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Ministry of Education

academic impact

HANDONG GLOBAL UNIVERSITY
WORLD CHANGING

Image Compression

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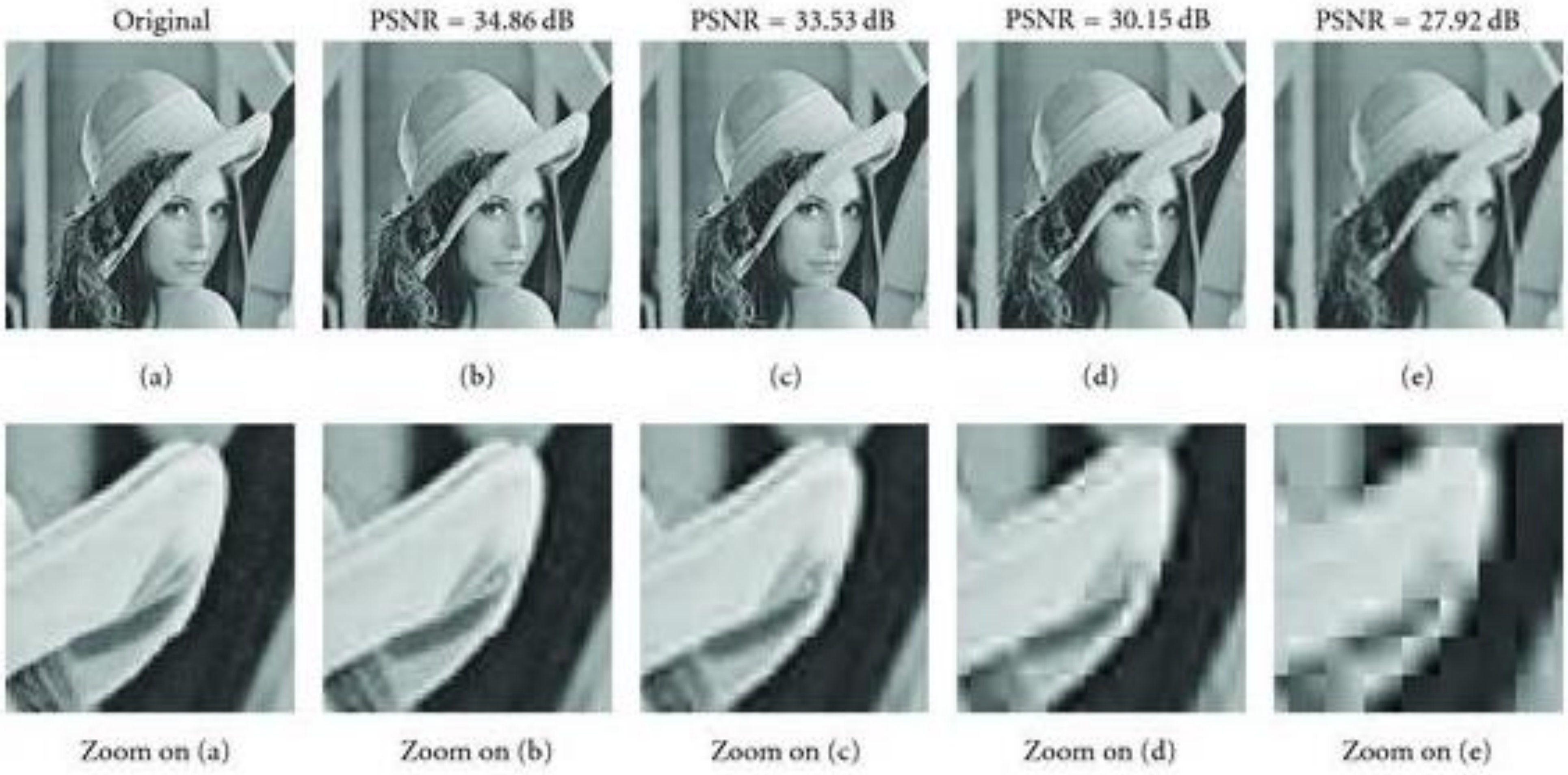
Introduction

