

# EE 375/475 and Data\_Sci 423 Machine Learning

Aggelos K. Katsaggelos

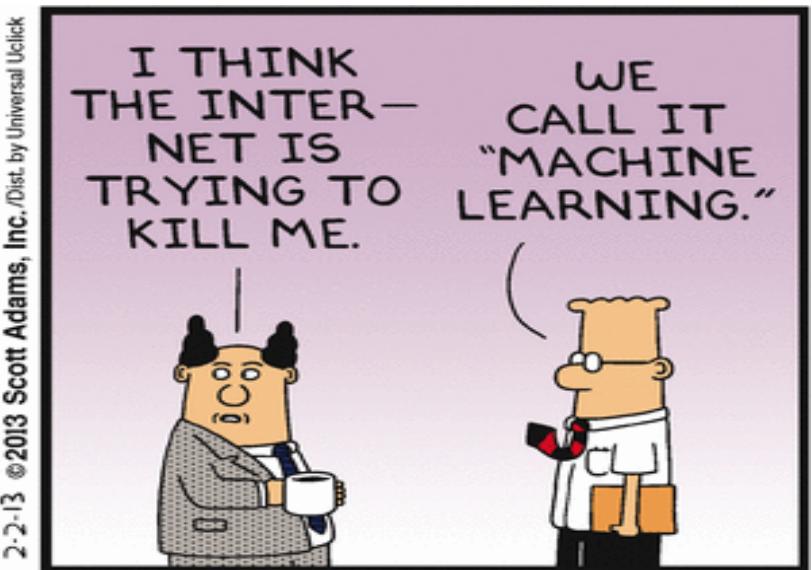
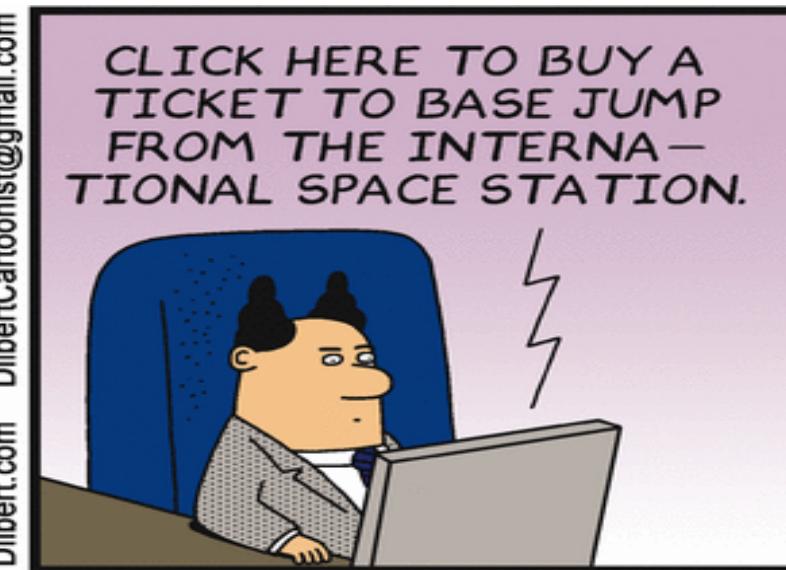
Joseph Cummings Professor  
Northwestern University  
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What is ML commonly used for today?

# What is ML commonly used for today?

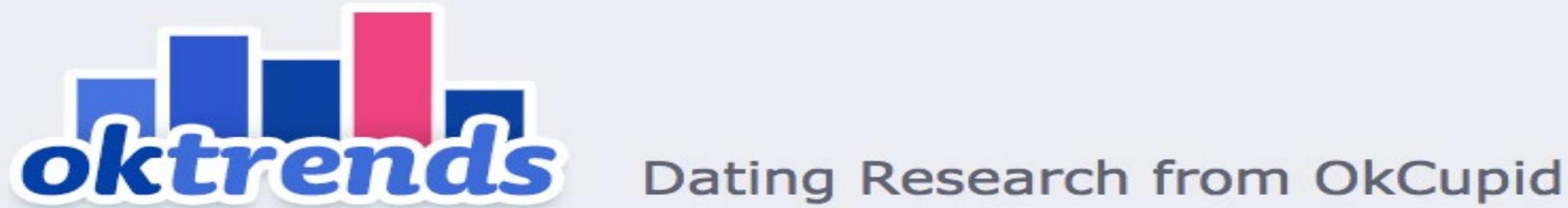
- **Target advertising:** recommend advertisements and products to users based on some understanding of their tastes, their consumption history, how they think, etc.,



# What is ML commonly used for today?

- **General recommendation/matching**

- Business partners – job websites e.g., LinkedIn
- Products – e.g., Amazon
- Romantic partners: e.g., Okcupid, match.com



# What is ML commonly used for today?

- **Object detection and recognition:**
  - driver assisted and self-driving cars



Image taken from <http://www.wsj.com/articles/panasonic-in-deal-to-help-computers-learn-on-the-job-1433840398>



There is a video here! Click on the whitespace above to bring out the window.

# Regression

Predicting a *continuous-valued* variable

# Classification

Predicting a *discrete-valued* variable  
i.e., distinguishing between different  
classes of data

# Regression

Predicting a *continuous-valued* variable

## Ex. Financial modeling

Brent crude oil prices, January 2014 - January 2016



Source: Bloomberg

BBC

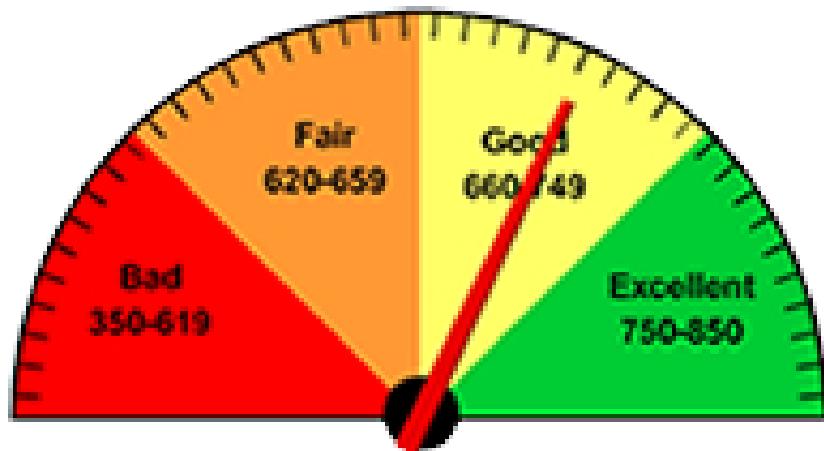
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Predicting a *continuous-valued* variable

**Ex. Financial modeling**



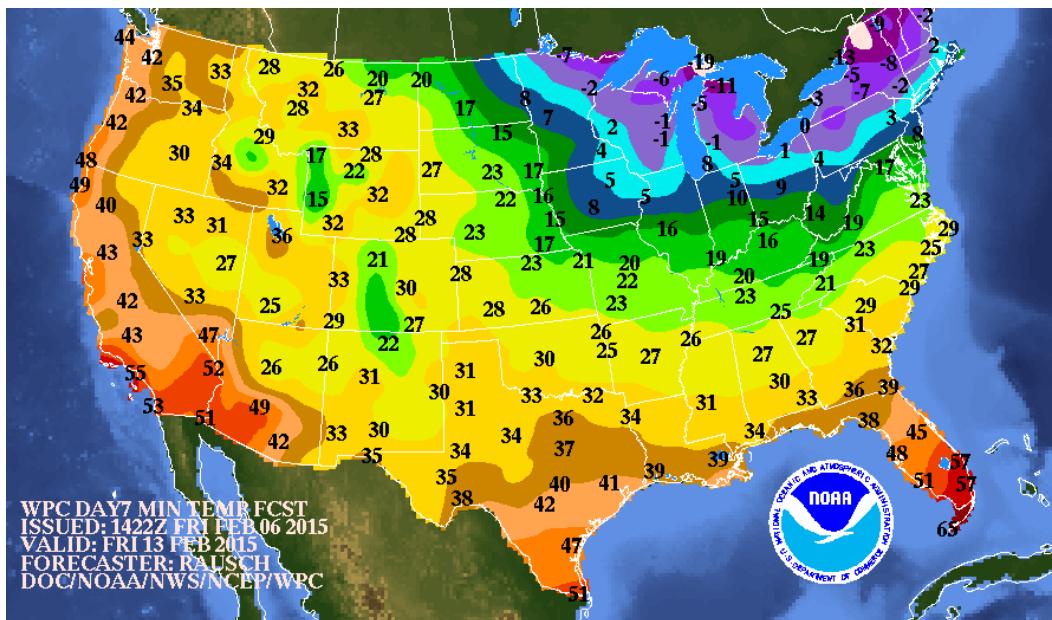
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# Regression

