LONDON METROPOLITAN UNIVERSITY

Machine Learning CS7052 Lecture 1

Dr. Elaheh Homayounvala

Autumn, 2023-2024, week 1

Outline of today's lecture

- About me
- About you
- About the Machine Learning (ML) module
  - VLE (Weblearn)
  - Assessment
  - Content

About me

- My name is Dr. Elaheh Homayounvala

- I am a PhD graduate of

  King’s College London

  University of London

About me

- teaching experience in HE
- doing research

About me

Research interests:

- How technology can be adapted to the needs and preferences of users?
- User Modeling and Personalisation
- Machine Learning
- Artificial Intelligence
- Technology Acceptance and more

About you

- Your background?
- Your first degree?
- Any work experience?
- Your current course at London Met?
- Why this course?
- Your motivations and goals?

About the ML module

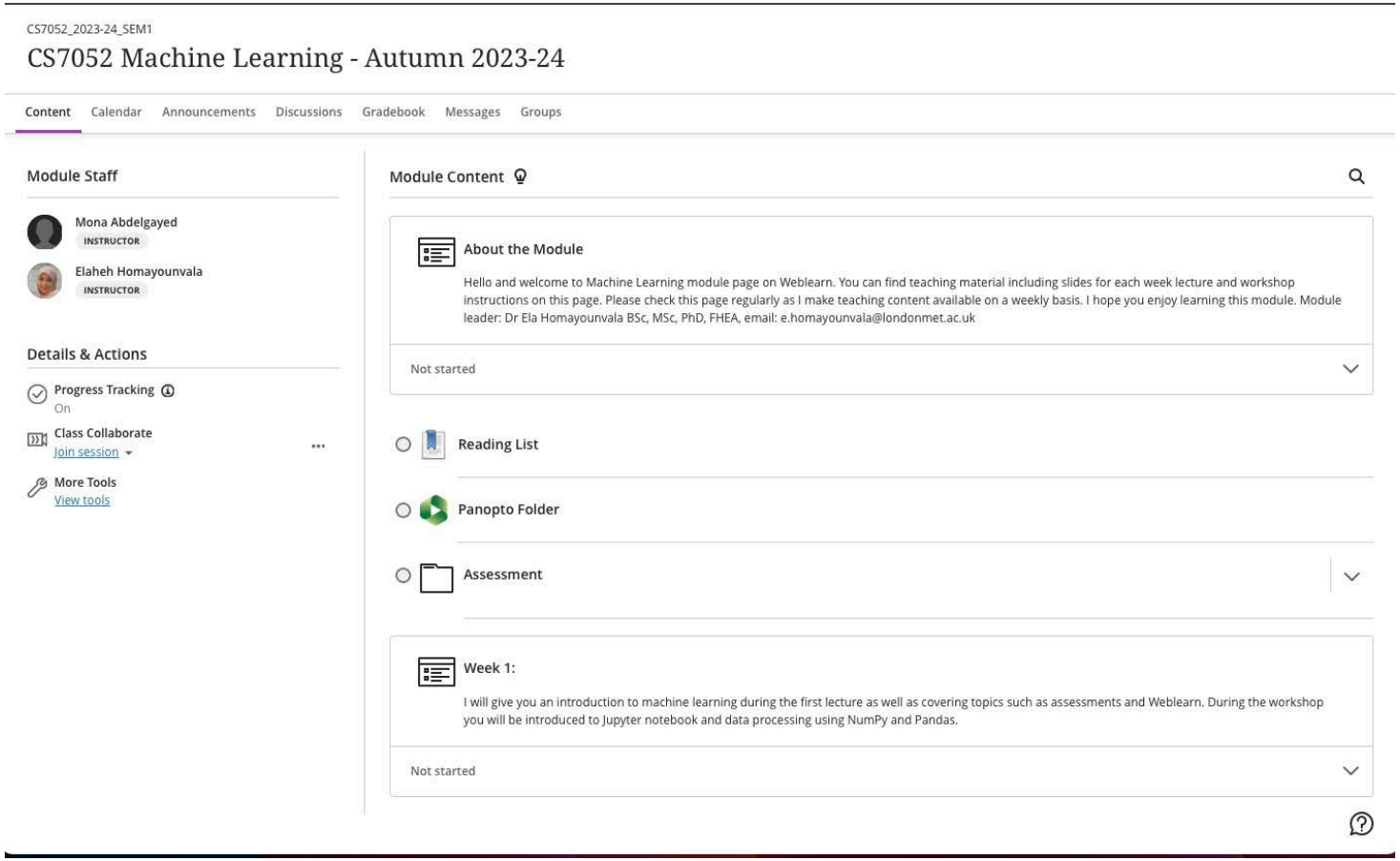
- Timing of lectures and workshops
- VLE, Weblearn
- Reading list
- Assessment

About the ML module, timing

- Lectures Wed 9-11am
- Workshops Wed 11-13pm
  - Jupyter notebooks
  - Python, numpy, pandas, sklearn, matplotlib and more
  - Lots of examples and materials on the web (e.g. Kaggle, scikit-learn, ...)

About the ML Module

- Module page on the VLE
- Weblearn tour



About the module, Assessment

- Coursework, 60%, week 11
- Exam, 40%, week 14-15

Coursework

- The coursework focuses on applying a machine learning technique and doing data analysis, writing report and presenting results
- The students are divided in groups of two
- The coursework must be submitted by the end of week 11

Coursework

- Each group is required to select one topic

- The group is expected to:
  - research into the selected topic
  - provide examples of how the technique can be used
  - provide a data driven example
  - write a report
  - present their research to other students

Exam

The examination will test

- Your retention
- an understanding and insight drawn

from the entire course.

- You will answer general questions
- and more detailed questions related to specific ML techniques, including analysis of data and results

About the module, Intro to ML

- What we'll cover in this module
- What is Machine Learning?
- When do we use ML?
- Some applications of ML
- States of the art applications of ML
- Types of learning

What we'll cover in this module

Supervised learning

- Classification and Regression
- K-Nearest Neighbours (KNN)
- Linear Models for Classification and Regression
- Decision Trees
- Neural Networks
- Deep Learning

Unsupervised learning

- Clustering
- Dimensionality reduction
- Feature Extraction
- PCA

- Essential Libraries and Tools
- Model Evaluation and Improvement, Cross Validation
- Legal and ethical issues related to ML
- Linguistic Models, working with text data

and more …

What is ML?

- Arthur Samuel (1959)

" ... gives computers the ability to learn without being explicitly programmed

- Tom Mitchell (90s)

"the study of computer algorithms that improve automatically through experience"

What is Machine Learning?

"Learning is any process by which a system improves performance from experience."

- Herbert Simon

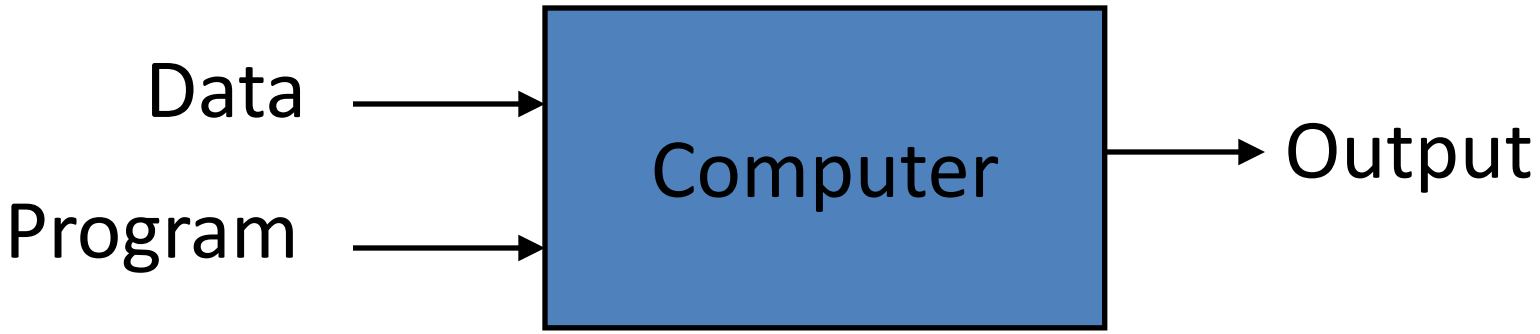
Definition by Tom Mitchell (1998):

Machine Learning is the study of algorithms that

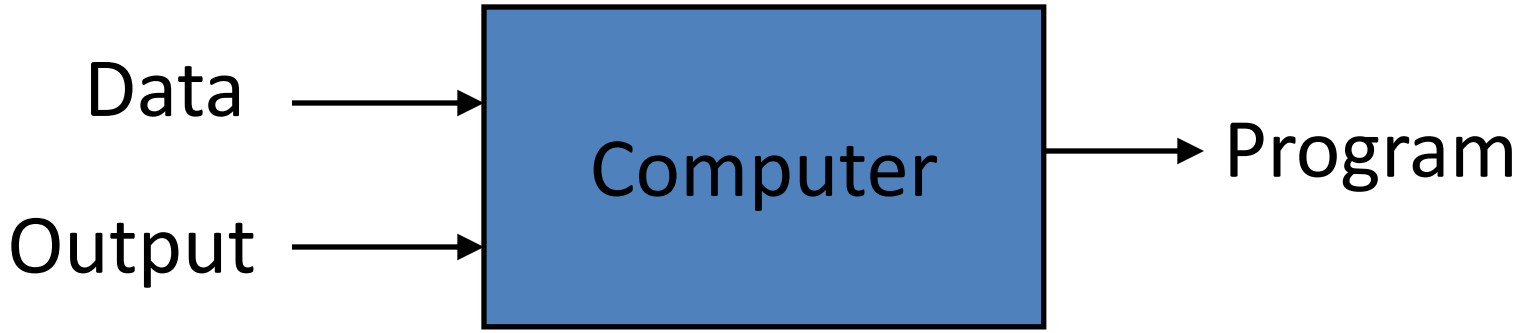
- improve their performance P
- at some task T
- with experience E.

