CIS602-02 Special Topics in CIS Computer Vision

Assignment # 1

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Problem 1) Image Manipulation (15 pts).

See the script **problem1.mlx.**

Assuming all the script and images are in same directory

Problem 2) Transformation Matrices (35 pts)

For problem a, b, c, d see the script problem2.mlx.

Assuming all the script and images are in same directory

b)

A =
$$\begin{matrix} (2^{1/2})/2 & -(2^{1/2})/2 \\ (2^{1/2})/2 & (2^{1/2})/2 \end{matrix}$$

X_0 =
$$\begin{matrix} X_0 \\ Y_0 \end{matrix}$$

After scaling operation

X_0 =
$$\begin{matrix} X_0 \\ Y_0/2 \end{matrix}$$

Z =
$$\begin{matrix} 1 & 0 \\ 0 & 1/2 \end{matrix}$$

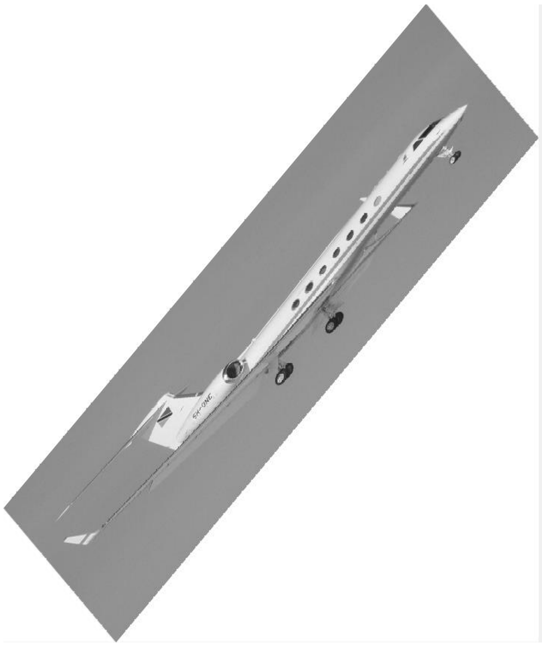
$X_2 = AZX_0$

C)

T = A.Z

T =

(2^1/2)/2	- (2^1/2)/4
(2^1/2)/2	(2^1/2)/4



e)

Given:

$RT = R^{-1}$

A is invertible.

$R^{T}R = I$

$RY\ A = B$

$R^{T}\ (RY\ A) = R^{T}\ B$

$(R^{T}\ R)\ (Y\ A) = R^{T}\ B$

Given $R^{T}\ R = I$

$IY\ A = R^{T}\ B$

$Y\ A = R^{T}\ B$

Adding A^{-1} on both sides

$Y\ AA^{-1} = R\ T\ BA^{-1}$

$AA^{-1} = 1$

$Y = R^{T}\ BA^{-1}$

Problem 3. Linear Filter (20 pts)

a) Convolve the following I and F. Assume we use zero-padding where necessary.

ANSWER:

$$I = \begin{matrix} 0 & 0 & 0 & 0 \\ 0 & 2 & 0 & 1 \\ 0 & 1 & -1 & 2 \end{matrix}$$

$$F = \begin{matrix} 1 & -1 \\ 1 & -1 \end{matrix}$$

I*F convolution

1)

$$\begin{matrix} 0 & 0 \\ 0 & 2 \end{matrix} \quad * \quad \begin{matrix} 1 & -1 \\ 1 & -1 \end{matrix}$$

= 0+0+0-2 = -2

2)

$$\begin{matrix} 0 & 0 \\ 2 & 0 \end{matrix} \quad * \quad \begin{matrix} 1 & -1 \\ 1 & -1 \end{matrix}$$

= 0+0+2+0 = 2

3)

$$\begin{matrix} 0 & 0 \\ 0 & 1 \end{matrix} \quad * \quad \begin{matrix} 1 & -1 \\ 1 & -1 \end{matrix}$$