Predicting a *continuous-valued* variable

Ex. Weather forecasting



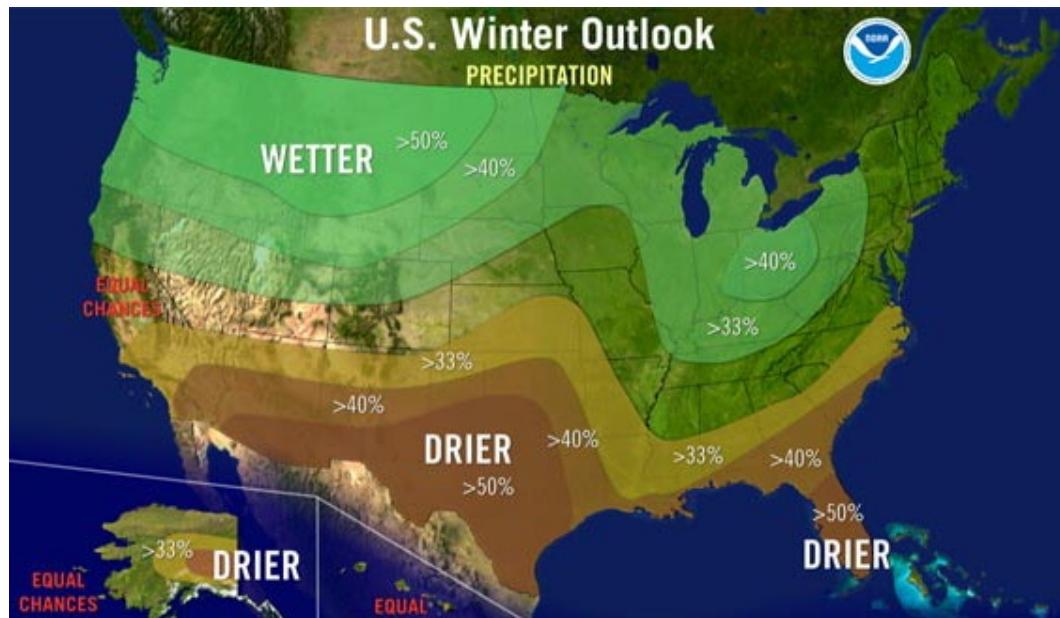
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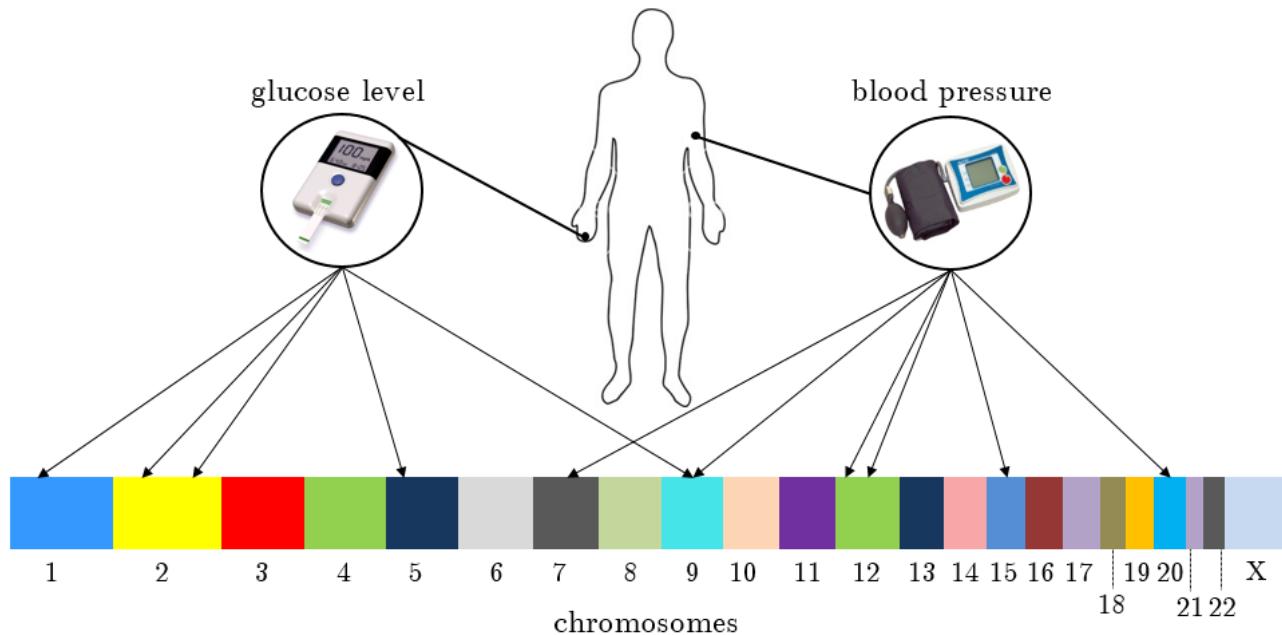
# Regression

Predicting a *continuous-valued* variable

# Classification

Predicting a *discrete-valued* variable  
i.e., distinguishing between different classes of data

## Ex. Genetics



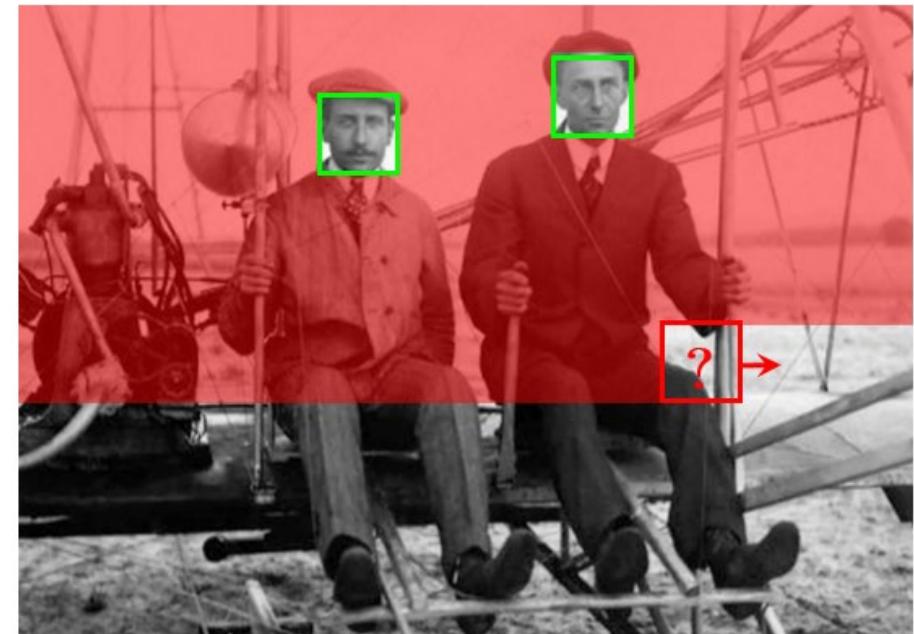
# Regression

Predicting a *continuous-valued* variable

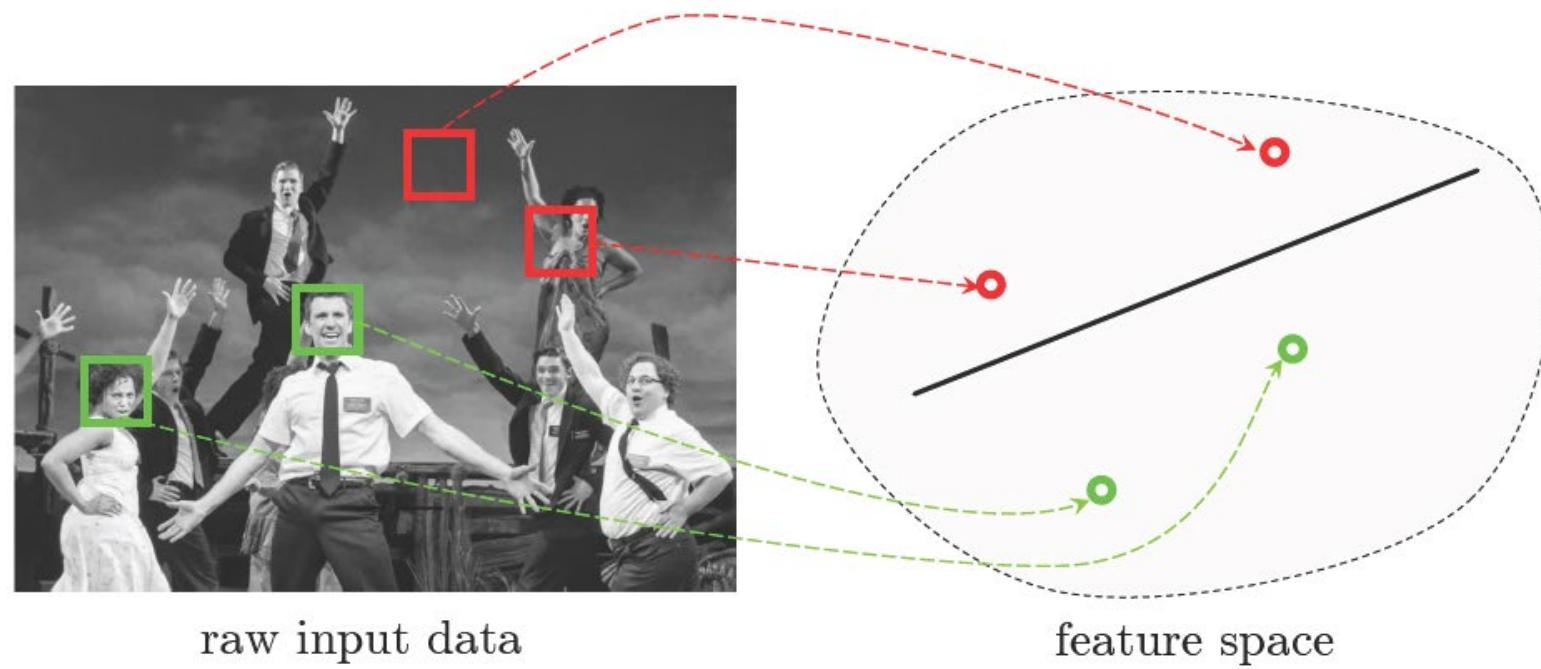
# Classification

Predicting a *discrete-valued* variable  
i.e., distinguishing between different classes of data

**Ex. Face detection**



# Face Detection



# Regression

Predicting a *continuous-valued* variable

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**Ex. Pedestrian detection**



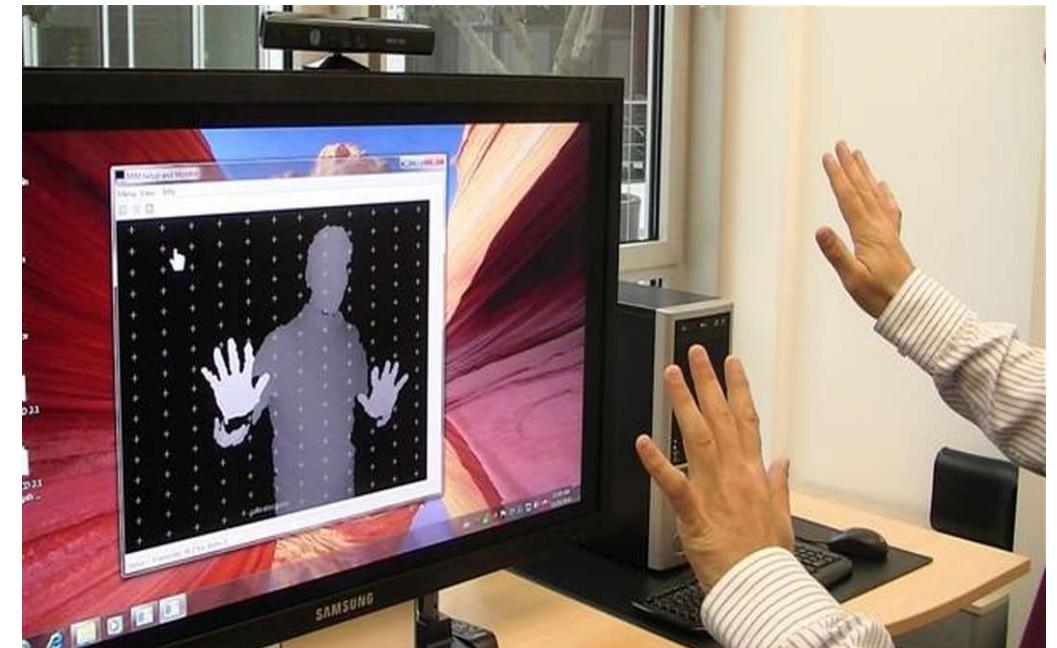
# Regression

Predicting a *continuous-valued* variable

# Classification

Predicting a *discrete-valued* variable  
i.e., distinguishing between different classes of data

**Ex. Hand gesture recognition**



# Regression

Predicting a *continuous-valued* variable

# Classification

Predicting a *discrete-valued* variable  
i.e., distinguishing between different classes of data

**Ex. Speech recognition**



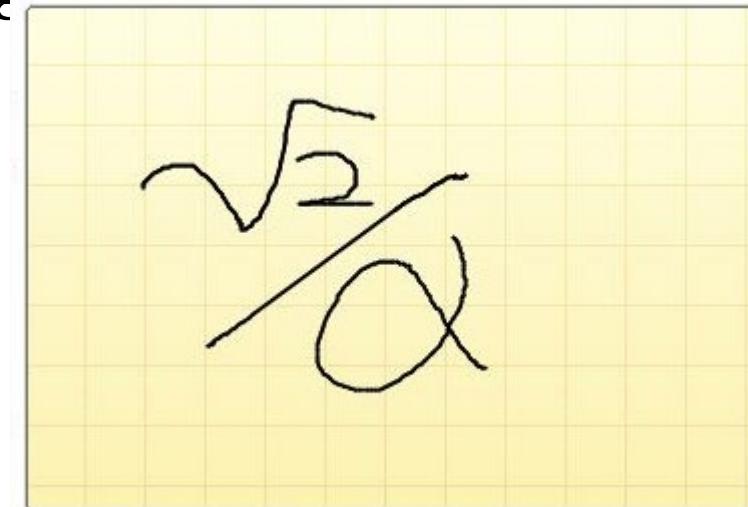
# Regression

Predicting a *continuous-valued* variable

# Classification

Predicting a *discrete-valued* variable  
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**Ex. Optical character recognition**



$$\sqrt{2}/\alpha$$

# Regression

Predicting a *continuous-valued* variable

# Classification

Predicting a *discrete-valued* variable  
i.e., distinguishing between different classes of data

## Ex. Sentiment analysis

A screenshot of a Twitter post featuring a customer review. The post includes a profile picture of a man, the handle @HVSVN, and a Twitter logo with a plus sign.

