

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

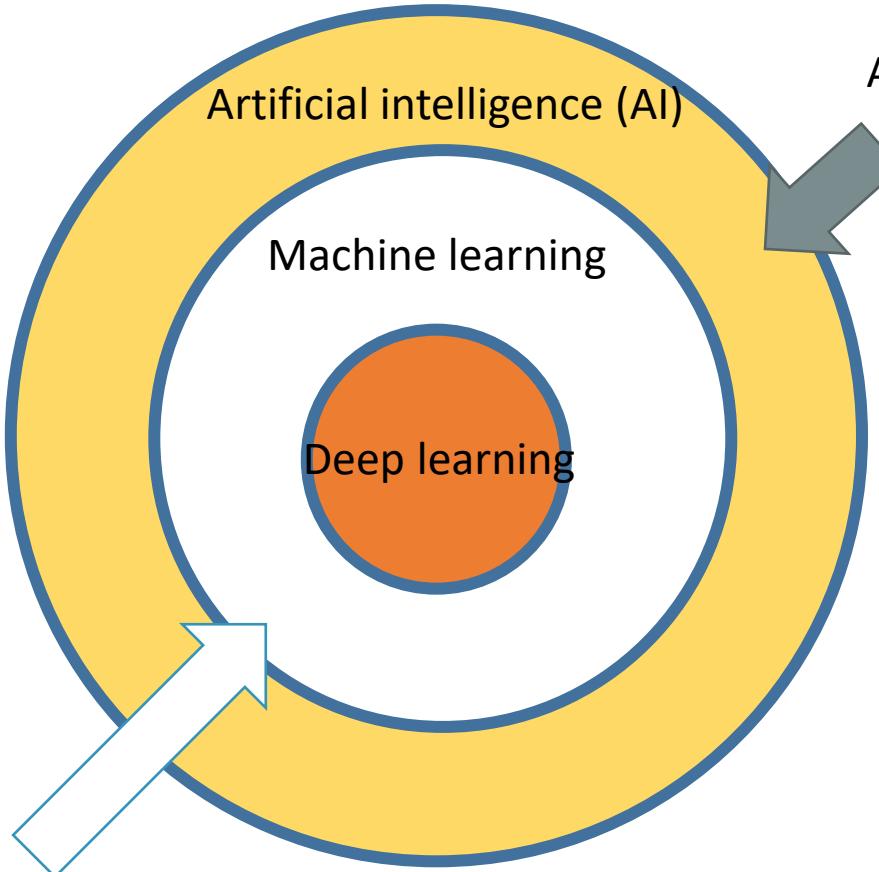
Scope of AI

What about?

Go



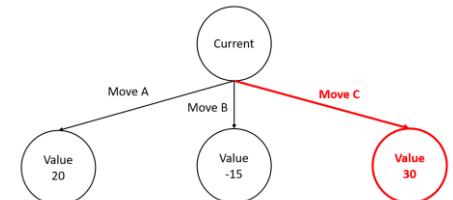
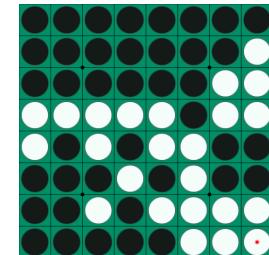
Can a PC learn by itself?



Learn what?

CS 460200

AI-ML=?
Othello



```
function alphabeta(node, depth, a, b, 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, a, b, FALSE))
      a := max(a, value)
      if a ≥ b then
        break (* a cutoff *)
    return value
  else
    value := +∞
    for each child of node do
      value := min(value, alphabeta(child, depth - 1, a, b, TRUE))
      b := min(b, value)
      if b ≤ a then
        break (* b 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?

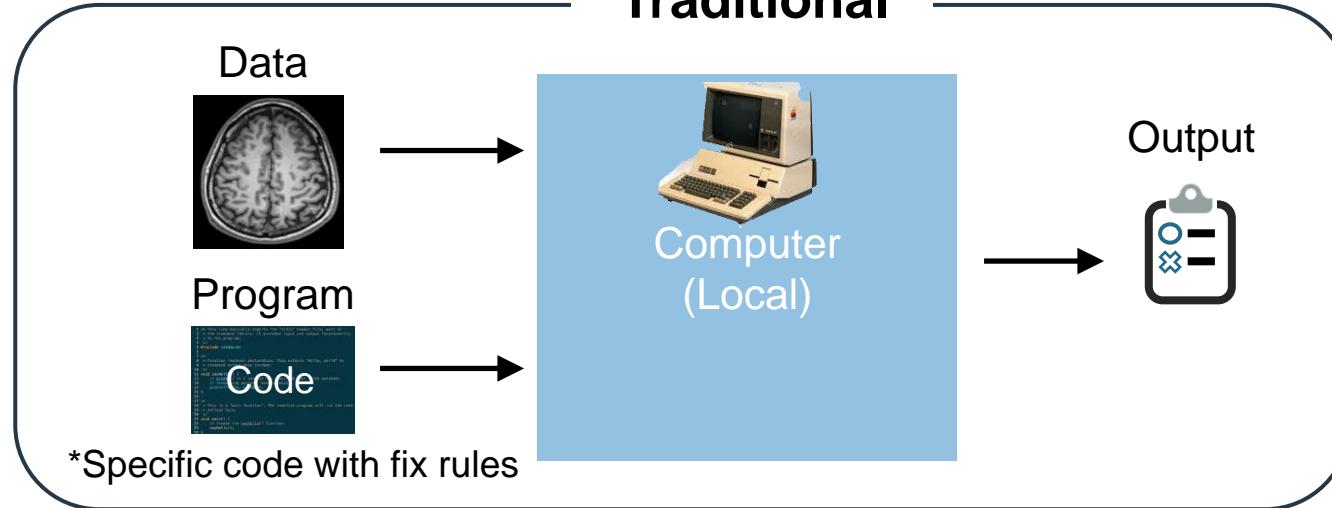
No, more like gardening

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

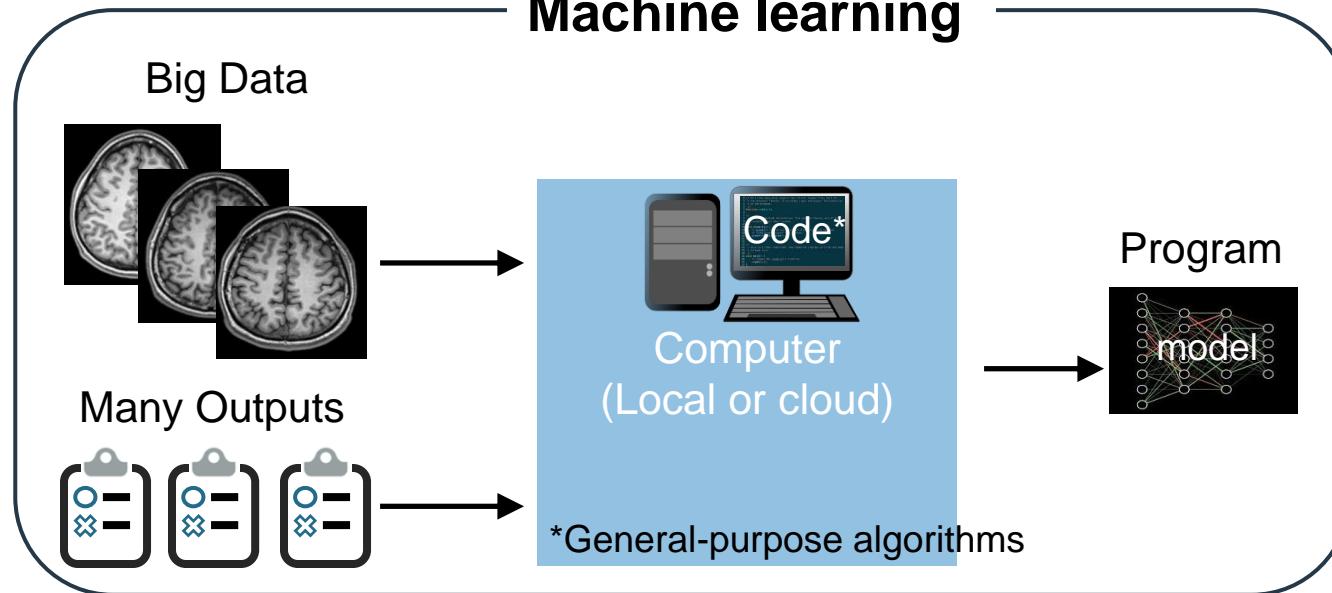


Role of computers is changing

Traditional



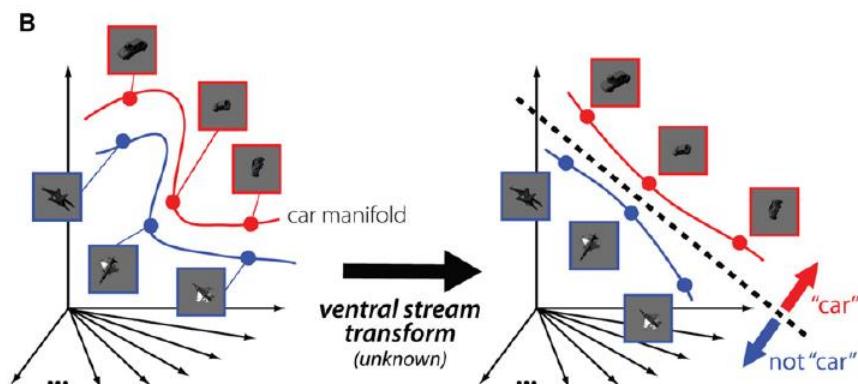
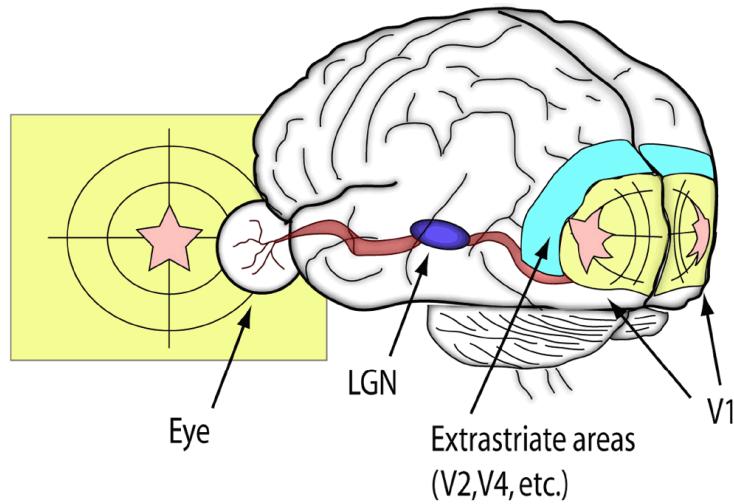
Machine learning



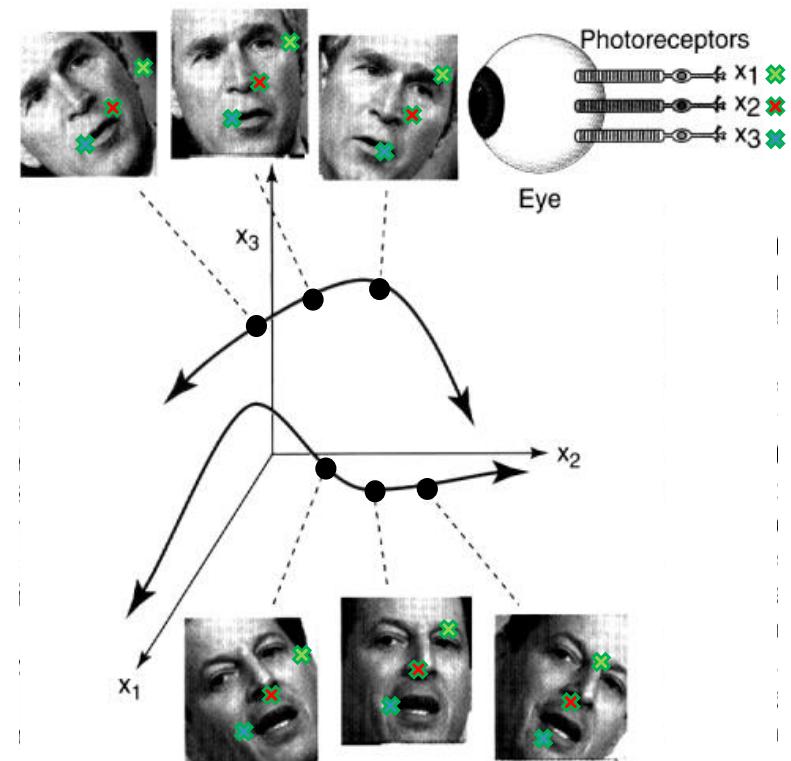
How does ML work?

