Homework 1

(Total 180 pts)

Due 5:00 pm on September 20, 2024 (Friday)

Canvas submission as a single PDF file ('e.g., hw1_lastname.pdf').

Note: The images used in this homework can be downloaded and unzipped from the following ZIP files:
http://www.ece.uah.edu/~dwpan/course/ee604/images/book/DIP3E_CH02_Original_Images.zip
http://www.ece.uah.edu/~dwpan/course/ee604/images/book/DIP3E_CH03_Original_Images.zip
For example, the image for Figure 2.27(a) refers to the file: "Fig0227(a)(washington_infrared).tif".

1. (30 pts)
Download and install the Image Processing Toolbox Hyperspectral Imaging Library. Read the hyperspectral image data 'paviaU.dat' into Matlab using the *hypercube* function, and visualize the data by using three representative bands with band indices being 56, 31, and 11, respectively. Fill in the table below with the wavelengths for these three bands, and then calculate the corresponding frequencies and fill in the blanks (showing two decimal places). Note the speed of light is 2.998×10^{8}m/s.

Band Index	**Order**	**Wavelength (nm)**	**Frequency (10^{14}Hz)**
56	1^{st} band		
31	2^{nd} band		
11	3^{rd} band		

Use the *colorize* function in Matlab to show the estimated color image of the hyperspectral data based on the above three representative bands in the specified order. Attach your Matlab script and the image displayed.

2. (10 pts)
A progressive-scan high-definition television (HDTV) generates 30 frames of images each second, with each image frame having 1125 horizontal TV lines. The width-to-height aspect ratio of the images is 16:9. A company has designed an image capture system that generates digital images from HDTV images. The resolution of each TV (horizontal) line in their system is in proportion to vertical resolution, with the proportion being the width-to-height ratio of the images. Each pixel in the color image has 24 bits of intensity resolution -- 8 bits each for a red, a green, and a blue image, with these three "primary" images forming a color image. How many bits would it take to store a 2-hour HDTV movie?

3. (15 pts) Consider the image segment shown below

```
    3  1  2  1 (q)
    2  2  0  2
    1  2  1  1
(p) 1  0  1  2
```

(a) Let $V = \{0, 1\}$ and compute the length of the shortest 8-path between p and q.
(b) Let $V = \{0, 1\}$ and compute the length of the shortest m-path between p and q.
(c) Let $V = \{1, 2\}$ and compute the length of the shortest 4-path between p and q.

4. (15 pts) Write a Matlab script to set to zero the most significant bit (MSB) of every pixel in the image for Figure 2.27(a). Find the difference $D(x, y) = I(x, y) - J(x, y)$, where $I(x, y)$ is the original image, and $J(x, y)$ is the image obtained after setting the MSB of every pixel of $I(x, y)$ to zero. Scale $D(x, y)$ to the range [0, 255] and display $D(x, y)$. Attach the Matlab script and the images $I(x, y)$ and $D(x, y)$.

5. (20 pts) Read into Matlab the image of Figure 2.36(a). First translate the image by $t_x = 50$, and $t_y = 50$. Then rotate the translated image clockwise by 45° using bilinear interpolation. You can use the *imtranslate* and *imrotate* functions. Attach the Matlab script and the translated and rotated images.

6. (20 pts) Read into Matlab the image of Figure 3.9(a). Apply to the image Gamma transformation $s = r^{\gamma}$, where $\gamma = 5.0$. Attach the Matlab script and the original and transformed images.

7. (30 pts) Reconstruction quality and compression ratio of the JPGE compressed image.
   (a) In Matlab, read in the image file "coins.png":
   >> I = imread ('coins.png');
   Then use *imwrite* to save the raw image variable I into a JPEG compressed file, "coins.jpg", by using a 'quality' value being 10.
   What it the size (in bytes) of the file "coins.jpg"?
   What is the compression ratio? Round your answer to the first digit to the right of the decimal point.
   Note the Compression Ratio is defined as: Size of I (in bytes) / Size of "coins.jpg" (in bytes).
   (b) Read in the image file "coins.jpg":
   >> J = imread ('coins.jpg');
   Take the difference between I and J:
   >> D = I – J;
   Note: Make sure to convert I and J to double type before taking the difference.
   Display D by using the *imagesc* function. Show the color bar at the side. Attach the image.
   (c) Calculate the Peak Signal-to-Noise Ratio (PSNR) of the difference between I and J.
   You can either use the Matlab function directly
   >> psnr (I, J)
   or you can write your own script to calculate the PSNR based on the following definition: PSNR=10 $\log_{10} 255^2/\text{MSE}$, where MSE is the mean square error (or difference) between I and J.
   What is the PSNR value (in dB)? Round your answer to the first digit to the right of the decimal point.

(d) Attach the Matlab script used and fill in the table below with your answers.

Size of "coins.jpg" (in bytes)	Compression Ratio	PNSR (in dB)
	: 1	

8. (30 pts)
Image Steganography: Hiding a bi-level image into a bit plane of another grayscale image.
In Matlab, read in the following image:
```
>> I = imread('rice.png');
```
(a) Extract the most significant bit of each pixel of I(x,y) to form a bi-level image I8(x,y). Attach the plot for I8. Note: for better visualization of the bi-level image, consider scaling its pixel values to the full range of [0, 255] (for display only, while retaining the original pixel values of I8 for information hiding).
(b) Read in another image:
```
>> J = imread ('cameraman.tif');
```
Write a script (M file) to set the least significant bit of each pixel of J(x,y) to the co-located pixel value of I8(x,y). Let J1 be the resulting image after "hiding" the bi-level image I8 into the LSB bit plane of J. Display the image J1 and attach the plot.
(c) Repeat (b) by setting the fourth bit of each pixel of J(x,y) to the co-located pixel value of I8(x,y). Display the resulting image J4 and attach the plot.
(d) Repeat (b) by setting the eighth bit (i.e., the MSB) of each pixel of J(x,y) to the co-located pixel value of I8(x,y). Display the resulting image J8 and attach the plot.
(e) Attach your script and comment on your results with regard to the effectiveness of image information hiding.

9. (10 pts) Independent Research Problem.
Conduct a self-study on the TIFF (Tag Image File Format) standard:
Below are some literature for your reference only:
https://www.itu.int/itudoc/itu-t/com16/tiff-fx/docs/tiff6.pdf
https://www.fileformat.info/format/tiff/egff.htm

Investigate the TIFF file for Figure 2.27(a):
"Fig0227(a)(washington_infrared).tif"
and answer the following questions by filling in the table with the values:
You can use a hex dump software to obtain a hexadecimal view of the file data. For example, https://www.hhdsoftware.com/free-hex-editor.

The byte order used within the file	Big Endian ( ) or Little Endian ( )? Check one.
How many bytes are used to represent the ImageWidth?	Two bytes ( ) or Four bytes ( )? Check one.
What is the value (in hexadecimal) for the ImageLength Tag?	0x( )
What is the hexadecimal value for the ImageLength?	0x( )
Was the stored data compressed?	Yes ( ) or No ( )? Check one.