Digital Video Technology

Homework #2 – 2D-DCT

2015/10/06

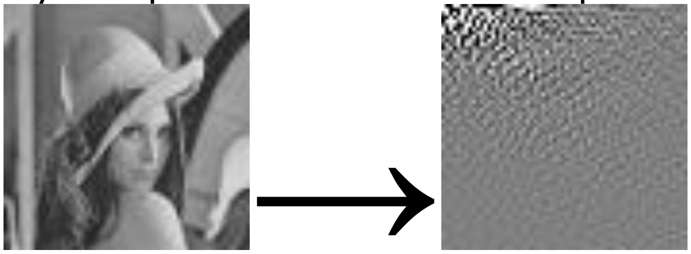
Write a 2D-DCT program and test it with the given 10 gray level images (lena64, pepper64, baboon64, gra1, gra2, wildcard, triangle, circle1, circle2, circle3)

Whole frame DCT

Use direct 2D and fast algorithm (two 1D DCT) to implement 2D DCT/IDCT, and verify your results with data generated by these two algorithms. Compare and explain their PSNR and evaluation time.

1. List the DCT coefficients of all images. The results need to be presented with images with pixel values as DCT coefficients added by 128. After that, remember to saturate the results between 0 and 255.

Note: Although the range of DCT output (block size: 64x64) is between -2^{15} and 2^{15}, just saturate it between 0 and 255, do NOT do scaling.
Try to explain the results. An example is shown below:



2. Apply IDCT to reconstruct the original images from the DCT coefficients, which are presented with floating-point numbers. Are they the same as the original images?

3. Use only 16 bits to present the DC value and use 8 bits to present the AC values. Calculate the bits required to present the image, and reconstruct the original images with the quantized coefficients.

Note:

- Just preserve to integer part. For example, if DC value is 184534.3421, you only need to preserve 184534.
- Next, 16-bits representation means you need to preserve this value with top 15 bits (because 1 bit for sign). Decide how many bits need to be truncated.

  $184534_{10} = \underline{101101000011010}110_{2}$.
- The number that underlined digits represent is the truncation result, which is 23066_{10}.
- When you need to reconstruct the original images with the quantized coefficients, be sure to shift 101101000011010 back to $101101000011010\underline{000}_{2}$.
- The 8-bits representation of AC is similar to the case of DC. But all AC should be truncated with the same bits. That means you have to find the biggest one of AC coefficients, decide how many bits need to be truncated, and apply to all other AC coefficients.
- The number of truncated bits of DC and AC needn't to be the same.
- Record the number of truncated bits of DC and AC in your report.

4. When the AC values of (3) (after truncation) is in the range -7 ~ 7, set them as 0 and use 0 bit to present those coefficients. Calculate the bits required to present the image and reconstruct the original images with the quantized coefficients.

Block-based DCT

5. (Bonus) Use fast algorithm to implement block-based (8x8) DCT/IDCT. Use the requirement stated in (1) & (2) to show the results.

Requirements:

1. Deadline: 2015/10/19 11:59 PM
   -10 points / day

2. All the files need to be compressed as a single ZIP or RAR file.
   Send this file to TA via FTP:
   Address: 140.112.175.53 Port: 6250
   Account (password):
   The same as the one used in the course website.
   Examples of filename:
   DVT_HW2_R04901001.zip
   DVT_HW2_R04901001_Ver2.zip

✧ If you have problem uploading your file, please try NTU VPN.

3. Required files
   a. Report, in PDF format
      (With pictures, you can use downscaled images in report)
   b. Source code (C/C++)
      Do NOT send entire project to TA!!
      All TA needs are related .cpp/.c
   c. Executable file (*.exe)/Makefile
   d. Text document (*.txt), to describe how to execute your program. Also indicate your output file names.
   e. DCT coefficient images of 1. (named as dct1_lena64.raw, dct1_pepper64.raw, dct1_baboon64.raw, …).
   f. Reconstructed images of 2. (named as r2_lena64.raw, r2_pepper64.raw, r2_baboon64.raw, …).
   g. Reconstructed images of 3. (named as r3_lena64.raw, r3_pepper64.raw, r3_baboon64.raw, …).
   h. Reconstructed images of 4. (named as r4_lena64.raw, r4_pepper64.raw, r4_baboon64.raw, …).
   i. DCT coefficient & reconstructed images of 5. (named as dct5_lena64.raw, r5_lena64.raw, dct5_pepper64.raw, r5_pepper64.raw, …).

4. Any further questions, please email to TA
   (郭品宏, setsunil@media.ee.ntu.edu.tw)

Two-dimensional DCT & IDCT:

$$F(u,v) = \frac{2}{N} C(u)C(v) \sum_{x=0}^{N-1} \sum_{y=0}^{N-1} f(x,y) cos \frac{(2x+1)u\pi}{2N} cos \frac{(2y+1)v\pi}{2N}$$

$$f(x,y) = \frac{2}{N} \sum_{u=0}^{N-1} \sum_{v=0}^{N-1} C(u)C(v)F(u,v) cos \frac{(2x+1)u\pi}{2N} cos \frac{(2y+1)v\pi}{2N}$$

$$\text{Where } \ C(u),C(v) = \begin{cases} \frac{1}{\sqrt{2}} & \text{for } u,v = 0 \\ 1 & \text{otherwise} \end{cases}$$

$$0 \le x,y,u,v \le N-1, \ \ N^2: frame\ size$$

One-dimensional DCT & IDCT:

$$F(u) = \sqrt{\frac{2}{N}} C(u) \sum_{x=0}^{N-1} f(x) cos \frac{(2x+1)u\pi}{2N}$$

$$f(x) = \sqrt{\frac{2}{N}} \sum_{u=0}^{N-1} C(u)F(u) cos \frac{(2x+1)u\pi}{2N}$$

$$\text{Where } \ C(u) = \begin{cases} \frac{1}{\sqrt{2}} & \text{for } u = 0 \\ 1 & \text{otherwise} \end{cases}$$

$$0 \le x,u \le N-1, \qquad N^2: frame\ size$$