



# EECS 230 Deep Learning

## Lecture 1: Introduction

# Machine learning

## ❑ What is machine learning?

- ❑ The capability of a machine to learn from data to imitate intelligent human behavior.

## ❑ Many Applications

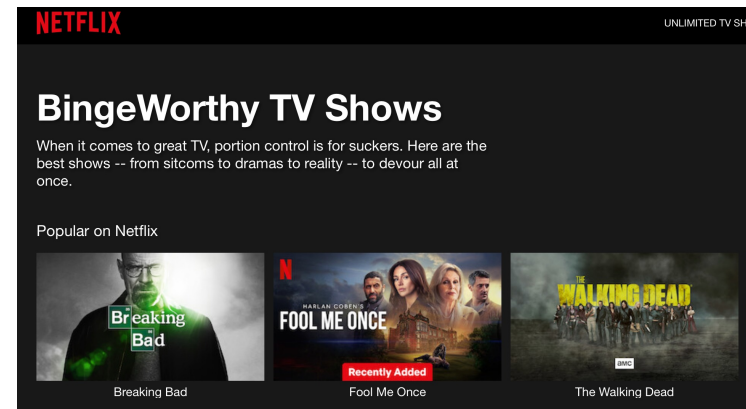


Autonomous driving



Hey Siri

Speech recognition



Recommendation system

# Machine learning $\neq$ Artificial Intelligence

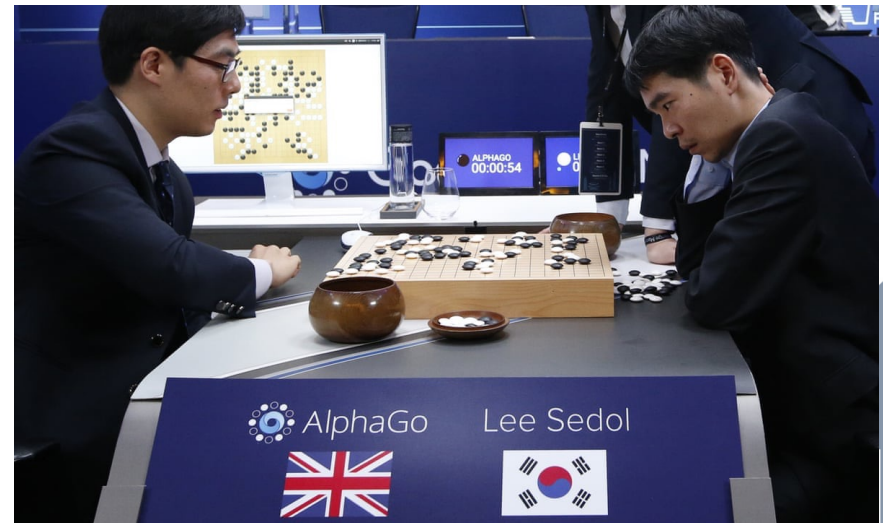
- ❑ Machine learning is a specific approach within the broader field of artificial intelligence.
- ❑ Machine learning specifically involves the use of algorithms and statistical models for learning from data.
- ❑ AI encompasses a wider range of techniques, including
  - ❑ rule-based systems
  - ❑ expert systems
  - ❑ machine learning
  - ❑ and more

# Machine learning $\neq$ Artificial Intelligence

- ❑ IBM DeepBlue (1997)
- ❑ Chess game
- ❑ sophisticated algorithm, expert-system, and brute-force computation
- ❑ Not machine learning



- ❑ Deepmind AlphaGo (2016)
- ❑ Go game (more complex)
- ❑ Use deep neural networks
- ❑ Trained on datasets of expert go game



# Major Types of machine learning

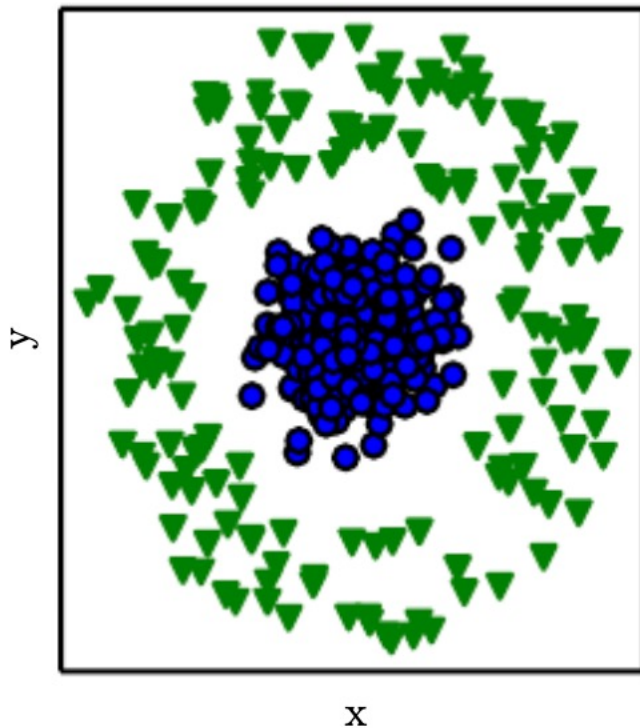
- ❑ Supervised learning: Given pairs of input-output, learn to map the input to output
  - ❑ Image classification
  - ❑ Speech recognition
  - ❑ Regression (continuous output)
- ❑ Unsupervised learning: Given unlabeled data, uncover the underlying structure or distribution of the data
  - ❑ Clustering
  - ❑ Dimensionality reduction
- ❑ Reinforcement learning: training an agent to make decisions within an environment to maximize a cumulative reward
  - ❑ Game playing (e.g., AlphaGo)
  - ❑ Robot control

