CS 460200

Introduction to Machine Learning

Introduction and Basic Concepts

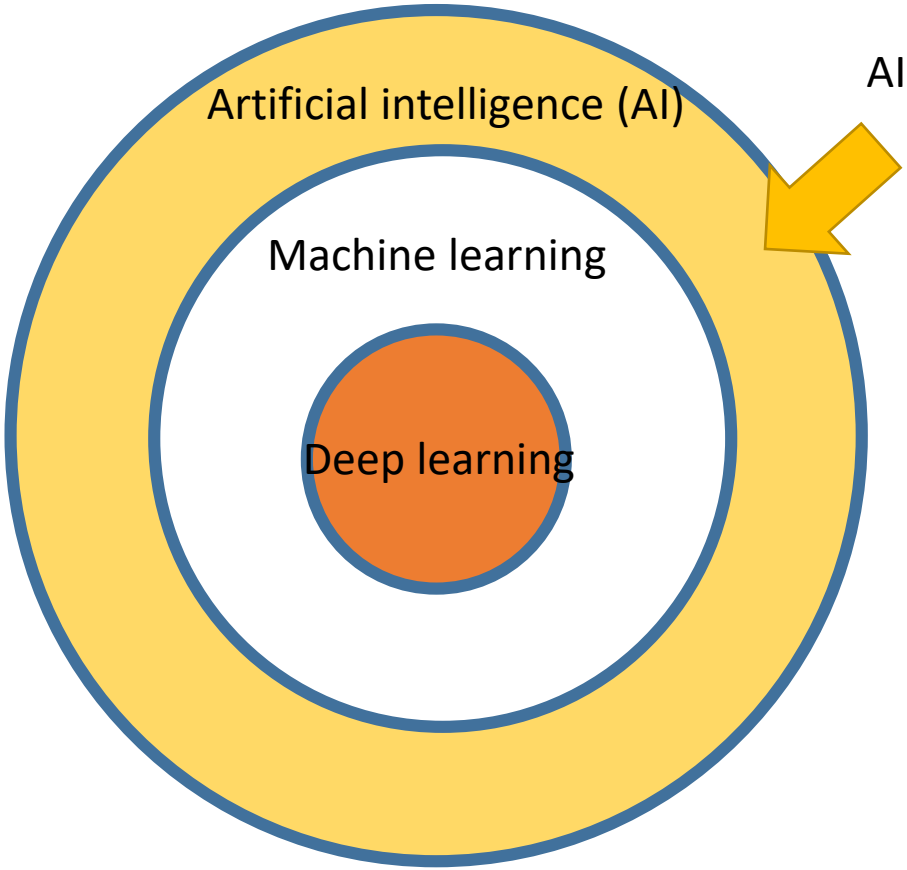
Instructor: Po-Chih Kuo

Roadmap

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

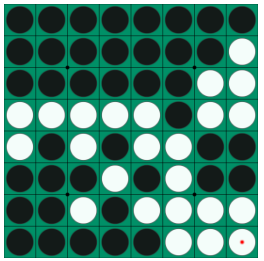
Scope of AI

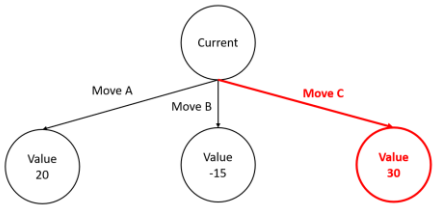
Go



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
```

Learn what?

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!

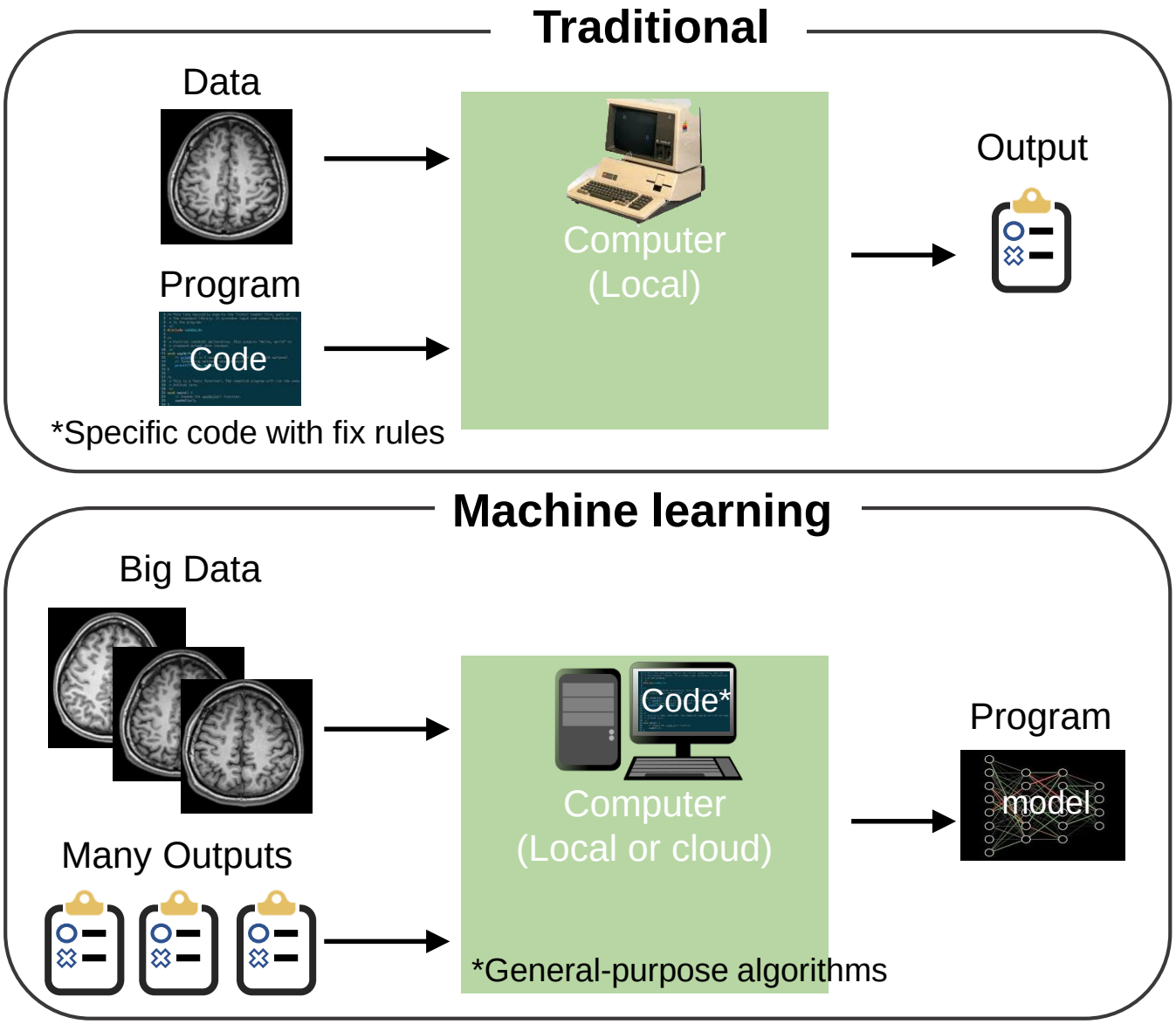
“Machine learning refers to a system capable of the autonomous acquisition and integration of knowledge.”

MAGIC?

No, more like gardening

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

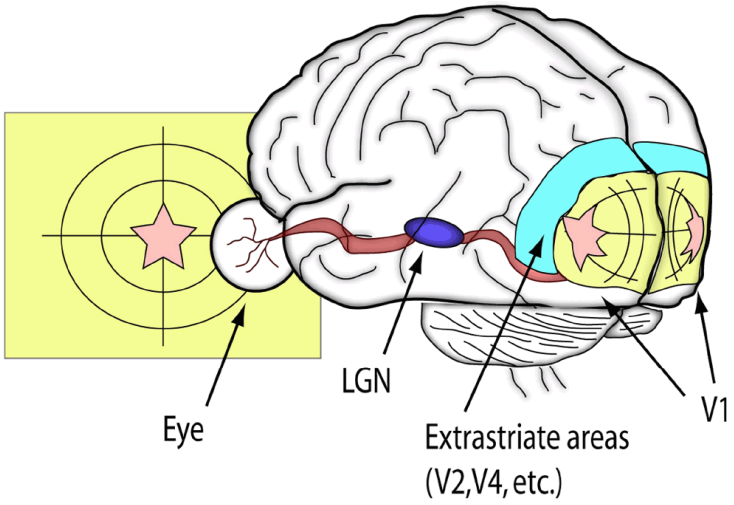
Role of computers is changing

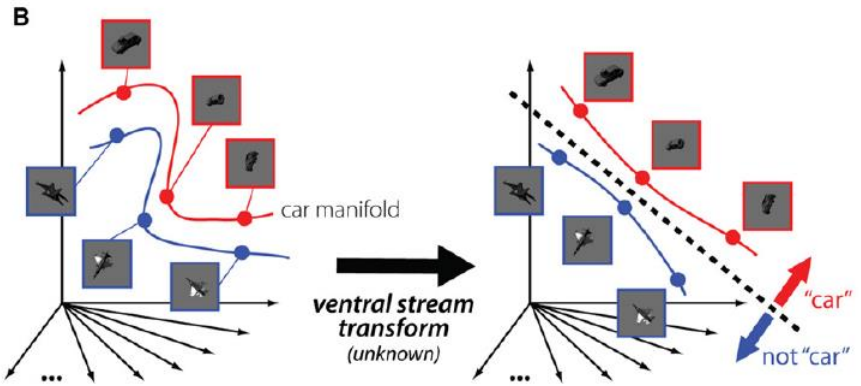


How does ML work?

