Digital Image Processing

HW#2

2D Discrete Cosine Transform

Instructor : Chih-Wei Tang (唐之瑋)
TA : Yu-Ting Huang (黃郁婷)
Visual Communications Lab
Department of Communication Engineering
National Central University

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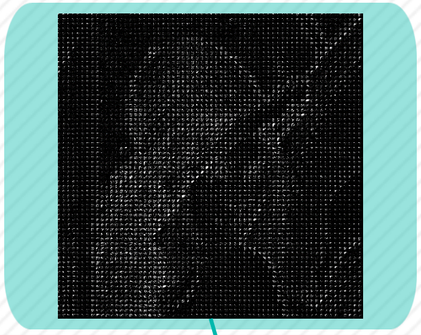
Outline

- Flow Chart
- Homework Details
  - 2D Discrete Cosine Transform
  - JPEG Format
  - MASK
  - Peak Signal to Noise Ratio(PSNR)
- Grading
- Due Date & Demo Schedule
- Note
- Reference

Flow Chart (1/2)



HW 2-1-1

512 pixels

512 pixels

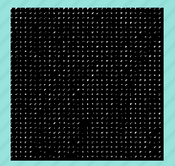
Shift -128 → 8 X 8 2-D DCT → Quantization → Inverse Quantization → 8 X 8 2-D IDCT → Shift +128 → HW 2-1-2

Downsample → Shift -128 → 8 X 8 2-D DCT → Filtering Mask → 8 X 8 2-D IDCT → Shift +128 → HW 2-2-3

256 pixels

256 pixels

HW 2-2-1



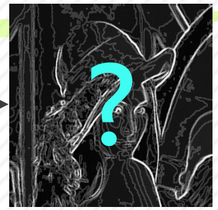
HW 2-2-2

Flow Chart (2/2)

Original image

HW 2-1-3

HW 2-1-2



PSNR=?

HW 2-2-3

PSNR=?

HW 2-2-4

HW 2-2-1

2D Discrete Cosine Transform

- DCT is a Fourier-related transform similar to the discrete Fourier transform (DFT), but using only real numbers.

The 8x8 DCT

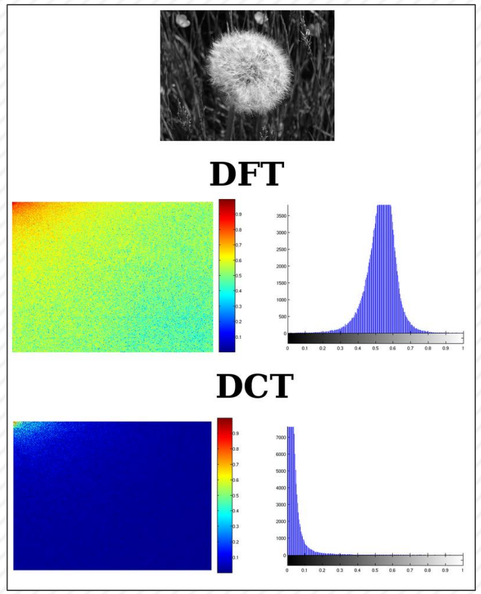
$$F(u,v) = \frac{1}{4}C(u)C(v)[\sum_{x=0}^{7}\sum_{y=0}^{7} f(x,y) * cos\frac{(2x+1)u\pi}{16} cos\frac{(2y+1)v\pi}{16}]$$

The 8x8 IDCT

$$f(x,y) = \frac{1}{4}\sum_{u=0}^{7}\sum_{v=0}^{7}[C(u)C(v)F(u,v) * cos\frac{(2x+1)u\pi}{16} cos\frac{(2y+1)v\pi}{16}]$$

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

$f(x,y)$: spatail domain image
$F(u,v)$: frequency domain image
(x,y): index of spatail domain
(u,v): index of frequency domain



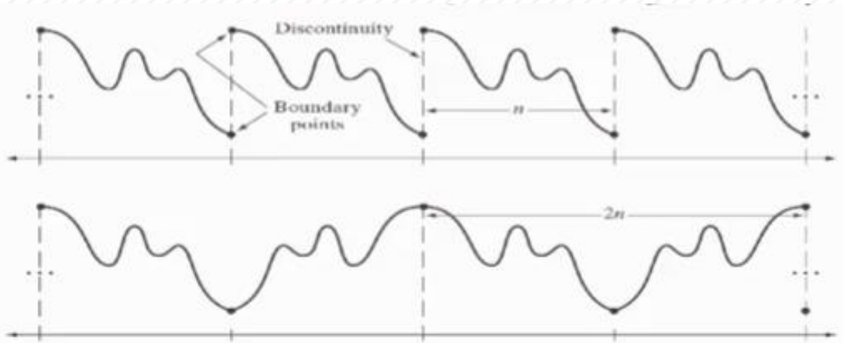


Image Source: Digital Image Processing, 3rd ed.