A well-defined learning task is given by <P, T, E>.

Traditional Programming



Machine Learning



Example 1

- A house price prediction ML program that predicts the price of a house based on data related to recently sold houses

Can you identify

- T
- E
- And P
- In this example

Example 2

- An email ML program that learns how to filter spam according to emails you do or do not mark spam
- Can you identify
- T
- E
- And P
- In this example

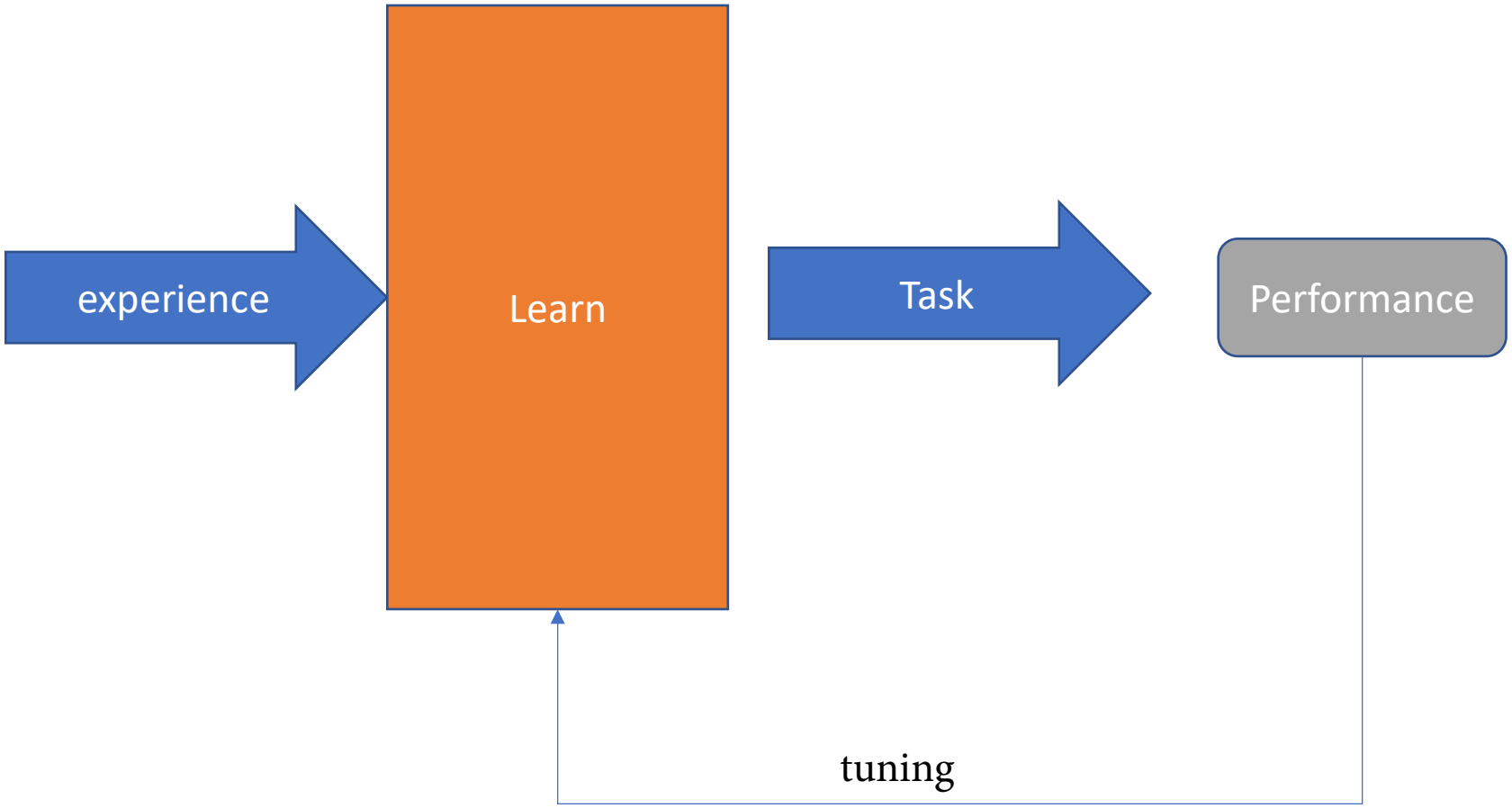
Example 3

- A loan approval ML program for a bank or a lender that approves or denies applicants' loan requests

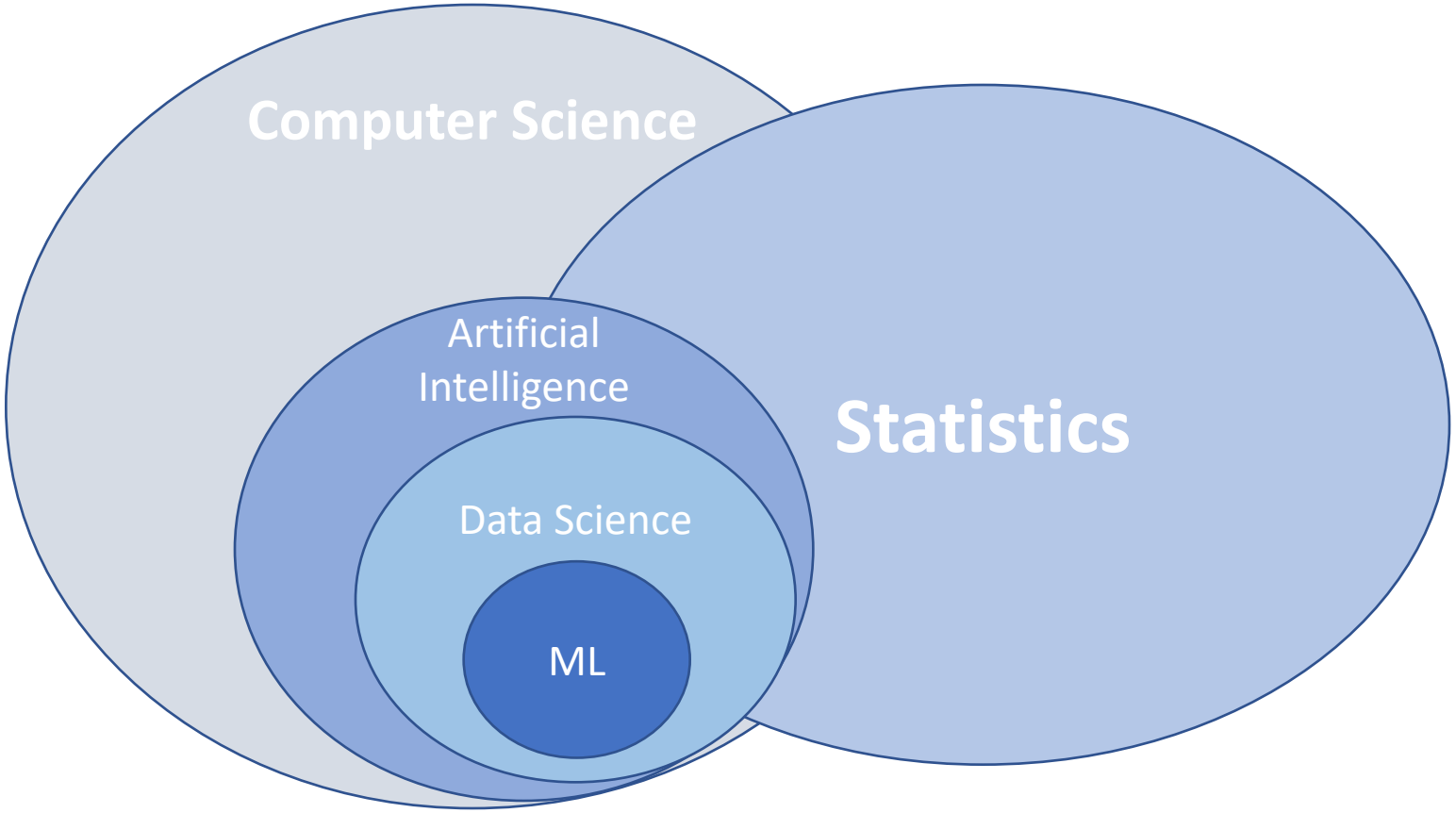
Can you identify

- T
- E
- And P
- In this example

What is ML?



ML and Artificial Intelligence



When do we use Machine Learning?

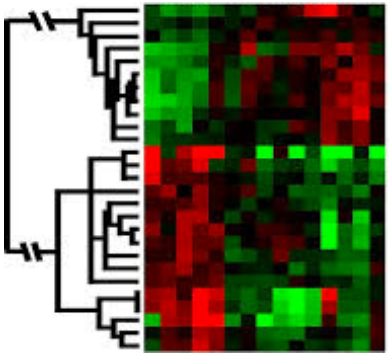
- A pattern exists
- We do not know it mathematically
- We have data on it

When Do We Use Machine Learning?