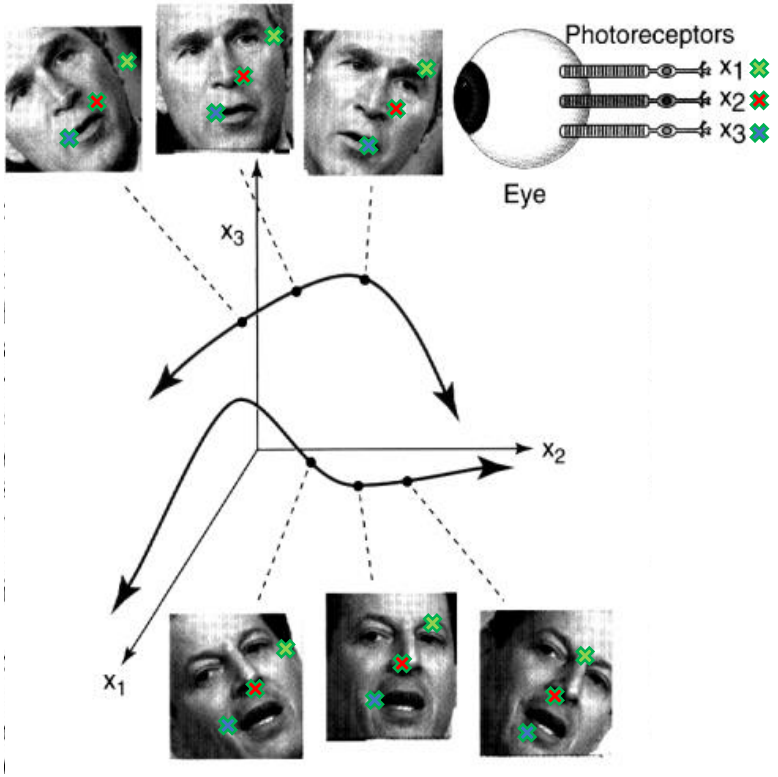
= How to design a good algorithm?

Human
~~Machine~~ learning



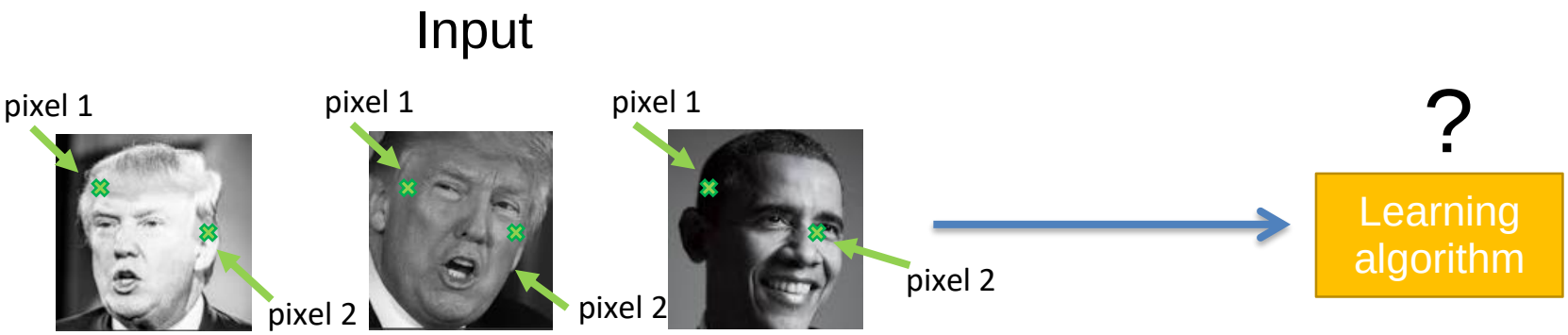


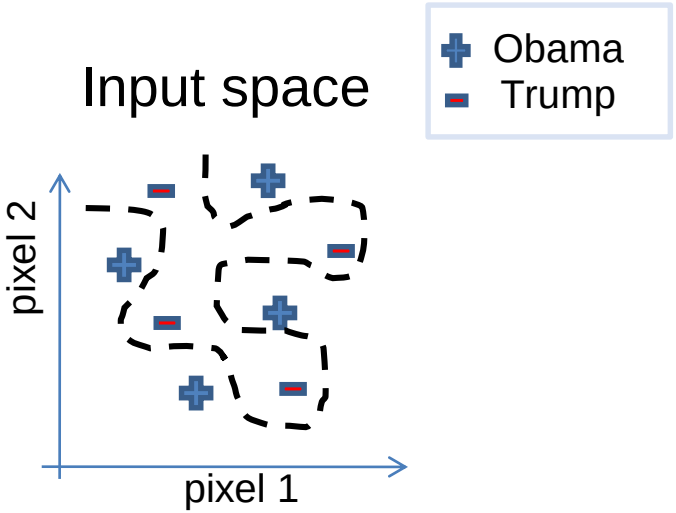
(DiCarlo et al., 2012)



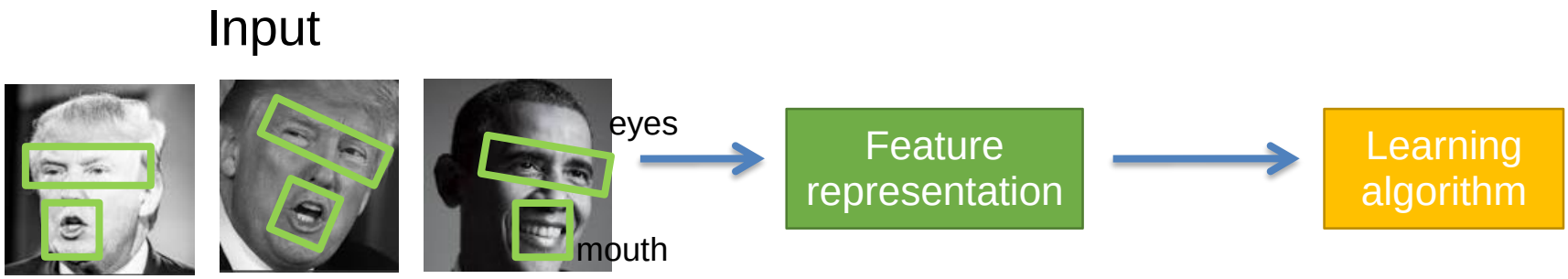
(Seung and Lee., 2000)

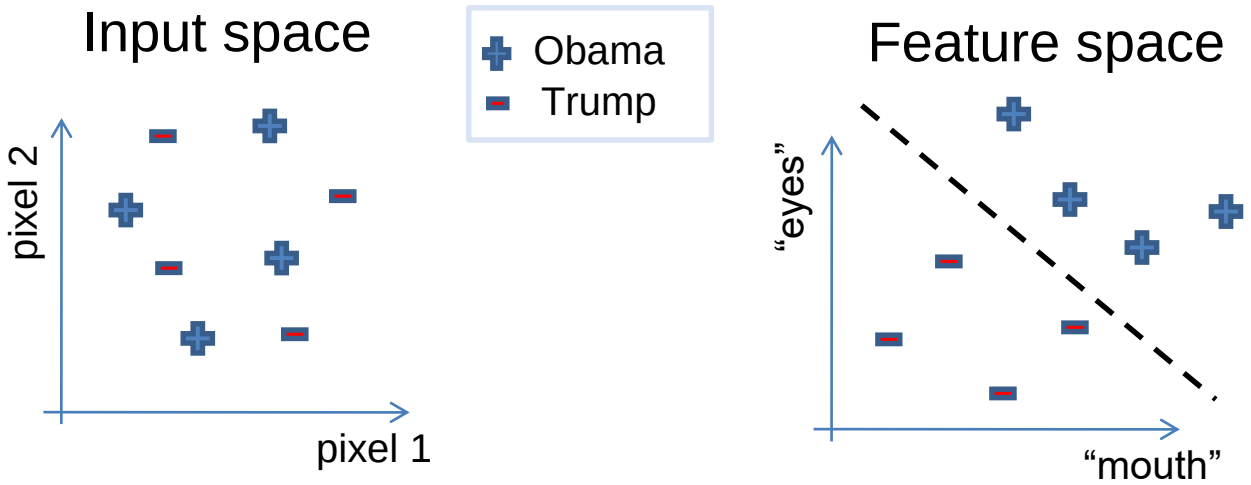
Image space


Input
pixel 1
pixel 2
pixel 1
pixel 2
pixel 1
pixel 2
?
