CS517 Digital Image Processing

Assignment 4

JPEG Compression

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Image: kodim01.png

Sr. No.	Block Size	Code Size	Image Color	RMSE	PSNR	Compression Ratio
1	8	1	Color	8.842	29.200	34.12
2	8	3	Color	8.433	29.611	15.70
3	8	6	Color	8.167	29.889	11.39
4	8	10	Color	7.889	30.190	8.62
5	8	15	Color	7.495	30.636	6.90
6	8	28	Color	6.698	31.612	5.19
7	8	64	Color	6.566	31.785	4.96
8	4	1	Gray	8.172	29.884	7.31
9	4	5	Gray	7.647	31.125	4.61
10	4	11	Gray	6.845	31.842	4.06
11	4	16	Gray	6.517	31.85	4.05

Average PSNR for Color Image: 30.4175
Average PSNR for Gray Image: 31.175

Image: kodim02.png

Sr. No.	Block Size	Code Size	Image Color	RMSE	PSNR	Compression Ratio
1	8	1	Color	6.376	32.040	26.53
2	8	3	Color	5.868	32.762	15.2
3	8	6	Color	5.622	33.134	12.11
4	8	10	Color	5.382	33.512	9.93
5	8	15	Color	5.199	33.812	8.6
6	8	28	Color	4.911	34.307	7.45
7	8	64	Color	4.898	34.330	7.35
8	4	1	Gray	5.232	33.758	9.95
9	4	5	Gray	4.332	35.398	6.57
10	4	11	Gray	4.094	35.888	6.20
11	4	16	Gray	4.093	35.891	6.19

Average PSNR for Color Image: 33.414
Average PSNR for Gray Image: 35.234

Image: kodim03.png

Sr. No.	Block Size	Code Size	Image Color	RMSE	PSNR	Compression Ratio
1	8	1	Color	5.787	32.881	25.62
2	8	3	Color	5.229	33.763	13.7
3	8	6	Color	4.932	34.271	11.11
4	8	10	Color	4.694	34.7	9.35
5	8	15	Color	4.451	35.163	8.32
6	8	28	Color	4.061	35.959	7.14
7	8	64	Color	3.995	36.101	6.97
8	4	1	Gray	4.955	34.229	7.74
9	4	5	Gray	3.997	36.095	5.82
10	4	11	Gray	3.776	36.591	5.53
11	4	16	Gray	3.773	36.596	5.52

Average PSNR for Color Image: 34.662
Average PSNR for Gray Image: 35.877

Image: kodim04.png

Sr. No.	Block Size	Code Size	Image Color	RMSE	PSNR	Compression Ratio
1	8	1	Color	6.954	31.286	28.26
2	8	3	Color	6.127	32.386	14.36
3	8	6	Color	5.725	32.975	11.32
4	8	10	Color	5.378	33.518	9.35
5	8	15	Color	5.097	33.985	8.13
6	8	28	Color	4.766	34.568	7.06
7	8	64	Color	4.739	34.617	6.96
8	4	1	Gray	5.714	32.991	8.16
9	4	5	Gray	4.480	35.106	6.03
10	4	11	Gray	4.257	35.549	5.76
11	4	16	Gray	4.256	35.551	5.76

Average PSNR for Color Image: 33.411
Average PSNR for Gray Image: 34.799

Image: kodim05.png

Sr. No.	Block Size	Code Size	Image Color	RMSE	PSNR	Compression Ratio
1	8	1	Color	8.977	29.068	26.87
2	8	3	Color	8.425	29.620	11.82
3	8	6	Color	7.976	30.095	8.53
4	8	10	Color	7.6329	30.482	6.61
5	8	15	Color	7.281	30.887	5.53
6	8	28	Color	6.605	31.733	4.48
7	8	64	Color	6.395	32.014	4.27
8	4	1	Gray	8.037	30.029	6.12
9	4	5	Gray	6.747	31.549	4.05
10	4	11	Gray	6.291	32.156	3.68
11	4	16	Gray	6.261	32.198	3.65

Average PSNR for Color Image: 30.394
Average PSNR for Gray Image: 31.483

Image: kodim06.png

Sr. No.	Block Size	Code Size	Image Color	RMSE	PSNR	Compression Ratio
1	8	1	Color	7.814	30.273	32.19
2	8	3	Color	7.477	30.656	13.93
3	8	6	Color	7.199	30.985	10.62
4	8	10	Color	6.955	31.285	8.18
5	8	15	Color	6.611	31.725	6.79
6	8	28	Color	5.940	32.655	5.27
7	8	64	Color	5.747	32.942	5.03
8	4	1	Gray	7.217	30.964	7.18
9	4	5	Gray	5.999	32.570	4.55
10	4	11	Gray	5.639	33.107	4.19
11	4	16	Gray	5.632	33.117	4.18