= How to design a good algorithm?

Human Machine learning



(DiCarlo et al., 2012)



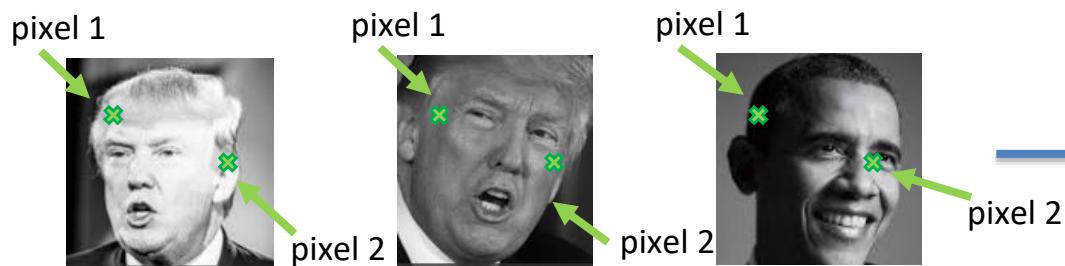
(Seung and Lee., 2000)

Image space

New image



Input

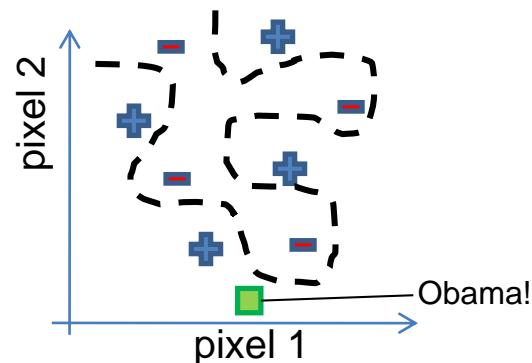


?

Learning
algorithm

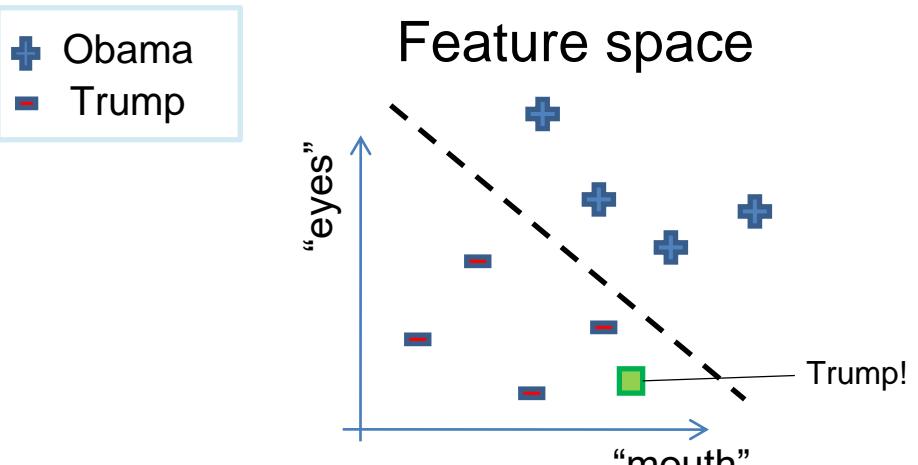
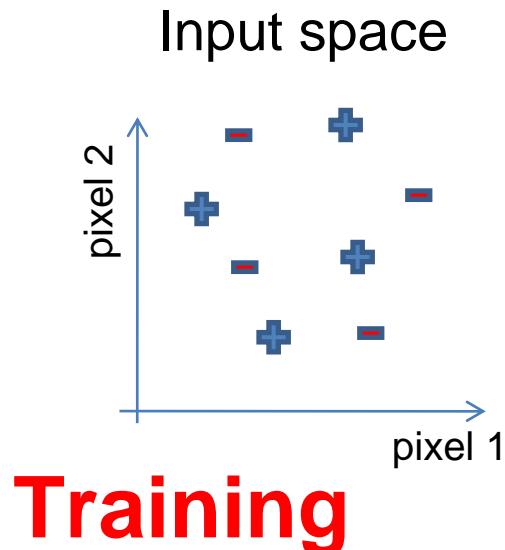
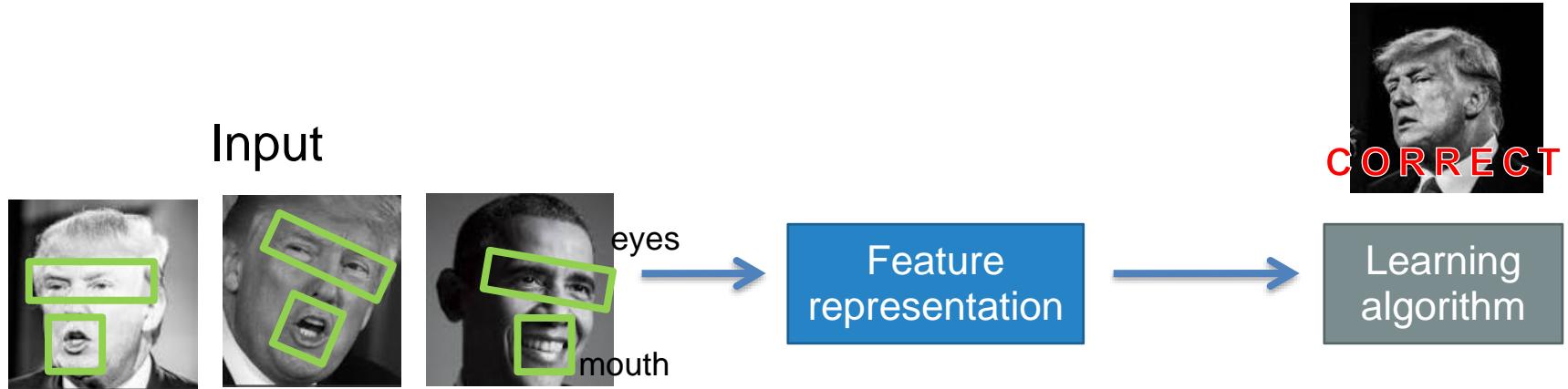
Input space

⊕ Obama
- Trump



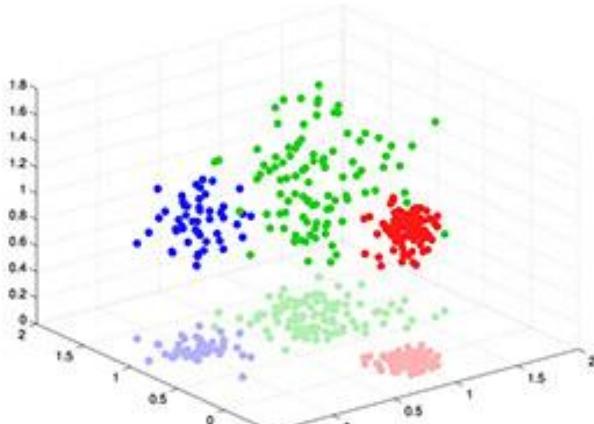
Feature representations

Testing
New image

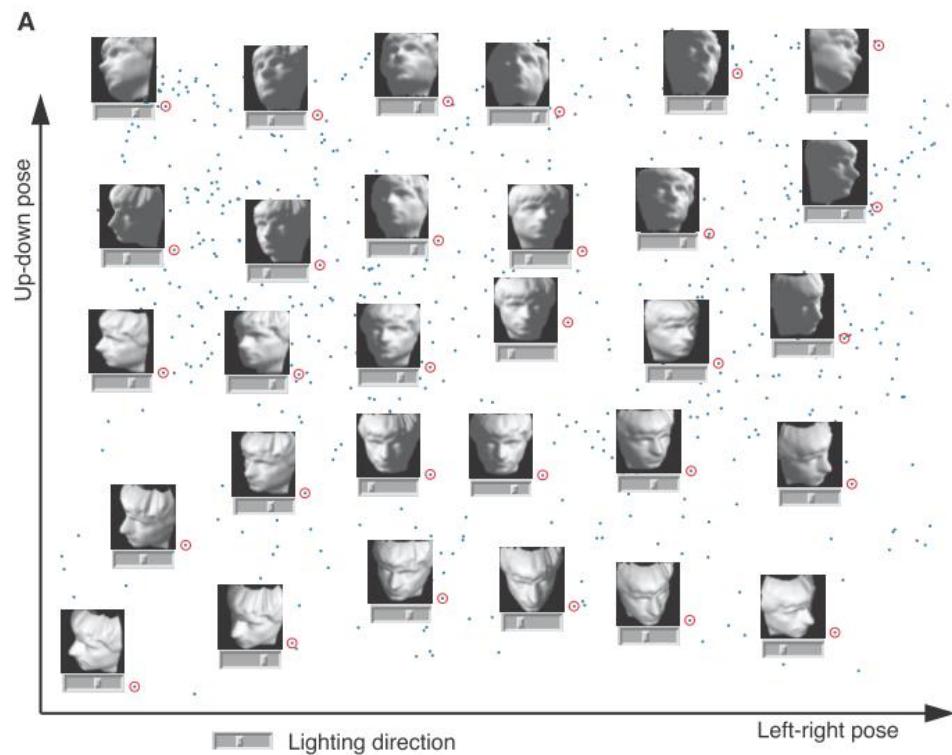


Problem of Dimension Transformation

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



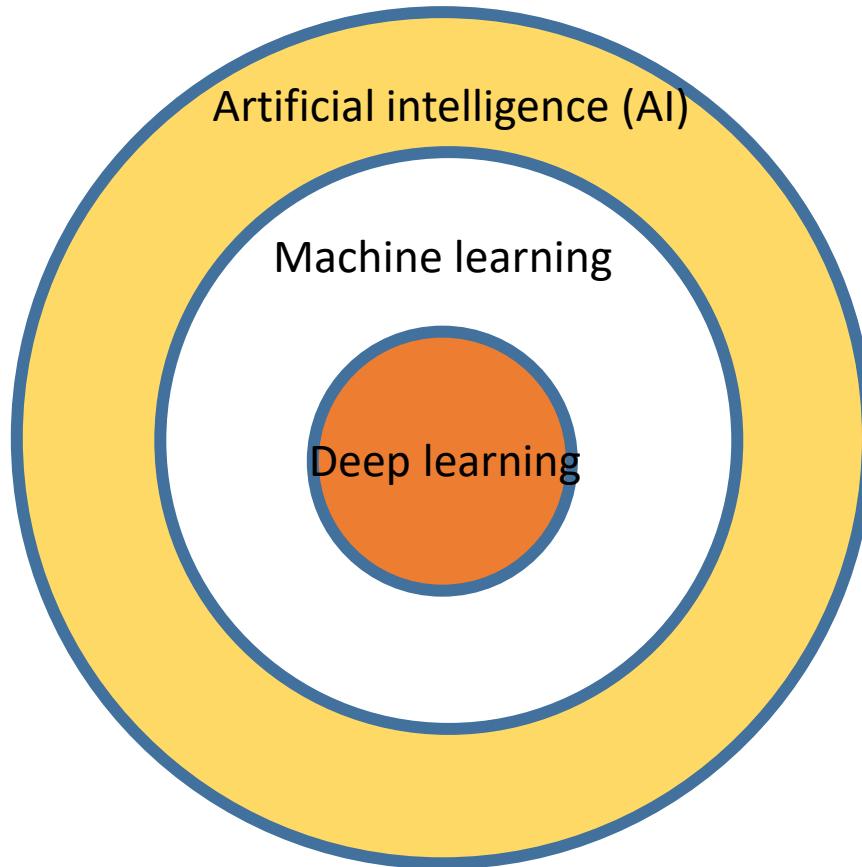
(<http://bigdata.csail.mit.edu>)



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)!