Learning algorithm


Input space
Obama
Trump
pixel 2
pixel 1

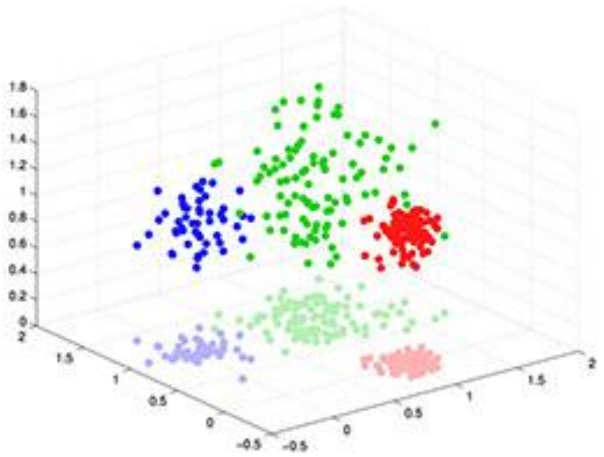
Feature representations



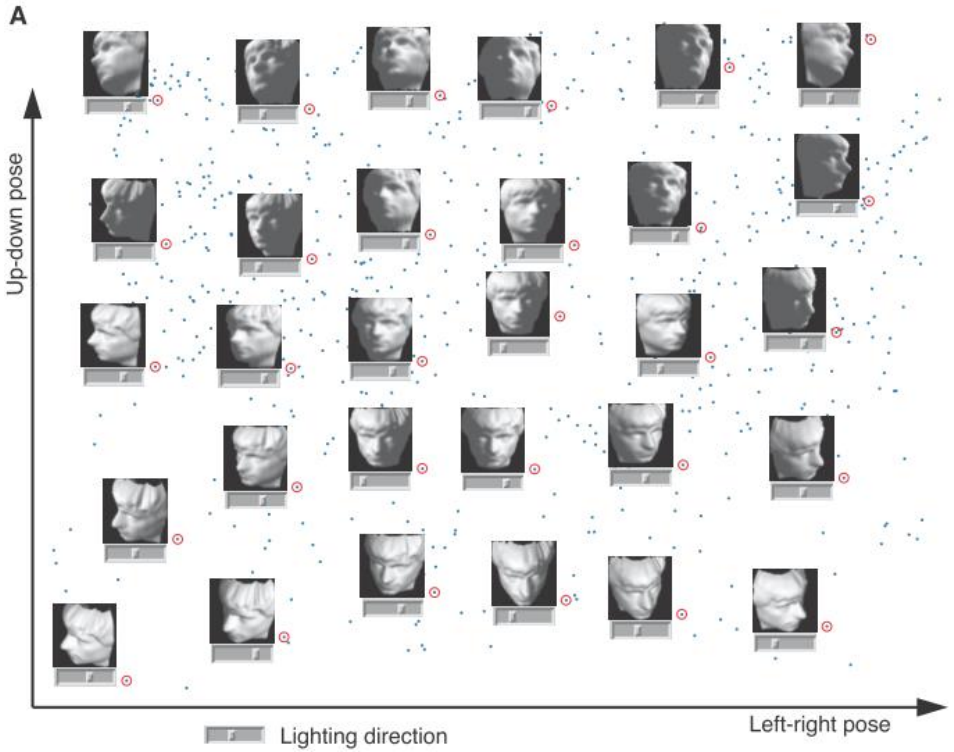


Problem of Dimension Transformation

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



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



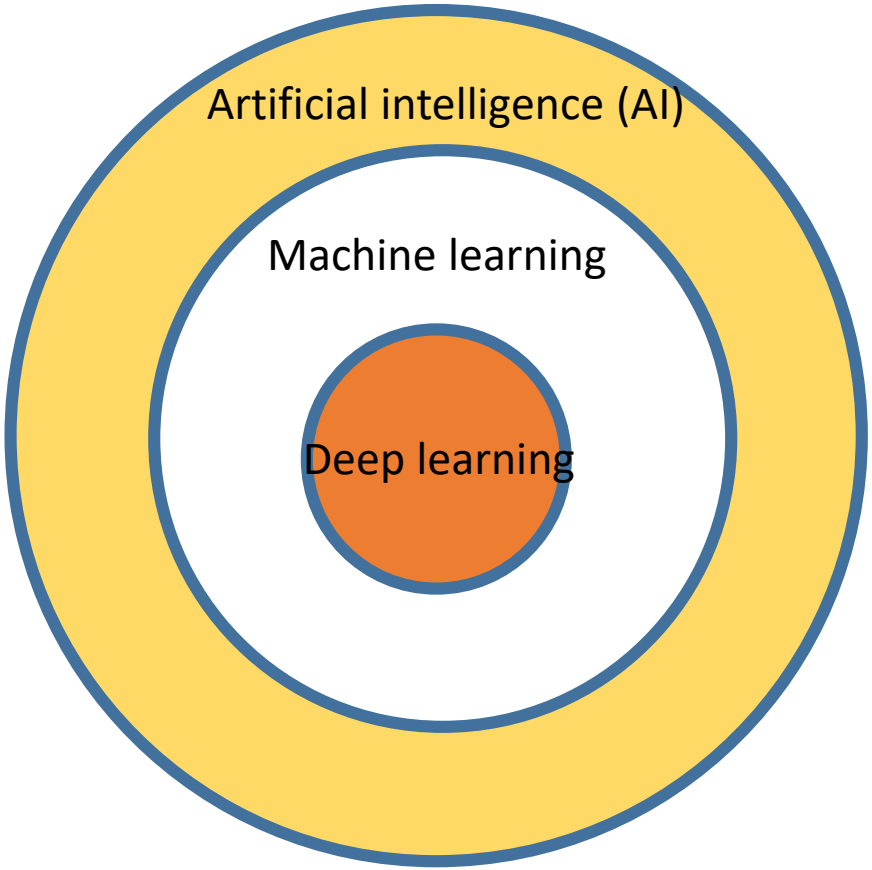
(Tenenbaum *et al.*, 2000)

How does ML work?

= How to design a good algorithm?

= How to find a good representation?

Machine learning?



A new representation!

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 of sensor readings in a nuclear power plant
- Prediction:
  - Future stock prices or currency exchange rates
  - Which movies will a person like?

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

Unsupervised Learning

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)* = Probability(*X*): Probability estimation

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

What you should know?

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

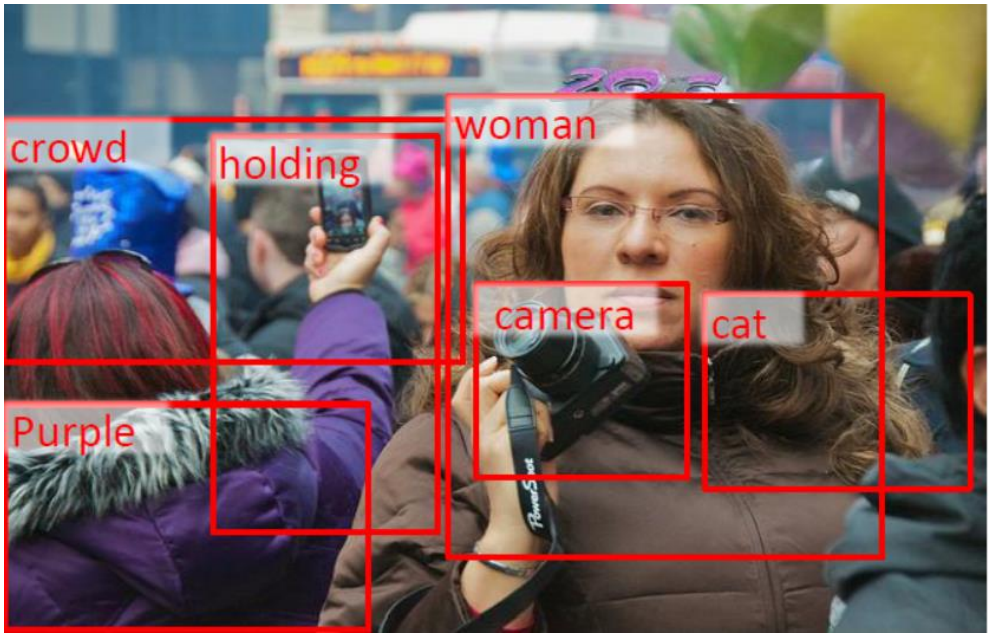
Deep learning

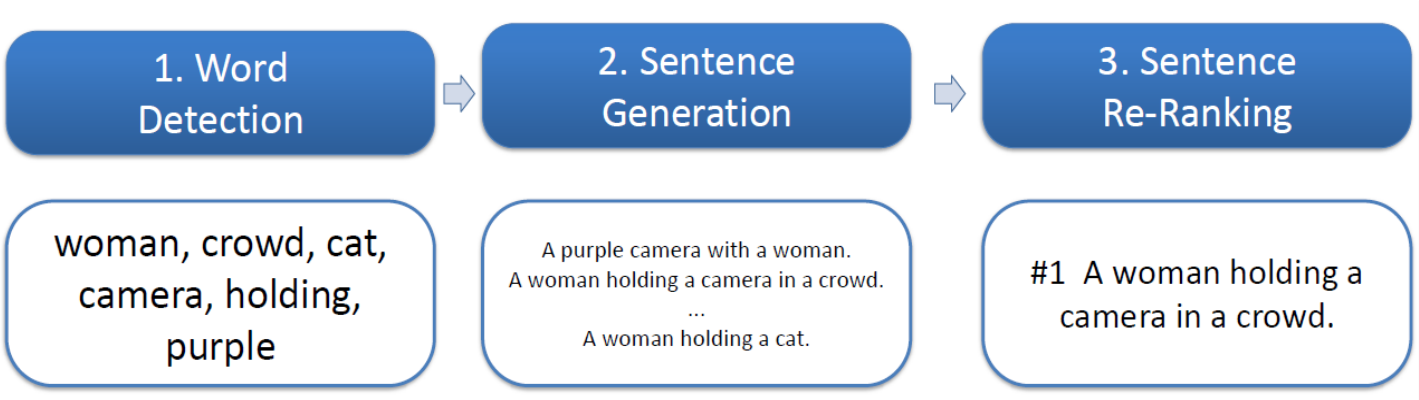
In “Nature” 27 January 2016:

- “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.”