ML is used when:

- Human expertise does not exist (navigating on Mars)
- Humans can't explain their expertise (speech recognition)
- Models must be customized (personalized medicine)
- Models are based on huge amounts of data (genomics)



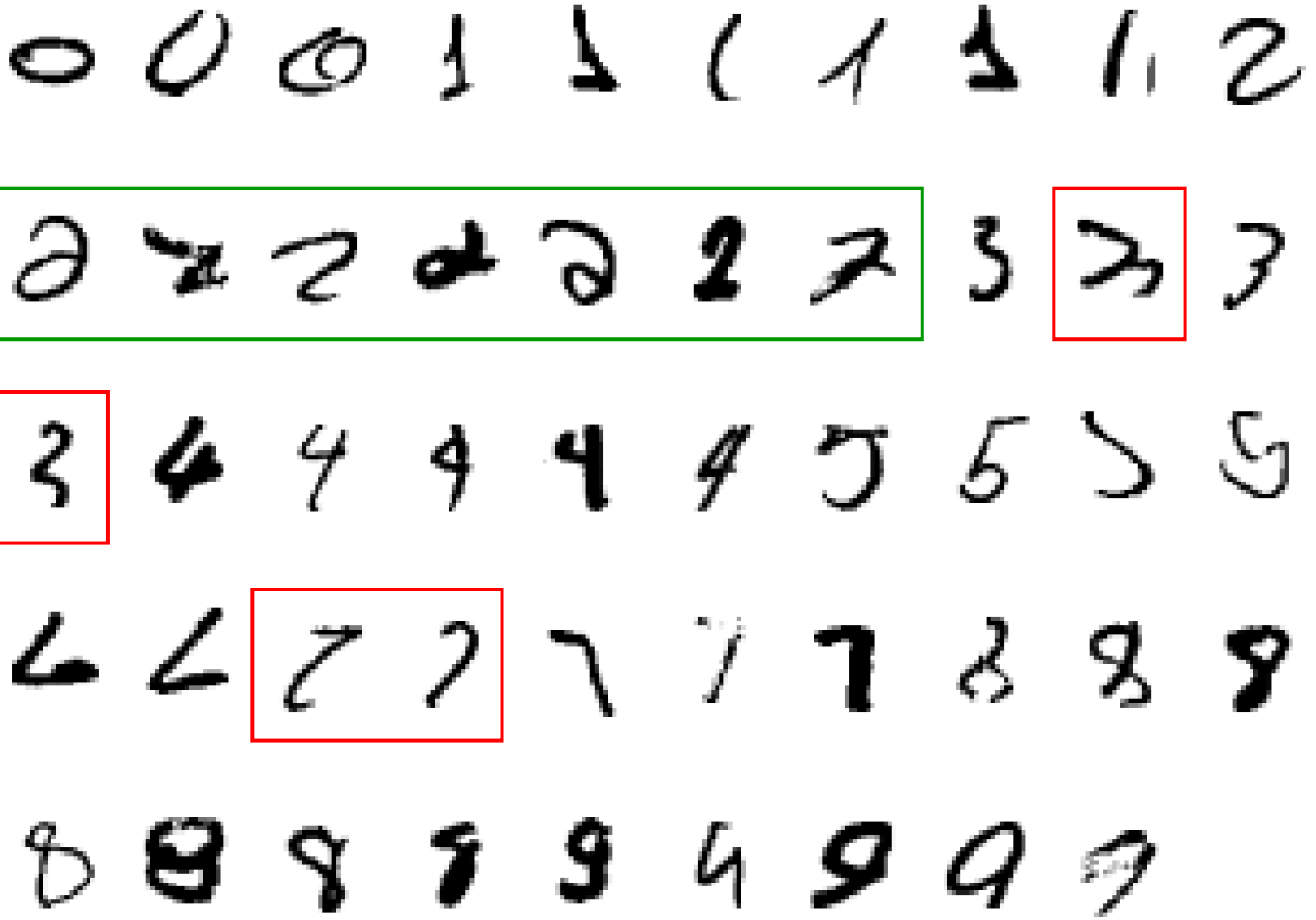



Learning isn't always useful:

- There is no need to "learn" to calculate payroll

A classic example of a task that requires machine learning:

It is very hard to say what makes a 2



Some more examples of tasks that are best solved by using a learning algorithm

- Recognizing patterns:
  - Facial identities or facial expressions
  - Handwritten or spoken words
  - Medical images
- Generating patterns:
  - Generating images or motion sequences
- Recognizing anomalies:
  - Unusual credit card transactions
  - Unusual patterns of sensor readings in a nuclear power plant
- Prediction:
  - Future stock prices or currency exchange rates

Sample Applications

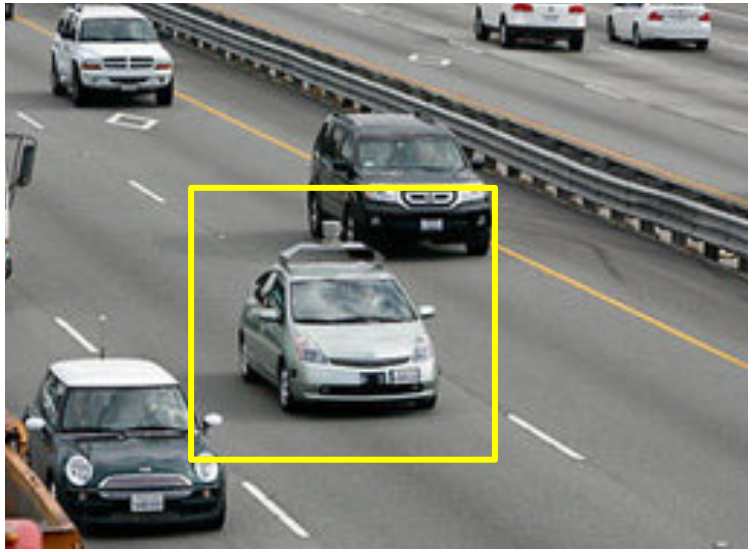
- Web search
- Computational biology
- Finance
- E-commerce
- Space exploration
- Robotics
- Information extraction
- Social networks
- Debugging software
- [Your favorite area]

Samuel's Checkers-Player

"Machine Learning: Field of study that gives computers the ability to learn without being explicitly programmed." -Arthur Samuel (1959)

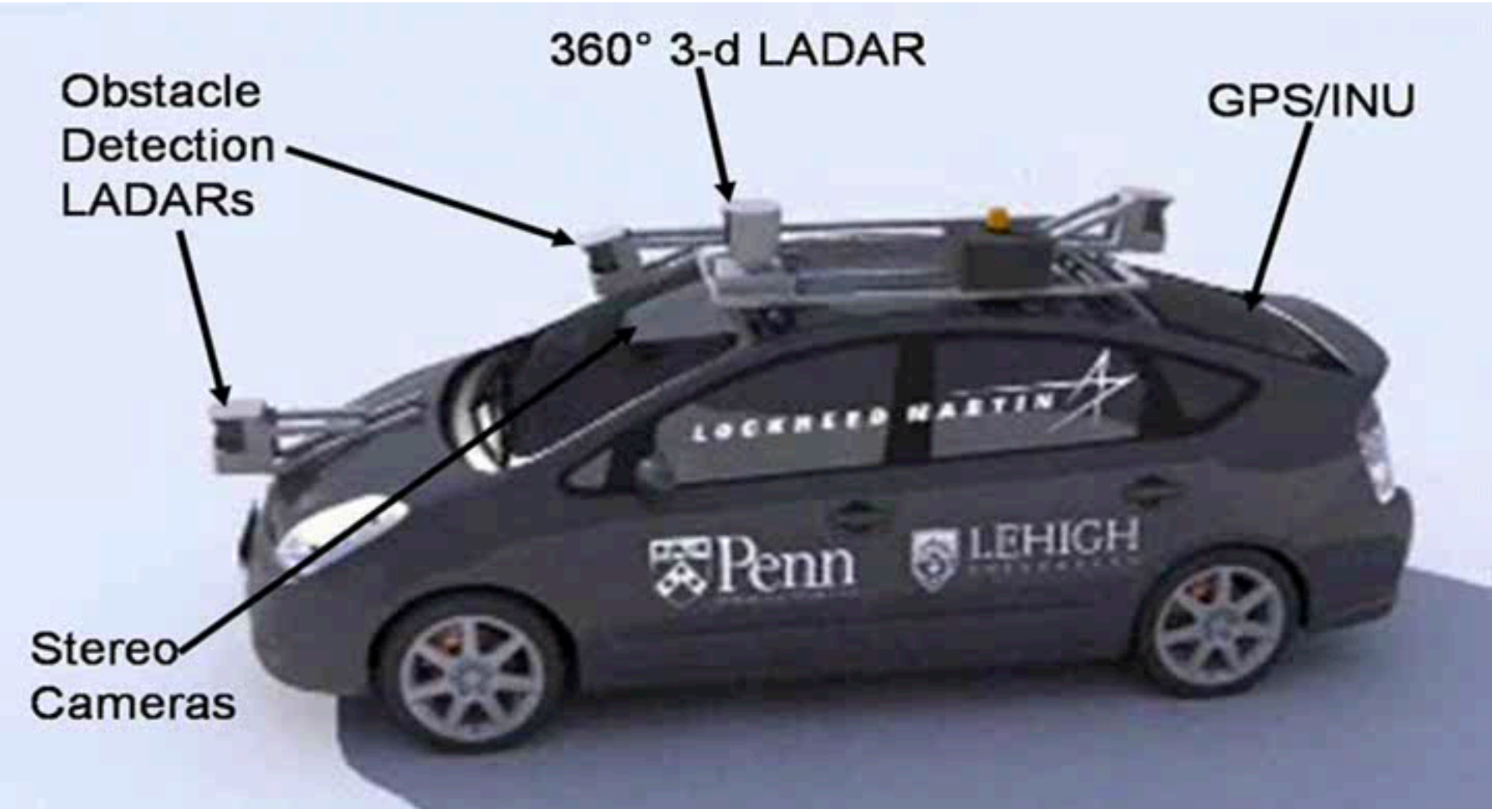
State of the Art Applications of Machine Learning