# Other Types of machine learning

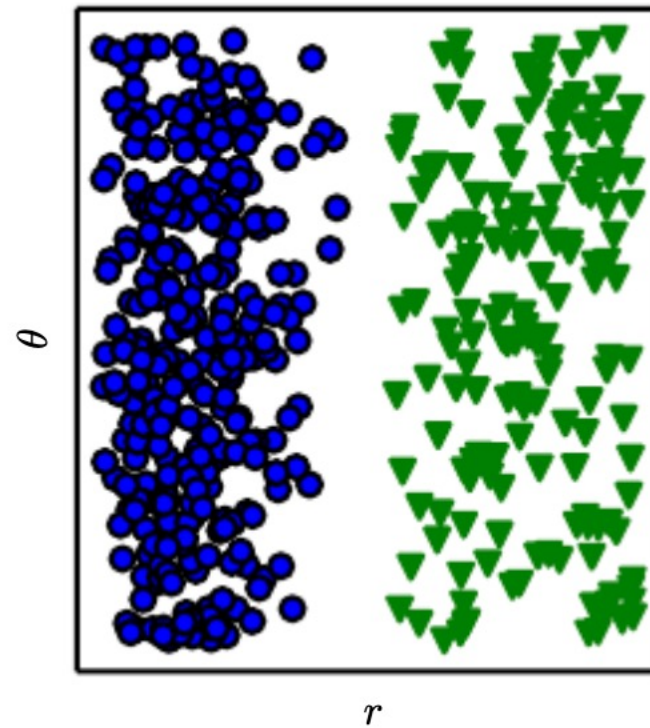
- ❑ Semi-supervised learning: Learning from a combination of labeled data and unlabeled data
- ❑ Transfer learning: applying knowledge learned from one task to another related task

# Examples of representations

Cartesian coordinates



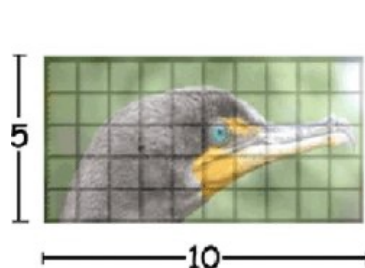
Polar coordinates



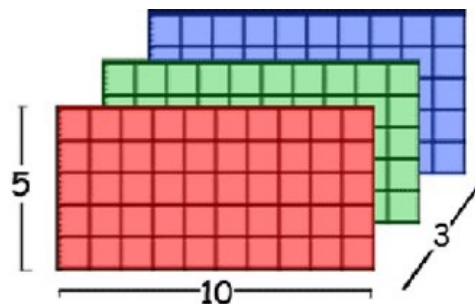


# How to represent raw sensory data?

- ❑ Cannot hand-craft representation
- ❑ Representation learning



**Original Color Image**



### Matlab RGB Matrix

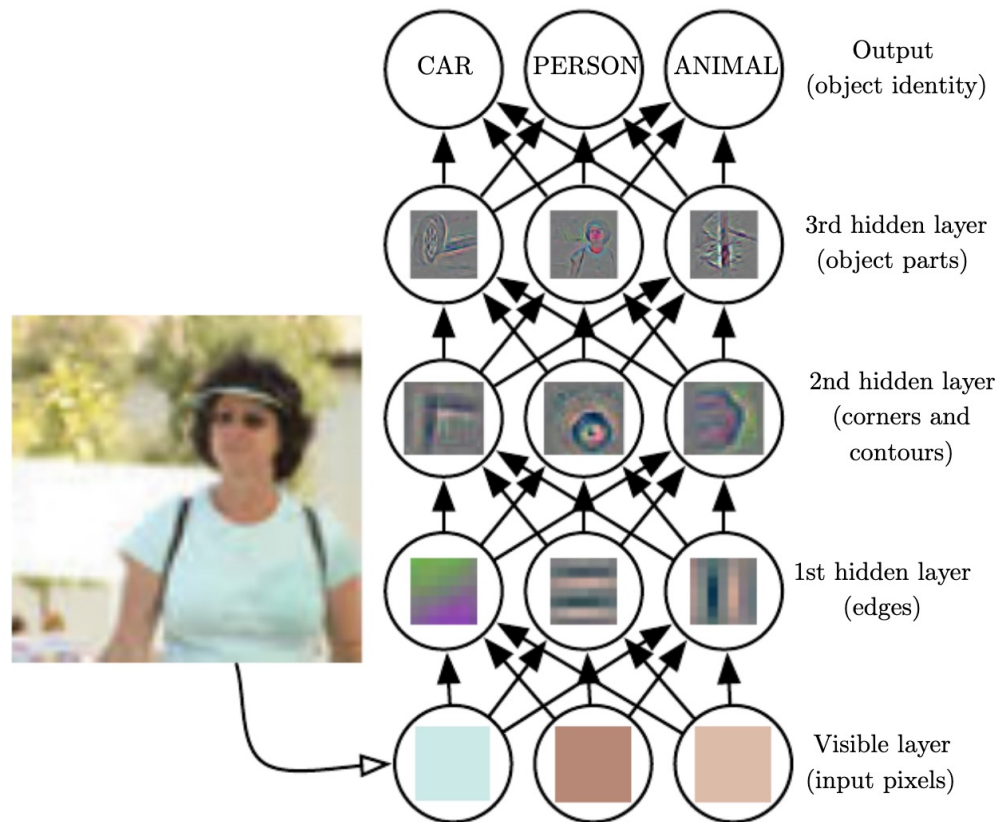
		0.2235	0.1294	<b>Blue</b>	0.4196	0.	
	5804	0.2902	<b>0.0627</b>	0.2902	0.2902	0.4824	
	10_5804	<b>0.0627</b>	<b>0.0627</b>	<b>0.0627</b>	<b>0.2235</b>	<b>0.2588</b>	0.
	5.5176	0.1922	<b>0.0627</b>	<b>Green</b>	0.1922	0.2588	0.2588
	0.5176	0.1294	<b>0.1608</b>	0.1294	0.1294	0.2588	0.2588
	0.5176	0.1608	<b>0.0627</b>	0.1608	0.1922	0.2588	0.2588
5490	0.2235	0.5490	<b>Red</b>	0.7412	0.7765	0.7765	902
490	0.3882	<b>0.5176</b>	0.5804	0.5804	0.7765	0.7765	196
0	0.2588	0.2902	0.2588	0.2235	0.4824	0.2235	
0	0.2235	0.1608	0.2588	0.2588	0.1608	0.2588	
38	0.	0.1608	0.2588	0.2588	0.2588	0.2	