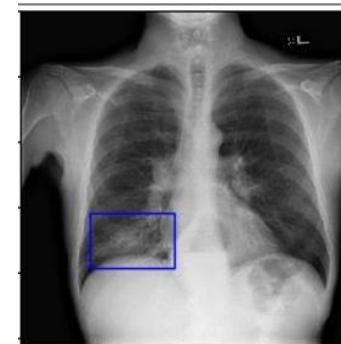
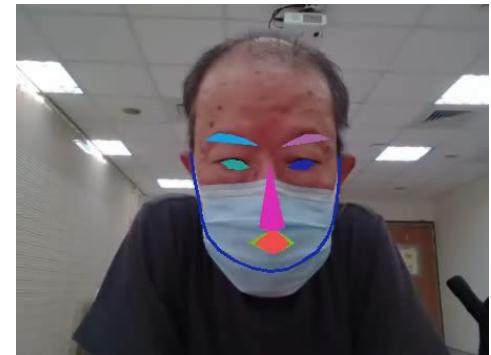
- “Learning is making useful **changes** in our minds.” - Marvin Minsky



We need a way to save changes!

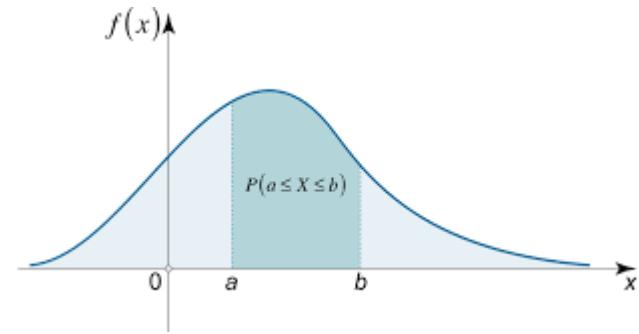
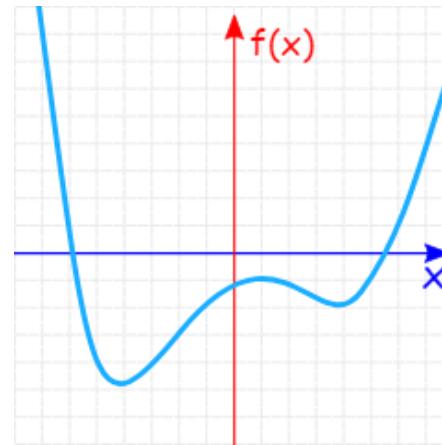
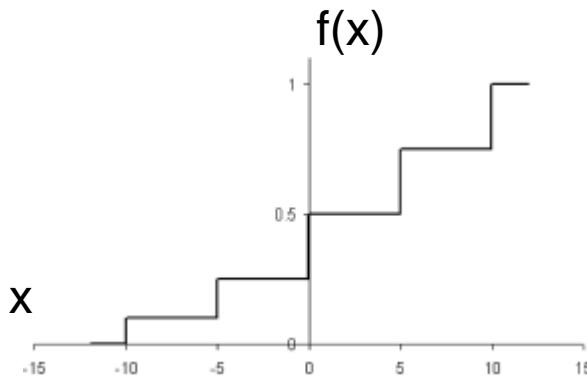
Examples of tasks best solved

- 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

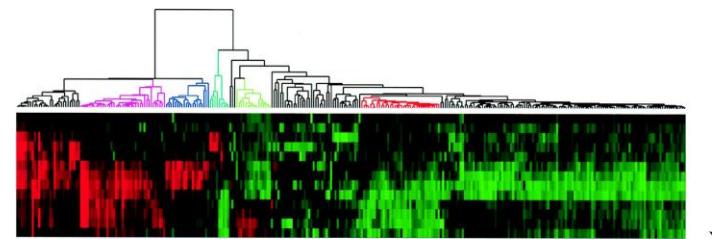
- Supervised (inductive) learning
 - Training data includes desired outputs
- Unsupervised learning
 - Training data does not include desired outputs
- Semi-supervised learning
 - Training data includes a few desired outputs
- Self-supervised Learning
 - Training data does not include desired but alternative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

Roadmap

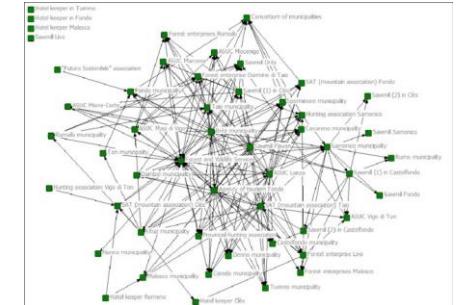
- Introduction and Basic Concepts
 - Regression
 - Bayesian Classifiers
 - Decision Trees
 - KNN
 - Linear Classifier
 - Neural Networks
 - Deep learning
 - Convolutional Neural Networks
 - Autoencoder
 - Adversarial
 - RNN
 - Reinforcement Learning
 - Model Selection and Evaluation
 - Clustering
 -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

Continuous $F(X)$?
Discrete $F(X)$?
 $F(X)$ = Probability(X)?

Supervised Learning



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 half of machine learning project is running model. The other 90% is cleaning data."

by Po-Chih Kuo

What you should know?

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



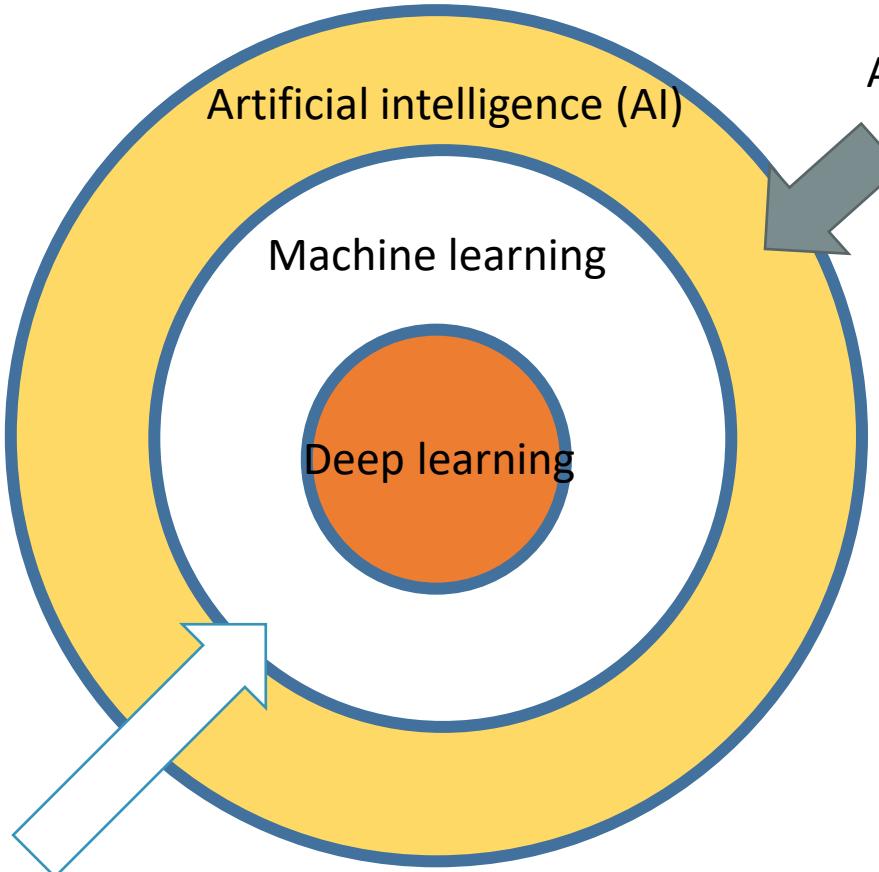
Scope of AI

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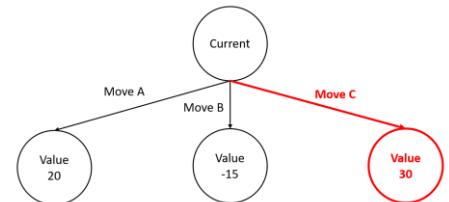
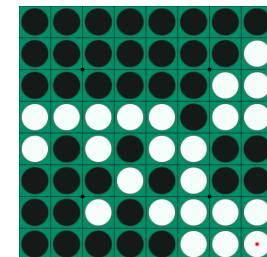
Go



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```

Deep learning

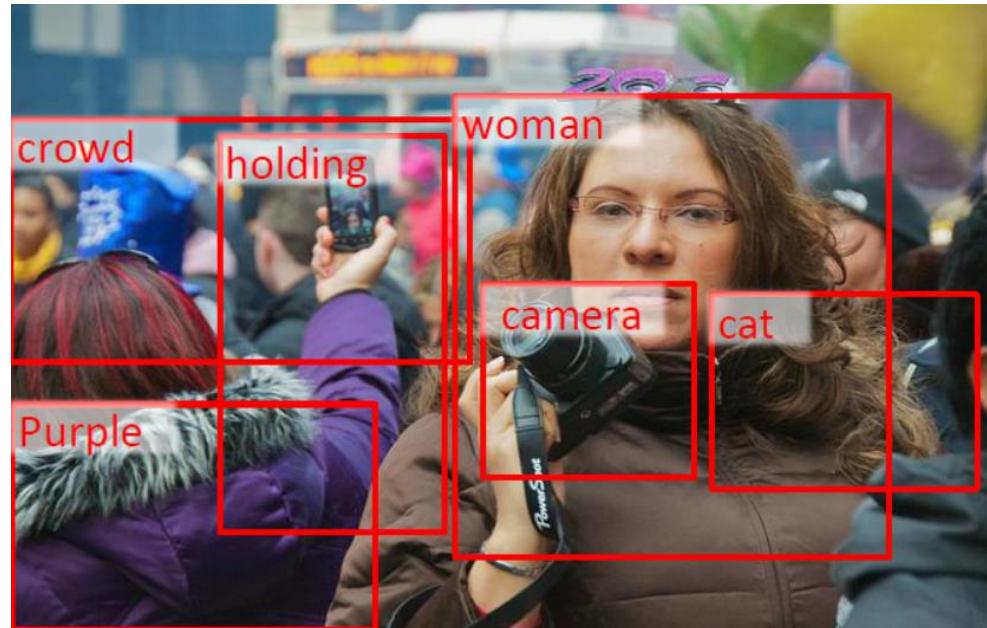


In "Nature" 27 January 2016:

- "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

Microsoft System
(MSR):
Use of DSSM for Global
Semantic Matching



1. Word
Detection

2. Sentence
Generation

3. Sentence
Re-Ranking

woman, crowd, cat,
camera, holding,
purple

A purple camera with a woman.
