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```matlab
clear all; close all;
```

PART 1

```matlab
peppers_org = imread("peppers.tif");
baboon_org = imread("baboon.tif");

fprintf('| %10s | %10s | %10s | %10s |
\n', "Images", "Quality", "Size", "PSNR");
fprintf('----------------------------------------------------\n');

quality_factors = [90, 70, 50, 30, 10];

for i = 1:length(quality_factors)
    filename = strcat('peppers_',
 num2str(quality_factors(i)), '.jpg');
    imwrite(peppers_org, filename, 'Quality', quality_factors(i));
    tmp_img = imread(filename);
    PSNR = 20*log10(255) - 10*log10(mse(tmp_img, peppers_org));
    fprintf('| %10s | %10d | %10lu | %10f |\n', "peppers",
 quality_factors(i), imfinfo(filename).FileSize, PSNR);
end

for i = 1:length(quality_factors)
    filename = strcat('baboon_', num2str(quality_factors(i)), '.jpg');
    imwrite(baboon_org, filename, 'Quality', quality_factors(i));
    tmp_img = imread(filename);
    PSNR = 20*log10(255) - 10*log10(mse(tmp_img, baboon_org));
    fprintf('| %10s | %10d | %10lu | %10f |\n', "baboon",
 quality_factors(i), imfinfo(filename).FileSize, PSNR);
end

fprintf("\r\n");

fprintf(['Question PART 1:\n', ...
    '1. The higher the image quality, the larger the image size.
\n', ...
    '2. JPEG Compression introduce lossy artifacts -- makes the image
 looks blocky.\n',...
```

```
    '3. They occurs because of quantization.\n',...
    '4. At quality factor of about 30 (PSNR=38.39), the distortion
 become strong.\n']);
```

Images	Quality	Size	PSNR
peppers	90	48956	53.581544
peppers	70	33276	49.503164
peppers	50	27405	39.497821
peppers	30	15902	38.399239
peppers	10	8221	34.749630
baboon	90	105820	40.367722
baboon	70	57172	34.604096
baboon	50	41548	33.198784
baboon	30	29624	32.241234
baboon	10	13258	30.773405

Question PART 1:
1. The higher the image quality, the larger the image size.
2. JPEG Compression introduce lossy artifacts -- makes the image looks blocky.
3. They occurs because of quantization.
4. At quality factor of about 30 (PSNR=38.39), the distortion become strong.

PART 2

```
current_dir = strcat(mfilename('fullpath'), '.m');
[current_dir,~,~] = fileparts(current_dir);

lum_quant = ...
[ 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;];

[zz_quant_dct_blks, enc_size] = JPEG_encode(peppers_org, current_dir,
 lum_quant);
[iZZDCTQIm, dec_img]          = JPEG_decode(current_dir);
PSNR = 20*log10(255) - 10*log10(mse(uint8(dec_img), peppers_org));

figure(1)
imshow(uint8(dec_img));
title(['Standard JPEG luminance quantization table. PSNR=',
 num2str(PSNR), ' Size=', num2str(enc_size)]);


lum_quant = ...
[ 80   55   50   80  120 200 255 255;
```

```matlab
 60   60   70   95  130 255 255 255;
 70   65   80  120 200 255 255 255;
 70   85  110 145 255 255 255 255;
 90  110 185 255 255 255 255 255;
120 175 255 255 255 255 255 255;
255 255 255 255 255 255 255 255;
255 255 255 255 255 255 255 255;];

[zz_quant_dct_blks, enc_size] = JPEG_encode(peppers_org, current_dir,
 lum_quant);
[iZZDCTQIm, dec_img]          = JPEG_decode(current_dir);
PSNR = 20*log10(255) - 10*log10(mse(uint8(dec_img), peppers_org));

figure(2)
imshow(uint8(dec_img));
title(['New JPEG luminance quantization table 1. PSNR=',
 num2str(PSNR), ' Size=', num2str(enc_size)]);
% Source: http://mail.ipb.ac.rs/~rakaj/home/fajpg.pdf

lum_quant = ...
[ 7 5 9 2    18  226 231 255;
  26   17   35   68  177 254 255 255;
  8    35   15   84  252 255 255 255;
  118 172 244 247 255 255 255 255;
  243 250 252 255 255 255 255 255;
  138 201 255 255 255 255 255 255;
  133 255 255 255 255 255 255 255;
  255 255 255 255 255 255 255 255;];

[zz_quant_dct_blks, enc_size] = JPEG_encode(peppers_org, current_dir,
 lum_quant);
[iZZDCTQIm, dec_img]          = JPEG_decode(current_dir);
PSNR = 20*log10(255) - 10*log10(mse(uint8(dec_img), peppers_org));

figure(3)
imshow(uint8(dec_img));
title(['New JPEG luminance quantization table 2. PSNR=',
 num2str(PSNR), ' Size=', num2str(enc_size)]);
% Source: http://mail.ipb.ac.rs/~rakaj/home/fajpg.pdf


fprintf(['Question PART 2:\n', ...
    'It is not possible to achieve both a lower file size and a higher
 PSNR. Because the lossless\n', ...
    'encoder will only be able to reduce the number of bits
 representing the sequence when the \n',...
    'sequence is "regular". If the quantization interval is high, then
 most of the numbers after\n',...
    'qunatization become highly regular, but the error is higher.
\n']);

function [zz_quant_dct_blks, enc_size] = JPEG_encode(X, current_dir,
 lum_quant)
```

