CS324e - Elements of Graphics and Visualization

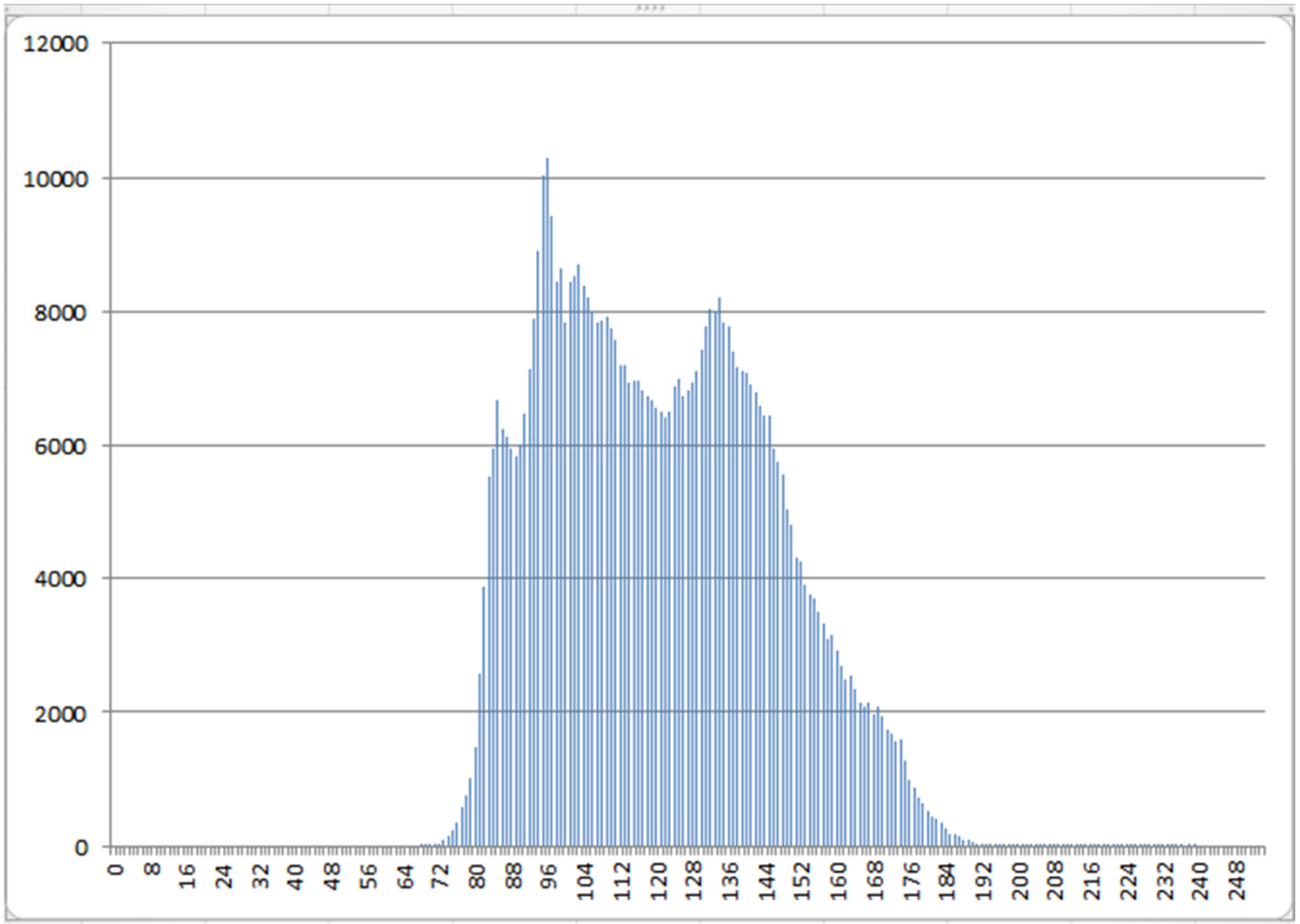
Color Histograms

Color Histogram

- Plot number of pixels with given intensity
- horizontal axis: intensity (0 - 255)
- Vertical axis:
  - number of pixels with given intensity
  - or normalize to a percentage

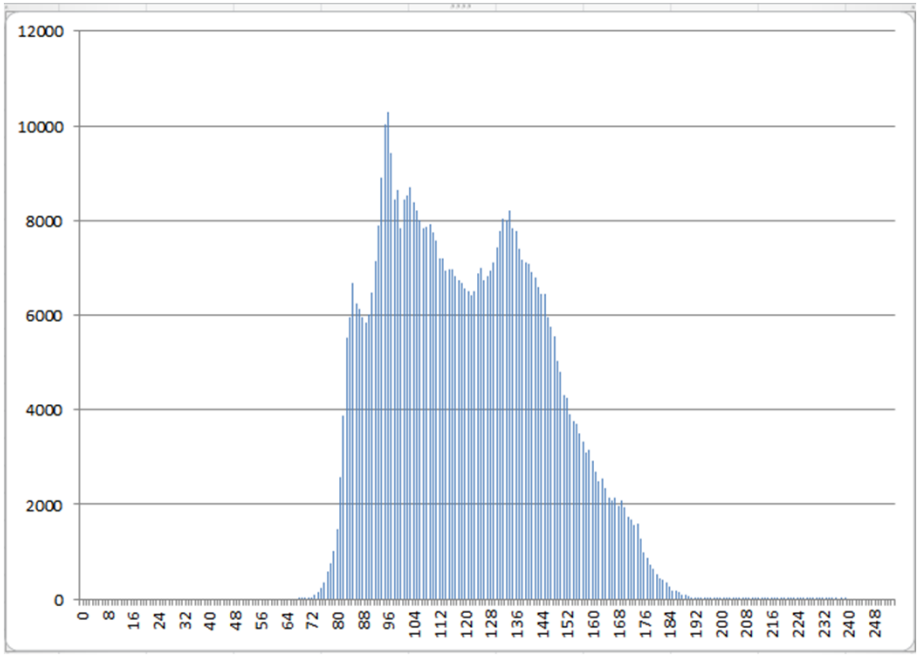
Sample Image

Histogram Of Grayscale



Histogram Equalization

- Note the cluster in the middle
- Not a lot of very bright or very dark pixels
- Apply a Histogram Equalization filter to the image



