Image Searches, Abstraction, Invariance

36-350: Data Mining
2 September 2009
• 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")
- tags
- 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

Similarity matching

Dimensionality Reduction

Classification

Clustering

etc.

v1
v2
v3
v4
v5
v6

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

Concrete level: meaningful objects

BoW

BoW

BoW

BoW

BoW

BoW

BoW
Concrete level: meaningful objects

Abstract level: feature vectors

Similarity matching
Dimensionality Reduction

Classification
Clustering

Topics

v1  v2  v3  v4  v5  v6

Topics

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

Topics

Similarity matching
Dimensionality Reduction

Topics

Abstract level: feature vectors

Classifcation
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etc.

Topics

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Topics

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

Topics
Concrete level: meaningful objects

Abstract level: feature vectors

- Similarity matching
- Dimensionality Reduction
- Classification
- Clustering
- 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
Concrete level: meaningful objects

Abstract level: feature vectors

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

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

Bag of colors
Concrete level: meaningful objects

Abstract level: feature vectors

Similarity matching

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Classification

Clustering

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

Similarity matching

Dimensionality Reduction

Network 1

Network 2

Network 3

Network 4

Network 5

Network 6

Abstract level: feature vectors

Classification

Clustering

etc.

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 kangaroos
    • both multicellular sexually-reproducing carbon-based lifeforms...

• A lot of your work will be designing representations
Concrete level: meaningful objects

Abstract level: feature vectors

Similarity matching
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BoW

Bitmap
Motifs

Bag of colors

Text 1
Text 2
Text 3

Pic. 1
Pic. 2

Social Network

Abstract level: feature vectors
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)
Multidimensional scaling

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
Similarity search with real images from the web ("retrievr", see notes)
Search by: Sketch • Image

Search for similar images by
- uploading an image file
- or entering the URL of an image.

New! Please help us rate sketches for The Art of retrieval! Only a million to go...

Still new! You can search by uploading images now as well. Also: Your sketches have URLs! Send 'em around.

This is an experimental service. Please treat it nicely and send copious amounts of feedback! For some background, read here.
• Typically works better with more restricted domains (actually pretty good for medical images)