

# CS 460200

# Introduction to Machine Learning

## Introduction and Basic Concepts

Instructor: Po-Chih Kuo

# Roadmap

- Introduction and Basic Concepts
- Regression
- Bayesian Classifiers
- Decision Trees
- KNN
- Linear Classifier
- Neural Networks
- Deep Learning
- CNN/RNN
- Reinforcement Learning
- Model Selection and Evaluation
- Clustering
- Dimensionality Reduction

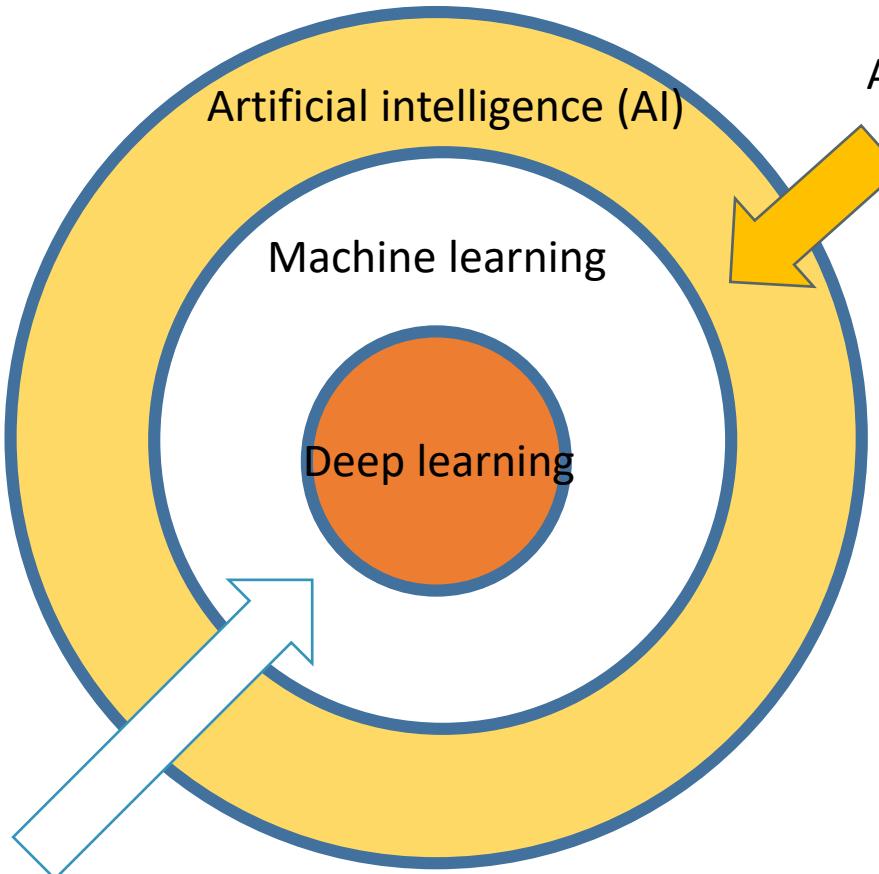
# Scope of AI

What about?

Go



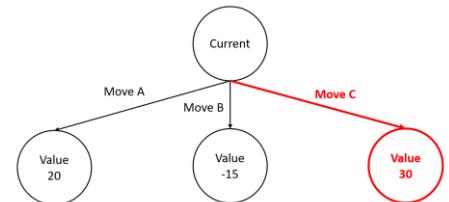
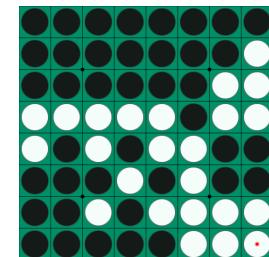
Can a PC learn by itself?



## Learn what?

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AI-ML=?  
Othello



```
function alphabeta(node, depth, α, β, maximizingPlayer) is
    if depth = 0 or node is a terminal node then
        return the heuristic value of node
    if maximizingPlayer then
        value := -∞
        for each child of node do
            value := max(value, alphabeta(child, depth - 1, α, β, FALSE))
            α := max(α, value)
            if α ≥ β then
                break (* β cutoff *)
        return value
    else
        value := +∞
        for each child of node do
            value := min(value, alphabeta(child, depth - 1, α, β, TRUE))
            β := min(β, value)
            if β ≤ α then
                break (* α cutoff *)
        return value
```

# What is Learning?

- “Learning denotes **changes** in a system that enable a system to do the same task **more efficiently the next time.**” - Herbert Simon
- “Learning is **constructing or modifying representations** of what is being experienced.” - Ryszard Michalski
- “Learning is making useful **changes** in our minds.” - Marvin Minsky



# What is Machine Learning?

Write programs that recognize a face



- It is very hard to write programs that solve problems like recognizing a face
  - We don't know what program to write because we don't know how it is done in our brain.
  - Even if we had a good idea about how to do it, the program might be very complicated.

# What is Machine Learning?

- Instead of writing a program by hand for each specific task, we collect lots of examples that specify the correct output for a given input.
- A machine learning algorithm then takes these examples and produces a program that does the job.
- Massive amounts of computation are now cheaper than paying someone to write a task-specific program.



# What is Machine Learning?

- Automating automation
- Getting computers to program themselves
- Let the data do the work (writing codes) instead!

*“Machine learning refers to a system capable of the autonomous acquisition and integration of knowledge.”*

# MAGIC?

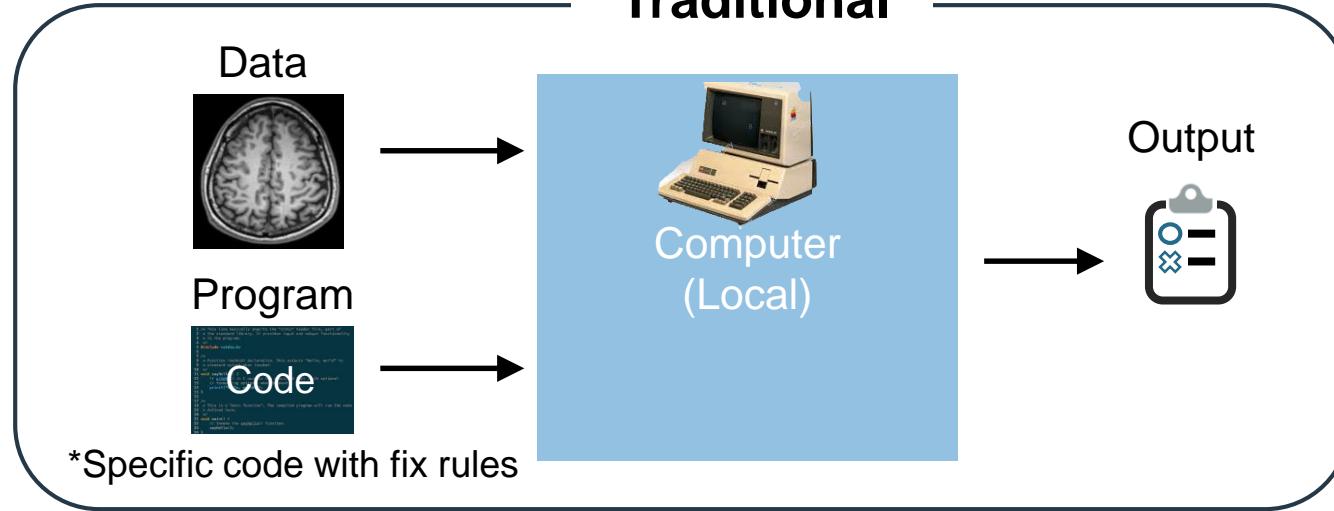
No, more like gardening

- **Seeds** = Algorithms
- **Nutrients** = Data
- **Gardener** = You
- **Plants** = Programs