A woman holding a camera in a crowd.
...
A woman holding a cat.

#1 A woman holding a
camera in a crowd.

Deep CNN for Image Classification

Classification

[Click for a Quick Example](#)



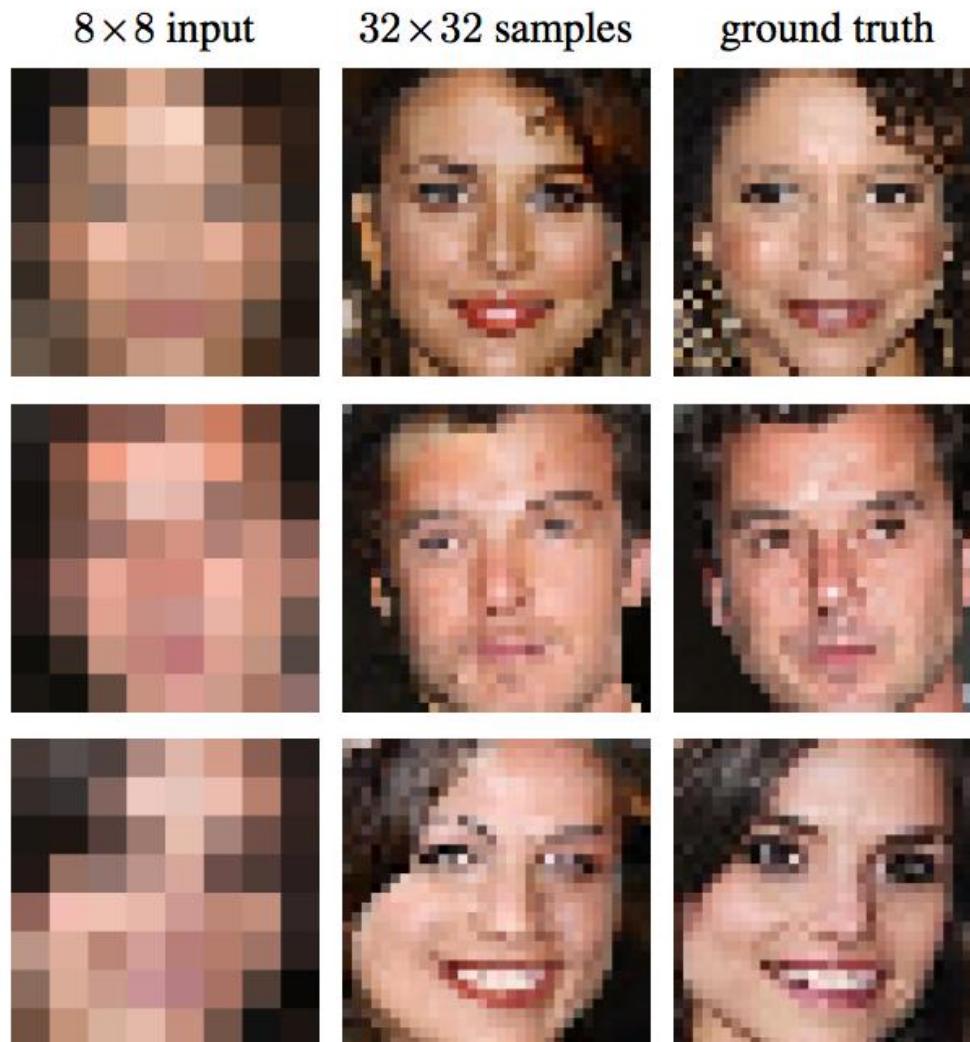
Maximally accurate	Maximally specific
cat	1.79306
feline	1.74269
domestic cat	1.70760
tabby	0.94807
domestic animal	0.76846

CNN took 0.064 seconds.

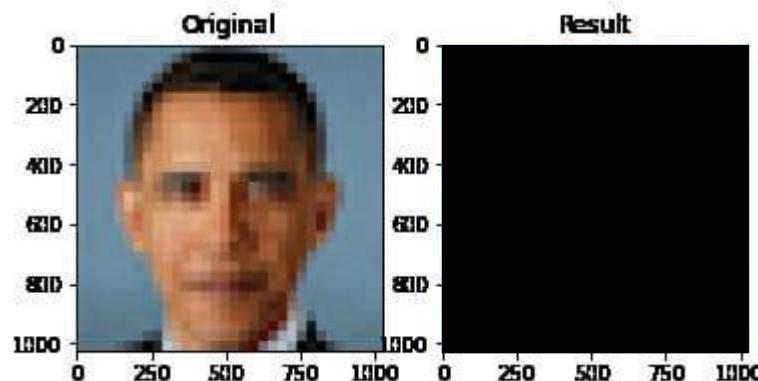
```
for pred in preds:  
    top_indices = pred.argsort()[-top:][::-1]  
  
    result = [tuple(CLASS_INDEX[str(i)]) + (pred[i],) for i in top_indices]  
    result.sort(key=lambda x: x[2], reverse=True)  
  
    results.append(result)  
  
return results
```

Try out a live demo at
<http://demo.caffe.berkeleyvision.org/>

Pixel Restoration ([Google Brain](#))



However,



https://github.com/tg-bomze/Face-Depixelizer?fbclid=IwAR2T0XRJMFMS-FjofeSVxz8zguoKj_j2Wy2KXCzljuv80c1YjzuJBe4eesA

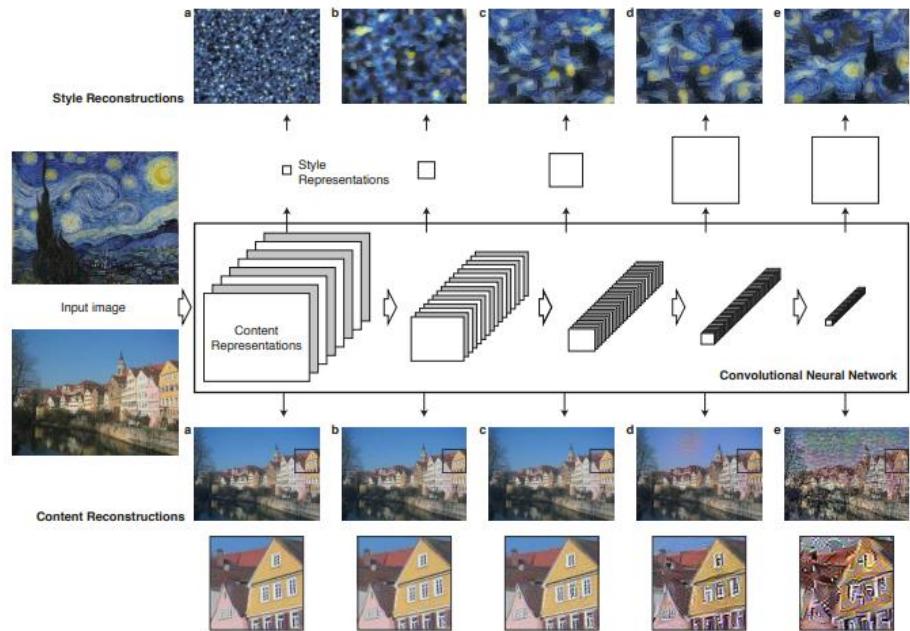
Colorization of Black and White Images (Zhang, 2016)



100 year old pictures...



