EE6403 Distributed Multimedia Systems Assignment 1

Instructions:

1. Submit only the **softcopy pdf file** through NTULearn EE6403 course site under the Assignment tab by **7 March 2023**. Late submission may be penalized.
2. Name your submitted file as FullStudentName_MetriculationNo.pdf (e.g., Tan_Yi_G1234567A.pdf)
3. Write your full name (as in student card) and matriculation no. clearly on the front page.
4. Be concise and to-the-point in your answers. Avoid long and irrelevant answers.
5. Highlight your final numerical answers (e.g., like this 88) to facilitate marking.
6. This is an individual home assignment. Do not plagiarize.
7. Completed assignment can include printouts of source codes and figures, if applicable.
8. You can use MATLAB or other programming languages/platforms to solve the problems, unless stated otherwise in the questions.
9. For calculation problems, you can choose to write your answers on the papers first, and then scan / convert them into pdf format.

1. Karhunen-Loeve Transform (KLT) is used in an image compression scheme. A 6×6 image is given as follows:

$$I = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 1 & 1 & 2 \\ 1 & 1 & 2 & 2 & 1 & 2 \\ 1 & 1 & 2 & 4 & 4 & 4 \\ 1 & 2 & 2 & 3 & 4 & 4 \\ 1 & 2 & 3 & 3 & 4 & 4 \end{bmatrix}$$

(a) Partition the image into 9 2×2 pixel blocks, and order them lexicographically to form 9 4×1 column vector (**x**). Calculate the mean vector, and show that its covariance matrix is given by:

$$\mathbf{C} = \begin{bmatrix} 1.6944 & 1.7361 & 1.4028 & 1.4167 \\ 1.7361 & 2.0278 & 1.6944 & 1.6667 \\ 1.4028 & 1.6944 & 2.1111 & 1.9167 \\ 1.4167 & 1.6667 & 1.9167 & 2.2500 \end{bmatrix}$$

(b) Determine the corresponding eigenvectors and eigenvalues for the covariance matrix **C**.

(c) A 2×2 image block after zero-mean centering is given by:

$$\begin{bmatrix} 0 & 0 \\ 1 & 1 \end{bmatrix}$$

Express the image block in terms of its principal components.

2. The singular value decomposition (SVD) of a matrix **A** is given by:

$$\mathbf{A} = \begin{bmatrix} 1 & 2 \\ 1 & 4 \\ 2 & 2 \end{bmatrix} = \mathbf{U}\mathbf{\Sigma}\mathbf{V}^{\mathrm{T}}$$

(a) Find the singular values in the SVD of **A manually**.

(b) Write a program (e.g., MATLAB) to perform color image compression using singular value decomposition (SVD). Choose a suitable color image and demonstrate how SVD can achieve image reconstruction using low-rank approximation with different ranks. Your answers should contain the program listing and various figures.

3. Choose an emerging media application/issue and briefly discuss its importance/impact/future direction in your opinion. You should keep your answer concise (preferably in point form) and **less than 300 words**. Note that this is an open-ended question, and you can choose any application/issue that you feel is important. However, you need to explain and justify its relevance/importance/direction clearly. You should not copy or plagiarize answers from some sources, but rather research, understand, and explain your own thought and opinion.