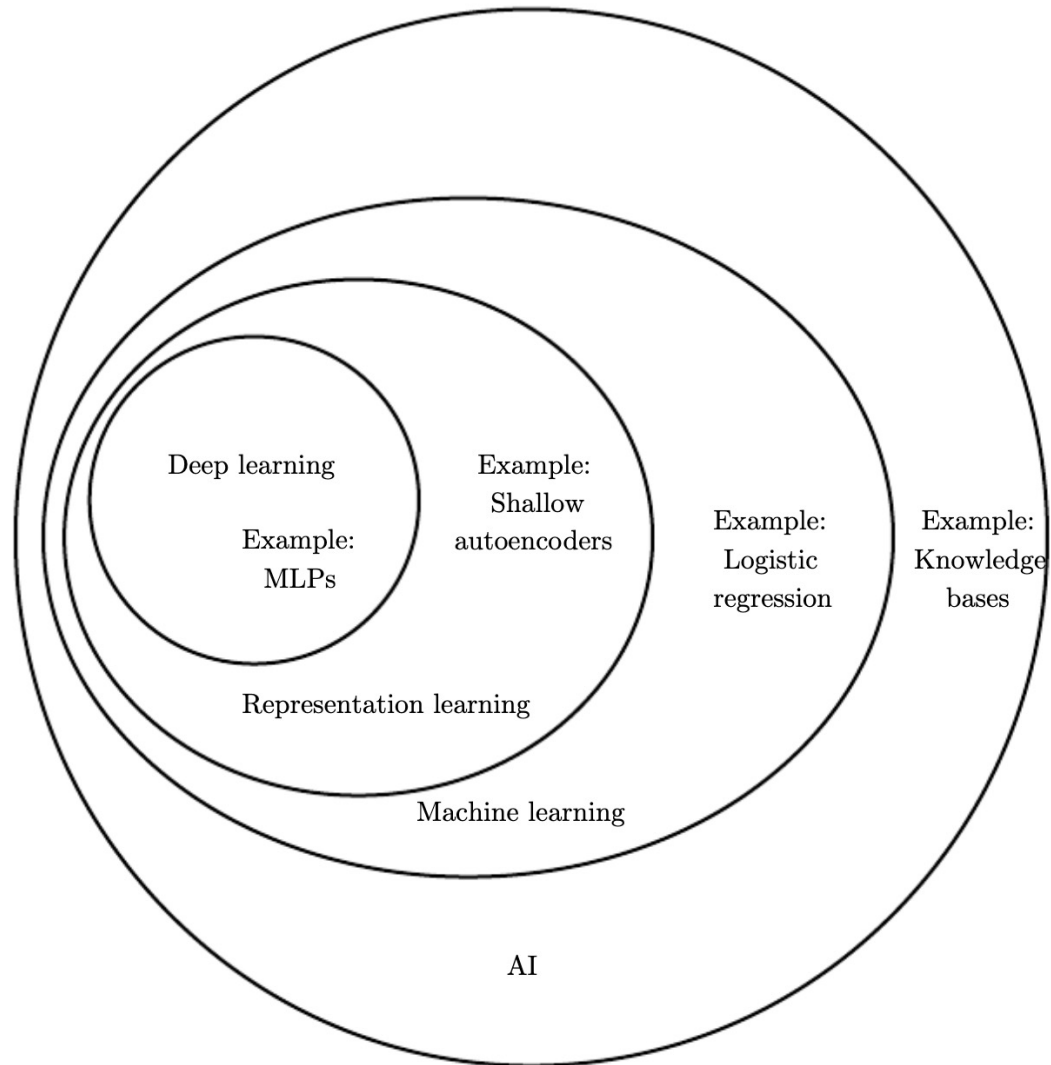


# A deep learning model

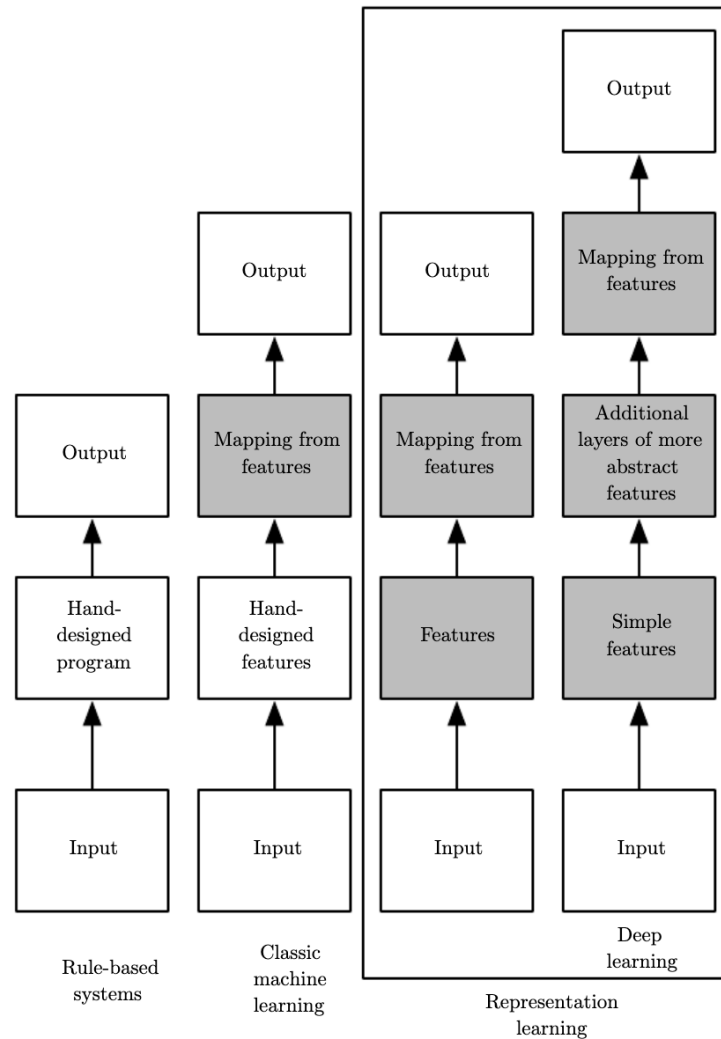
□ Deep neural networks learn hierarchical representation



# Deep Learning



# Different AI systems



# Deep Learning is not new

- ❑ Deep learning dates back to 1940s!

- ❑ McCulloch, W. S. and Pitts, W., A logical calculus of ideas immanent in nervous activity. Bulletin of Mathematical Biophysics, 1943

- ❑ Rebranded multiple times, three waves of development

- ❑ Known as “cybernetics” in the 1940s-1960s

- ❑ “Connectionism” in the 1980s-1990s

