University of Colombo School of Computing, Sri Lanka.

BSc (Comp Sc) - Year II
Semester II - 2019

Take Home Assignment on Octave
PC Applications Laboratory II - Octave/MATLAB
Deadline: Friday, 24^{th} of January, 2020

1. Prepare a Latex document with answers to ALL questions. Name it as $< your - index - number >$ $.tex$ and $< your - index - number >$ $.pdf$. It should include the source codes where necessary, figures as questioned, and your written answers. Put the question number as a section heading. Upload this document to **ASSIGNMENT LINK 1 - Take Home Assignment** of UGVLE. Several online Latex editors exist: `https://www.overleaf.com/`, `https://www.sharelatex.com/`, `https://latexbase.com/`.
2. Submit a PRINTED COPY of this Latex document to **Academic and Publications Division at Level 3 of UCSC** before the deadline mentioned in UGVLE. Sign the sheet upon submission.
3. Prepare a zip file named (your-index-number).zip with the Octave scripts, input data files, output figures or anything required to run your Octave script files. Include a RUN.sh (on Linux) or RUN.cmd (on Windows) file that includes commands to run the script. Upload this zip file to **ASSIGNMENT LINK 2 - Take Home Assignment** of UGVLE.

Name: ______________________________

Index Number: ______________________________

1. Section Heading: **Wavelets**.

   Plot the following first three wavelets a to c (Haar, Shannon, 1-D Mexican Hat) by using the Octave's `plot(.)` function in the range $t \in [-2, 2]$. Use an appropriate increment for t when displaying the wavelet with `linspace(.)`.

   For the part d (2-D Mexican Hat), use the `meshgrid(.), mesh()` Octave function to draw the 3D visualization of the 2D Mexican hat. A tutorial is available at `https://octave.org/doc/v4.2.1/Three_002dDimensional-Plots.html`

   (a) 1-dimensional Haar Wavelet

   $$\psi(t) = \begin{cases} 1 & 0 \leq t < \frac{1}{2} \\ -1 & \frac{1}{2} \leq t < 1 \\ 0 & \text{otherwise} \end{cases} \tag{1}$$

   (b) Shannon/Sinc Wavelet

   $$\psi(t) = \frac{\sin \pi t}{\pi t} \cos\left(\frac{3\pi t}{2}\right) \tag{2}$$

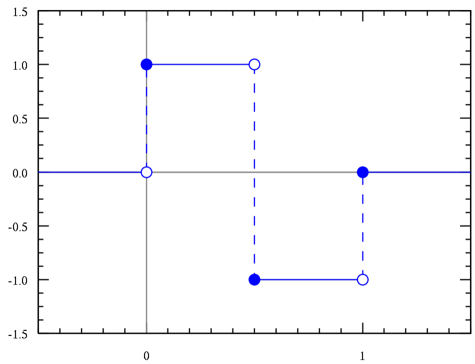

Figure 1: 1-D Haar Wavelet as equation 1.

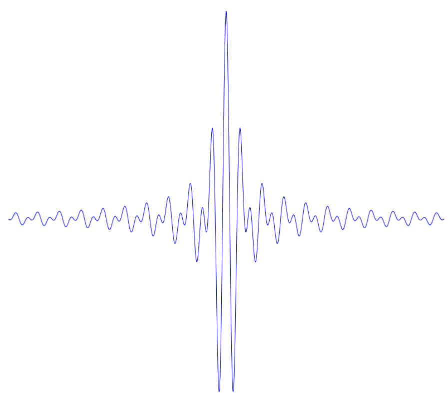

Figure 2: Shannon/Sinc Wavelet as equation 2.

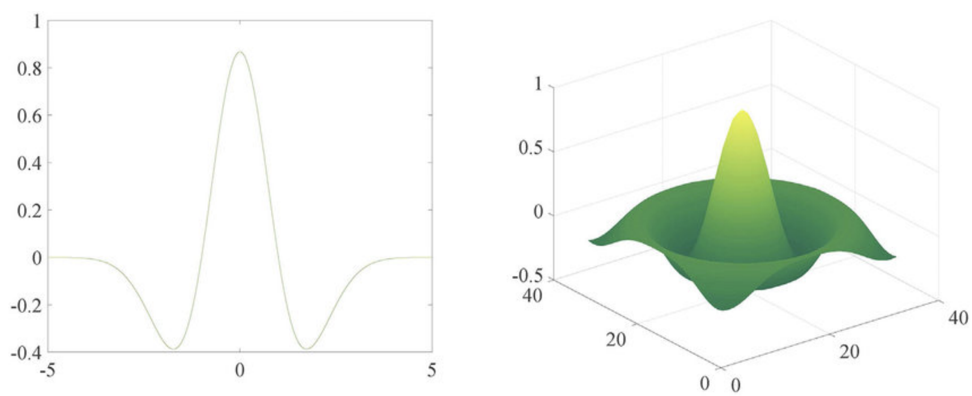

Figure 3: Left: 1-D Mexican Hat Wavelet as equation 3. Right: 2-D Mexican Hat Wavelet as equation