Histogram Equalization

- An algorithm to try and improve the local contrast of an image without altering overall contrast to a significant degree
- Spread out the clumps of intensities to improve the contrast

Histogram Equalization Example

- Consider a color model with only 10 shades of gray 0 - 9
- Consider a simple image with only 25 pixels

1	1	2	2	3
1	5	9	1	3
0	4	4	9	9
0	1	2	7	6
9	8	0	1	2

Histogram Equalization Example

- Step 1: count the number of pixels with each intensity

intensity	count
0	3
1	6
2	4
3	2
4	2
5	1
6	1
7	1
8	1
9	4

1	1	2	2	3
1	5	9	1	3
0	4	4	9	9
0	1	2	7	6
9	8	0	1	2

What must the sum of counts be?

Histogram Equalization Example

- Normalize the counts to fractions or percentages

intensity	count	fraction
0	3	3/25
1	6	6/25
2	4	4/25
3	2	2/25
4	2	2/25
5	1	1/25
6	1	1/25
7	1	1/25
8	1	1/25
9	4	4/25

Why divide by 25?

Histogram Equalization Example

- Step 3: compute the cumulative distribution function CDF
  - probability a pixel's intensity is less than or equal to the given intensity
  - just a running total of the fractions / percentages from step 2

Histogram Equalization Example

- Step 3:

intensity	count	fraction	Cumulative Distribution
0	3	3/25	3/25
1	6	6/25	9/25 (3 + 6)
2	4	4/25	13/25 (3 + 6 + 4)
3	2	2/25	15/25
4	2	2/25	17/25
5	1	1/25	18/25
6	1	1/25	19/25
7	1	1/25	20/25
8	1	1/25	21/25
9	4	4/25	25/25

Histogram Equalization Example

Step 4: Scale Cumulative Distribution to intensity range

intensity	count	fraction	CDF	Scaled Intensity
0	3	3/25	3/25	0 (10 * 3 / 25 = 1 - 1 = 0)
1	6	6/25	9/25	3
2	4	4/25	13/25	4
3	2	2/25	15/25	5
4	2	2/25	17/25	6
5	1	1/25	18/25	6
6	1	1/25	19/25	7
7	1	1/25	20/25	7
8	1	1/25	21/25	7
9	4	4/25	25/25	9

Histogram Equalization Example

- Step 5: The scaled intensities become a lookup table to apply to original image

intensity in original	intensity in result
0	0
1	3
2	4
3	5
4	6
5	6
6	7
7	7
8	7
9	9

Histogram Equalization Example

- Step 6: apply lookup table

original	0	1	2	3	4	5	6	7	8	9
result	0	3	4	5	6	6	7	7	7	9

1	1	2	2	3
1	5	9	1	3
0	4	4	9	9
0	1	2	7	6
9	8	0	1	2

original

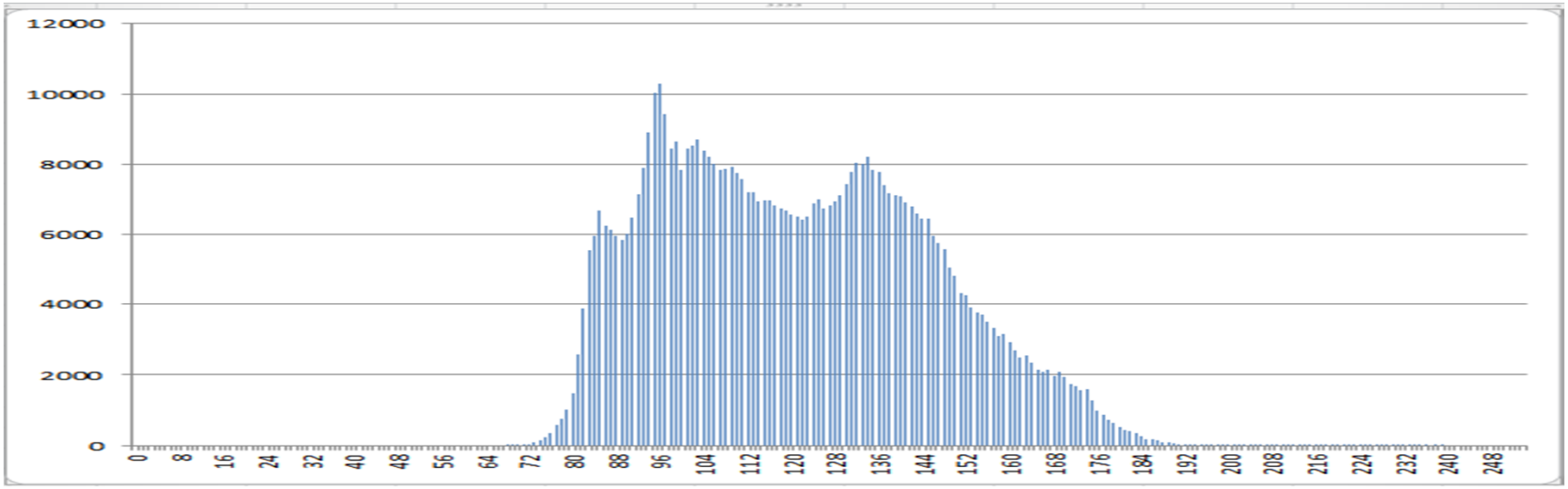
3	3	4	4	5
3	6	9	3	5
0	6	6	9	9
0	3	4	7	7
9	7	0	3	4