Average PSNR for Color Image: 31.333
Average PSNR for Gray Image: 32.439

Image: kodim07.png

Sr. No.	Block Size	Code Size	Image Color	RMSE	PSNR	Compression Ratio
1	8	1	Color	7.218	30.962	25.78
2	8	3	Color	6.351	32.074	12.97
3	8	6	Color	5.534	33.27	10.21
4	8	10	Color	4.905	34.319	8.38
5	8	15	Color	4.567	34.938	7.35
6	8	28	Color	4.211	35.643	6.4
7	8	64	Color	4.164	35.741	6.29
8	4	1	Gray	6.047	32.500	6.74
9	4	5	Gray	4.130	35.812	5.61
10	4	11	Gray	3.887	36.338	5.32
11	4	16	Gray	3.882	36.349	5.31

Average PSNR for Color Image: 33.584
Average PSNR for Gray Image: 35.999

Image: kodim08.png

Sr. No.	Block Size	Code Size	Image Color	RMSE	PSNR	Compression Ratio
1	8	1	Color	9.096	28.954	30.85
2	8	3	Color	8.719	29.322	11.89
3	8	6	Color	8.399	29.646	8.5
4	8	10	Color	8.114	29.946	6.57
5	8	15	Color	7.711	30.388	5.45
6	8	28	Color	6.921	31.327	4.41
7	8	64	Color	6.568	31.782	4.2
8	4	1	Gray	8.473	29.57	6.77
9	4	5	Gray	7.437	30.703	4.3
10	4	11	Gray	6.444	31.948	3.77
11	4	16	Gray	6.411	31.992	3.76

Average PSNR for Color Image: 30.187
Average PSNR for Gray Image: 31.053

Image: kodim09.png

Sr. No.	Block Size	Code Size	Image Color	RMSE	PSNR	Compression Ratio
1	8	1	Color	6.284	32.166	31.88
2	8	3	Color	5.745	32.945	16.51
3	8	6	Color	5.36	33.547	13.08
4	8	10	Color	4.998	34.155	10.9
5	8	15	Color	4.64	34.8	9.55
6	8	28	Color	4.173	35.723	8.16
7	8	64	Color	4.118	35.837	8.02
8	4	1	Gray	5.418	33.453	8.88
9	4	5	Gray	4.371	35.32	6.84
10	4	11	Gray	3.985	36.122	6.44
11	4	16	Gray	3.979	36.135	6.43

Average PSNR for Color Image: 33.961
Average PSNR for Gray Image: 35.507

Image: kodim10.png

Sr. No.	Block Size	Code Size	Image Color	RMSE	PSNR	Compression Ratio
1	8	1	Color	6.644	31.683	30.41
2	8	3	Color	5.93	32.669	15.04
3	8	6	Color	5.45	33.396	11.59
4	8	10	Color	5.066	34.038	9.51
5	8	15	Color	4.712	34.667	8.27
6	8	28	Color	4.348	35.365	7.19
7	8	64	Color	4.281	35.501	7.05
8	4	1	Gray	5.683	33.04	8.07
9	4	5	Gray	4.382	35.298	6.07
10	4	11	Gray	4.071	35.937	5.7
11	4	16	Gray	4.056	35.968	5.68

Average PSNR for Color Image: 33.944
Average PSNR for Gray Image: 35.311

Image: kodim11.png

Sr. No.	Block Size	Code Size	Image Color	RMSE	PSNR	Compression Ratio
1	8	1	Color	7.542	30.581	29.02
2	8	3	Color	6.967	31.27	13.91
3	8	6	Color	6.625	31.707	10.63
4	8	10	Color	6.291	32.156	8.39
5	8	15	Color	5.948	32.643	7.02
6	8	28	Color	5.428	33.438	5.68
7	8	64	Color	5.352	33.561	5.49
8	4	1	Gray	6.849	31.418	7.44
9	4	5	Gray	5.605	33.16	4.7
10	4	11	Gray	5.287	33.667	4.31
11	4	16	Gray	5.278	33.682	4.3

Average PSNR for Color Image: 32.135
Average PSNR for Gray Image: 32.982

Image: kodim12.png

Sr. No.	Block Size	Code Size	Image Color	RMSE	PSNR	Compression Ratio
1	8	1	Color	6.209	32.271	29.91
2	8	3	Color	5.71	32.998	14.19
3	8	6	Color	5.377	33.521	11.46
4	8	10	Color	5.117	33.951	9.27
5	8	15	Color	4.741	34.614	8.17
6	8	28	Color	4.324	35.414	7.04
7	8	64	Color	4.215	35.634	6.97
8	4	1	Gray	5.34	33.58	8.26
9	4	5	Gray	4.205	35.656	5.62
10	4	11	Gray	4.026	36.033	5.43
11	4	16	Gray	4.021	36.044	5.41

Average PSNR for Color Image: 33.964
Average PSNR for Gray Image: 35.828

Image: kodim13.png

Sr. No.	Block Size	Code Size	Image Color	RMSE	PSNR	Compression Ratio
1	8	1	Color	9.185	28.869	35.19
2	8	3	Color	8.866	29.177	14.57
3	8	6	Color	8.615	29.425	10.07
4	8	10	Color	8.377	29.669	7.54
5	8	15	Color	8.094	29.968	5.97
6	8	28	Color	7.619	30.492	4.49
7	8	64	Color	7.435	30.705	4.11
8	4	1	Gray	8.71	29.331	6.7
9	4	5	Gray	7.725	30.373	4.16
10	4	11	Gray	7.364	30.788	3.7
11	4	16	Gray	7.325	30.835	3.65