**Customer Review**  
Apple Airport Expr

45 Reviews

Star Rating	Count
5 star	(20)
4 star	(13)
3 star	(5)
2 star	(2)
1 star	(5)

**The most helpful favorable review**

20 of 21 people found the following review helpful:

★★★★★ **Airport Express Set-up Instructions**

The CD that comes with the Airport Express has been useless to me in setting up a Windows XP computer to work with an AE. The instructions below should get you up and running.

1. First download the latest version of both the Airport Update and Airport Express Firmware Updater from [...]
2. Run the latest version of the Airport Update (4.1 at the...  
[Read the full review >](#)

Published 3 months ago by S. Monroe

**The most helpful critical review**

6 of 7 people found the following review helpful:

★★★☆☆ **Works fine after a painfully difficult set up.**

It took me a full day to work out the bugs in setting my Express up to work with my Mac Mini and my wife's Mac Powerbook. First it worked on one, but the other could not find it. Then it didn't work at all. There is a lot more involved in setting up your own wireless network and making decisions as to what level of security you want (with no ready explanation of what the...  
[Read the full review >](#)

Published 3 months ago by David Haggith

▶ See more [3 star, 2 star, 1 star](#) reviews

# Regression

Predicting a *continuous-valued* variable

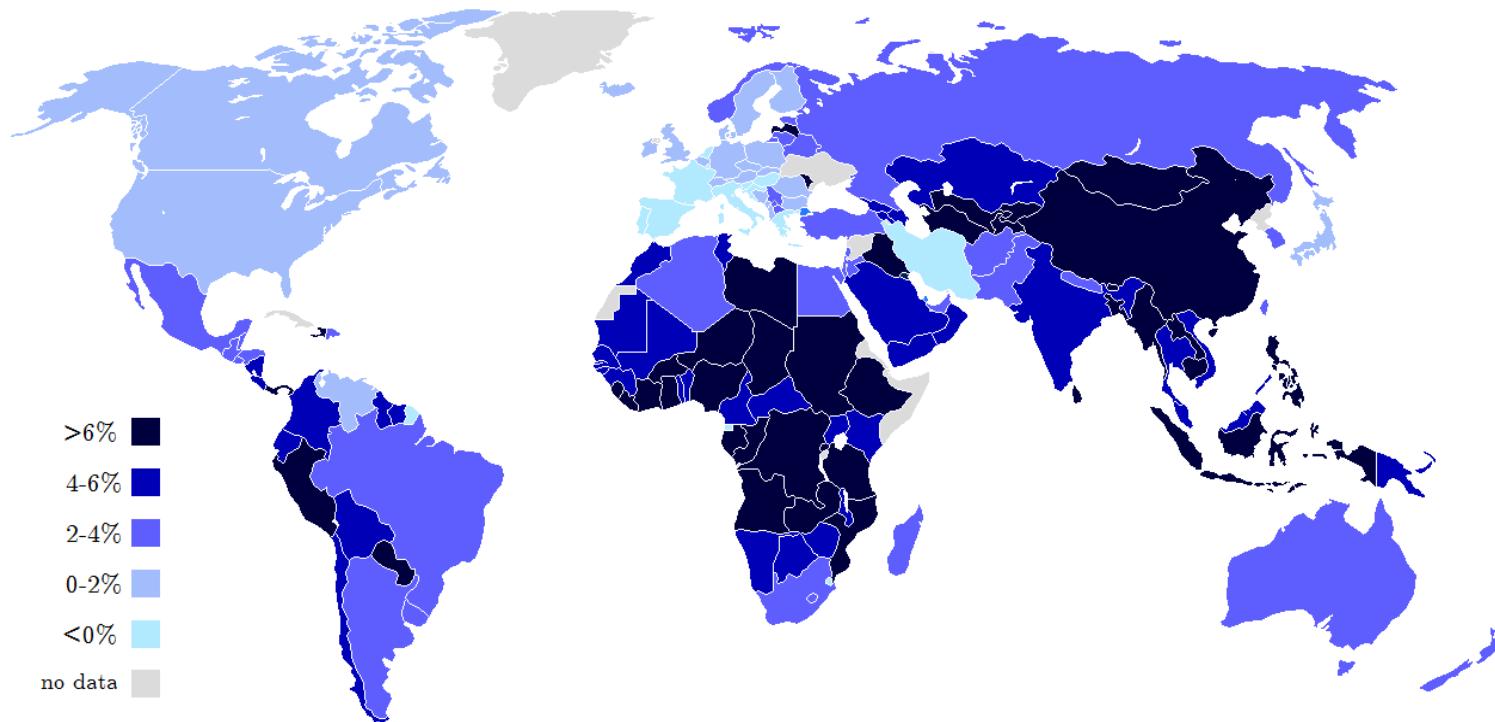
# Classification

Predicting a *discrete-valued* variable  
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Ex. **Spam detection**



# Econometrics



Population density

Fraction of tropical area

Size of economy

Defense spending

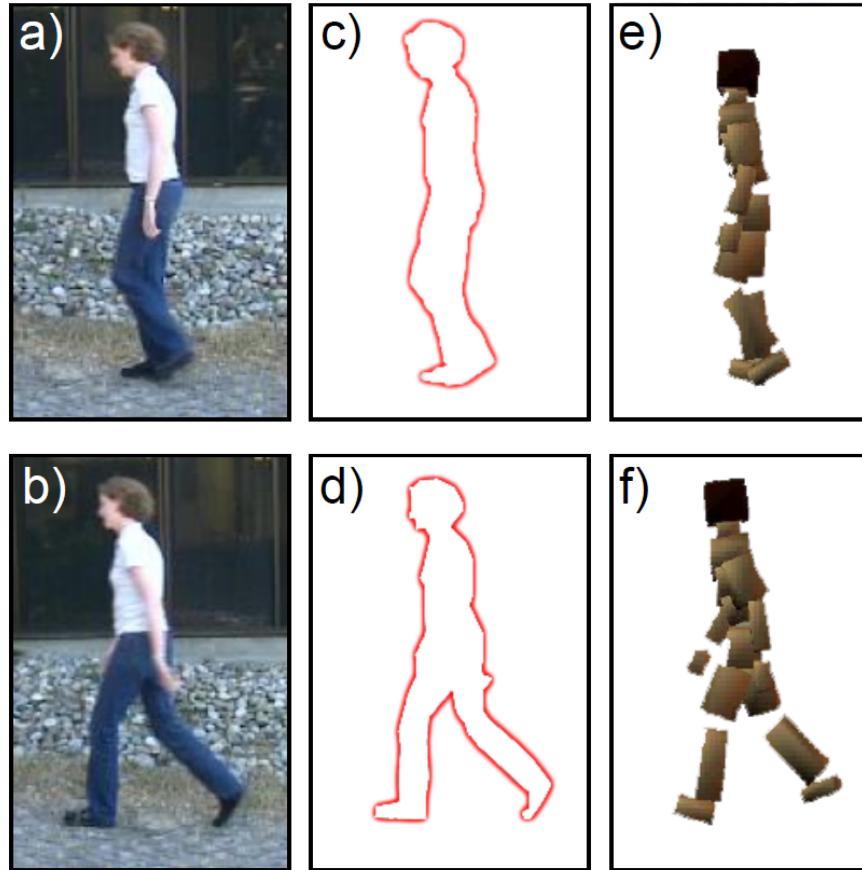
Life expectancy

Public investment

•  
•  
•

Land area

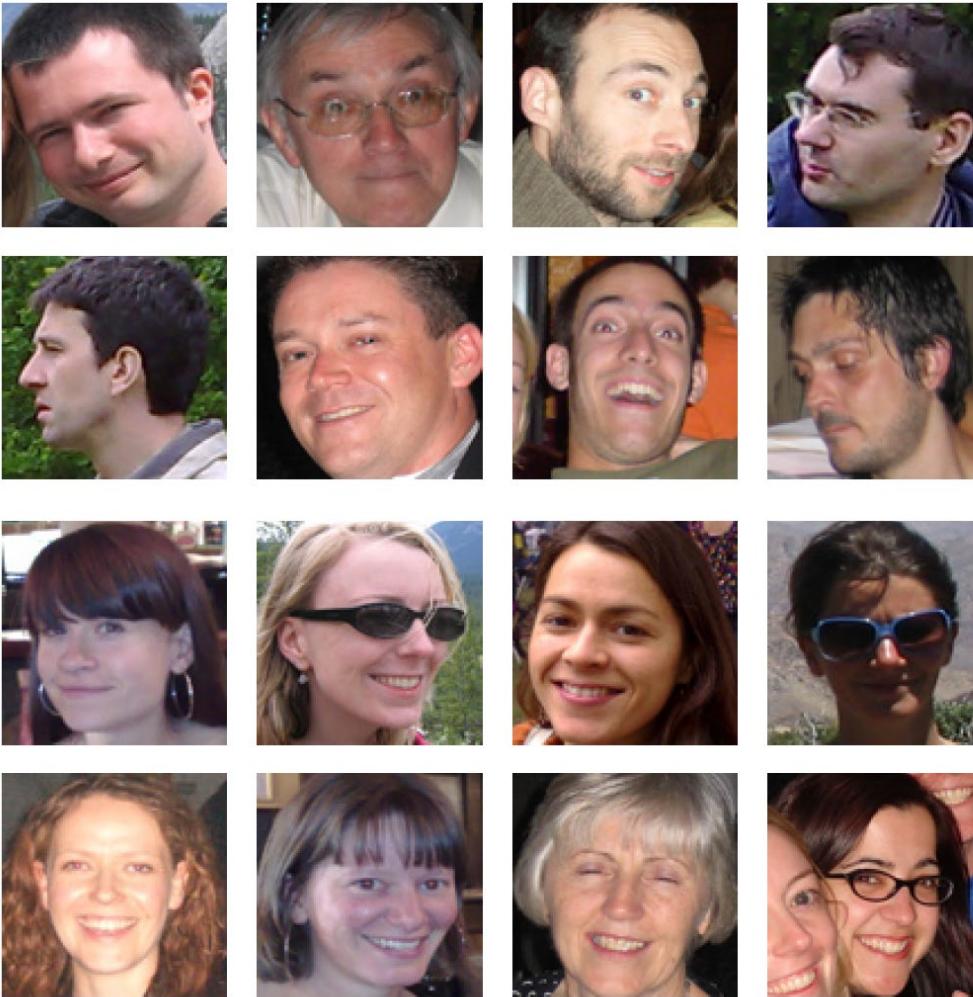
# Estimation of the Pose using a Regression Model