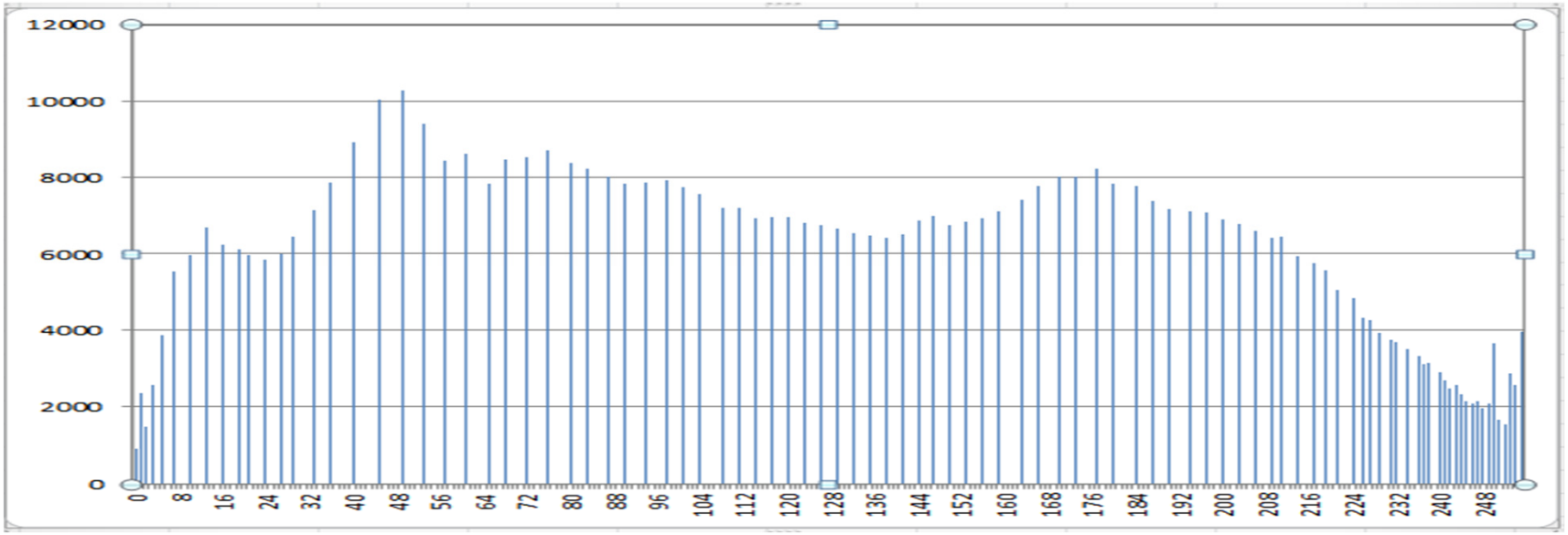
result

0s stay 0
1s become 3
2s become 4
and so forth

Recall Actual Image

Resulting Histogram



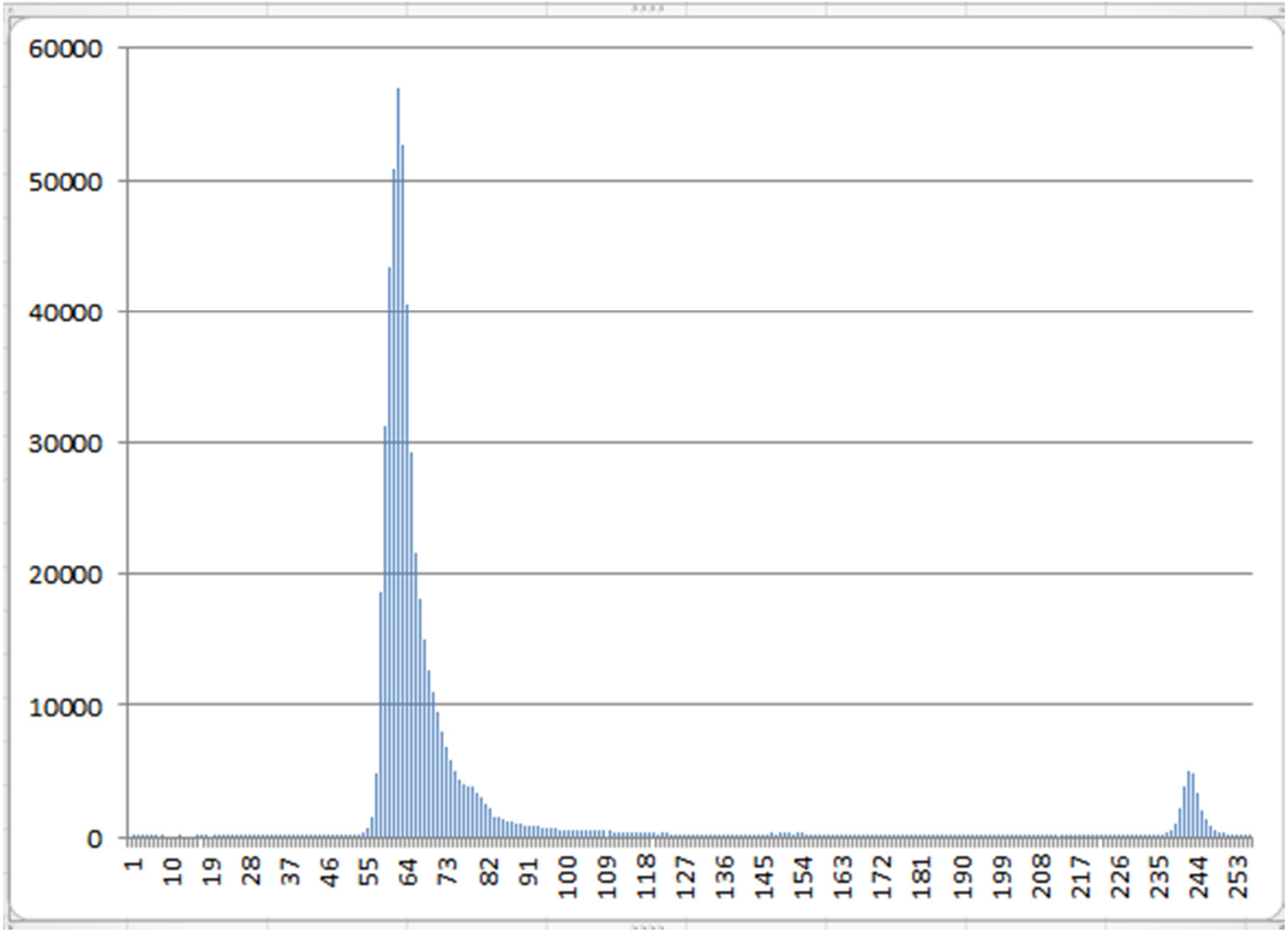


Resulting Image

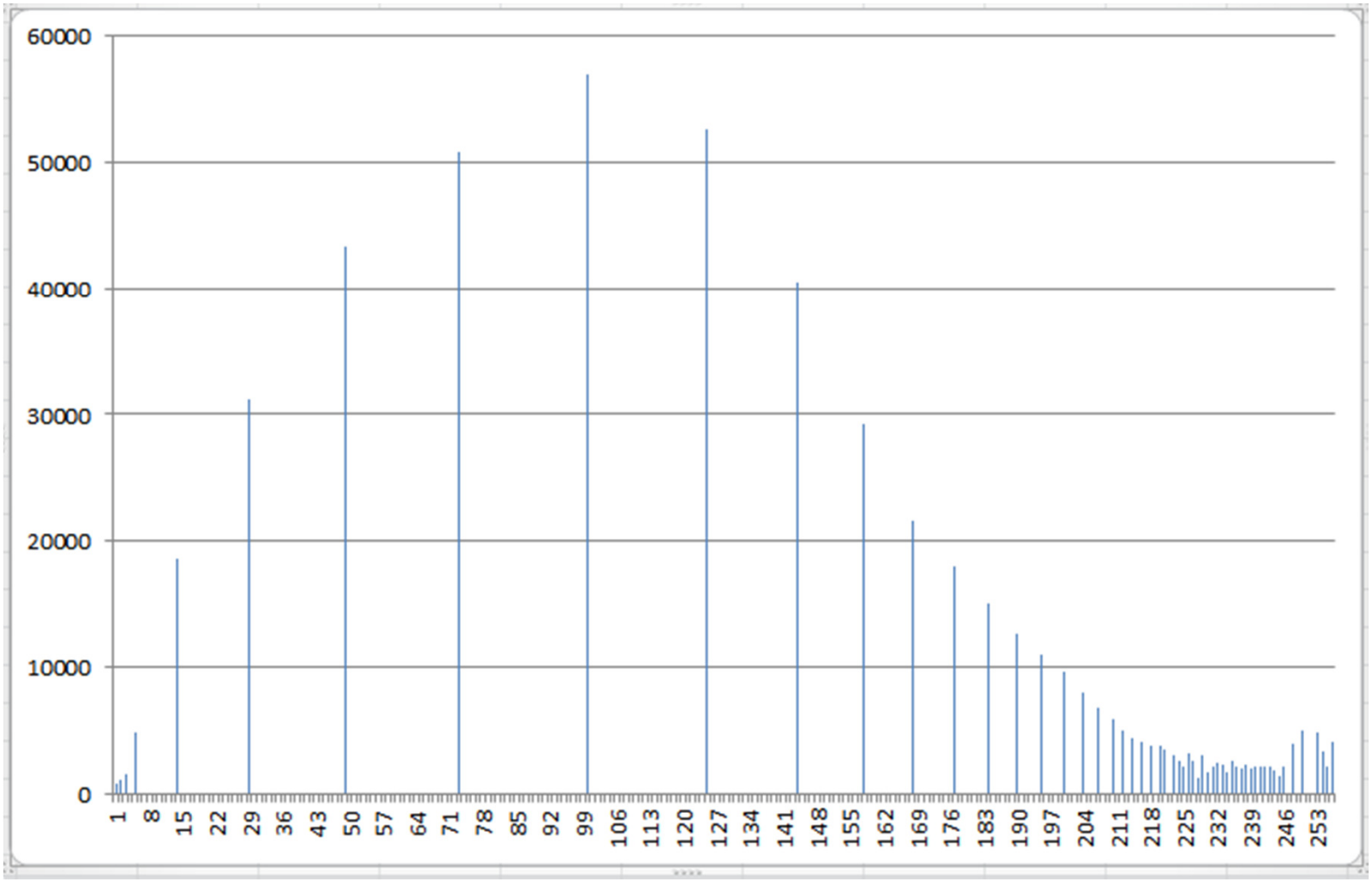
Comparison

Example 2

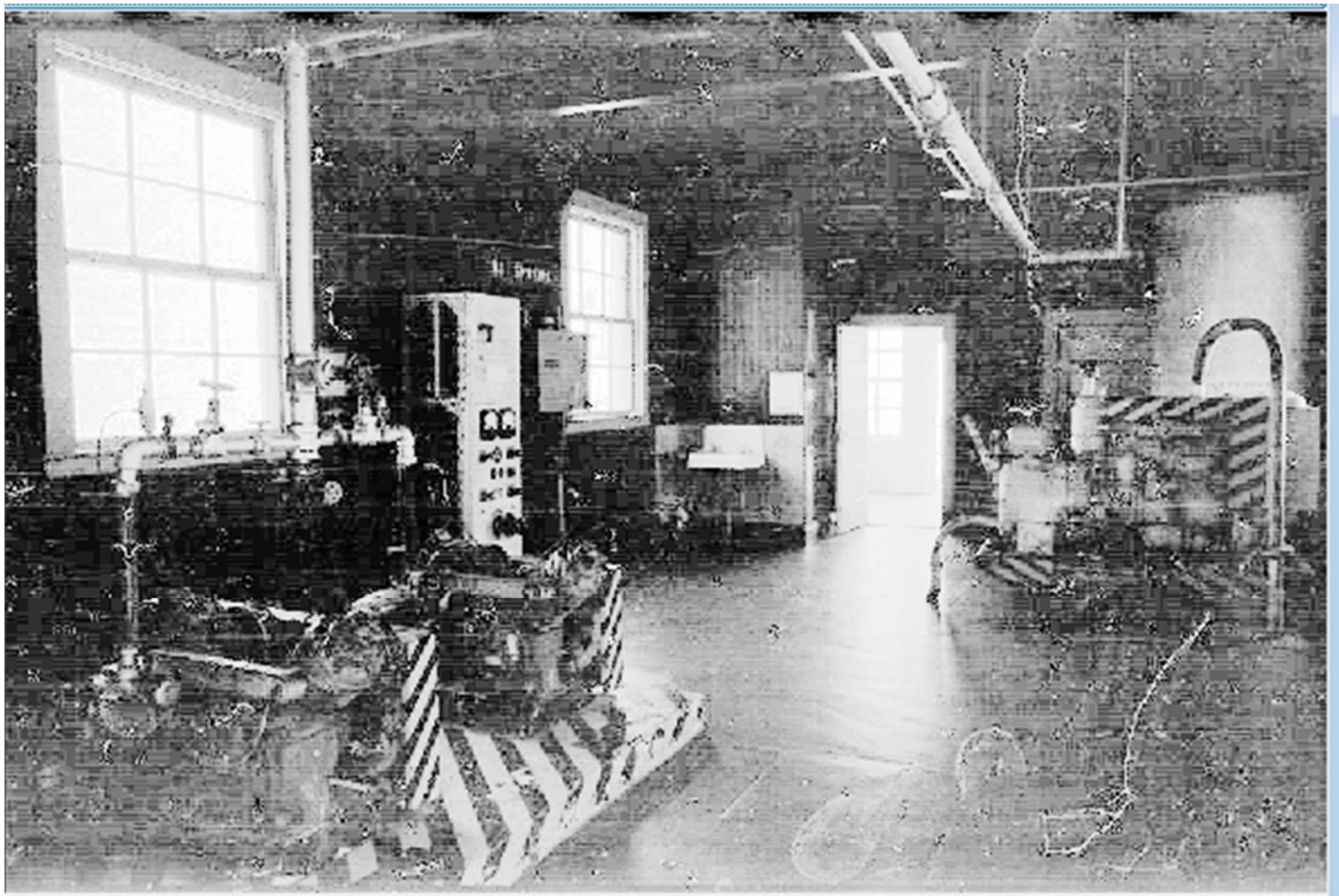
Original Histogram



Resulting Histogram



Resulting Image

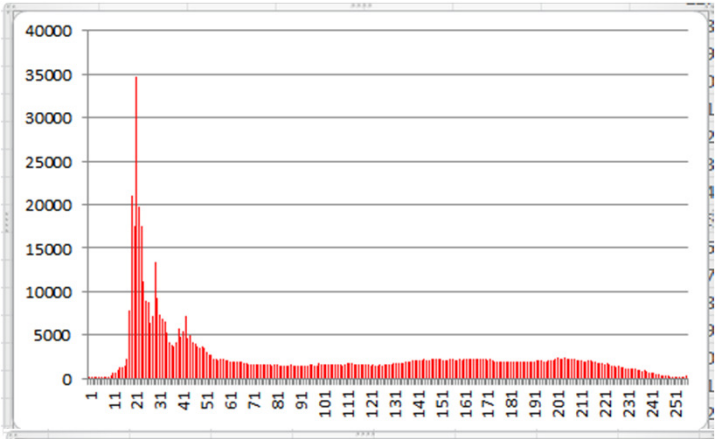


