
Assignment 4

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Problem1

1.

a.

$$T_{pq} = \begin{cases} \frac{1}{\sqrt{M}} & p = 0, \quad 0 \leq q \leq M-1 \\ \sqrt{\frac{2}{M}} \cos \frac{\pi(2q+1)p}{2M} & 1 \leq p \leq M-1, \quad 0 \leq q \leq M-1 \end{cases}$$

```
>> q1_1a
Using function create_mat_dct-

a =

0.4472    0.4472    0.4472    0.4472    0.4472
0.6015    0.3717    0.0000   -0.3717   -0.6015
0.5117   -0.1954   -0.6325   -0.1954    0.5117
0.3717   -0.6015   -0.0000    0.6015   -0.3717
0.1954   -0.5117    0.6325   -0.5117    0.1954
```

Using dctmtx-

```
b =

0.4472    0.4472    0.4472    0.4472    0.4472
0.6015    0.3717    0.0000   -0.3717   -0.6015
0.5117   -0.1954   -0.6325   -0.1954    0.5117
0.3717   -0.6015   -0.0000    0.6015   -0.3717
0.1954   -0.5117    0.6325   -0.5117    0.1954
```

b. For a MxM image im and the basis matrix F, the two-dimensional DCT of im can be computed as B = F*im*F' as done in the following function-

```
function a = myDCT(im, F)
    a = F*im;
    a = a*F';
end
```

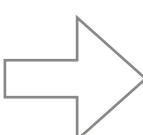
c. Since the basis matrix F is a real orthonormal matrix, its inverse is the same as its transpose. Therefore, the inverse two-dimensional DCT of B is given by F'*B*T as done in the following function-

```
function a = myIDCT(im, F)
    a = F'*im;
    a = a*F;
end
```

d.

$$qm = \begin{bmatrix} 16 & 11 & 10 & 16 & 24 & 40 & 51 & 61 \\ 12 & 12 & 14 & 19 & 26 & 58 & 60 & 55 \\ 14 & 13 & 16 & 24 & 40 & 57 & 69 & 56 \\ 14 & 17 & 22 & 29 & 51 & 87 & 80 & 62 \\ 18 & 22 & 37 & 56 & 68 & 109 & 103 & 77 \\ 24 & 35 & 55 & 64 & 81 & 104 & 113 & 92 \\ 49 & 64 & 78 & 87 & 103 & 121 & 120 & 101 \\ 72 & 92 & 95 & 98 & 112 & 100 & 103 & 99 \end{bmatrix}$$

imDCT is converted to i after quantization.

$imDCT =$ $\begin{array}{cccccccc} 90 & 82 & 36 & 39 & 57 & 17 & 23 & 11 \\ 96 & 25 & 84 & 57 & 47 & 61 & 92 & 97 \\ 55 & 93 & 59 & 8 & 2 & 27 & 16 & 1 \\ 14 & 35 & 55 & 6 & 34 & 66 & 83 & 78 \\ 15 & 20 & 92 & 54 & 17 & 69 & 54 & 82 \\ 26 & 26 & 29 & 78 & 80 & 75 & 100 & 87 \\ 85 & 62 & 76 & 94 & 32 & 46 & 8 & 9 \\ 26 & 48 & 76 & 13 & 53 & 9 & 45 & 40 \end{array}$		$i =$ $\begin{array}{cccccccc} 1 & 1 & 1 & 0 & 0 & 0 & 0 & 0 \\ 2 & 0 & 1 & 1 & 0 & 0 & 0 & 0 \\ 1 & 1 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{array}$
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e. imDCT converted to imqDCT and further to i.

