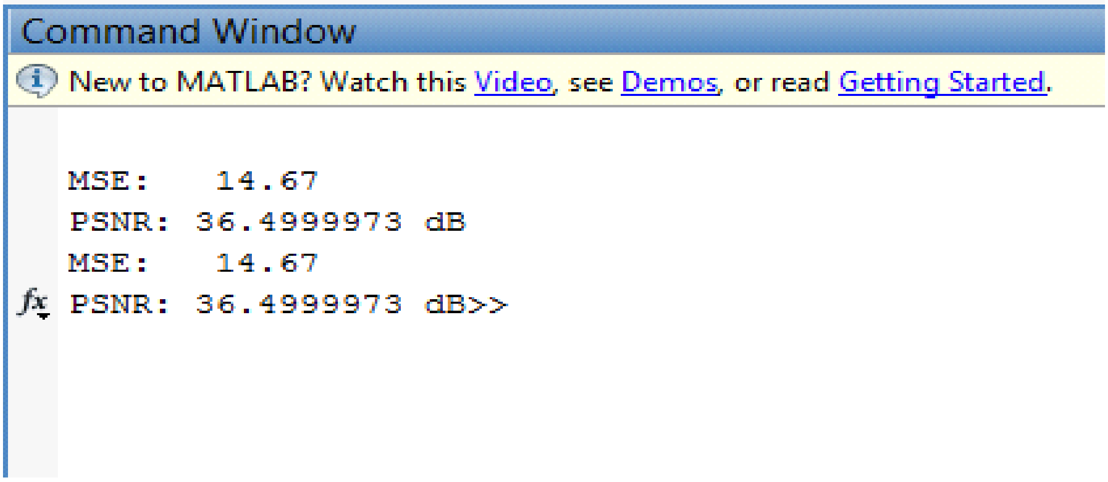

Command Window
New to MATLAB? Watch this Video, see Demos, or read Getting Started.
MSE: 14.67
PSNR: 36.4999973 dB
MSE: 14.67
PSNR: 36.4999973 dB>>

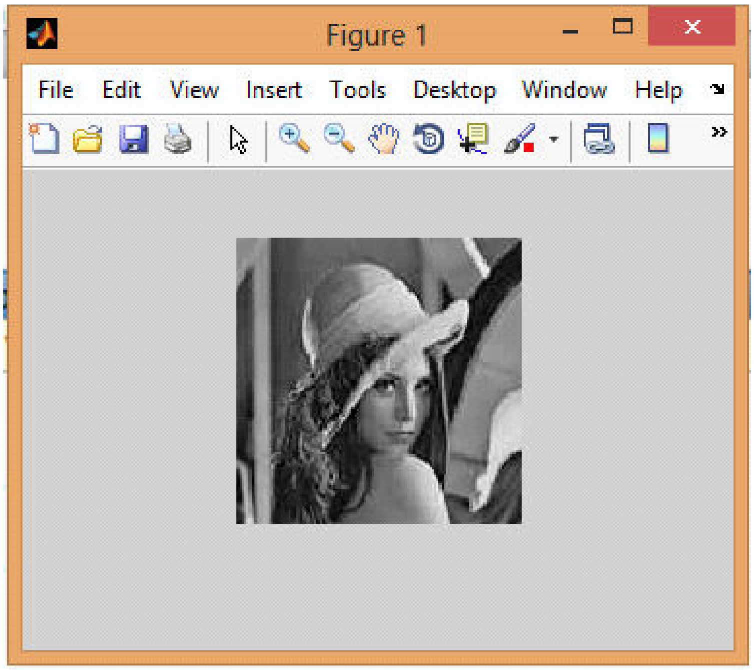


Figure 1
