Image and Video Processing

Programming Assignment 9

Transformations computation

Submitted by
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Compute the DCT of any image and prove the energy compaction property. Calculate DCT matrix of order N = 8
Plot the basis images of Walsh and Hadamard transformation of order N = 4
Implement KL Transform without using inbuilt functions. Reconstruct the original image taking

Principal Component K = 3

Principal Component K = 10

Find the KL Transform of the given 2-D vectors with N=2 and M=27. Coordinates: (1,1) (1,2) (2,1) (2,2) (2,3) (3,1) (3,2) (3,3) (4,2) (4,3) (4,4) (4,5) (4,6) (5,3) (5,4) (5,5) (5,6) (5,7) (6,4) (6,5) (6,6) (6,7) (6,8) (7,5) (7,6) (7,7) (7,8)

1. DCT and Walsh-Hadamard

```
img = im2double(imread('mountain.tif'));
if size(img, 3) == 3
    img = rgb2gray(img);
end
```

Compute the DCT of the image

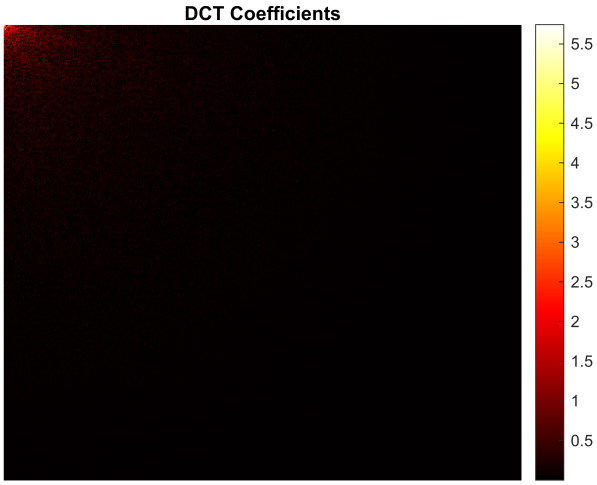
```
dct_img = dct2(img);
```

Compute log-scaled DCT coefficients

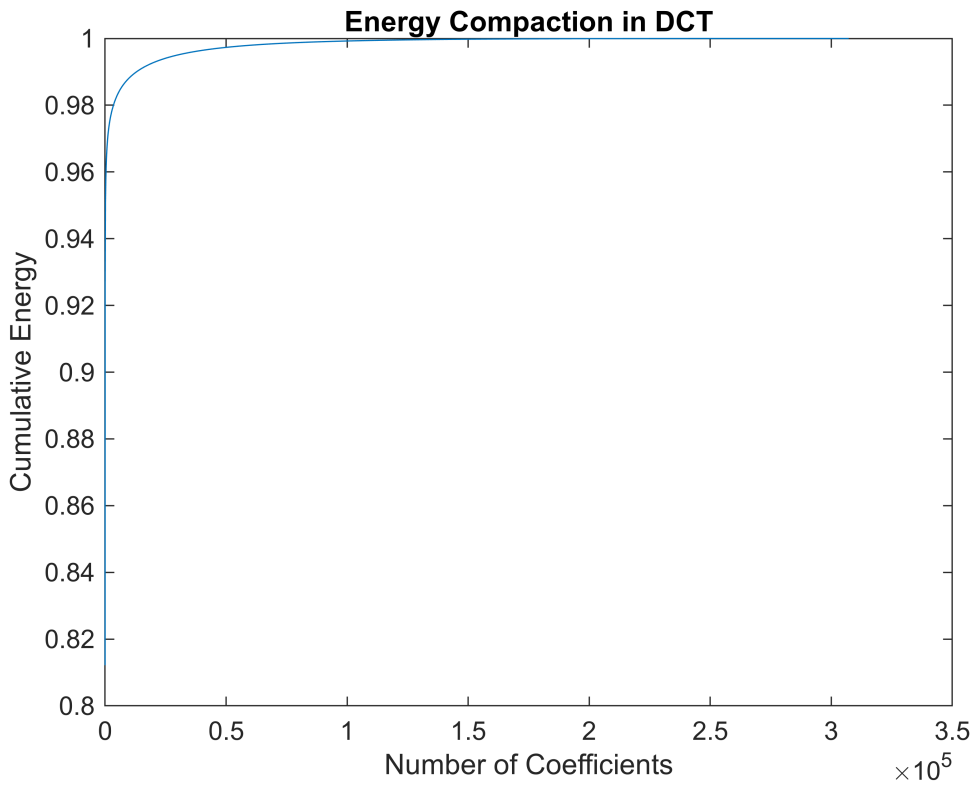
```
dct_scaled = log(1 + abs(dct_img));
```

