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

Concrete level: meaningful objects

BoW

v1

v2

v3

v4

v5

v6

Similarity matching

Dimensionality Reduction

Classification

Clustering

etc.

Text 1

Text 2

Text 3

Text 4

Text 5

Text 6

BoW

BoW

BoW

BoW

BoW

BoW

BoW
Concrete level: meaningful objects

Abstract level: feature vectors

- Similarity matching
- Dimensionality Reduction
- Classification
- Clustering
- etc.

Text 1
Text 2
Text 3
Text 4
Text 5
Text 6

Topics
Topics
Topics
Topics
Topics
Topics

Similarity matching
Dimensionality Reduction
Classification
Clustering

Concrete level: meaningful objects
Concrete level: meaningful objects

Abstract level: feature vectors

Similarity matching
Dimensionality Reduction

Classification
Clustering etc.

v1 v2 v3 v4 v5 v6

Pic. 1
Pic. 2
Pic. 3
Pic. 4
Pic. 5
Pic. 6

Bitmap

Bitmap

Bitmap

Bitmap

Bitmap

Bitmap

Concrete level: meaningful objects
Concrete level: meaningful objects

Abstract level: feature vectors

Similarity matching
Dimensionality Reduction

Classification
Clustering etc.

Bag of colors

Pic. 1 Pic. 2 Pic. 3 Pic. 4 Pic. 5 Pic. 6

Concrete level: meaningful objects
Concrete level: meaningful objects

Abstract level: feature vectors

Similarity matching
Dimensionality Reduction

Classification
Clustering
e tc.

Motifs

v1
v2
v3
v4
v5
v6

Network 1
Network 2
Network 3
Network 4
Network 5
Network 6

Similarity matching
Dimensionality Reduction

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 platypus
  - both multicellular sexually-reproducing carbon-based lifeforms...

A lot of your work will be designing representations
Euclidean Distance of Images

- Image is MxN 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
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