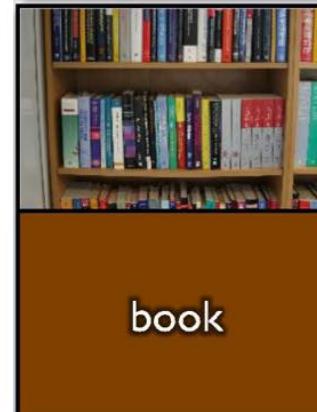
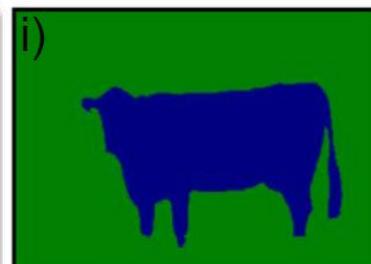
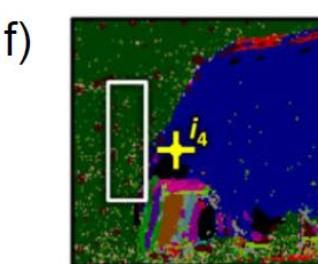
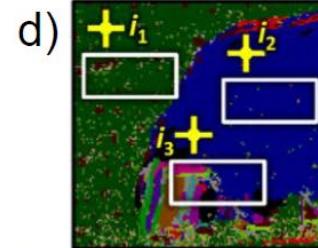
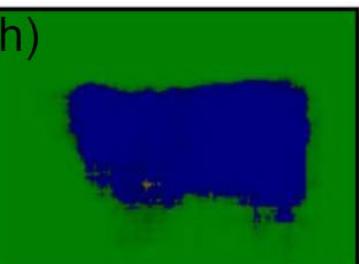
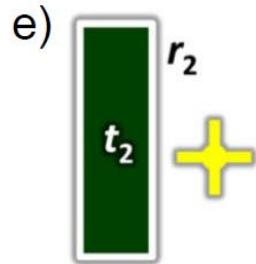
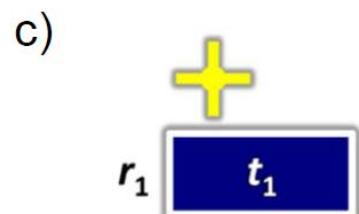
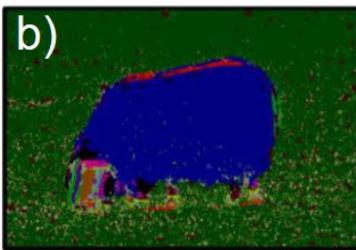
The pose is encoded as a  $55 \times 1$  vector. It contains three angles in 18 major joints of the body and the global azimuth.

We encode the silhouette as a  $100 \times 1$  vector. From this vector, we want to calculate the pose as a  $55 \times 1$  vector and learn the relation between the features and the pose.

# Gender Classification

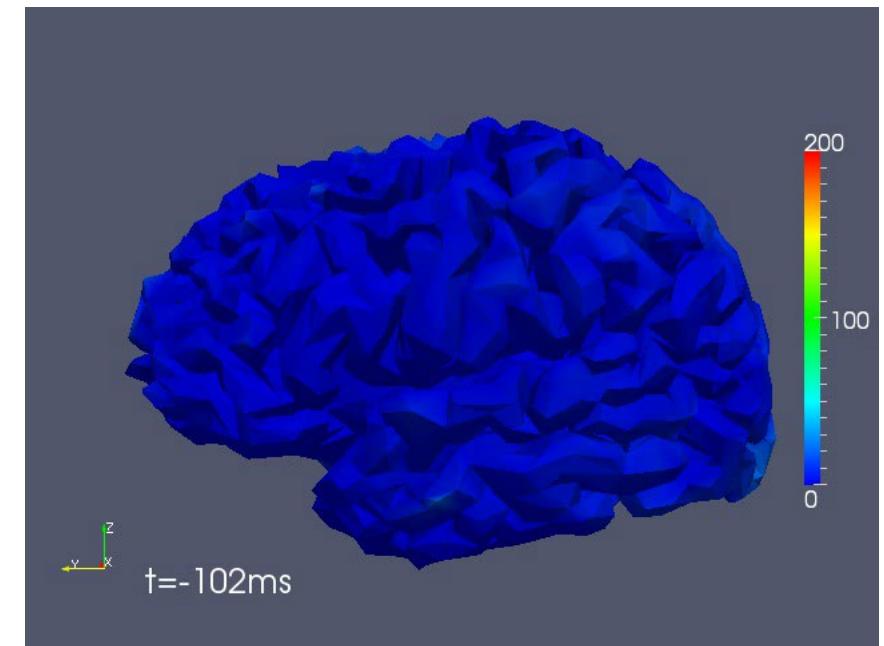
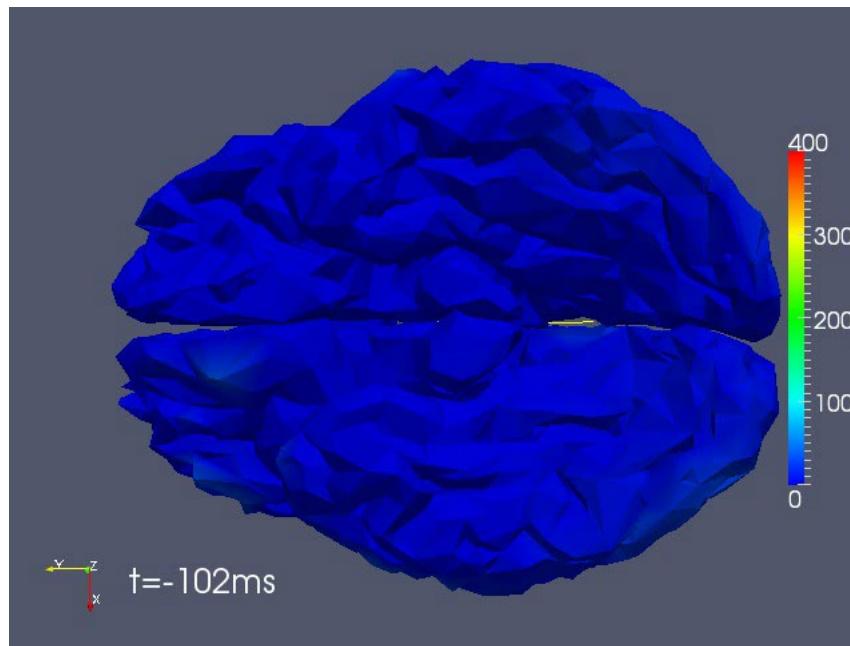
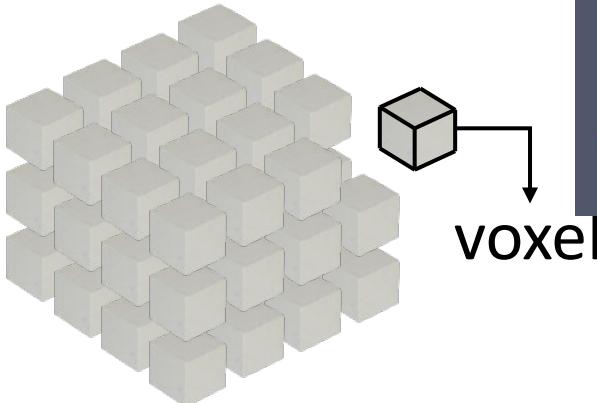
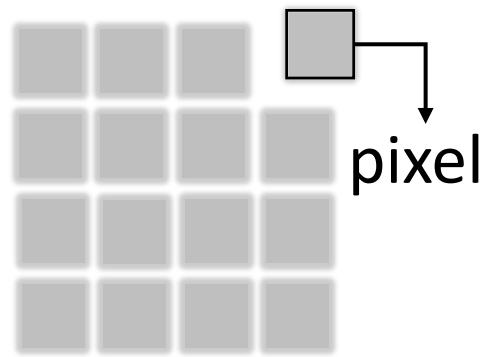


# Semantic segmentation



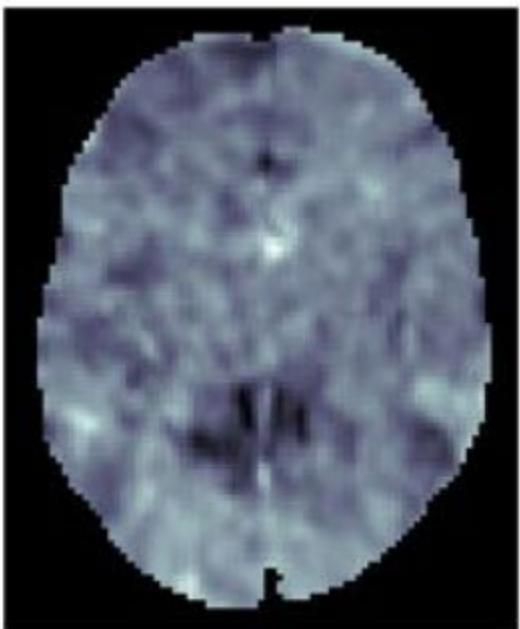
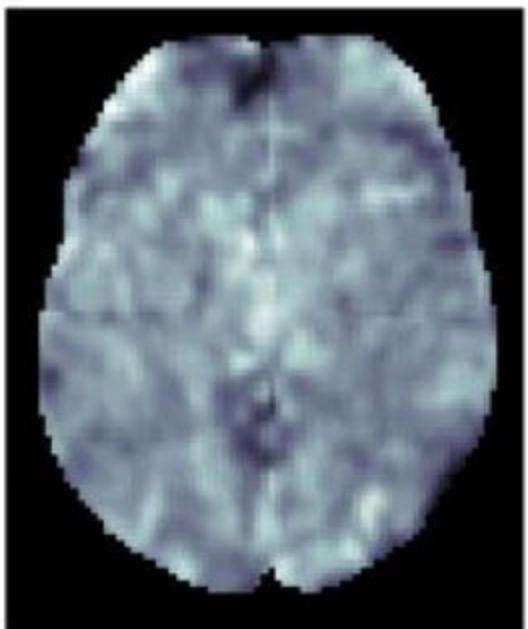
Shotton *et al.* (2009)