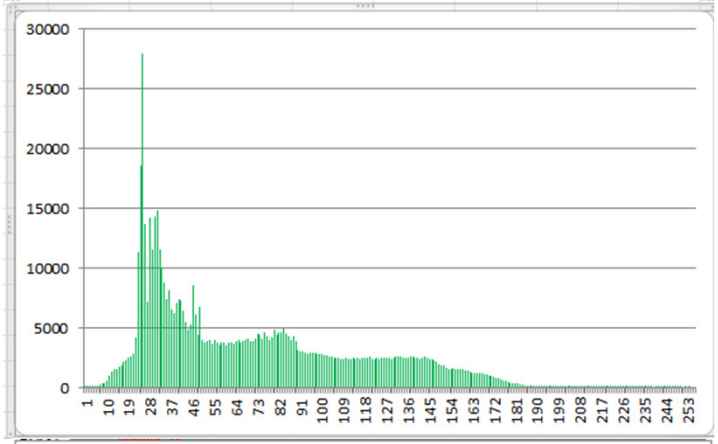
Comparison

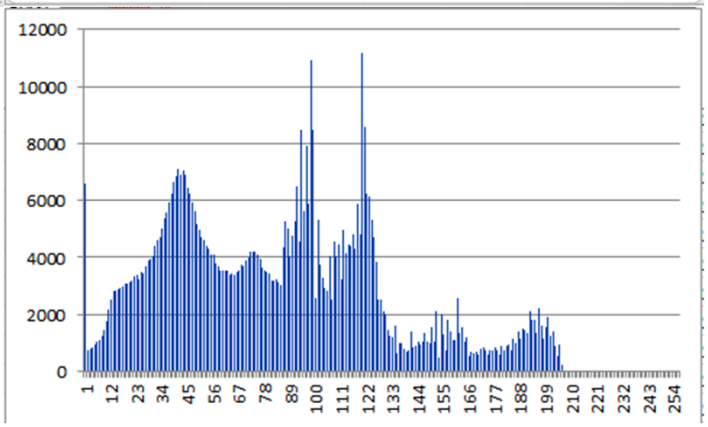
Histogram Equalization on Color Images

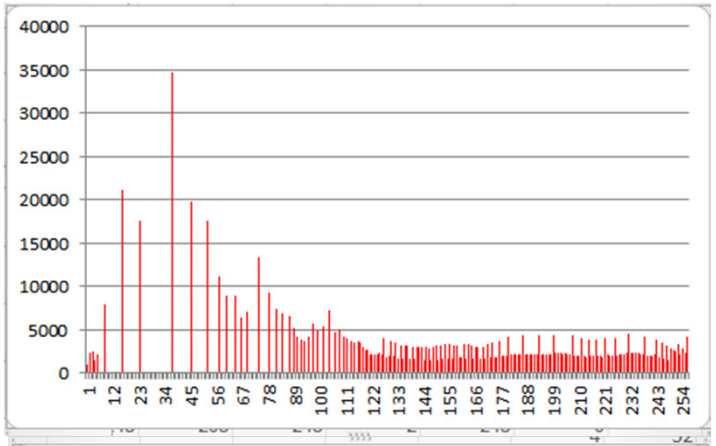
- apply to color images
- each channel (red, green, blue) treated as separate histogram
- equalize each independently
- can lead to radical color changes in result

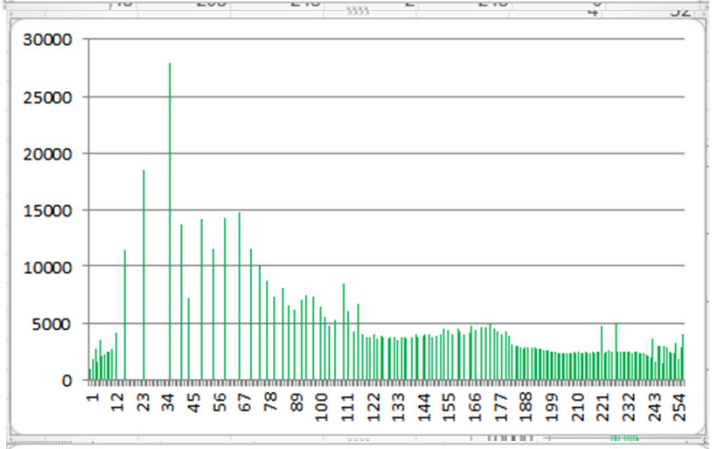
Histograms

