

# Recommender Systems

A Lecture in the Freshman Seminar Series:  
Puzzling Problems in Science and Technology



Oct. 2018



Recommender Systems



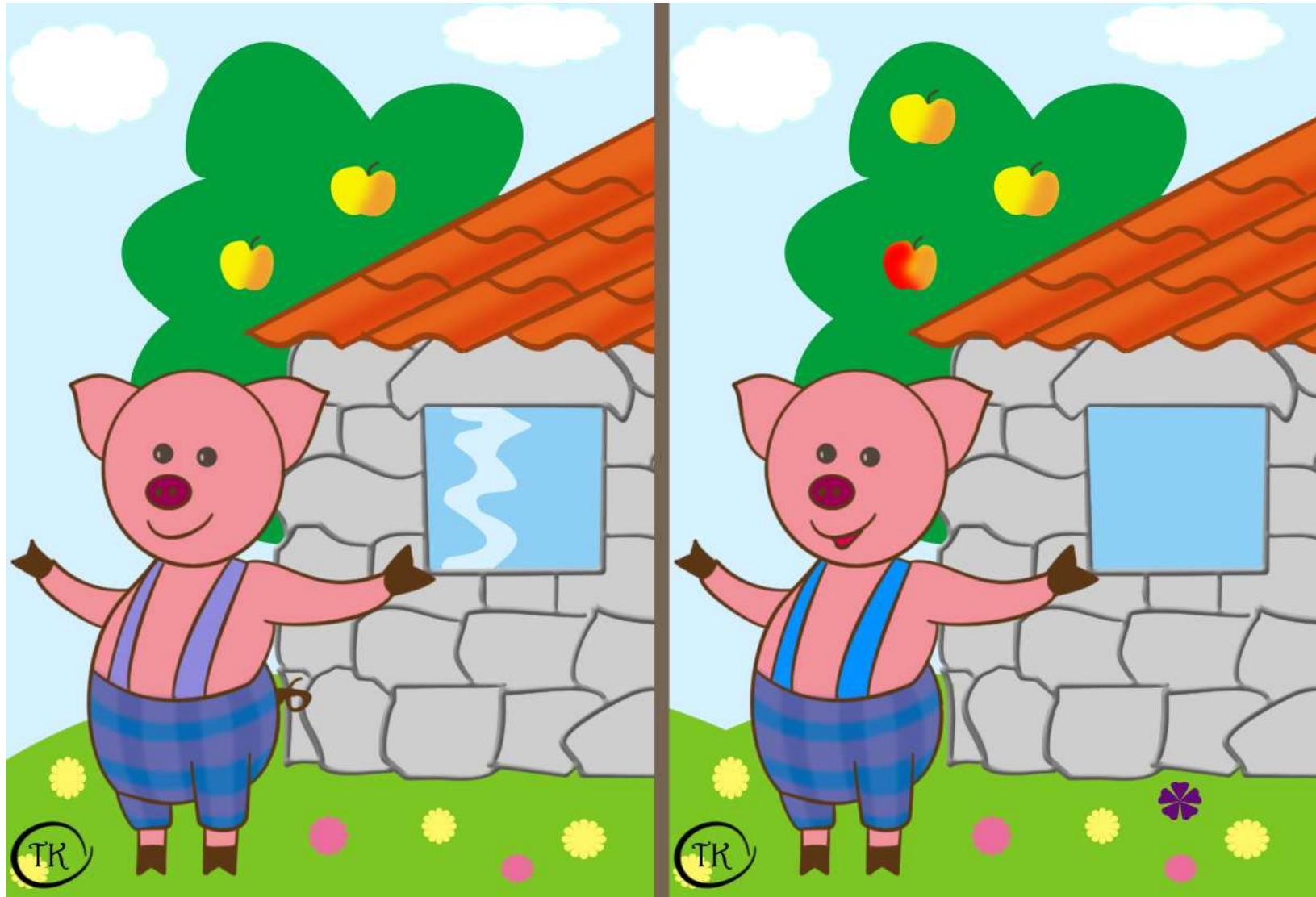
Slide 1

# About This Presentation

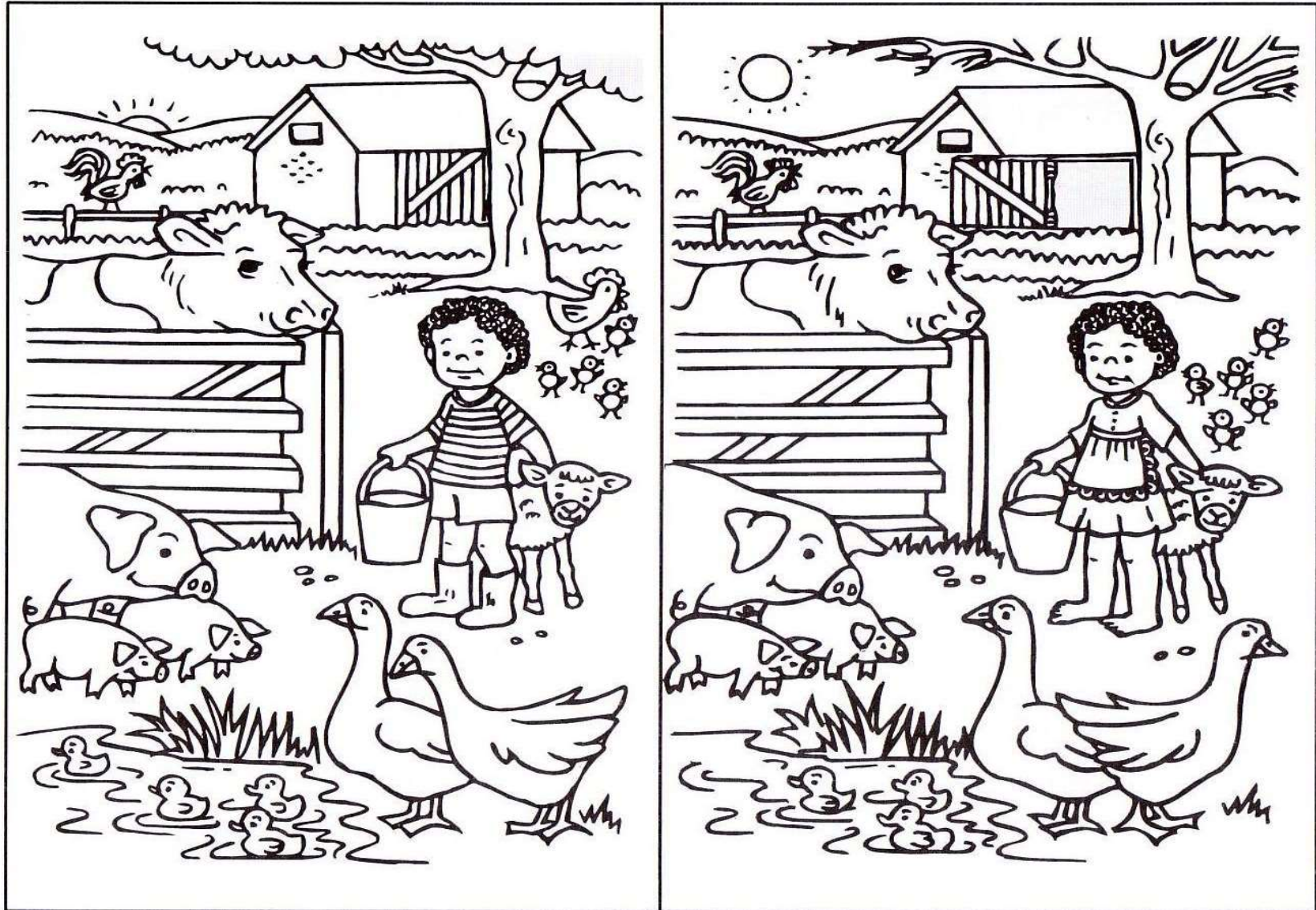
This presentation belongs to the lecture series entitled “Puzzling Problems in Science and Technology,” devised for a ten-week, one-unit, freshman seminar course by Behrooz Parhami, Professor of Computer Engineering at University of California, Santa Barbara. The material can be used freely in teaching and other