- Data compression
  - Process of reducing the amount of data required to represent a given quantity of information
- During image compression, there may exist information loss
  - MSE
    - $e_{mse} = \frac{1}{MN}\sum_{x=0}^{M-1}\sum_{y=0}^{N-1}\left[\hat{f}(x,y) - f(x,y)\right]^2$
  - PSNR
    - $10 \cdot log_{10}\left(\frac{MAX^2{}_I}{MSE}\right) = 20 \cdot log_{10}\left(\frac{MAX_I}{\sqrt{MSE}}\right)$
      $= 20 \cdot log_{10}(MAX_I) - 10 \cdot log_{10}(MSE)$

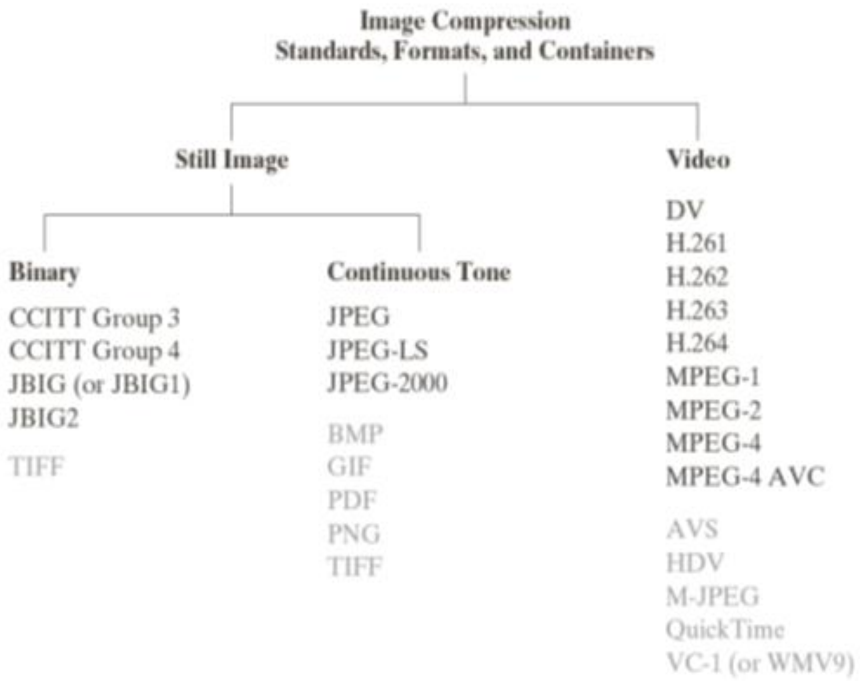
Introduction

- PSNR



Introduction

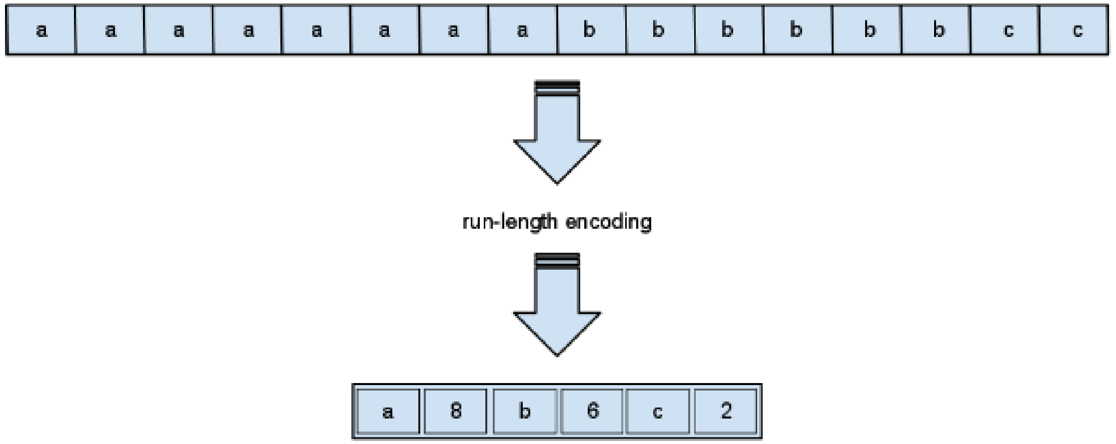
- Video codec
  - Codec is a portmanteau of coder/decoder
  - Compression codecs are classified primarily into lossy codecs and lossless codecs



