

EE6403 Distributed Multimedia Systems

Assignment 3

Instructions:

1. Submit only the **softcopy pdf file** (name it as FullStudentName_MatriculationNo.pdf) of your completed assignment through NTULearn EE6403 course site under the Assignment tab by **28 April 2020**.
 2. Write your full name and matriculation no clearly on the front page.
 3. This is an individual home assignment. Do not plagiarize.
 4. **Late submission will not be accepted.**
 5. **Be concise and to-the-point in your answers.** Avoid unnecessarily long and irrelevant answers.
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1. Karhunen-Loeve Transform (KLT) is used to perform image compression for a class of images. The images are partitioned into a number of 2×2 pixel blocks, and ordered lexicographically to form 4×1 vectors. The **covariance matrix** of the vectors is given by

$$\mathbf{C} = \begin{bmatrix} 3.7533 & 1.8767 & 0.0766 & 3.7083 \\ 1.8767 & 6.7630 & 3.5137 & 5.5418 \\ 0.0766 & 3.5137 & 2.7629 & 2.5665 \\ 3.7083 & 5.5418 & 2.5665 & 6.3208 \end{bmatrix}.$$

- (i) Find the eigenvalues and eigenvectors of \mathbf{C} . You may use any programming language, platform or other relevant method to obtain the results.
 - (ii) The KLT scheme based on the covariance matrix \mathbf{C} is used to compress a new 20×20 grayscale image I. List the key steps to perform image compression using KLT for image I.
 - (iii) The KLT scheme based on the covariance matrix \mathbf{C} is used to compress a different 40×40 grayscale image J. If it is observed that the reconstruction error of image J is large, discuss possible reason(s) for the large reconstruction error in image J.
2. (a) In an application, a user would like to compress a raw video using the MPEG-2 standard. The compressed MPEG-2 video has a Group-of-Picture (GOP) structure of IBBPBBPBB, and a frame rate of 30 frames per second (fps). The average compression ratios for the I-frames, P-frames, and B-frames of this video are assumed to be 10:1, 20:1, and n :1, respectively, where n is a positive real number. The video is to be displayed using the following format:

Resolution of the luminance plane: 720×480 pixels

Color depth of every pixel in each luminance and chrominance plane: 8 bits/pixel

Chroma subsampling format: 4:2:0

Given that the target average bitrate of the compressed video is to be less than 3.3×10^6 bits/s.

- (i) Find the minimum value n that can satisfy the bitrate requirement.
 - (ii) Discuss whether the target bitrate of 3.3×10^6 bits/s is reasonable for the given video settings.
- (b) A data sequence 10111011 (most significant bit on the left) is to be coded and transmitted using Cyclic Redundancy Check (CRC) with the generator polynomial $x^3 + 1$.
- (i) Determine the transmitted codeword.
 - (ii) Discuss the capability and effectiveness of this CRC scheme to perform error correction.
3. A student would like to develop a video compression algorithm for transmission over communications networks.
- (a) The student proposes to compress a video by performing baseline JPEG compression on each frame of the video. Discuss the pros and cons of the proposed method, and comment whether the proposal is a good idea in performing video compression for this application.
 - (b) The student would like to transmit videos over noisy communication channels. Suggest some suitable strategies to achieve the goal.
4. Video conferencing has become increasingly important during the Covid-19 pandemic situation. In this question, you will propose a video conferencing solution using current or emerging technologies to transmit videos over communications networks. Your proposed solution may include system requirements, video compression technology to be used, and any other relevant issues. Please keep your answer to a maximum of two A4 pages. The answer should be concise, organized and preferably in point form. Note that this is an open-ended question, and you can choose any solution and discuss any issues that you feel is relevant. However, you need to explain and justify the proposed solution clearly. You should not copy or plagiarize answers directly from some sources, but rather research, understand, and explain in your own words.