Partial JPEG encoding/decoding

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Aims: simulate partial JPEG encoding and decoding procedures on a grayscale image, and assess the reconstructed image quality using RMSE metric

The test image **lennaY.png** is used in this case and the partial JPEG encoding procedure block splitting, level shifting, DCT, and quantization are followed to compute encoding step results (after DCT and quantization). The partial JPEG decoding de-quantization, IDCT, level shifting and block merging are followed to compute reconstructed images.

The image is splitting **64** blocks in total and each block has size **8x8**. The image scaling is performed by applying quantization table. The different scaling factor is selected during the decoding procedure. The reconstructed images are shown below:

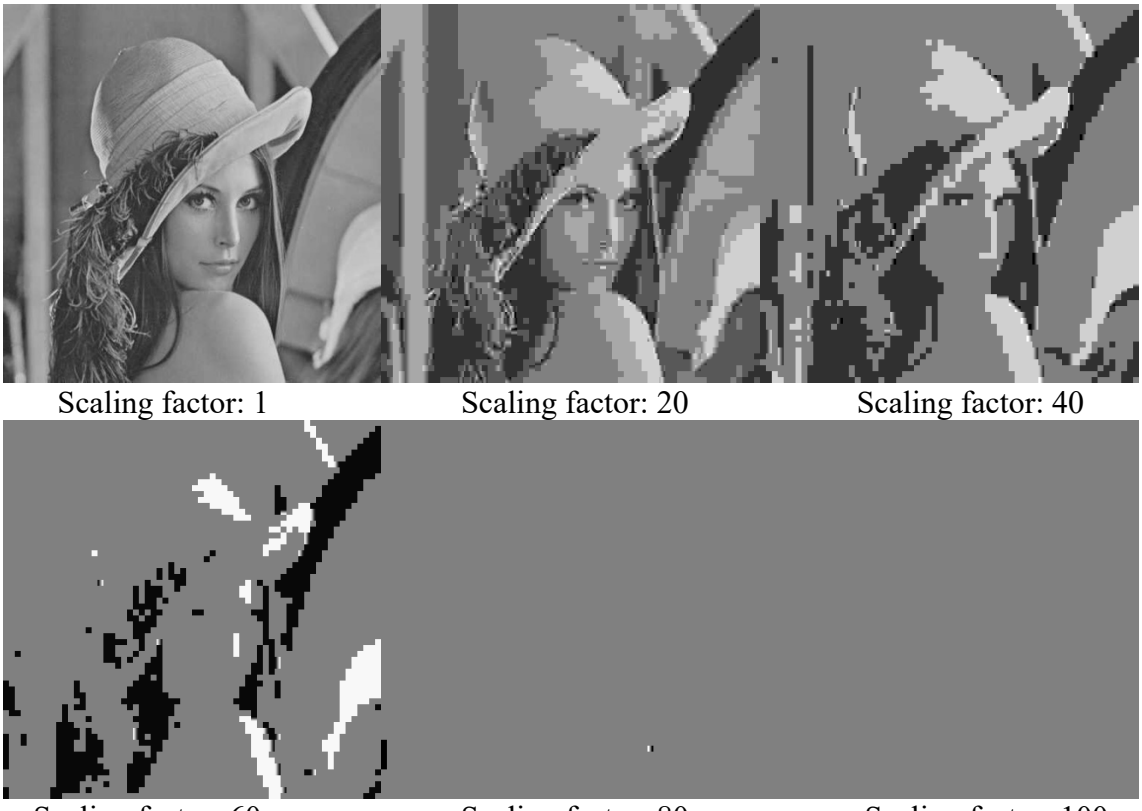

Figure 1. Reconstructed image with different scaling factor

From the image, we can notice that when the scaling factor is bigger, the image quality is decreased. Due to the **round()** operation in the quantization, more values are rounded to zero when the big scaling factor. Therefore, more fine detail information is lost with increased scaling factor. Specially for the edges in image, the differences of pixels which allow us to distinguish the details and outline of image are decreased. We can see the image cannot represent the people's contour after scaling factor 60.

In order to compare the differences between reconstructed images and original image and to see the effect of the different scaling factor, the RMSE are computed.