Style Transfer



(Gatys et al., 2015)

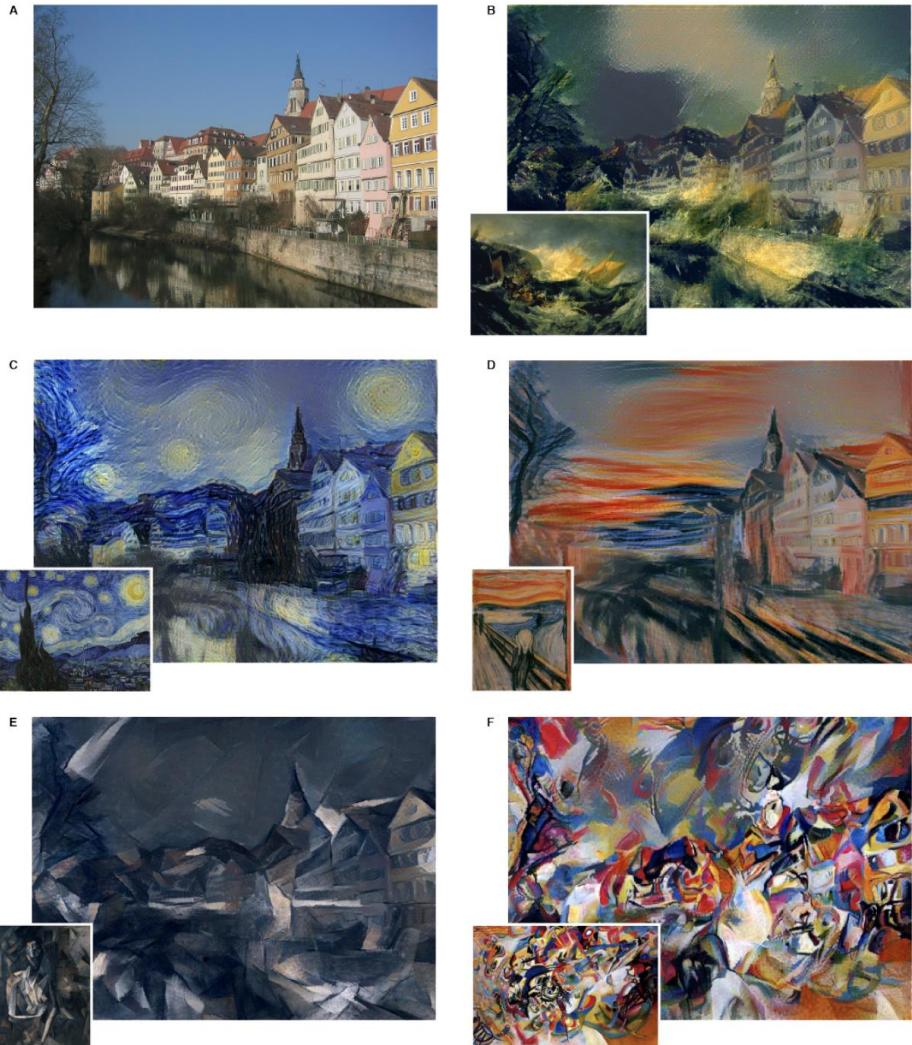
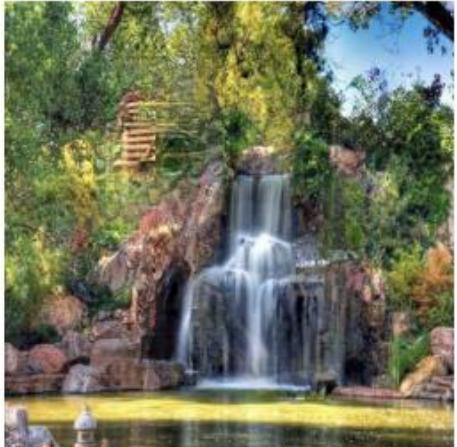
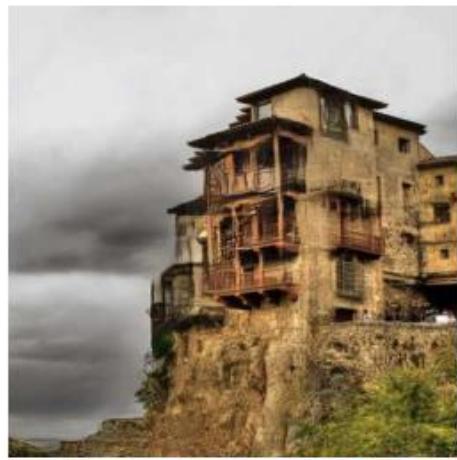
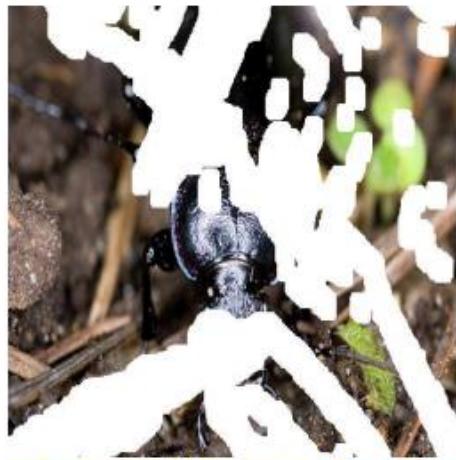
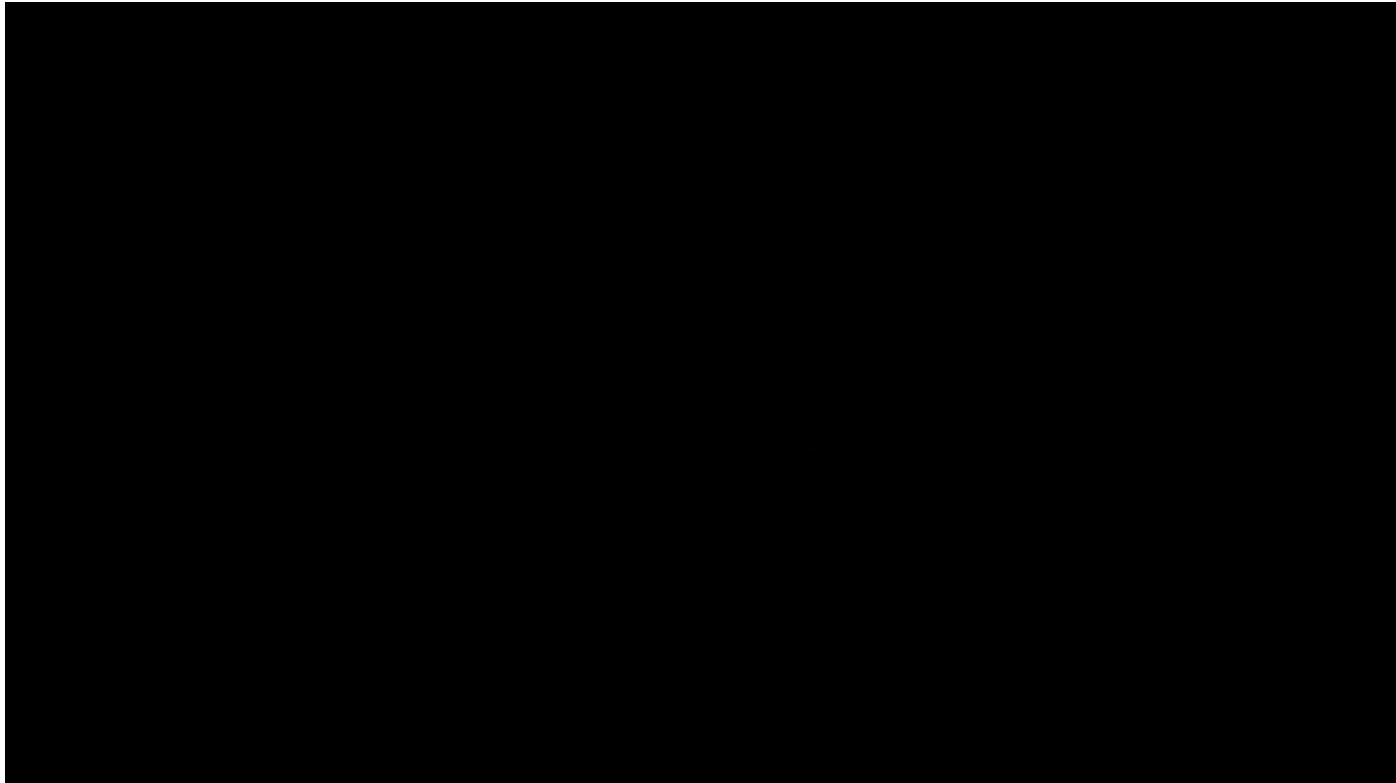


Image Reconstruction ([van den Oord](#), 2016)



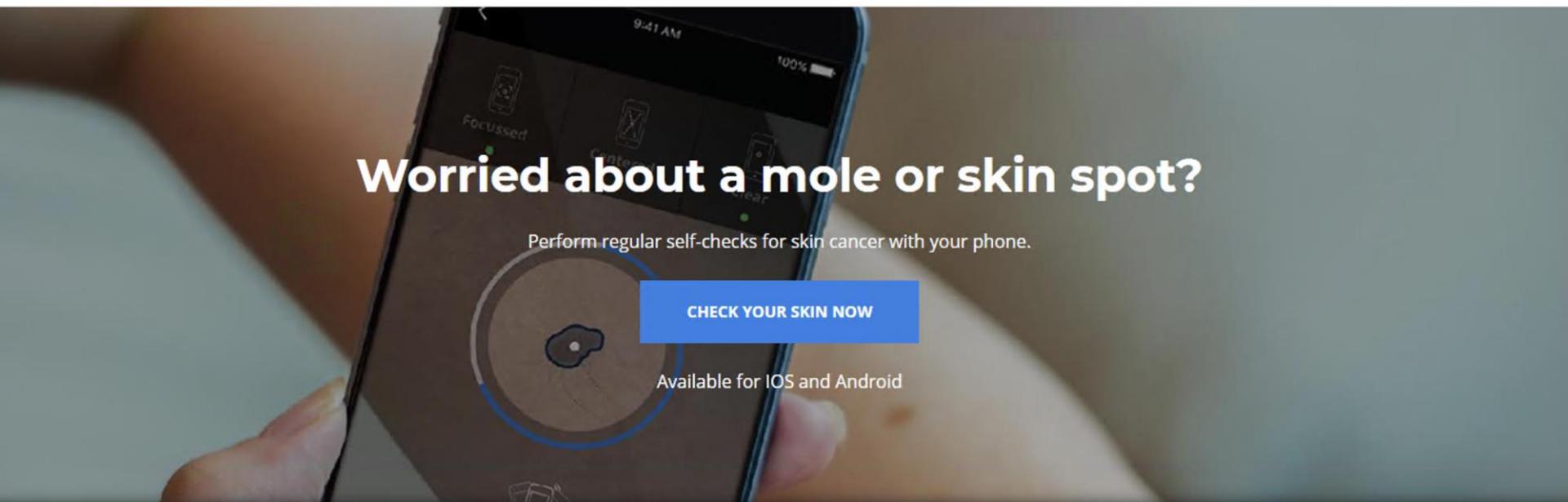
Lip Reading (2016)



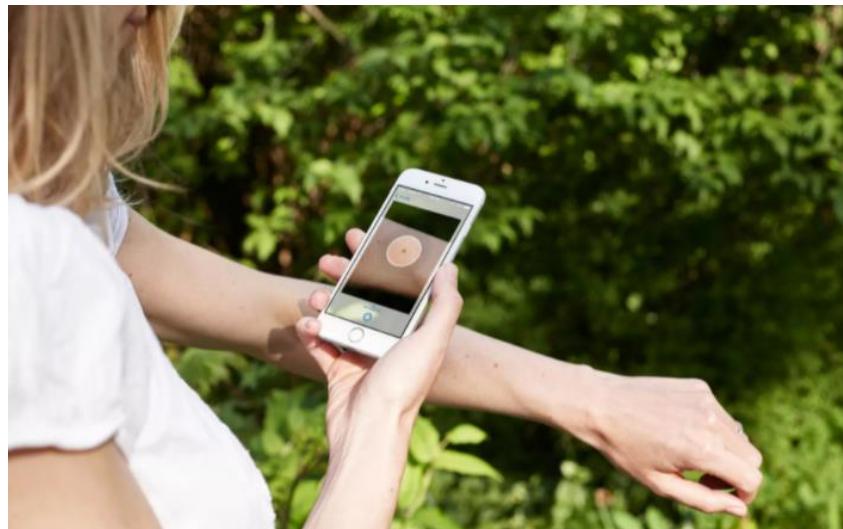
LipNet

Machines Play Machines





A close-up photograph of a person's arm being held by another person. A smartphone is held vertically, displaying the SkinVision app interface. The screen shows a circular skin lesion with a dark center and a blue border. The text "Worried about a mole or skin spot?" is displayed in large white letters at the top. Below it, a subtext reads "Perform regular self-checks for skin cancer with your phone." A blue button in the center says "CHECK YOUR SKIN NOW". At the bottom, it says "Available for iOS and Android". The phone's screen also shows a "9:41 AM" timestamp and a "100%" battery icon.



