

Image Searches, Abstraction, Invariance

36-350: Data Mining
8 September 2008

- Medical: x-rays, brain imaging, histology (“do these look like cancerous cells?”)
- Satellite imagery
- Fingerprints
- Finding illustrations for lectures...

Searching for Images by Searching for Text

- Assume there's text accompanying the images (“annotation”)
- Search those text records with the query phrase
- Take images which appear close to the query phrase on highly-ranked records
- This how Google does it

Sometimes
this works
perfectly...

cathedral of learning - Google Image Search

http://images.google.com/images?svnum=15&hl=en&lr=&newwindow=1&s Google

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The Mysterious Disappe... cathedral of learning - ...

Google Images cathedral of learning Search Advanced Image Search Preferences

SafeSearch is off

Images Showing: All image sizes Results 1 - 20 of about 3,360 for cathedral of learning. (0.14 seconds)

Cathedral of Learning 006
524 x 800 pixels - 87k - jpg
www.pitt.edu

Cathedral of Learning Residents
...
1960 x 2988 pixels - 1405k - jpg
www.wpic.pitt.edu

Cathedral of Learning,
University ...
400 x 302 pixels - 22k - jpg
travelchannel.igougo.com

Cathedral of Learning
469 x 663 pixels - 110k - jpg
www.eddyelmer.com

Cathedral Of Learning
542 x 800 pixels - 62k - jpg
www.pbase.com

The Cathedral of Learning was
...
600 x 800 pixels - 162k - jpg
www.northeastroads.com

Cathedral of Learning
280 x 350 pixels - 19k - jpg
www.wqed.org

cathedral-of-learning-1a.jpg ...
450 x 600 pixels - 98k - jpg
www.fifthavesuites.com

... The Cathedral of Learning
301 x 504 pixels - 36k - jpg
www.alumni.pitt.edu

Cathedral of Learning - an ...
259 x 367 pixels - 106k - jpg
www.fielderschlosser.com

... Pittsburgh's Cathedral of
The Cathedral of Learning
Jen Hartman at Cathedral of
... Cathedral of Learning, U. of
Cathedral of Learning.jpg

Open "http://images.google.com/imgres?imgurl=http://www.netspace.org...%26safe%3Doff%26client%3Dsafari%26rls%3Den%26sa%3DC" in a new window

...and
sometimes
it doesn't;
depends on
the text!

kitten - Google Image Search

http://images.google.com/images?svnum=15&hl=en&lr=&newwindow=1&s...

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The Mysterious Disappe... kitten - Google Image S...

Google Images

Web Images Video **New!** News Maps more »

kitten

SafeSearch is off

Search Advanced Image Search Preferences

Images Showing: All image sizes

Results 1 - 20 of about 359,000 for kitten [definition]. (0.08 seconds)

Cat names, kitten names picture
400 x 300 pixels - 44k - jpg
www.cat-dog-names.com

picture of cute kitten on kitten ...
193 x 299 pixels - 17k - jpg
www.kitten-stork.com

30 2006 2:45 PM KITTEN FOR
SUSAN ...
640 x 480 pixels - 65k - jpg
profile.myspace.com

Cory as a kitten .
222 x 281 pixels - 34k - gif
www.clock.org

stuffed kitten
661 x 500 pixels - 54k - jpg
www.fadeeva.com

Burmilla Cat & Kitten Central
234 x 302 pixels - 8k - jpg
cat-breeds.cats-central.com

... 18 The only kitten worth
having is a
1280 x 960 pixels - 329k - jpg
ice.cream.org

The review kitten was provided
with ...
520 x 417 pixels - 28k - jpg
www.dansdata.com

Eva Longoria 'desperate' to
shake ...
400 x 500 pixels - 62k -
www.chinadaily.com.cn

Index of kitten
450 x 338 pixels - 23k - jpg
mirrorshades.net

Kitten Anonymous 12th century
Album ...
440 x 440 pixels - 36k - jpg
www.asianart.com

kitten Diler Maaw
450 x 556 pixels - 41k - jpg
maaw.net

Wallpaper Musik Atomic-Kitten
1024 x 768 pixels - 99k - jpg
www.new-dream.de

... kitten information, cat and ...
189 x 226 pixels - 9k - jpg
www.kitten-stork.com
[More results from www.kitten-stork.com]

kitten Darwin Maaw
450 x 320 pixels - 31k - jpg
maaw.net
[More results from maaw.net]

Searching for images by representing images

- For text, we only cared about *features*, and only worked with *feature vectors*
- Define numerical features for images and everything carries over
- Abstraction

Abstraction

- Remove some of the details but keep others
 - Kept details = features
- Then act on abstracta
- Hopes:
 - Simplifies problem
 - Lets you treat many problems similarly