imDCT =

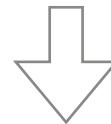
26	87	41	91	79	58	65	69	0	2	1	1	1	0	0	0
81	58	8	95	39	6	74	19	1	1	0	1	0	0	0	0
44	55	24	50	25	24	65	37	1	1	0	0	0	0	0	0
92	15	13	49	41	36	46	63	1	0	0	0	0	0	0	0
19	86	19	34	10	83	55	79	0	1	0	0	0	0	0	0
27	63	24	91	14	2	30	9	0	0	0	0	0	0	0	0
15	36	42	37	95	5	75	93	0	0	0	0	0	0	0	0
14	52	5	12	96	17	19	78	0	0	0	0	0	0	0	0

imqDCT =



i =

0	110	50	80	120	0	0	0
60	60	0	95	0	0	0	0
70	65	0	0	0	0	0	0
70	0	0	0	0	0	0	0
0	110	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



f. RMSE stands for Root mean square error.

```
function e = RMSE(im1, im2)
    a = im1 - im2;
    a = a.^2;
    m = mean(a, 'all');
    e = sqrt(m);
end
```

g.

```
function e = My_entropy(im)
    [p, ~] = imhist(im);
    p = p / numel(im);
    p(p == 0) = 1;
    e = -sum(p.*log2(p));
end
```

2.



im1 =

196	202	195	192	126	76	55	42		203	203	203	185	133	75	54	63
195	198	197	189	133	78	57	51		199	202	205	189	137	77	53	59
199	200	199	194	149	83	54	43		193	199	207	195	142	79	50	54
193	201	193	195	157	80	52	55		189	198	209	199	146	81	49	50
200	195	202	197	149	71	49	60		189	198	209	199	146	81	49	50
192	204	201	197	139	65	59	45		193	199	207	195	142	79	50	54
191	193	198	192	127	67	60	58		199	202	205	189	137	77	53	59
193	192	199	190	127	72	74	62		203	203	203	185	133	75	54	63



im2 =

188	194	186	173	164	169	180	187		203	192	177	164	162	169	180	189
186	173	153	158	172	195	204	211		179	175	171	171	179	193	208	217
177	164	176	186	207	210	216	216		168	170	175	183	195	208	219	226
178	179	197	197	196	205	201	206		178	181	186	192	197	200	201	202
158	179	173	186	183	184	194	187		180	183	187	190	190	187	183	180
171	158	177	180	185	179	178	182		169	172	176	181	183	184	183	182
176	174	183	177	174	180	176	181		172	173	174	176	178	181	183	185
183	184	170	180	177	172	182	174		188	185	181	177	175	177	178	