educational settings. Unauthorized uses, including any use for financial gain, are prohibited. © Behrooz Parhami

<b>Edition</b>	<b>Released</b>	<b>Revised</b>	<b>Revised</b>	<b>Revised</b>	<b>Revised</b>
<b>First</b>	Oct. 2016	Oct. 2018			

# Find Seven Differences between These Images



# How Are These Two Images Different?







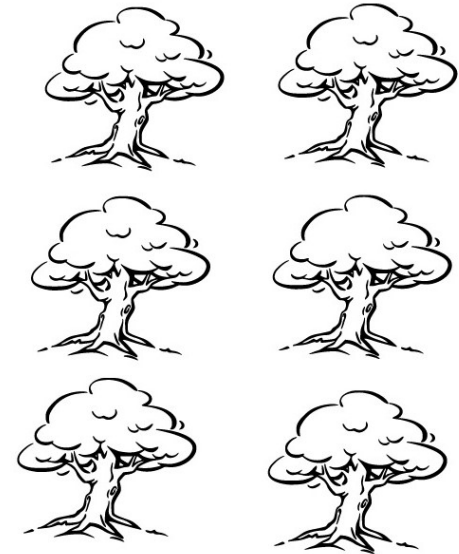
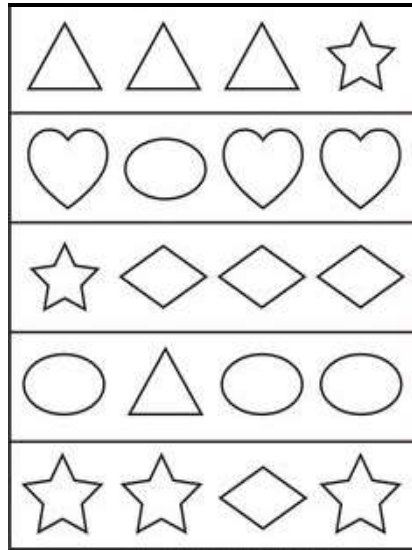
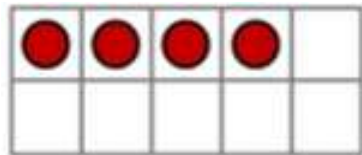
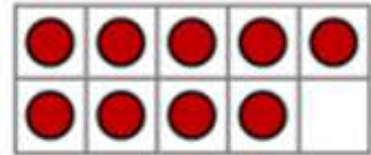
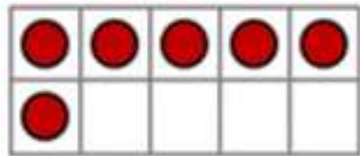
# Identify All the Differences in these Two Images