Autonomous Cars

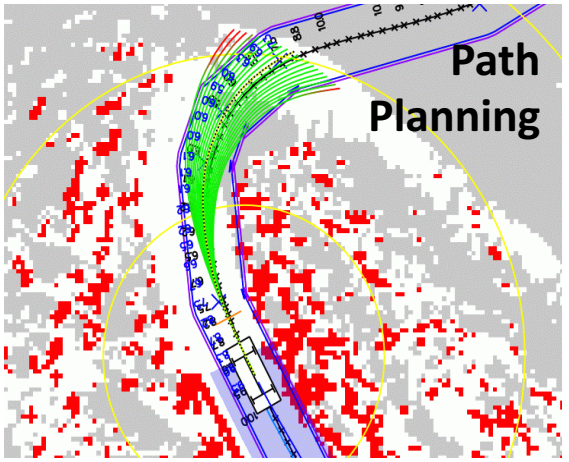


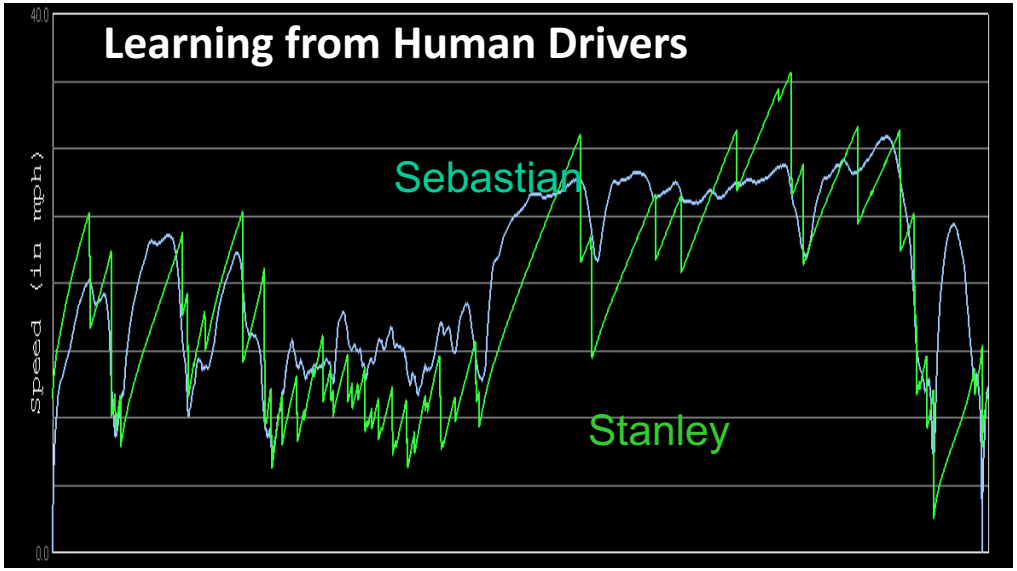
- Nevada made it legal for autonomous cars to drive on roads in June 2011
- As of 2013, four states (Nevada, Florida, California, and Michigan) have legalized autonomous cars

Autonomous Car Sensors



Autonomous Car Technology





Deep Learning in the Headlines

BUSINESS NEWS

MIT Technology Review

Is Google Cornering the Market on Deep Learning?

A cutting-edge corner of science is being wooed by Silicon Valley, to the dismay of some academics.

By Antonio Regalado on January 29, 2014

How much are a dozen deep-learning researchers worth? Apparently, more than $400 million.

This week, Google reportedly paid that much to acquire DeepMind Technologies, a startup based in

BloombergBusinessweek Technology

Acquisitions

The Race to Buy the Human Brains Behind Deep Learning Machines

By Ashlee Vance | January 27, 2014

intelligence projects. "DeepMind is bona fide in terms of its research capabilities and depth," says Peter Lee, who heads Microsoft Research.

According to Lee, Microsoft, Facebook (FB), and Google find themselves in a battle for deep learning talent. Microsoft has gone from four full-time deep learning experts to 70 in the past three years. "We would have more if the talent was there to

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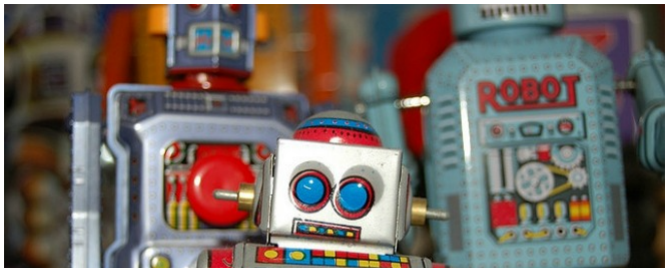
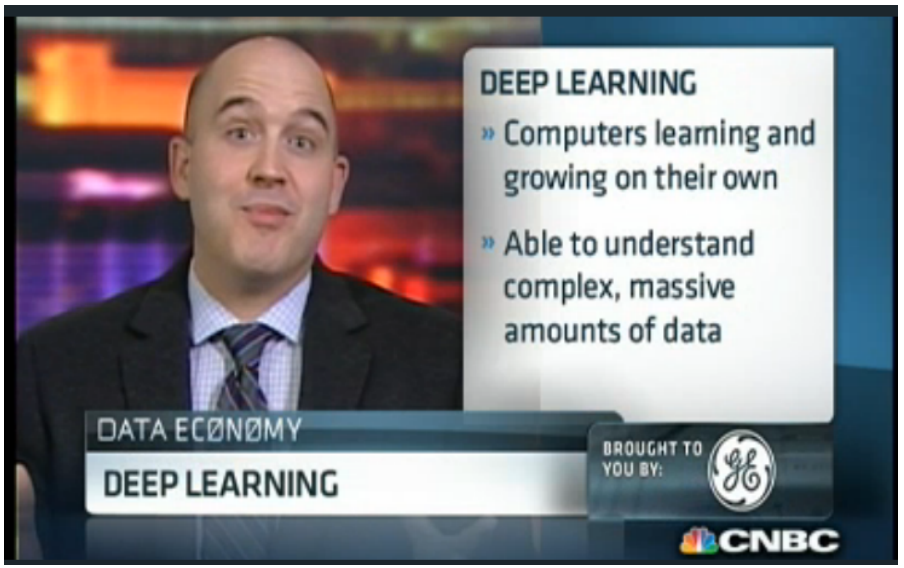
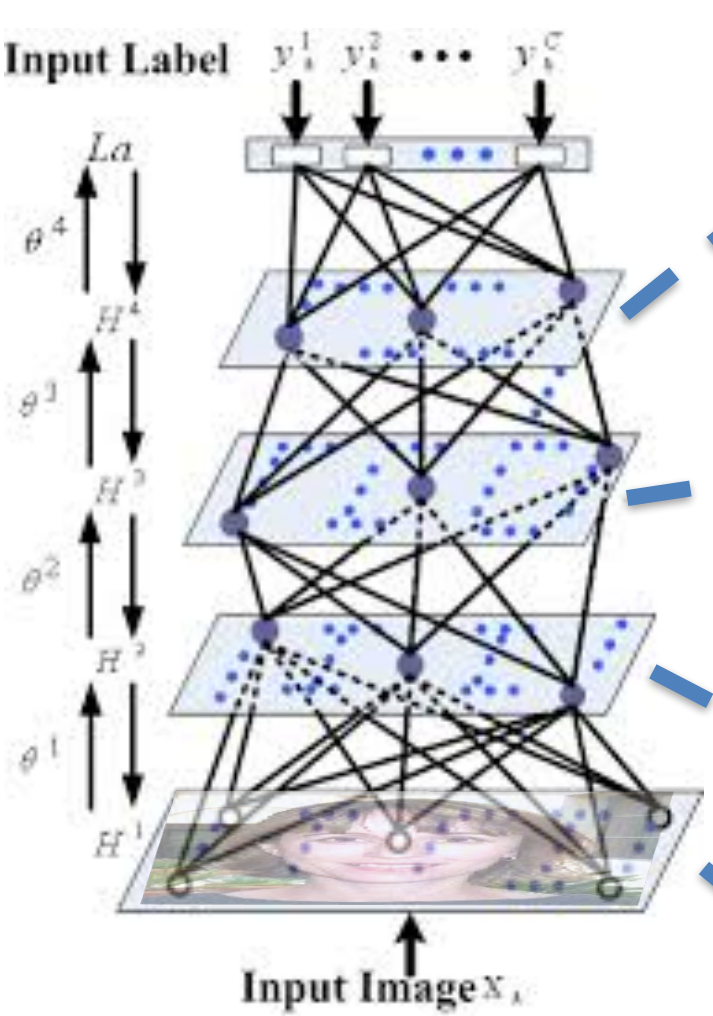
Deep Learning's Role in the Age of Robots

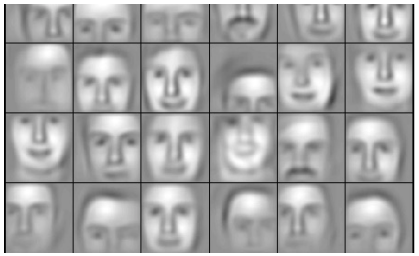
BY JULIAN GREEN, JETPAC 05.02.14 2:56 PM