[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



COVID-19 Sounds App

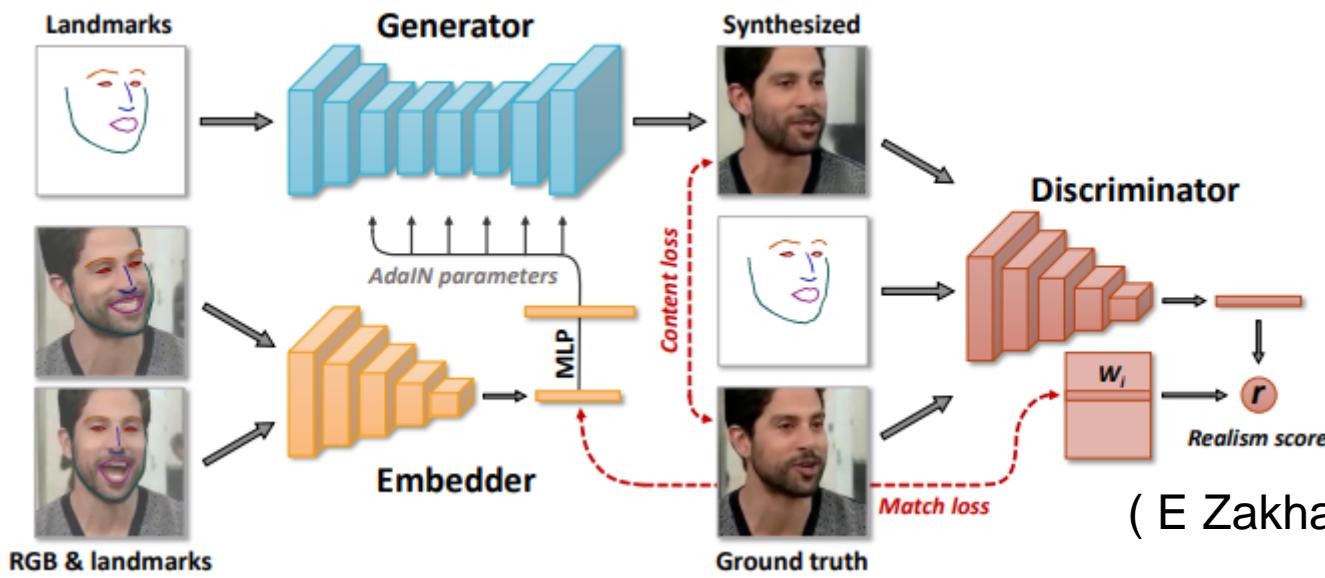
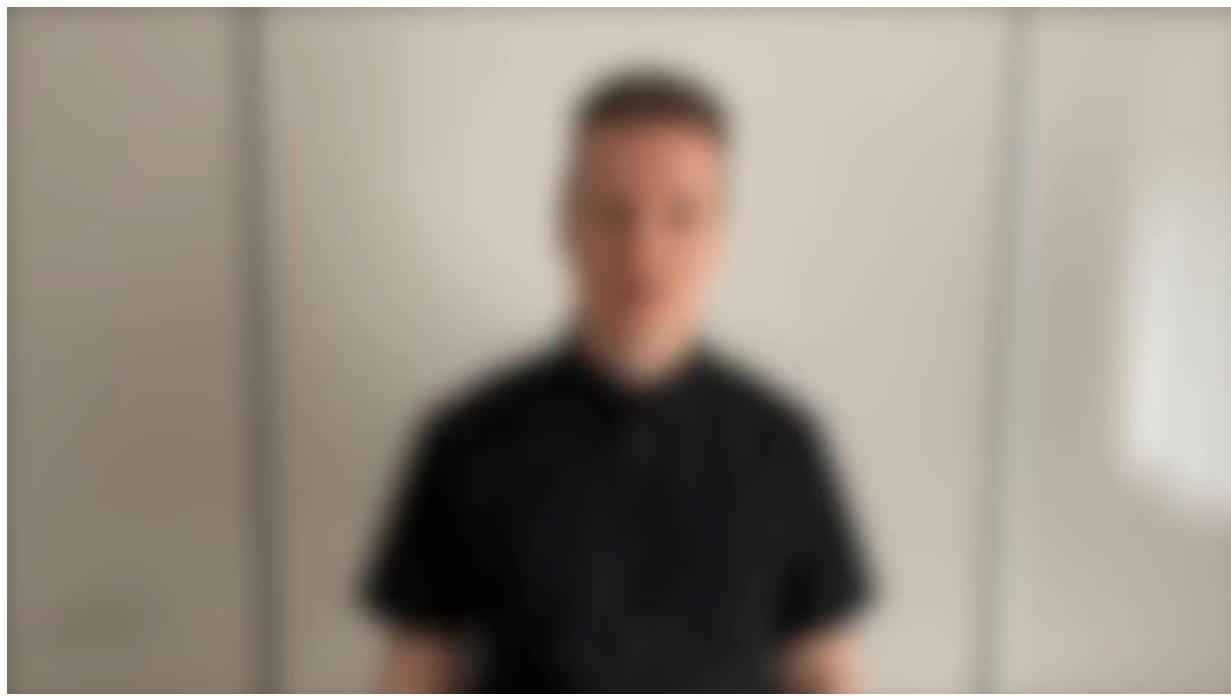
Upload short recordings of cough and breathing and report symptoms to help researchers from the University of Cambridge detect if a person is suffering from COVID-19. Healthy and *non-healthy* participants welcome.



or use the [online form](#)



Fake video



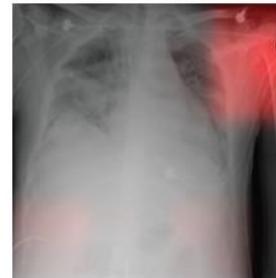
Can you spot the deepfake video?



<https://moondisaster.org/film>

Shortcut Learning

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 Super 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

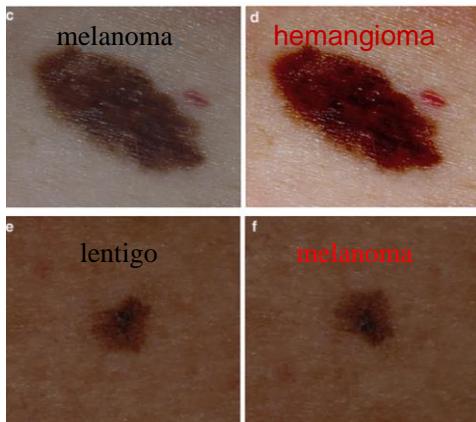
Task for DNN	Caption image	Recognise object	Recognise pneumonia	Answer question
Problem	Describes green hillside as grazing sheep	Hallucinates teapot if certain patterns are present	Fails on scans from new hospitals	Changes answer if irrelevant information is added
Shortcut	Uses background to recognise 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)

Bias in AI healthcare

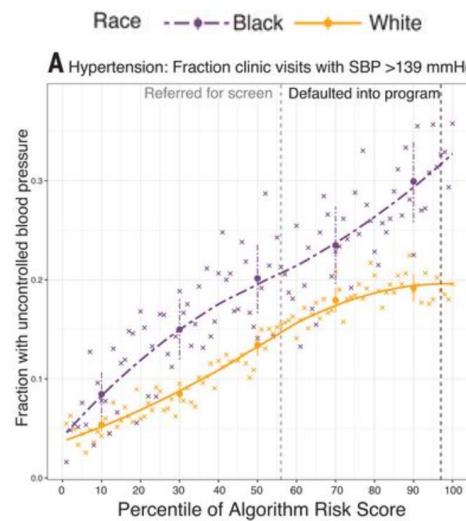
Bias has also been discussed in many **healthcare** applications including skin **cancer detection**, **mortality prediction** and **healthcare utilization prediction** algorithms.

skin cancer detection



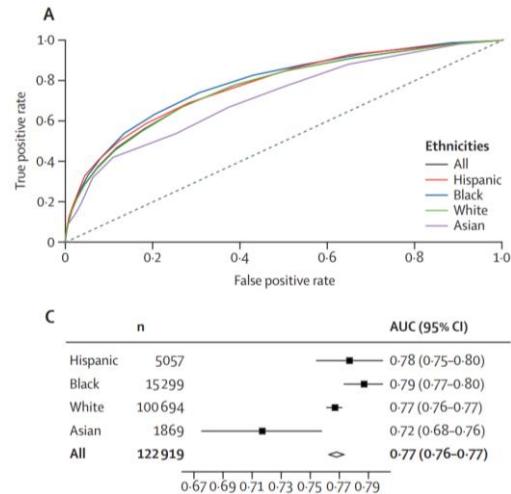
Navarrete-Decent et al., J. Invest. Dermatol. 2018

healthcare algorithms



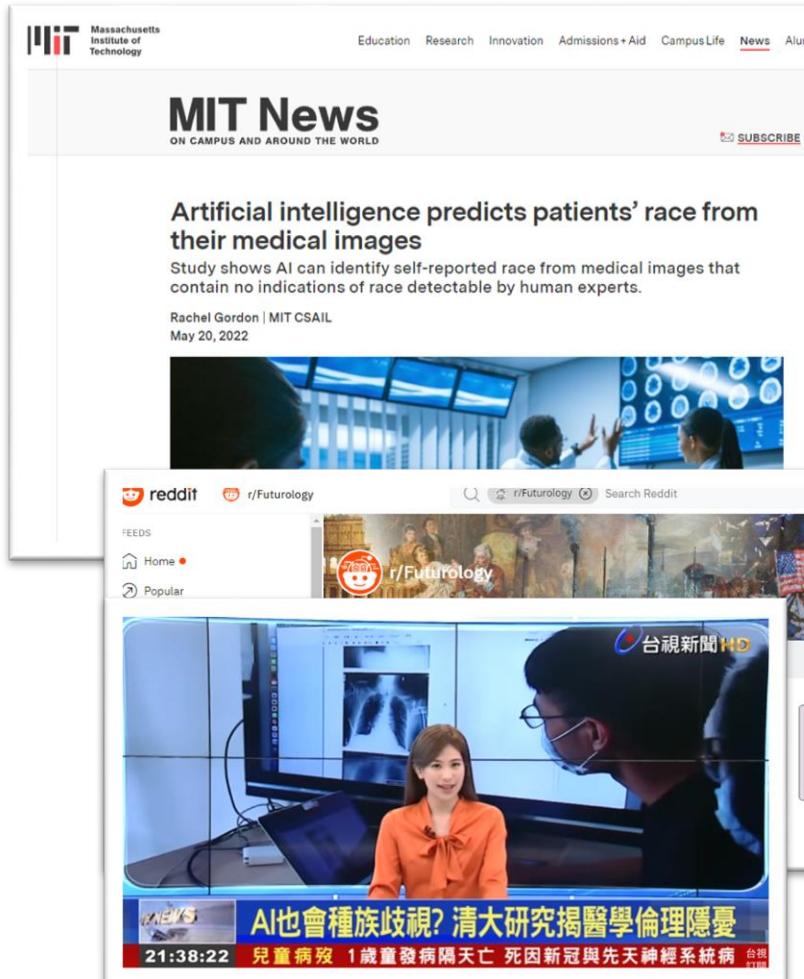
Obermeyer et al., Science 2019

mortality prediction



Sarkar R et al., Lancet Digit Health 2021

AI can recognize race



Massachusetts Institute of Technology

Education Research Innovation Admissions + Aid Campus Life News Alumni

MIT News

ON CAMPUS AND AROUND THE WORLD

[SUBSCRIBE](#)

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

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



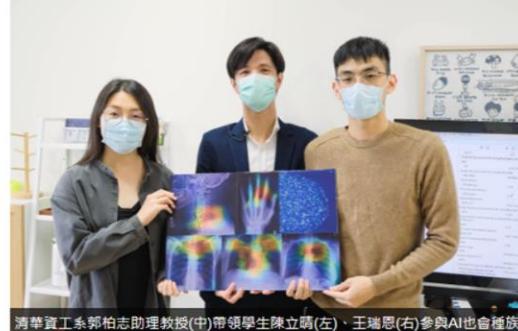


國立清華大學 NATIONAL TSING HUA UNIVERSITY

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

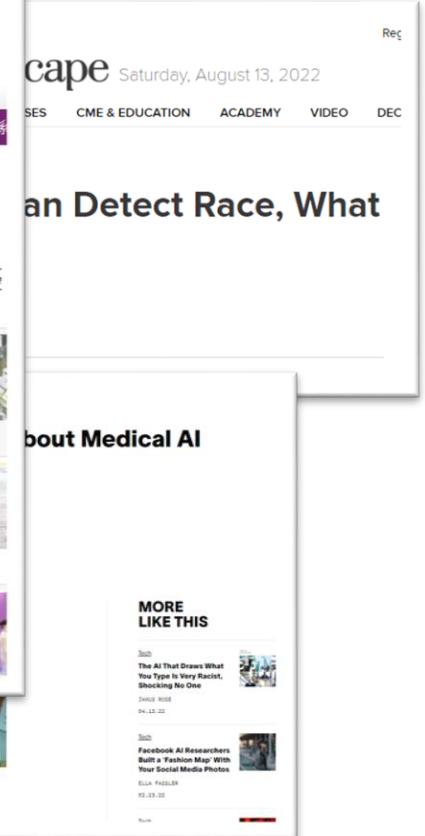
AI竟會種族歧視 清華與跨國團隊揭露醫學倫理隱憂



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

LETTER: DRAGS

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



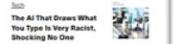
cape Saturday, August 13, 2022

SES CME & EDUCATION ACADEMY VIDEO DEC

an Detect Race, What

about Medical AI

MORE LIKE THIS



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

DATE: 08/12/22



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

ELLA PASKLER

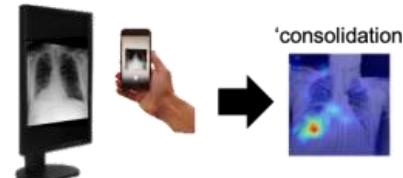
DATE: 07/27/22

What about our LAB ?