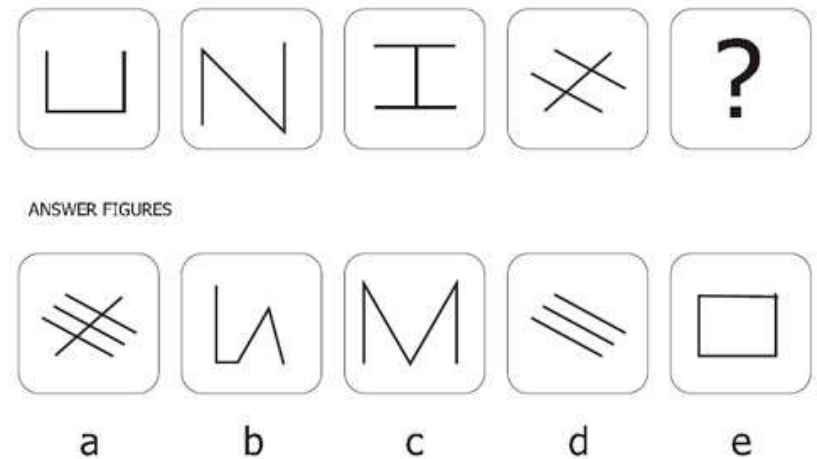
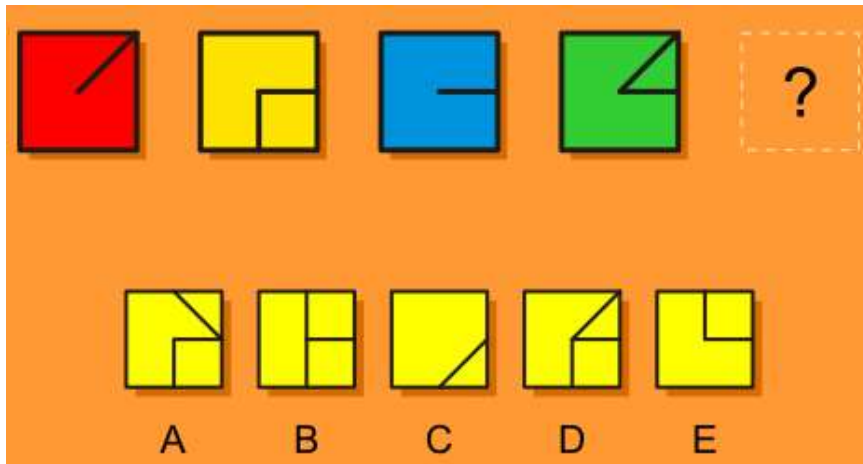
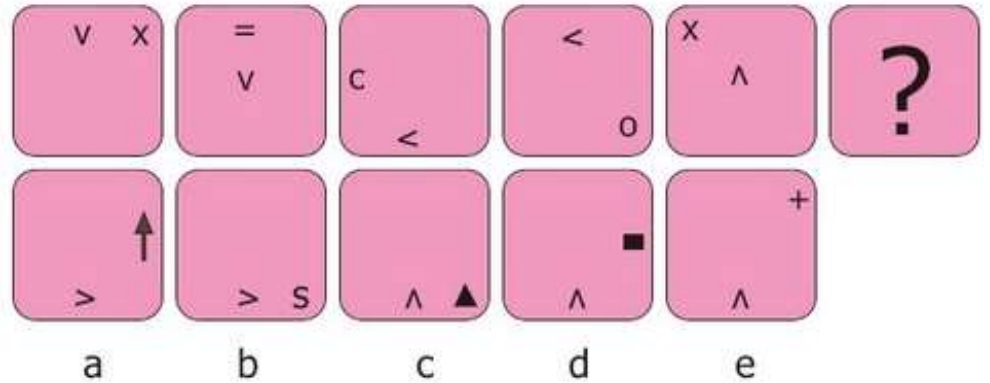
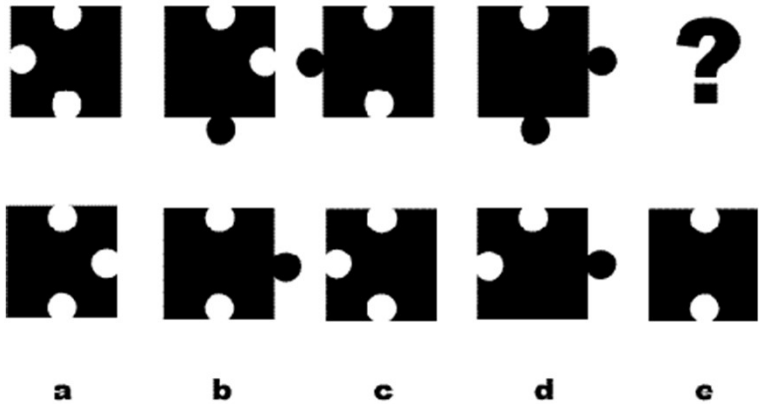
# Which Term Isn't Like the Others?