Abstract level: feature vectors

Similarity
matching

Dimensionality
Reduction

Classification

Clustering

etc.

v1

v2

v3

v4

v5

v6

BoW

BoW

BoW

BoW

BoW

BoW

Text 1

Text 2

Text 3

Text 4

Text 5

Text 6

Concrete level: meaningful objects

Abstract level: feature vectors

Similarity
matching

Dimensionality
Reduction

Classification

Clustering

etc.

v1

v2

v3

v4

v5

v6

Topics

Topics

Topics

Topics

Topics

Topics

Text 1

Text 2

Text 3

Text 4

Text 5

Text 6

Concrete level: meaningful objects

Abstract level: feature vectors

Similarity
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etc.

v1

v2

v3

v4

v5

v6

Bitmap

Bitmap

Bitmap

Bitmap

Bitmap

Bitmap



Pic. 1



Pic. 2



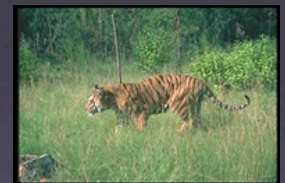
Pic. 3



Pic. 4



Pic. 5



Pic. 6

Concrete level: meaningful objects

Abstract level: feature vectors

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etc.

v1

v2

v3

v4

v5

v6

Bag of colors

Bag of colors

Bag of colors

Bag of colors

Bag of colors

Bag of colors



Pic. 1



Pic. 2



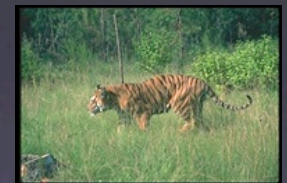
Pic. 3



Pic. 4



Pic. 5



Pic. 6

Concrete level: meaningful objects

Abstract level: feature vectors

Similarity
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etc.

v1

v2

v3

v4

v5

v6

Motifs

Motifs

Motifs

Motifs

Motifs

Motifs

Network 1

Network 2

Network 3

Network 4

Network 5

Network 6

Concrete level: meaningful objects

- Need to find right (relevant) representation
- Representation = concrete/abstract interface
 - Go read *The Sciences of the Artificial!*
- Great methods at the abstract level generally fail if the representation is bad
 - missing what's relevant
 - including what's irrelevant
 - comparing apples to platypi
 - both multicellular sexually-reproducing carbon-based lifeforms...
- A lot of your work will be designing representations

Abstract level: feature vectors

Similarity
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etc.

v1

v2

v3

v4

v5

v6

BoW

BoW

Topics

Bitmap

Bag of colors

Motifs

Text 1

Text 2

Text 3



Pic. 1



Pic. 2

Social
Network

Concrete level: meaningful objects



flower1



flower2



flower3



tiger1



tiger2



tiger3



ocean1



ocean2



ocean3

Euclidean Distance of Images

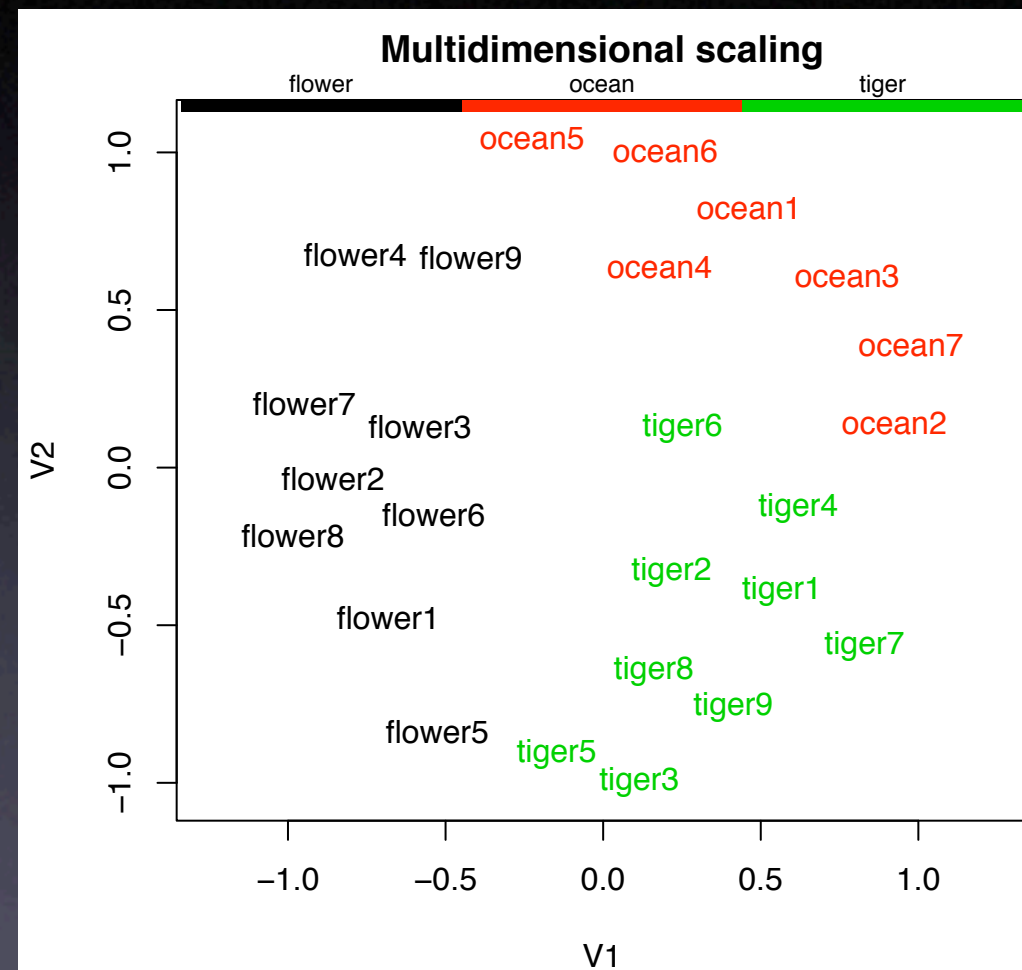
- Image is $M \times N$ pixels, each with 3 color components, so a $3MN$ vector
- Euclidean distance possible, and OK for some kinds of noise-removal
- but hopeless even at grouping flower1 with flower2
- or slight changes in perspective, lighting...