- ❑ Also known as “Artificial Neural Network” (ANN)

- ❑ Out of fashion since the mid 1990s until 2006. In the meantime, kernel methods and graphical model has advanced much more

- ❑ Breakthrough in 2006: greedy layer-wise pretraining

# Deep Learning Era since 2012

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## ImageNet Classification with Deep Convolutional Neural Networks

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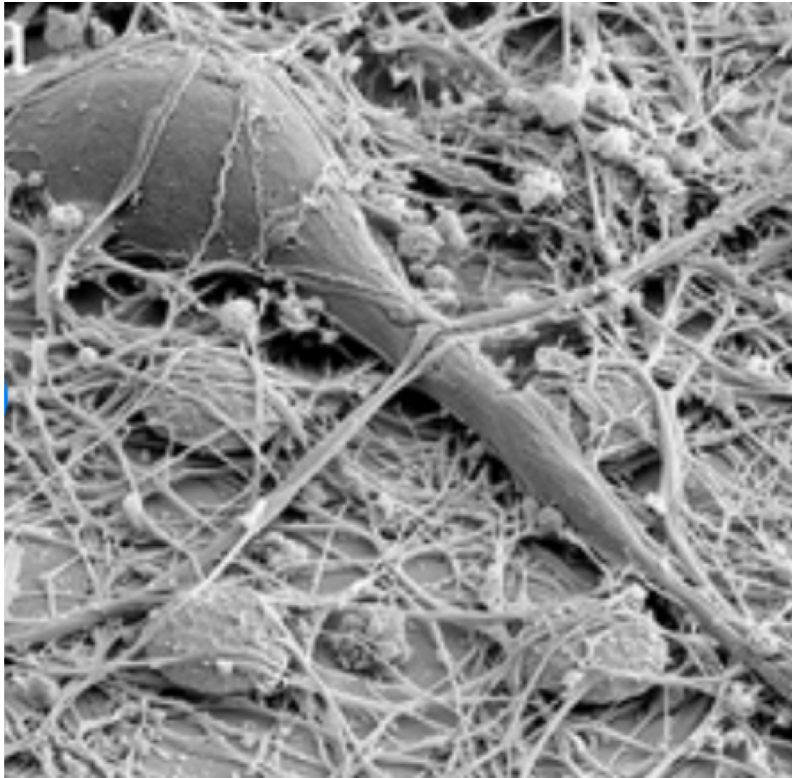
**Geoffrey E. Hinton**  
University of Toronto  
hinton@cs.utoronto.ca