Scaling factor	1	20	40	60	80	100
RMSE	3.7401	16.2978	37.4549	41.4978	41.4978	41.5124

Table 1. RMSE values in different scaling factor

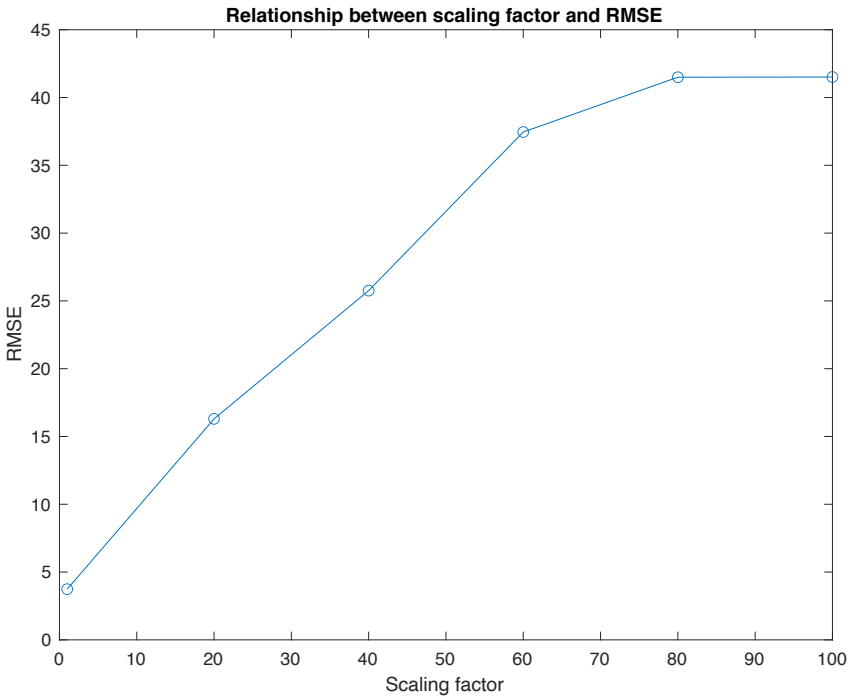

Figure 2. Relationship between scaling factor and RMSE

The RMSE values are shown in **Table 1** and the relationship with scaling factor is shown in **Figure 2.** We can see the RMSE has a nonlinear relationship with scaling factor. The RMSE are gradually reach the peak when scaling factor increased to some extent. The bigger scaling factor, the more information lost in the image.

In order to see the influences of quantization operation and also the difference between **block1** and **block34**, the DCT coefficients are visualized below:

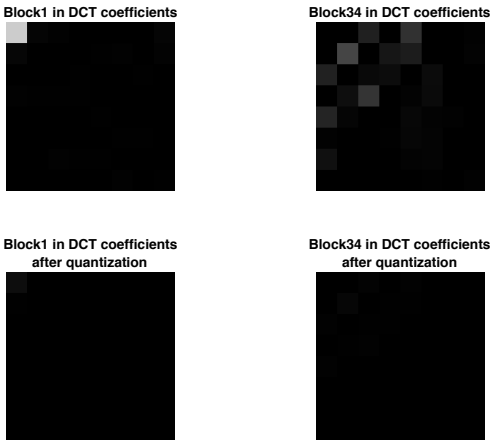

Figure 3. DCT coefficients in specific block

The brightness of each square corresponds to the magnitude of that particular transform coefficient. Actually, the magnitude indicates amplitude of that frequency in the square.

In **block1**, since it is located in top left corner of image and also a quite smooth region, the amplitudes are not variant like in **block34** which represent the eye of human body in image. The **block34** contain more high frequency information then **block1**. After quantization, more pixels are rounded to zero.

The more information about original data, DCT coefficients, DCT coefficients after quantization and reconstructed image data of the **block1** and **block34** shows below (when scaling factor is 1) :

```
Original image of block1.
   155   155   155   154   155   150   156   153
   155   155   155   154   155   150   156   153
   155   155   155   154   155   150   156   153
   155   155   155   154   155   150   156   153
   155   155   155   154   155   150   156   153
   157   157   151   149   154   153   152   153
   153   153   156   152   153   154   153   149
   152   152   149   150   152   152   150   151

Original image of block34.
    49    46    49    90    90    71    90   119
    48    46    49    62    93    72    59    78
    56    49    51    74   112    82    63    73
    77    72    73    93   109    80    61    91
    88    88    94    87    77    65    72   123
    89    92    84    80    62    72   113   165
    62    68    65    70    82   108   153   185
    70    71    80    92   124   152   177   189
```

DCT coefficients of block1.

