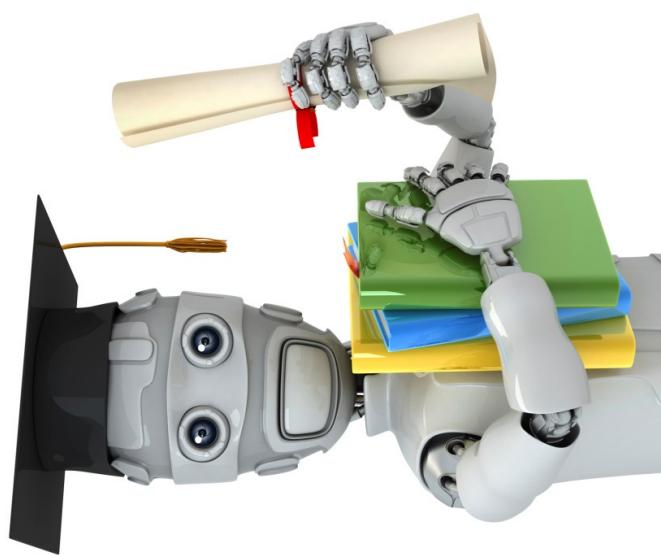


---

# Welcome

# Introduction



Machine Learning

Andrew Ng

The screenshot shows the Apple iLife '11 website on a computer screen. The main navigation bar at the top includes links for Store, Mac, iPod, iPhone, iPad, iTunes, Support, and Upgrade Now. Below the navigation bar, there's a large banner for iPhoto '11 featuring a smiling couple. To the left of the banner, there's a sidebar with icons for iPhoto, iMovie, GarageBand, Video Showcase, and Resources. The main content area has a heading "iPhoto '11" with a camera icon. Below it, a paragraph of text reads: "From your Facebook Wall to your coffee table to your best friend's inbox (or mailbox). Do more with your photos than you ever thought possible. And do it all in one place. iPhoto." To the right of the text is a small thumbnail image of the iPhoto interface. Further down the page, there's a section titled "What's New in iPhoto" with a link to "Watch the iPhoto video".



## Machine Learning

- Grew out of work in AI
- New capability for computers

### Examples:

- Database mining

Large datasets from growth of automation/web.

E.g., Web click data, medical records, biology, engineering

- Applications can't program by hand.

E.g., Autonomous helicopter, handwriting recognition, most of  
Natural Language Processing (NLP), Computer Vision.

## Machine Learning

- Grew out of work in AI

- |

Exam

- |

- ,

lost of  
lg



## Machine Learning

- Grew out of work in AI
- New capability for computers

### Examples:

- Database mining

Large datasets from growth of automation/web.

E.g., Web click data, medical records, biology, engineering

- Applications can't program by hand.

E.g., Autonomous helicopter, handwriting recognition, most of  
Natural Language Processing (NLP), Computer Vision.

## Machine Learning

- Grew out of work in AI
- New capability for computers

### Examples:

- Database mining

Large datasets from growth of automation/web.

E.g., Web click data, medical records, biology, engineering

- Applications can't program by hand.

E.g., Autonomous helicopter, handwriting recognition, most of  
Natural Language Processing (NLP), Computer Vision.

- Self-customizing programs

E.g., Amazon, Netflix product recommendations

## Machine Learning

- Grew out of work in AI
- New capability for computers

### Examples:

- Database mining

Large datasets from growth of automation/web.

E.g., Web click data, medical records, biology, engineering

- Applications can't program by hand.

E.g., Autonomous helicopter, handwriting recognition, most of  
Natural Language Processing (NLP), Computer Vision.

- Self-customizing programs

E.g., Amazon, Netflix product recommendations

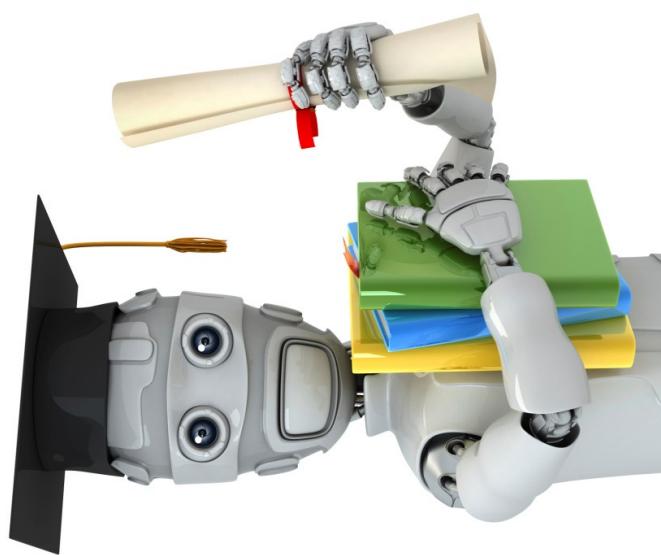
- Understanding human learning (brain, real AI).

Andrew Ng

# Introduction

---

# What is machine learning



Machine Learning

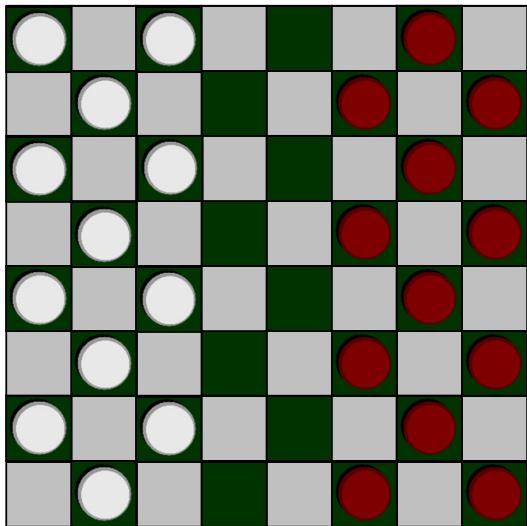
# Machine Learning definition

# Machine Learning definition

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

# Machine Learning definition

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



# Machine Learning definition

- Arthur Samuel (1959). Machine Learning: Field of study that gives computers the ability to learn without being explicitly programmed.
- Tom Mitchell (1998) Well-posed Learning Problem: A computer program is said to *learn* from experience E with respect to some task T and some performance measure P, if its performance on T, as measured by P, improves with experience E.

