dans les images. "C'est une boîte noire," il dit. "Mais je ne comprends pas complètement ce qu'il fait. Chaque année, cette différence va s'aggraver."

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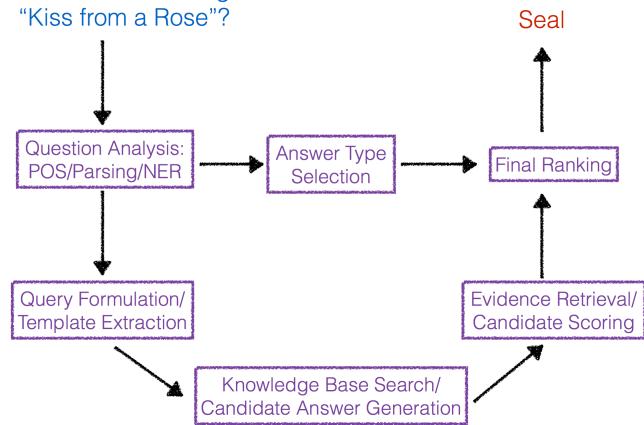
French

Google Translate

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Question Answering

Who wrote the song
"Kiss from a Rose"?



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Object Picking Robot



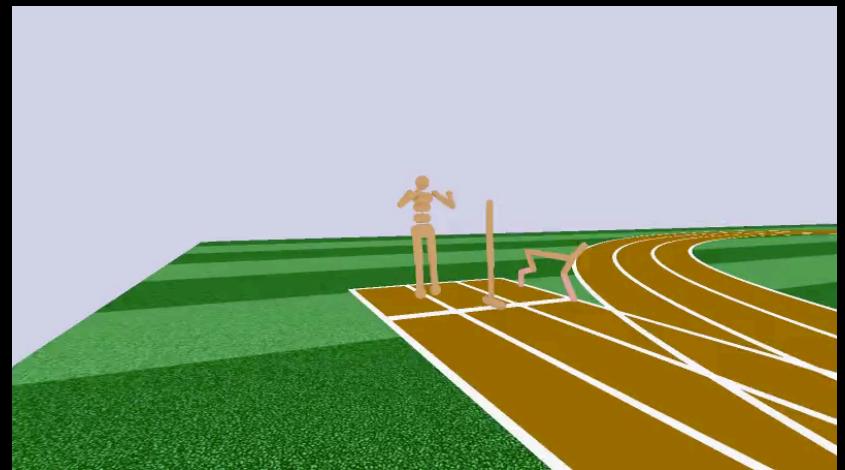
S. Levine, et. al. Learning Hand-Eye Coordination for Robotic Grasping with Deep Learning and Large-Scale Data Collection.. IJRR 2017.