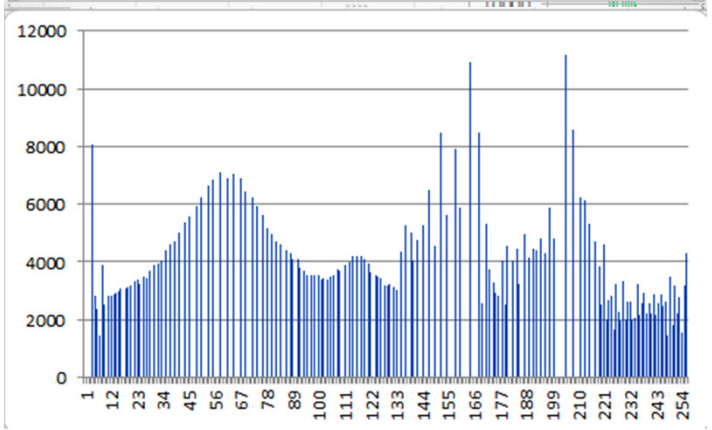

40000
35000
30000
25000
20000
15000
10000
5000
0
1 11 21 31 41 51 61 71 81 91 101 111 121 131 141 151 161 171 181 191 201 211 221 231 241 251


30000
25000
20000
15000
10000
5000
0
1 10 19 28 37 46 55 64 73 82 91 100 109 118 127 136 145 154 163 172 181 190 199 208 217 226 235 244 253


12000
10000
8000
6000
4000
2000
0