# Neuroscience

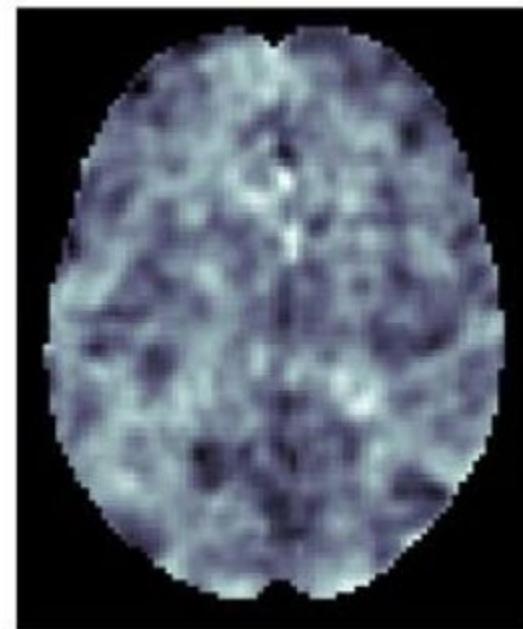
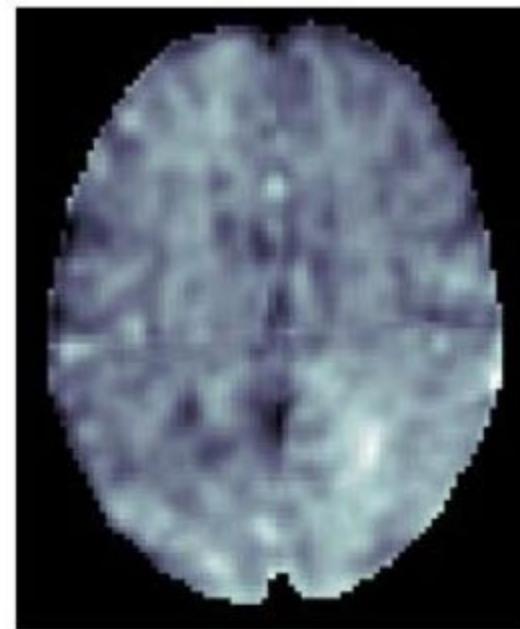


**ADHD**

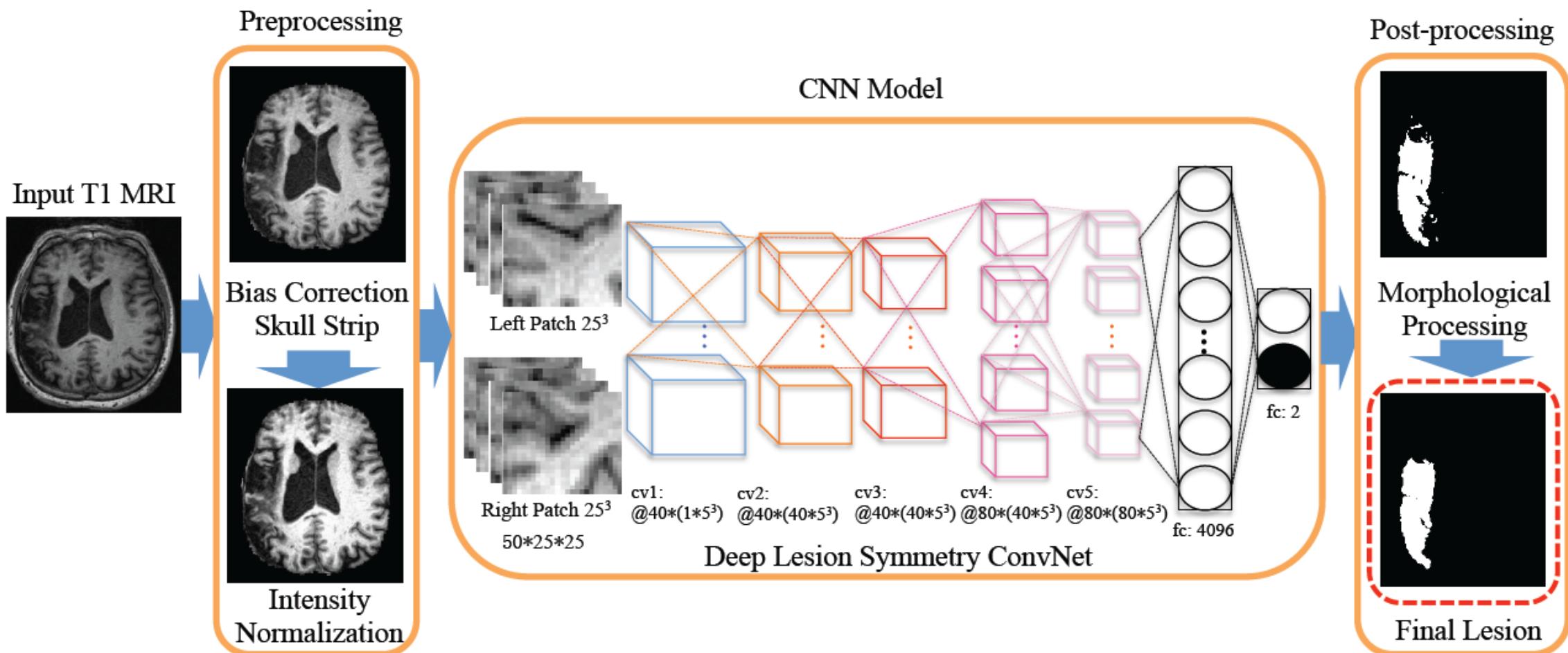
Normal



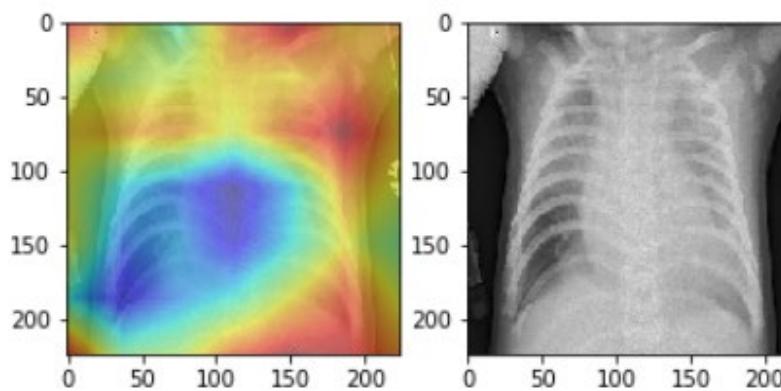
**ADHD**



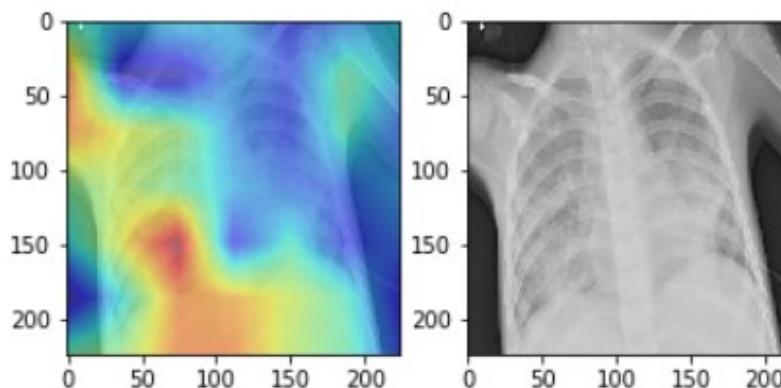
# Lesion Classification



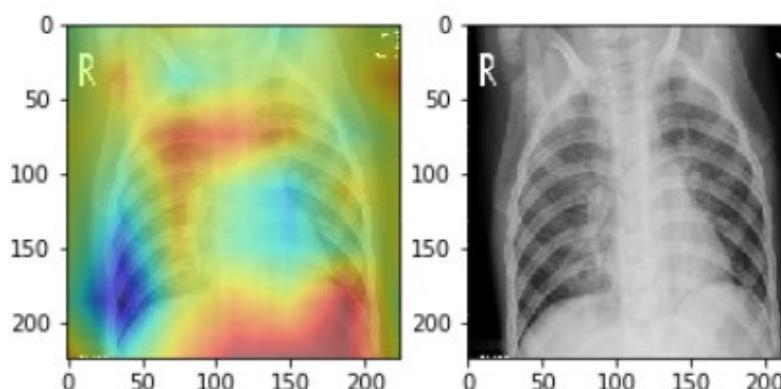
# COVID-19



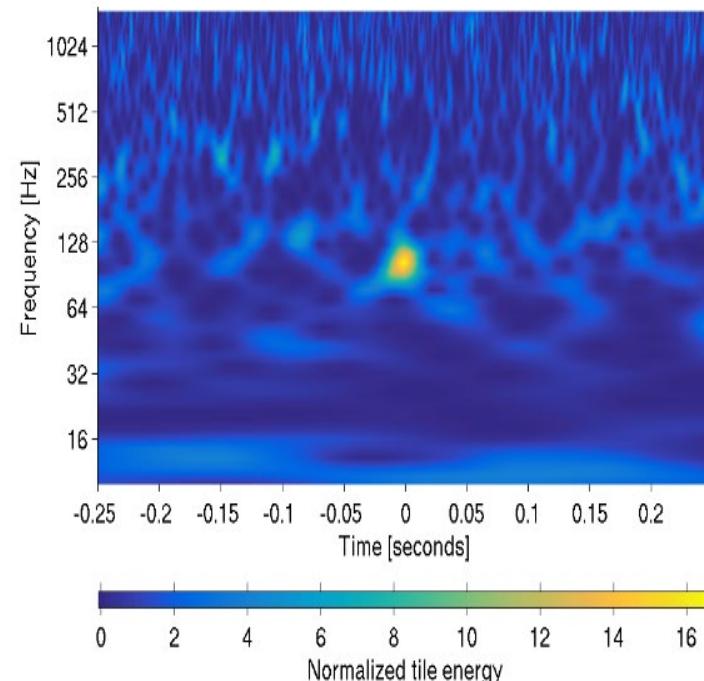
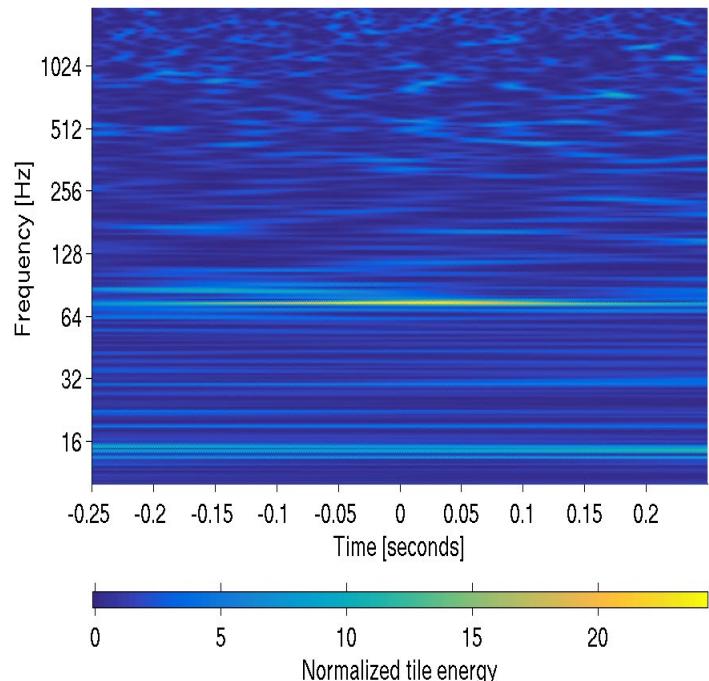
Continue? (Y/n)Y