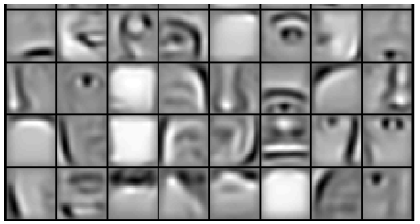


Deep Belief Net on Face Images

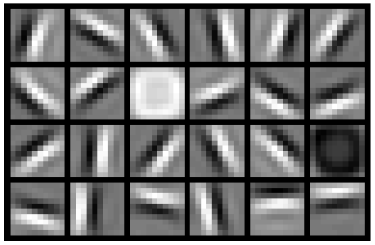




object models



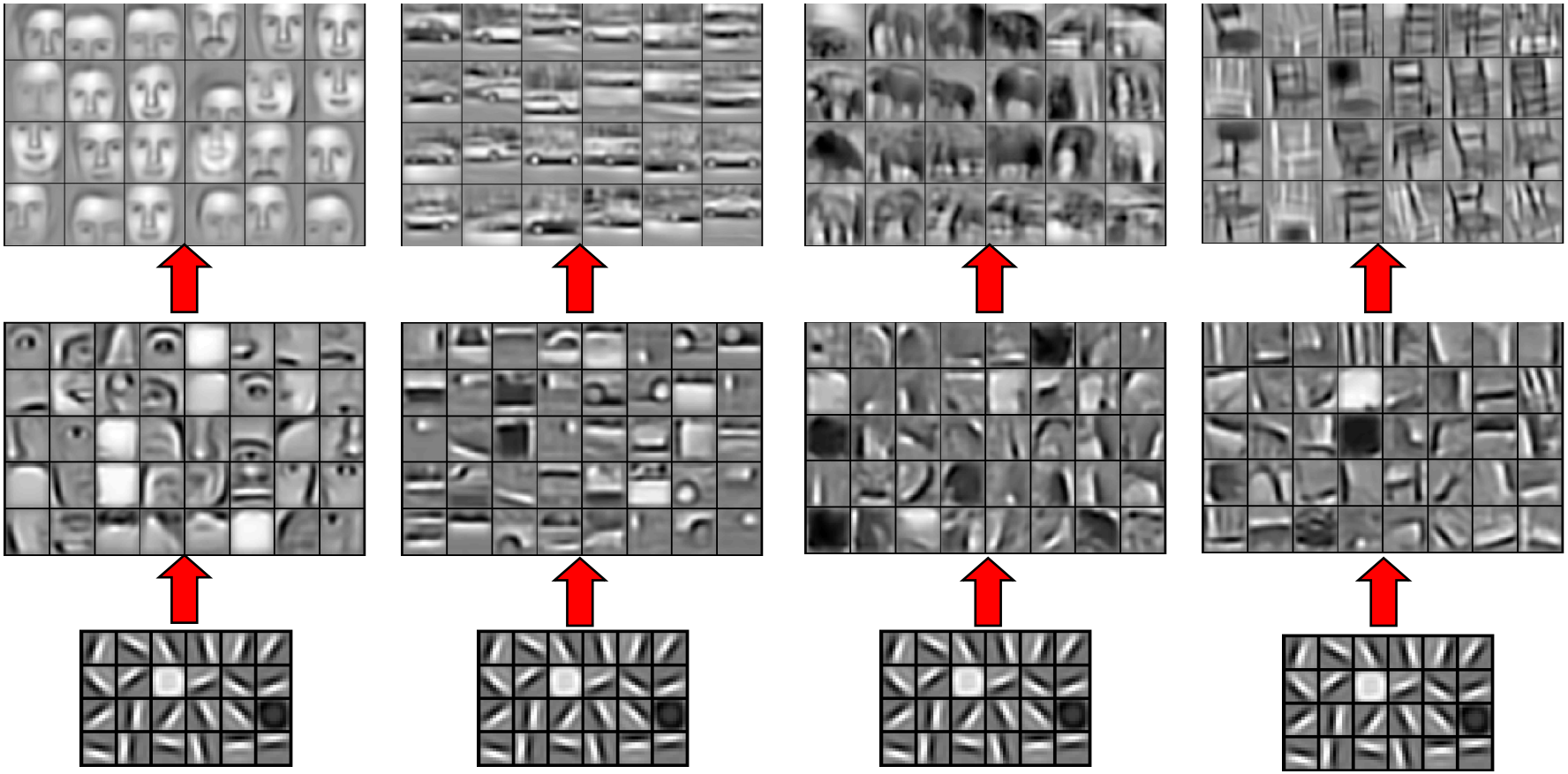
object parts (combination of edges)



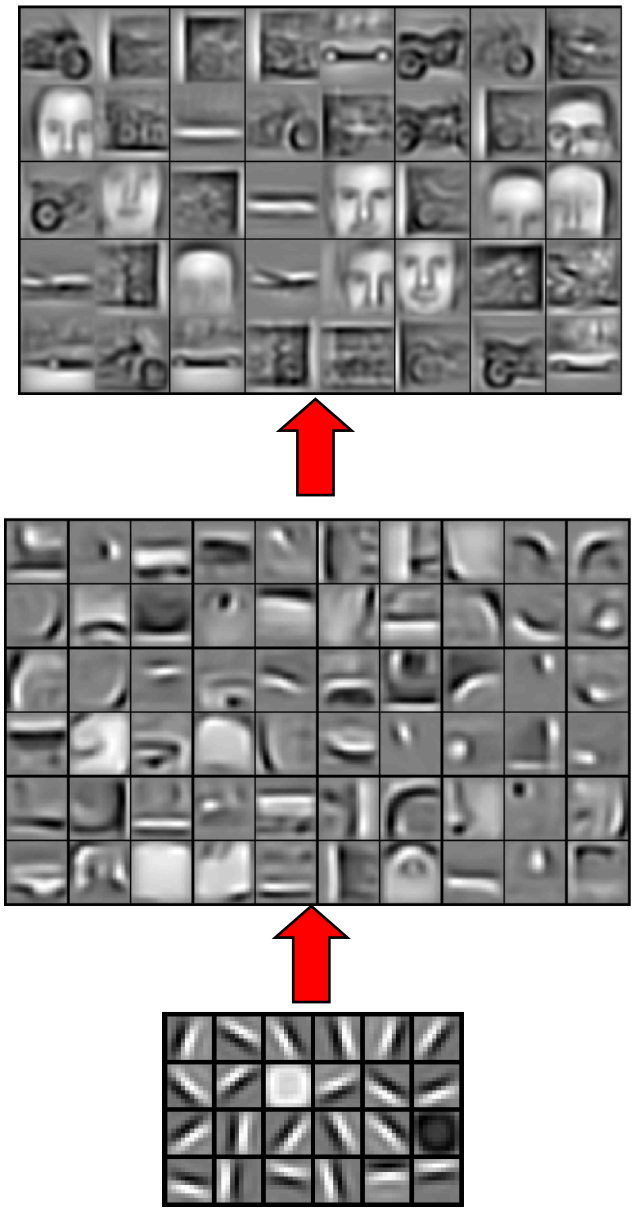
edges

pixels

Learning of Object Parts



Training on Multiple Objects



Trained on 4 classes (cars, faces, motorbikes, airplanes).

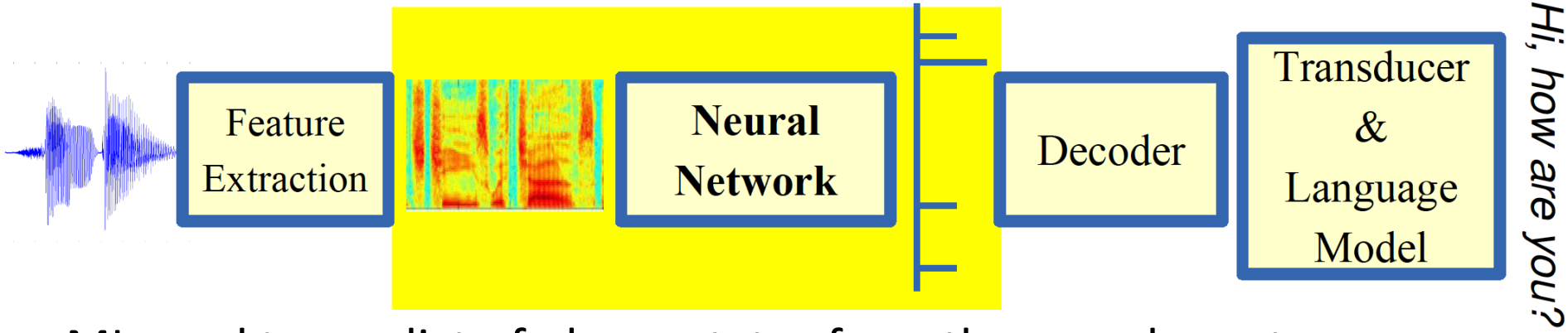
Second layer: Shared-features and object-specific features.

Third layer: More specific features.