A	H	I	M	N	O	V	W	X
0	3	6	7	8	9			
3	4	7	13	20	33	53	86	139

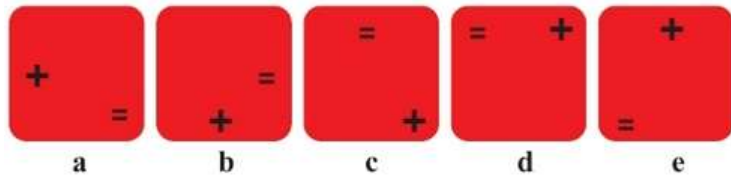
			
Big	Fast	Green	Warm



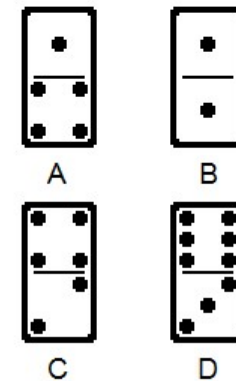
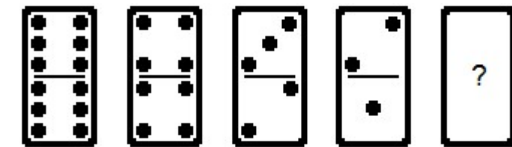
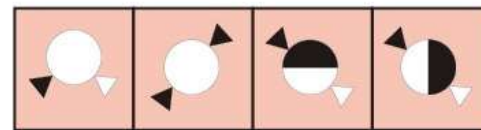
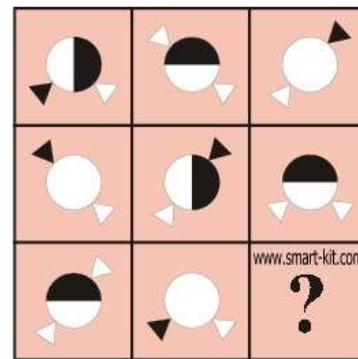
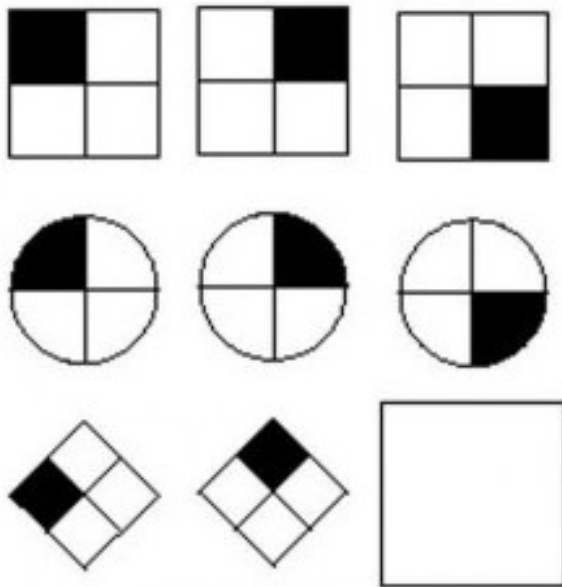
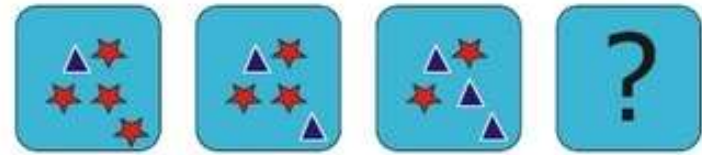
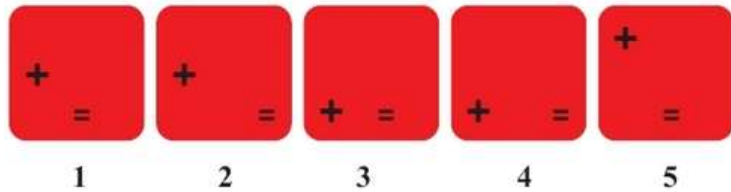
# Which Image Should Come Next?