# Landmarks in deep learning

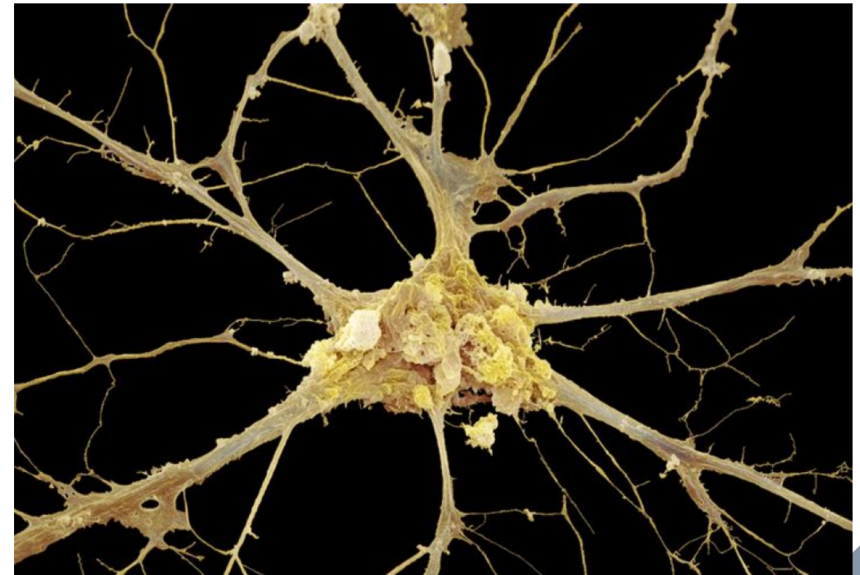
- ❑ 1958 Perceptron (Simple 'neural' model)
- ❑ 1986 Backpropagation (Practical Deep Neural networks)
- ❑ 1989 Convolutional networks (Supervised learning)
- ❑ 2012 AlexNet Image classification (Supervised learning)
- ❑ 2014 Generative adversarial networks (Unsupervised learning)
- ❑ 2014 Deep Q-Learning -- Atari games (Reinforcement learning)
- ❑ 2016 AlphaGo (Reinforcement learning)
- ❑ 2017 Machine translation (Supervised learning)
- ❑ 2019 Language models ((Un)supervised learning)
- ❑ 2022 Dall-E2 Image synthesis from text prompts ((Un)supervised learning)
- ❑ 2022 ChatGPT ((Un)supervised learning)
- ❑ 2023 GPT4 Multimodal model ((Un)supervised learning)

# Biological Motivation for Neural Network

## □ SEM of brain tissue



A colored scanning electron micrograph (SEM) of a neuron (nerve cell).





# Biological Motivation for Neural Network

## ❑ Human Brain

- ❑ Densely interconnected network of  $10^{11}$  (100 billion) neurons
- ❑ Each connected to  $10^4$  (10,000) others
- ❑ Fastest neuron switching time is  $10^{-3}$  seconds
- ❑ Activity excited or inhibited through connections to other neurons
- ❑ Slow compared to computer switching speed:  $10^{-10}$  secs



# Human Information Processing Speed

- ❑ Humans can make certain decisions (visually recognize your mother) in  $10^{-1}$  secs
- ❑ Implies that in  $10^{-1}$  sec interval cannot possibly have more than a few hundred steps, given switch speed
- ❑ Therefore, information processing abilities of biological systems follow from highly parallel processing operations distributed over many neurons



# Applications of Deep Learning

# Computer Vision

## ❑ Object detection and segmentation

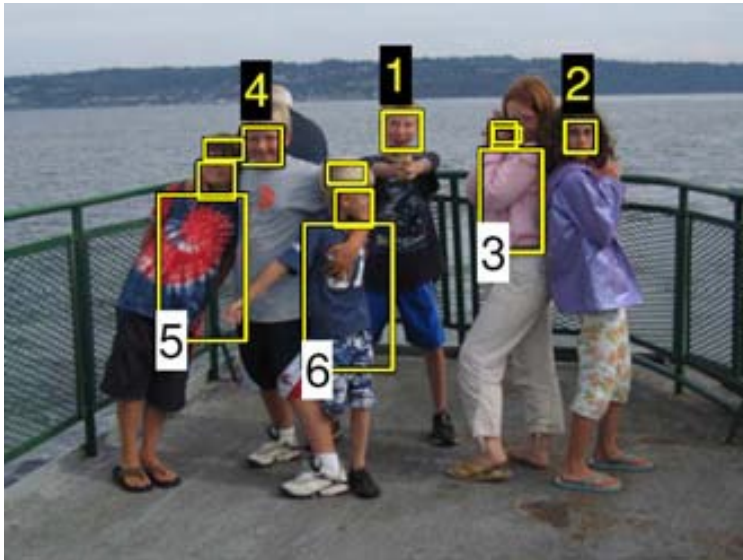


[Detectron2](#)