Average PSNR for Color Image: 29.682
Average PSNR for Gray Image: 30.582

Image: kodim14.png

Sr. No.	Block Size	Code Size	Image Color	RMSE	PSNR	Compression Ratio
1	8	1	Color	8.333	29.715	26.27
2	8	3	Color	7.672	30.433	12.77
3	8	6	Color	7.246	30.929	9.58
4	8	10	Color	6.873	31.388	7.45
5	8	15	Color	6.503	31.868	6.2
6	8	28	Color	5.986	32.614	5.01
7	8	64	Color	5.881	32.742	4.86
8	4	1	Gray	7.446	30.692	6.41
9	4	5	Gray	5.929	32.671	4.42
10	4	11	Gray	5.658	33.078	4.16
11	4	16	Gray	5.651	33.088	4.14

Average PSNR for Color Image: 31.173
Average PSNR for Gray Image: 32.132

Image: kodim15.png

Sr. No.	Block Size	Code Size	Image Color	RMSE	PSNR	Compression Ratio
1	8	1	Color	6.278	32.175	27.56
2	8	3	Color	5.763	32.917	12.78
3	8	6	Color	5.472	33.368	10.96
4	8	10	Color	5.290	33.662	9.26
5	8	15	Color	5.076	34.02	8.19
6	8	28	Color	4.734	34.627	7.11
7	8	64	Color	4.604	34.868	6.94
8	4	1	Gray	5.58	33.198	8.59
9	4	5	Gray	4.733	34.628	5.47
10	4	11	Gray	4.378	35.305	5.14
11	4	16	Gray	4.371	35.319	5.13

Average PSNR for Color Image: 33.936
Average PSNR for Gray Image: 34.613

Image: kodim16.png

Sr. No.	Block Size	Code Size	Image Color	RMSE	PSNR	Compression Ratio
1	8	1	Color	6.931	31.315	30.3
2	8	3	Color	6.387	32.025	14.21
3	8	6	Color	6.08	32.453	11.2
4	8	10	Color	5.799	32.864	8.72
5	8	15	Color	5.483	33.35	7.43
6	8	28	Color	4.902	34.324	5.99
7	8	64	Color	4.814	34.481	5.81
8	4	1	Gray	6.279	32.174	7.16
9	4	5	Gray	4.948	34.243	4.79
10	4	11	Gray	4.748	34.601	4.58
11	4	16	Gray	4.746	34.605	4.58

Average PSNR for Color Image: 33.017
Average PSNR for Gray Image: 33.905

Image: kodim17.png

Sr. No.	Block Size	Code Size	Image Color	RMSE	PSNR	Compression Ratio
1	8	1	Color	7.102	31.103	31.75
2	8	3	Color	6.151	32.352	14.01
3	8	6	Color	5.568	33.218	11.11
4	8	10	Color	5.130	33.928	9.05
5	8	15	Color	4.859	34.4	7.85
6	8	28	Color	4.519	35.03	6.83
7	8	64	Color	4.443	35.137	6.67
8	4	1	Gray	6.201	32.282	6.58
9	4	5	Gray	4.888	34.348	4.12
10	4	11	Gray	4.66	34.762	3.95
11	4	16	Gray	4.653	34.775	3.94

Average PSNR for Color Image: 33.695
Average PSNR for Gray Image: 34.042

Image: kodim18.png

Sr. No.	Block Size	Code Size	Image Color	RMSE	PSNR	Compression Ratio
1	8	1	Color	8.003	30.066	31.07
2	8	3	Color	7.523	30.602	15.26
3	8	6	Color	7.128	31.072	10.91
4	8	10	Color	6.761	31.530	8.61
5	8	15	Color	6.416	31.986	7.12
6	8	28	Color	5.997	32.573	5.86
7	8	64	Color	5.915	32.691	5.62
8	4	1	Gray	7.396	30.751	7.71
9	4	5	Gray	6.141	32.365	5.16
10	4	11	Gray	5.797	32.866	4.75
11	4	16	Gray	5.774	32.901	4.72

Average PSNR for Color Image: 31.471
Average PSNR for Gray Image: 32.221

Image: kodim19.png

Sr. No.	Block Size	Code Size	Image Color	RMSE	PSNR	Compression Ratio
1	8	1	Color	7.245	30.93	32.76
2	8	3	Color	6.804	31.476	15.41
3	8	6	Color	6.514	31.854	11.84
4	8	10	Color	6.272	32.182	9.4
5	8	15	Color	6.009	32.555	8.01
6	8	28	Color	5.422	33.447	6.65
7	8	64	Color	5.248	33.731	6.47
8	4	1	Gray	6.602	31.737	8.05
9	4	5	Gray	5.708	33.001	5.57
10	4	11	Gray	5.099	33.981	5.17
11	4	16	Gray	5.095	33.988	5.16