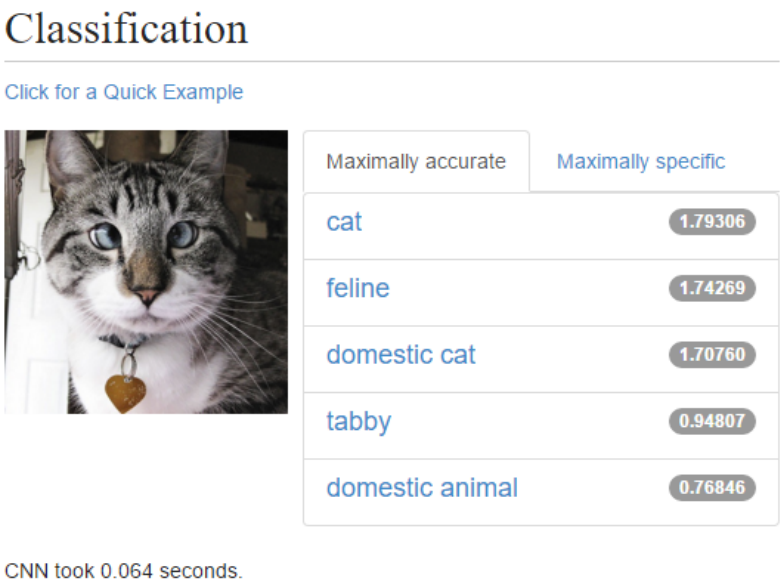
Photo Descriptions

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





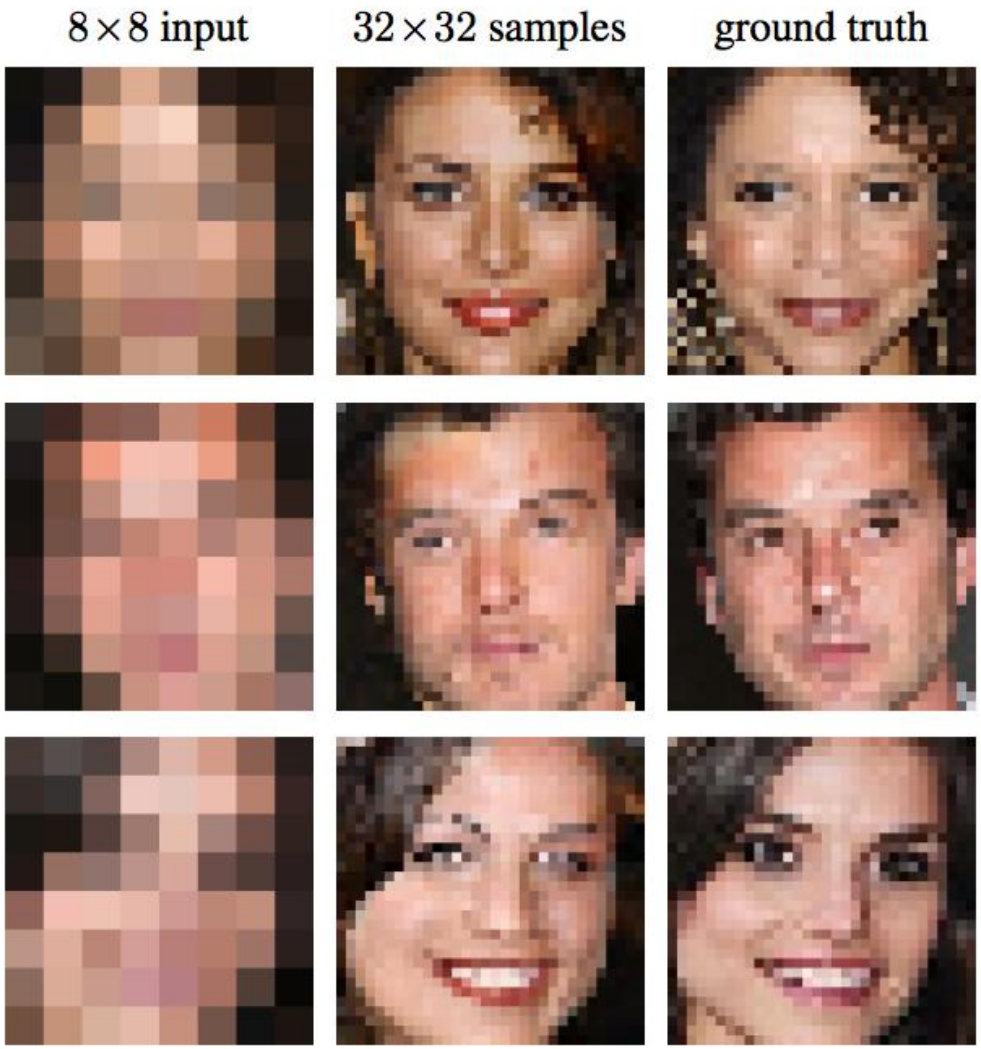
Deep CNN for Image Classification



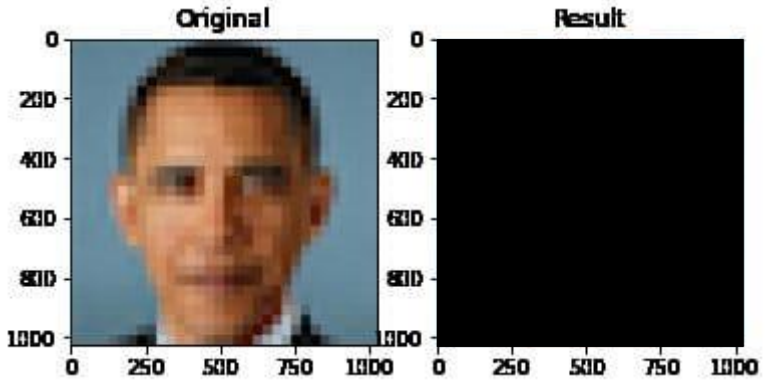

```
for pred in preds:
top_indices = pred.argsort()[-top:][::-1]
result = [tuple(CLASS_INDEX[str(i)]) + (pred[i],) for i in top_indices]
result.sort(key=lambda x: x[2], reverse=True)
results.append(result)
return results
```

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

Pixel Restoration (Google Brain)



However,

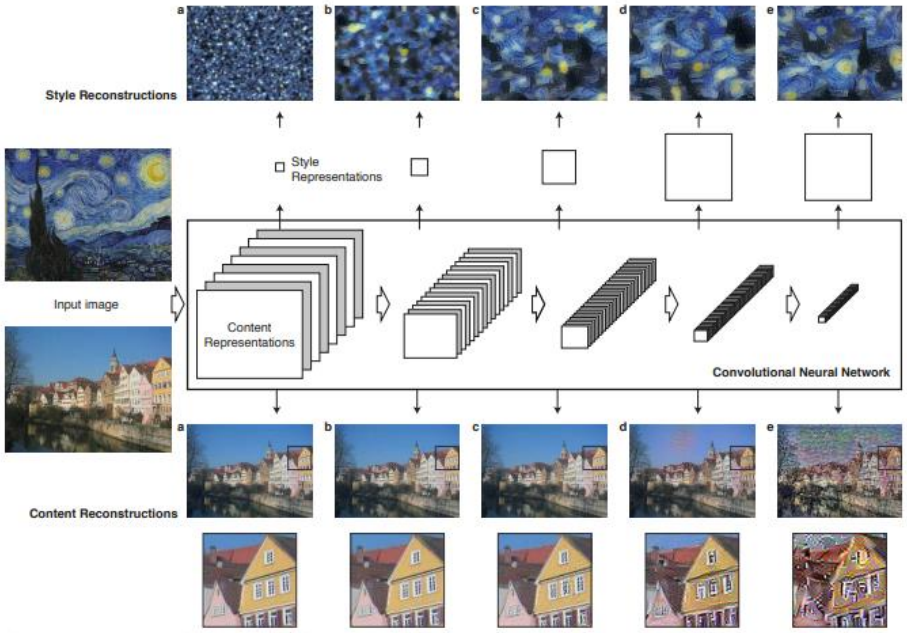


