Lab 4 - Image Processing EEE412

Image compression

Report is due **14 days** from the date of running this lab

Objectives:

1- To familiarize with the concepts of image compression.
2- To develop some basic image compression tools.

Download:

Download "`Lenna512.bmp`", and load them into your Matlab workspace **.**

Matlab functions:

The following are some built-in *Matlab* functions that might be used in this session:

```
DCT2, IDCT2
```

Hint: read the help about each of the previous functions and any other function you might use. Some Matlab functions have a section describing the *Algorithm(s)* they use; it is worth reading this section.

Flexibility in a design[1]

"The flexibility in a design is important, in fact it provides the design with room to grow, to cater for requirement changes during development and for additional requirements that the users will want in the future. Putting the right amount of flexibility into a design is an important part of the act of designing: it requires human creativity.

During the design process, the designer has to make choices about the construction he/she is creating and about the building blocks he will be using. The choice of these building blocks determine part of the flexibility that will be exhibited by the final product. As an example, if I order a wall, the supplier can deliver a concrete wall or a brick wall. Both walls fit the requirements, yet if I change my mind later on, e.g., because I want windows in my wall, adding

[1] The "Flexibility in a design" section is from "On the Flexibility of Programming Languages" by Pieter J. Schoenmakers

windows to the brick wall will be easier than to the concrete one. The bricks offer more flexibility than the concrete. As another example, if a problem needs to be solved by writing a Matlab program, some code needs to be written as the solution. The code is designed by the programmer, and the flexibility of the solution is determined by its design. If the code is packed into a single function, the code can only be applied to solve that particular problem. If the solution is split in several sub-solutions to sub-problems, and the code split in various functions, each of which solves a sub-problem, those functions may later be applied to solve the same sub-problem in other bigger problems. But differently, while the design of the solution is not different, making the sub-solutions accessible makes them usable for solving other problems. Multiple functions exhibit more flexibility than a single function."

Tasks:

1. Finish the following tasks:

(1) Write a function to calculate the entropy of an image. (**10'**)

(2) Use the above function in task (1) to calculate the entropy of the following images:

   (a) The original image "lenna512.bmp"; (**2'**)

   (b) Reduce the "lenna512.bmp" to the half size (both horizontally and vertically) by the down-sampling of using mean value; (**3'**)

   (c) Reduce the gray level of "lenna512.bmp" to 16 values by quantization with the base 16. (**3'**)

   (d) Compare the above three entropy values, what can you find? And explain your finding. (**8'**)

(3) Predictive coding:

(a) Write a function of Raster-scan DPCM (differential pulse code modulation) coding for the input image. Here, the predictive function is the weighted average value of the neighboring pixels (left, left-top, and top): p(r,c) = (2*x(r,c-1)+x(r-1,c-1)+2*x(r-1,c))/5, and the difference is presented by e(r,c) = x(r,c) – p(r,c). The padding is suggested to use the same value as its neighbor. (**10'**)

(b) Use the "lenna512.bmp" as input for the function (3.a) and show the output of difference *e*. (**2'**)

(c) Calculate the entropy of the output image of task (3.b). (**2'**)

(d) Compare the original image "lenna512.bmp" and the DPCM output image from the view of entropy, which image is easier to be compressed? And Why? (**10**')

2. Image DCT and quantization (**50'**)

   a) Write a function to do the two-dimensional DCT of all the 8 X 8 non-overlapping blocks of the image ***im***, and merge the left-top pixel of all blocks after the DCT transformation to get a smaller image ***ims.*** Using the image `Lenna512.bmp` as input image, please show the image ***ims*** here, and what can you find on comparing it with the original input image and explain your finding (**15**')

b) To convert the floating point numbers of the 2D-DCT into integer numbers, write a function to quantize each 8 X 8 block using the following formula: $round\left(\frac{b_{ij}}{Sq_{ij}}\right)$, where b_{ij} is the i[th] row and j[th] column of the 8 X 8 2D-DCT transformed block, whereas, q_{ij} is the element of the quantization matrix $\boldsymbol{Q_{mat}}$ (equation (1)). And S is a scalar value given by equation (2). (**10**')

c) Write a function to decompress image ***imo***, which should invert the above two steps. (**15**')

d) Using the image `Lenna512.bmp` as input image ***im*** in the above functions, fill the following table with different QP values in the equation (2) for the PSNR between the original input image ***im*** and the decompressed image ***imo***. Please give the comments on this table. (**10**')

QP	**1**	**15**	**29**	**43**	**…**	**…**	**99**
PSNR [dB]							

Please note that you can directly use the Matlab functions of DCT2 and IDCT2 in the above functions.

$$\text{Qmat} = \begin{bmatrix} 16 & 11 & 10 & 16 & 24 & 40 & 51 & 61 \\ 12 & 12 & 14 & 19 & 26 & 58 & 60 & 55 \\ 14 & 13 & 16 & 24 & 40 & 57 & 69 & 56 \\ 14 & 17 & 22 & 29 & 51 & 87 & 80 & 62 \\ 18 & 22 & 37 & 56 & 68 & 109 & 103 & 77 \\ 24 & 35 & 55 & 64 & 81 & 104 & 113 & 92 \\ 49 & 64 & 78 & 87 & 103 & 121 & 120 & 101 \\ 72 & 92 & 95 & 98 & 112 & 100 & 103 & 99 \end{bmatrix} \quad (1)$$

$$S = \frac{100 - QP}{50}, QP > 50$$
$$S = \frac{50}{QP}, QP \le 50 \quad (2)$$

Lab Report

Write a **short** report which should contain a **concise description** of your results and observations. **Include** listings of the **Matlab scripts** that you have written. **Describe each of the images** that you were asked to display.

Submit the report electronically and a hardcopy version into the collecting box beside the office EB310 (Hand written reports are not accepted).

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