Average PSNR for Color Image: 32.478
Average PSNR for Gray Image: 32.927

Image: kodim20.png

Sr. No.	Block Size	Code Size	Image Color	RMSE	PSNR	Compression Ratio
1	8	1	Color	5.878	32.747	27.95
2	8	3	Color	5.517	33.297	12.51
3	8	6	Color	5.275	33.686	10.4
4	8	10	Color	5.07	34.03	8.71
5	8	15	Color	4.856	34.405	7.57
6	8	28	Color	4.5	35.066	6.35
7	8	64	Color	4.435	35.193	6.19
8	4	1	Gray	5.179	33.846	7.86
9	4	5	Gray	4.368	35.326	5.44
10	4	11	Gray	4.127	35.817	5
11	4	16	Gray	4.117	35.838	4.98

Average PSNR for Color Image: 33.893
Average PSNR for Gray Image: 35.457

Image: kodim21.png

Sr. No.	Block Size	Code Size	Image Color	RMSE	PSNR	Compression Ratio
1	8	1	Color	7.093	31.114	31.02
2	8	3	Color	6.74	31.558	15.24
3	8	6	Color	6.438	31.955	11.57
4	8	10	Color	6.184	32.306	9.14
5	8	15	Color	5.922	32.682	7.73
6	8	28	Color	5.46	33.387	6.08
7	8	64	Color	5.366	33.538	5.83
8	4	1	Gray	6.492	31.883	7.93
9	4	5	Gray	5.452	33.4	5.44
10	4	11	Gray	5.183	33.839	4.98
11	4	16	Gray	5.176	33.85	4.96

Average PSNR for Color Image: 32.489
Average PSNR for Gray Image: 33.493

Image: kodim22.png

Sr. No.	Block Size	Code Size	Image Color	RMSE	PSNR	Compression Ratio
1	8	1	Color	7.55	30.799	29.52
2	8	3	Color	6.836	31.435	14.98
3	8	6	Color	6.447	31.944	11.43
4	8	10	Color	6.081	32.452	9.1
5	8	15	Color	5.779	32.893	7.62
6	8	28	Color	5.421	33.45	6.37
7	8	64	Color	5.374	33.524	6.24
8	4	1	Gray	6.591	31.752	8.41
9	4	5	Gray	5.381	33.513	5.77
10	4	11	Gray	5.05	34.065	5.34
11	4	16	Gray	5.044	34.075	5.32

Average PSNR for Color Image: 32.51
Average PSNR for Gray Image: 33.351

Image: kodim23.png

Sr. No.	Block Size	Code Size	Image Color	RMSE	PSNR	Compression Ratio
1	8	1	Color	5.781	32.891	22.46
2	8	3	Color	4.766	34.568	12.57
3	8	6	Color	4.412	35.237	10.67
4	8	10	Color	.4.182	35.703	9.39
5	8	15	Color	4.017	36.052	8.67
6	8	28	Color	3.802	36.532	7.97
7	8	64	Color	3.767	36.611	7.92
8	4	1	Gray	4.535	34.998	8.16
9	4	5	Gray	3.527	37.182	6.93
10	4	11	Gray	3.299	37.764	6.69
11	4	16	Gray	3.295	37.775	6.69

