

L1 norm (distance 2)

Beach1

Load database
Dcase
Open Query Image

Query Image:
beach_1
[Check for Distance 2]
Query database

Progress:
9.98257
Distance to image 38 = 10.76808
Distance to image 39 = 8.32579
Distance to image 40 = 8.87278

Reset

Reference distance weighted (distance 1)

Load database
Dcase
Open Query Image

Query Image:
beach_1
[Check for Distance 2]
Query database

Progress:
12.37287
Distance to image 38 = 1.18657
Distance to image 39 = 4.33108
Distance to image 40 = -17.55172

Reset

Boat4

Load database
Dcase
Open Query Image

Query Image:
boat_4
[Check for Distance 2]
Query database

Progress:
11.96822
Distance to image 38 = 13.33419
Distance to image 39 = 14.27508
Distance to image 40 = 10.04545

Reset

Load database
Dcase
Open Query Image

Query Image:
boat_4
[Check for Distance 2]
Query database

Progress:
-12.80560
Distance to image 38 = -12.29216
Distance to image 39 = 4.61762
Distance to image 40 = -26.05962

Reset

Cherry3

Load database
Dcase
Open Query Image

Query Image:
cherry_3
[Check for Distance 2]
Query database

Progress:
12.28167
Distance to image 38 = 12.20966
Distance to image 39 = 15.86701
Distance to image 40 = 10.18332

Reset

Load database
Dcase
Open Query Image

Query Image:
cherry_3
[Check for Distance 2]
Query database

Progress:
-19.47127
Distance to image 38 = -14.58145
Distance to image 39 = -12.78429
Distance to image 40 = -14.06214

Reset

Crater_3

Load database
Dcase
Open Query Image

Query Image:
crater_3
[Check for Distance 2]
Query database

Progress:
11.26256
Distance to image 38 = 11.13278
Distance to image 39 = 11.88672
Distance to image 40 = 15.40470

Reset

Load database
Dcase
Open Query Image

Query Image:
[Check for Distance 2]
Query database

Progress:
-17.59821
Distance to image 38 = -3.38875
Distance to image 39 = -15.15456
Distance to image 40 = -16.01578

Reset

L1

Pond_2

Load database

Query

Open Query Image

Query Image:

☐ Check for Distance 2

Query database

Progress:

Distance to image 38 = 14.096285
Distance to image 39 = 13.857906
Distance to image 40 = 16.314664
Distance to image 40 = 14.918445

Reset

pond_2 d = 1.32833	pond_1 d = 8.05219	pond_5 d = 9.38973	boat_3 d = 9.44846	sunset1_1 d = 9.50116	pond_3 d = 9.62358	crater_5 d = 9.62784	boat_4 d = 9.99223
cherry_2 d = 10.02329	affidens_5 d = 10.25196	beach_1 d = 10.33887	affidens_3 d = 10.40381	pond_4 d = 10.54721	crater_2 d = 10.61375	affidens_4 d = 10.94157	crater_4 d = 11.05994
crater_3 d = 11.12007	affidens_2 d = 11.30201	boat_5 d = 11.50332	beach_3 d = 11.72996	boat_2 d = 12.05248	cherry_1 d = 12.31955	crater_1 d = 12.48564	cherry_3 d = 12.92467
boat_1 d = 13.03717	cherry_3 d = 13.55749	sunset2_3 d = 13.55761	affidens_1 d = 14.05619	beach_4 d = 14.07964	sunset2_2 d = 14.09628	sunset1_4 d = 14.46162	sunset2_5 d = 14.91845
beach_3 d = 15.42809	cherry_4 d = 15.53005	sunset1_4 d = 16.31464	beach_3 d = 16.76095	sunset1_3 d = 18.54075	sunset1_5 d = 19.59936	sunset1_3 d = 20.95344	sunset1_1 d = 21.53491

Reference distance weighted

Load database

Query

Open Query Image

Query Image:

☒ Check for Distance 2

Query database

Progress:

Distance to image 38 = 11.694423
Distance to image 39 = 12.709090
Distance to image 39 = 10.979893
Distance to image 40 = 13.069095

