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Homework 8

Matlab code with parts a-g labelled:

```
%Load in the matlab images so that they are accessible to the workspace
in01 = load('IMG_7401.mat');
in05 = load('IMG_7405.mat');
orig1 = in01.I;
orig5 = in05.I;

%One argument sanity check.
%Calls myJpeg to make sure that function can be called with only the image
%as an argument, with QF defaulting to 5. IT DOES WORK!
[J0, C0, rms0] = myJpeg(orig1);
figure
imshow(J0);
disp("Compression Factor 0");
disp(C0);
disp("RMSE 0");
disp(rms0);


%TESTING BEGIN
%-------------

%Calls myJpeg on the first image (IMG_7401)
[J1, C1, rms1] = myJpeg(orig1, 1);
[J2, C2, rms2] = myJpeg(orig1, 5);
[J3, C3, rms3] = myJpeg(orig1, 10);

%Calls myJpeg on the second image (IMG_7405)
[J4, C4, rms4] = myJpeg(orig5, 1);
[J5, C5, rms5] = myJpeg(orig5, 5);
[J6, C6, rms6] = myJpeg(orig5, 10);


%Display the first image with QF = 1, 5, 10

%QF = 1
%image = IMG_7401
figure
imshow(J1);
disp("Compression Factor 1");
disp(C1);
disp("RMSE 1");
disp(rms1);

%QF = 5
%image = IMG_7401
figure
imshow(J2);
```

```
disp("Compression Factor 2");
disp(C2);
disp("RMSE 2");
disp(rms2);

%QF = 10
%image = IMG_7401
figure
imshow(J3);
disp("Compression Factor 3");
disp(C3);
disp("RMSE 3");
disp(rms3);



%Display the second image with QF = 1, 5, 10

%QF = 1
%image = IMG_7405
figure
imshow(J4);
disp("Compression Factor 4");
disp(C4);
disp("RMSE 4");
disp(rms4);

%QF = 5
%image = IMG_7405
figure
imshow(J5);
disp("Compression Factor 5");
disp(C5);
disp("RMSE 5");
disp(rms5);

%QF = 10
%image = IMG_7405
figure
imshow(J6);
disp("Compression Factor 6");
disp(C6);
disp("RMSE 6");
disp(rms6);



%PART A
%Pads the image to be a factor of 8x8.
function J = padImage(image)
    [M, N] = size(image);
    %Find modulo of M and N to determine if rows and columns are divisible
    %by 8
    rowMod = mod(M,8);
    colMod = mod(N,8);
    %if M (rows) is not divisible by 8
    if(rowMod ~= 0)
```

```
        %adds (8 - remainder) to M.  If remainder when dividing by 8 was 3
        %for example, this would add 5 to M, making it divisible by 8.
        newM = M + 8 - rowMod;
    %M is divisible by 8
    else
        newM = M;
    end
    %if N (rows) is not divisible by 8
    if(colMod ~= 0)
        %adds (8 - remainder) to N.  If remainder when dividing by 8 was 3
        %for example, this would add 5 to N, making it divisible by 8.
        newN = N + 8 - rowMod;
    %M is divisible by 8
    else
        newN = N;
    end
    %if padding was necessary for either M or N
    if(newM ~= M || newN ~= N)
       %create a new matrix of zeros with padded dimensions
       output = zeros(newM, newN);
       %Copy the corresponding indexes from the original image
       for m=1:M
           for n=1:N
               output(m,n) = image(m,n);
           end
       end
       %Output padded image
       J=output;
    else
       %Output unmodified image (no padding necessary)
       J=image;
    end
end

%PART B
%Level shifts  the image by the mean (128)
function J= levelShift(image)
    J = padImage(double(image))-128;
end

%PART C and D
%Perform DCT and threshold coding using quantization matrix Q, on 8x8 blocks
function J = quantization(image, QF)
    %Make sure image has been level shifted.
    im = levelShift(image);

    %Declare/initialize quantization matrix from slides
    Q = [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];

    %Check quality factor, and implement changes on Q, if any.
```

```
    if(QF > 5)
        %Downscales image by multiplying Q matrix. This is scaled by the