Image Source: https://zh.wikipedia.org/wiki/%E7%A6%BB%E6%95%A3%E4%BD%99%E5%BC%A6%E5%8F%98%E6%8D%A2

[1] G. K. Wallace, "The JPEG still picture compression standard." Communications of the ACM 34.4 (1991): 30-44.

JPEG Format (1/2)

An Example of JPEG (1/2)

52	55	61	66	70	61	64	73
63	59	66	90	109	85	69	72
62	59	68	113	144	104	66	73
63	58	71	122	154	106	70	69
67	61	68	104	126	88	68	70
79	65	60	70	77	68	58	75
85	71	64	59	55	61	65	83
87	79	69	68	65	76	78	94

Level shifting (-128)

−76	−73	−67	−62	−58	−67	−64	−55
−65	−69	−62	−38	−19	−43	−59	−56
−66	−69	−60	−15	16	−24	−62	−55
−65	−70	−57	−6	26	−22	−58	−59
−61	−67	−60	−24	−2	−40	−60	−58
−49	−63	−68	−58	−51	−65	−70	−53
−43	−57	−64	−69	−73	−67	−63	−45
−41	−49	−59	−60	−63	−52	−50	−34

http://140.115.154.40/vclab/advisor/2018DIP/8%20Image%20Compression.pdf

JPEG Format (2/2)

An Example of JPEG (2/2)

−415	−29	−62	25	55	−20	−1	3
7	−21	−62	9	11	−7	−6	6
−46	8	77	−25	−30	10	7	−5
−50	13	35	−15	−9	6	0	3
11	−8	−13	−2	−1	1	−4	1
−10	1	3	−3	−1	0	2	−1
−4	−1	2	−1	2	−3	1	−2
−1	−1	−1	−2	−1	−1	0	−1

DCT Coefficients

round[-415/16]

Quantization

−26	−3	−6	2	2	0	0	0
1	−2	−4	0	0	0	0	0
−3	1	5	−1	−1	0	0	0
−4	1	2	−1	0	0	0	0
1	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0

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

Quantization Matrix

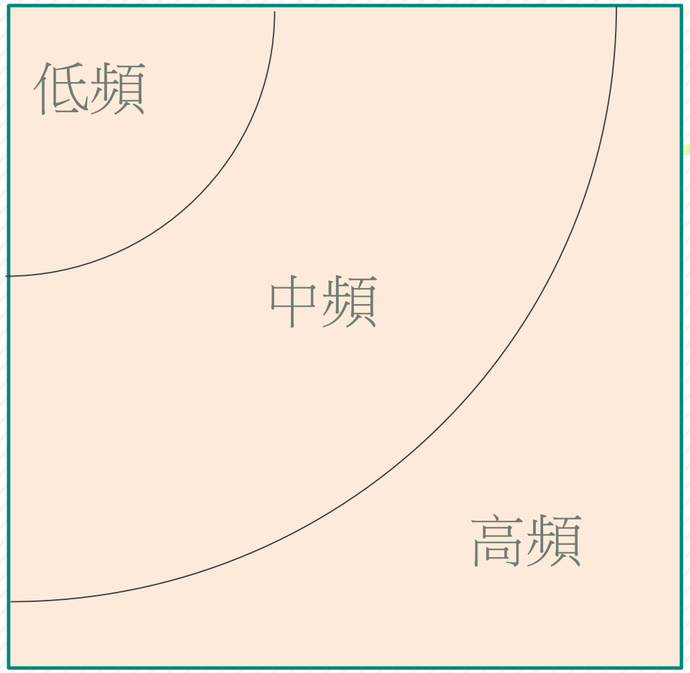
http://140.115.154.40/vclab/advisor/2018DIP/8%20Image%20Compression.pdf