# Computer Vision

## ❑ Face Detection



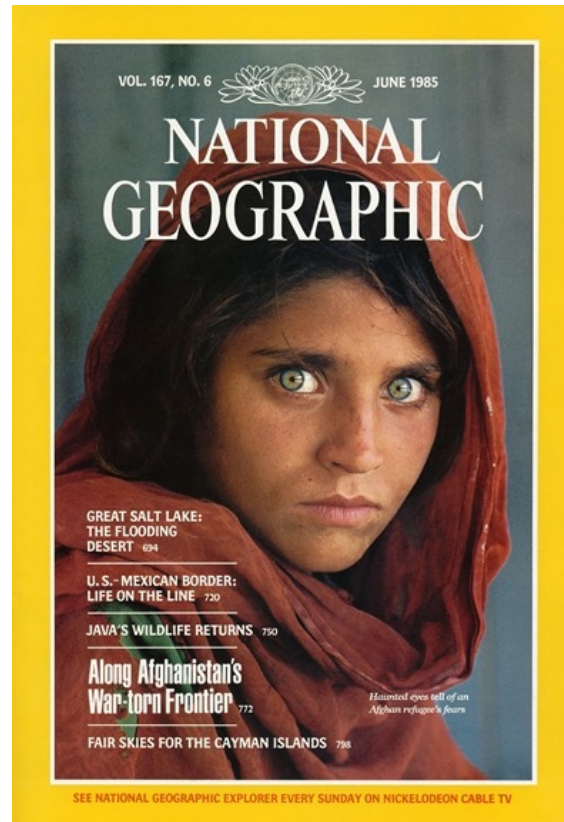
face detection around 00's



and now

# Computer Vision

## ☐ Face recognition



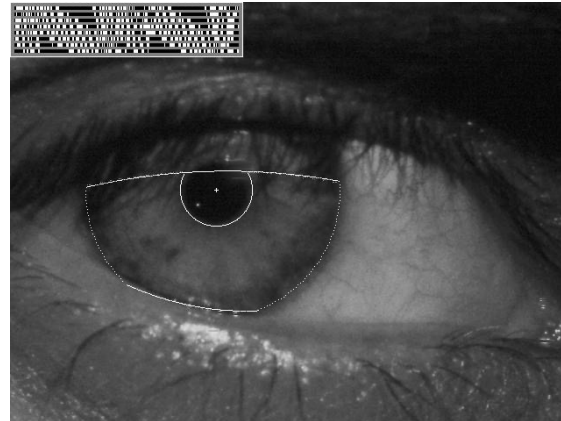
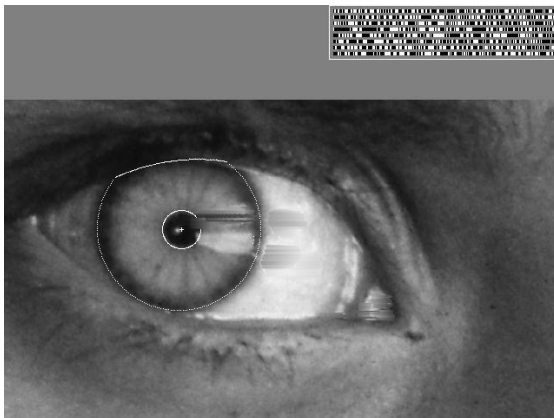
Who is she?