1 12 23 34 45 56 67 78 89 100 111 122 133 144 155 166 177 188 199 210 221 232 243 254

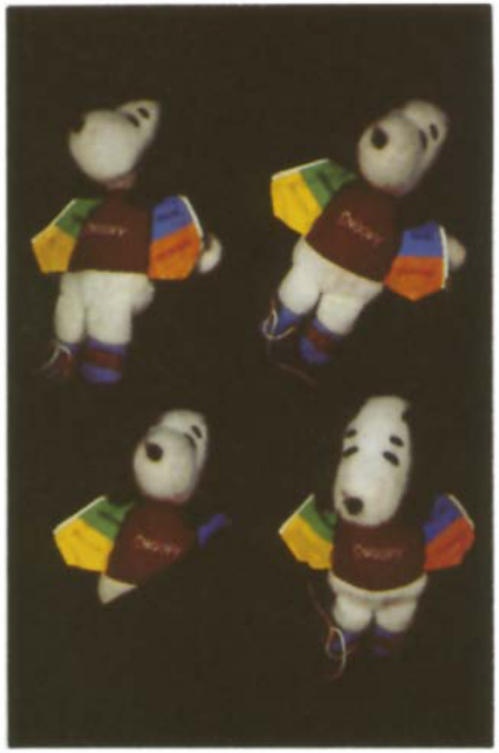

40000
35000
30000
25000
20000
15000
10000
5000
0
1 12 23 34 45 56 67 78 89 100 111 122 133 144 155 166 177 188 199 210 221 232 243 254

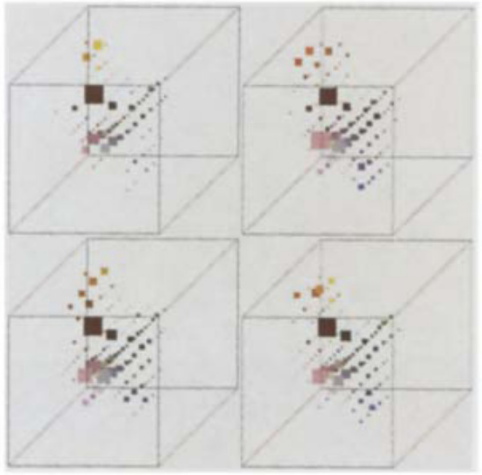

30000
25000
20000
15000
10000
5000
0
1 12 23 34 45 56 67 78 89 100 111 122 133 144 155 166 177 188 199 210 221 232 243 254