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Learning to Walk

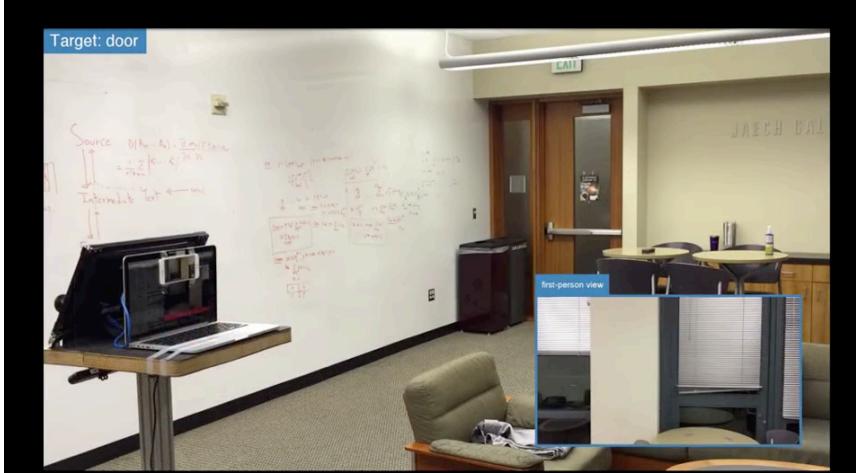


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Navigation Robot



Y. Zhu, et. al. Target-driven Visual Navigation in Indoor Scenes using Deep Reinforcement Learning. ICRA 2017.

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Autonomous Driving



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AutoX
Introducing autonomy

Night
Highway
Express Way
10 Miles

Sunny
Arterial Street
Residential Road
6 Miles

Cloudy Night
Arterial Street
Residential Road
6 Miles

Light Rain
Winding
Hilly Drive
5 Miles



input performance



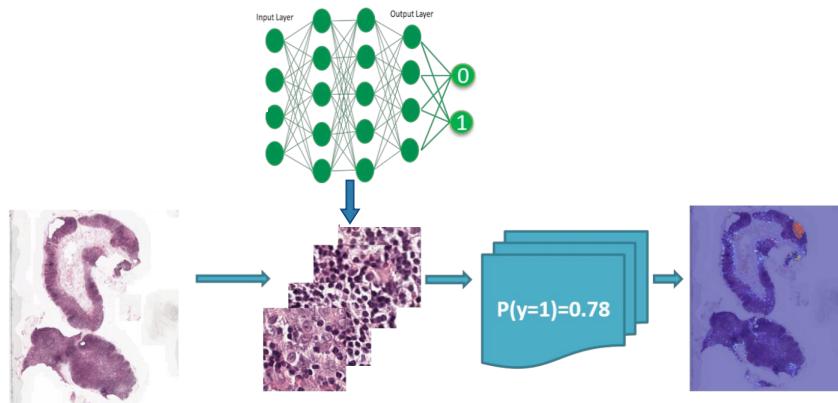
mouth camera



real-time
facial animation

K. Olszewski, J. Lim, S. Saito, H. Li. High-Fidelity Facial and Speech Animation for VR HMDs. SIGGRAPH Asia 2016.

Cancer Metastases Detection



From PathAI's submission to CAMELYON16.

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Deep Learning is impacting everywhere

- Machine Learning
- Computer Vision
- Natural Language Processing
- Robotics
- Medical Application
- Graphics
- Finance
- and many more

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Why is DL so powerful?

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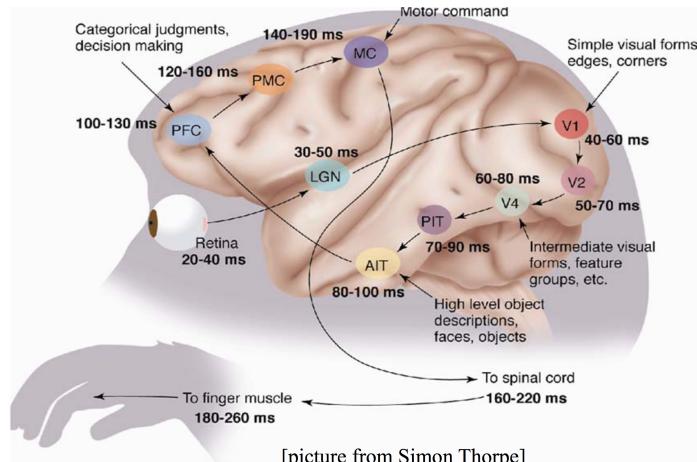
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?

Deep Learning is motivated by

Deep Learning is motivated by human brain



Slide credit: Marc'Aurelio Ranzato, Yann LeCun

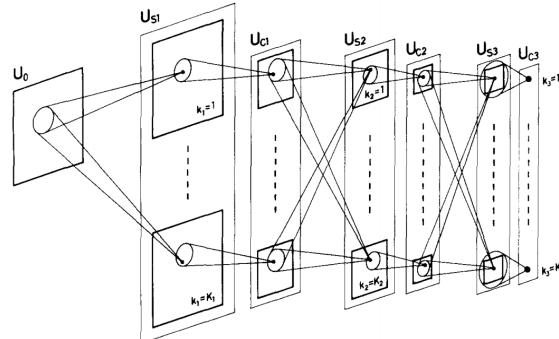
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History of DL in 3 slides

First idea



Fukushima, Kunihiko. Neocognitron: A self-organizing neural network model for a mechanism of visual pattern recognition. Competition and cooperation in neural nets 1982.