(c) 1-dimensional Mexican Hat Wavelet (Ricker Wavelet)

$$\psi(t) = \frac{2}{\sqrt{2\sigma}\pi^{\frac{1}{4}}} \left[1 - \left(\frac{t}{\sigma}\right)^2\right] e^{\left[-\frac{t^2}{2\sigma^2}\right]} \tag{3}$$

(d) 2-dimensional Mexican Hat Wavelet

$$\psi(x, y) = \frac{1}{\pi\sigma^2} \left(1 - \frac{1}{2}\left(\frac{x^2 + y^2}{\sigma^2}\right)\right) e^{-\frac{x^2+y^2}{2\sigma^2}} \tag{4}$$

Draw the 2D Mexican Hat for $\sigma = 1, 2, 0.5$ by using `mesh(.)`, `meshgrid()` as mentioned above. Adjust the axis range to display the function properly.

Figure 4: Threholding the image `M` by using 127.

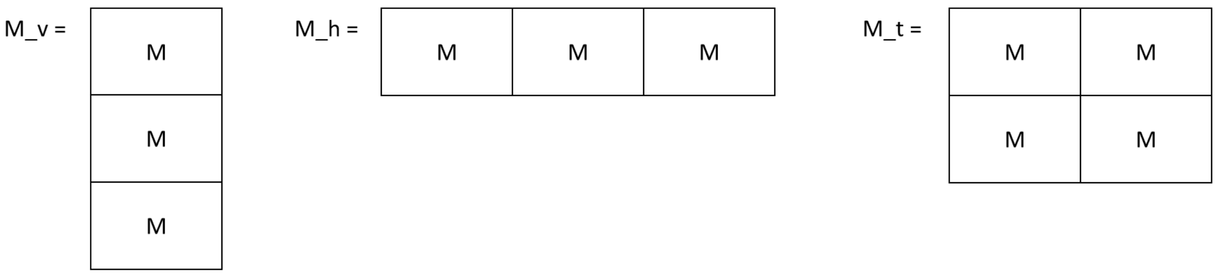

Figure 5: Matrices `M_v, M_h, M_t`.

2. Section heading: **Image Manipulation**

   Include all figures, **source codes**, and answers to each sub question in the Latex document.

   (a) Download an image of yourself (perhaps from Social Media, e.g. Facebook profile picture, family photo, Instagram photos etc.). Save that file in the folder as `test.png`. Load it to a variable `M0` and display `M0` with `imshow(.)`.

   (b) Convert the `M0` to a 2D matrix `M` which is a gray scale image by using `rgb2gray(.)` (Reference: `https://octave.sourceforge.io/image/function/rgb2gray.html`).

   (c) Identify the width and height of the image by using `size(.)`. Identify your face location in the image. Assign that face portion to a matrix named `Me`. Display `Me` by using `imshow(M)`. Set your name as the title of the figure.

   (d) Increase the brightness by multiplying `M` by $r > 1.0$ such that all values in `M` are between $[0, ..., 255]$ range. Use the `round(.)` and `M2 = min(255, r*M)` to make sure that the `M2` values are within the limits. Display `M2` by using `imshow(.)`.

   (e) Threshold the matrix `M` with a value `127` such that only values greater than 127 are dsiplayed in white colour and others in black colour. See Figure 4 for an example.

   (f) Create the matrices `M_v, M_h, M_t` as shown in Figure 5. Display them using `imshow(.)`. If the image is too large, you may use `Me` instead of `M` in this operation.

   (g) `rank(.)` of a matrix gives the number of linearly independent rows. Perform `rank(M), rank(M_v), rank(M_h), rank(M_t)`. Explain why `rank(M) = rank(M_v) = rank(M_h) = rank(M_t)` by considering linear independence.

   (h) Let us try to visualize the matrix `M` in 3D where intensities are represented as spikes and darker regions as flat areas. For example, see the Figure 6.