12000
10000
8000
6000
4000
2000
0
1 12 23 34 45 56 67 78 89 100 111 122 133 144 155 166 177 188 199 210 221 232 243 254

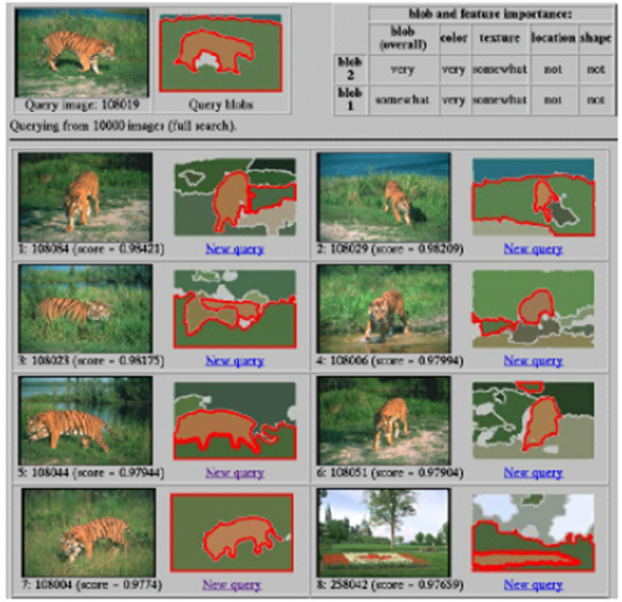
Example of Color Histogram Equalization

Color as a low-level cue for Color Based Image Retreival





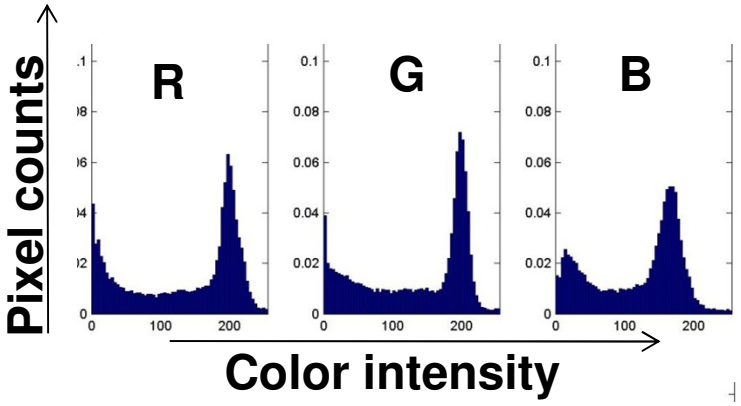
Swain and Ballard, Color Indexing, IJCV 1991