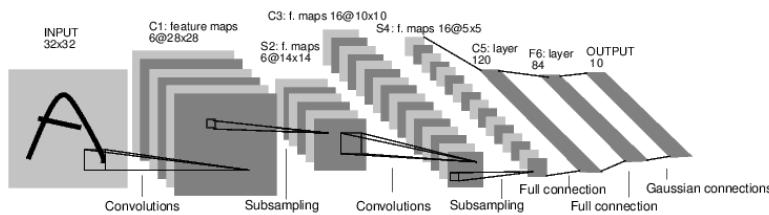
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History of DL in 3 slides

Backpropagation for training



Y. LeCun, et. al. Handwritten digit recognition with a back-propagation network. NIPS 1989.

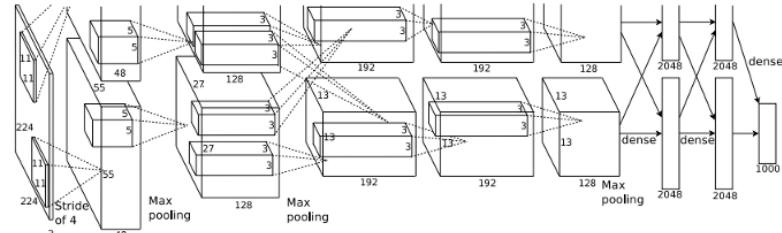
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History of DL in 3 slides

Large-scale data (& GPU)



A Krizhevsky, et. al. ImageNet Classification with Deep Convolutional Neural Networks. NIPS 2012.

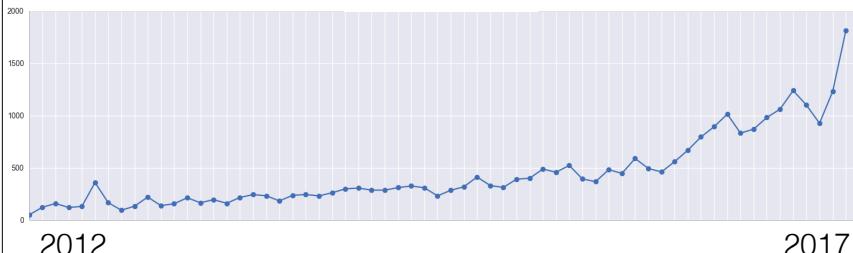
Also known as, **AlexNet**

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DL trend in arXiv



AlexNet

By Andrej Karpathy

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DL trend in arXiv



AlexNet

3 magnitude!!!

By Andrej Karpathy

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- Machine Learning
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- Natural Language Processing
- Robotics
- Medical Application
- Graphics
- Finance
- and many more

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Is Artificial Intelligence solved?

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What is Artificial Intelligence?

What is Artificial Intelligence?

- Artificial intelligence (AI, also machine intelligence, MI) is **intelligence exhibited by machines**, rather than humans or other animals (natural intelligence, NI).

From wikipedia

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AI is **intelligence exhibited by machines**

- Object Detection
- Visual Question Answering
- Question Answering
- Autonomous Driving
- ...

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Is AI solved (by deep learning)?!

AI is **intelligence exhibited by machines**

- Object Detection
- Visual Question Answering
- Question Answering
- Autonomous Driving
- ...

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Is AI solved (by deep learning)?!

- **No!** There are many domains of problems that we don't even know how to tackle.

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Is AI solved (by deep learning)?!

- Supervised Learning
- Unsupervised Learning
- Reinforcement Learning

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Is AI solved (by deep learning)?!

- Supervised Learning
- Unsupervised Learning
- Reinforcement Learning

We are quite good

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Is AI solved (by deep learning)?!

- Supervised Learning
- Unsupervised Learning
- Reinforcement Learning

We are quite good

Yet to explore more

Specific AI vs General AI

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Is AI solved (by deep learning)?!

- Supervised Learning

We are quite good

- Unsupervised Learning

Yet to explore more

- Reinforcement Learning

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Is AI solved (by deep learning)?!

- Supervised Learning

We are quite good

- Unsupervised Learning

Yet to explore more

- Reinforcement Learning

Specific AI vs General AI

ok..

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Is AI solved (by deep learning)?!

- Supervised Learning

We are quite good

- Unsupervised Learning

Yet to explore more

- Reinforcement Learning

Specific AI

vs

General AI

ok..

Yet to explore more

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Today's agenda

- A brief introduction to Deep Learning
- Survey
- CSCI 599 overview

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Degree Level

1. Undergraduate
2. Master's
3. PhD

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Department

1. Computer Science
2. Electrical Engineering
3. Science / Engineering
4. Medical
5. Business
6. Others

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Background in Programming

1. Python Guru
2. Python Proficient
3. Python Intermediate
4. Python Beginner
5. Proficient in other languages
6. Others

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Background in Deep Learning

1. Know all state-of-the-art topics (e.g. memory networks, relation networks, and A3C)
2. Worked on 1-2 projects
3. Heard about it
4. None of the above

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Background in Machine Learning

1. Research experience in ML
2. Took some relevant courses
3. None of the above

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Research experience?