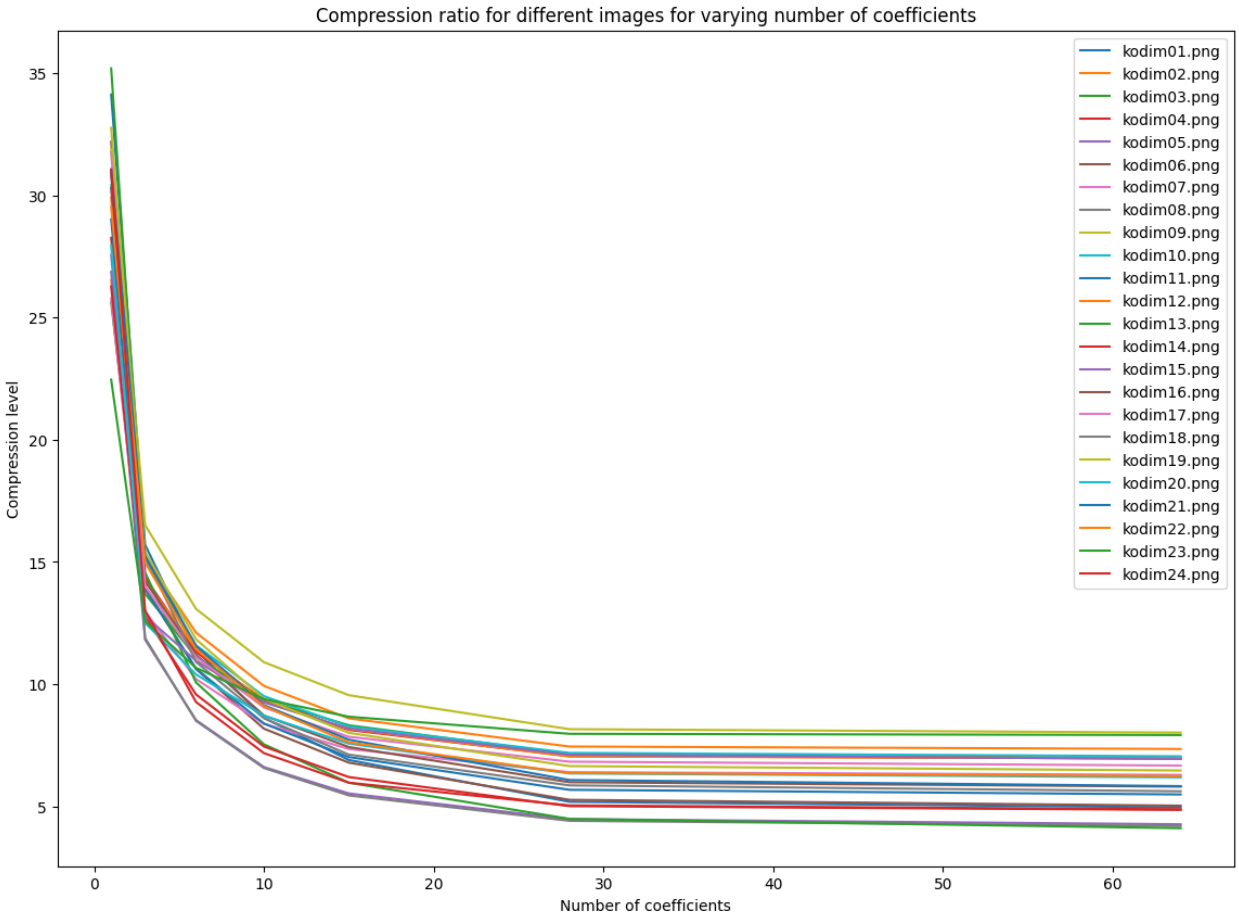
Average PSNR for Color Image: 35.546
Average PSNR for Gray Image: 37.43

Image: kodim24.png

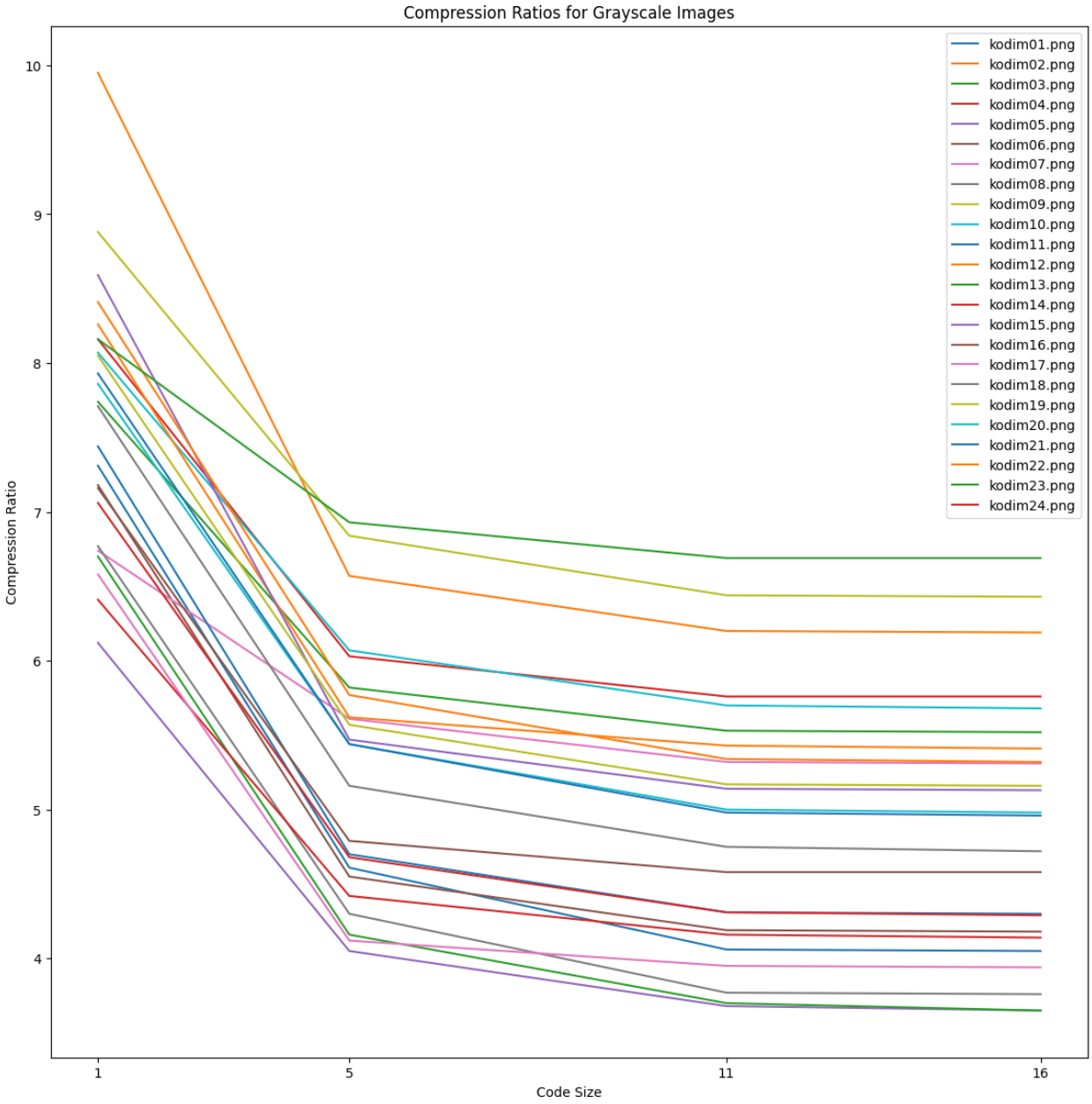
Sr. No.	Block Size	Code Size	Image Color	RMSE	PSNR	Compression Ratio
1	8	1	Color	7.941	30.134	31.04
2	8	3	Color	7.398	30.749	13.01
3	8	6	Color	6.983	31.25	9.27
4	8	10	Color	6.626	31.706	7.18
5	8	15	Color	6.27	32.186	5.97
6	8	28	Color	5.859	32.774	5.04
7	8	64	Color	5.751	32.936	4.88
8	4	1	Gray	7.194	34.998	7.06
9	4	5	Gray	6.056	37.182	4.68
10	4	11	Gray	5.606	37.764	4.31
11	4	16	Gray	5.58	37.775	4.29