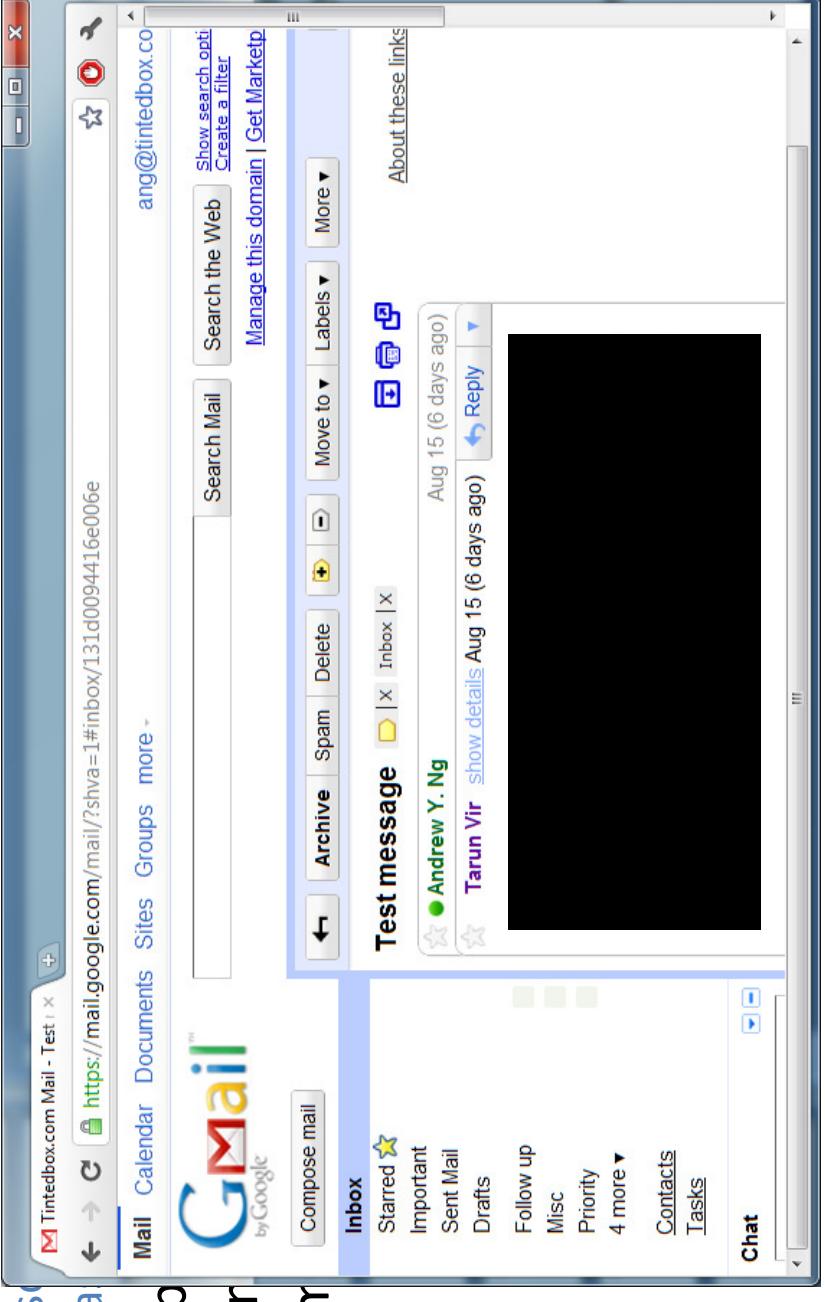
"A computer program is said to *learn from experience E* with respect to some task T and some performance measure P, if its performance on T, as measured by P, improves with experience E."

Suppose your email program watches which emails you do or do not mark as spam, and based on that learns how to better filter spam. What is the task T in this setting?

- Classifying emails as spam or not spam.  $T \leftarrow$
- Watching you label emails as spam or not spam.  $E \leftarrow$
- The number (or fraction) of emails correctly classified as spam/not spam.
- None of the above—this is not a machine learning problem.  $P \leftarrow$

"A computer program is said to *learn* from experience E with respect to class C if its performance improves with respect to class C as it is exposed to more examples from E."

Support not spam



The screenshot shows a Gmail inbox with one visible message:

- From:** Andrew Y. Ng (andrew.y.ng@gmail.com)
- To:** [Redacted]
- Date:** Aug 15 (6 days ago)
- Subject:** [Redacted]
- Message Preview:** [Redacted]

The interface includes standard Gmail controls like Compose mail, Inbox, Starred, Important, Sent Mail, Drafts, Follow up, Misc, Priority, and Chat.

pam.

"A computer program is said to *learn from experience E* with respect to some task T and some performance measure P, if its performance on T, as measured by P, improves with experience E."

Suppose your email program watches which emails you do or do not mark as spam, and based on that learns how to better filter spam. What is the task T in this setting?

- Classifying emails as spam or not spam.  $T \leftarrow$
- Watching you label emails as spam or not spam.  $E \leftarrow$
- The number (or fraction) of emails correctly classified as spam/not spam.
- None of the above—this is not a machine learning problem.  $P \leftarrow$

Machine learning algorithms:

- Supervised learning
- Unsupervised learning



Others: Reinforcement learning, recommender systems.