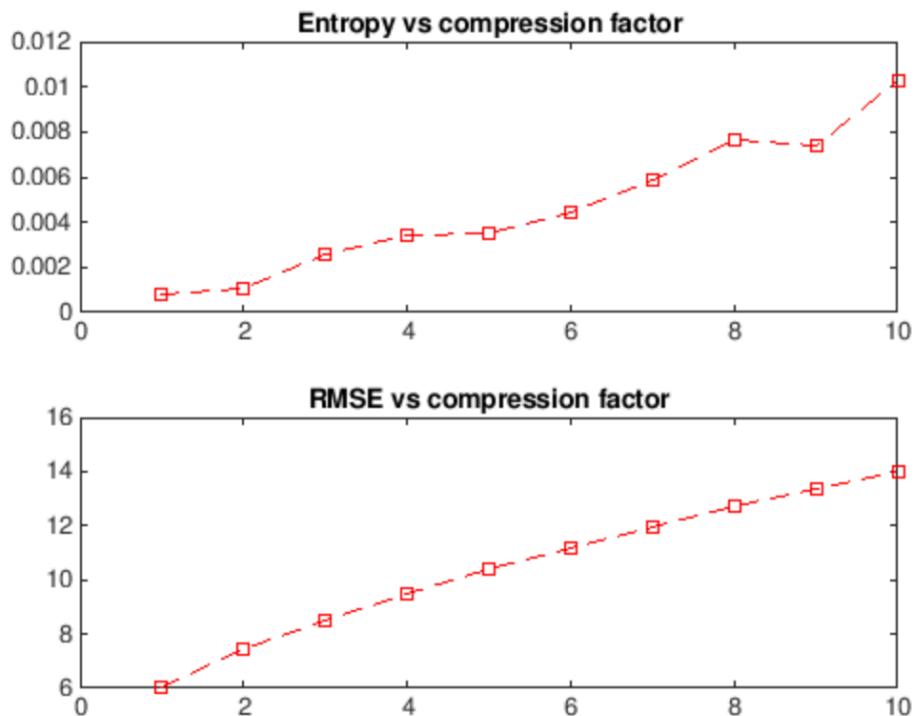


im3 =

187	185	182	187	183	186	184	184		184	184	184	184	184	184	184	184
187	185	182	187	181	185	181	182		184	184	184	184	184	184	184	184
183	185	192	183	194	186	178	189		184	184	184	184	184	184	184	184
186	184	185	191	179	186	183	181		184	184	184	184	184	184	184	184
183	184	187	178	190	182	181	187		184	184	184	184	184	184	184	184
188	181	182	189	184	184	185	181		184	184	184	184	184	184	184	184
181	181	180	185	186	185	183	184		184	184	184	184	184	184	184	184
182	185	187	184	187	181	185	186		184	184	184	184	184	184	184	184



4.

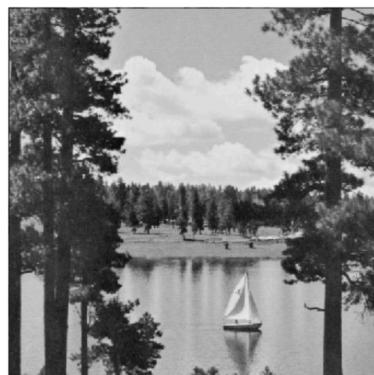


Entropy-

1	2	3	4	5	6	7	8	9	10
0.0008	0.0010	0.0025	0.0034	0.0035	0.0045	0.0059	0.0077	0.0074	0.0103

RMSE-

1	2	3	4	5	6	7	8	9	10
6.0175	7.4132	8.5218	9.4709	10.3763	11.1791	11.9238	12.7261	13.3816	14.0217

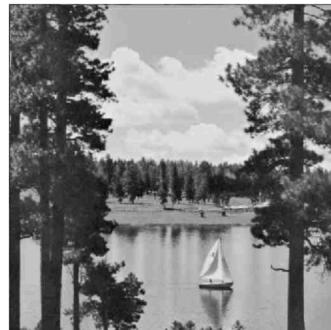


After $c = 5$, the distortions in the reconstructed image are perceptible.

$c = 1$



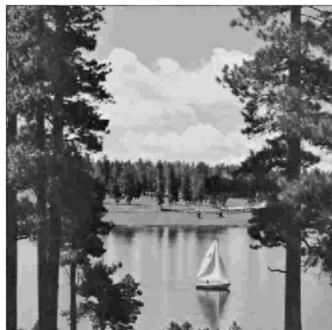
$c = 2$



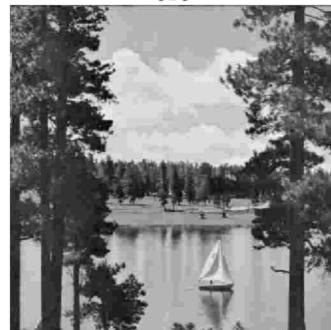
$c = 3$



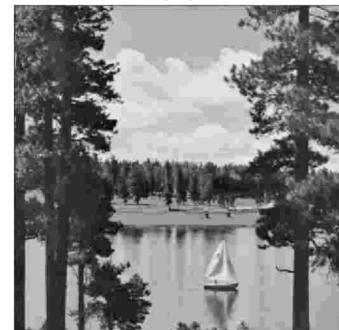
$c = 4$



$c = 5$



$c = 6$



$c = 7$



$c = 8$



$c = 9$



$c = 10$