Reset

boat_1 d = 76.15528	cherry_1 d = 46.67369	boat_2 d = 48.33835	beach_1 d = 37.00253	affidens_2 d = 33.11108	boat_4 d = 25.59205	boat_5 d = 25.47165	boat_3 d = 25.43861
cherry_2 d = 25.43823	crater_1 d = 24.48306	beach_5 d = 24.43139	affidens_4 d = 24.39543	sunset1_5 d = 23.06891	crater_5 d = 21.75670	cherry_3 d = 21.54134	cherry_3 d = 21.10038
pond_4 d = 20.79297	pond_2 d = 18.97233	sunset1_1 d = 18.11108	affidens_5 d = 17.72409	crater_4 d = 14.69240	affidens_3 d = 13.66755	cherry_4 d = 13.43312	crater_3 d = 11.97321
sunset2_3 d = 11.69442	beach_4 d = 11.58039	crater_2 d = 11.06995	sunset2_4 d = 10.97089	beach_3 d = 9.57006	beach_3 d = 9.31428	pond_5 d = 8.38355	sunset1_4 d = 7.10966
sunset1_2 d = 5.64356	pond_3 d = 5.12146	sunset1_3 d = 4.90280	sunset1_5 d = 4.69937	sunset2_3 d = 4.27008	pond_1 d = 4.14753	affidens_1 d = 3.83175	sunset1_1 d = 3.27352

stHelens_5

Load database

Query

Open Query Image

Query Image:

☐ Check for Distance 2

Query database

Progress:

Distance to image 38 = 17.027654
Distance to image 39 = 15.151408
Distance to image 39 = 17.828233
Distance to image 40 = 9.659572

Reset

affidens_5 d = 1.51078	affidens_3 d = 5.17247	affidens_4 d = 5.40328	beach_3 d = 5.59655	cherry_2 d = 6.08803	crater_5 d = 6.29835	crater_4 d = 6.43572	crater_3 d = 6.53250
boat_3 d = 6.57203	pond_4 d = 6.83540	beach_1 d = 7.01431	crater_1 d = 7.28737	affidens_1 d = 7.29905	cherry_5 d = 7.46137	boat_5 d = 7.56922	pond_2 d = 7.56922
boat_5 d = 7.84859	crater_3 d = 7.89993	pond_5 d = 7.90311	boat_3 d = 8.07808	affidens_2 d = 8.32040	pond_1 d = 8.52253	sunset2_5 d = 8.61993	pond_3 d = 9.62369
cherry_3 d = 9.55196	beach_4 d = 9.56447	sunset1_1 d = 10.00222	cherry_3 d = 10.29255	affidens_4 d = 10.55349	cherry_4 d = 10.94541	boat_1 d = 10.94560	beach_2 d = 11.75217
beach_3 d = 14.52744	sunset2_3 d = 15.15141	sunset1_5 d = 15.79788	sunset2_2 d = 17.02765	sunset1_4 d = 17.92823	sunset1_2 d = 18.11519	sunset1_3 d = 18.36767	sunset1_1 d = 22.23967

Load database

Query

Open Query Image

Query Image:

☒ Check for Distance 2

Query database

Progress:

Distance to image 38 = 13.792123
Distance to image 39 = 4.008840
Distance to image 39 = 23.617778
Distance to image 40 = 30.425311

Reset

boat_1 d = 161.74405	cherry_2 d = 91.43017	crater_1 d = 80.81743	crater_4 d = 70.51440	cherry_1 d = 66.02408	boat_5 d = 65.31466	crater_5 d = 50.92080	beach_3 d = 41.18935
boat_4 d = 40.30331	beach_5 d = 38.21451	affidens_3 d = 38.13286	boat_3 d = 37.82832	beach_4 d = 36.56971	affidens_4 d = 35.56793	sunset1_1 d = 34.21366	affidens_3 d = 31.60495
sunset2_5 d = 30.42531	affidens_5 d = 27.96512	pond_4 d = 26.53438	boat_2 d = 26.15031	sunset1_4 d = 23.61774	pond_5 d = 22.99856	cherry_3 d = 22.83761	crater_3 d = 19.53200
crater_2 d = 17.69236	sunset2_3 d = 13.79212	affidens_1 d = 12.69024	cherry_4 d = 12.24767	cherry_5 d = 12.11349	beach_3 d = 11.39408	pond_2 d = 10.48397	sunset1_4 d = 9.25766
pond_3 d = 8.83830	beach_3 d = 8.00980	pond_1 d = 6.53096	pond_3 d = 6.00884	sunset1_2 d = 5.82738	sunset1_3 d = 5.22337	sunset1_5 d = 4.39031	sunset1_1 d = 3.44352