Normalize to [0,1] for proper display

```
dct_scaled=(dct_scaled - min(dct_scaled(:)))/(max(dct_scaled(:)) - min(dct_scaled(:)));

figure;
imagesc(log(1 + abs(dct_img)));
colormap("hot");
colorbar;
axis off;
title('DCT Coefficients');
```



```
energy = sum(dct_img(:).^2);
sorted_coeffs = sort(abs(dct_img(:)), 'descend');
energy_cumsum = cumsum(sorted_coeffs.^2) / energy;

figure, plot(energy_cumsum), title('Energy Compaction in DCT');
xlabel('Number of Coefficients'); ylabel('Cumulative Energy');
```



2. Calculate DCT matrix of order N = 8

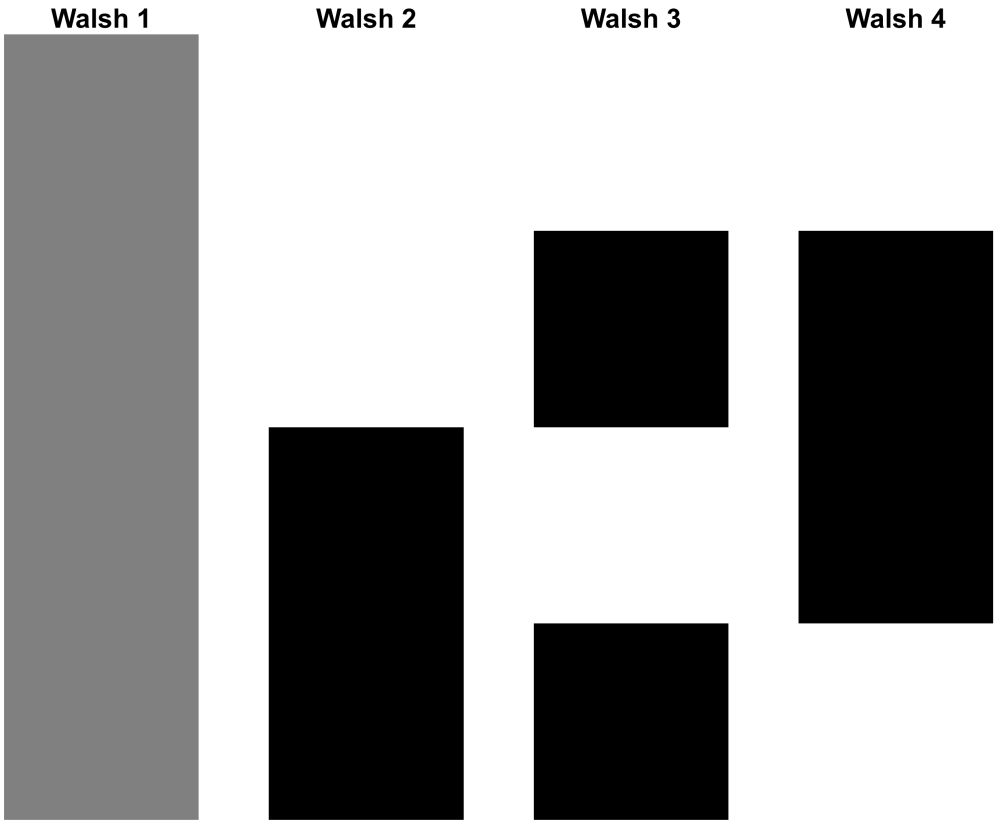
```
N = 8;
DCT_matrix = dctmtx(N);
disp('DCT Matrix of order 8:');
disp(DCT_matrix);
```