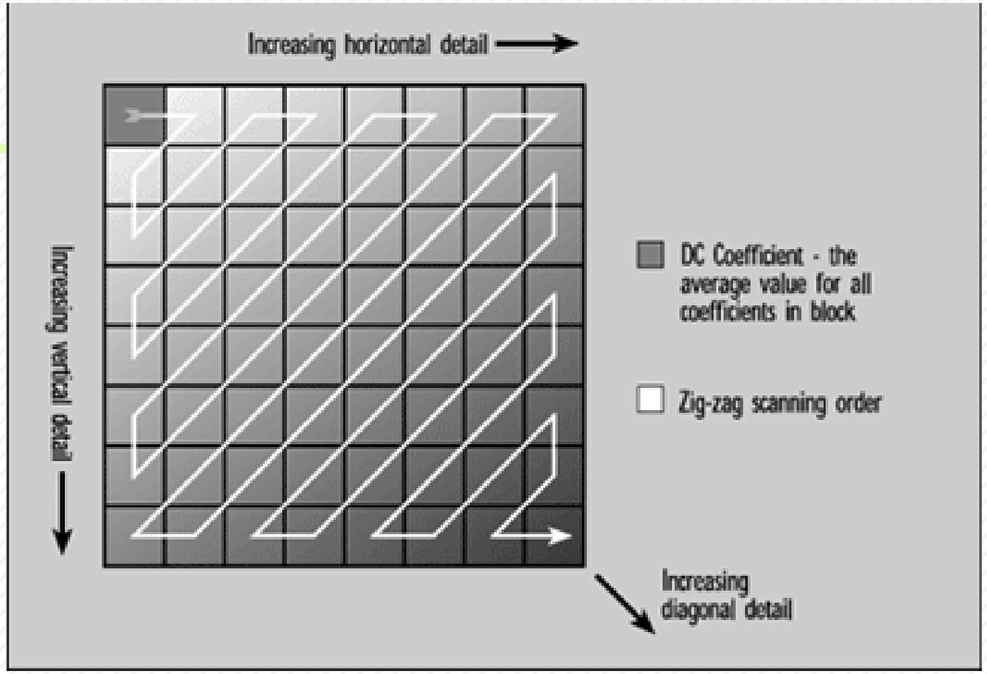
MASK

```
mask=[ 1 1 1 0 0 0 0 0
       1 1 0 0 0 0 0 0
       1 0 0 0 0 0 0 0
       0 0 0 0 0 0 0 0
       0 0 0 0 0 0 0 0
       0 0 0 0 0 0 0 0
       0 0 0 0 0 0 0 0
       0 0 0 0 0 0 0 0]
```

8

8





Ordering of DCT coefficients
Zigzag arrangement

http://www.thevideoguru.com/consulting/dtvbook/ch2f.shtml

Peak Signal to Noise Ratio(PSNR)

- PSNR = $10 * \log(\frac{255^2}{MSE})$
- MSE(Mean Square Error) = $\frac{\sum_{n=1}^{Image\ size}(I_n - P_n)^2}{Image\ Size}$

- I_n:The nth pixel value of the original image.
- P_n: The nth pixel value of the image processed by (IDCT).
- Image size: Image length * image width.

https://cg2010studio.com/2013/01/06/%E5%B3%B0%E5%80%BC%E4%BF%A1%E8%99%9F%E9%9B%9C%E8%A8%8A%E6%AF%94-peak-signal-to-noise-ratio/

Grading

- Demo Code(70%)
  - –HW2-1(JPEG 30%)
    - HW2-1-1 (15%)
    - HW2-1-2 (10%)
    - HW2-1-3 (5%)
  - –HW2-2(40%)
    - HW2-2-1 (5%)
    - HW2-2-2 (15%)
    - HW2-2-3 (15%)
    - HW2-2-3 (5%)

- Report (30%)
  - – Flow Chart (10%)
  - – Experiment Results (10%)
  - – Discussions (10%)

  Please discuss:
  To observe the experiment result when using different image after IDCT .(PSNR)

- Using the C/C++ only. Matlab or OpenCV is not allowed.

Due Date & Demo Schedule

Demo Date：Monday Nov.12 or Tuesday Nov.13
Demo time：13:30 ~ 17:30.

- The domo schedule will be announced at the TA webpage.
- You should send your project and report to LMS before Nov.12, 13:00.
- No delay. (If you have special case, please send email tell us early.)
- You will get a zero when you delay or fail to operation in demo(code and demo part),but you can still get points in report part.

Note

The details will be announced on our course website.
(http://140.115.154.40/vclab/html/course/DIP2018.html)

- Do it yourself.
- The TA will use another image to test your code.
- If you have a notebook, please bring your own notebook. Otherwise, some people may not be able to execute the code during the demo.
- Cannot use 『Remote Connection』.

Reference

- Gonzalez, Rafael C., and Richard E. Woods, “Digital image processing,“ Prentice Hall, 2007.

- 8 bits Lena.bmp download ：
  https://www.ece.rice.edu/~wakin/images/

Any Questions?