File Edit View Insert Tools Desktop Window Help

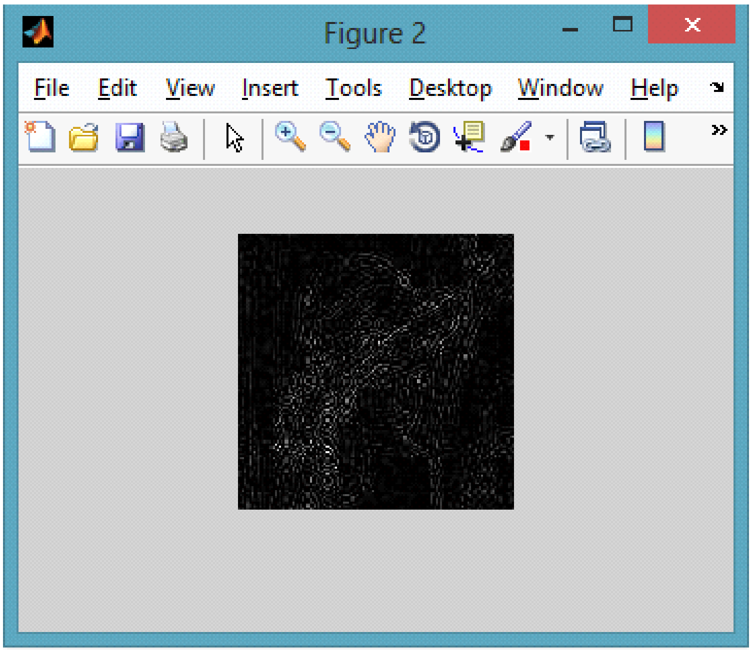


Figure 2
File Edit View Insert Tools Desktop Window Help

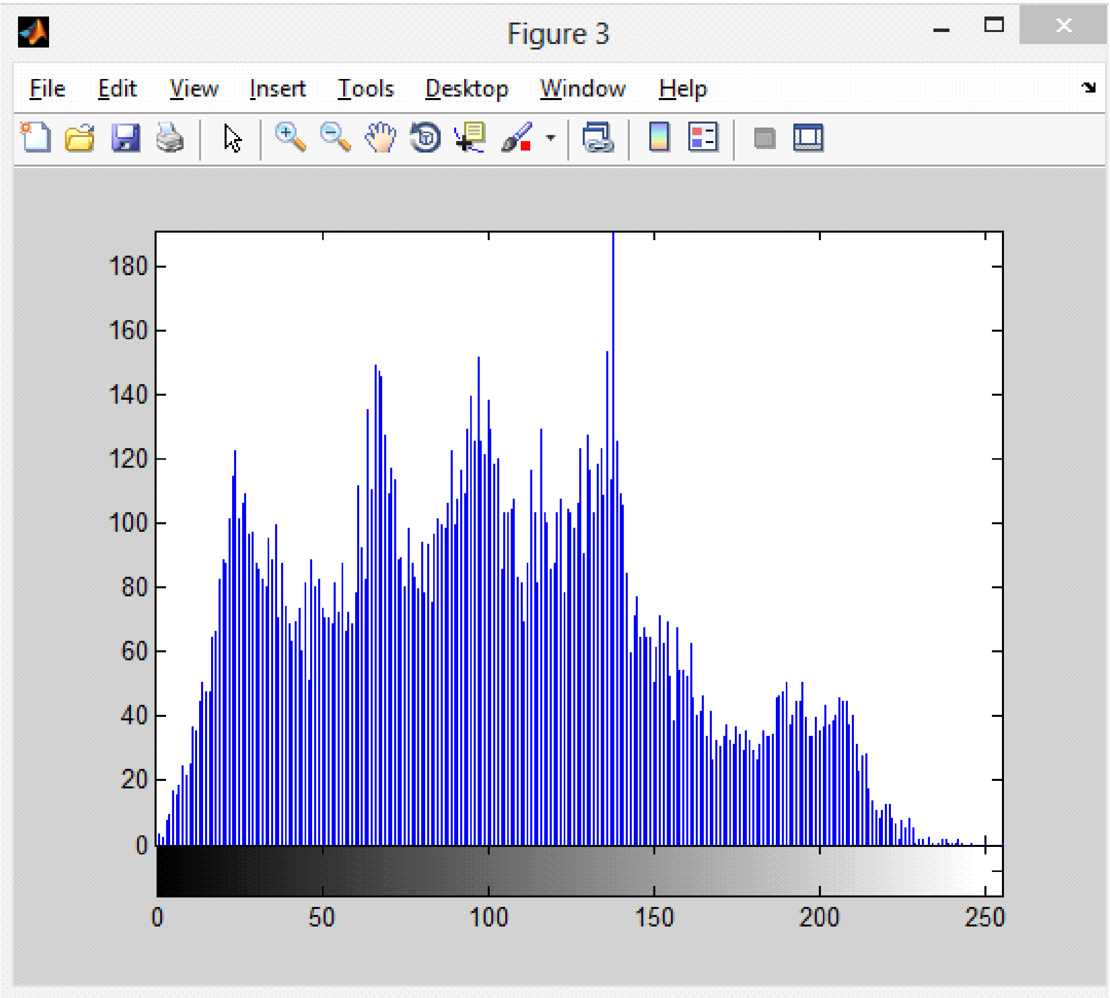
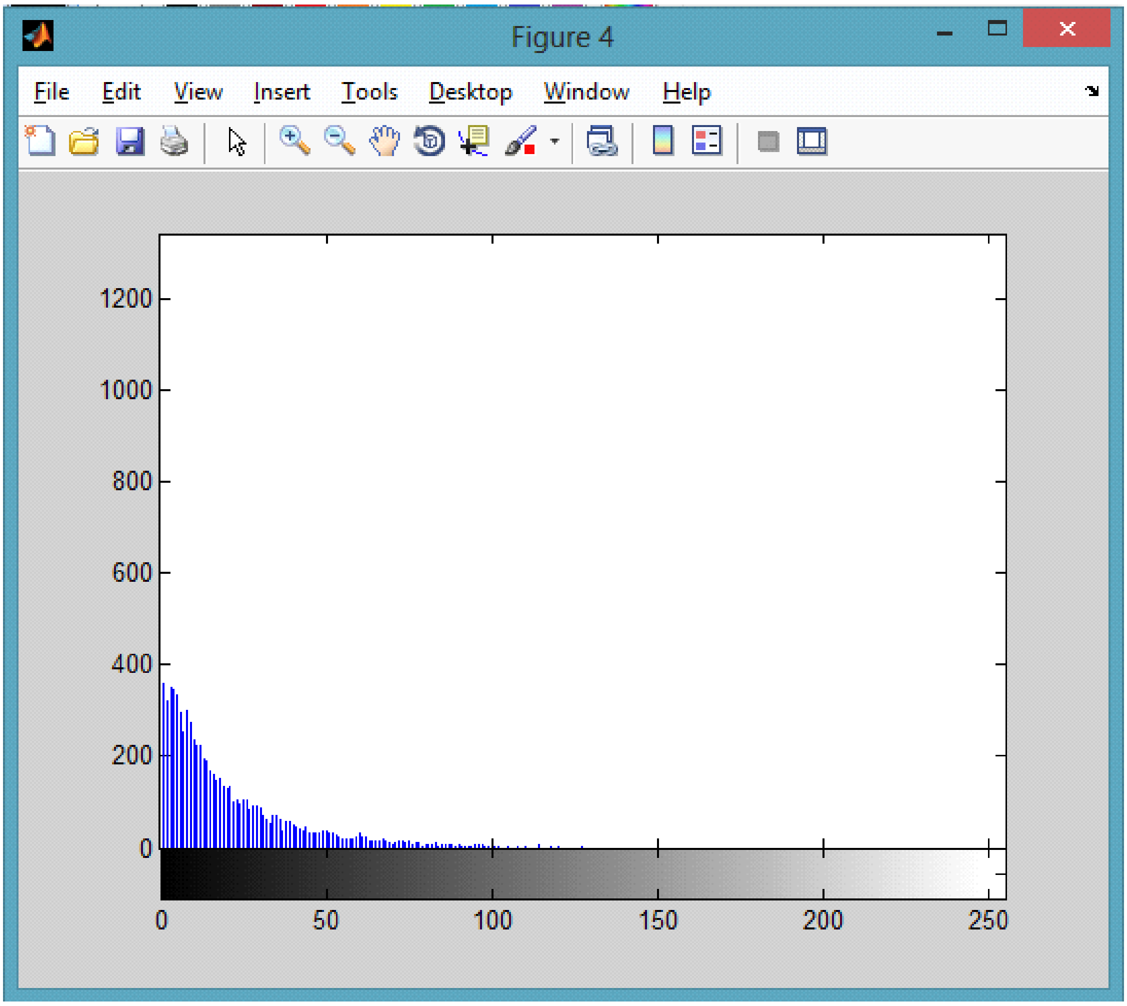


Figure 3
File Edit View Insert Tools Desktop Window Help
180
160
140
120
100
80
60
40
20
0
0
50
100
150
200
250




```
%% LOSSLESS COMPRESSION-DECOMPRESSION USNIG DISCRETE COSINE TRANSFORM
TECHNIQUE.
function[]=dct1(filename,n,m)
% "filename" is the string of characters including Image name and its
% extension.