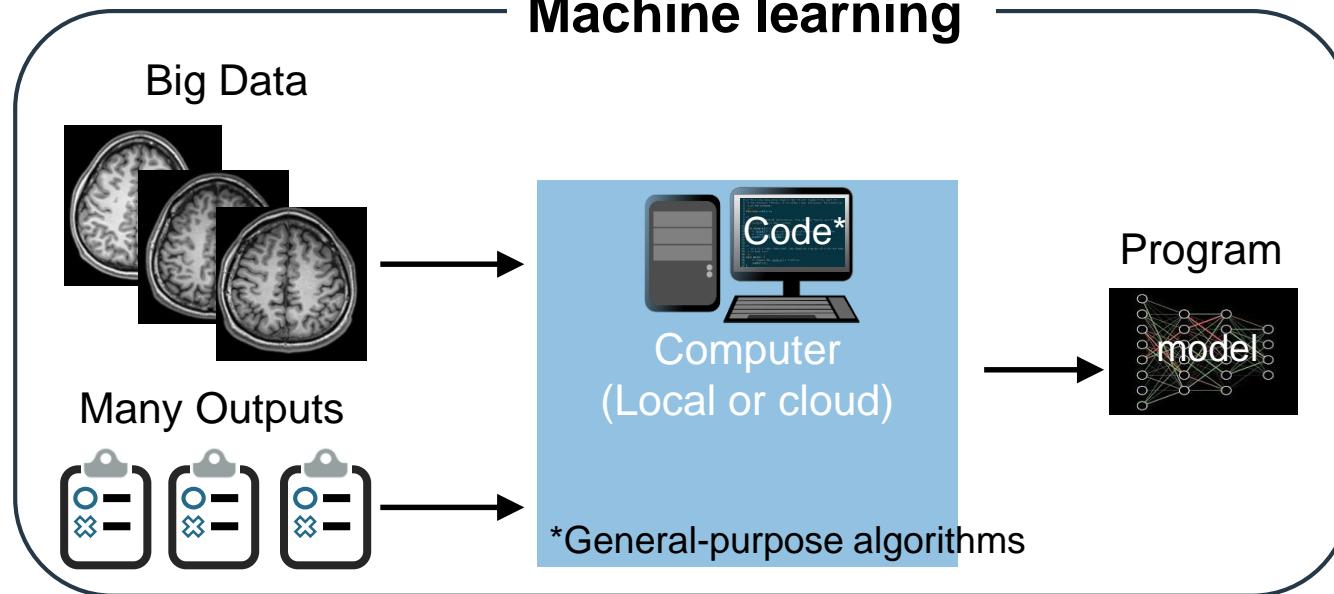


# Role of computers is changing

## Traditional



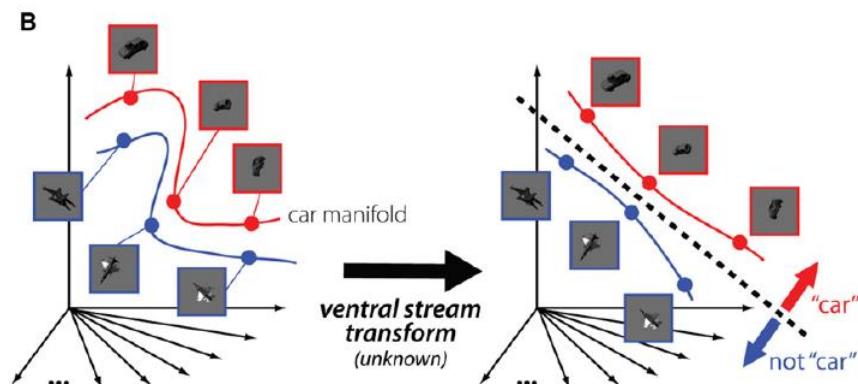
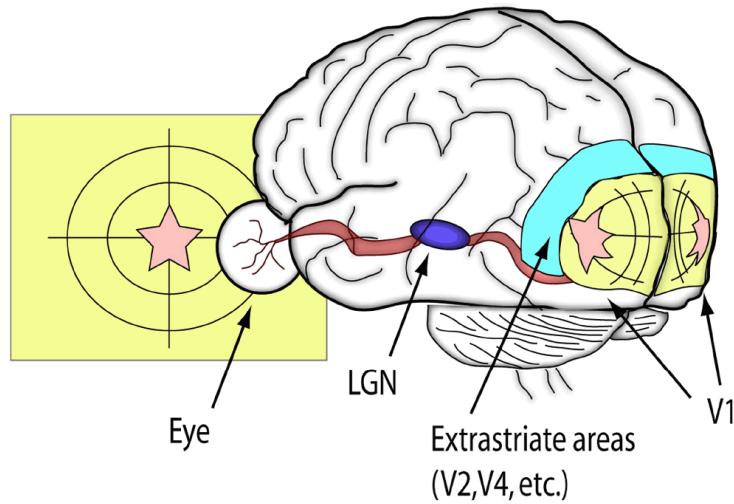
## Machine learning



# How does ML work?

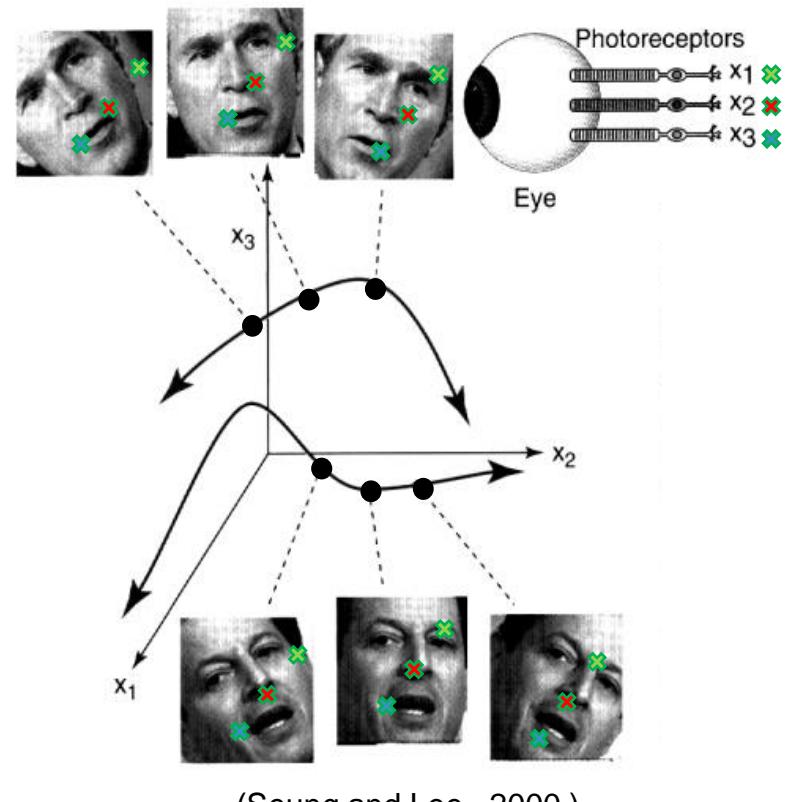
= How to design a good algorithm?

# Human Machine learning



(DiCarlo et al., 2012)

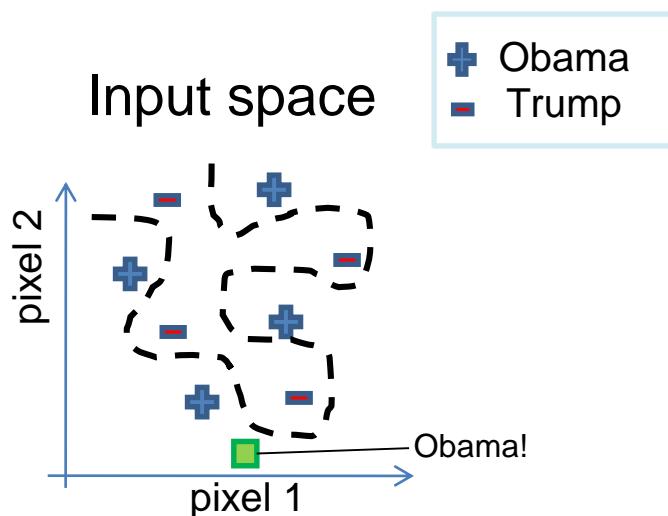
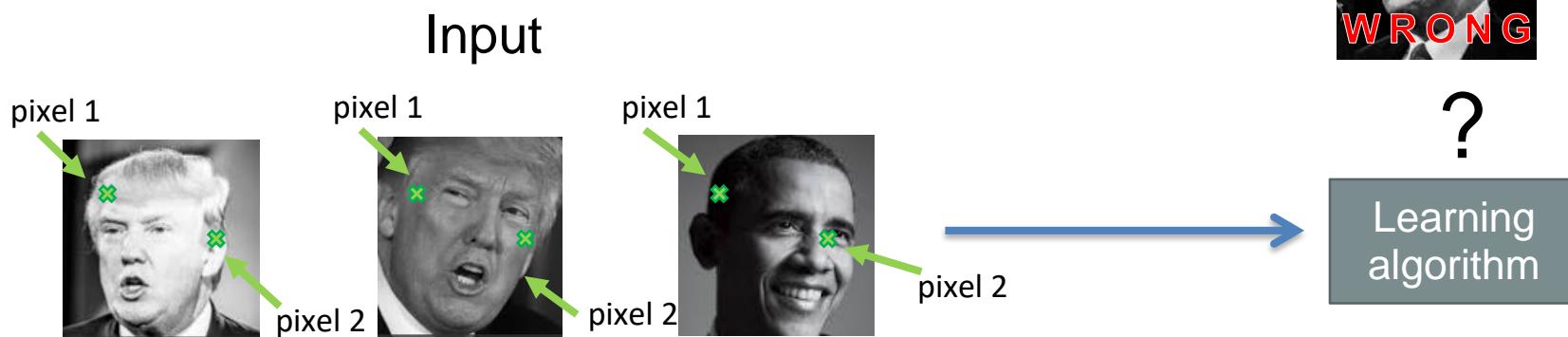
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(Seung and Lee., 2000 )

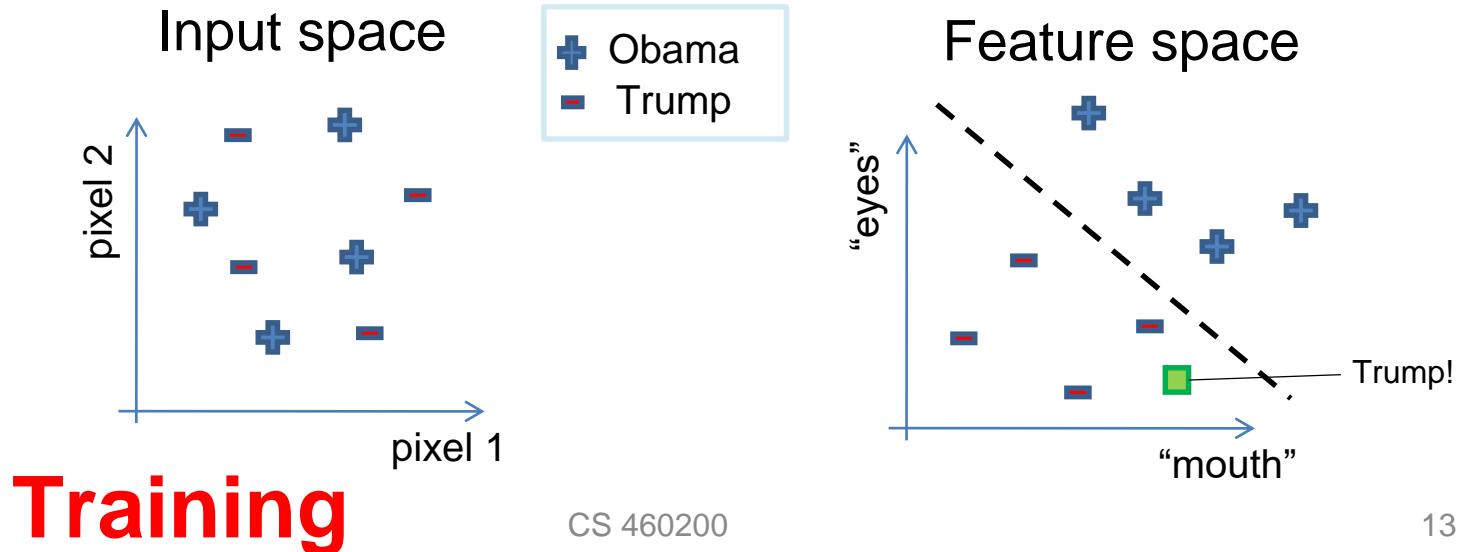
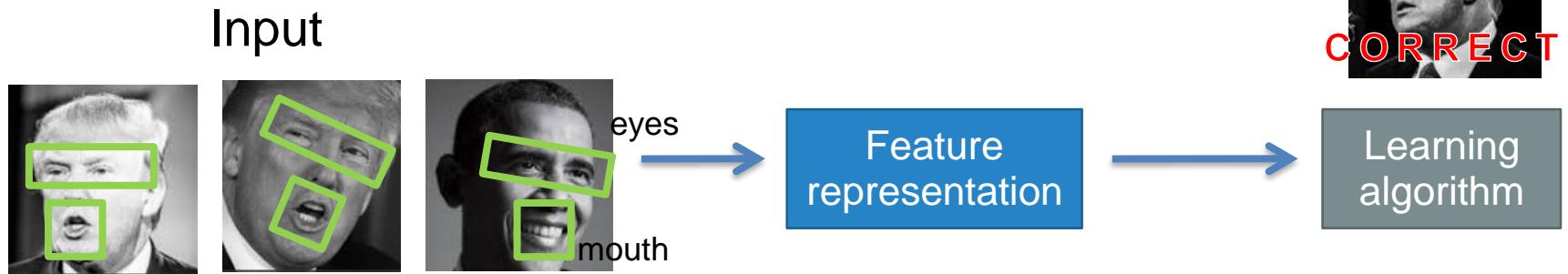
# Image space