```
    [nrow, ncol] = size(X);
    image_flat = X(:);

    block_size = 8;
    blocks = zeros(int16(length(image_flat)/(block_size^2)),
 block_size^2);
    k = 1;
    i = 1;
    while i <= length(image_flat)
        for j = 0:block_size-1
            m = i + ncol*j;
            n = j*block_size + 1;
            blocks(k,n:n+block_size-1) = image_flat(m:m+block_size-1);
        end

        if (mod(k,int16(ncol/block_size)))
            i = i + block_size;
        else
            i = block_size^2*k + 1;
        end
        k = k + 1;
    end

    zz_quant_dct_blks = zeros(size(blocks));

    for i = 1:size(zz_quant_dct_blks,1)
        blk_dct = round(dct2(reshape(blocks(i,:), block_size,
 block_size))./(lum_quant));
        zz_quant_dct_blks(i,:) = ZigzagMtx2Vector(blk_dct);
    end

    enc_size = JPEG_entropy_encode(nrow, ncol, block_size, ...
                        lum_quant, zz_quant_dct_blks, current_dir,
 []);

end


function [iZZDCTQIm, dec_img] = JPEG_decode(current_dir)
    [nrow,ncol,dct_block_size,iQ,iZZDCTQIm] =
 JPEG_entropy_decode(current_dir);

    dec_img = zeros(nrow, ncol);

    k = 1;
    for i = 1:dct_block_size:nrow
        for j = 1:dct_block_size:ncol
            dec_img(j:j+dct_block_size-1, i:i+dct_block_size-1) = ...
                idct2((iQ).*Vector2ZigzagMtx(iZZDCTQIm(k,:)));
            k = k + 1;
        end
    end

end
```

wine /home/sweet/2-coursework/435eces/assgn2/jpeg_entropy_encode.exe:
 Signal 24
wine /home/sweet/2-coursework/435eces/assgn2/jpeg_entropy_decode.exe:
 Signal 100
wine /home/sweet/2-coursework/435eces/assgn2/jpeg_entropy_encode.exe:
 Signal 24
wine /home/sweet/2-coursework/435eces/assgn2/jpeg_entropy_decode.exe:
 Signal 100
wine /home/sweet/2-coursework/435eces/assgn2/jpeg_entropy_encode.exe:
 Signal 24
wine /home/sweet/2-coursework/435eces/assgn2/jpeg_entropy_decode.exe:
 Signal 100
Question PART 2:
It is not possible to achieve both a lower file size and a higher
 PSNR. Because the lossless
encoder will only be able to reduce the number of bits representing
 the sequence when the
sequence is "regular". If the quantization interval is high, then most
 of the numbers after
qunatization become highly regular, but the error is higher.

New JPEG luminance quantization table 1. PSNR=34.7265 Size=6622
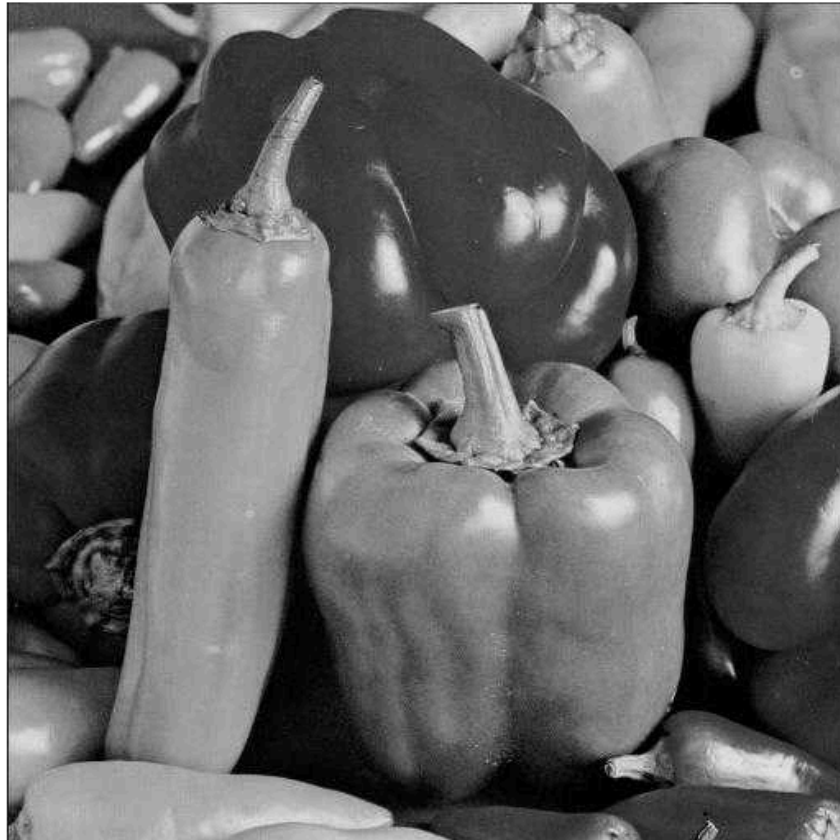
New JPEG luminance quantization table 2. PSNR=37.2891 Size=20334

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