# Which Image Should Come Next? (Part 2)



Answer figures





# Similarity Puzzles with Words

What do the following sets of words have in common?

assess; banana; dresser; grammar; potato; revive; uneven  
(besides all having at least two repeating letters)

bulb; orange; angel; silver; month; revive; uneven

baobab; youngberry; hopscotch; yieldability; dachshund;  
dumbfounded

aquamarine; beloved; discrepancy; frangipani; freedom;  
gallipot; overflowing; pagoda; scrounger

# Classifying by Color, Shape, or Other Features

Very young kids are taught about classification by features  
(2-minute video: <http://www.youtube.com/watch?v=5bip0bcFlgo>)

Possible features in the shapes shown in the video:

Color: Blue, Green, Orange, Yellow

Geometric shape: Square, Rectangle, Triangle, Circle, ...

Curvature: Straight sides only, at least one curved side

Size: Large, Small (area)

Number of sides: 2, 3, 4

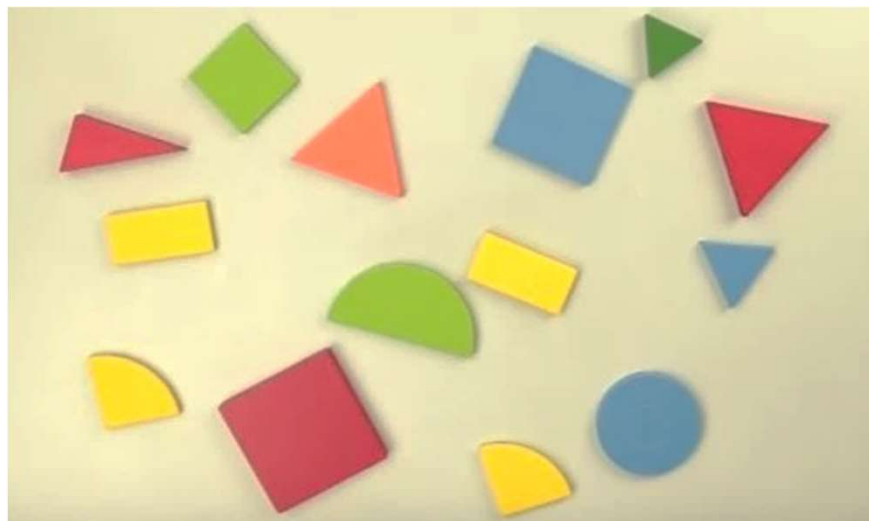
Triangleness: Yes, No

Thickness?

Material?

Weight?

Floats on water?



# Example: Recognizing Five Letters

**A, B, C, D, E**

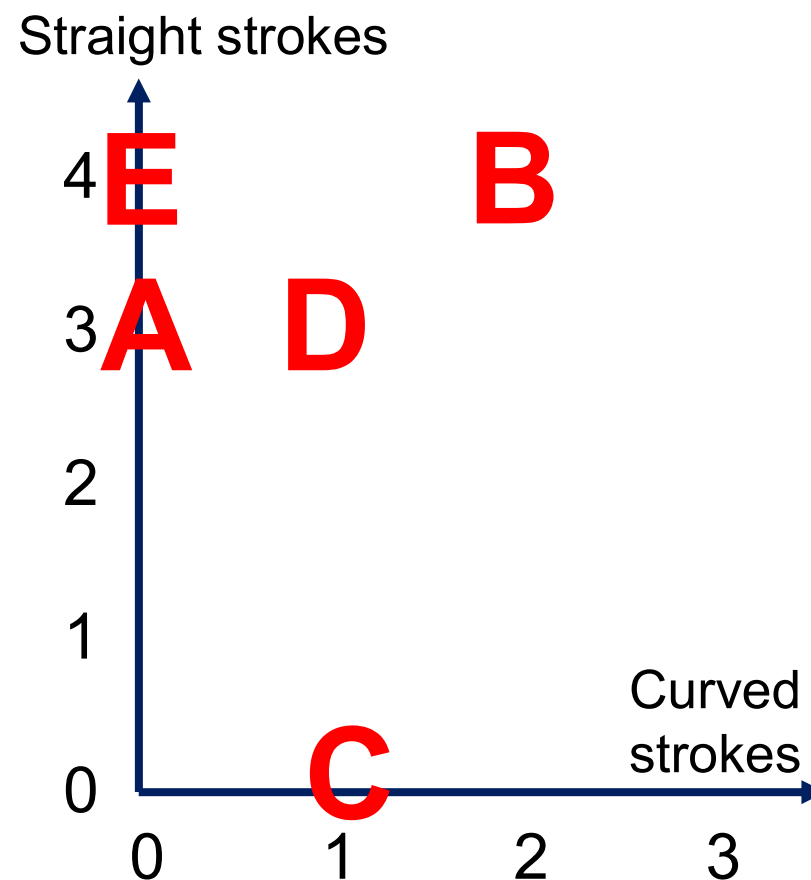
Example features:

$x$ : Number of curved segments

$y$ : Number of straight segments

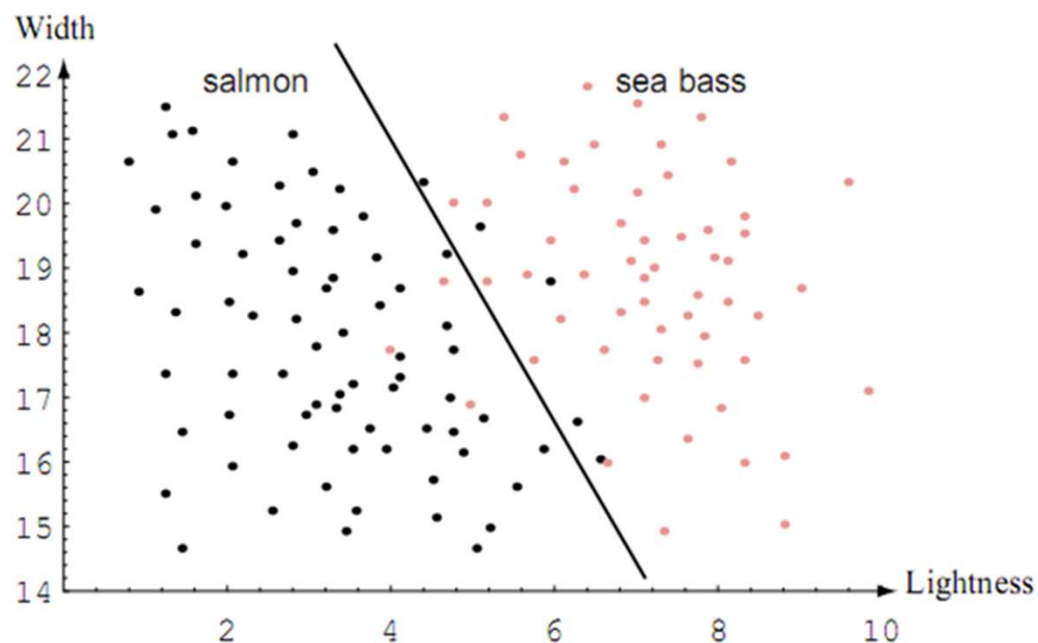
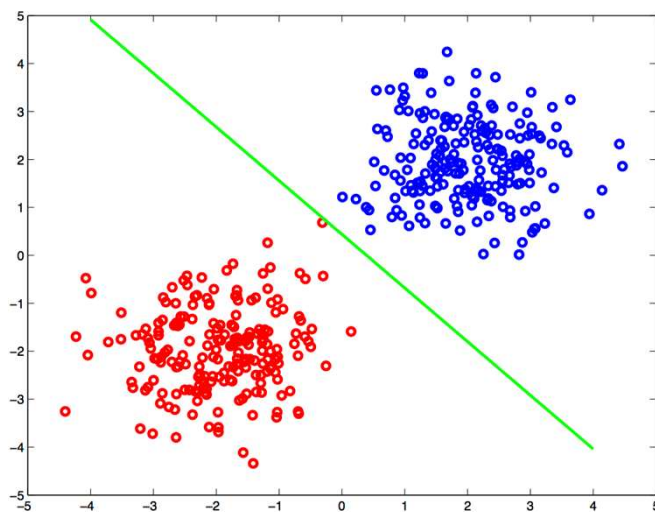
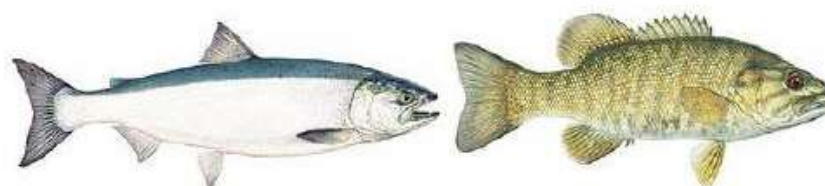
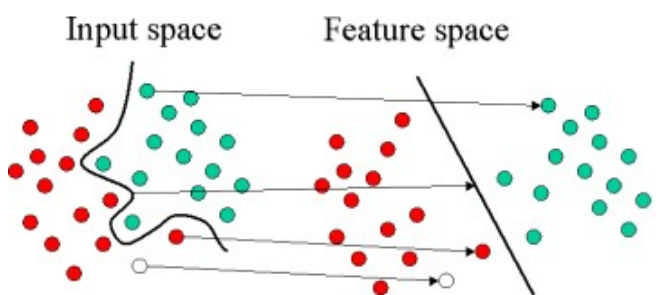
Where would “F” fall?

Suggest an additional feature



# Pattern Classification

Extracting features from given inputs allows us to separate and classify the inputs according to desired categories



# Which Book/Movie/Song Should Come Next?

**amazon.com**

**More Items to Consider**

You viewed      Customers who viewed this also viewed

LOOK INSIDE!



**The Appeal**  
John Grisham  
Paperback  
~~\$14.00~~ \$11.20

LOOK INSIDE!



**The Innocent Man**  
John Grisham  
Mass Market Paperback  
\$7.99

LOOK INSIDE!













**The Associate: A Novel**  
John Grisham  
Mass Market Paperback  
\$9.99

LOOK INSIDE!