        %taking the distance from 5 (our default value for Q), dividing by
        %two so it doesnt scale too crazy, and adding one (to differentiate
        %from 5 in the case of 4 and 6, and then squaring the result.
        Q = Q*(((QF-4)/2)+1)^2;
    elseif(QF < 5)
        %Upscales image by dividing Q matrix. This is scaled by the
        %taking the distance from 5 (our default value for Q), dividing by
        %two so it doesnt scale to crazy, and adding one (to differentiate
        %from 5 in the case of 4 and 6, and then squaring the result.
        Q = Q/(((6-QF)/2)+1)^2;
    end

    %Performs block process on our image, calculating the dct of the 8 by 8
    %blocks and then divides the element by the corresponding element in Q.
    dct = @(block_struct) dct2(block_struct.data)./Q;
    J = blockproc(im,[8 8],dct);
end

%PART E
function J = compressionFactor(image)
    imageRound = round(image);
    [M,N] = size(imageRound);
    counter = 0;
    totalPixels = M*N;

    %Counts the number of pixels in the image withvalue 0
    for m=1:M
        for n=1:N
            if(imageRound(m,n) == 0)
                counter = counter + 1;
            end
        end
    end
    %Returns ratio of zeros to total pixels.
    J = (counter/totalPixels);
end

%PART F
%Perform inverse process from part C and D, and shift the level back.
function J = reconstruct(image, QF)
    %Declare/initialize quantization matrix from slides
    Q = [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];

    %Check quality factor, and implement changes on Q, if any.
    if(QF > 5)
        %Downscales image by multiplying Q matrix. This is scaled by the
        %taking the distance from 5 (our default value for Q), dividing by
        %two so it doesnt scale too crazy, and adding one (to differentiate
```

```
        %from 5 in the case of 4 and 6, and then squaring the result.
        Q = Q*(((QF-4)/2)+1)^2;
    elseif(QF < 5)
        %Upscales image by dividing Q matrix. This is scaled by the
        %taking the distance from 5 (our default value for Q), dividing by
        %two so it doesnt scale to crazy, and adding one (to differentiate
        %from 5 in the case of 4 and 6, and then squaring the result.
        Q = Q/(((6-QF)/2)+1)^2;
    end

    IDCT = Q;
    %Performs a block process on our image, calculating the inverse dct of
the 8 by 8
    %blocks and then multiplies the element by the corresponding element in
Q.
    invdct = @(block_struct)   idct2(block_struct.data.*IDCT);
    recon = blockproc(image,[8 8],invdct);

    %Shift the image back by the mean value, and return.
    J=uint8(recon+128);
end

%PART G
%Calculates root mean square error, same as in HW7
function X = RMSE(original, reconstruct)
    [M, N] = size(original);
    sum = 0;

    for m=1:M
        for n=1:N
            sum = sum + (double(original(m,n)) - double(reconstruct(m,n)))^2;
        end
    end
    X = sqrt(sum/(M*N));
end

function [J, C, rms] = myJpeg(image, varargin)
    %Checks to see if only one argument was passed.
    if(nargin == 1)
        %Calls myJpeg with default QF.
        [J, C, rms] = myJpeg(image, 5);
    %Checks to see if both the image and the quality factor were passed
    %into the function
    elseif(nargin == 2)
        %Performs jpeg calculations (quantize and reconstruct)
        quantize = quantization(image, varargin{1});
        recon = reconstruct(round(quantize), varargin{1});
        J = recon;

        %Calculates compression factor
        C = compressionFactor(quantize);

        %Calculates root mean square error.
        rms = RMSE(image, recon);
    end
end
```