Bag of Colors

- “If it works, try it some more”
- For each possible color, count how many pixels there are of that color
- Use Euclidean distance on color-count vectors
- Too many colors, so *quantize* them down to a manageable number (like stemming, or combining synonyms)



Distances between images



MDS plot of images

Representation and Invariance

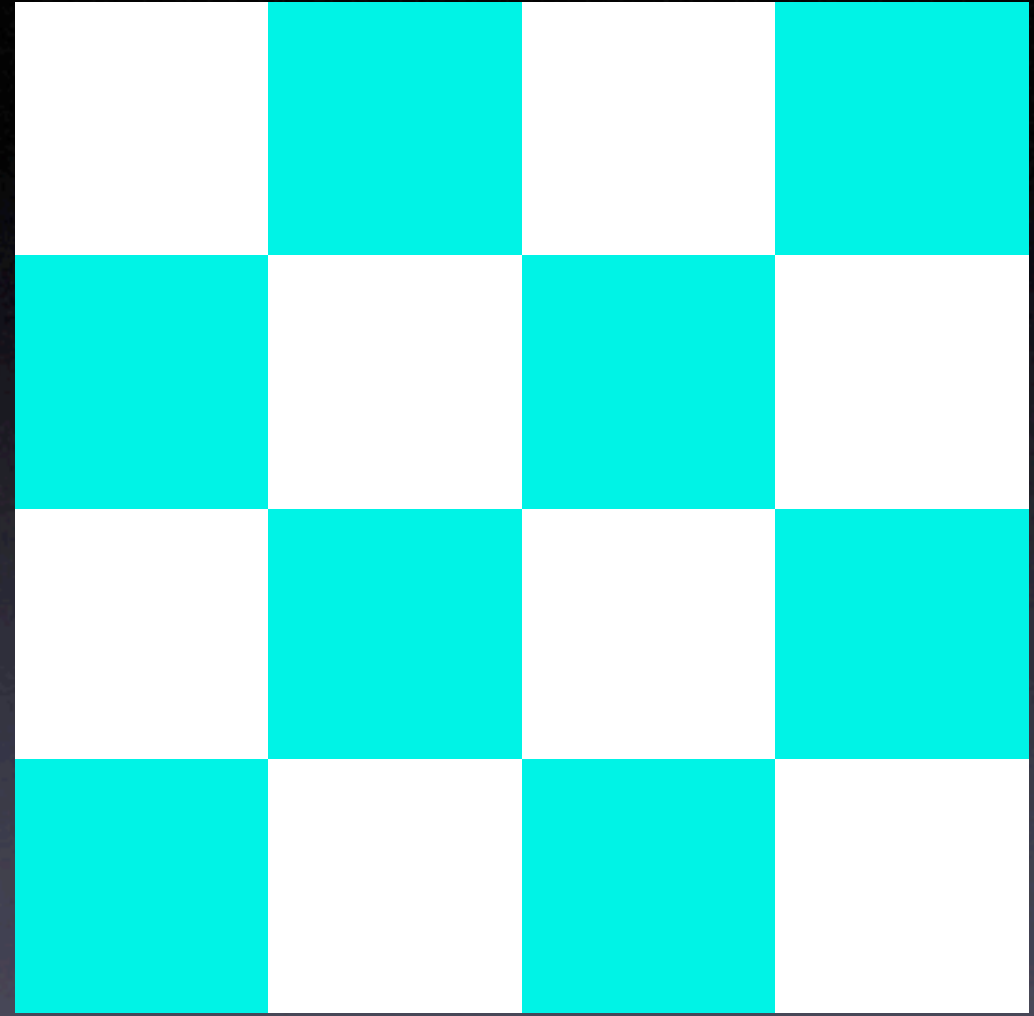
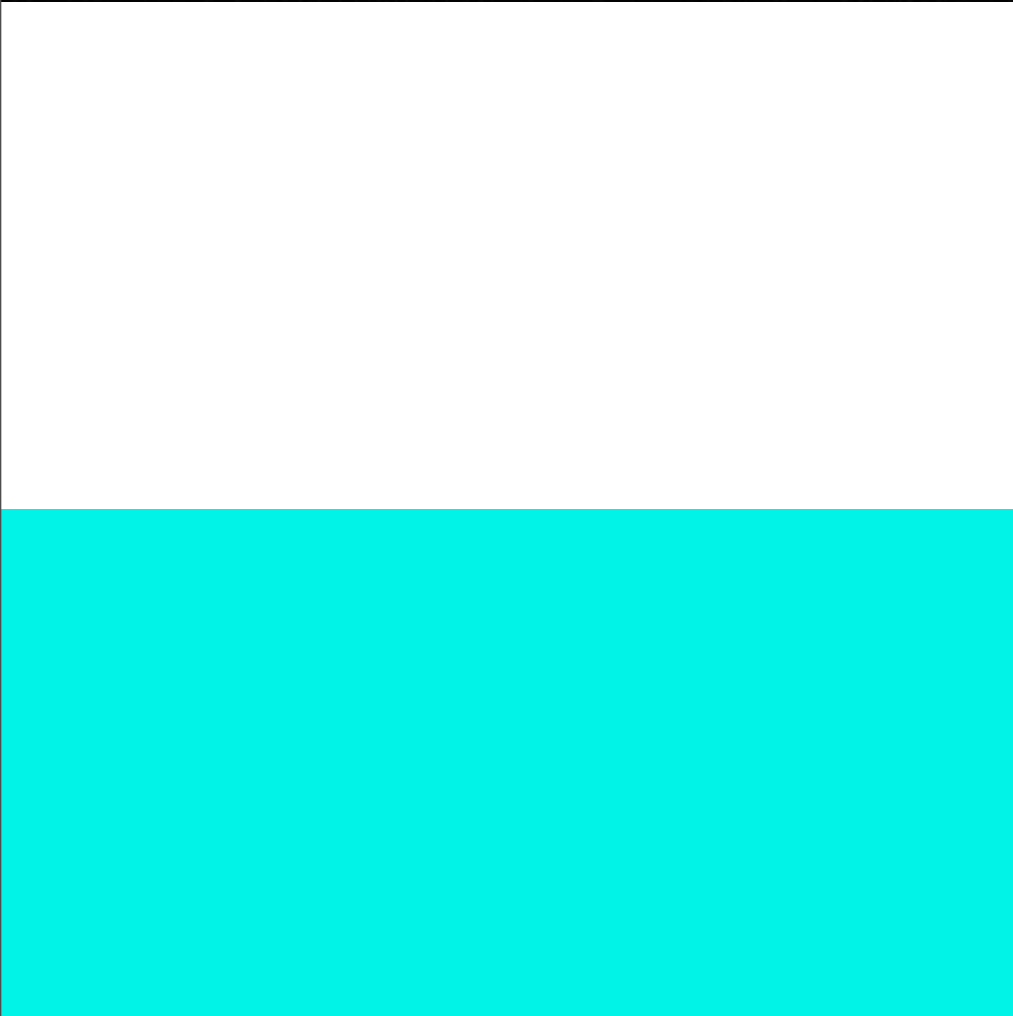
- Invariances of a representation = how can we change the underlying object without changing the representation?
- What differences does the representation ignore?

Invariants of bags of words

- Punctuation and word order
- Universal words (exact count of “the”, “of”, “to”, ...), if using inverse document frequency
- Word-endings, if using stemming
- Grammar, context, word proximity ...
 - “Send lawyers, guns and money” vs. “Sending the Guns’ lawyers for the money”

Invariants of bags of colors

- Small changes in orientation, pose, some rotations
- Small amounts of color noise or weird colors
- Texture



Same color counts, different textures

Non-invariants

- Lighting, shadows
- Occlusion, 3D effects
- Blurring
 - There are good ways to deal with blur (from astronomy)
- but full vision is *very, very hard*

- Breaking an invariance is easy
 - e.g., add features for textures
 - or sub-divide the image and do color-counts on each part
- Adding invariances is hard
 - often need to go back to scratch and chose a different representation