Average PSNR for Color Image: 31.485
Average PSNR for Gray Image: 32.958

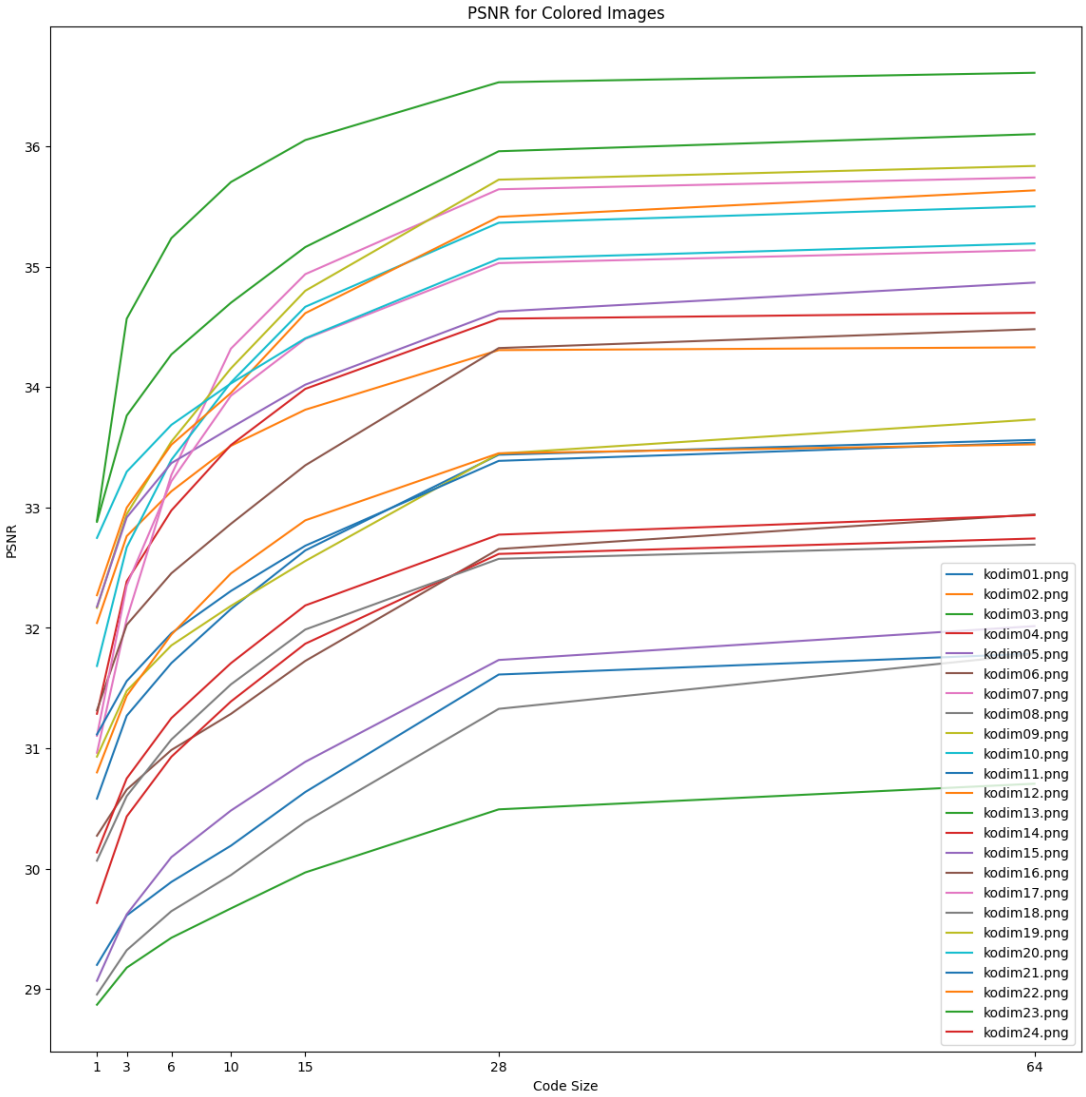
Normalized PSNR Color Image: 32.7733
Normalized PSNR Gray Image: 33.771