https://github.com/tg-bomze/Face-Depixelizer?fbclid=IwAR2T0XRJMFMS-FjofeSVxz8zguoKj_j2Wy2KXCzljuv80c1YjzuJBe4eesA

Colorization of Black and White Images (Zhang, 2016)

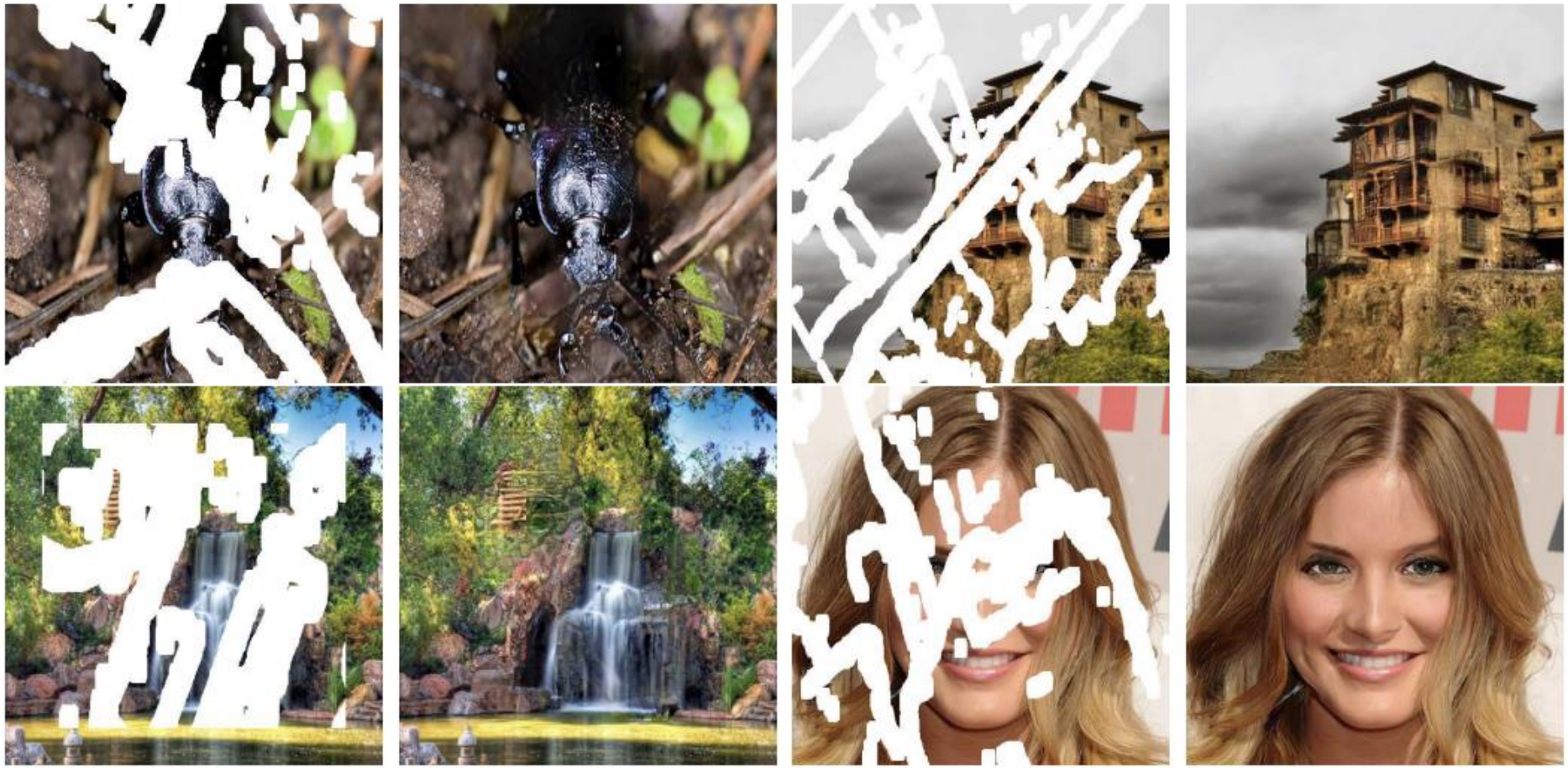
100 year old pictures...

Style Transfer



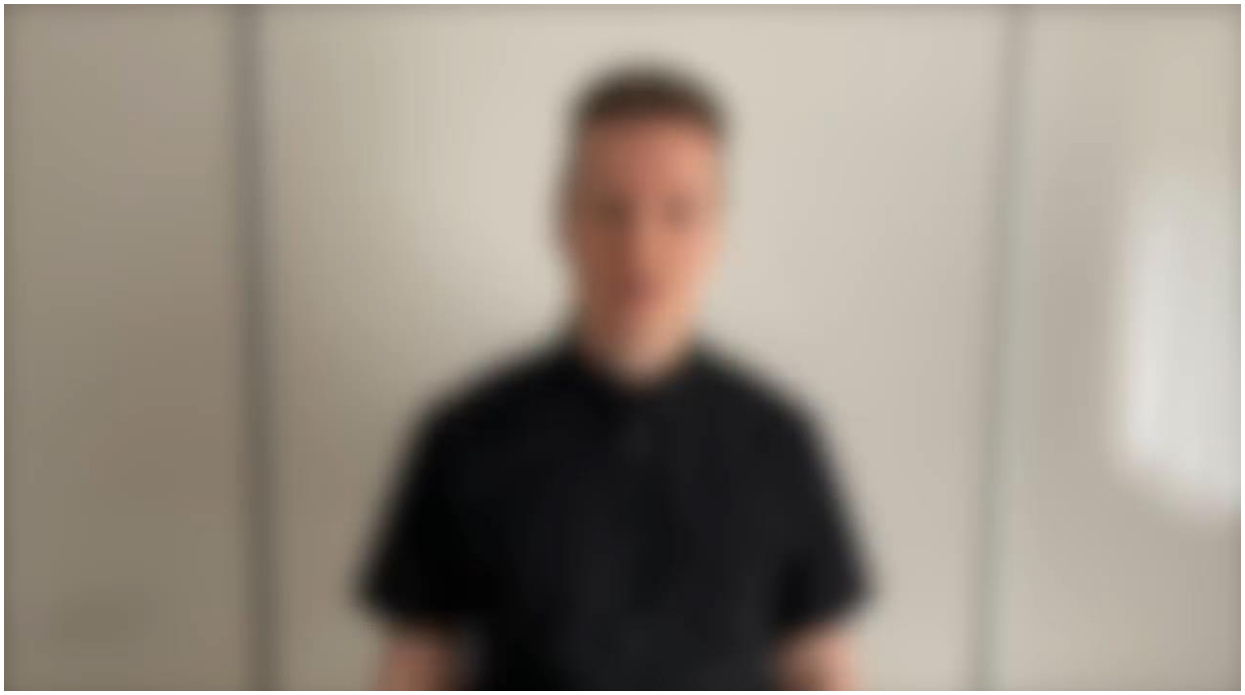
(Gatys et al., 2015)

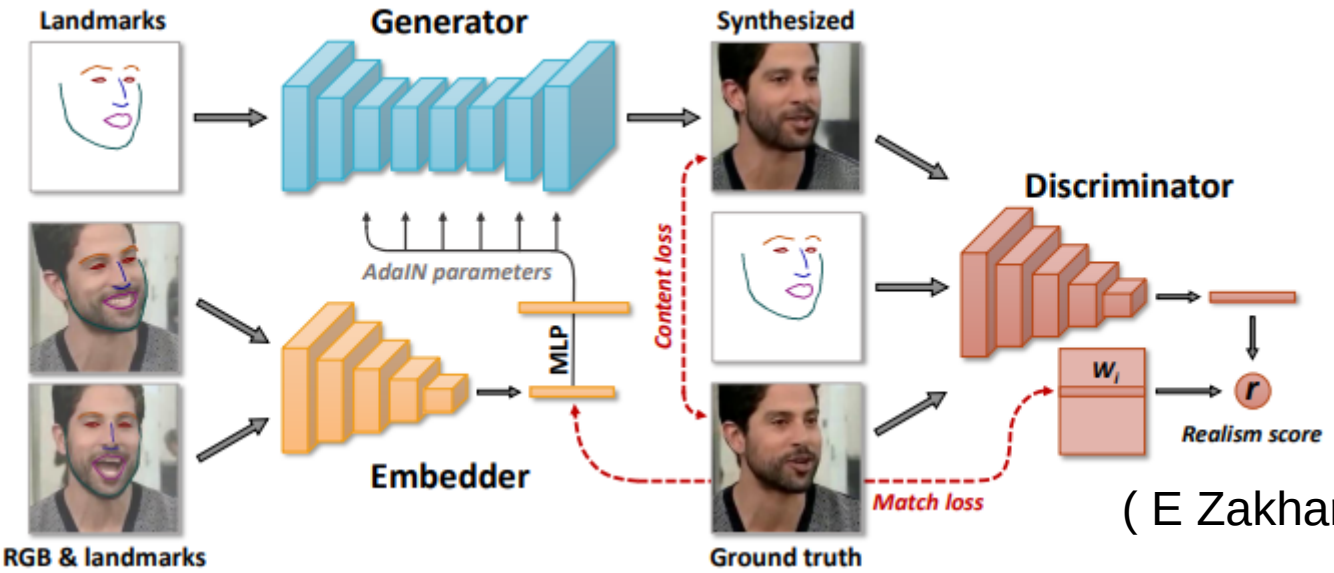
Image Reconstruction (van den Oord, 2016)



Lip Reading

Fake video



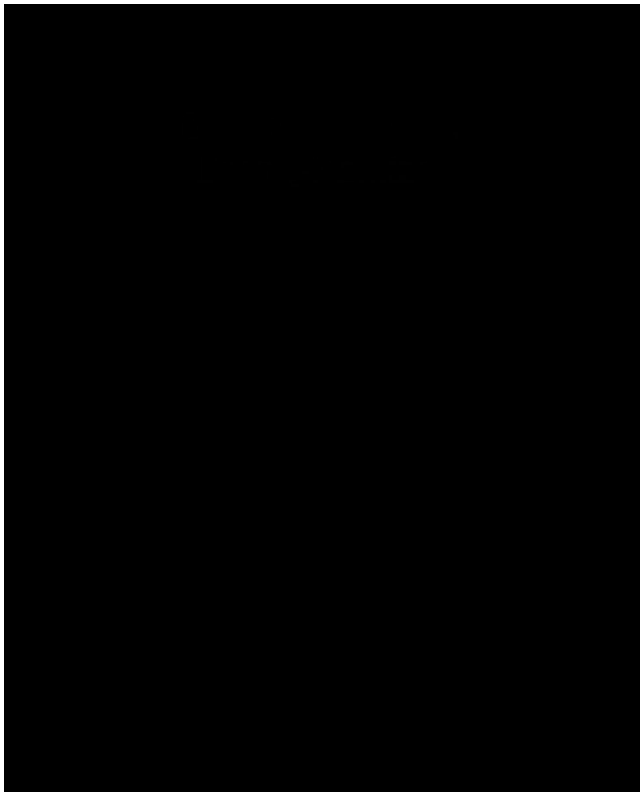


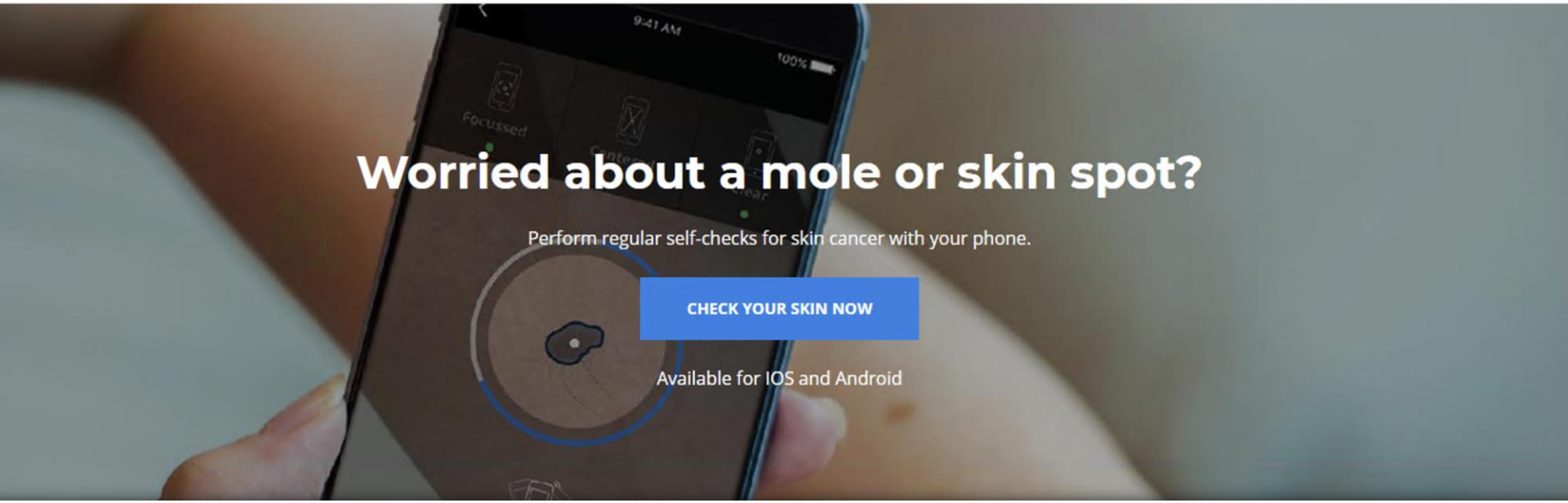
(E Zakharov · 2019)

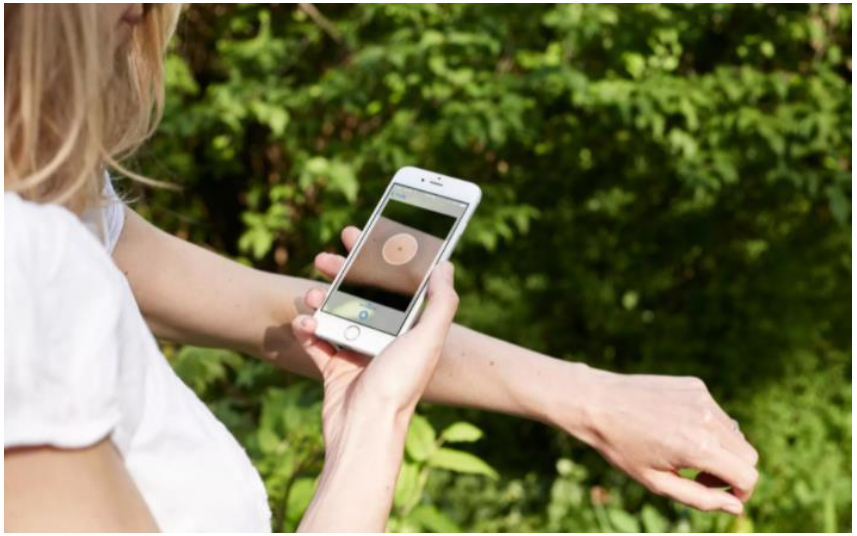
Can you spot the deepfake video?