# Computer Vision

## ❑ Face recognition



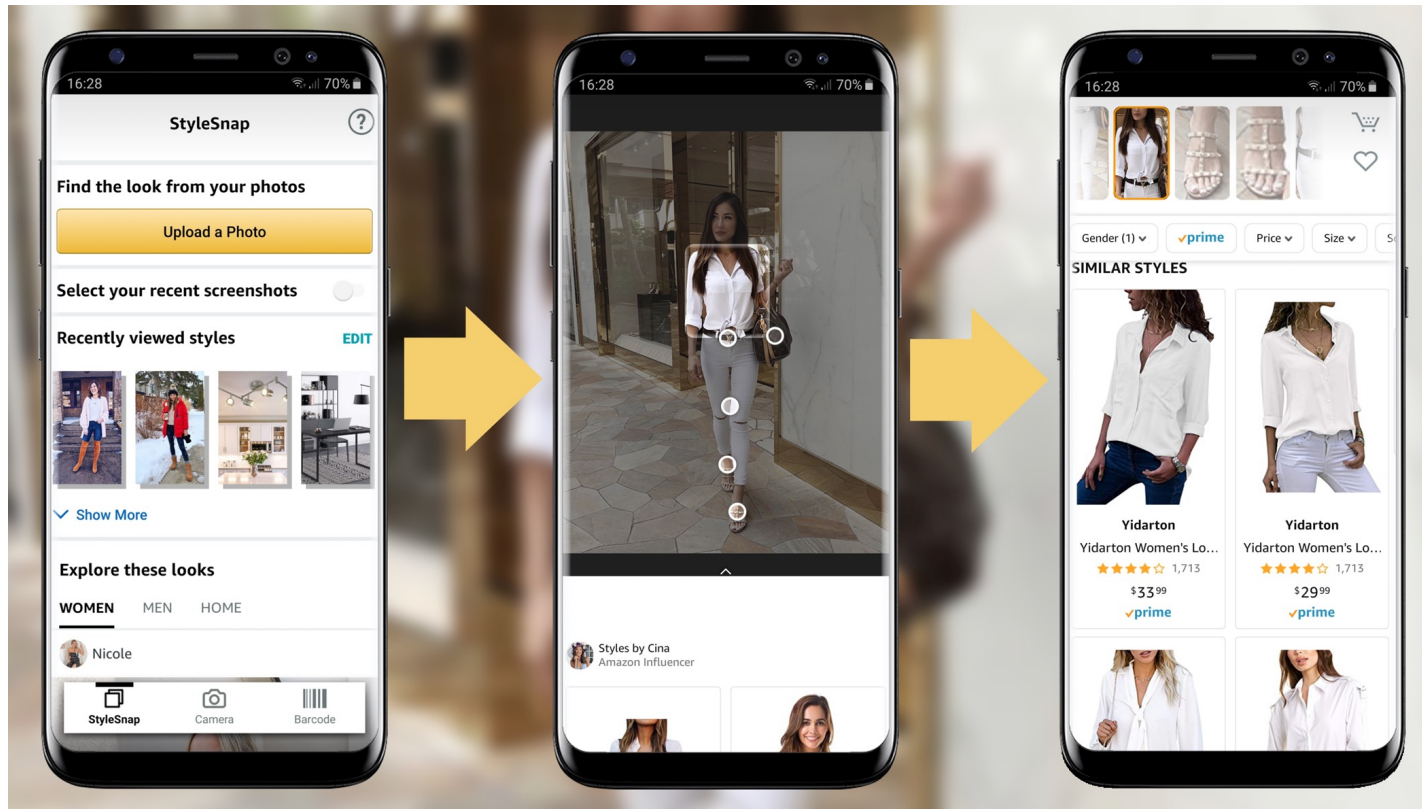
*“How the Afghan Girl was Identified by Her Iris Patterns”* Read the [story](#)





# Computer Vision

## □ Visual Search



[Amazon Shop the Look: A Visual Search System for Fashion and Home](#)

# Computer Graphics

## □ Avatar



Meta Reality Labs Research - Codec Avatar

# Image Synthesis

## □ Generative Adversarial Network (GAN)





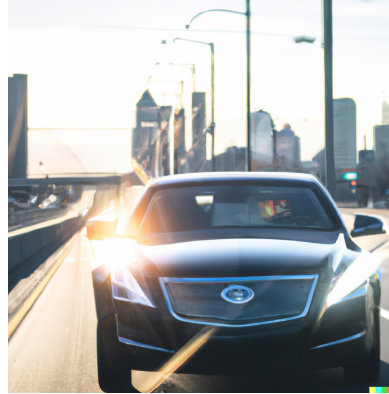
# Image Synthesis from Text

□ DALLE-2

□ IMAGEN



"A photo of an astronaut riding a horse."



"A modern, sleek Cadillac drives along the Gardiner expressway with downtown Toronto in the background, with a lens flare, 50mm photography."



"A man walking through the bustling streets of Kowloon at night, lit by many bright neon shop signs, 50mm lens."

# ChatGPT- <https://chat.openai.com/>



**You**

How to obtain A+ grade in a graduate level course on deep learning?



**ChatGPT**

Achieving an A+ grade in a graduate-level course on deep learning requires a combination of dedication, effective study strategies, and practical application of knowledge. Here are some tips to help you excel in your deep learning course:

**1. Understand the Basics:**

- Ensure you have a solid understanding of the foundational concepts in machine learning and neural networks before delving into deep learning.

**2. Master the Fundamentals:**

- Thoroughly understand key deep learning concepts, such as activation functions, loss functions, optimization algorithms, and backpropagation.

**3. Stay Current:**

- Deep learning is a rapidly evolving field. Stay updated on the latest research papers, advancements, and trends by following relevant conferences, journals, and online platforms.

**4. Hands-On Practice:**

- Apply theoretical concepts through hands-on projects. Use deep learning frameworks like TensorFlow or PyTorch to implement algorithms and models.

# ChatGPT- <https://chat.openai.com/>

## 5. **Work on Real-World Projects:**

- Apply deep learning to real-world problems. This not only solidifies your understanding but also provides you with practical experience.

## 6. **Participate in Competitions:**

- Join online platforms like Kaggle to participate in deep learning competitions. This will give you exposure to diverse problems and help you improve your problem-solving skills.

## 7. **Effective Time Management:**

- Allocate dedicated time for studying and completing assignments. Avoid procrastination, and break down larger tasks into smaller, manageable chunks.

## 8. **Engage with Class Material:**

- Attend lectures regularly, actively participate in discussions, and ask questions. Engaging with the material will deepen your understanding.

## 9. **Collaborate with Peers:**

- Work on group projects or collaborate with classmates. Discussing concepts with others can provide different perspectives and enhance your learning.