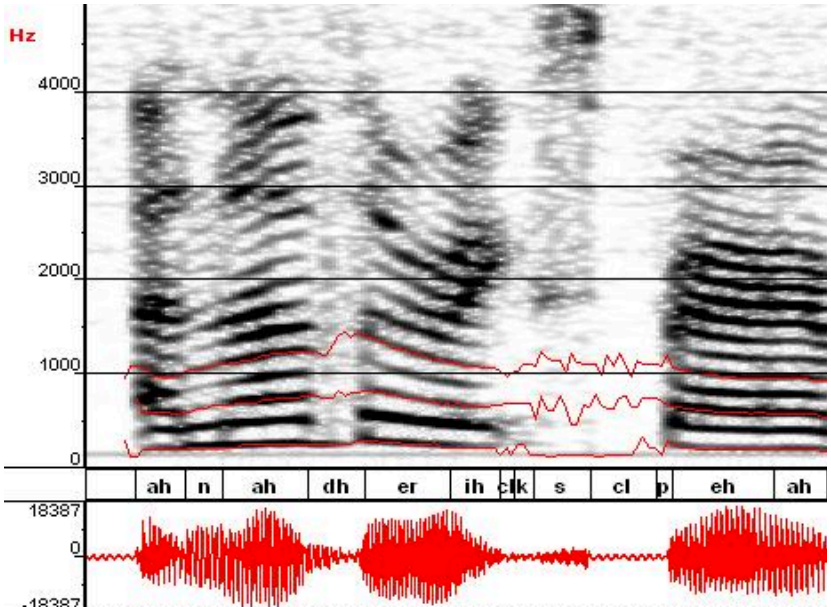
Scene Labeling via Deep Learning

Machine Learning in Automatic Speech Recognition

A Typical Speech Recognition System



ML used to predict of phone states from the sound spectrogram



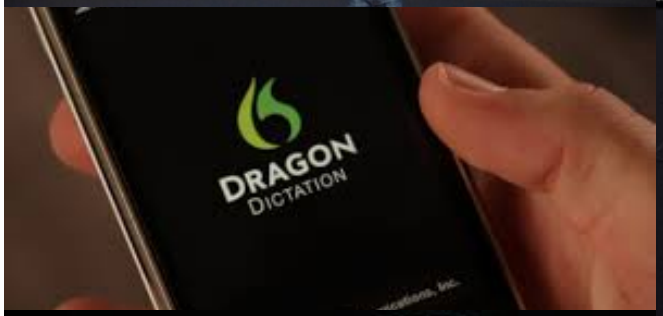
Deep learning has state-of-the-art results

# Hidden Layers	1	2	4	8	10	12
Word Error Rate %	16.0	12.8	11.4	10.9	11.0	11.1

Baseline GMM performance = 15.4%

[Zeiler et al. "On rectified linear units for speech recognition" ICASSP 2013]

Impact of Deep Learning in Speech Technology



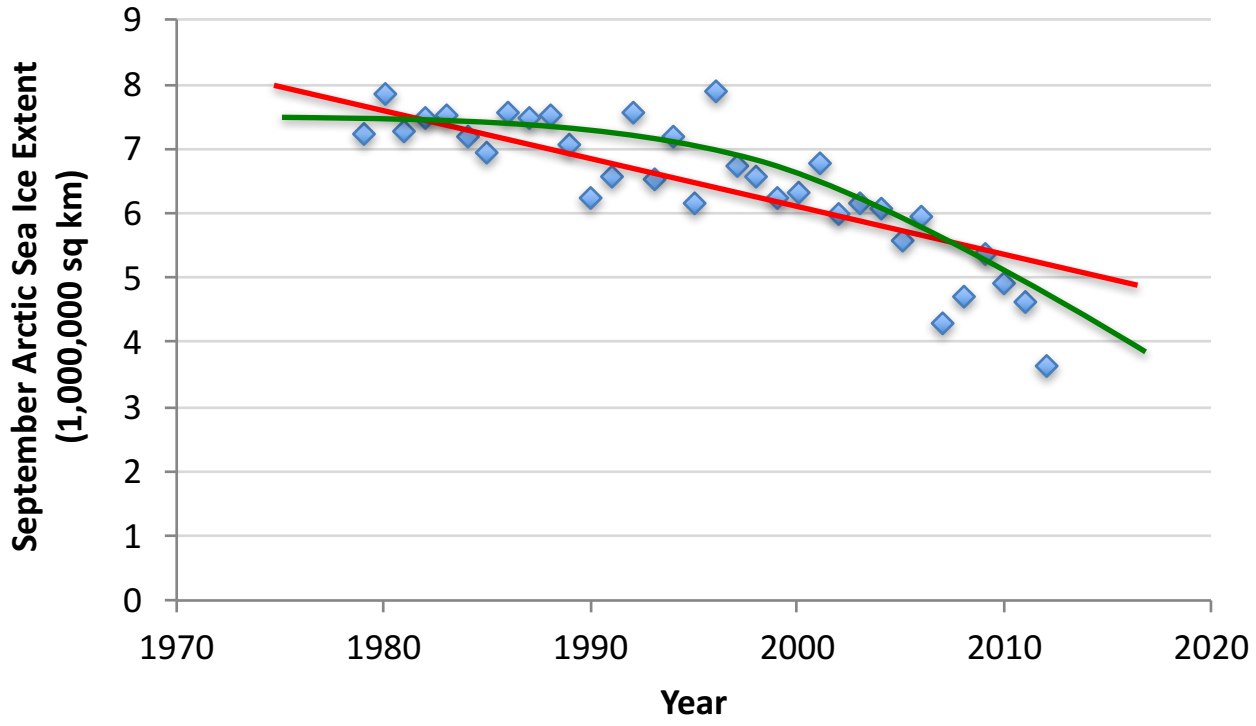
Types of Learning

Types of Learning

- **Supervised (inductive) learning**
  - Given: training data + desired outputs (labels)
- **Unsupervised learning**
  - Given: training data (without desired outputs)
- **Semi-supervised learning**
  - Given: training data + a few desired outputs
- **Reinforcement learning**
  - Rewards from sequence of actions

Supervised Learning: Regression

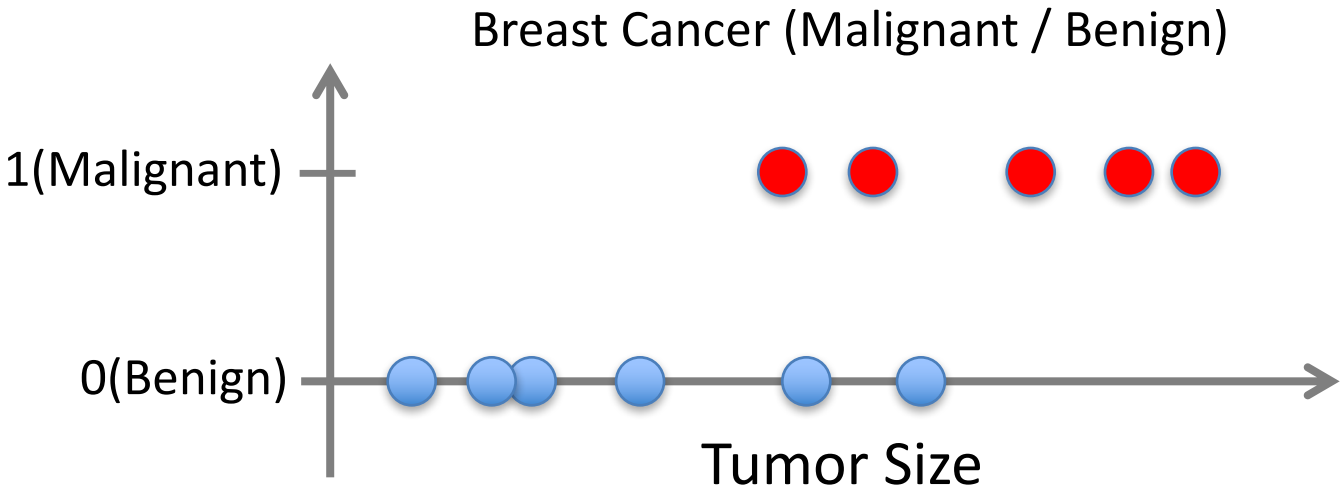
- Given (x_1, y_1), (x_2, y_2), …, (x_n, y_n)
- Learn a function $f(x)$ to predict y given x
  - y is real-valued == regression



Data from G. Witt. Journal of Statistics Education, Volume 21, Number 1 (2013)

Supervised Learning: Classification

- Given (x_1, y_1), (x_2, y_2), ..., (x_n, y_n)
- Learn a function $f(x)$ to predict y given x
  - y is categorical == classification



Supervised Learning: Classification

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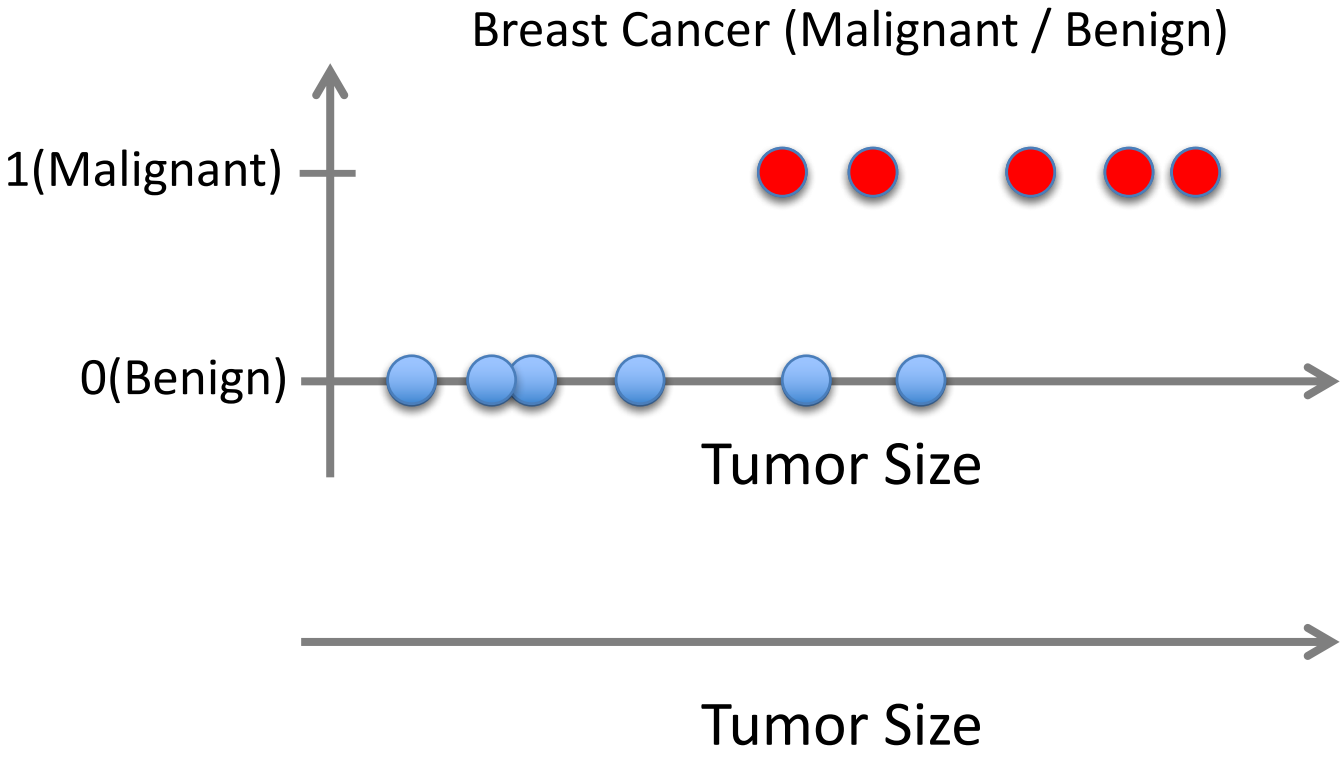