https://moondisaster.org/film

Machines Play Machines




SkinVision
SkinVision Service
For doctors
Skin Cancer Information
Stories
Partners
Blog
Try SkinVision
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]

zebra MEDICAL.VISION

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

CS

UNIVERSITY OF CAMBRIDGE

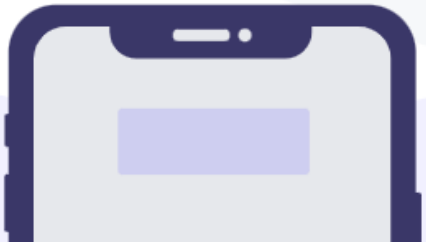
COVID-19 Sounds App

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.

GET IT ON Google Play

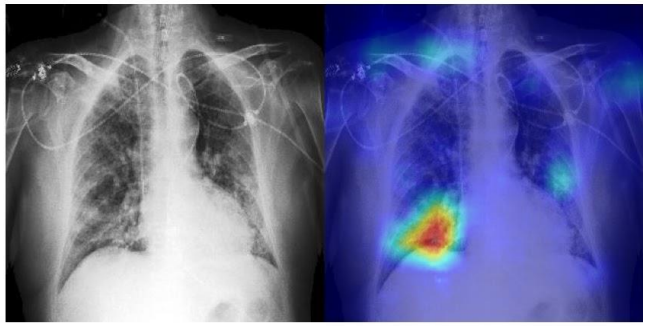
Download on the App Store

or use the **online form**

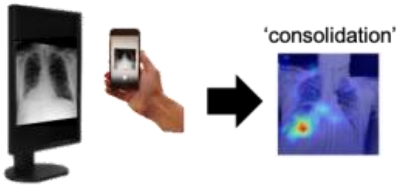


What about our LAB ?