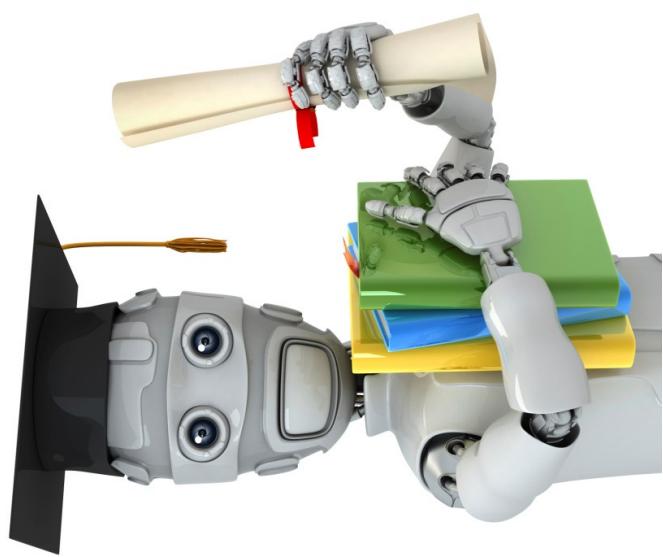
Also talk about: Practical advice for applying learning algorithms.



Andrew Ng

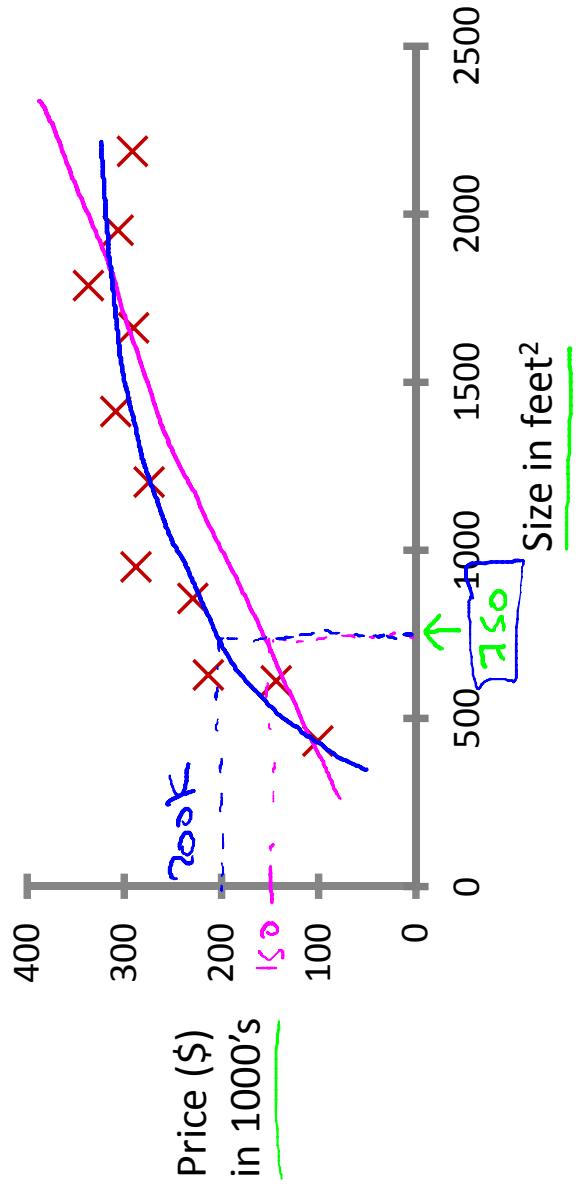
# Introduction Supervised Learning

---



Machine Learning

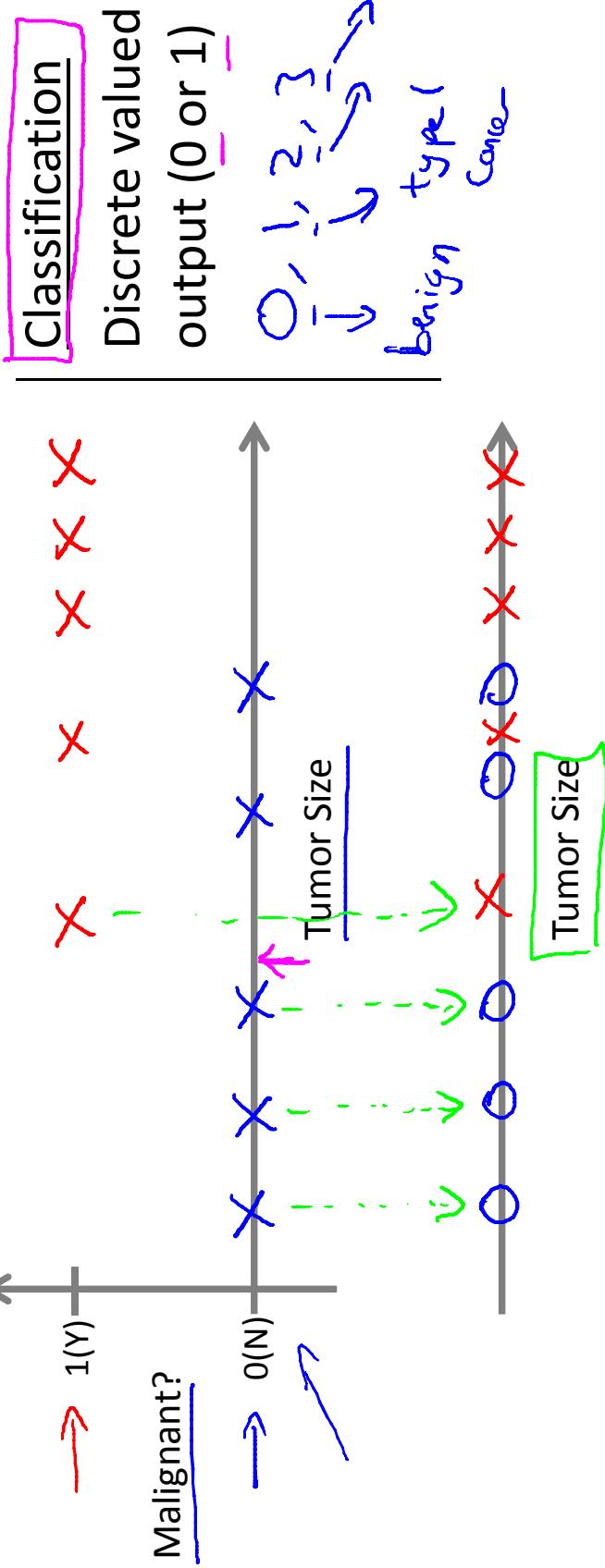
## Housing price prediction.