DCT Matrix Output

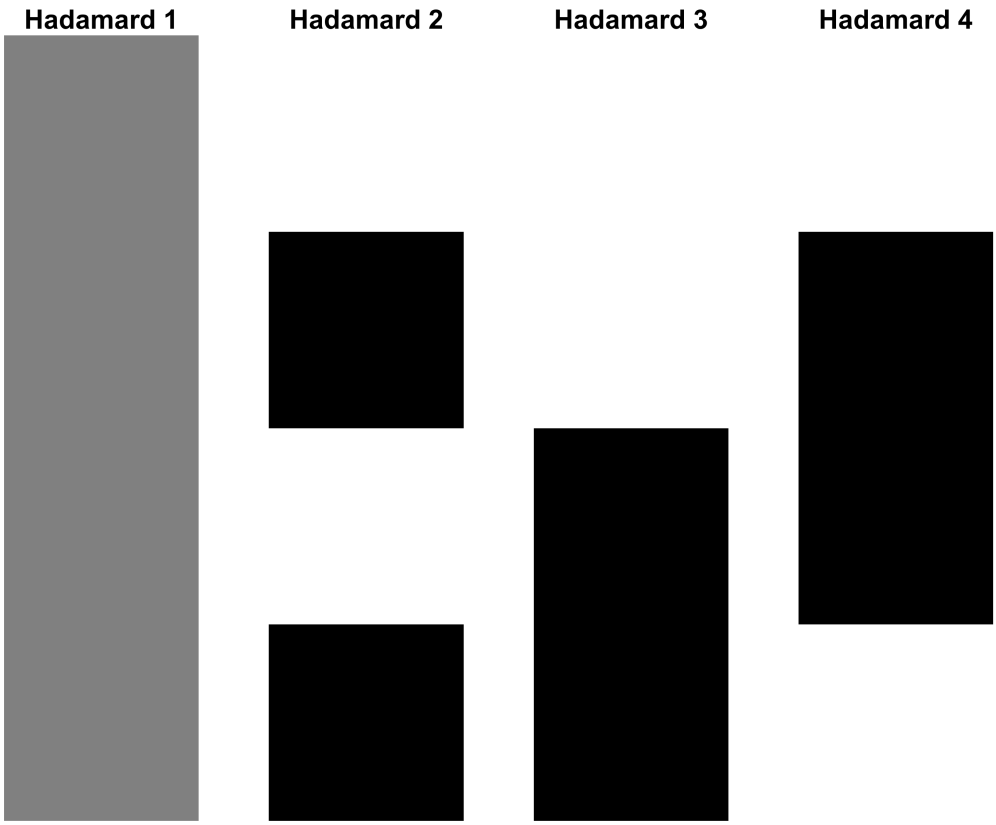
```
DCT_matrix =

    [ 0.3536  0.3536  0.3536  0.3536  0.3536  0.3536  0.3536  0.3536 ]
    [ 0.4904  0.4157  0.2778  0.0975 -0.0975 -0.2778 -0.4157 -0.4904 ]
    [ 0.4619  0.1913 -0.1913 -0.4619 -0.4619 -0.1913  0.1913  0.4619 ]
    [ 0.4157 -0.0975 -0.4904 -0.2778  0.2778  0.4904  0.0975 -0.4157 ]
    [ 0.3536 -0.3536 -0.3536  0.3536  0.3536 -0.3536 -0.3536  0.3536 ]
    [ 0.2778 -0.4904  0.0975  0.4157 -0.4157 -0.0975  0.4904 -0.2778 ]
    [ 0.1913 -0.4619  0.4619 -0.1913 -0.1913  0.4619 -0.4619  0.1913 ]
    [ 0.0975 -0.2778  0.4157 -0.4904  0.4904 -0.4157  0.2778 -0.0975 ]
```

3. Plot the basis images of Walsh and Hadamard transformation of order N = 4

```
N = 4;
H = hadamard(N);
walsh_basis = H(bitrevorder(1:N), :);

figure;
for i = 1:N
    subplot(1, N, i);
    imagesc(walsh_basis(:, i)); colormap(gray);
    axis off; title(['Walsh ', num2str(i)]);
end
```




```
figure;
for i = 1:N
    subplot(1, N, i);
    imagesc(H(:, i)); colormap(gray);
    axis off; title(['Hadamard ', num2str(i)]);
end
```