203.7500	5.3005	2.1648	0.1861	-0.2500	0.3672	-5.2263	5.9464
6.4918	0.2155	0.2223	-3.9601	1.3947	2.8534	-3.6352	3.0722
-4.2860	-0.8325	-1.2286	1.1187	-0.4455	-0.4984	1.6731	-1.5312
2.1161	1.2640	1.4553	1.1121	-0.6652	-1.1186	0.2711	0.2492
-1.0000	-1.1550	-0.2474	-1.2384	1.5000	0.7124	-1.2505	-0.0058
0.9629	0.5991	-1.7241	-0.3561	-1.7975	1.1682	1.1354	0.6302
-1.2013	-0.0324	2.9231	1.8624	1.5375	-2.6446	-0.5214	-1.2243
0.9090	-0.1652	-2.2418	-1.7195	-0.8696	2.1916	0.0858	1.0041

DCT coefficients of block34.

-333.2500	-140.4464	31.8863	-25.1716	49.0000	-23.4092	-0.7602	2.8851
-123.5522	69.2984	-70.8123	22.0398	28.5701	-10.3529	-3.2997	3.0234
32.9839	-95.3319	9.4675	12.7391	-11.7002	11.9267	-9.2426	0.6650
-3.8402	14.1677	52.5818	-49.7131	3.7149	10.8779	-3.3335	-10.6176
36.5000	4.9958	-15.7552	-3.8782	7.7500	3.1748	2.4670	-3.1299
2.7349	-20.6857	0.8899	1.4784	6.1802	4.0232	-8.1967	-3.5143
16.9152	-1.1092	0.7574	-0.4810	3.7640	4.8963	-3.9675	-1.5577
-6.3840	-7.3761	-0.8692	-0.9652	-1.2755	1.3431	0.1947	2.3915

DCT & Quantization of block1.

13	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0

DCT & Quantization of block34.

-21	-13	3	-2	2	-1	0	0
-10	6	-5	1	1	0	0	0
2	-7	1	1	0	0	0	0
0	1	2	-2	0	0	0	0
2	0	0	0	0	0	0	0
0	-1	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0

```
Reconstructed image of block1.
  156.0806  156.0806  156.0806  156.0806  156.0806  156.0806  156.0806  156.0806
  155.7638  155.7638  155.7638  155.7638  155.7638  155.7638  155.7638  155.7638
  155.1785  155.1785  155.1785  155.1785  155.1785  155.1785  155.1785  155.1785
  154.4138  154.4138  154.4138  154.4138  154.4138  154.4138  154.4138  154.4138
  153.5862  153.5862  153.5862  153.5862  153.5862  153.5862  153.5862  153.5862
  152.8215  152.8215  152.8215  152.8215  152.8215  152.8215  152.8215  152.8215
  152.2362  152.2362  152.2362  152.2362  152.2362  152.2362  152.2362  152.2362
  151.9194  151.9194  151.9194  151.9194  151.9194  151.9194  151.9194  151.9194


Reconstructed image of block34.
   46.1132   47.6158   52.7205   76.3153   91.4221   74.0475   80.6542  125.2504
   54.3294   49.0614   48.7184   74.7136   94.6655   70.6991   55.2590   78.6021
   52.1783   47.7085   48.6409   78.5817  105.0949   82.7040   58.0141   69.6407
   65.4118   70.5944   72.9474   89.3266  102.6735   82.8962   73.1295   97.3289
   86.5731  101.6452  100.1526   90.5803   79.1860   61.2508   76.8001  124.3359
   72.4127   91.8041   90.1097   76.2707   68.5343   67.1939  102.6714  162.1331
   56.9768   69.6241   66.9106   70.1623   92.7800  112.7876  146.0934  192.9238
   73.7991   74.3426   64.5590   79.5061  123.7931  151.1901  167.4541  192.3845
```

In the end, the JPEG is in lossy compression and also has block artifact, since the image is partitioned into blocks, there is often not a smooth transition between blocks in the compressed image.