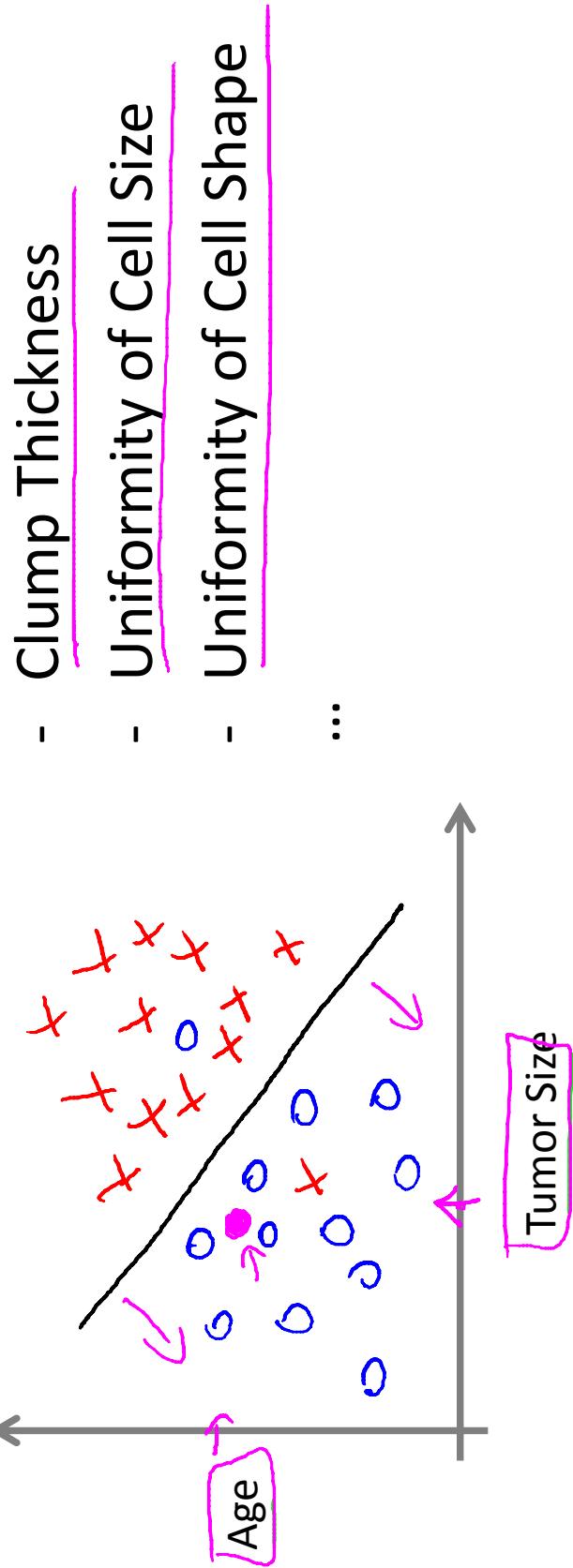


Supervised Learning  
"right answers" given

Regression: Predict continuous  
valued output (price)

## Breast cancer (malignant, benign)





You're running a company, and you want to develop learning algorithms to address each of two problems.

1000's

Problem 1: You have a large inventory of identical items. You want to predict how many of these items will sell over the next 3 months.

Problem 2: You'd like software to examine individual customer accounts, and for each account decide if it has been hacked/compromised.

$\xrightarrow{0 - \text{not hacked}}$

$\xrightarrow{1 - \text{hacked}}$

Should you treat these as classification or as regression problems?

- Treat both as classification problems.
- Treat problem 1 as a classification problem, problem 2 as a regression problem.
- Treat problem 1 as a regression problem, problem 2 as a classification problem.
- Treat both as regression problems.