Chest X-ray interpretation

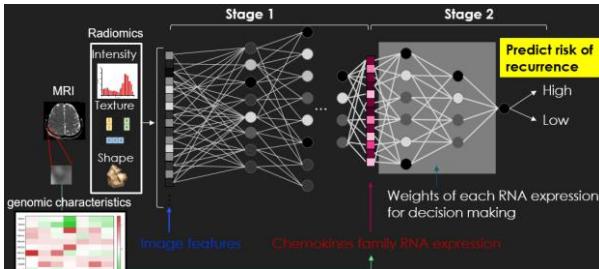
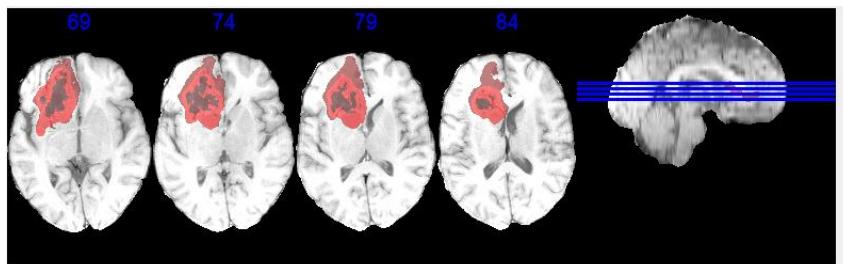


Smartphone-based detection in CXR

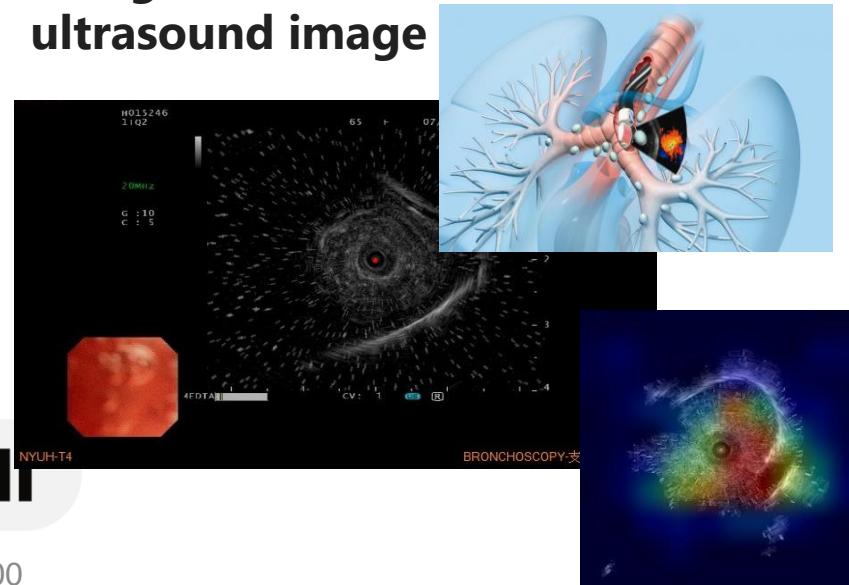


Trustworthy AI

Brain tumor segmentation

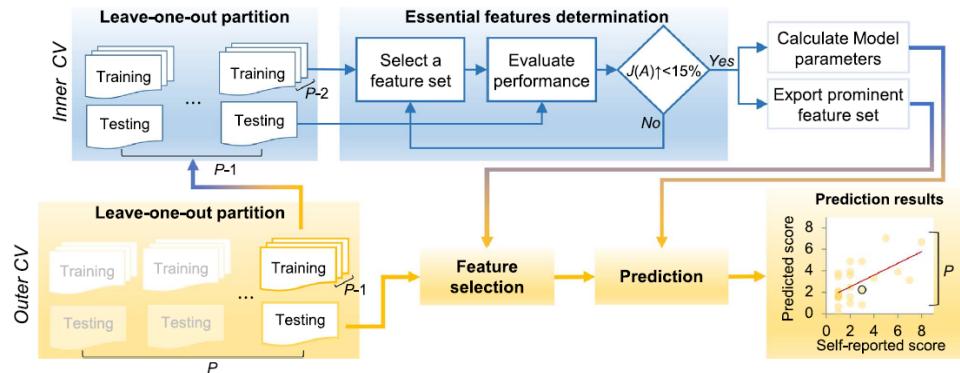


Malignant classification in ultrasound image



CS 460200

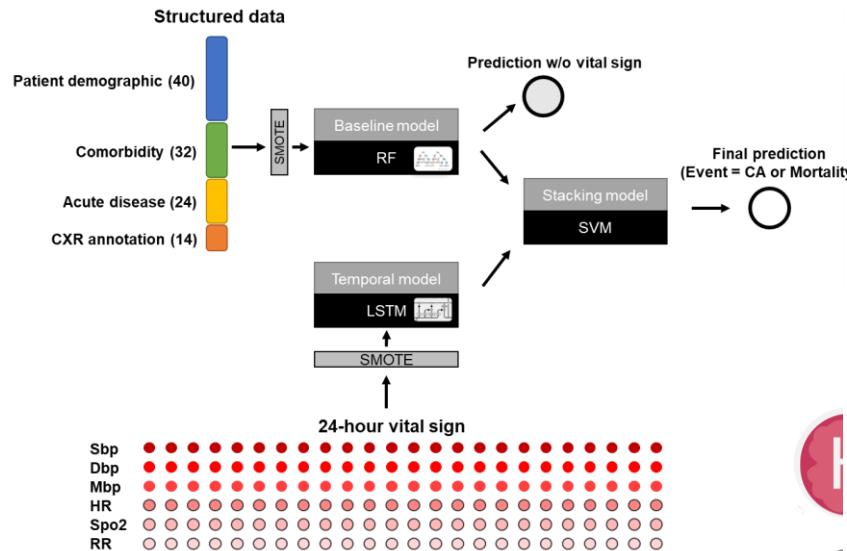
Decoding Pain Level from Magnetoencephalography (MEG)



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 $P-1$ 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.



