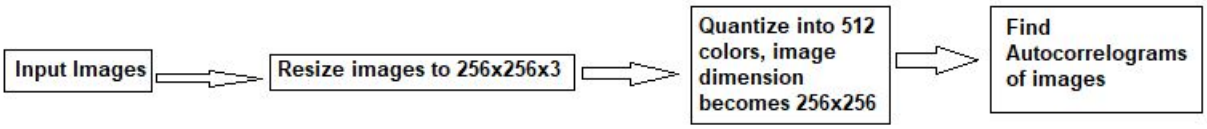
Question 1

Color autocorrelogram:

Pipeline of the solution:



While constructing the autocorrelogram for a distance d, we consider 8 neighbours per pixel, i.e. for a pixel (x, y) we consider the neighbours (x + d, y), (x + d, y - d), (x, y - d), (x - d, y - d) (x - d, y), (x - d, y + d), (x, y + d). To further speed up the construction, we skip d/2 pixels while constructing the correlogram for distance d.
For retrieval of images, we explore rankings based on various distance metrics. Summary statistics for various distance metrics are summarized in the table below:

Distance Metric	Number of images retrieved	Mean precision	Mean recall
Relative distance	150	0.04303030303030	0.09625913125661
Relative distance	100	0.05121212121212	**0.07691281466431**
Relative distance	50	**0.06121212121212**	0.04897165550696
L1	100	0.05121212121212	0.07093997244943
L1	50	0.05818181818181	0.04309752868264
L2	100	0.03787878787878	0.04915508479218
L2	50	0.04121212121212	.034083582606501

The distance metrics were define as follows:

Relative distance:

$$|I_1 - I_2|_{\alpha,d_1} = \sum_{\substack{i\in\{1,\ldots,m\}\\ k\in\{1,\ldots,n\}}} d_1\left[\alpha_{c_i}^{(k)}(I_1), \alpha_{c_i}^{(k)}(I_2)\right].$$

Where $d_1(r,s) = |r-s|/(1+r+s)$

L_2 distance:

$$|I_1 - I_2|_{\alpha,d_1} = \sum_{\substack{i\in\{1,\ldots,m\}\\ k\in\{1,\ldots,n\}}} d_1\left[\alpha_{c_i}^{(k)}(I_1), \alpha_{c_i}^{(k)}(I_2)\right].$$

Where $d_1(r,s) = ||r-s||_2$

L_1 distance:

$$|I_1 - I_2|_{\alpha,d_1} = \sum_{\substack{i\in\{1,\ldots,m\}\\ k\in\{1,\ldots,n\}}} d_1\left[\alpha_{c_i}^{(k)}(I_1), \alpha_{c_i}^{(k)}(I_2)\right].$$

Where $d_1(r,s) = ||r-s||_1$

The evaluation metrics used are defined as follows:

Precision:

The ratio of the number of relevant images retrieved to the total number of images retrieved.

Recall:

The ratio of the number of relevant images retrieved to total number of relevant images.

F1 Score:
The harmonic mean of precision and recall.

The results on each query with relative distance and 100 images retrieved are summarized in the table below:

Query	Precision (%)	Recall (%)	F1-Score	Good	Ok	Junk	Time (s)
all_souls_3_query	7	6.3	0.066	3	3	1	0.21
all_souls_1_query	2	1.8	0.019	0	2	0	0.17
all_souls_2_query	1	0.9	0.009	0	0	1	0.17
bodleian_1_query	5	16.6	0.07	3	1	1	0.17
bodleian_3_query	4	13.3	0.06	2	2	0	0.18
balliol_1_query	1	5.5	0.01	0	1	0	0.18
balliol_3_query	1	5.5	0.01	0	1	0	0.19
ashmolean_1_query	5	16.1	0.07	4	1	0	0.17
balliol_2_query	1	5.5	0.01	0	1	0	0.18
ashmolean_3_query	2	6.4	0.03	1	1	0	0.17
ashmolean_2_query	1	3.2	0.01	0	1	0	0.20
bodleian_2_query	5	16.6	0.07	4	1	0	0.21
christ_church_1_query	6	4.5	0.05	1	3	2	0.17
hertford_1_query	11	18	0.13	7	4	0	0.18
christ_church_3_query	5	3.7	0.04	2	2	1	0.17
christ_church_2_query	10	7.5	0.08	5	1	4	0.17
cornmarket_1_query	3	23	0.05	2	1	0	0.16
cornmarket_3_query	4	30.7	0.07	3	1	0	0.19
cornmarket_2_query	0	0	0	0	0	0	0.18
magdalen_2_query	2	1.9	0.02	0	0	2	0.18
magdalen_1_query	3	2.9	0.02	1	1	1	0.18
magdalen_3_query	9	8.7	0.08	1	4	4	0.18
hertford_3_query	2	3.2	0.04	1	1	0	0.18
keble_2_query	0	0	0	0	0	0	0.20
keble_3_query	1	9	0.01	1	0	0	0.17
keble_1_query	1	9	0.01	1	0	0	0.20

hertford_2_query	8	13.1	0.09	6	2	0	0.18
pitt_rivers_1_query	0	0	0	0	0	0	0.19
pitt_rivers_2_query	0	0	0	0	0	0	0.22
radcliffe_camera_3_query	30	8.6	0.137	14	12	4	0.19
radcliffe_camera_2_query	16	4.5	0.07	7	4	5	0.19
radcliffe_camera_1_query	23	6.6	0.10	8	10	5	0.19
pitt_rivers_3_query	0	0	0	0	0	0	0.18
Mean	5.12	7.65	0.04	2.33	1.84	0.93	0.18

The results can be summarized in the table below:

	Precision	Recall	F1-Score	Time
Maximum	30%	30.7%	0.13	0.22s
Minimum	0%	0%	0%	0.17s
Mean	5.12%	7.65%	0.04	0.18s

Analysis

As a whole, the results obtained were mainly poor. This is mainly due to the loss of information arising out of reshaping the images to a much smaller dimension than the original, quantizing the rgb image into a limited set of colors, skipping pixels while constructing the correlogram, skipping pixels while considering neighbors of a particular pixel. However, these measures were necessary to ensure that the construction is complete in a reasonable amount of time.

The best precision was obtained on radcliffe_camera_3_query.

The query image was :

This may be attributed to the fact that the image has a high number of relevant images in the database (105 good + 127 junk + 116 ok). Thus, there is a higher chance of images with similar color distribution being relevant to the query image.

The best recall was obtained on cornmarket_3_query.

The query image was :

This may be attributed to the fact that the image has small number of relevant images in the database (5 good + 4 junk + 4 ok). Thus, the chance of missing a relevant image in 100 retrievals is low.

The best F1-Score was obtained on radcliffe_camera_3_query.

As noted above, this query also has the highest precision. The query also has a relatively higher recall 8.6%. We note that hertford_1_query also has an F1-score which is approximately equal to that of radcliffe_camera_3_query. Since the gain in precision on radcliffe_camera_3_query is higher than the loss in recall on radcliffe_camera_3_query(compared to hertford_1_query), it has a slightly higher F1-score than hertford_1_query.

We note that in the above-mentioned images, spatial correlation of colors is enough to encapsulate relevant images and hence correlograms work well.

The worst results are obtained on quite a few images, where no relevant images are retrieved. This may be attributed to the reasons mentioned above. Some of these queries are: pitt_rivers_3_query, pitt_rivers_2_query, pitt_rivers_1_query, keble_2_query.