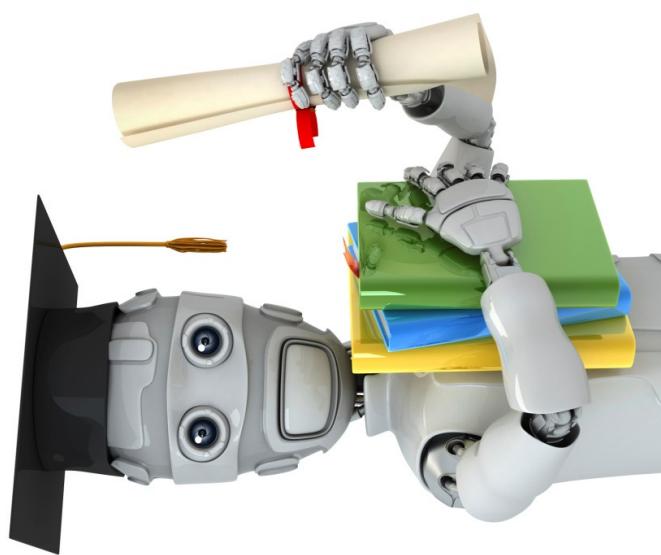
Andrew Ng

# Introduction

---

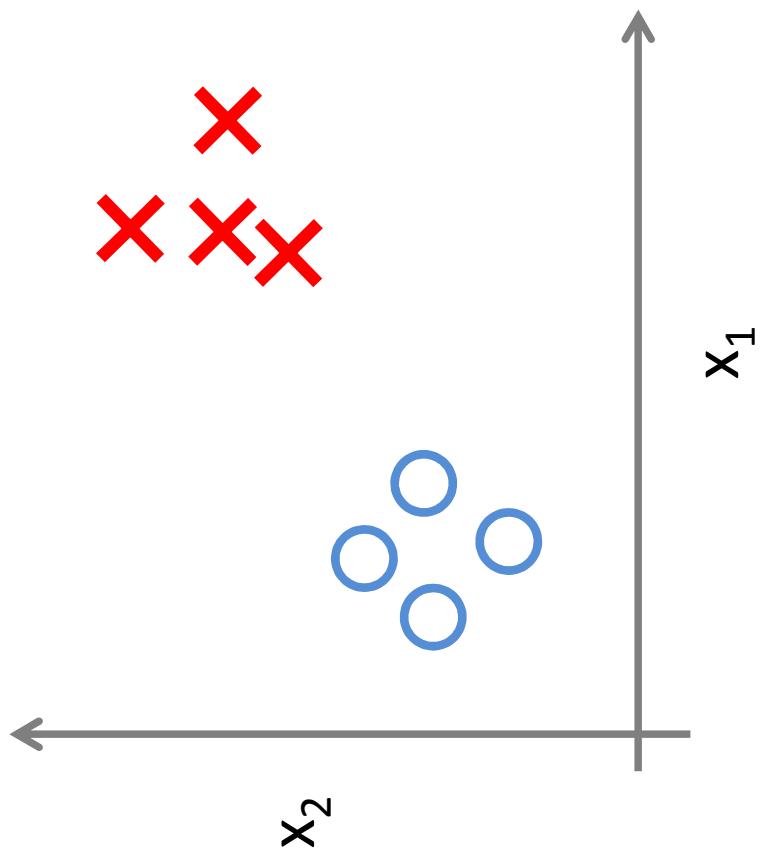
# Unsupervised

# Learning

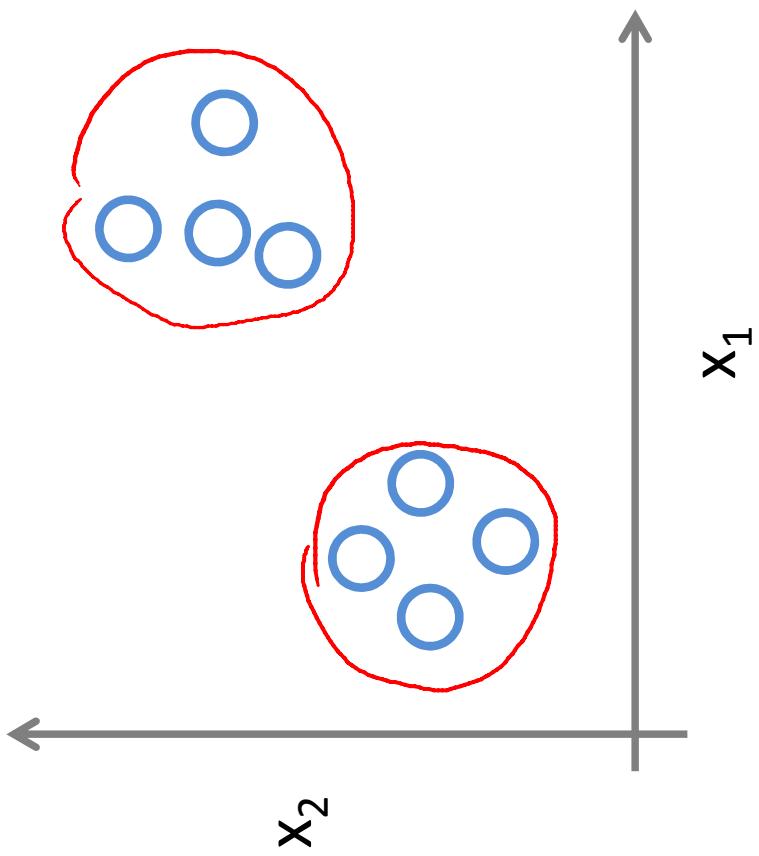


Machine Learning

# Supervised Learning



# Unsupervised Learning



news.google.com

andrewyantakng@gmail.com | Web History | Settings ▾ | Sign out

## Google news

Search News Search the Web Advanced news search

Top Stories

- Deepwater Horizon
- Fed meeting
- Foreign exchange market
- Lindsay Lohan
- IBM
- Tom Brady
- Toronto International Film Festival
- Paris Hilton
- Iran
- Hurricane Igor

Starred ★

- San Francisco Bay Area
- World
- U.S.
- Business
- Sci/Tech
- More Top Stories
- Spotlight
- Health
- Sports
- Entertainment

All news Headlines Images

Top Stories

Christine O'Donnell » **White House official denies Tea Party-focused ad campaign** CNN International - Ed Henry - 1 hour ago Democratic sources say the White House is not considering an ad campaign tying Republicans to the Tea Party. Washington (CNN) -- A top White House official sharply denied a report that claims President Obama's political advisers are weighing a national ...  
Tea Party is misplacing the blame, former President Bill Clinton claims New York Daily News  
GOP tea party backer defends Christine O'Donnell The Associated Press Atlanta Journal Constitution - Politics Daily - MyFox Washington DC - Salon all 726 news articles »

**US Stocks Climb After Recession Called Over, Homebuilders Gain** MarketWatch - Kristina Peterson - 16 minutes ago NEW YORK (MarketWatch) -- US stocks climbed Monday, gaining speed after a key nonprofit organization officially called the recession over, giving investors a boost of confidence in the gradual economic recovery.  
Longest recession since 1930s ended in June 2009, group says Los Angeles Times  
Downturn Was Longest in Decades, Panel Confirms New York Times Wall Street Journal - AFP - CNN - USA Today all 276 news articles »

Deepwater Horizon » **BP Oil Well, Site of National Catastrophe, Dies at One** Vanity Fair - Juli Weiner - 22 minutes ago The BP oil well, site of the Deepwater Horizon explosion that led to the worst oil spill in US history, died today at one year old.  
Video: Blown-out BP Well Finally Killed in Gulf You Tube The Associated Press Weiss Doubts BP Would End Operations in Gulf of Mexico: Video Bloomberg CNN International - Wall Street Journal (blog) - The Guardian - New York Times all 2,292 news articles »