Upon analyzing the graph, it is evident that there exists a strong negative relationship between the number of coefficients and the compression ratio in JPEG compression. The graph clearly shows that as the number of coefficients increases, the compression ratio decreases exponentially. This means that more coefficients used for compression lead to the removal of high-frequency components, resulting in less compression and thus, lower compression ratio. Conversely, a decrease in the number of coefficients leads to the retention of high-frequency components, increasing compression, and resulting in higher compression ratio. This observation can be attributed to the use of DCT in JPEG compression, which separates the image into different frequency components. High-frequency components are less important for visual perception than low-frequency components, and therefore can be discarded to achieve higher compression ratio.

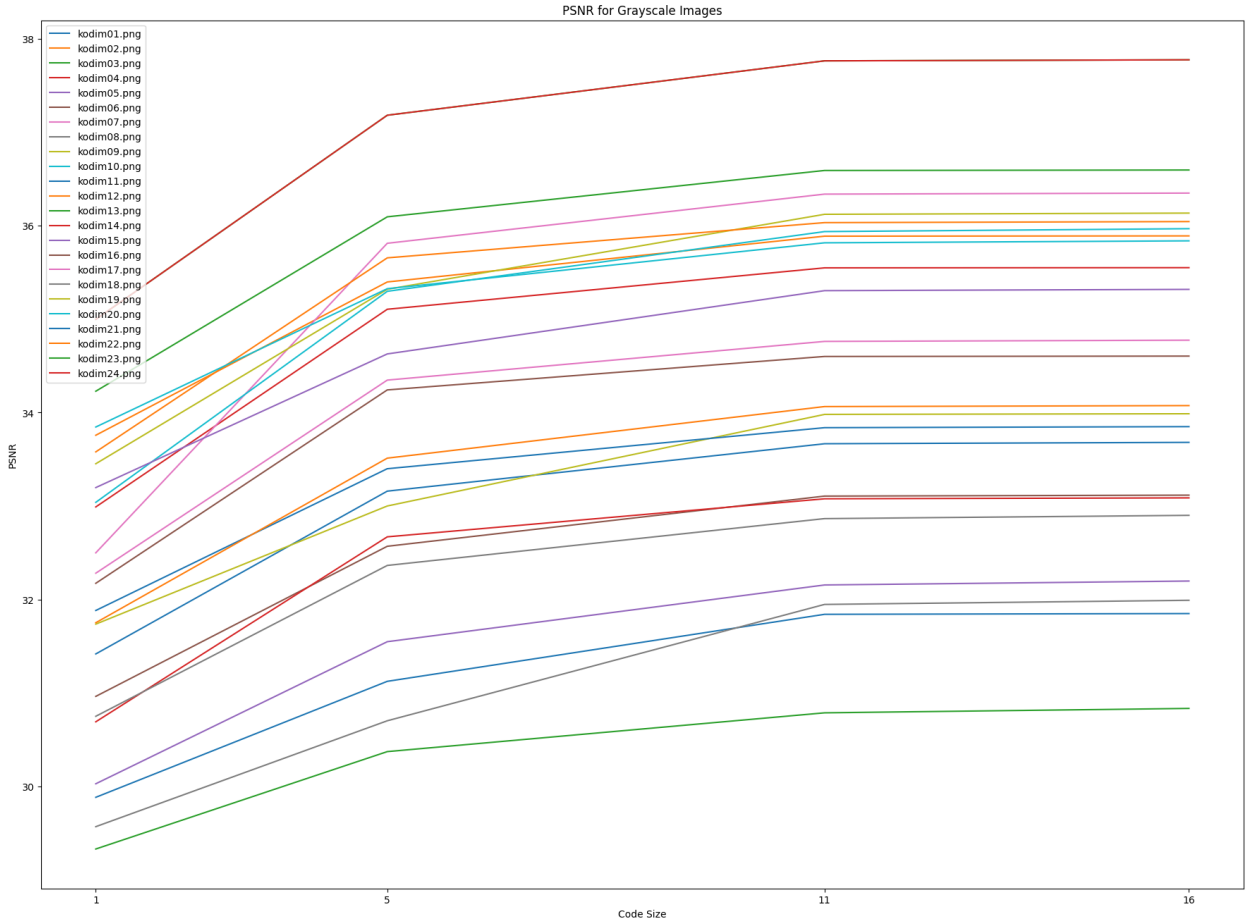


Similar observations like we saw in colored images. The compression ratio decrease with the increase in number of coefficients(code size)