Cardiac arrest prediction



Tachycardia detection device

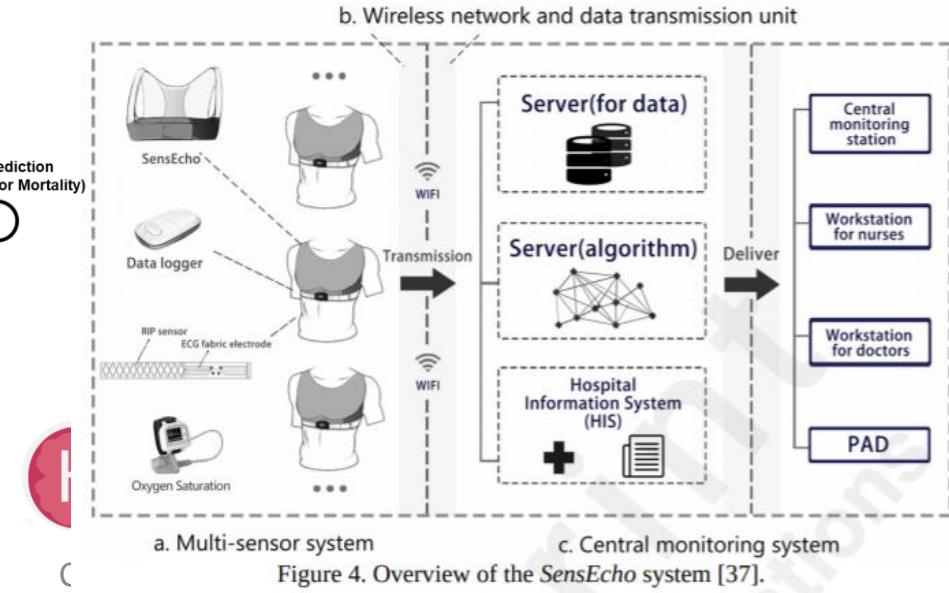
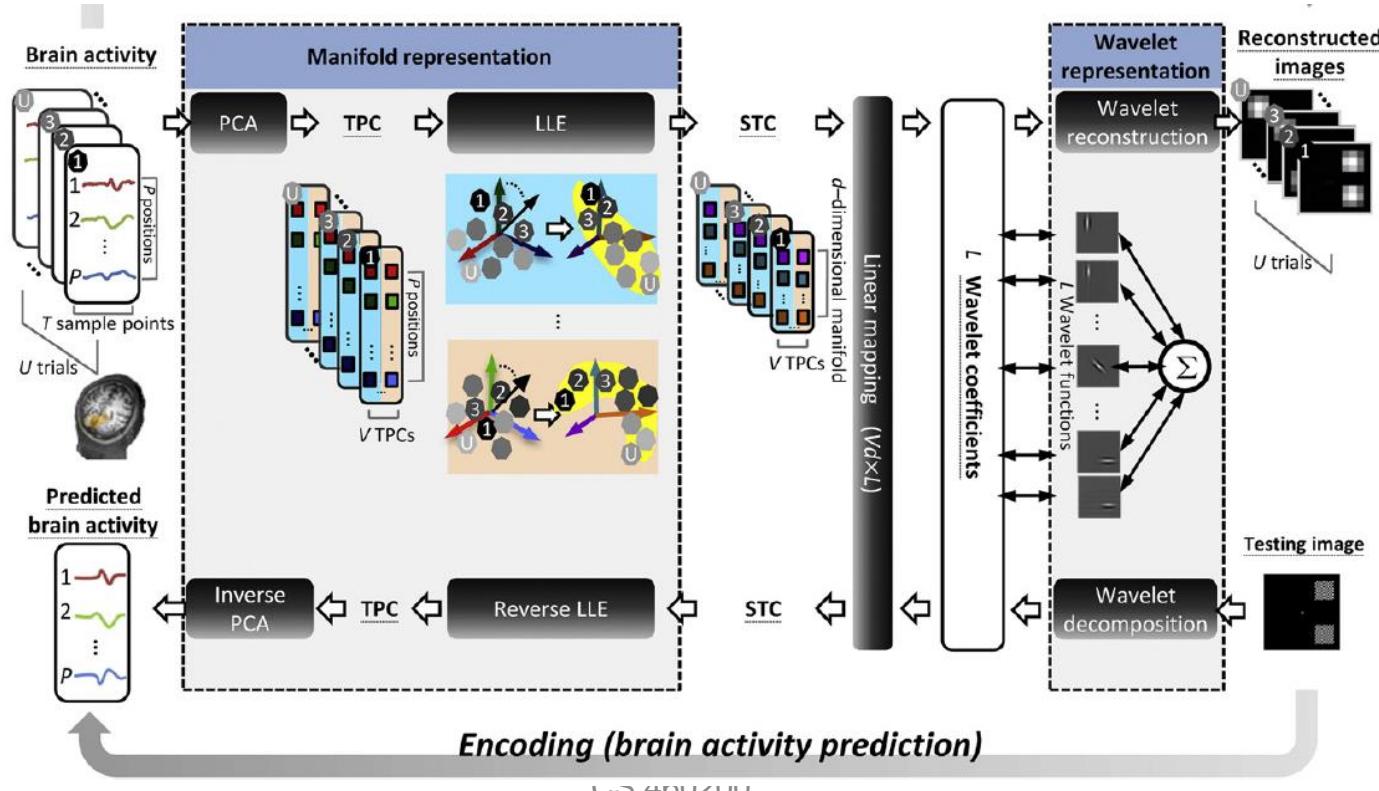
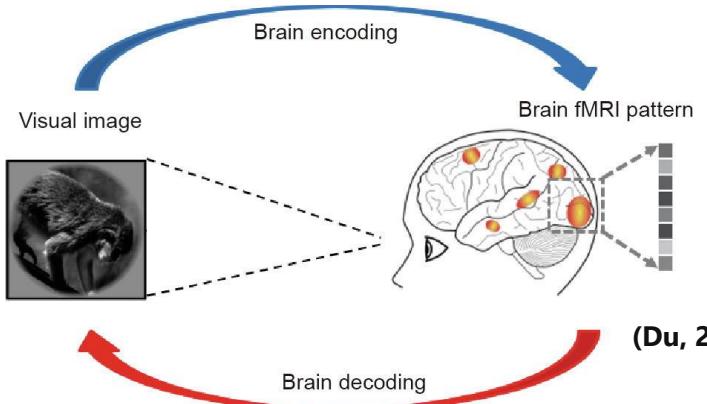


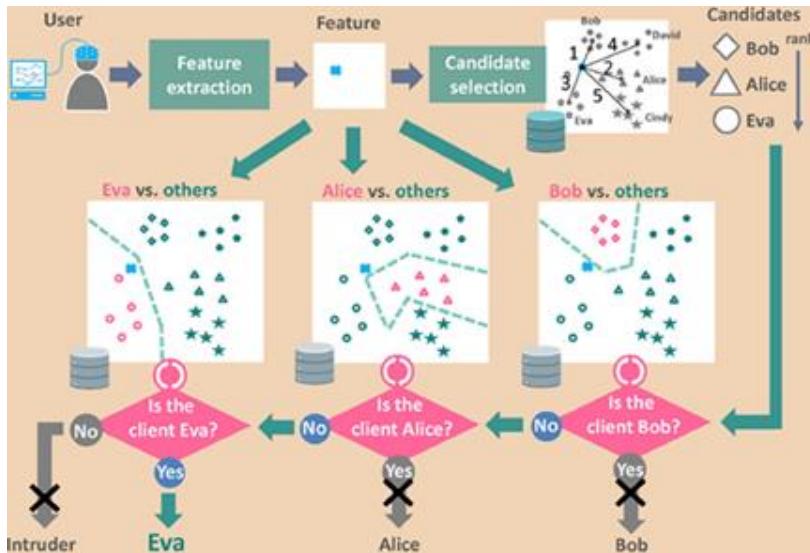
Figure 4. Overview of the SensEcho system [37].

Decoding and Encoding in Human Brain

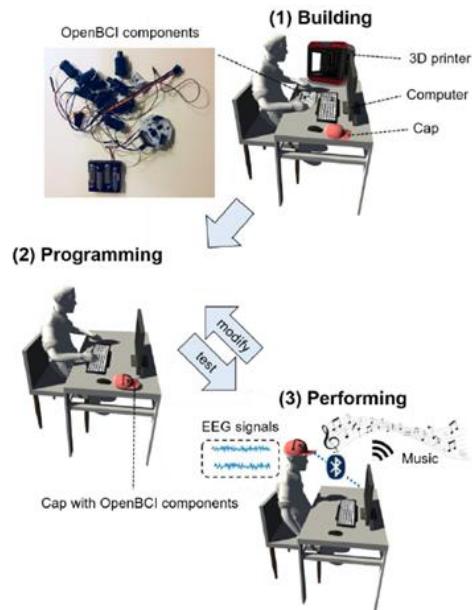




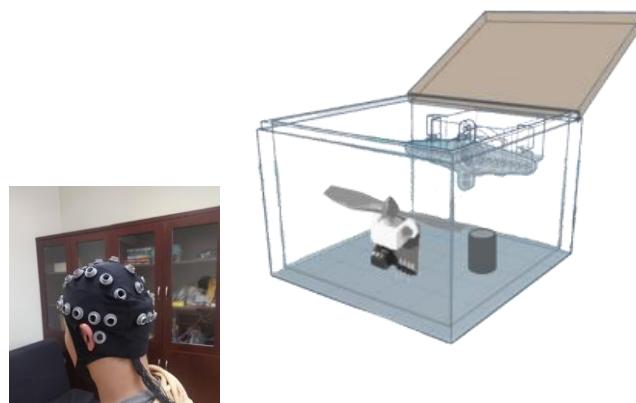
EEG-Based Biometrics



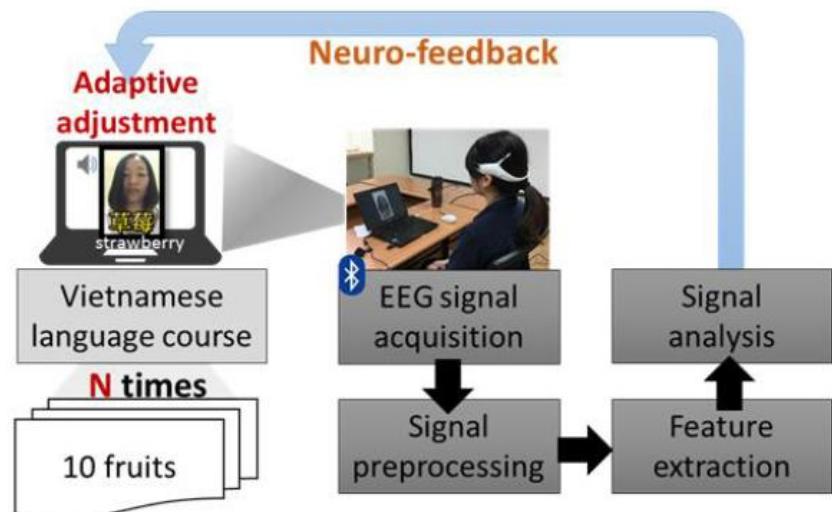
DIY Brain computer interface



Brain-sensing fragrance diffuser



ML-based E-learning System



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



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AI can recognize race!

⌚ September 16, 2022

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

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

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Turing Test

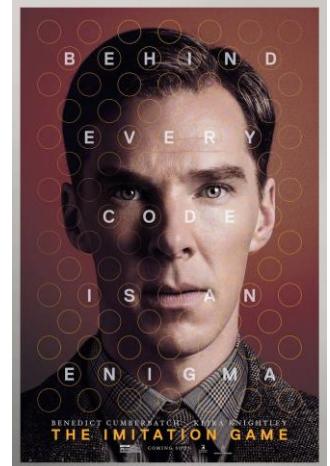
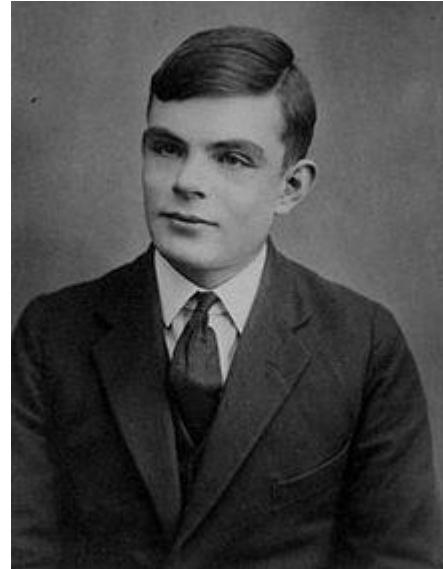


A

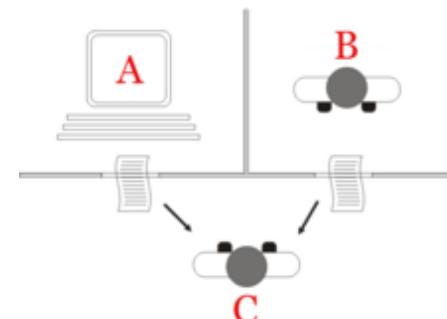
a woman in a kitchen preparing food

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