RECESSION

REUTERS

Recent

Recession officially ended in June 2009 CNNMoney - Chris Isidore - 39 minutes ago Hurricane Igor lashes Bermuda USA Today - Gerry Broome - 5 minutes ago 'Explain what you want from us.' reads front-page editorial msnbc.com - Olivia Torres - 10 minutes ago

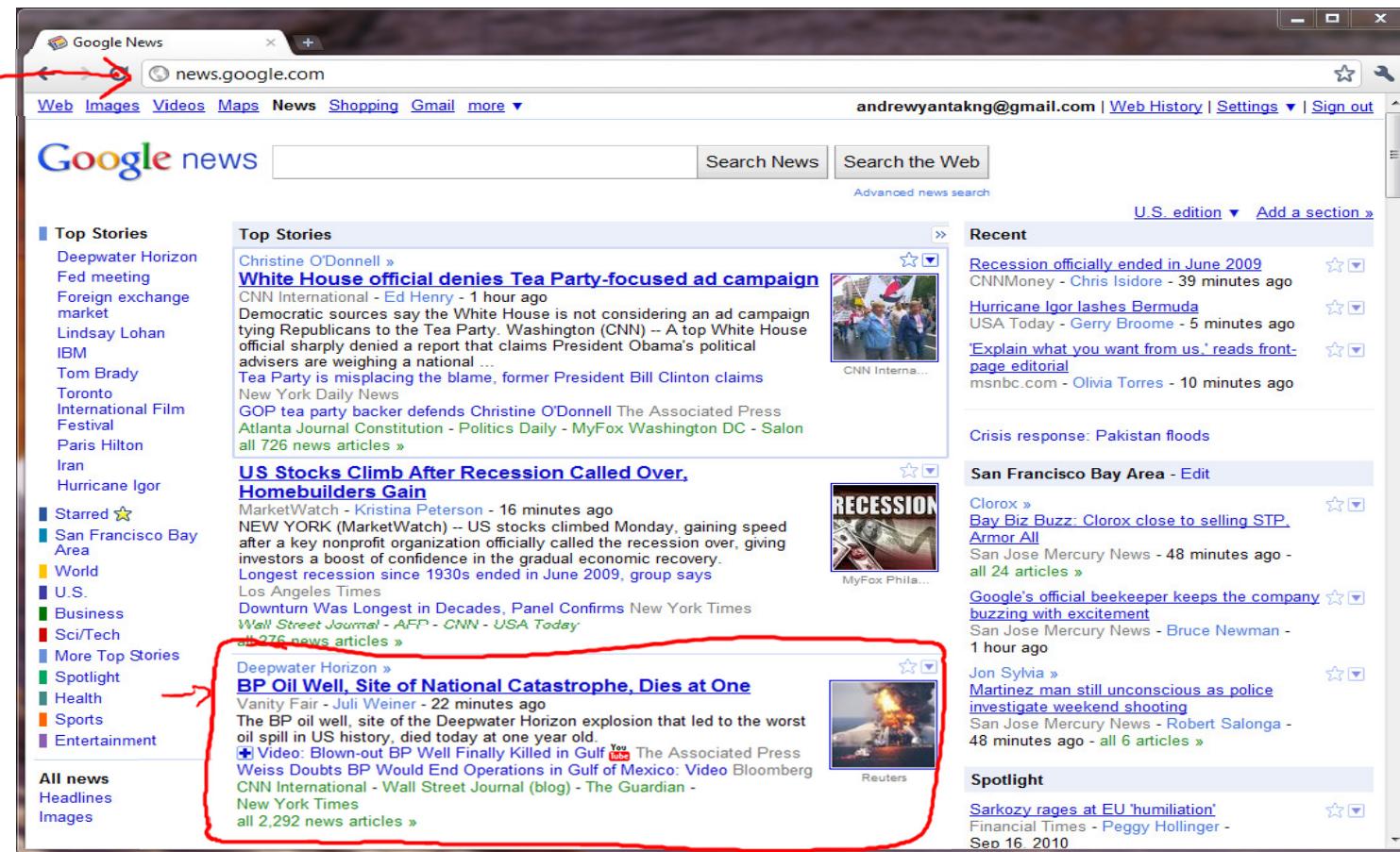
Crisis response: Pakistan floods

San Francisco Bay Area - Edit

Clorox » Bay Biz Buzz: Clorox close to selling STP, Armor All San Jose Mercury News - 48 minutes ago - all 24 articles » Google's official beekeeper keeps the company buzzing with excitement San Jose Mercury News - Bruce Newman - 1 hour ago Jon Sylvia » Martinez man still unconscious as police investigate weekend shooting San Jose Mercury News - Robert Salonga - 48 minutes ago - all 6 articles »

Spotlight

Sarkozy rages at EU 'humiliation' Financial Times - Peggy Hollinger - Sep 16, 2010