New image



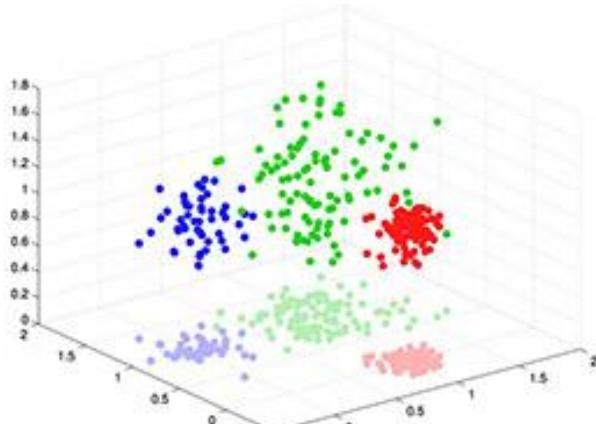
# Feature representations

Testing  
New image

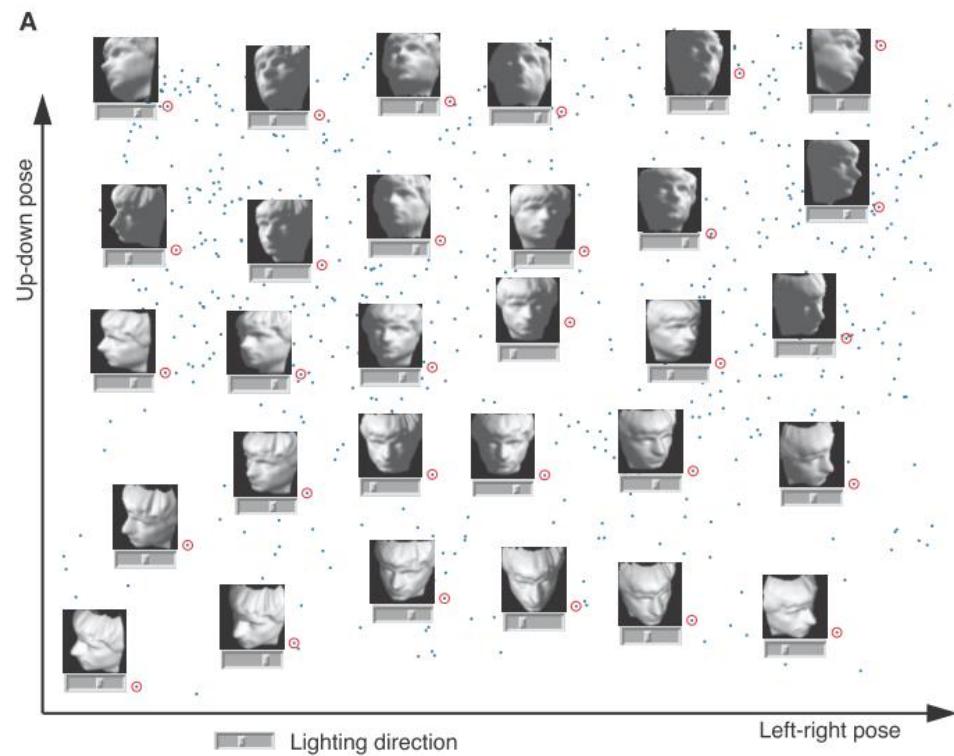


# Problem of Dimension Transformation

- Find a low-dimensional basis for describing high-dimensional data
  - PCA, LDA, LLE, Isomap...



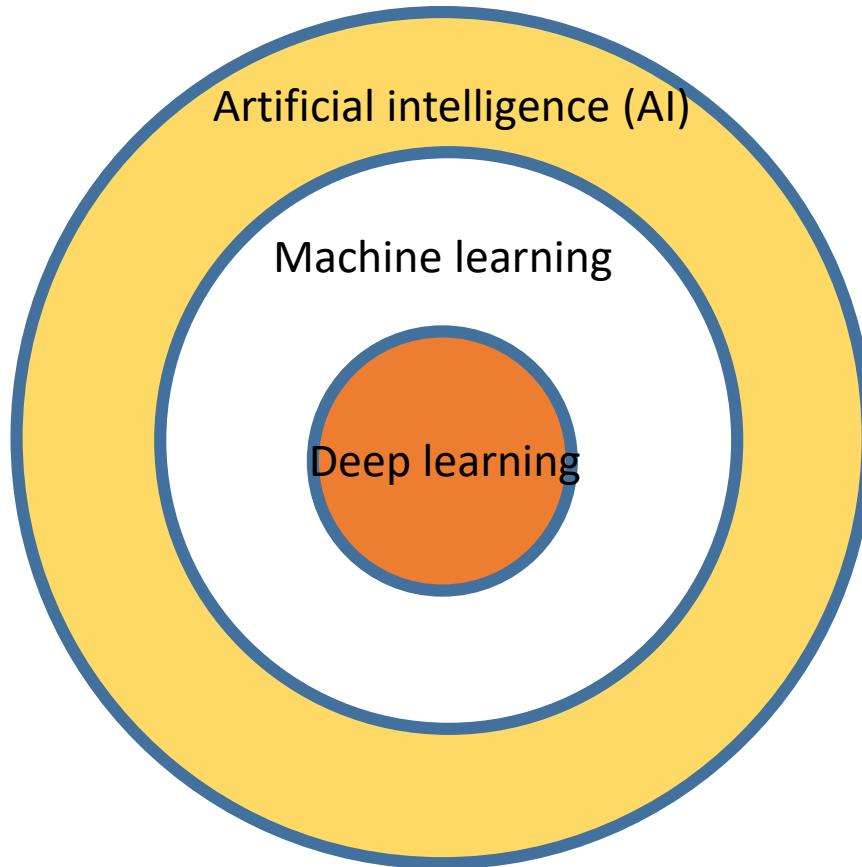
(<http://bigdata.csail.mit.edu>)



# How does ML work?

- = How to design a good algorithm?
- = How to find a good representation?

# Machine learning?



A new representation!

# What is Learning?

- “Learning denotes changes in a system that enable a system to do the same task **more efficiently the next time.**” -



Herbert Simon    **We need more data and time for training!**

- “Learning is **constructing or modifying representations** of what is being experienced.” - Ryszard Michalski



**We need a new representation (model)!**

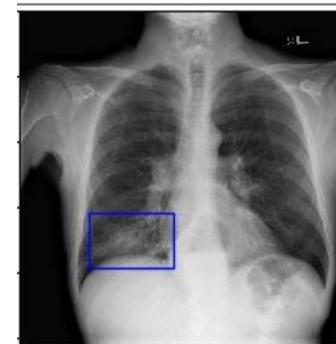
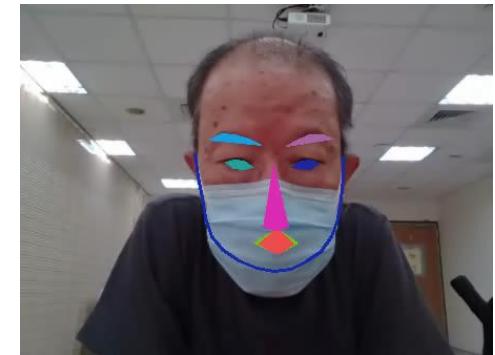
- “Learning is making useful **changes** in our minds.” - Marvin Minsky



**We need a way to save changes!**

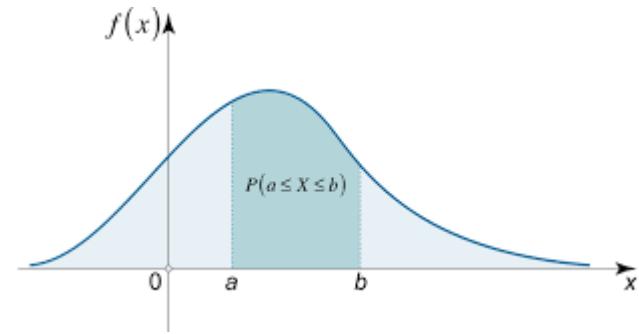
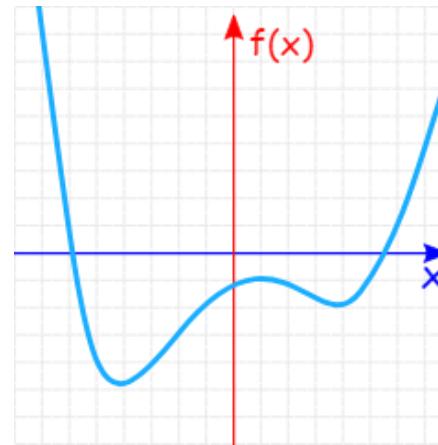
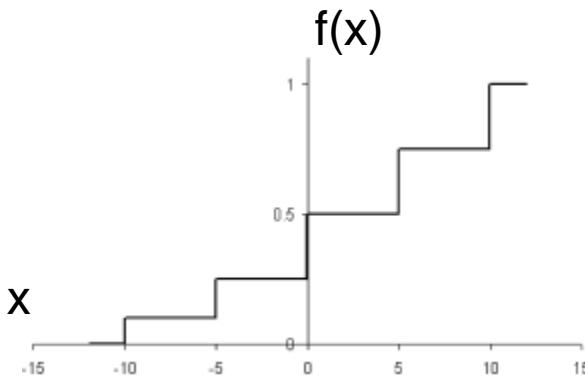
# Examples of tasks best solved

- Recognizing patterns:
  - Objects in real scenes
  - Facial identities or facial expressions
  - Spoken words
- Recognizing anomalies:
  - Unusual sequences of credit card transactions
  - Unusual patterns in X-ray image
- Prediction:
  - Future stock prices or currency exchange rates
  - Which movies will a person like?