Sunset1_1

Load database

Query

Open Query Image

Query Image:

☐ Check for Distance 2

Query database

Progress:

Distance to image 38 = 14.830276
Distance to image 39 = 15.787477
Distance to image 39 = 11.006481
Distance to image 40 = 20.007511

Reset

sunset1_3 d = 7.32507	sunset1_2 d = 8.51279	sunset1_4 d = 10.95651	sunset1_1 d = 11.05662	sunset2_4 d = 11.03848	crater_4 d = 11.06834	beach_4 d = 11.10496	pond_3 d = 11.72552
affidens_3 d = 13.00768	pond_3 d = 13.08815	crater_3 d = 13.10515	pond_4 d = 13.40546	cherry_2 d = 13.98120	boat_1 d = 14.00589	crater_3 d = 14.09388	sunset1_1 d = 14.21367
sunset1_5 d = 14.37719	pond_2 d = 14.38430	beach_3 d = 14.40637	boat_2 d = 14.41279	affidens_5 d = 14.51166	pond_5 d = 14.63542	sunset2_2 d = 14.83028	beach_1 d = 14.89552
crater_5 d = 15.19274	beach_2 d = 15.54336	sunset2_3 d = 15.78748	boat_2 d = 16.64205	crater_1 d = 17.04334	boat_5 d = 17.16137	beach_3 d = 17.31474	affidens_4 d = 17.45751
boat_4 d = 18.30888	affidens_2 d = 18.40662	cherry_5 d = 18.80617	cherry_1 d = 19.16134	cherry_3 d = 19.88022	sunset2_5 d = 20.00751	affidens_1 d = 22.50738	cherry_4 d = 27.30443

Load database

Query

Open Query Image

Query Image:

☒ Check for Distance 2

Query database

Progress:

Distance to image 38 = 3.721822
Distance to image 39 = 4.736630
Distance to image 39 = 4.960409
Distance to image 40 = 7.269733

Reset

boat_5 d = 109.17909	boat_4 d = 46.36668	affidens_4 d = 23.97659	cherry_1 d = 23.14170	boat_1 d = 21.13717	crater_4 d = 19.16459	beach_4 d = 18.65024	crater_2 d = 18.50097
beach_1 d = 13.95258	cherry_2 d = 11.89733	pond_2 d = 11.43738	affidens_5 d = 10.61098	cherry_4 d = 10.58564	cherry_4 d = 10.02098	pond_5 d = 9.92464	crater_3 d = 9.39671
sunset1_1 d = 9.23985	crater_1 d = 8.36166	boat_2 d = 7.91919	affidens_1 d = 6.55581	beach_3 d = 7.60856	affidens_3 d = 7.45331	pond_3 d = 7.26973	boat_3 d = 7.10608
pond_1 d = 6.97906	pond_4 d = 6.83319	affidens_2 d = 6.54063	cherry_3 d = 6.16336	sunset1_2 d = 5.43506	beach_5 d = 5.43796	beach_2 d = 4.90120	crater_5 d = 4.86037
sunset1_3 d = 4.71663	sunset1_4 d = 4.01477	sunset2_4 d = 3.98950	sunset1_3 d = 3.89222	sunset2_2 d = 3.72182	pond_3 d = 3.08063	sunset1_3 d = 2.33683	sunset1_1 d = 2.10650

Sunset2_2

Load database

Query

Open Query Image

Query Image:

☐ Check for Distance 2

Query database

Progress:

Distance to image 38 = 7.460002
Distance to image 39 = 7.727730
Distance to image 39 = 9.640352
Distance to image 40 = 12.538028

Reset

sunset2_2 d = 7.46002	sunset2_3 d = 7.72730	crater_3 d = 8.86961	affidens_2 d = 8.90985	affidens_3 d = 8.97138	boat_4 d = 9.11297	crater_5 d = 9.53945	boat_2 d = 9.54777
sunset1_1 d = 9.56932	sunset2_4 d = 9.62483	boat_1 d = 9.64119	boat_5 d = 9.84433	beach_3 d = 10.03974	crater_2 d = 10.05265	pond_2 d = 10.06087	cherry_2 d = 10.70576
cherry_3 d = 10.81043	pond_3 d = 10.91565	boat_3 d = 11.13450	pond_1 d = 11.21222	beach_3 d = 12.05907	beach_2 d = 12.13549	crater_4 d = 12.31386	beach_4 d = 12.39052
affidens_5 d = 12.30094	sunset2_5 d = 12.53803	sunset1_4 d = 12.53809	crater_1 d = 12.62012	cherry_1 d = 12.76005	sunset1_2 d = 13.11008	pond_5 d = 13.58236	affidens_4 d = 13.50039
beach_3 d = 13.53031	cherry_3 d = 13.75105	sunset1_3 d = 14.82942	pond_4 d = 15.20383	sunset1_1 d = 16.37849	cherry_4 d = 17.15361	affidens_1 d = 18.30083	sunset1_5 d = 18.41617

Load database

Query

Open Query Image

Query Image:

☒ Check for Distance 2

Query database

Progress:

Distance to image 38 = 12.227265
Distance to image 39 = 3.314141
Distance to image 39 = 11.928280
Distance to image 40 = 12.222471

Reset

boat_1 d = 146.06840	boat_5 d = 132.54589	cherry_2 d = 108.82090	pond_4 d = 104.76289	boat_5 d = 57.19545	boat_3 d = 46.34352	affidens_3 d = 40.07066	crater_5 d = 37.22635
boat_4 d = 36.57790	crater_4 d = 33.20023	beach_3 d = 26.61801	cherry_3 d = 22.74527	beach_5 d = 22.23230	affidens_4 d = 20.75508	crater_1 d = 18.61319	pond_3 d = 15.80748
pond_2 d = 12.69967	affidens_5 d = 12.26768	sunset2_2 d = 12.22720	sunset1_5 d = 12.22347	sunset2_4 d = 11.92828	cherry_4 d = 11.82937	affidens_2 d = 10.55104	crater_2 d = 9.93314
beach_2 d = 7.23590	affidens_1 d = 6.83588	crater_3 d = 6.80020	cherry_3 d = 7.73788	beach_3 d = 7.61723	beach_3 d = 7.25986	pond_3 d = 6.88880	beach_4 d = 5.98609
sunset1_1 d = 5.79255	pond_1 d = 5.15459	sunset1_2 d = 5.13455	sunset1_4 d = 4.75561	sunset1_5 d = 4.34951	sunset2_3 d = 3.31141	sunset1_3 d = 3.30078	sunset1_1 d = 3.30337

Discussion:

0.

I implemented 8*8 and 256*256 GLCM but they are not much difference in retrieval and in running time. The major problem for me in this assignment is how to tune parameters of weighting.

1.

From the experiment results above, you can see that both measurements yield the same top 1 result. And I found that "beach_1" is difficult to yield 3 images retrieve from the same class on the top 5. For "beach_1", I think it's because the light is much different from the other images in the same class. For "sunset1_1", I got 5 out of top 5 result which is impressive. Also, I found that every time when clustering the image pixels, the cluster may be different which also influence the result a little bit.