Blobworld system
Carson et al, 1999

Slides on CBIR from Kristen Grauman

Color as a low-level cue for CBIR

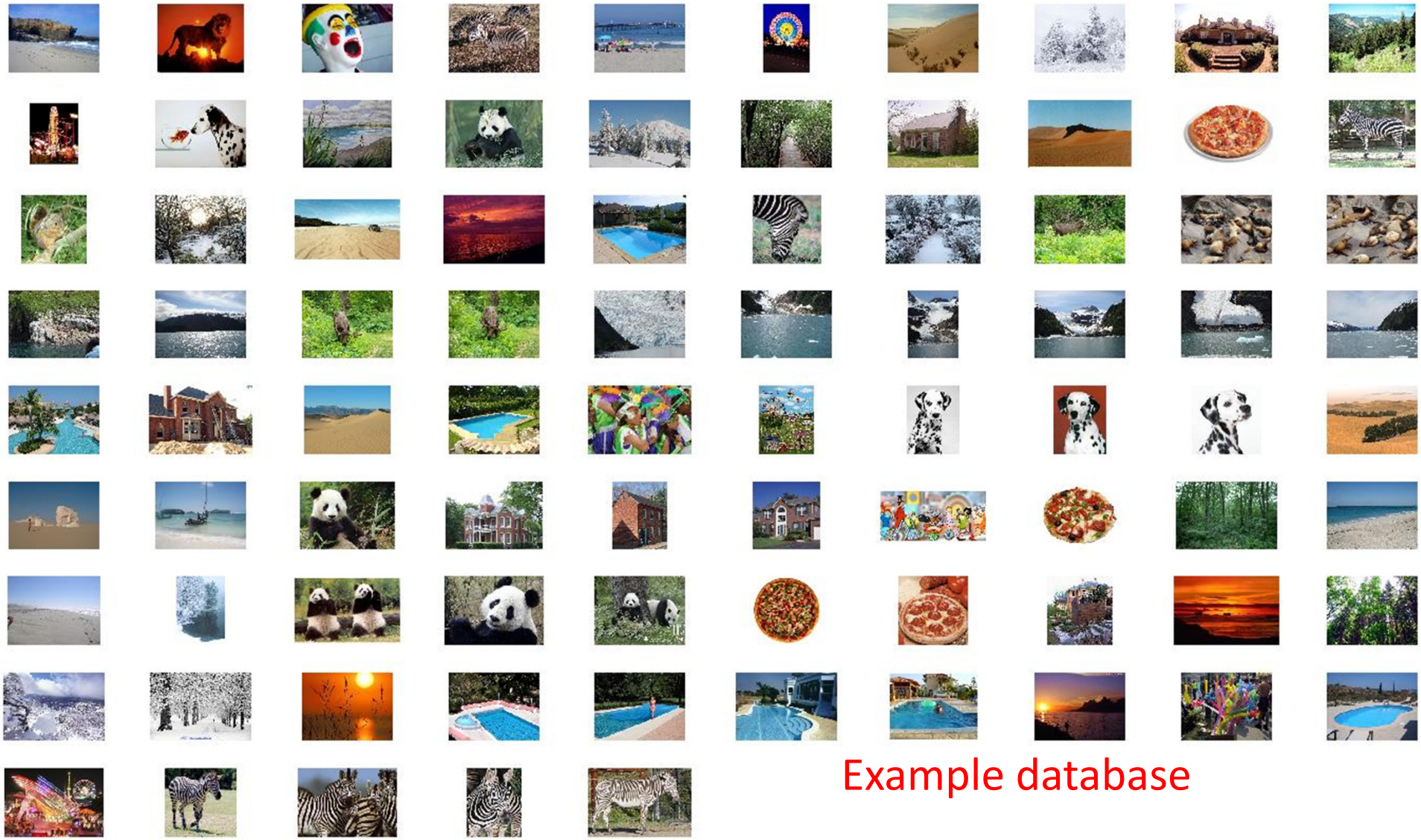


- Color histograms: Use distribution of colors to describe image
- No spatial info – invariant to translation, rotation, scale

Color-based image retrieval

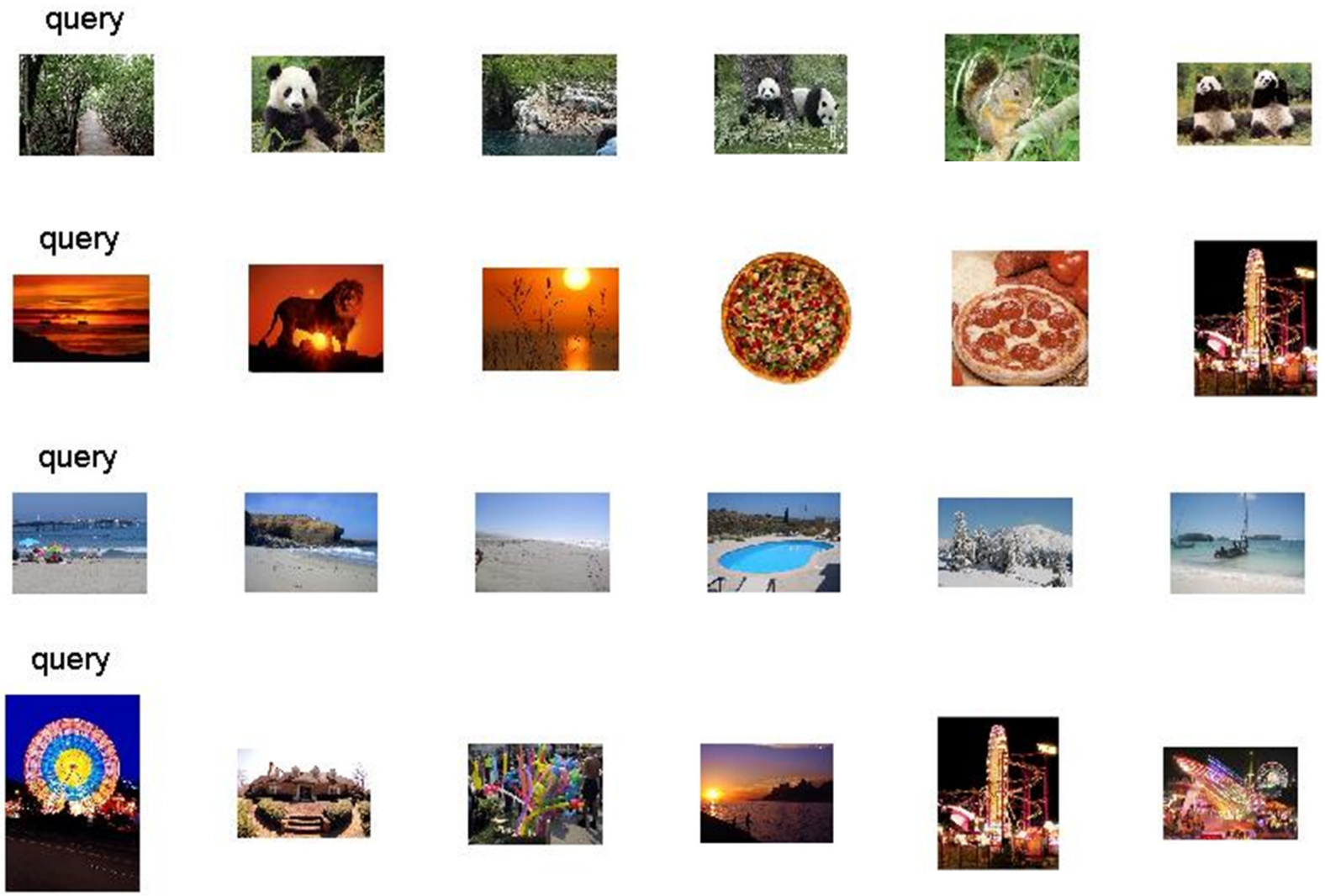
- Given collection (database) of images:
  - Extract and store one color histogram per image
- Given new query image:
  - Extract its color histogram
  - For each database image:
    - Compute intersection between query histogram and database histogram
  - Sort intersection values (highest score = most similar)
  - Rank database items relative to query based on this sorted order

Color-based image retrieval



Example database

Color-based image retrieval



Example retrievals

Color-based image retrieval

query

query

query

Example retrievals

Google

pizza

Search

SafeSearch moder

About 3,030,000 results (0.32 seconds)

Advanced search

- Everything
- Images
- Videos
- News
- Shopping
- More

Any size

Large
Medium
Icon
Larger than...
Exactly...

Any type

Face
Photo
Clip art
Line drawing

Any color
Full color
Black and white

Standard view

Show sizes

Reset tools

Green

Related searches: pizza **coupons** pizza **slice** **cartoon** pizza pizza **clip art** pizza **hut** pizza **italian** pizza