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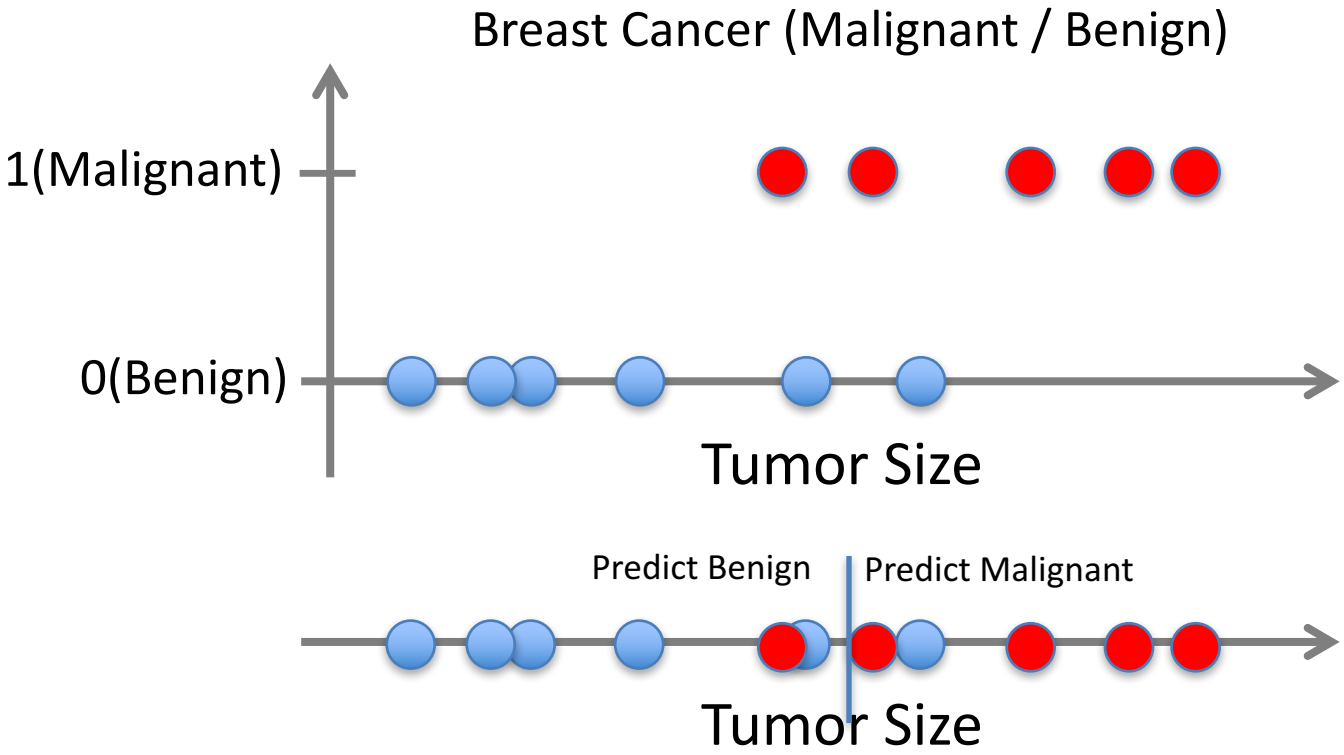
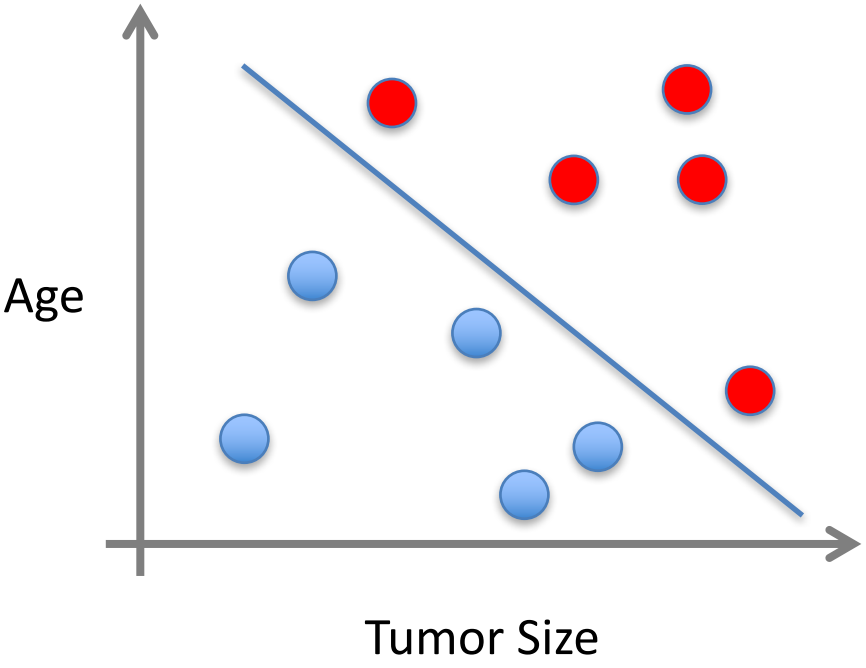