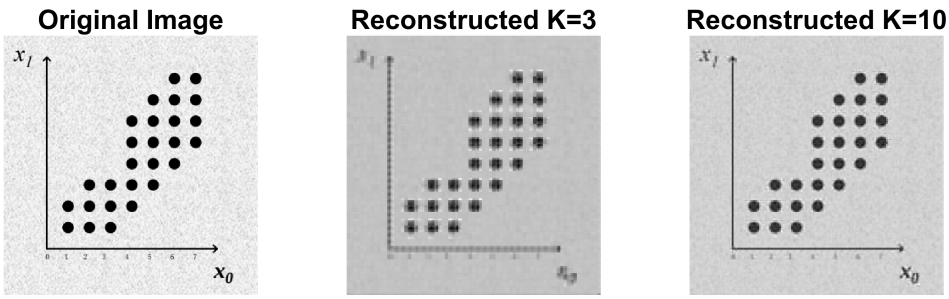
4. KL Transform & Reconstruction

```
img = im2double(imread('image.png'));
if size(img, 3) == 3
    img = rgb2gray(img);
end

block_size = 8;
[m, n] = size(img);
X = im2col(img, [block_size block_size], 'distinct');

X_mean = mean(X, 2);
X_centered = X - X_mean;
cov_matrix = (X_centered * X_centered') / size(X, 2);

[eig_vectors, eig_values] = eig(cov_matrix);
eig_values = diag(eig_values);
[~, idx] = sort(eig_values, 'descend');
eig_vectors = eig_vectors(:, idx);

K_values = [3, 10];
reconstructed_images = cell(1, length(K_values));

for i = 1:length(K_values)
    K = K_values(I);
```

```
    X_reduced = eig_vectors(:, 1:K)' * X_centered;
    X_reconstructed = eig_vectors(:, 1:K) * X_reduced + X_mean;
    reconstructed_images{i} = col2im(X_reconstructed, [block_size block_size],
    [m n], 'distinct');
end
```

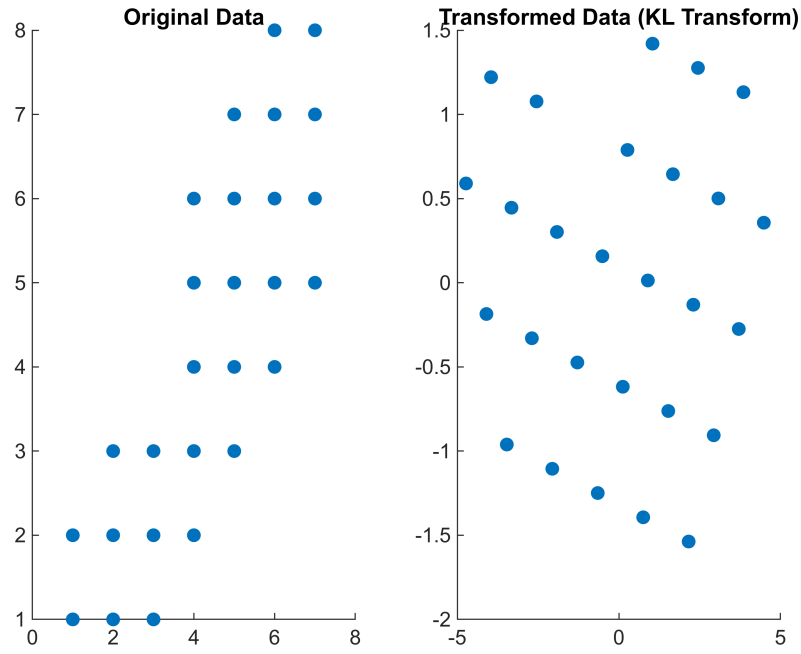
Display Original, Reconstructed K=3, and K=10

```
figure;
subplot(1,3,1), imshow(img, []), title('Original Image');
subplot(1,3,2), imshow(reconstructed_images{1}, []), title('Reconstructed K=3');
subplot(1,3,3), imshow(reconstructed_images{2}, []), title('Reconstructed K=10');
```



5. KL Transform on 2D Vectors

```
coordinates = [1,1; 1,2; 2,1; 2,2; 2,3; 3,1; 3,2; 3,3;
               4,2; 4,3; 4,4; 4,5; 4,6; 5,3; 5,4; 5,5;
               5,6; 5,7; 6,4; 6,5; 6,6; 6,7; 6,8; 7,5;
               7,6; 7,7; 7,8];

X = coordinates - mean(coordinates);

cov_matrix = cov(X);
[eig_vectors, eig_values] = eig(cov_matrix);
eig_values = diag(eig_values);
[~, idx] = sort(eig_values, 'descend');
eig_vectors = eig_vectors(:, idx);

X_transformed = X * eig_vectors;

figure;
subplot(1,2,1);
scatter(coordinates(:,1), coordinates(:,2), 'filled');
title('Original Data');

subplot(1,2,2);
scatter(X_transformed(:,1), X_transformed(:,2), 'filled');
title('Transformed Data (KL Transform)');
```


Original Data
Transformed Data (KL Transform)
8
7
6
5
4
3
2
1
0
2
4
6
8
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-5
0
5