% "n" denotes the number of bits per pixel.
% "m" denotes the number of most significant bits (MSB) of DCT
Coefficients.

% Matrix Intializations.
N=8;                            % Block size for which DCT is Computed.
M=8;
n=8;
m=8;
I=imread('8.tif');             % Reading the input image file and storing
intensity values in 2-D matrix I.
I_dim=size(I);                  % Finding the dimensions of the image file.
I_Trsfrm.block=zeros(N,M);  % Initialising the DCT Coefficients Structure
Matrix "I_Trsfrm" with the required dimensions.

Norm_Mat=[16 11 10 16 24 40 51 61        % Normalization matrix (8 X 8) used
to Normalize the DCT Matrix.
          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];

save('LenaInitial.txt','I');

%% PART-1: COMPRESSION TECHNIQUE.

% Computing the Quantized & Normalized Discrete Cosine Transform.
% Y(k,l)=(2/root(NM))*c(k)*c(l)*sigma(i=0:N-1)sigma(j=0:M-
1)y(i,j)cos(pi(2i+1)k/(2N))cos(pi(2j+1)l/(2M))
% where c(u)=1/root(2) if u=0
%             = 1       if u>0

for a=1:I_dim(1)/N
    for b=1:I_dim(2)/M
        for k=1:N
            for l=1:M
                prod=0;
                for i=1:N
                    for j=1:M
                        prod=prod+double(I(N*(a-1)+i,M*(b-1)+j))*cos(pi*(k-
1)*(2*i-1)/(2*N))*cos(pi*(l-1)*(2*j-1)/(2*M));
                    end
                end
                if k==1
                    prod=prod*sqrt(1/N);
                else
                    prod=prod*sqrt(2/N);
                end
                if l==1
                    prod=prod*sqrt(1/M);
                else
                    prod=prod*sqrt(2/M);
                end
                I_Trsfrm(a,b).block(k,l)=prod;
            end
        end
        % Normalizing the DCT Matrix and Quantizing the resulting values.
        I_Trsfrm(a,b).block=round(I_Trsfrm(a,b).block./Norm_Mat);
    end
end

% zig-zag coding of the each 8 X 8 Block.
for a=1:I_dim(1)/N
    for b=1:I_dim(2)/M
        I_zigzag(a,b).block=zeros(1,0);
        freq_sum=2:(N+M);
        counter=1;
        for i=1:length(freq_sum)
            if i<=((length(freq_sum)+1)/2)
                if rem(i,2)~=0
                    x_indices=counter:freq_sum(i)-counter;
                else
                    x_indices=freq_sum(i)-counter:-1:counter;
                end
                    index_len=length(x_indices);
                    y_indices=x_indices(index_len:-1:1); % Creating reverse
of the array as "y_indices".
                    for p=1:index_len
                        if I_Trsfrm(a,b).block(x_indices(p),y_indices(p))<0
```

```
                                bin_eq=dec2bin(bitxor(2^n-
1,abs(I_Trsfrm(a,b).block(x_indices(p),y_indices(p)))),n);
                            else

bin_eq=dec2bin(I_Trsfrm(a,b).block(x_indices(p),y_indices(p)),n);
                            end

I_zigzag(a,b).block=[I_zigzag(a,b).block,bin_eq(1:m)];
                        end
                else
                    counter=counter+1;
                    if rem(i,2)~=0
                        x_indices=counter:freq_sum(i)-counter;
                    else
                        x_indices=freq_sum(i)-counter:-1:counter;
                    end
                        index_len=length(x_indices);
                        y_indices=x_indices(index_len:-1:1); % Creating reverse
of the array as "y_indices".