Supervised Learning

- x can be multi-dimensional
  - Each dimension corresponds to an attribute

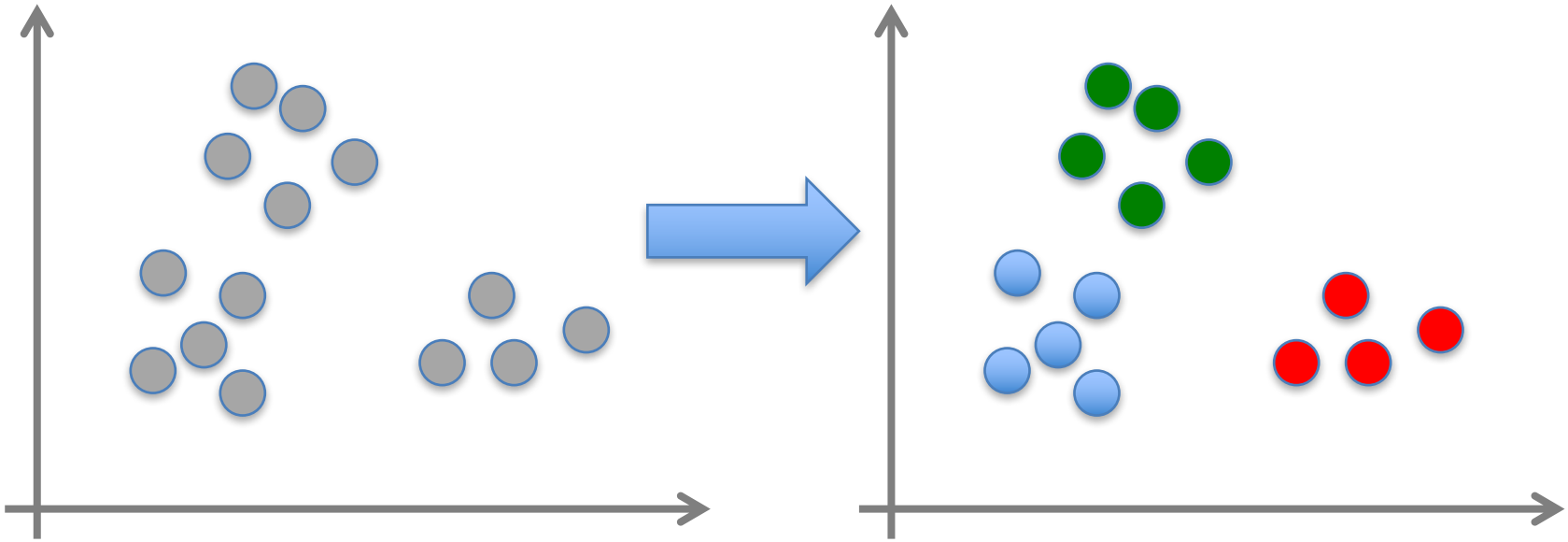


- Clump Thickness
- Uniformity of Cell Size
- Uniformity of Cell Shape

…

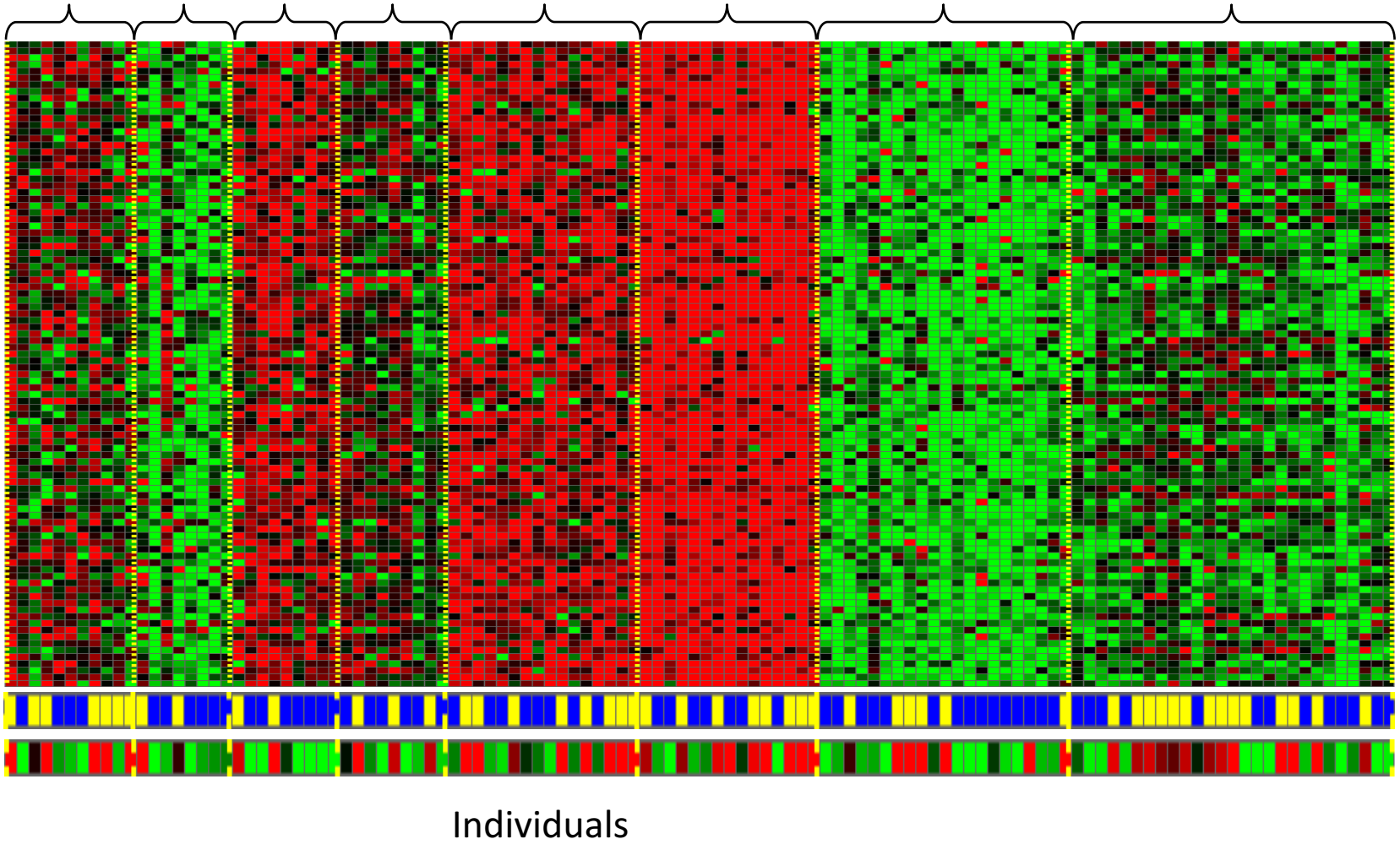
Unsupervised Learning

- Given x_1, x_2, …, x_n (without labels)
- Output hidden structure behind the x's
  - E.g., clustering



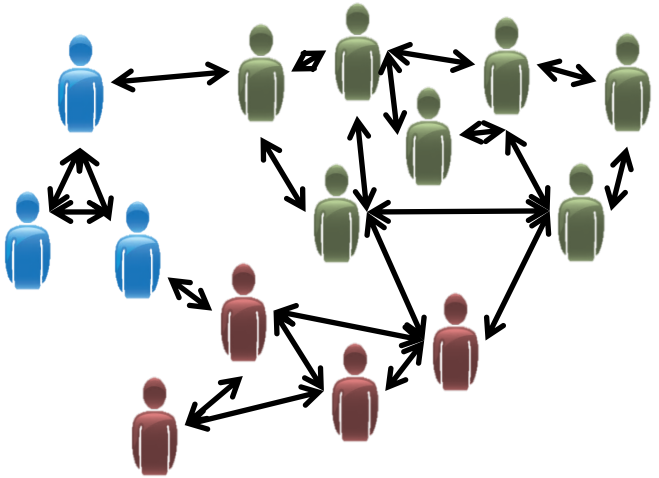
Unsupervised Learning

Genomics application: group individuals by genetic similarity



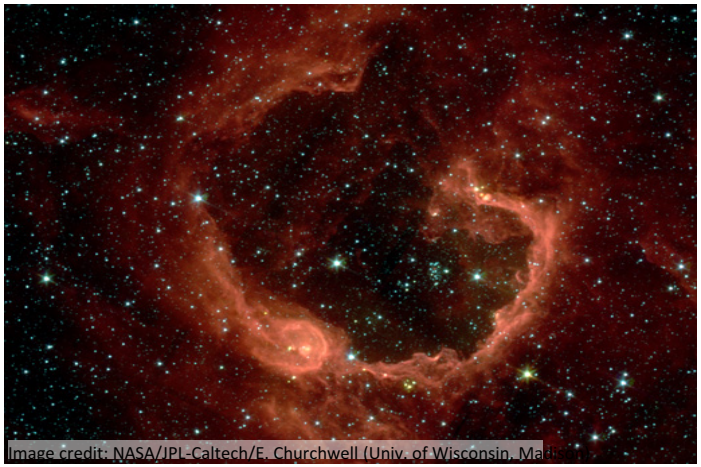
Unsupervised Learning

Organize computing clusters



Social network analysis

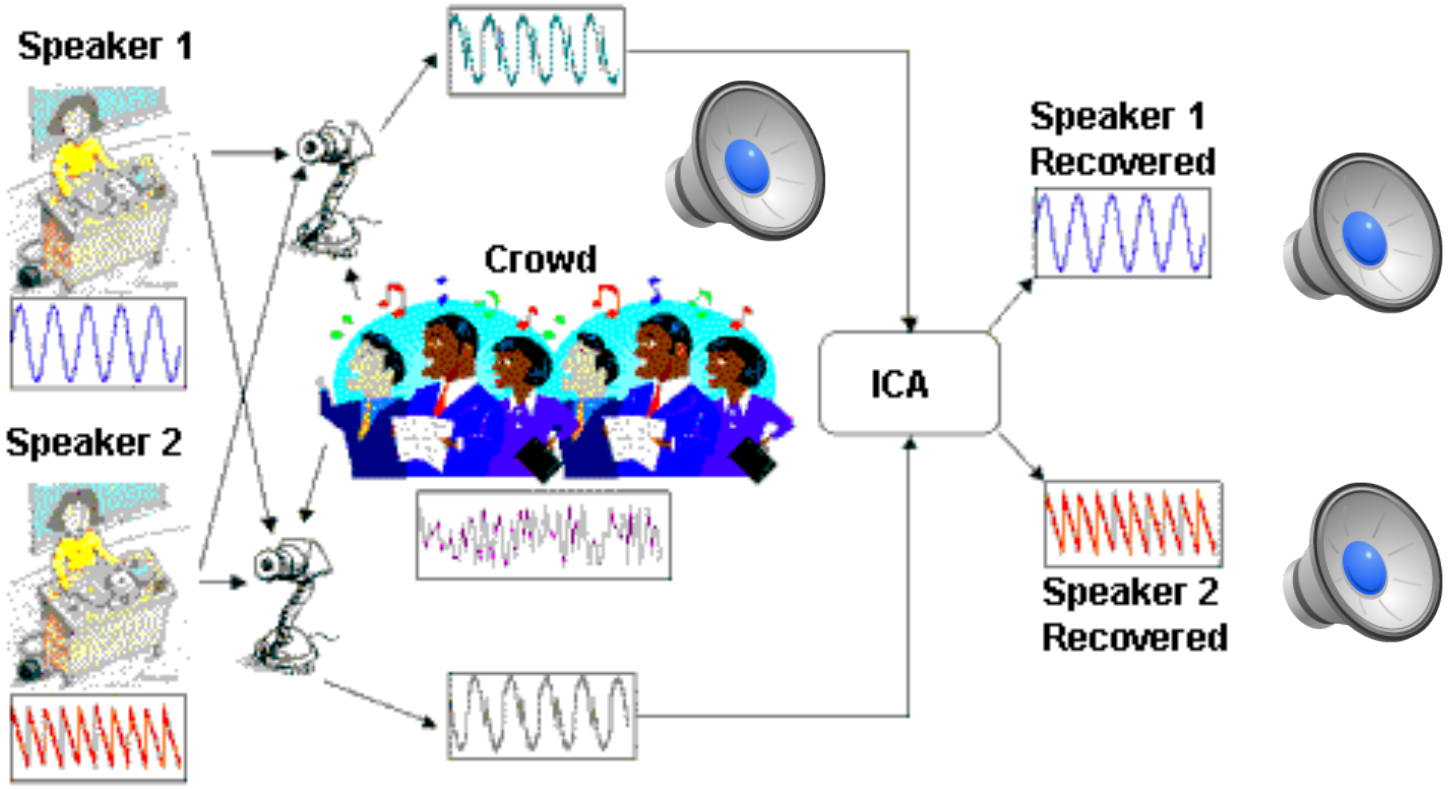
Market segmentation



Astronomical data analysis

Unsupervised Learning

- Independent component analysis – separate a combined signal into its original sources



Reinforcement Learning

- Given a sequence of states and actions with (delayed) rewards, output a policy
  - Policy is a mapping from states → actions that tells you what to do in a given state
- Examples:
  - Credit assignment problem
  - Game playing
  - Robot in a maze
  - Balance a pole on your hand