2. Attributes: I implemented energy, entropy, contrast, boundary, centroid, 8*8 GLCM and 256*256 GLCM

Formula :

Gray-Level Co-occurrence Matrices (GLCMs)

Consider the image (below left). If we use the position operator "1 pixel to the right and 1 pixel down" then we get the gray-level co-occurrence matrix (below right)

$$\begin{array}{ccccc} 0 & 0 & 0 & 1 & 2 \\ 1 & 1 & 0 & 1 & 1 \\ 2 & 2 & 1 & 0 & 0 \\ 1 & 1 & 0 & 2 & 0 \\ 0 & 0 & 1 & 0 & 1 \end{array} \quad C = \frac{1}{16} \begin{bmatrix} 4 & 2 & 1 \\ 2 & 3 & 2 \\ 0 & 2 & 0 \end{bmatrix}$$

where an entry c_{ij} is a count of the number of times that $F(x, y) = i$ and $F(x + 1, y + 1) = j$. For example, the first entry comes from the fact that 4 times a 0 appears below and to the right of another 0. The factor $1/16$ is because there are 16 pairs entering into this matrix, so this normalizes the matrix entries to be estimates of the co-occurrence probabilities.

For statistical confidence in the estimation of the joint probability distribution, the matrix must contain a reasonably large average occupancy level. Achieved either by (a) restricting the number of amplitude quantization levels (causes loss of accuracy for low-amplitude texture), or (b) using large measurement window. (causes errors if texture changes over the large window). Typical compromise: 16 gray levels and window size of 30 or 50 pixels on each side. Now we can analyze C :

- maximum probability entry

- element difference moment of order k : $\sum_i \sum_j (i - j)^k c_{ij}$

This descriptor has relatively low values when the high values of C are near the main diagonal. For this position operator, high values near the main diagonal would indicate that bands of constant intensity running "1 pixel to the right and 1 down" are likely. When $k = 2$, it is called the contrast:

- Contrast = $\sum_i \sum_j (i - j)^2 c_{ij}$

- Entropy = $-\sum_i \sum_j c_{ij} \log c_{ij}$

For entropy term, I found that a smoother image will yield high entropy. But for image retrieval, it's not that important. For contrast term, I found that a image with more difference will result in higher contrast. But for image retrieval, it's not that important. For boundary term, it's greatly influenced by shifting, thus this term isn't suitable for looking for similar images in the same class. For centroid term, this is ok if there is not much rotation in camera coordinate.

Among all the features, I found that energy is the most important one which quite make sense since

it's a important feature when you take a picture at about the same position and orientation, the relative position of the landscape is about the same which will result in similar parts of GLCM. But if you only focus on this term, when there are two totally different picture but with the same color distribution, then it hard to tell the difference. Thus, in stead of only focus on energy, we also need to consider the correlation between pixels. So I also implemented contrast, correlation, entropy. But I think I should not only focus on local features, thus I also tried to add some global feature like GIST feature but I failed, so I just use randomSelect to select some global pixels' values but it turns out to be a noise term. Thus I deleted it. I also think boundary and centroid are important terms which also separate the similar image from the dissimilar ones.

3. Distance measures: I implemented L1, reference distance weighted (RDW), cosine and Bray-Curtis.

L1 norm is

```
Sum += abs(vector1[i] - vector2[i]);  
return Sum;
```

RDW is

```
Sum+=abs((vector1[i]-vector2[i])/vector1[i]);  
Sum /= vector length;  
Return Sum;
```

Bray-Curtis is

```
sum+= (vector1[i]-vector2[i])/(vector1[i]+vector2[i]);  
return sum;
```

L1 works quite well while RDW doesn't. RDW is used to measure the dissimilarity between two vectors and I thought if I use it when RDW is small which means you are similar but in the end it doesn't work. It's mainly because the denominator would be too small so the value will be close to infinity so they cannot be compared. And also some features' values are dominating the measurements in denominator terms. Thus I also considered these edge cases. I also tried cosine of two vectors but it doesn't work well for it's a higher dimension vector. [Bray-Curtis is not suitable for this case though.](#)

4. I also study a paper[1] which includes the methods developments of CBIR after 2003. From this paper I learned whole ideas of how they deal with computer vision problems in CBIR. I just want to mention for it's a good paper.

Reference:

[1] W. Zhou, H. Li, Q. Tian : Recent Advance in Content-based Image Retrieval: A Literature Survey, 2017.