                        for p=1:index_len
                            if I_Trsfrm(a,b).block(x_indices(p),y_indices(p))<0
                                bin_eq=dec2bin(bitxor(2^n-
1,abs(I_Trsfrm(a,b).block(x_indices(p),y_indices(p)))),n);
                            else

bin_eq=dec2bin(I_Trsfrm(a,b).block(x_indices(p),y_indices(p)),n);
                            end

I_zigzag(a,b).block=[I_zigzag(a,b).block,bin_eq(1:m)];
                        end
                end
            end
        end
end

% Clearing unused variables from Memory space
clear I_Trsfrm prod;
clear x_indices y_indices counter;

% Run-Length Encoding the resulting code.
for a=1:I_dim(1)/N
    for b=1:I_dim(2)/M

        % Computing the Count values for the corresponding symbols and
        % savin them in "I_run" structure.
        count=0;
        run=zeros(1,0);
        sym=I_zigzag(a,b).block(1);
        j=1;
        block_len=length(I_zigzag(a,b).block);
        for i=1:block_len
            if I_zigzag(a,b).block(i)==sym
                count=count+1;
            else
                run.count(j)=count;
                run.sym(j)=sym;
                j=j+1;
                sym=I_zigzag(a,b).block(i);
                count=1;
            end
            if i==block_len
                run.count(j)=count;
```

```
                run.sym(j)=sym;
            end
        end

        % Computing the codelength needed for the count values.
        dim=length(run.count);  % calculates number of symbols being
encoded.
        maxvalue=max(run.count);  % finds the maximum count value in the
count array of run structure.
        codelength=log2(maxvalue)+1;
        codelength=floor(codelength);

        % Encoding the count values along with their symbols.
        I_runcode(a,b).code=zeros(1,0);
        for i=1:dim

I_runcode(a,b).code=[I_runcode(a,b).code,dec2bin(run.count(i),codelength),r
un.sym(i)];
        end
    end
end
% Saving the Compressed Code to Disk.
save ('LenaCompressed.txt','I_runcode');

% Clearing unused variables from Memory Space.
clear I_zigzag run;

%% PART-2: DECOMPRESSION TECHNIQUE.

% Run-Length Decoding of the compressed image.
for a=1:I_dim(1)/N
    for b=1:I_dim(2)/M
        enc_str=I_runcode(a,b).code;

        % Computing the length of the encoded string.
        enc_len=length(enc_str);

        % Since Max. Count is unknown at the receiver, Number of bits used
for each
        % count value is unknown and hence cannot be decoded directly.
Number of bits
        % used for each count can be found out by trial and error method
for all
        % the possible lengths => factors of encoded string length.

        % Computing the non-trivial factors of the "enc_len" (length of
encoded
        % string) i.e., factors other than 1 & itself.
        factors_mat=zeros(1,0);
        if enc_len<=(n+1)
            realfact=enc_len;
        else
            for i=2:enc_len-2       % "enc_len-1" is always not a divisor
of "enc_len".
                if(rem(enc_len,i)==0)
                    factors_mat=[factors_mat,i];
                end
            end

            % Trial and Error Method to Find the Exact count value.
            for i=1:length(factors_mat)
```

```
                flagcntr=0;
                temp_dim=enc_len/factors_mat(i);
                for j=1:temp_dim
                    if strcmp(enc_str(1+(j-
1)*factors_mat(i):j*factors_mat(i)),dec2bin(0,factors_mat(i)))==0
                        if j==1
                            flagcntr=flagcntr+1;
                        else
                            if enc_str((j-
1)*factors_mat(i))~=enc_str(j*factors_mat(i))
                                flagcntr=flagcntr+1;
                            else
                                break;
                            end
                        end
                    else
                        break;
                    end
                end
                if flagcntr==temp_dim
                    realfact=factors_mat(i);
                    break;
                end
            end
        end

        % Clearing unused variables from Memory space
        clear factors_mat flagcntr j

        % Finding out the count values of corresponding symbols in the
encoded
        % string and then decoding it accordingly.
        dec_str=zeros(1,0);
        temp_dim=enc_len/realfact;
        for i=1:temp_dim
            count_str=enc_str(1+(i-1)*realfact:(i*realfact)-1);
            countval=bin2dec(count_str);
            for j=1:countval
                dec_str=[dec_str,enc_str(i*realfact)];
            end
        end
        I_runcode(a,b).code=dec_str;
    end
end

% Clearing unused variables from Memory space
clear enc_str dec_str temp_dim realfact enc_len
clear countval count_str

% Reconstructing the 8 X 8 blocks in Zig-Zag fashion.