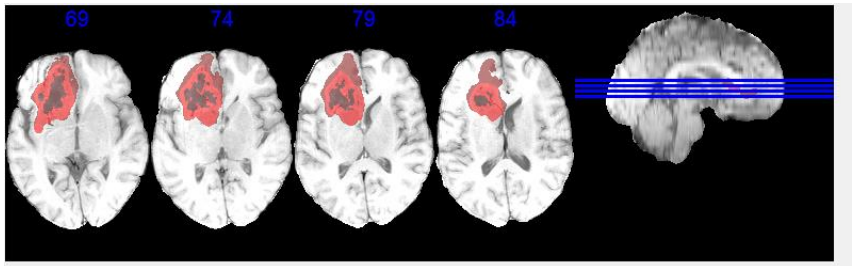
Chest X-ray interpretation

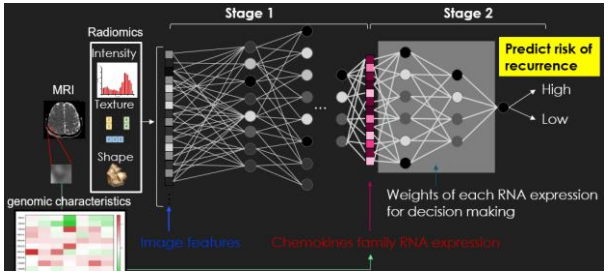


Smartphone-based detection in CXR

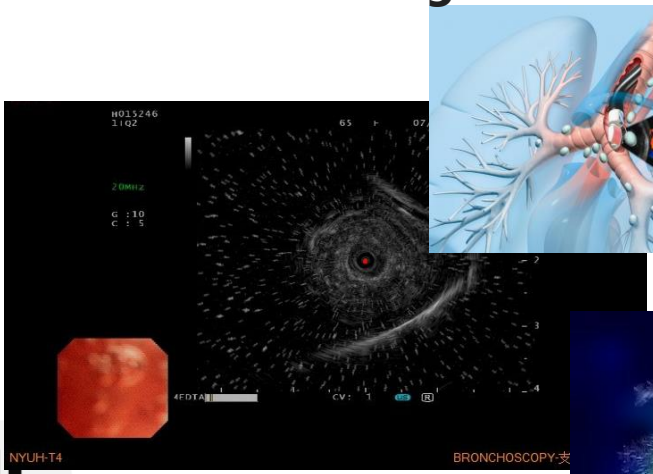


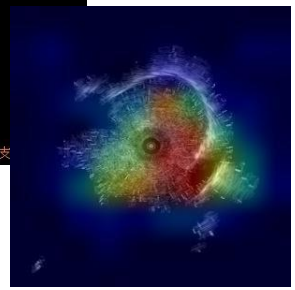
Brian tumor segmentation





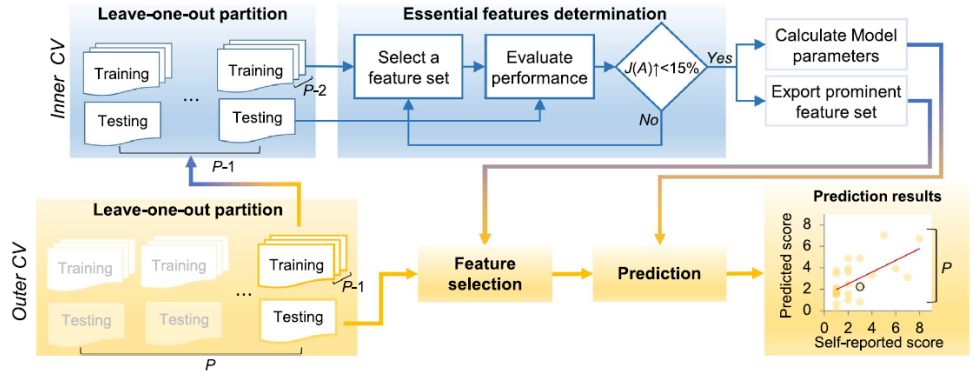
Malignant classification in ultrasound image





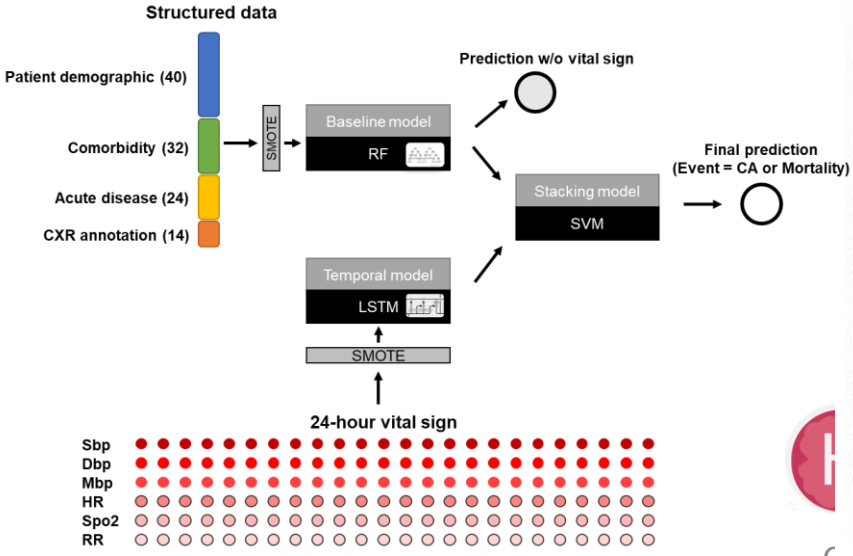
In Intensive Care Unit (ICU)

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 ano -one-out partitioning for sequential forward search.

Cardiac arrest prediction



Tachycardia detection device

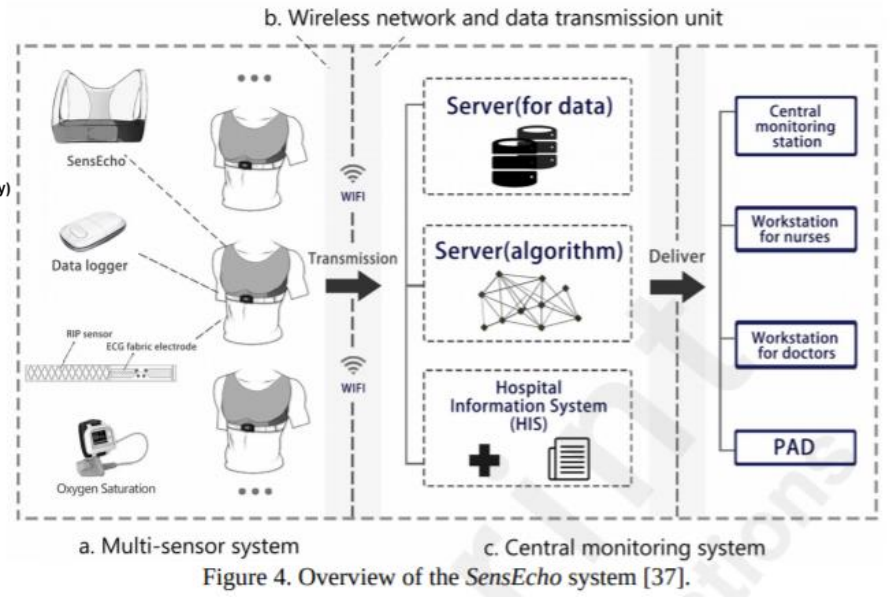
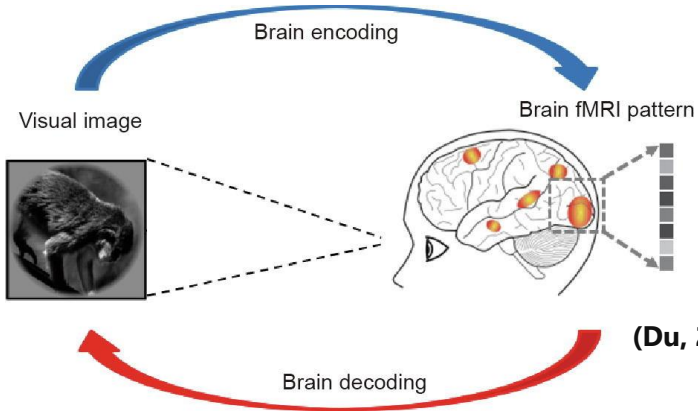
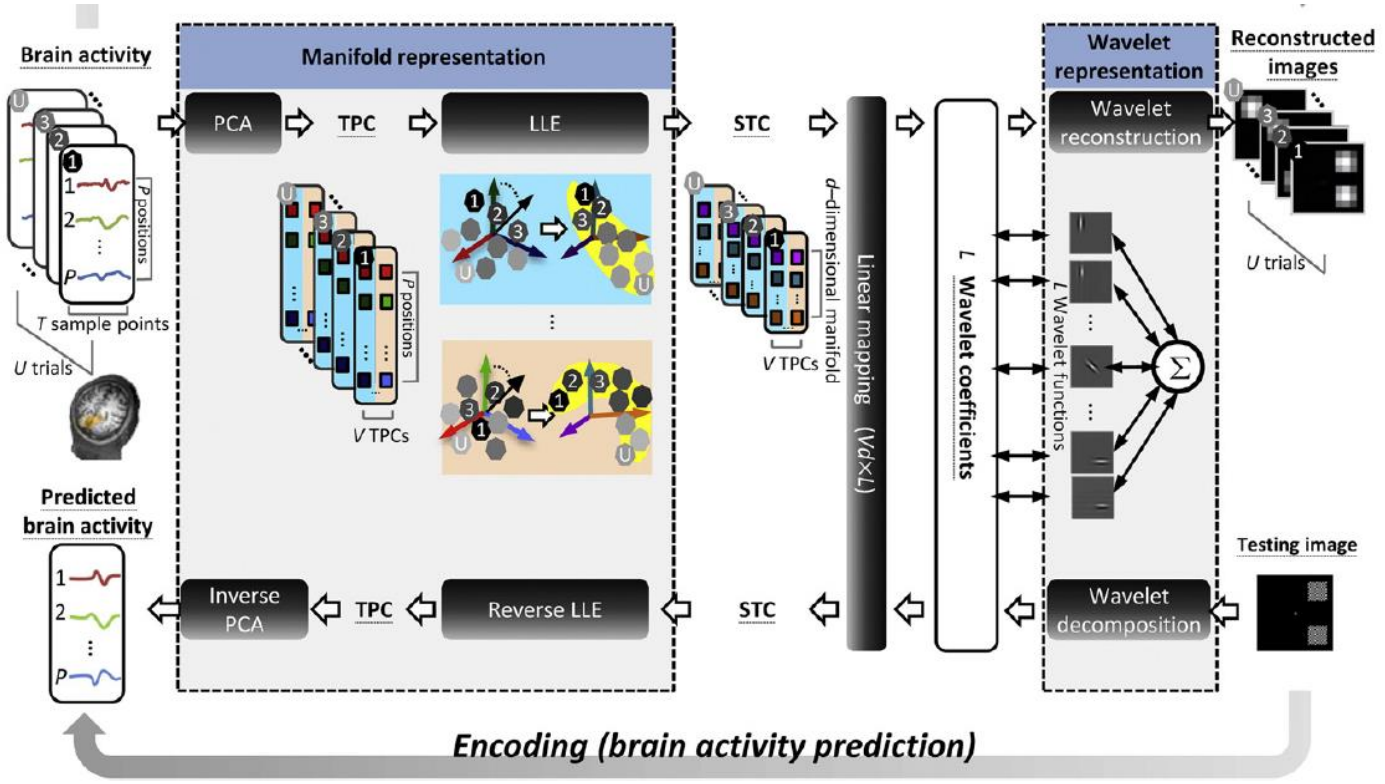


Figure 4. Overview of the *SensEcho* system [37].