# Inductive Learning

- **Given** examples of a function  $(X, F(X))$
- **Predict** function  $F(X)$  for new examples  $X$ 
  - Discrete  $F(X)$ : Classification
  - Continuous  $F(X)$ : Regression
  - $F(X) = \text{Probability}(X)$ : Probability estimation



# Types of Learning

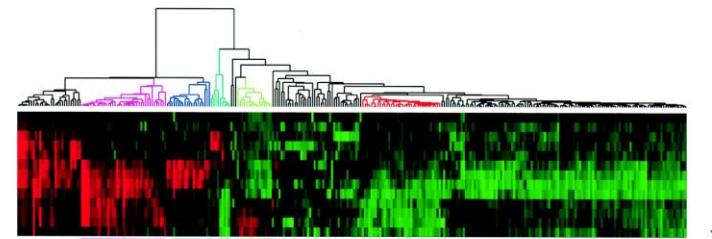
- Supervised (inductive) learning
  - Training data includes desired outputs
- Unsupervised learning
  - Training data does not include desired outputs
- Semi-supervised learning
  - Training data includes a few desired outputs
- Self-supervised Learning
  - Training data does not include desired but alternative outputs
- Reinforcement learning
  - Rewards from sequence of actions

# Roadmap

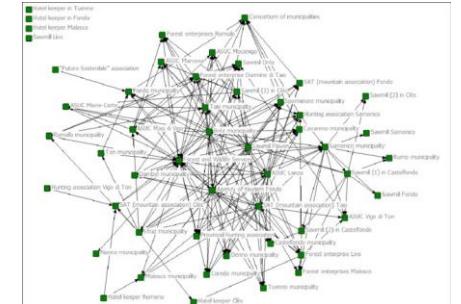
- Introduction and Basic Concepts
  - Regression
  - Bayesian Classifiers
  - Decision Trees
  - KNN
  - Linear Classifier
  - Neural Networks
  - Deep learning
  - Convolutional Neural Networks
    - Autoencoder
    - Adversarial
  - RNN
  - Reinforcement Learning
  - Model Selection and Evaluation
  - Clustering
  - Dimensionality reduction

## Supervised Learning

Continuous  $F(X)$ ?  
Discrete  $F(X)$ ?  
 $F(X) = \text{Probability}(X)$



# Unsupervised Learning



# ML in Practice

- 
- Understanding domain, prior knowledge, and goals
  - Data integration, selection, cleaning, pre-processing, etc.
  - Learning models
  - Interpreting results
  - Consolidating and deploying discovered knowledge
  - Loop

*“Only 10% of ML project is coding. The other 90% is cleaning data or tuning models.”*

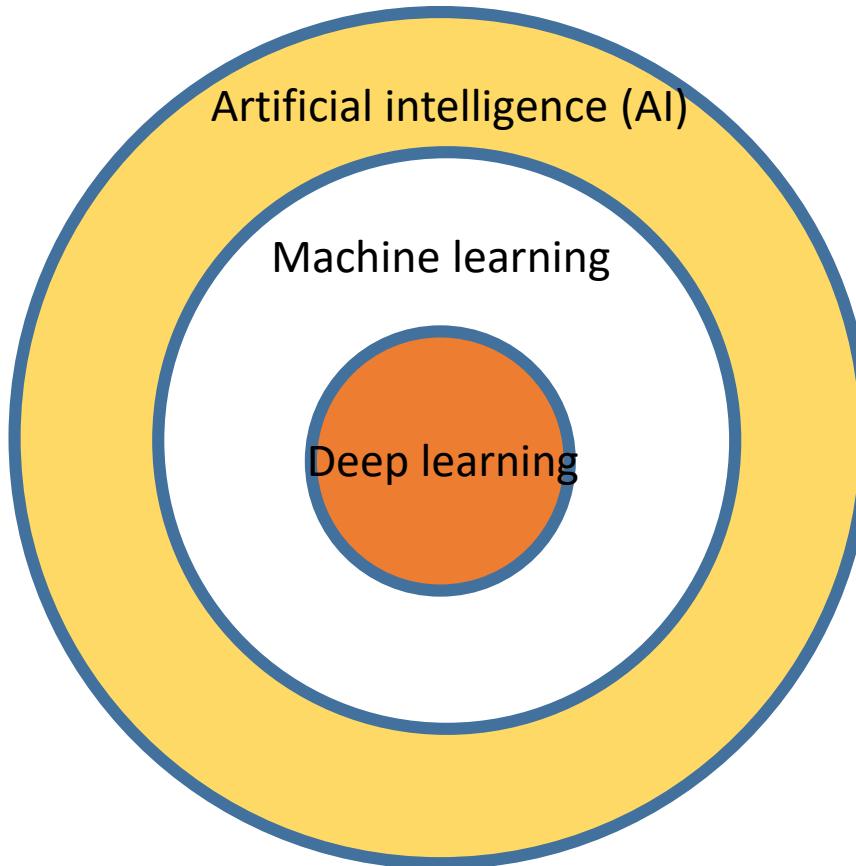
by Po-Chih Kuo

# What you should know?

- More and more people want to learn machine learning. But...



# Scope of AI



# Deep learning



In "Nature" 27 January 2016:

- “DeepMind’s program AlphaGo beat Fan Hui, the European Go champion, five times out of five in tournament conditions...”
- “AlphaGo was not preprogrammed to play Go: rather, it learned using a general-purpose algorithm that allowed it to interpret the game’s patterns.”
- “...AlphaGo program applied **deep learning** in neural networks (convolutional NN) — brain-inspired programs in which connections between layers of simulated neurons are strengthened through examples and experience.”

# Photo Descriptions



Explore image and video storytelling beyond pixels



Default

**Narrator:** Iron Man, his eyes concerned behind his helmet, chides Deadpool while Jenny watches with wide eyes.

Iron Man

I You have to think about the consequences, Wade!

Deadpool

D Oh please, major killjoy. The kid deserves some action!

Jenny

J I want to learn, and I can handle it! Both of you, stop arguing!



在前景中，一幅充满活力的蓝色和黄色画作显示在墙上。这件艺术品以其复杂的笔触和鲜艳的色彩精美地捕捉了自然景观的精髓。在图像的中心，一幅更大画作展示了一座高耸的山峰，风景如画的瀑布从岩石表面倾泻而下。背景展示了宁静的蓝天，进一步突出了画作的宁静。在这幅艺术品旁边，一幅亚洲风格的画作以连绵起伏山脉和郁郁葱葱的绿树为特色。错综复杂的细节和细腻的笔触捕捉了传统亚洲景观艺术的精髓。在图像的底部，一幅画描绘了一个被树木环绕的宁静蓝色湖泊。这件艺术品的宁静氛围唤起了一种平静和放松的感觉。



ENGLISH ▾ Bolt Default

In a serene park setting, two individuals find respite on a bench, enjoying each other's company and the tranquil surroundings. As they converse, life bustles around them: a person strolls down a nearby sidewalk, and a man ambles in front of an impressive monument. Further off, a group of people congregates amidst the verdant landscape, taking in the beauty of the park. A solitary woman sits on another bench nearby, her presence adding to the diverse array of visitors. This picturesque scene captures the essence of urban parks as havens for relaxation and socialization amid the hustle and bustle of city life.

# Deep CNN for Image Classification

The screenshot shows a CodeSandbox workspace. On the left, the `index.js` file is displayed with the following code:

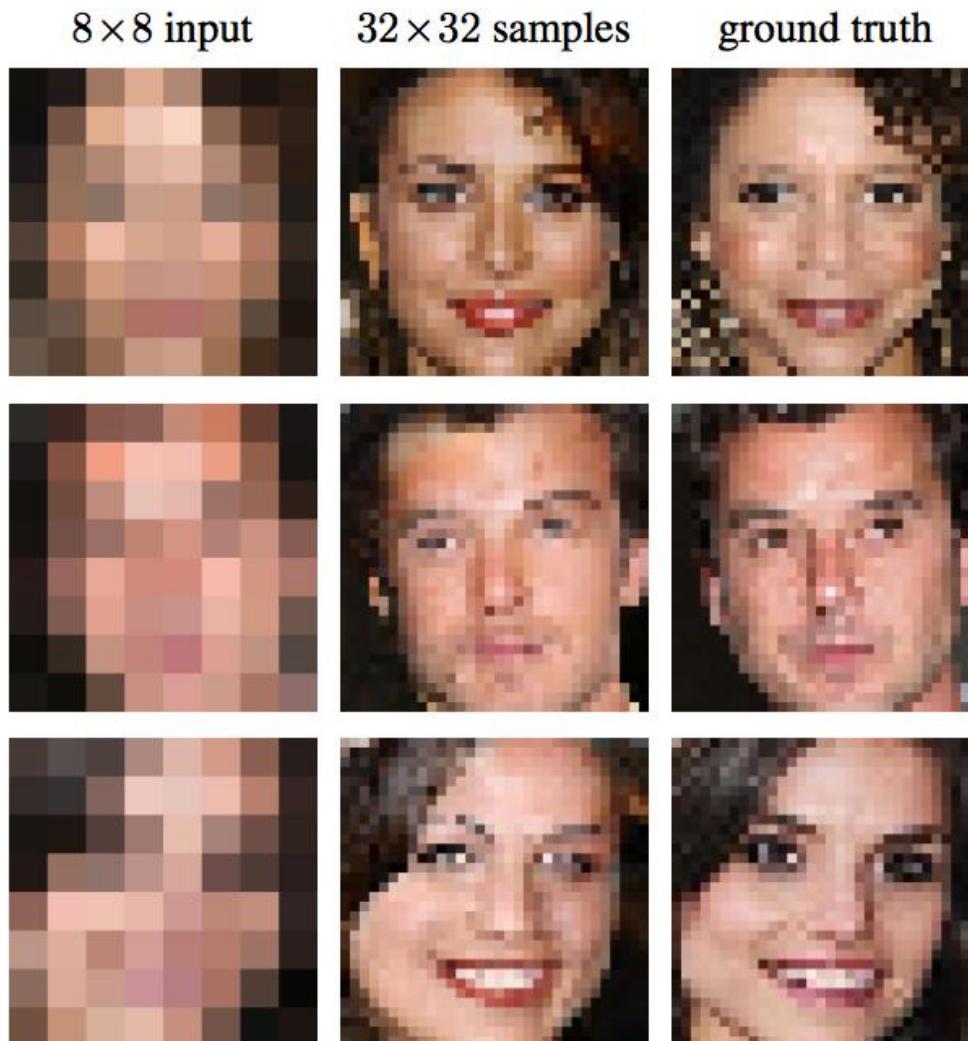
```
1 import { useState, useEffect, useRef } from "react";
2 import DOM from "react-dom";
3 import tensorflow/tfjs";
4 import mobileNet from "@tensorflow-models/mobilenet";
5 import Spin from "antd";
6 import "antd/dist/antd.css";
7
8 import styles.css;
9 import TagsContainer from "./Components/TagsContainer";
10
11 const ClassificationDemo = () => {
12   [model, setModel] = useState(null);
13   [predictions, setPredictions] = useState([]);
14   [imageUrl, setImageUrl] = useState(null);
15   [canvasRef] = useRef(null);
16
17   useEffect(() => {
18     const loadModel = async () => {
19       const model = await mobileNet.load();
20       setModel(model);
21     }
22     loadModel();
23   }
24
25   const handleUploadChange = ({ target }) => {
26     imageUrl(URL.createObjectURL(target.files[0]));
27
28   const drawImageOnCanvas = (image, canvas, ctx) => {
29     naturalWidth = image.naturalWidth;
```

The right side of the screenshot shows a browser window with the URL <https://ch2g5.csb.app/>. A file input field labeled "Choose File" contains the file "OldYoungW...llusion.jpeg". Below the file input is a black and white image of a person wearing a hat. At the bottom, there are five classification results in blue rounded rectangles:

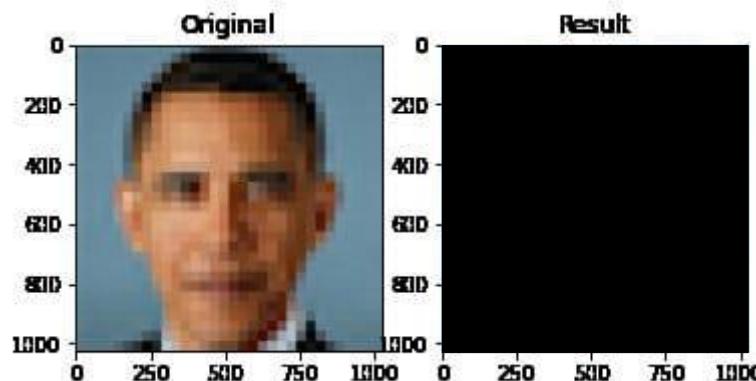
- Book Jacket 0.373
- Pickelhaube 0.106
- Microphone 0.055
- Panpipe 0.048
- Comic Book 0.038

<https://codesandbox.io/s/image-classification-demo-with-tensorflowjs-ch2g5>

## Pixel Restoration ([Google Brain](#))

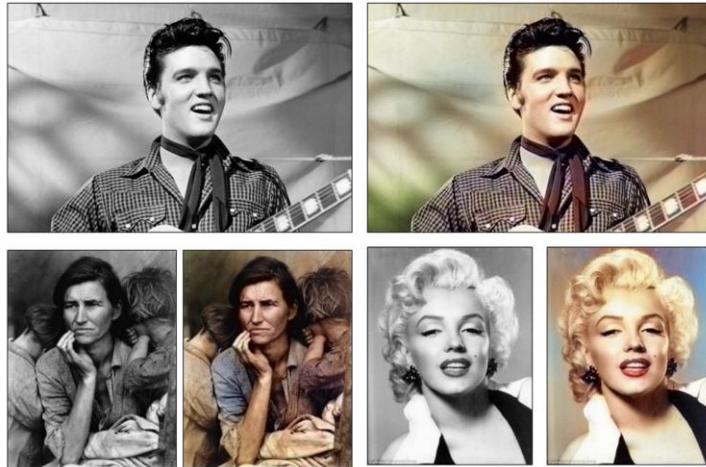


# However,



[https://github.com/tg-bomze/Face-Depixelizer?fbclid=IwAR2T0XRJMFMS-FjofeSVxz8zguoKj\\_j2Wy2KXCzljuv80c1YjzuJBe4eesA](https://github.com/tg-bomze/Face-Depixelizer?fbclid=IwAR2T0XRJMFMS-FjofeSVxz8zguoKj_j2Wy2KXCzljuv80c1YjzuJBe4eesA)

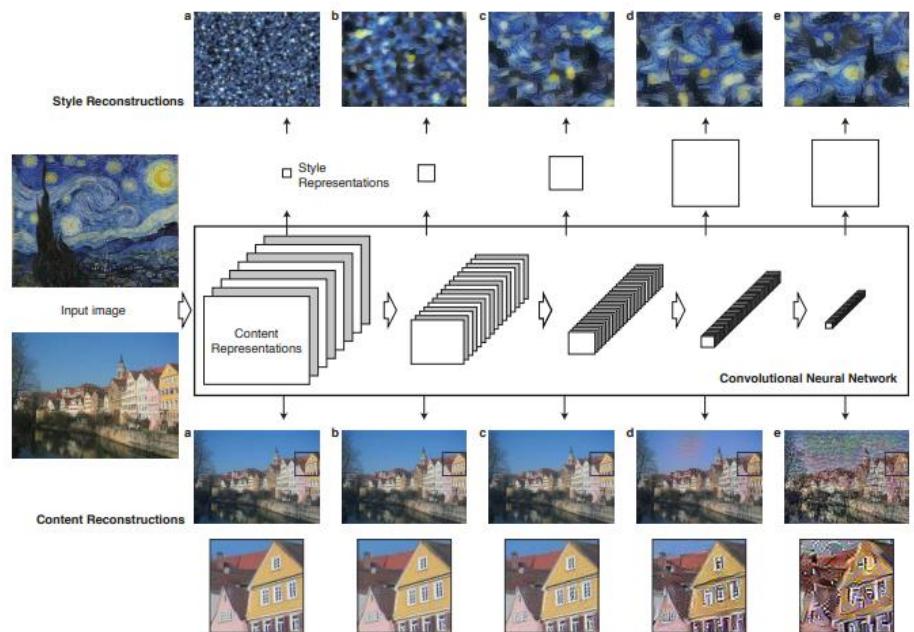
## Colorization of Black and White Images (Zhang, 2016)



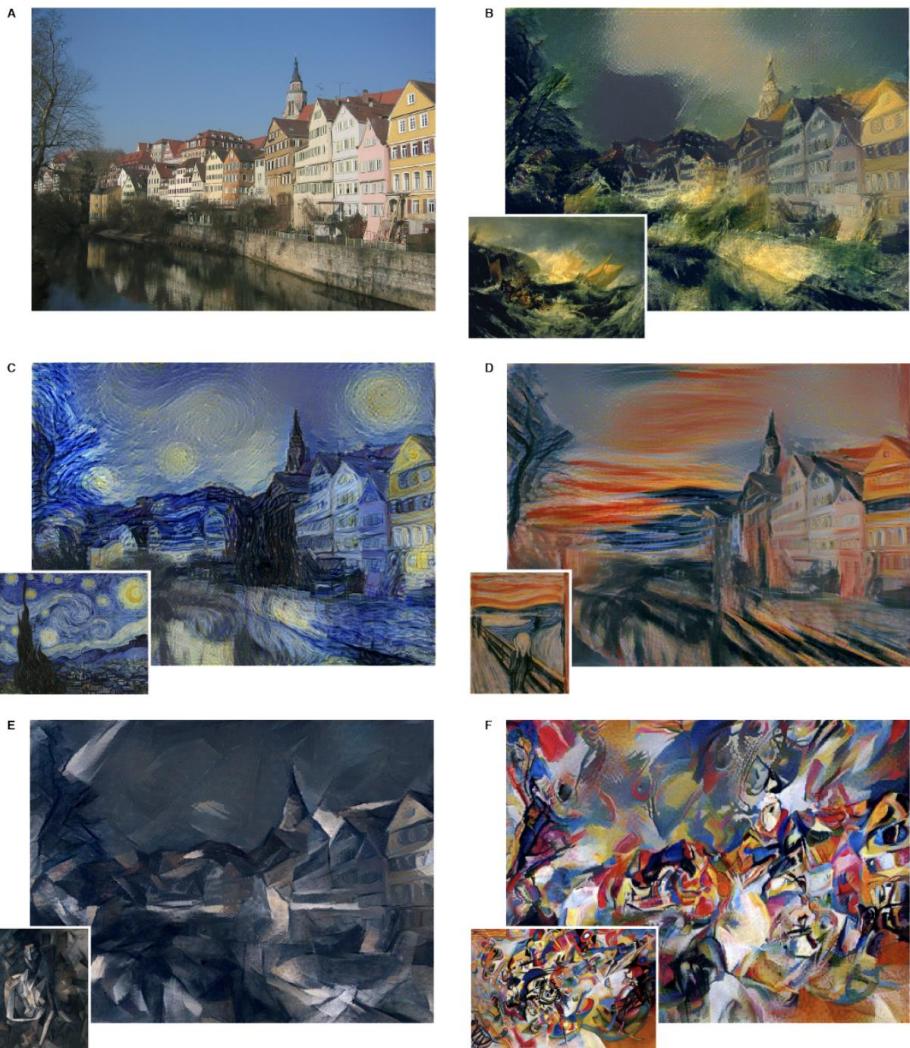
100 year old pictures...