IMG_7401
QF = 1

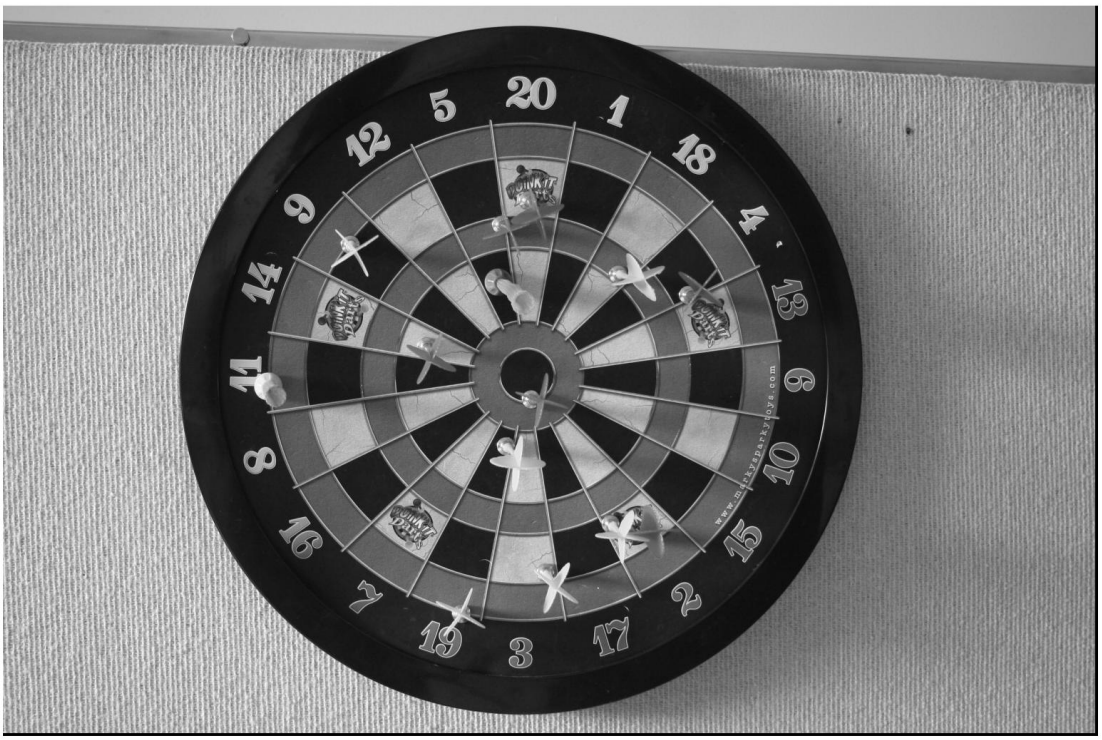
QF = 5

QF = 10

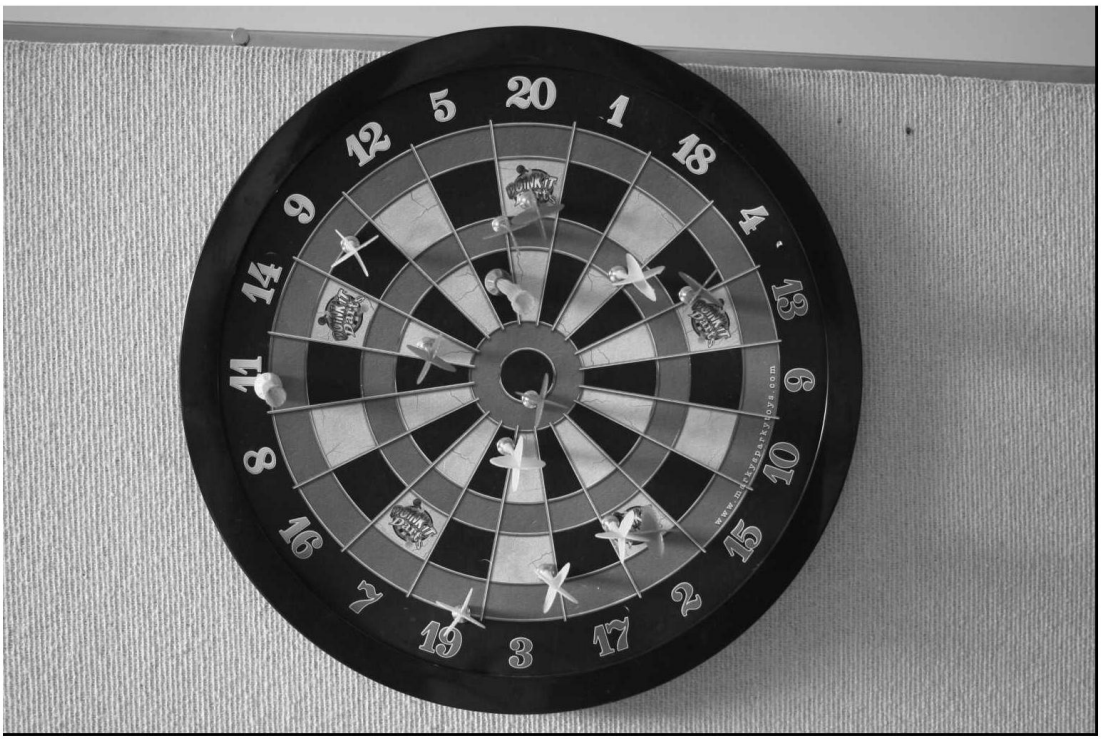
Table for IMG_7401

Quality Factor (QF)	1	5	10
Compression Factor	0.7053	0.8818	0.9844
RMS Error	0.5822	4.5055	15.7626

IMG_7405
QF = 1



QF = 5