I_rec_Trnsfm.block=zeros(N,M);
for a=1:I_dim(1)/N
    for b=1:I_dim(2)/M
        bpp=length(I_runcode(a,b).code)/(N*M);  % "bpp" is the bits-per-
pixel in reconstruction of image.
        bpp_diff=n-bpp;
        freq_sum=2:(N+M);
        counter=1;
        c_indx=1;
        for i=1:length(freq_sum)
            if i<=((length(freq_sum)+1)/2)
                if rem(i,2)~=0
```

```
                    x_indices=counter:freq_sum(i)-counter;
                else
                    x_indices=freq_sum(i)-counter:-1:counter;
                end
                    index_len=length(x_indices);
                    y_indices=x_indices(index_len:-1:1); % Creating reverse
of the array as "y_indices".
                    for p=1:index_len
                        decm_eq=bin2dec([I_runcode(a,b).code(1+m*(c_indx-
1):m*c_indx),dec2bin(0,bpp_diff)]);
                        if decm_eq>(2^(n-1))-1
                            decm_eq=decm_eq-(2^n-1);
                        end

I_rec_Trnsfm(a,b).block(x_indices(p),y_indices(p))=decm_eq;
                       c_indx=c_indx+1;
                    end
            else
                counter=counter+1;
                if rem(i,2)~=0
                    x_indices=counter:freq_sum(i)-counter;
                else
                    x_indices=freq_sum(i)-counter:-1:counter;
                end
                    index_len=length(x_indices);
                    y_indices=x_indices(index_len:-1:1); % Creating reverse
of the array as "y_indices".
                    for p=1:index_len
                        decm_eq=bin2dec([I_runcode(a,b).code(1+m*(c_indx-
1):m*c_indx),dec2bin(0,bpp_diff)]);
                        if decm_eq>(2^(n-1))-1
                            decm_eq=decm_eq-(2^n-1);
                        end

I_rec_Trnsfm(a,b).block(x_indices(p),y_indices(p))=decm_eq;
                        c_indx=c_indx+1;
                    end
            end
        end
    end
end

% Clearing unused variables from Memory space
clear I_runcode x_indices y_indices
clear c_indx freq_sum

% Denormalizing the Reconstructed Tranform matrix using the same
% Normalization matrix.
for a=1:I_dim(1)/N
    for b=1:I_dim(2)/M
        I_rec_Trnsfm(a,b).block=(I_rec_Trnsfm(a,b).block).*Norm_Mat;
    end
end


% Inverse-Discrete Cosine Transform on the reconstructed Matrix.
% y(i,j)=(2/root(NM))*sigma(i=0:N-1)sigma(j=0:M-1)
Y(k,l)c(k)*c(l)*cos(pi(2i+1)k/(2N))cos(pi(2j+1)l/(2M))
% where c(u)=1/root(2) if u=0
%             = 1       if u>0
for a=1:I_dim(1)/N
    for b=1:I_dim(2)/M
```

```
        for i=1:N
            for j=1:M
                prod=0;
                for k=1:N
                    for l=1:M
                        if k==1
temp=double(sqrt(1/2)*I_rec_Trnsfm(a,b).block(k,l))*cos(pi*(k-1)*(2*i-1)/(2*N))*cos(pi*(l-1)*(2*j-1)/(2*M));
                        else
temp=double(I_rec_Trnsfm(a,b).block(k,l))*cos(pi*(k-1)*(2*i-1)/(2*N))*cos(pi*(l-1)*(2*j-1)/(2*M));
                        end
                        if l==1
                            temp=temp*sqrt(1/2);
                        end
                        prod=prod+temp;
                    end
                end
                prod=prod*(2/sqrt(M*N));
                I_rec((a-1)*N+i,(b-1)*M+j)=prod;
            end
        end
    end
end

% Clearing unused variables from Memory Space.
clear I_rec_Trnsfm

% Displaying the Reconstructed Image.
diff=im2double(I)*255-I_rec;
diff=diff/max(max(diff));
diff=im2uint8(diff);
I_rec=I_rec/max(max(I_rec));
I_rec=im2uint8(I_rec);
 figure,imshow(I_rec,[0,2^n-1]);
 figure,imshow(diff,[0 2^n-1])
figure, imhist(I_rec);
figure, imhist(diff);


n=size(I);
 M=n(1);
 N=n(2);
 MSE = sum(sum((I- I_rec).^2))/(M*N);
PSNR = 10*log10(256*256/MSE);
 fprintf('\nMSE: %7.2f ', MSE);
 fprintf('\nPSNR: %9.7f dB', PSNR);
```