Continue? (Y/n)Y

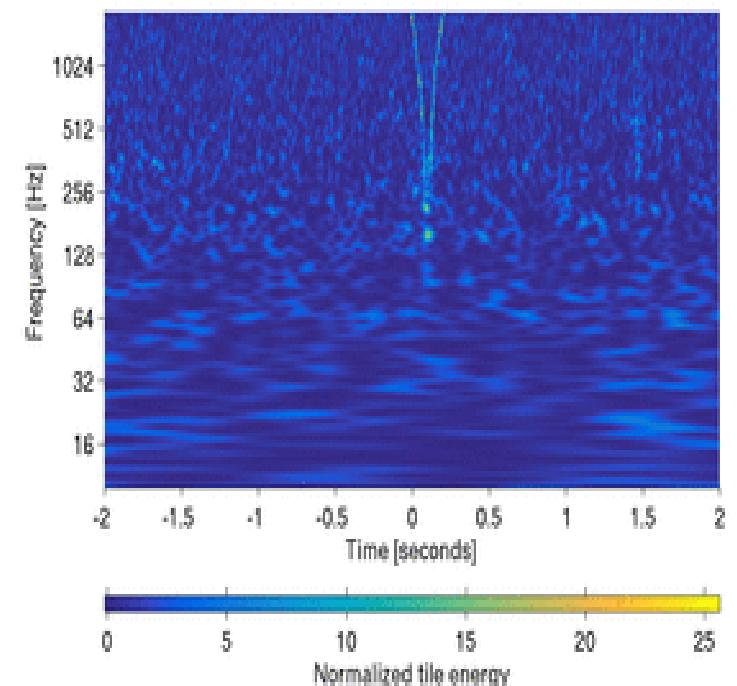
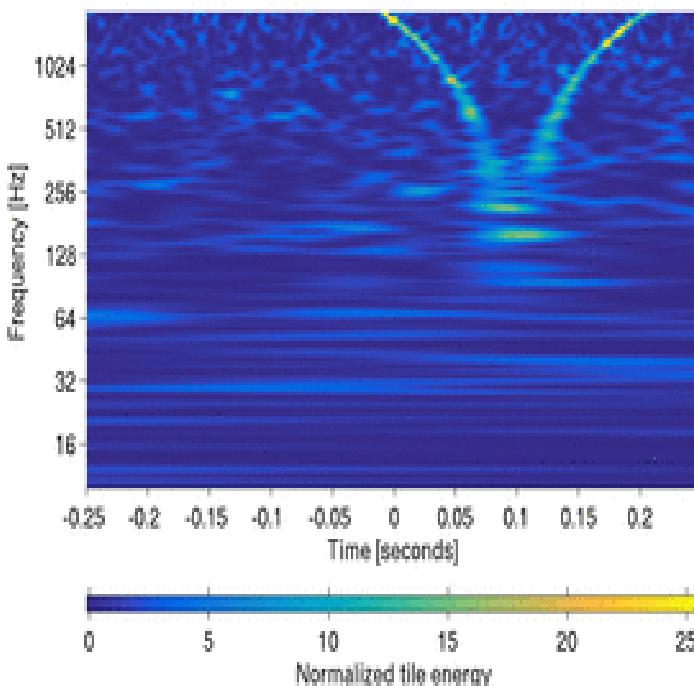


- LIGO (Laser Interferometer Gravitational wave Observatory) data “glitches”
- Visualized as images on a time-frequency plane that display visually recognizable shapes
- 5930 images/ 20 classes

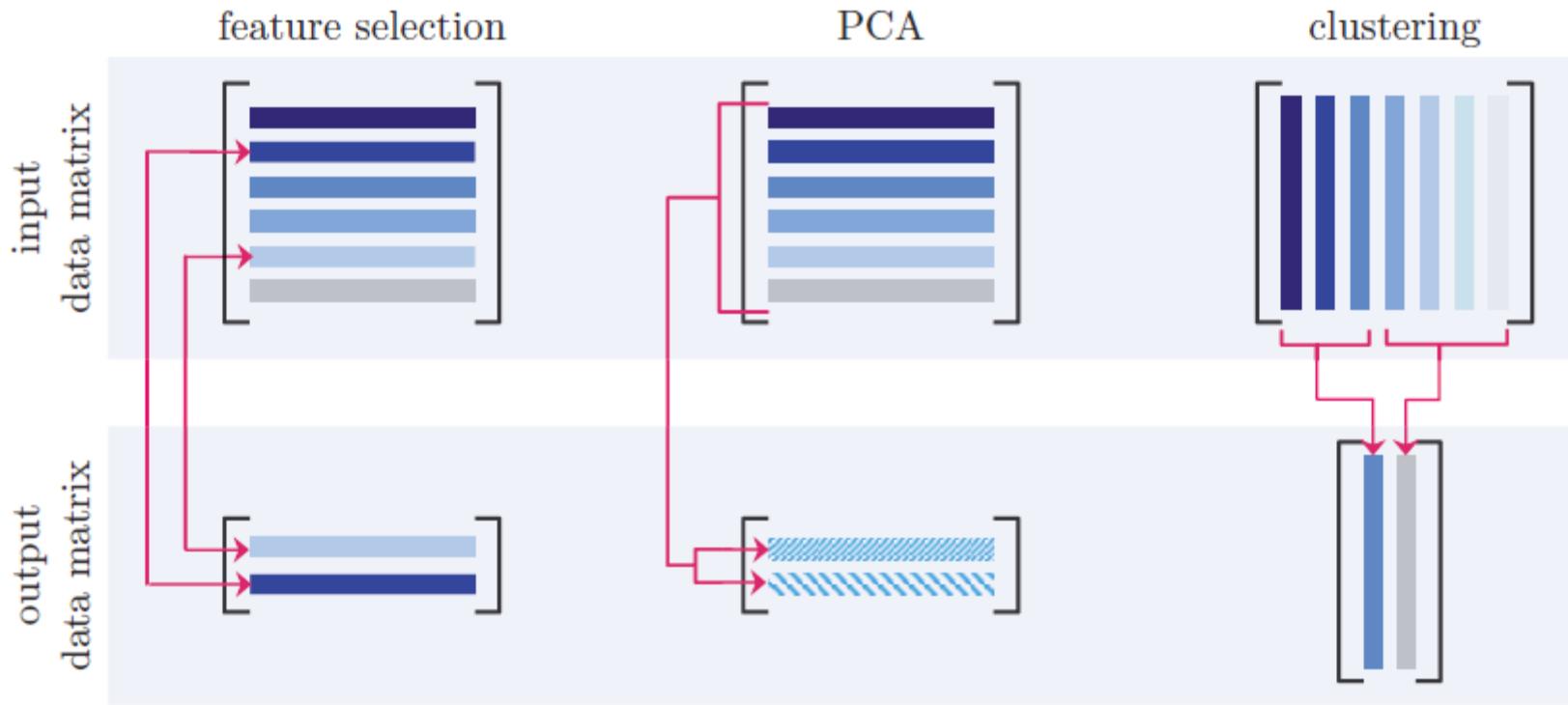


# Fusion of Multiple Time Duration Images Classification

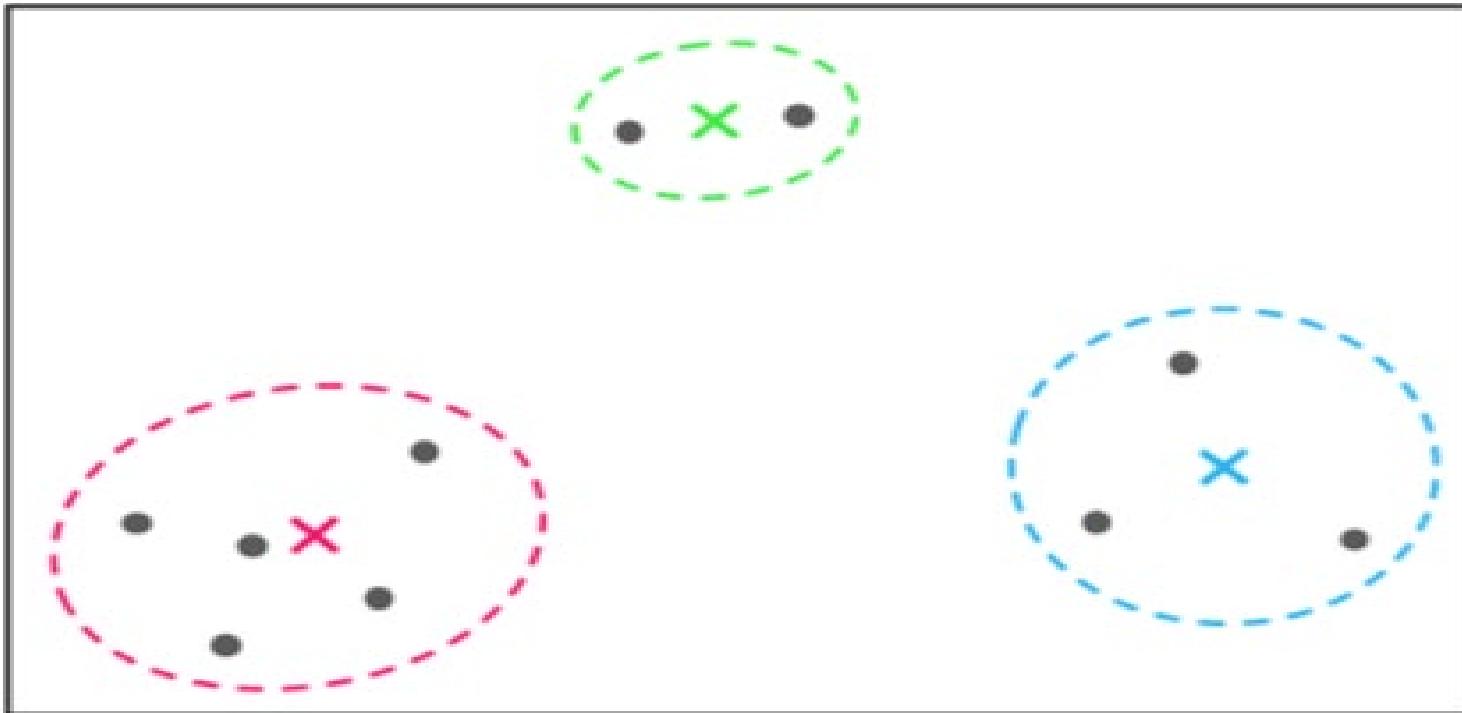
- Image classification using multiple time duration images
- An example of “whistle” image with two different time durations