Andrew Ng

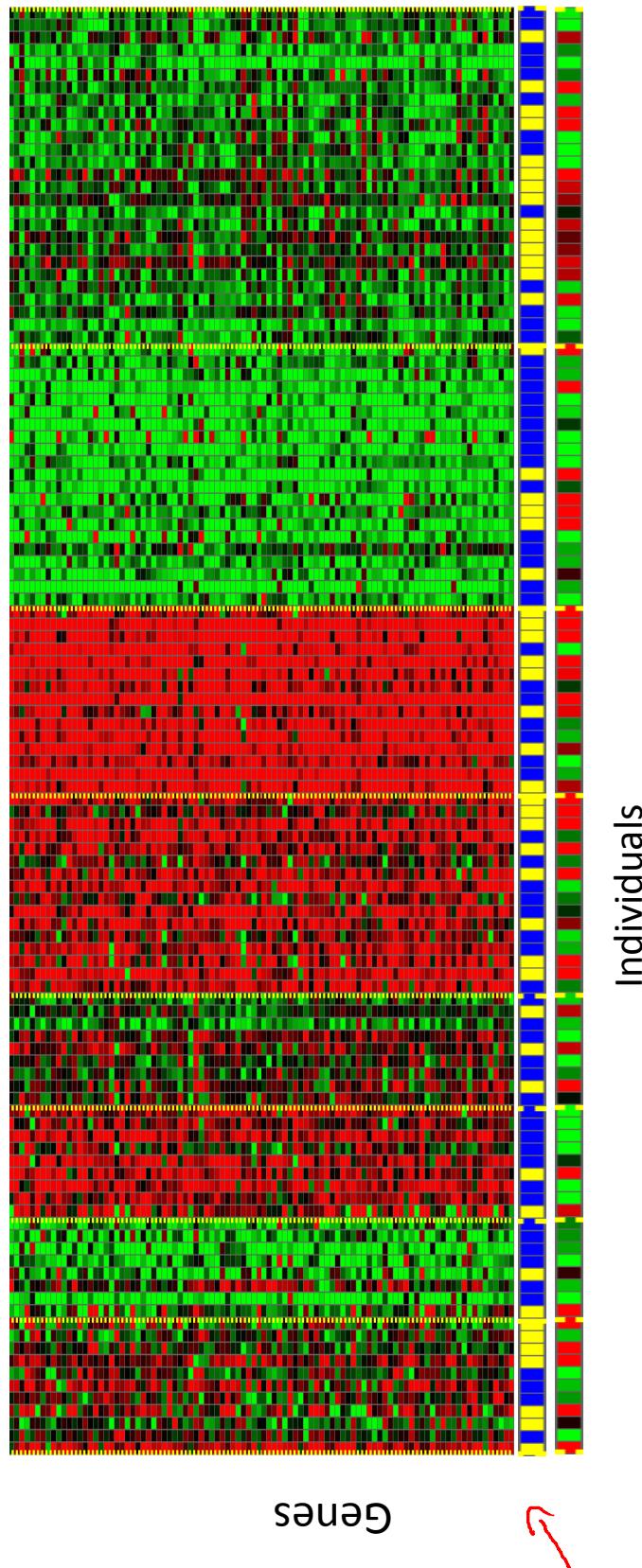
Andrew

**BP Kills Macondo, But Its Legacy Lives On**

**BP oil spill cost hits nearly \$10bn**

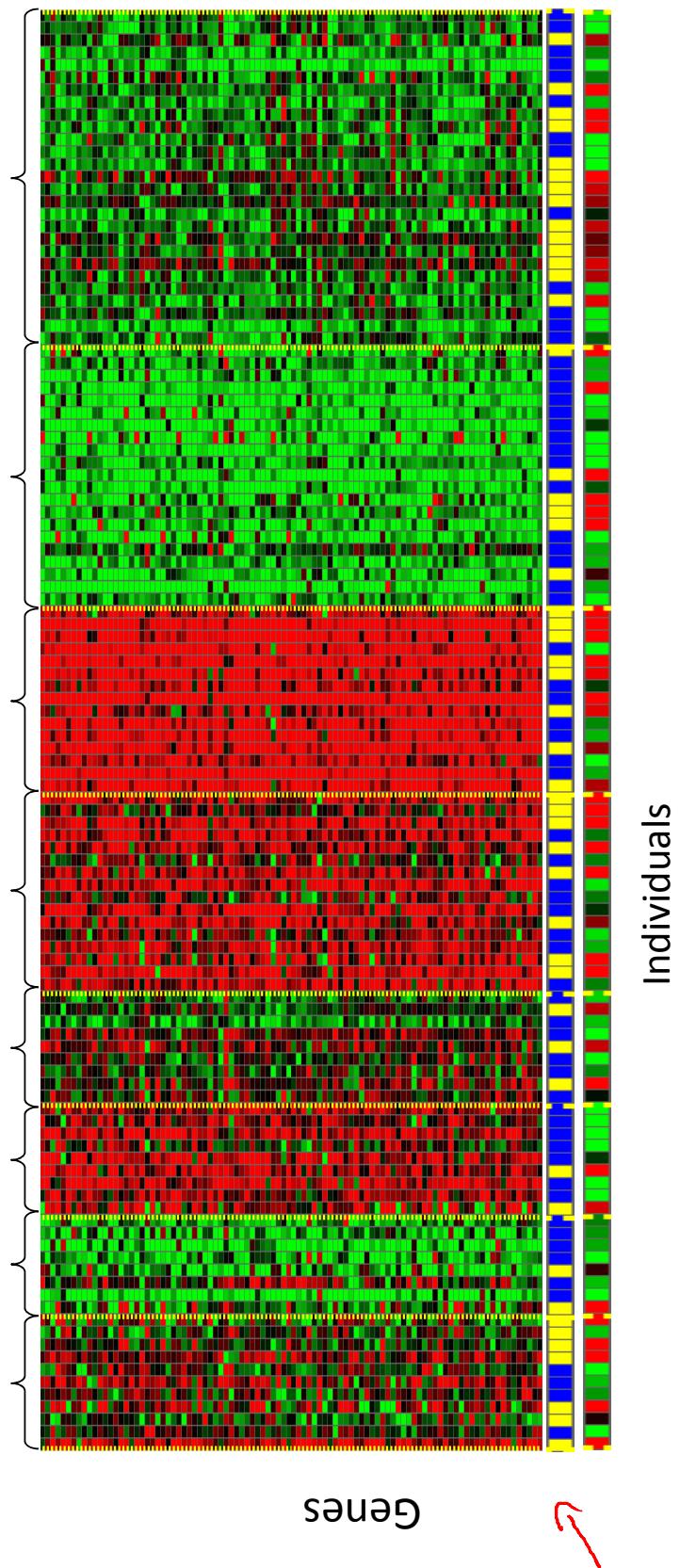
**Alien: Well is dead, but much Gulf Coast work remains**