## 10. **Seek Feedback:**

- Actively seek feedback from professors, TAs, or peers on your assignments and projects. Use constructive criticism to improve your work.

## 11. **Review Regularly:**

- Periodically review previous material to reinforce your understanding. Deep learning builds on foundational concepts, so a strong grasp of the basics is crucial.

# ChatGPT- <https://chat.openai.com/>

## 12. **Utilize Resources:**

- Take advantage of online resources, tutorials, and books to supplement your learning. Recommended textbooks, online courses, and research papers can provide additional insights.

## 13. **Stay Organized:**

- Keep your study materials, notes, and assignments well-organized. This makes it easier to review and revise when necessary.

## 14. **Balance Theory and Practice:**

- Find the right balance between theoretical understanding and practical application. Both are essential for success in deep learning.

## 15. **Take Care of Yourself:**

- Ensure a healthy work-life balance. Take breaks, get enough sleep, and maintain your overall well-being to stay focused and productive.

Remember, achieving an A+ grade is not just about memorizing information but demonstrating a deep understanding and application of concepts. Consistent effort, active engagement, and a genuine interest in the subject will contribute to your success.



# Topics

- ❑ Brief review of machine learning (10%, 1 lec.)
- ❑ Basics of neural networks (20%, 3 lec.)
  - ❑ Multi-layer perceptron
  - ❑ Feed-forward network and Recurrent neural network
  - ❑ Optimization and regularization
- ❑ Modern neural network architectures (40%, 5 lec)
  - ❑ Convolutional neural network
  - ❑ Neural network for graph and set
  - ❑ Transformer
- ❑ Advanced topics and applications (30%, 4 lec)
  - ❑ Deep structured model
  - ❑ Deep generative model (VAE, GAN, diffusion model)
  - ❑ Multimodal deep learning
- ❑ Guest lecture (1 lec.)

# Prerequisites

- ☐ Linear algebra
- ☐ Probability and Statistics
- ☐ Basics of machine learning (To be reviewed)
- ☐ Data structure and algorithms
- ☐ Python programming
  - ☐ Will use Pytorch or Tensorflow framework

# Grading

- ☐ Exams (20%)

- ☐ Midterm: 20%

- ☐ Project (50%)

- ☐ Midterm report 10%

- ☐ Final presentation 10%

- ☐ Final report 30%

- ☐ Assignment (30%)

- ☐ 3 assignments

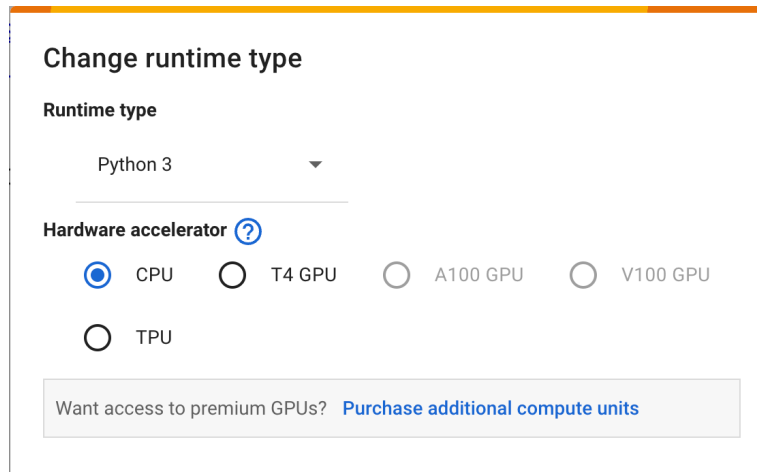
- ☐ 5%, 10%, 15%

# Project

- ☐ At most two students for each project
  - ☐ If two, expect more complex/larger scale project, include a statement of each student's contribution.
- ☐ Midterm report (Up to 2 pages excluding reference)
  - ☐ Project proposal
  - ☐ Preliminary results
- ☐ Final project presentation (10 minutes + 2 minutes Q/A)
- ☐ Final project report (Up to 8 pages excluding reference)
- ☐ Can choose your own research project
- ☐ Alternatively, a list of projects provided

# GPU

☐ Use Python notebook via Google Colab for assignment



Change runtime type

Runtime type

Python 3 ▼

Hardware accelerator ?

☒ CPU ☐ T4 GPU ☐ A100 GPU ☐ V100 GPU

☐ TPU

Want access to premium GPUs? [Purchase additional compute units](#)

☐ For project

☐ Your own GPU

☐ Google cloud credit (spot VM)

# Course Materials

## ☐ Course webpage

- ☐ <https://ucmercedeecs230.github.io/>
- ☐ Syllabus
- ☐ Lecture notes
- ☐ Assignments

## ☐ Textbook

- ☐ Understanding Deep Learning by Simon J.D. Prince Published by MIT Press 2023.  
<https://udlbook.github.io/udlbook/>

## ☐ Reference for background study:

- ☐ Deep Learning by Ian Goodfellow and Yoshua Bengio and Aaron Courville  
<https://www.deeplearningbook.org/>
- ☐ UvA Deep Learning Tutorials <https://uvadlc-notebooks.readthedocs.io/en/latest/>