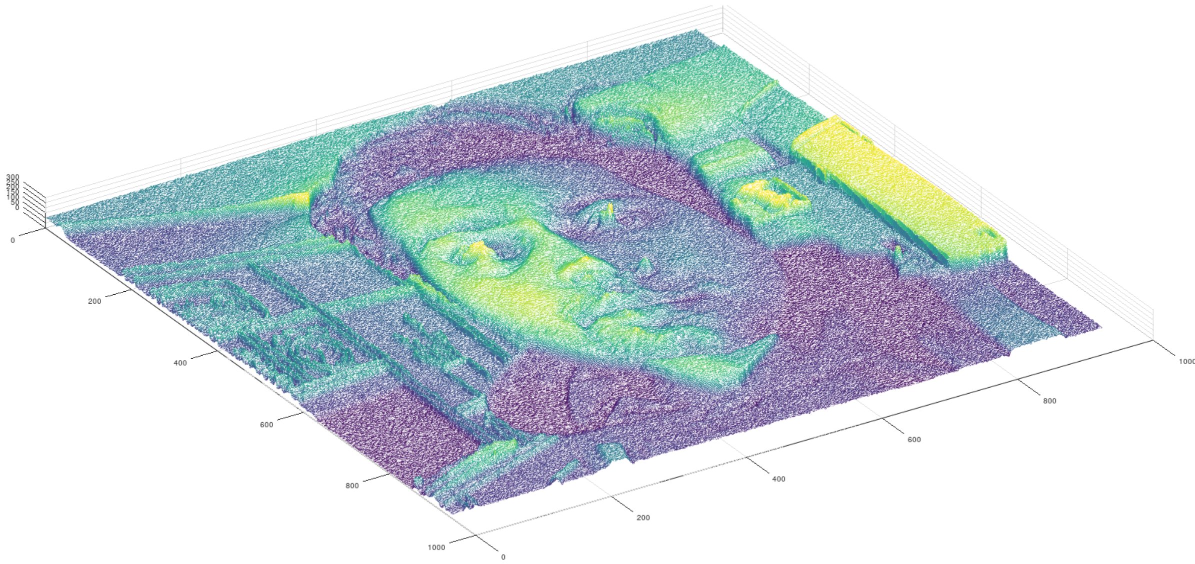

Figure 6: By using **meshgrid()** and **mesh()**, the gray scale image M is visualized in 3D where intensities in spikes and dark regions in flat area. Use the 3D rotation tool. If the operation is too computationally expensive in your computer, you may reduce the size of the image.

```
        [a,b]=  meshgrid(1:size(M,1) ,1:size(M,2));
        mesh(a,b,double(M'))
```

3. Section heading: **Fourier Analysis on Elephant Audio (Rumbles vs. Trumpet)**
   (a) Download the "Elephan6. wav" file and "Elephant9.wav" file from the following URL: `https://www.freesoundeffects.com/free-sounds/elephant-10064/`
   (b) Read the two files by using the following Octave function: `X = audioread(filename)`
   (c) Perform the Fast Fourier Transform on the two signals by using the following code for both the elephant audios, i.e. "elephan6.wav', "elephant9.wav".
   Hint: Use the ***`hold on/off`*** *to plot the both figures in one plot.*

```
        clear;
        close all;
        clc;

        % Fs Sampling frequency.

        [X, Fs] = audioread('elephan6.wav');

        Y = fft(X); %Compute the Fourier transform of the signal

        L = size(Y,1);

        P2 = abs(Y/L); %Compute the two-sided spectrum P2
        P1 = P2(1:L/2+1);  % compute the single-sided spectrum P1
        P1(2:end-1) = 2*P1(2:end-1);

        f = Fs*(0:(L/2))/L; %to define the frequency domain f

        plot(f , P1)
        % bar(f,P1) % bar() can also be used, but when using two, plot is easier to compare.
        title('Single-Sided Amplitude Spectrum of X(t)')
        xlabel('f (Hz)')
        ylabel('|P1(f)|')
        axis([0, 1000]);
```

   (d) What do you think about the frequencies of the two elephants? Which one is having more of the higher frequency and which one is of lower frequencies?
   (e) Read about elephant trumpet and rumble sound patterns. Write two to four sentences about them.

4. Section heading: **Understanding How Octave Shell Works – Under-the-Hood**

   Write a Java/C/C++ programme to construct the following Octave-like interface from scratch:

   (a) User will be displayed the following message at the beginning.

   ```
   Welcome to Universal Complex Scripting Calculator by UCSC, Sri Lanka.
   Version:  1.0
   >>
   ```

   The prompt indicated by `>>` should repeat until the user input `exit`. An expression can be executed at this prompt as in Octave by pressing the Enter key.

   User can perform the following **simple operations**:

   (b) Initialize a matrix similar to octave. For example:

   ```
   M = [1 3 4; 4 10 11];
   output:
   M =
   1 3 4
   4 10 11
   ```

   (c) User should be able to perform addition for scalars, vectors, and matrices as in Octave.

   (d) User should be able to perform subtraction for scalars, vectors, and matrices as in Octave.

   (e) User should be able to perform elementwise matrix multiplication as in Octave.

   (f) User should be able to standard matrix multiplication as in Octave.

   Upload your java/C/C++ sources, images/screenshots of your interfaces. Include the interface screenshots in the Latex document.

5. Section Heading: **Introduction to Data Mining**

   Analyze the Iris dataset and find which two features are the most discriminative when it comes to classifying each Iris flower type. A similar implementation is available at `https://academic.bancey.com/plotting-multivariate-data-with-matplotlibpylab-edgar-andersons-iris-flower-data-set/`. You may refer to this link but each code line should be well understood by yourself. Include both the output figure, answers, and the Octave code to the Latex document.

   (a) Download the `iris.csv` file from `https://gist.github.com/netj/8836201` or any convenient source/UGVLE.

   (b) Read the `iris.csv` file into Octave.

   (c) Visualize each pair of dimensions in subplots. Indicate the Iris class type by different colours. Include this to the Latex document.

   (d) What is the most discriminative two features in Iris dataset by referring to the plots in the previous sub question? Explain.