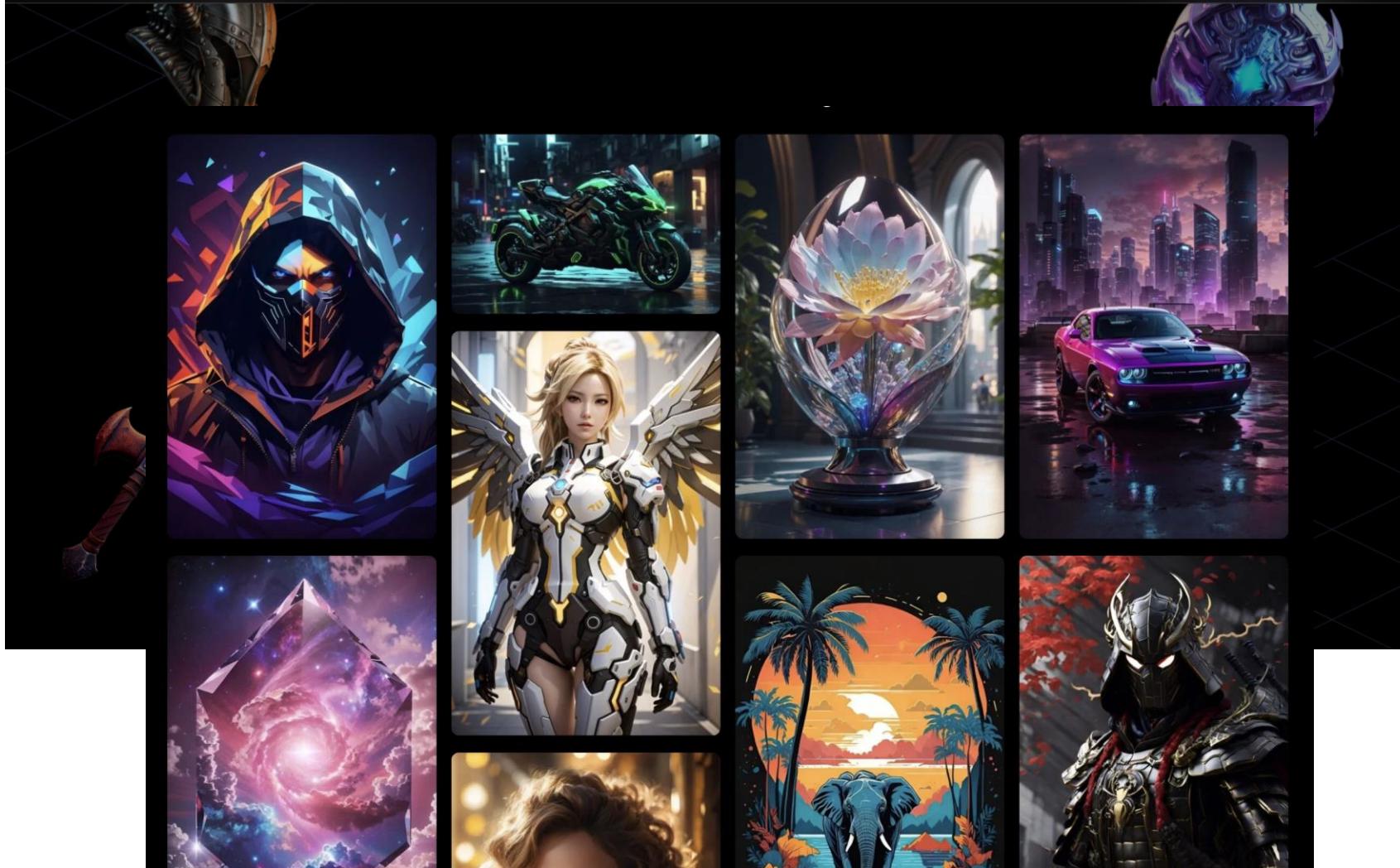


# Style Transfer



(Gatys et al., 2015)



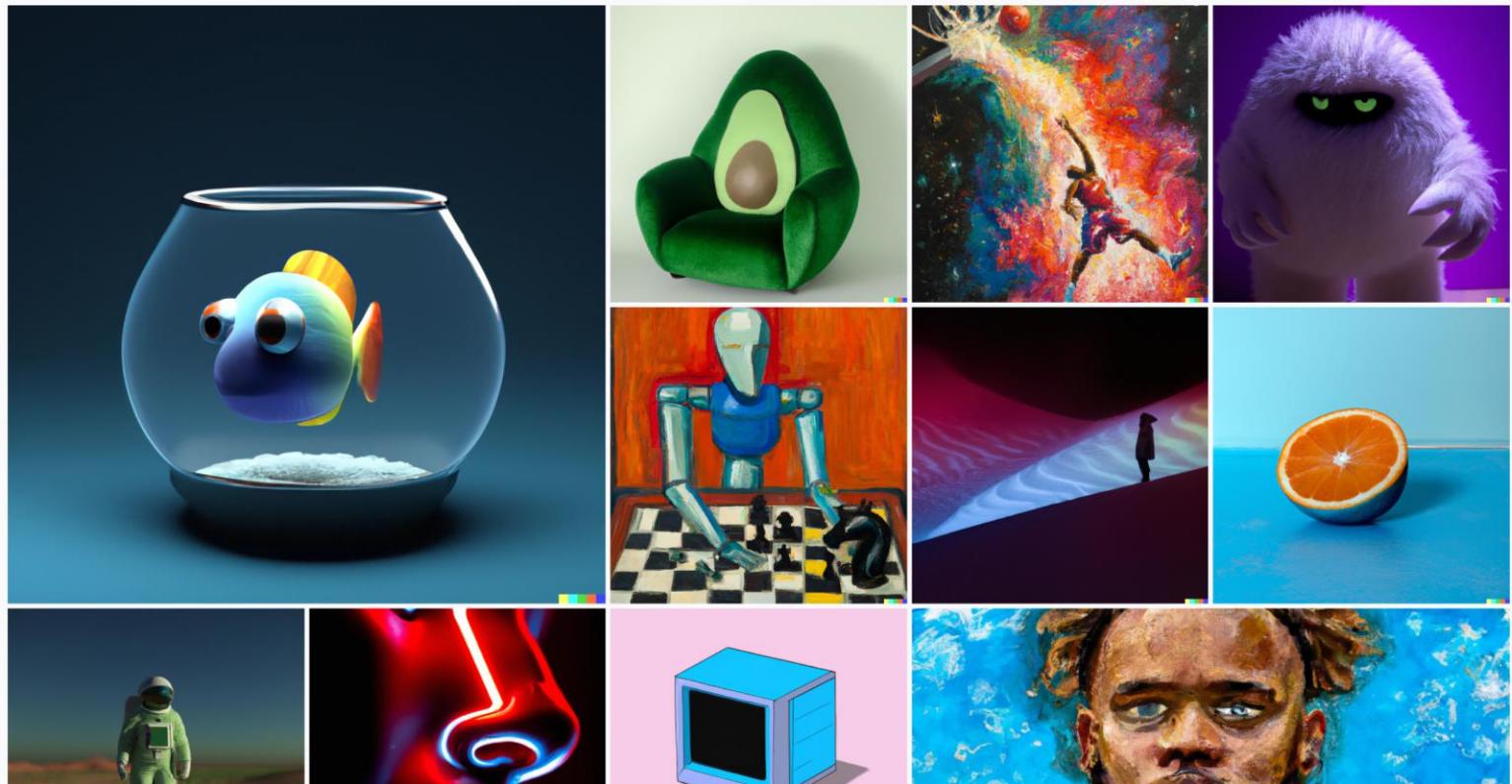




DALL-E History Collections

An Impressionist oil painting of sunflowers in a purple vase...

Generate





Rooms that are tiny can be tricky to decorate but they can also be a lot of fun. So when a client challenged us to give her pocket size space a summer makeover for under \$500 dollars, we just couldn't say no. Transforming a very small space doesn't have to blow your budget. Small things like finding a vintage piece of furniture from a relative or adding a fresh coat of paint to your own dated items can add a stylish splash to any abode.

#### Correctness

2 alerts



#### Clarity

A bit unclear



#### Engagement

A bit bland



#### Delivery

Slightly off



# ChatGPT



## Examples

"Explain quantum computing in simple terms" →



## Capabilities

Remembers what user said earlier in the conversation



## Limitations

May occasionally generate incorrect information

"Got any creative ideas for a 10 year old's birthday?" →

Allows user to provide follow-up corrections

"How do I make an HTTP request in Javascript?" →

Trained to decline inappropriate requests

May occasionally produce harmful instructions or biased content

Limited knowledge of world and events after 2021

ChatGPT Mar 14 Version. Free Research Preview. Our goal is to make AI systems more natural and safe to interact with. Your feedback will help us improve.