**Ford County: Stories**  
John Grisham  
Paperback  
~~\$15.00~~ \$8.19




- 1  **The a Team**  
Ed Sheeran
- 2  **Brave**  
Sara Bareilles
- 3  **Carry On**  
Fun.
- 4  **Catch My Breath**  
Kelly Clarkson
- 5  **The Cave**  
Mumford & Sons
- 6  **Dani California**  
Red Hot Chili Peppers
- 7  **Die Young**  
Ke\$ha
- 8  **Everybody Talks**  
Neon Trees
- 9  **Give Your Heart a Break**  
Demi Lovato
- 10  **Gone, Gone, Gone**  
Phillip Phillips

**NETFLIX** Home Just for Kids Genres Taste Profile Michael O'Leary Your Account & Help

Films, TV, actors, directors, genres

**Recently Watched**      **Top 10 for Michael**



# Fingerprint Classification and Matching

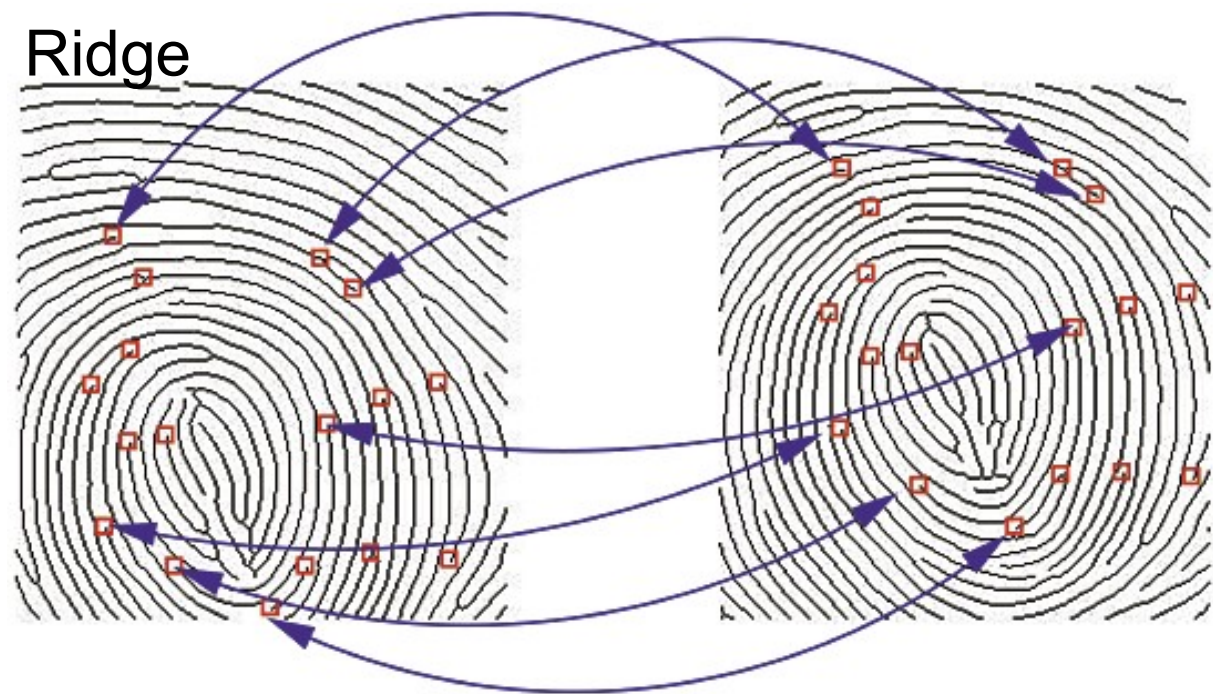
**Needed for criminal investigations and biometric identification**

Does a fingerprint match any of the prints in a criminal database?

Does the fingerprint match one recorded for an authorized user?

Human fingerprints tend to be unique

Even identical twins have different prints



# The Basics of Comparing Fingerprints

(6-minute video: <http://www.youtube.com/watch?v=IrpTqKkgygA>)



# Image Search

By keywords (when stored images have been indexed previously)

By photographer, location, etc. (image metadata)

By providing an image as key (not quite possible yet)

<https://images.google.com/>

Example searches:

Sunset

UCSB

Soccer

INT 94TN





# Searching the Worldwide Web

Google has indexed the entire contents of the Web

a b c b b b a b c b a b b c a a b c b a b c b a b c b b  
 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27

a a b	14
a b b	10
a b c	0, 6, 15, 19, 23
b a b	5, 9, 18, 22
b b a	4
b b b	3
b b c	11
b c a	12
b c b	1, 7, 16, 20, 24
c a a	13
c b a	8, 17, 21
c b b	2, 25