# Dimensionality Reduction



# Dimension reduction: create a simpler representation of a dataset



Common preprocessing step for regression/classification

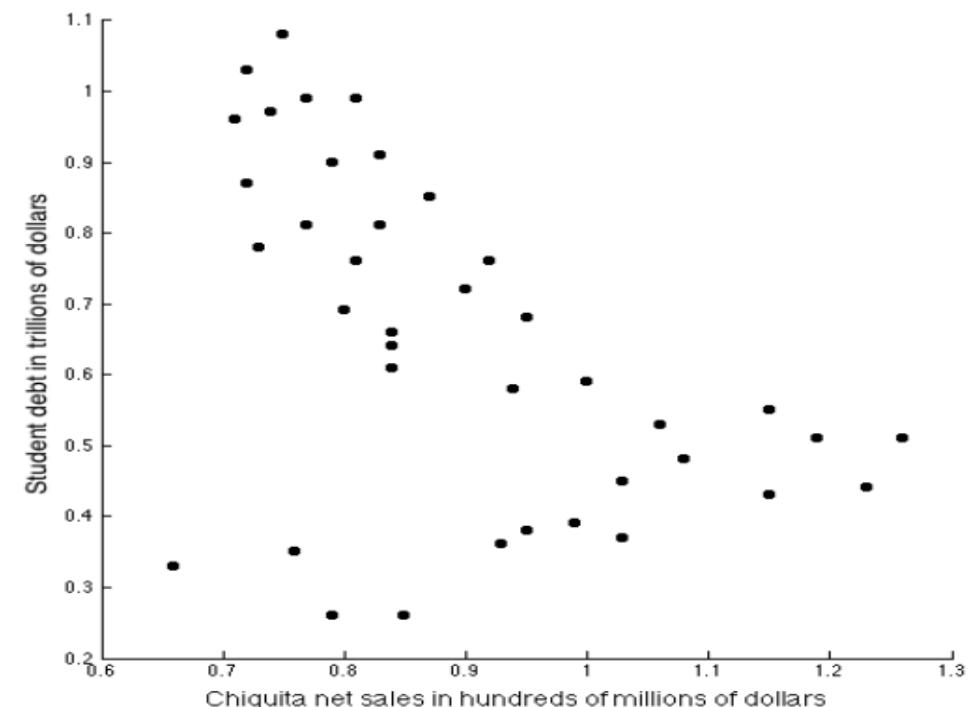
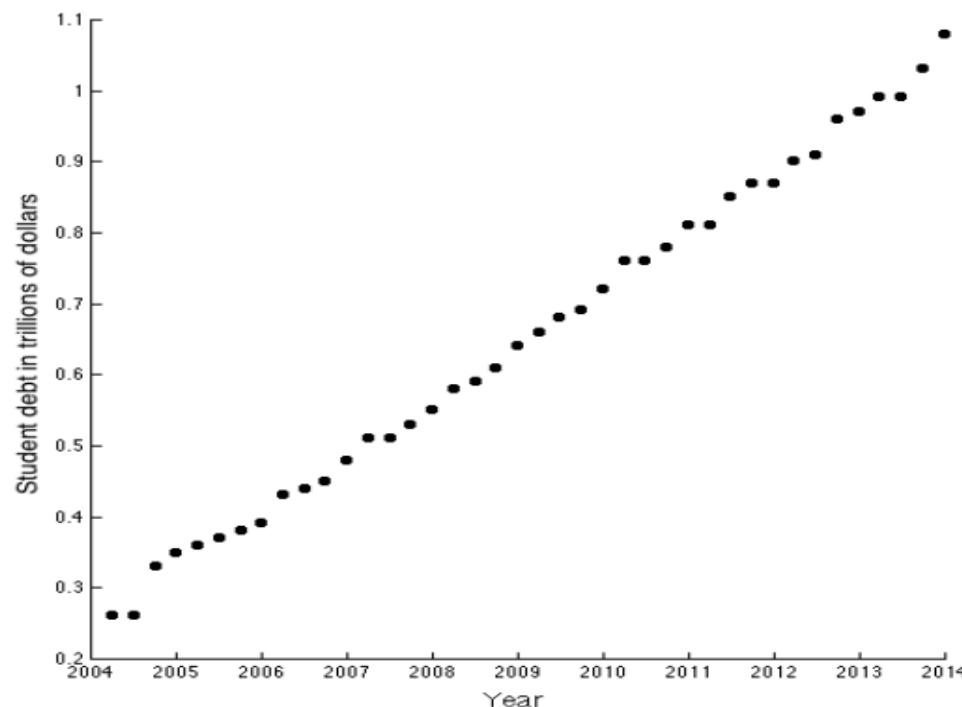
# Inpainting /Imputation of missing values

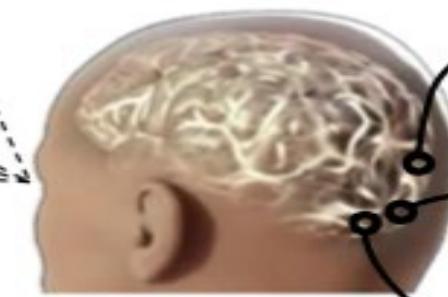
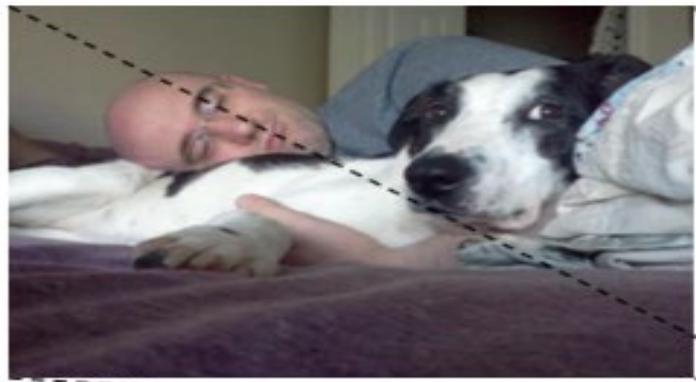


Two crucial ingredients

# Features: characteristics of a dataset that allow for optimal learning

- crucial to the performance of the basic building blocks





# Day-to-day Life Apps

- Virtual Personal Assistants (Siri, Alexa, Google Now)
- Predictions while Commuting
  - Traffic Predictions
  - Online Transportation Networks (Uber)
- Video Based Surveillance
- Social Media Services
  - People you may know
  - Face Recognition
  - Similar Pins (objects)
- Email Spam and Malware Filtering

# Day-to-day Life Apps

- Online Customer Support (chatbots)
- Search Engine Results Refining
- Product Recommendations
- Online Fraud Detection

# Top 10 (?)

1. Data Security
2. Personal Security
3. Financial Trading
4. Healthcare
5. Marketing Personalization
6. Fraud Detection
7. Recommendations
8. Online Search
9. Natural Language Processing
10. Smart Cars

# “Concerns” (at least in Medicine)

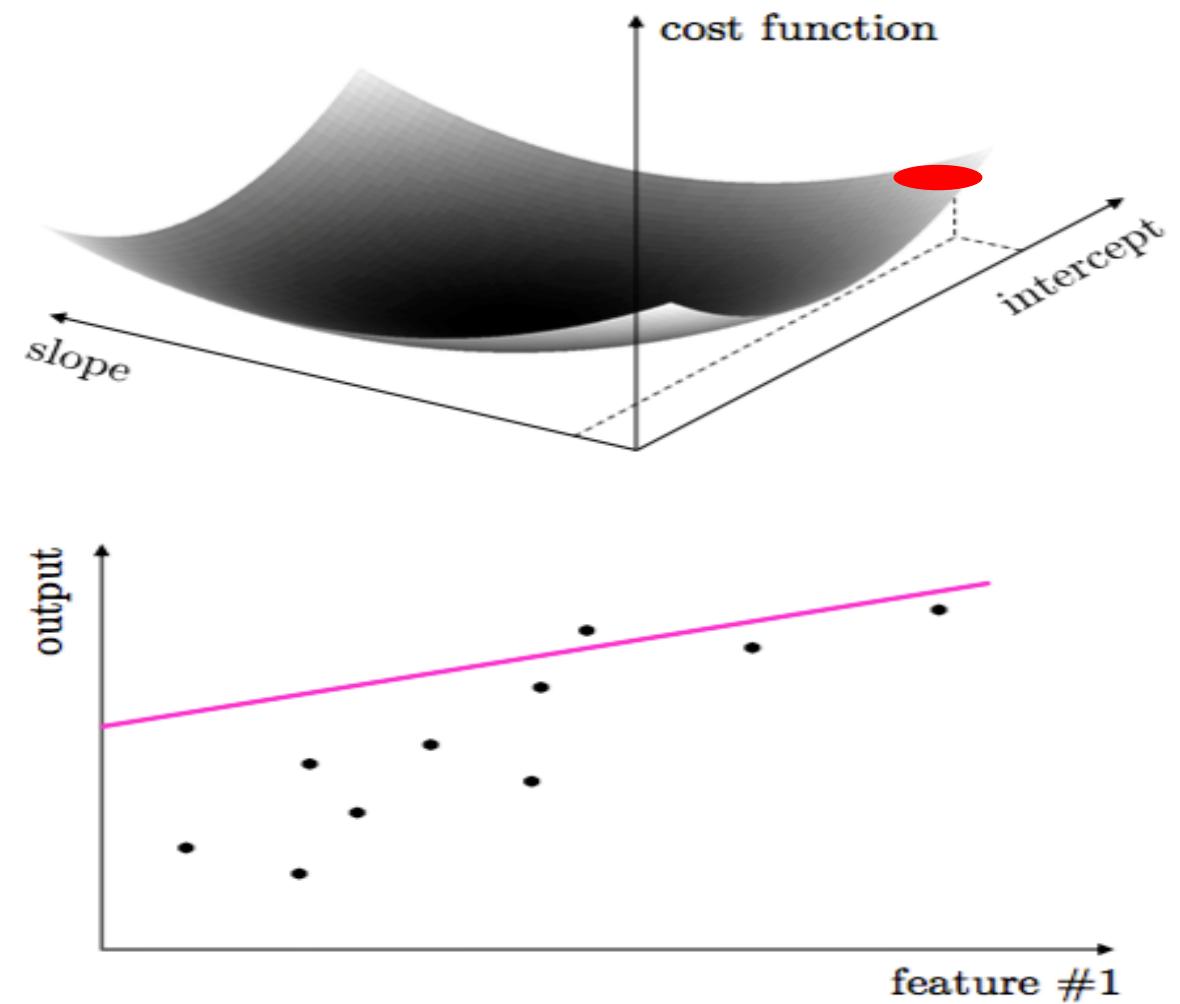
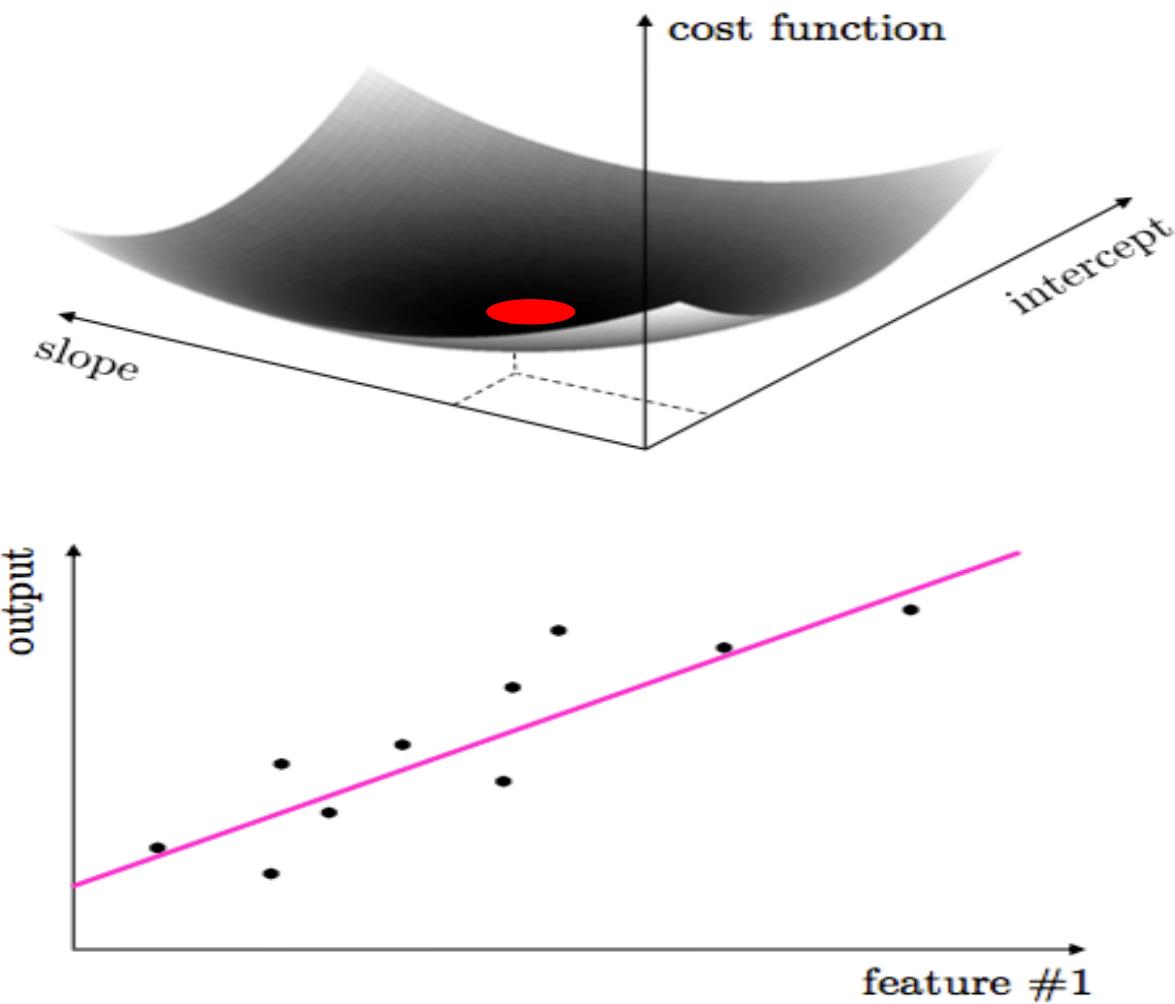
- Depersonalization (of medicine)
- Privacy of data
- Security of data
- Ownership of data
- Consistency of medical diagnoses
- Virtual therapists/medical assistants
- Remote monitoring