# **Machines Play Machines**

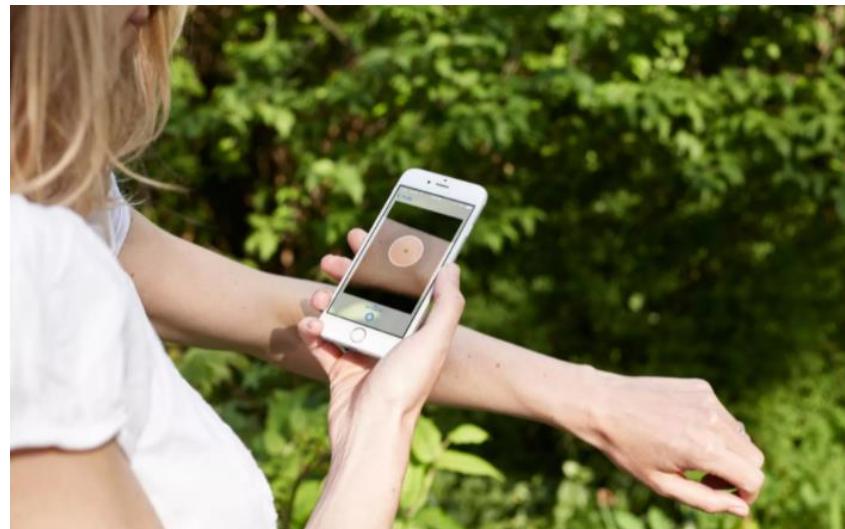


# Worried about a mole or skin spot?

Perform regular self-checks for skin cancer with your phone.

[CHECK YOUR SKIN NOW](#)

Available for iOS and Android



[MoleScope](#)



RECENT POSTS

# Introducing AI in Healthcare That's Just \$1 Per Use

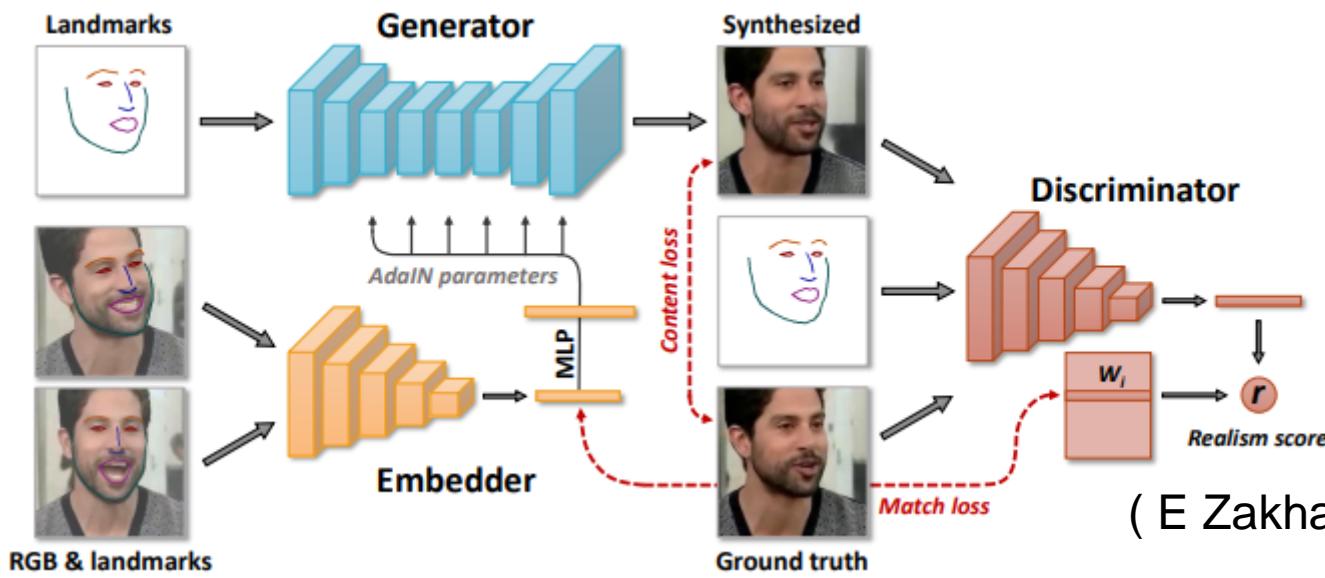
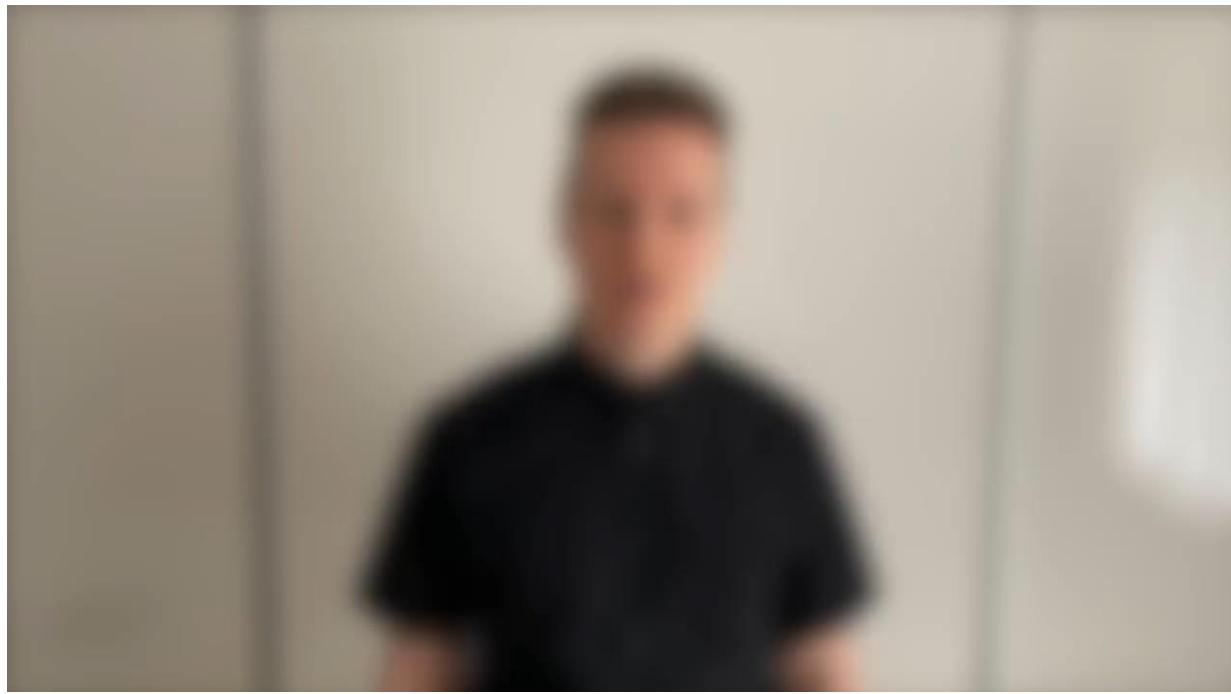
OCTOBER 27, 2017

By: Elad Benjamin

Over the last few years, we've been hard at work at Zebra to develop and introduce AI into radiology. We've written before about why this is important to us, based on the challenges this field is facing, and the impact we believe we can make. Healthcare is challenging – with long cycles, regulatory barriers and slow adoption of new technology, but our vision of affordable, accessible imaging technology for everyone keeps us continually thinking of ways to accelerate the realization of



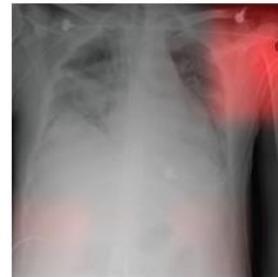
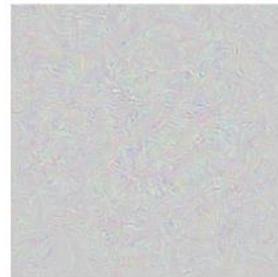
# Fake video



( E Zakharov · 2019 )  
39

# Model finds shortcut

Shortcuts are decision rules that perform well on standard benchmarks but fail to transfer to more challenging testing conditions, such as real-world scenarios.



Article: Super Bowl 50

Paragraph: "Peyton Manning became the first quarterback ever to lead two different teams to multiple Super Bowls. He is also the oldest quarterback ever to play in a Super Bowl at age 39. The past record was held by John Elway, who led the Broncos to victory in Super Bowl XXXIII at age 38 and is currently Denver's Executive Vice President of Football Operations and General Manager. Quarterback Jeff Dean had a jersey number 37 in Champ Bowl XXXIV."

Question: "What is the name of the quarterback who was 38 in Super Bowl XXXIII?"

Original Prediction: John Elway

Prediction under adversary: Jeff Dean

| Task for DNN | Caption image                               | Recognise object                                    | Recognise pneumonia               | Answer question                                   |
|--------------|---|---|-----------------------------------|---|
| Problem      | Describes green hillside as grazing sheep   | Hallucinates teapot if certain patterns are present | Fails on scans from new hospitals | Changes answer if irrelevant information is added |
| Shortcut     | Uses background to recognise primary object | Uses features irreducible to humans                 | Looks at hospital token, not lung | Only looks at last sentence and ignores context   |

(Geirhos et al., 2020)

# AI can recognize race

**MIT News**  
ON CAMPUS AND AROUND THE WORLD

**Artificial intelligence predicts patients' race from their medical images**

Study shows AI can identify self-reported race from medical images that contain no indications of race detectable by human experts.