= 0+0+0-1 = -1

4)

$$\begin{matrix} 0 & 2 \\ 0 & 1 \end{matrix} \quad * \quad \begin{matrix} 1 & -1 \\ 1 & -1 \end{matrix}$$

= 0-2+0-1 = -3

5)

$$\begin{matrix} 2 & 0 \\ 1 & -1 \end{matrix} \quad * \quad \begin{matrix} 1 & -1 \\ 1 & -1 \end{matrix}$$

= 2+0+1+1 = 4

6)

$$\begin{matrix} 0 & 1 \\ -1 & 2 \end{matrix} \quad * \quad \begin{matrix} 1 & -1 \\ 1 & -1 \end{matrix}$$

= 0-1-1-2 = -4

Result I*F =

-2	**2**	**-1**
-3	**4**	**-4**

(b) Note that the F given in (2) is separable; that is, it can be written as a product of two 1D filters: $F = F1F2$.

$$I = \begin{matrix} 0 & 0 & 0 & 0 \\ 0 & 2 & 0 & 1 \\ 0 & 1 & -1 & 2 \end{matrix}$$

$$F1 = \begin{matrix} 1 \\ 1 \end{matrix}$$

$$F2 = \begin{matrix} 1 & -1 \end{matrix}$$

I*F1 convolution

1)

$$\begin{matrix} 0 \\ 0 \end{matrix} * \begin{matrix} 1 \\ 1 \end{matrix} = 0$$

2)

$$\begin{matrix} 0 \\ 2 \end{matrix} * \begin{matrix} 1 \\ 1 \end{matrix} = 2$$

3)

$$\begin{matrix} 0 \\ 0 \end{matrix} * \begin{matrix} 1 \\ 1 \end{matrix} = 0$$

4)

$$\begin{matrix} 0 \\ 1 \end{matrix} * \begin{matrix} 1 \\ 1 \end{matrix} = 1$$

5)

$$\begin{matrix} 0 \\ 0 \end{matrix} * \begin{matrix} 1 \\ 1 \end{matrix} = 0$$

6)

$$\begin{matrix} 2 \\ 1 \end{matrix} * \begin{matrix} 1 \\ 1 \end{matrix} = 3$$

7)

0	*	1	=	-1
-1		1		

8)

1	*	1	=	3
2		1		

I*F1 =

0	2	0	1
0	3	-1	3

(I*F1)*F2 convolution

1)

0 2 * 1 -1 = - 2

2)

2 0 * 1 -1 = 2

3)

0 1 * 1 -1 = - 1

4)

0 3 * 1 -1 = - 3

5)

3 -1 * 1 -1 = 4

6)

-1 3 * 1 -1 = - 4

(I*F1)*F2 =

-2	**2**	**-1**
-3	**4**	**-4**

Problem 4. SVD for Image Compression (30 pts)