Decoding and Encoding in Human Brain

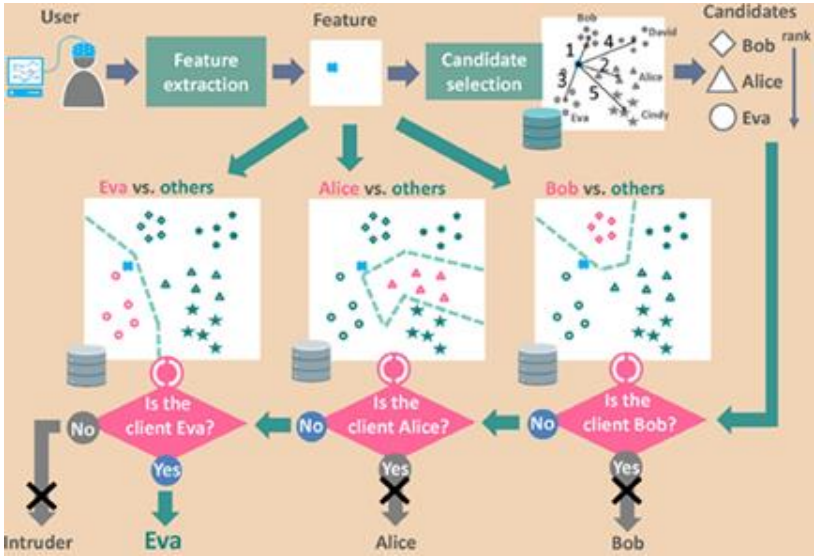


(Du, 2019)

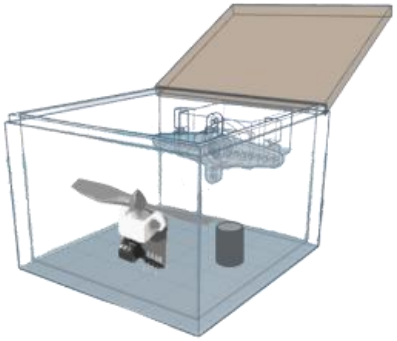


(Kuo, 2014)

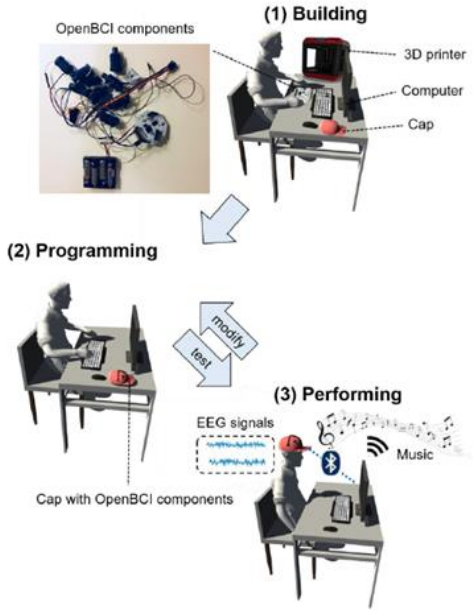
EEG-Based Biometrics



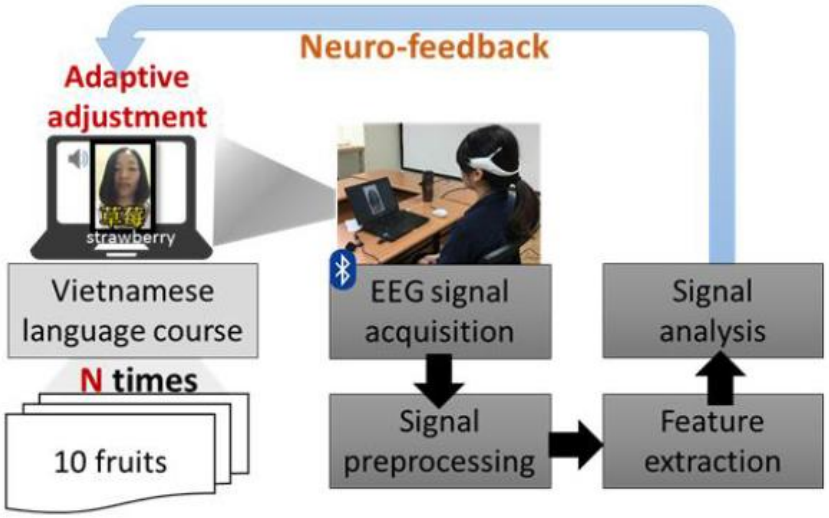
Brain-sensing fragrance diffuser



DIY Brain computer interface



ML-based E-learning System



https://pochihkuo.github.io/

HMI

HOME ABOUT PEOPLE RESEARCH PHOTO COLLABORATOR

Paper accepted!

July 7, 2021

Our paper has been accepted for presentation at IEEE International Conference on Human-Machine Systems (ICHMS) 2021. TITLE: A brain-sensing fragrance diffuser for mental state regulation using electroencephalography AUTHORS: An-Yu Zhuang, Yang Chen Lin, Shang-Lin Yu

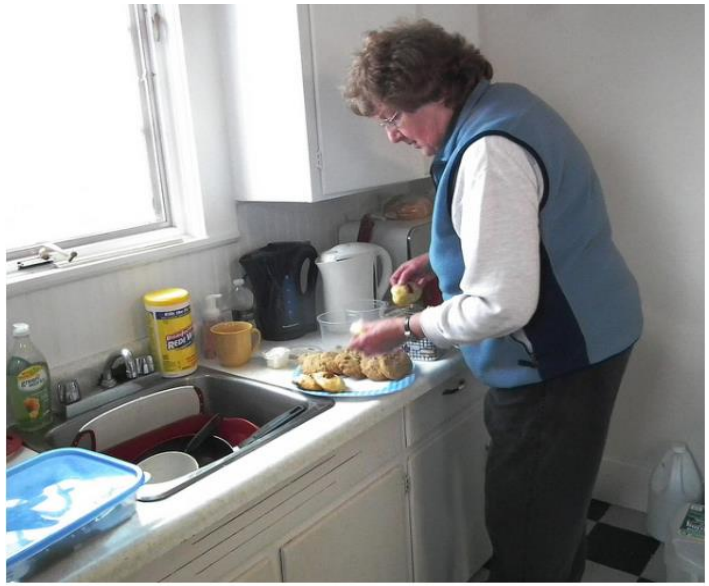
READ MORE

ABOUT THIS SITE

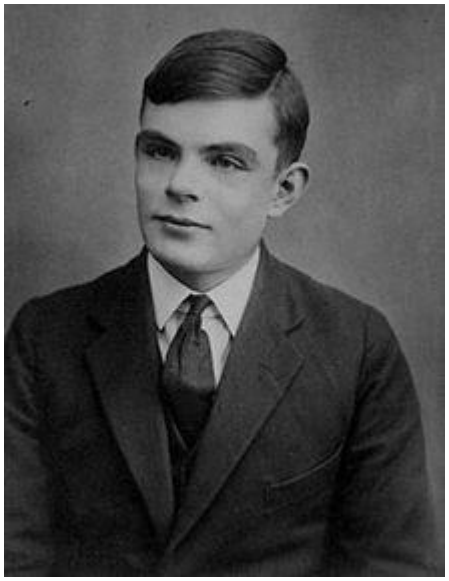
We believe that AI system is to enhance and support humans rather than replace them.

Search …

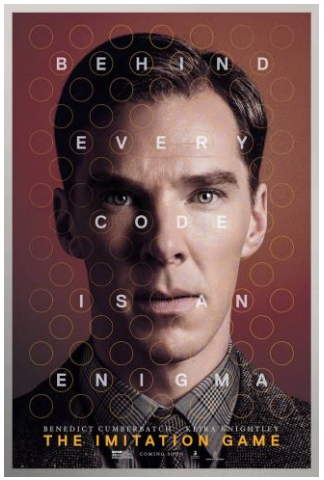
Turing Test

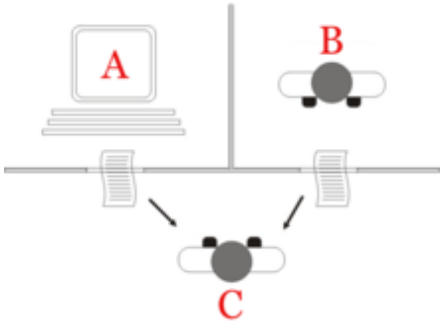


A	a woman in a kitchen preparing food
B	woman working on counter near kitchen sink preparing a meal



Alan Mathison Turing





Questions?


Beginning of the course
Other Computer Vision Tasks
Semantic Segmentation
Classification + Localization
Object Detection
Instance Segmentation
GRASS, CAT, TREE, SKY
CAT
DOG, DOG, CAT
DOG, DOG, CAT
No objects, just pixels
Single Object
Multiple Object
End of the course
After becoming an expert
Hmm! It makes sense