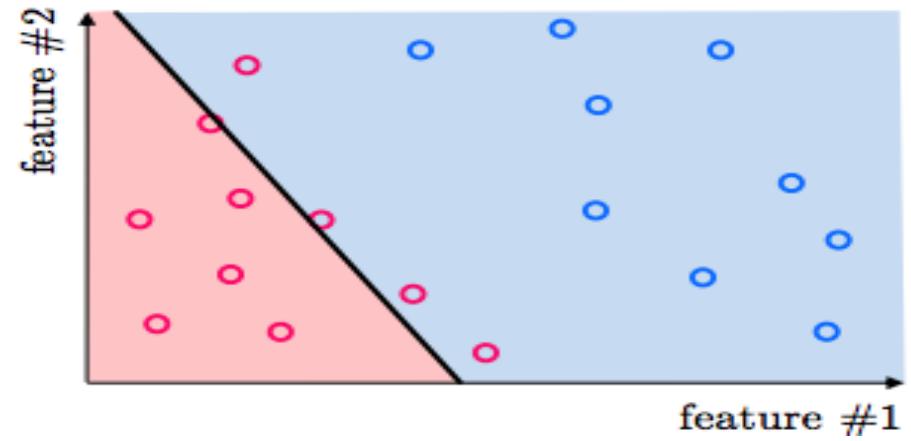
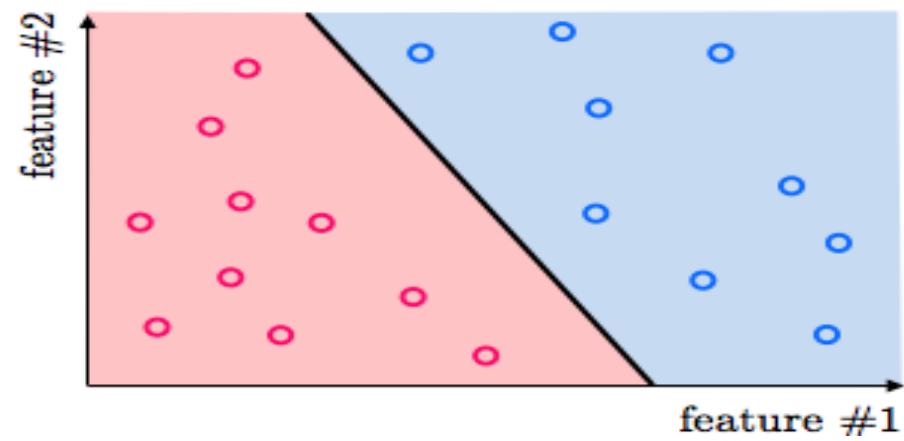
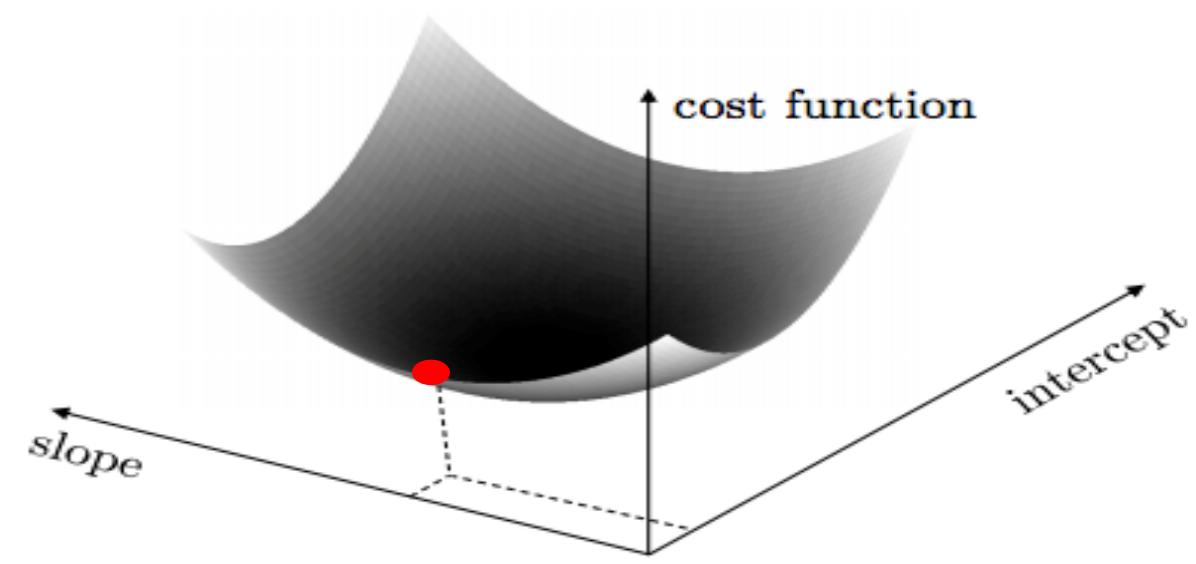
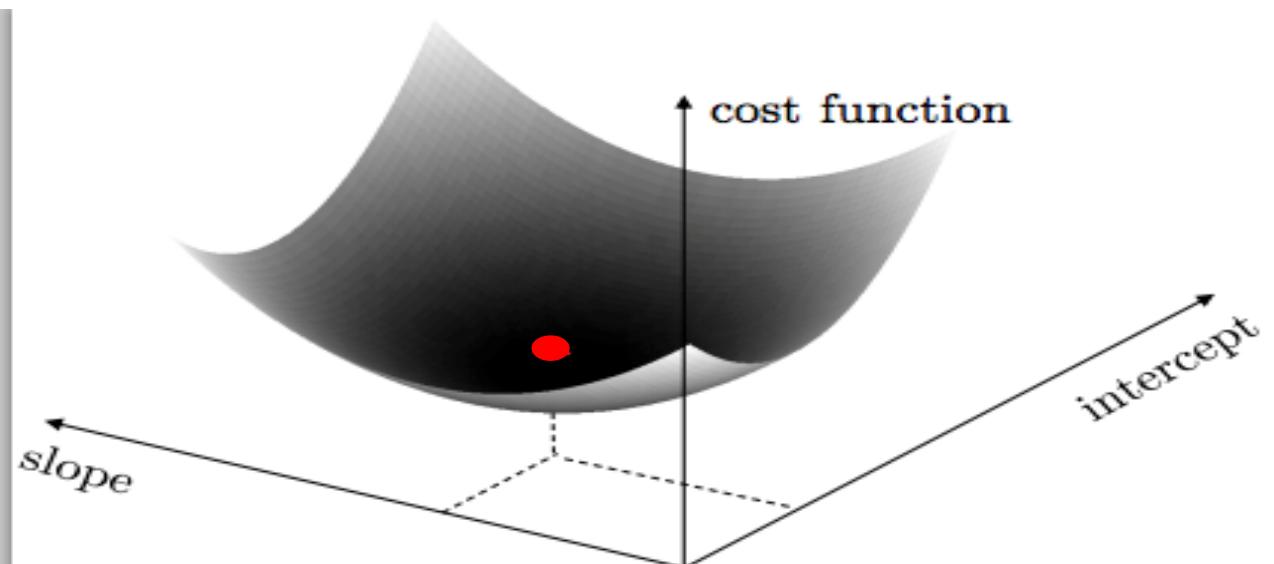
# Features: characteristics of a dataset that allow for optimal learning

- crucial to the performance of the basic building blocks
- how well we can design features dependent on our understanding of a phenomenon

# Numerical optimization: how we properly determine parameters of a model

- the search for proper parameters is codified in a mathematical *cost function*
- cost function take in model parameters and return score indicating how well we have performed a given task
- the *lower* the score the *better* the choice of parameters





# All together