20 1 18 4 13 6 10 15 2 17 3 19 7 16 8 11 14 9 12 5

QF = 10

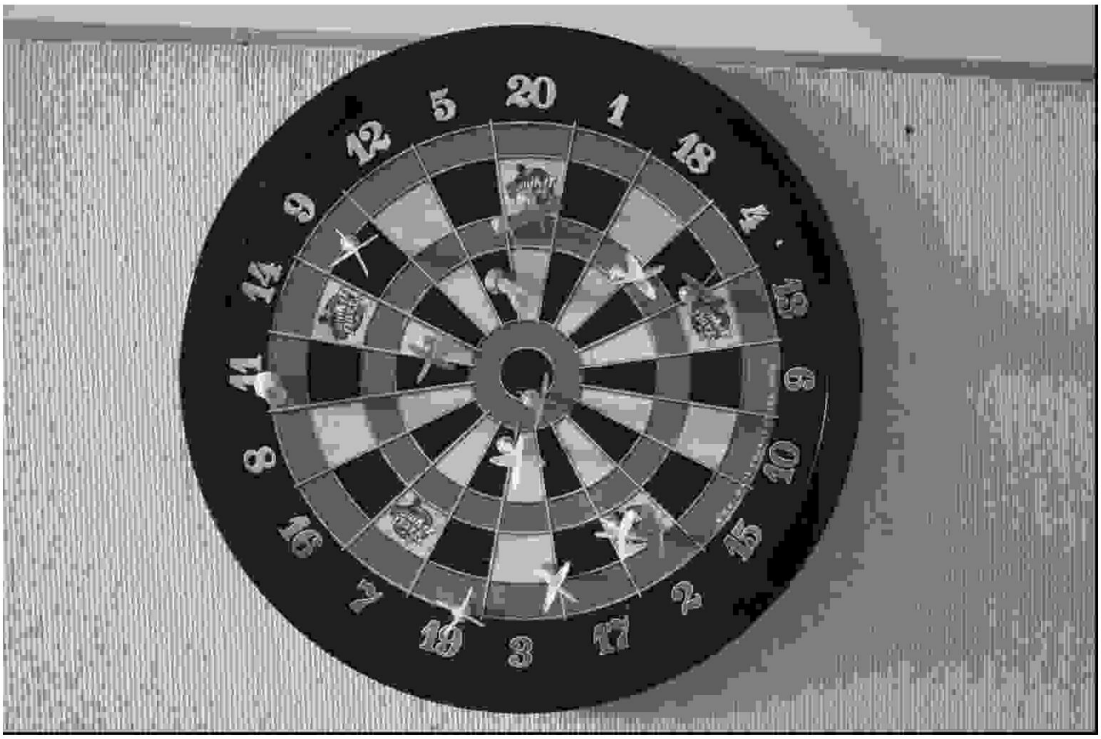

20 1 18 4 13 6 10 15 2 17 3 19 7 16 8 11 14 9 12 5

Table for IMG_7405

Quality Factor (QF)	1	5	10
Compression Factor	0.6311	0.8435	0.9763
RMS Error	0.6815	5.3388	17.2115