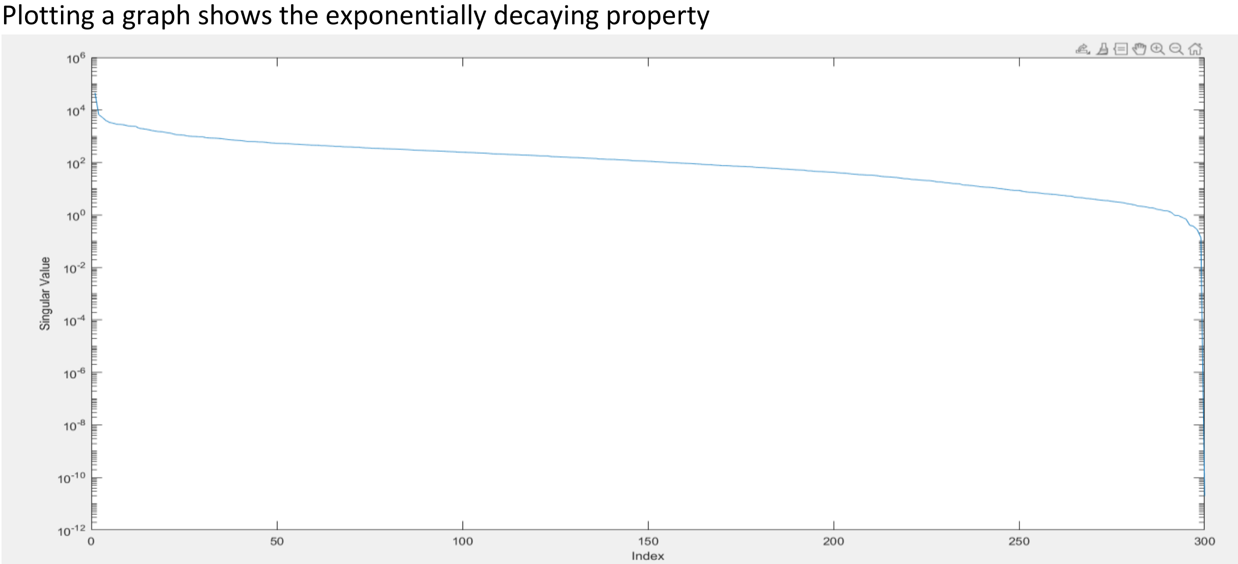
Assuming all the script and images are in same directory
Run the script problem4.mlx.

A)

Computation of top 10 largest values

```
>> flower

ans =

   1.0e+04 *

     4.4672
     0.6623
     0.5166
     0.3875
     0.3328
     0.3069
     0.2853
     0.2773
     0.2651
     0.2455

>> |
```

Plotting a graph shows the exponentially decaying property

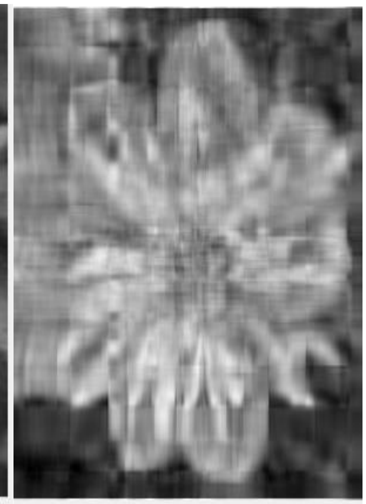


b)

Verify that you can reconstruct and display the image using the three SVD matrices (note that the svd command returns V, not $V\ T$). Then, perform compression by using only the top k singular values and their corresponding left/right singular vectors. Let k = 10, 50, and 100. Reconstruct and print the compressed images for the three different values of k. Briefly describe what you observe.

k = 100

k = 50



k = 10

After performing the image compression on the bit map image using values k = 10, k =50, k =100

The result shows that quality of an image increase with increase in singular k compression value as k = 100 image looks very much like an original

Problem 5. Instead of transmitting the original (grayscale) image, you can perform SVD compression on it and transmit only the top k singular values and the corresponding left/right singular vectors. This should be much smaller than the original image for low values of k. With this specific image, will we still save space by compressing when k = 200? Show why or why not.

1) By transmitting the k = 200 singular values along with left/right singular vectors space will not be saved.

2) when we transmit typical bitmap image into a grayscale 300 * 300 8- bit integer matrix should be sent.

3) so total bits required are 300*300*8 = 7.2 * 10^5 bits

4) in singular vector decomposition of the gray image this information must be 8 byte double precision number in order to reduce the substantial round off errors during the recreation of the image.

5) if the k = 200 values are used this indicates (200 + 2 × 200^2) × 64 = 5.13 × 10^6 bits of information to be transmitted.

6)to save the transmitting image using this specific method we should consider a critical point k where svd quantities drops below the original information.

(k+ 2 *k^2) * 8^2 , 8*300^2

K < (-1/2) +/- ((1/4)+(300^2/4))^1/2

K<=74

I.e., we should expect the reduction inn the required resources on or beyond the k<=74