Andrew Ng



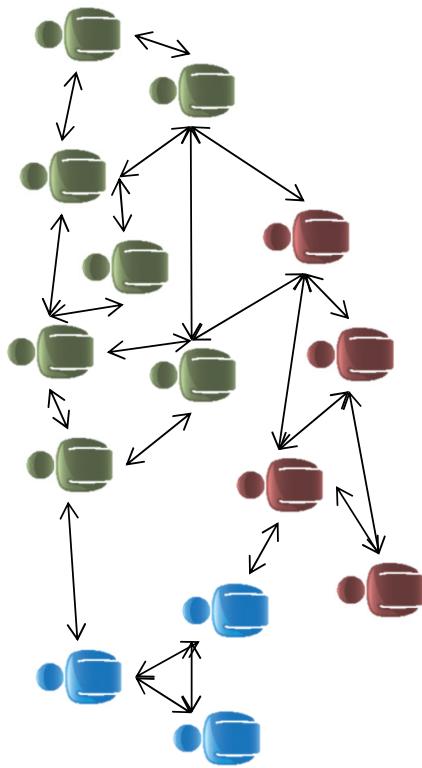
[Source: Daphne Koller]

Andrew Ng

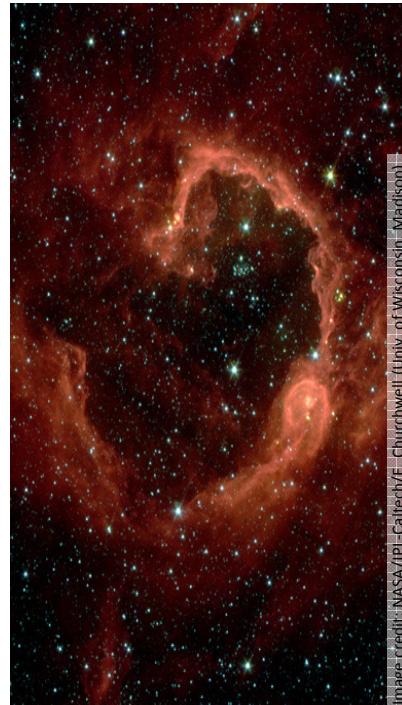


[Source: Daphne Koller]

Andrew Ng



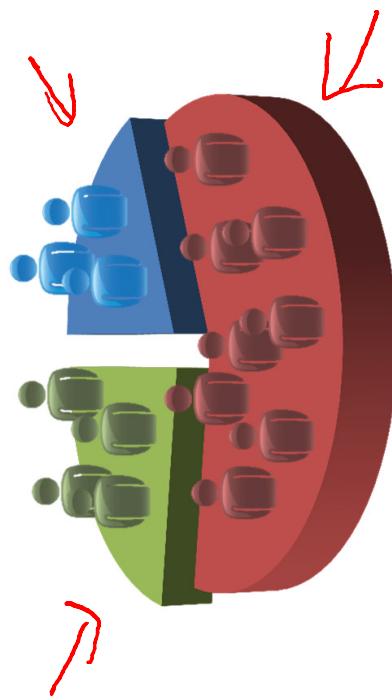
Social network analysis



Astronomical data analysis

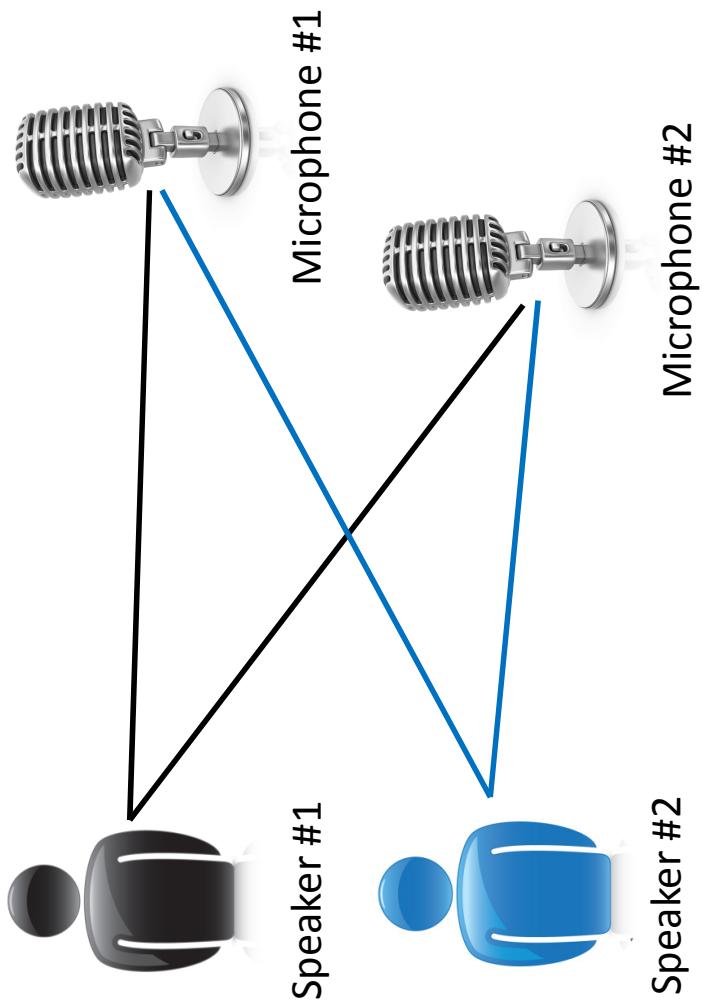


Organize computing clusters



Market segmentation

# Cocktail party problem



Microphone #1: 

Output #1: 

Microphone #2: 

Output #2: 

---

Microphone #1: 

Output #1: 

Microphone #2: 

Output #2: 

[Audio clips courtesy of Te-Won Lee.]

# Cocktail party problem algorithm

```
[W,s,v] = svd((repmat(sum(x.*x,1),size(x,1),1).*x).*x');
```

[Source: Sam Roweis, Yair Weiss & Eero Simoncelli]

Andrew Ng

Of the following examples, which would you address using an unsupervised learning algorithm? (Check all that apply.)

- Given email labeled as spam/not spam, learn a spam filter.
- Given a set of news articles found on the web, group them into a set of articles about the same story.
- Given a database of customer data, automatically discover market segments and group customers into different market segments.
- Given a dataset of patients diagnosed as either having diabetes or not, learn to classify new patients as having diabetes or not.

Andrew Ng