1. Multiple projects in AI
2. Worked on at least 1 project in AI
3. Research experience in CS/EE
4. Research experience in Engineering
5. Research experience in others
6. No experience

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When to eat dinner?

1. Before
2. After
3. During

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Today's agenda

- A brief introduction to Deep Learning
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Our Goal

- Creating and tackling challenging yet interesting **deep learning projects**
- Teaching **practical deep learning** knowledge

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Topics

- Basic ML
- Convolutional Neural Networks (CNNs)
- Recurrent Neural Networks (RNNs)
- Generative Models
- Deep Reinforcement Learning
- Advanced Deep Learning (e.g. memory networks)

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Course Staff



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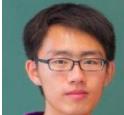
Ayush Jain



Karl Pertsch



Youngwoon Lee



Hanpeng Luo



Shao-Hua Sun



Te-Lin Wu

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Office Hours

- Instructor OH @ RTH 402
 - Tuesday 2-3:30pm
 - This is NOT for homework related questions.
- TA OH @ SAL 125
 - TBD

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Pre-requisite

- Proficiency in Python
- College calculus, linear algebra
- Probability and statistics
- Equivalent knowledge of CSCI 567 (Machine Learning)
 - Online course may or may not be sufficient
- (Ideally) experience with cloud services

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Entrance Exam: In-class exam

- Background Knowledge
 - Calculus
 - Linear algebra
 - Probability and statistics
 - Machine Learning
- Open-ended questions (1 paragraph each):
 - Why are you taking this course?
 - Which project(s) are you excited about?

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Grading

| Entry | % of grade |
|----------------|------------|
| Participation | 5 |
| Assignment #1 | 15 |
| Assignment #2 | 15 |
| Midterm | 25 |
| Course project | 40 |
| TOTAL | 100 |

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Important Dates

- Entrance exam: 1/15
- Assignment 1: 2/19
- Midterm: 3/5
- Project meeting with Instructor #1: 3/6 — 3/8
- Assignment 2: 3/26
- Project meeting with Instructor #2: 4/1 — 4/3
- Project meeting with TA: 3 times (arranged later)
- Final presentation: 4/23 5-9:00pm **4 hours**

Subject to change!

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Course Project

- Team-based project (3-5 students per team)
- Each team will have at least 1 dedicated TA
 - 2 Mandatory meetings with TA
 - 2 meetings with me
- Create your own problems (extra points)
 - **Talk and discuss** with your TAs and me!
 - In the worst case, we will give a project idea
 - Less fun, Less points!

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Course Project

- Computational resource (**be conservative!**):
\$150 Google Cloud credit per student
\$125 Amazon AWS credit per student
- Tentative Schedule for Project
 - Week 5 (2/5): Course Project Team
 - Week 8 (2/26): Course Project Proposal
 - Week 13 (4/2): Mid-report
 - Week 16 (4/23): **Project Presentation** (5-9pm) + Report

Subject to change!

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Collaboration Policy

Please list all names of people whom you had discussions with!

No code sharing

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Other Policy

- Regrading: **within 1 week** after we hand out grades
- Late days: 5 days for the entire semester (no exception).
 - **No late day** for the final project presentation and report!

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Communication

- Please use **Piazza** for any course related communication
<https://piazza.com/usc/spring2019/csci599>
- Any non-necessary e-mail will be ignored. Period.

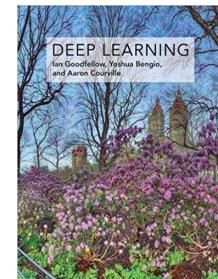
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Course material

- Deep Learning (MIT Press)
Ian Goodfellow, Yoshua Bengio, and Aaron Courville
 - Free online version is available at <http://www.deeplearningbook.org/>



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Course website

- <https://csci599-dl.github.io/>

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Syllabus

- Syllabus is on the course website.
- This will keep changing.

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Disclaimer

- This course is taught for the 2nd time @ USC. This course is 599, and thus an **experimental** course.
- The syllabus, course policy, and grading details **may change** over the semester (**check website!**)
- If you prefer a well-structured course, this is **not** a course for you, and I encourage you to take the course next year.
- It will be fun but challenging!

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Questions?

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Todo

- Check in before you leave with TAs
- Next week: In-class exam

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Welcome to CSCI 599!

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