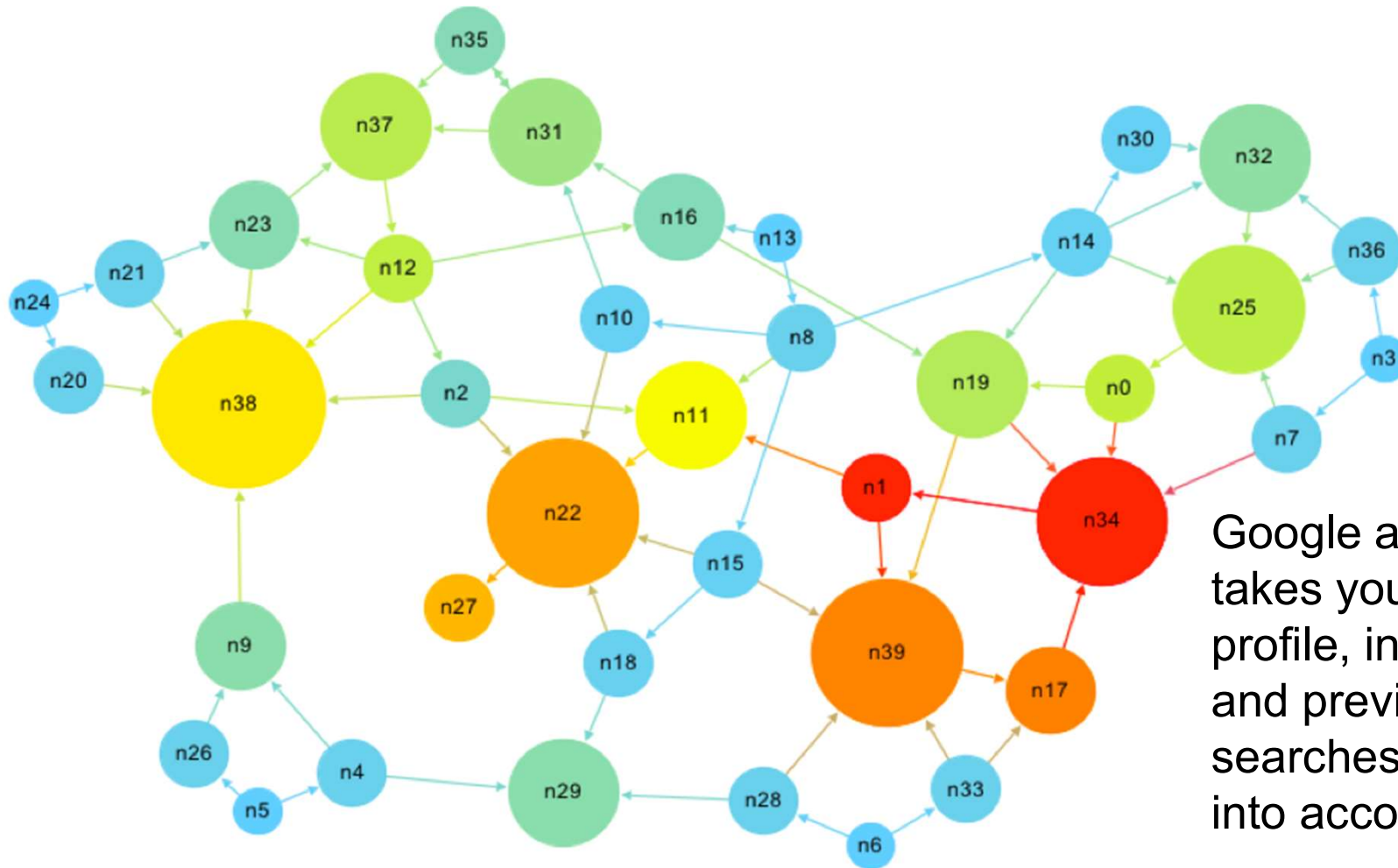
Find all occurrences of the pattern "abcbab"

a b c	0, 6, 15, 19, 23
b c b	1, 7, 16, 20, 24
c b a	8, 17, 21
b a b	5, 9, 18, 22

a b c	0, 6, 15, 19, 23
b c b	1, 7, 16, 20, 24
c b a	8, 17, 21
b a b	5, 9, 18, 22

# Google's "Pagerank" Algorithm

Algorithm to rank the hits so that the most useful ones come first



Google also takes your profile, interests, and previous searches into account

# Neural-Network Pattern Recognition

**Train the system using known patterns, then use it on others**  
(4-minute video: <http://www.youtube.com/watch?v=kGv-1it8Sac>)



# Facial Recognition Technology

**Train the system using known patterns, then use it on others**  
(1-minute video: <http://www.youtube.com/watch?v=tZzIH4Qf5Y8>)



# Gender Classification by Neural Networks

**Train the system using known faces, then use it on others**  
(2-minute video: <http://www.youtube.com/watch?v=3jAqlu7HtnI>)



# Overview of Recommender Systems

Track activity, interactions, and ratings, combine with other data  
(17-minute video: <http://www.youtube.com/watch?v=1JRrCEgiyHM>)

## Formal Model

- $C$  = set of Customers
- $S$  = set of Items
- Utility function  $u: C \times S \rightarrow R$ 
  - $R$  = set of ratings
  - $R$  is a totally ordered set
  - e.g., 0-5 stars, real number in  $[0,1]$