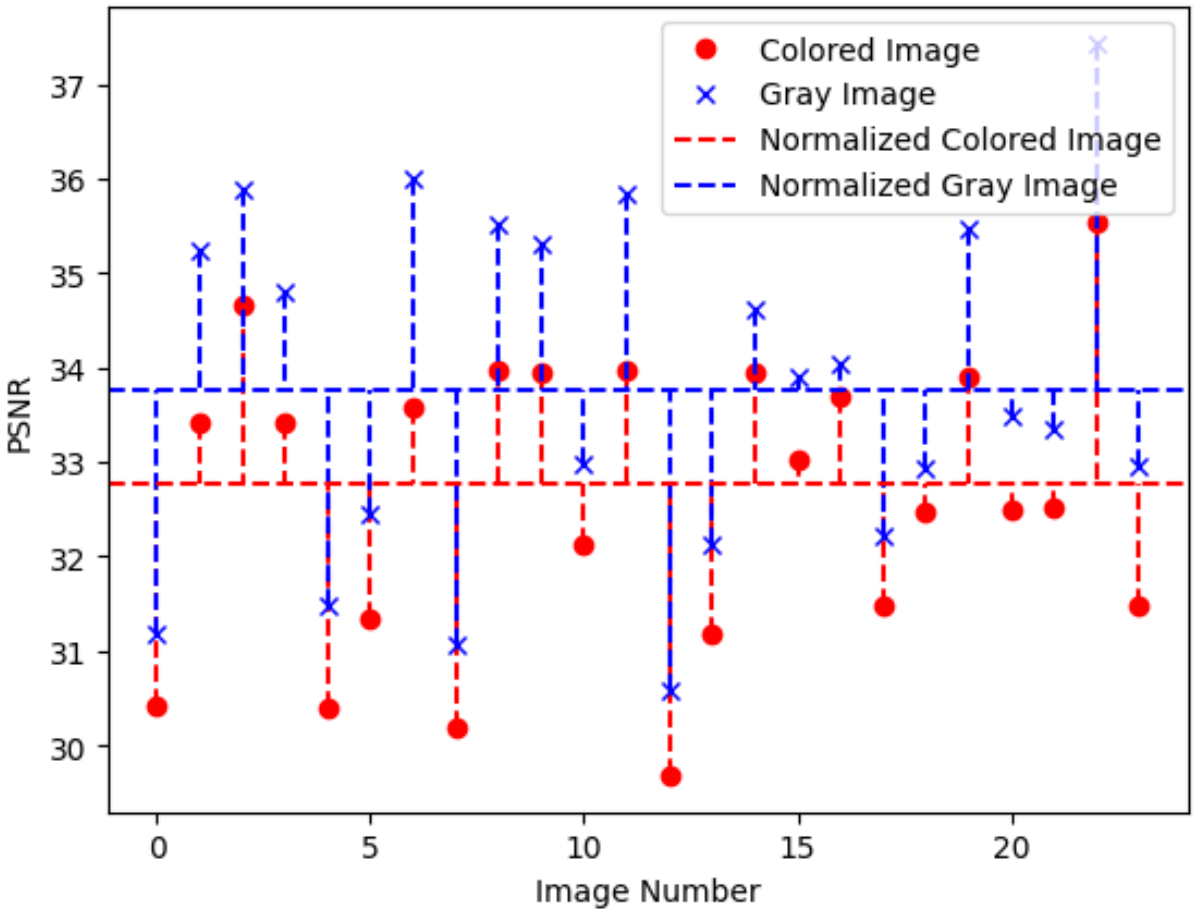
The relationship between the number of coefficients and PSNR for colored images can be seen from the graph above. As we increase the number of coefficients, the PSNR initially increases rapidly and then gradually levels off, forming a curve with a concave shape.

This behavior is due to the fact that increasing the number of coefficients results in a better approximation of the original image, and therefore a higher PSNR value. However, after a certain point, the added coefficients do not provide significant improvements in the quality of the reconstructed image, and the PSNR begins to level off.



In the above graph as well, we can observe the same trend.

Plot showing deviation from normalized PSNR value for respective image in color and grayscale variant



Upon analyzing the plot of the PSNR values for the colored and gray images, we can infer that the PSNR values for the colored image are generally lower than those for the gray image, indicating that the gray image has better quality than the colored image. However, this trend is not consistent across all images and there are some exceptions where the colored image has higher PSNR values. Additionally, we can observe that both plots exhibit a considerable amount of variability in PSNR values across the different images.

The dotted lines connecting each point to its respective normalized line serve to highlight the distance between each PSNR value and the normalized value. This provides an intuitive way to visualize how much each image deviates from the normalized value, and allows us to identify which images have the most significant loss of image quality.