Rachel Gordon | MIT CSAIL  
May 20, 2022

reddit r/Futurology

FEEDS Home Popular

台視新聞 HD

AI也會種族歧視？清大研究揭醫學倫理隱憂

21:38:22 兒童病歿 1歲童發病隔天亡 死因新冠與先天神經系統病

國立清華大學 NATIONAL TSING HUA UNIVERSITY

認識清華 行政單位 教學單位 研究中心 圖書館 計通中心 招生專區 校務資訊系

... 首頁 > 首頁故事

首頁故事

AI竟會種族歧視 清華與跨國團隊揭露醫學倫理隱憂

清華資工系郭柏志助理教授(中)帶領學生陳立晴(左)、王瑞恩(右)參與AI也會種族歧視的跨國研究

GETTY IMAGES

Researchers are trying to puzzle out one of the most disturbing recent findings in the field of machine learning: why AI systems can accurately

MORE LIKE THIS

Tech The AI That Draws What You Type Is Very Racist, Shocking No One

Tech Facebook AI Researchers Built a 'Fashion Map' With Your Social Media Photos

cape Saturday, August 13, 2022

SES CME & EDUCATION ACADEMY VIDEO DEC

an Detect Race, What

about Medical AI

# What about our LAB ?

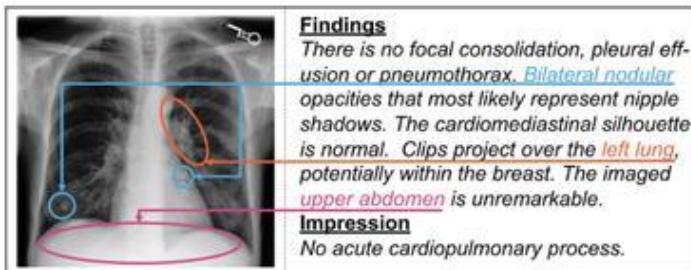


Human-centered Machine Intelligence

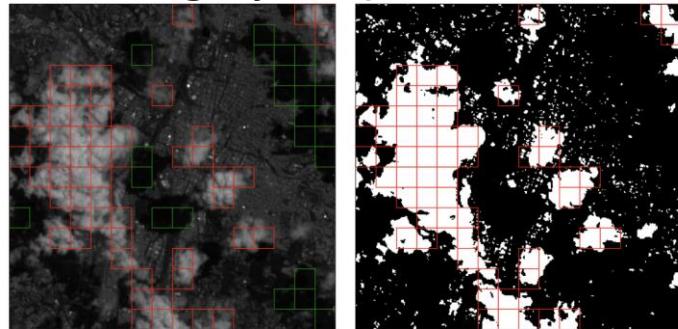
Chest X-ray interpretation



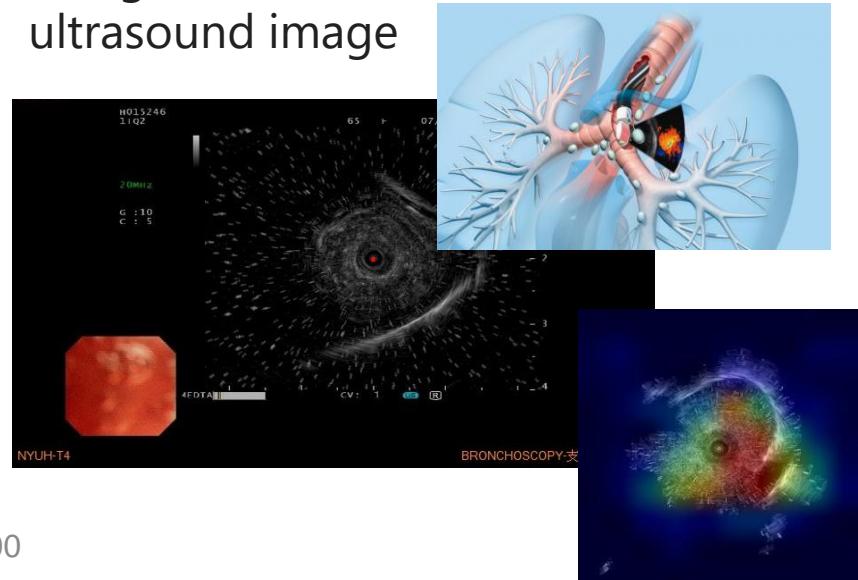
Diagnostic report generation



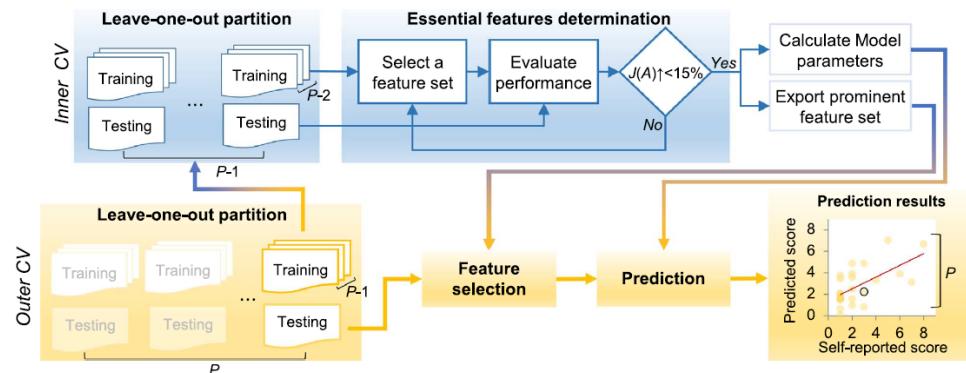
Satellite imagery for public health



Malignant classification in ultrasound image



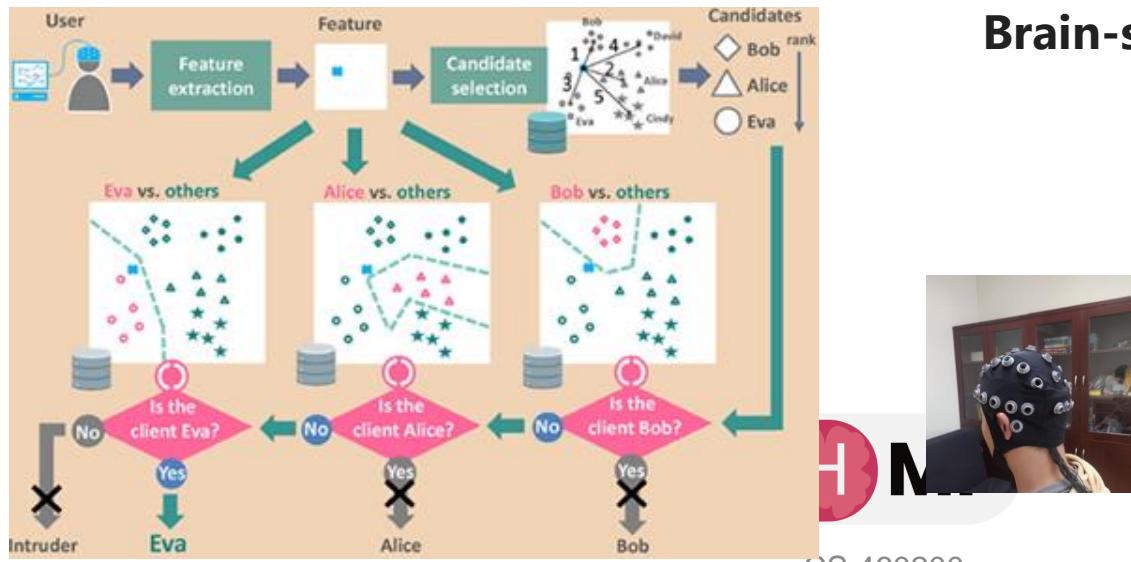
# Decoding Pain Level from Magnetoencephalography (MEG)



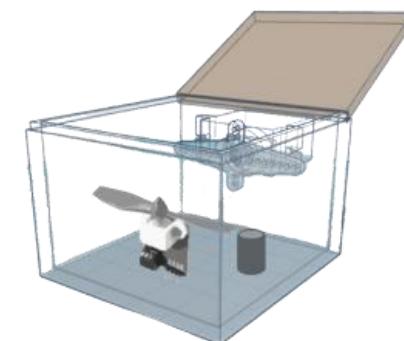
3. Schematic diagram of the nested CV procedure for the determination of essential features and pain level prediction. In the outer CV (yellow), leave-one-out CV using all  $P$  was applied to evaluate the accuracy of pain level prediction. In the inner CV (blue),  $P-1$  training data in the outer CV were used to determine a set of essential features using an  $\geq$ -one-out partitioning for sequential forward search.



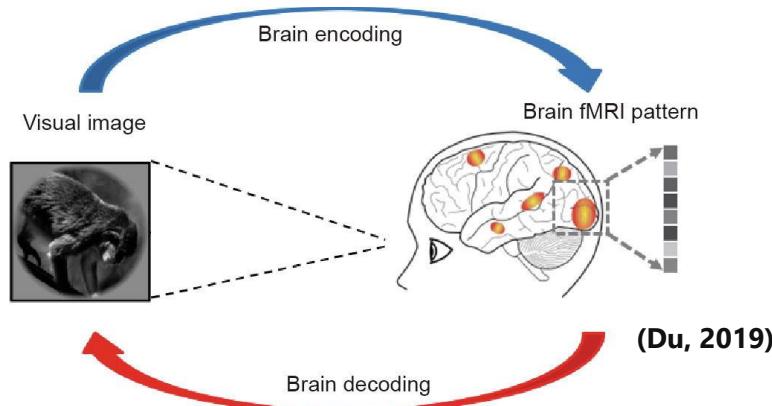
## EEG-Based Biometrics



## Brain-sensing fragrance diffuser



# Decoding and Encoding in Human Brain



<https://pochihkuo.github.io/>



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AI can recognize race!

⌚ September 16, 2022

<https://www.nthu.edu.tw/hotNews/content/1089>

— ABOUT THIS SITE —

We believe that AI system is to enhance and support humans rather than replace them.

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# Turing Test

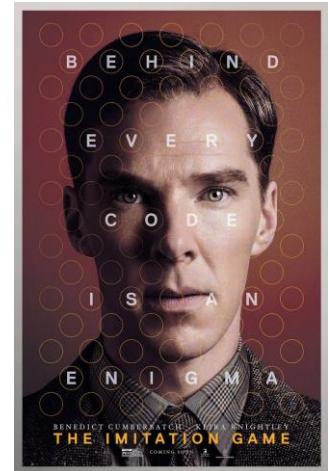


**A**

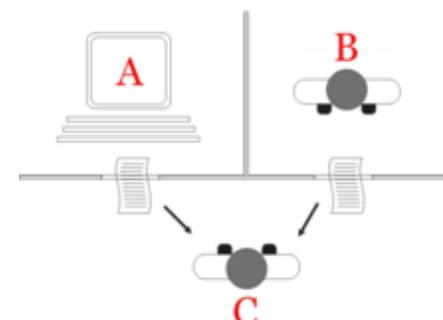
a woman in a kitchen preparing food

**B**

woman working on counter near kitchen sink preparing a meal



Alan Mathison Turing



# Questions?



# Beginning of the course

# End of the course

# After becoming an expert