종류	압축 기술	
Lossless compression	run length coding(반복 길이 코딩)	
	Huffman coding(허프만 코딩)	
	Lempel-Ziv coding(렘펠-지프 코딩)	
Lossy compression	transform coding(변환 코딩)	DCT, FFT
	predictive coding(예측 코딩)	PCM, ADPCM, DM, ADM
	quantization(양자화)	
	wavelet-based coding(웨이블릿 코딩)	
	interpolation(보간법)	
	fractal compression(프렉탈 압축)	
Hybrid	JPEG, GIF, MPEG, H.26x...	

Basic compression methods

- Run-length coding



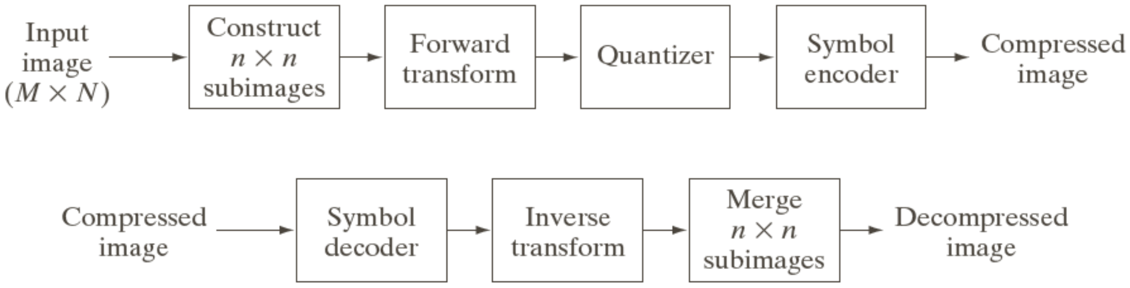
- Golomb coding

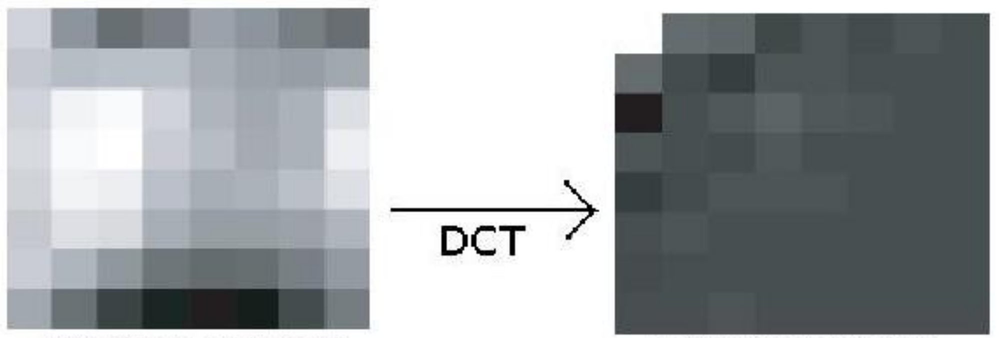
n	$G_1(n)$	$G_2(n)$	$G_4(n)$	$G^0_{\exp}(n)$
0	0	00	000	0
1	10	01	001	100
2	110	100	010	101
3	1110	101	011	11000
4	11110	1100	1000	11001
5	111110	1101	1001	11010
6	1111110	11100	1010	11011
7	11111110	11101	1011	1110000
8	111111110	111100	11000	1110001
9	1111111110	111101	11001	1110010

  - There should be lots of zeros

Basic compression methods

- Transform coding





PICTURE MATRIX

40	24	15	19	28	24	19	15
38	34	35	35	31	28	27	29
40	47	49	40	33	29	32	43
42	49	50	39	34	30	32	46
40	47	46	35	31	32	35	43
38	43	42	31	27	27	28	33
39	33	25	17	14	15	19	26
29	16	6	1	-4	0	7	18

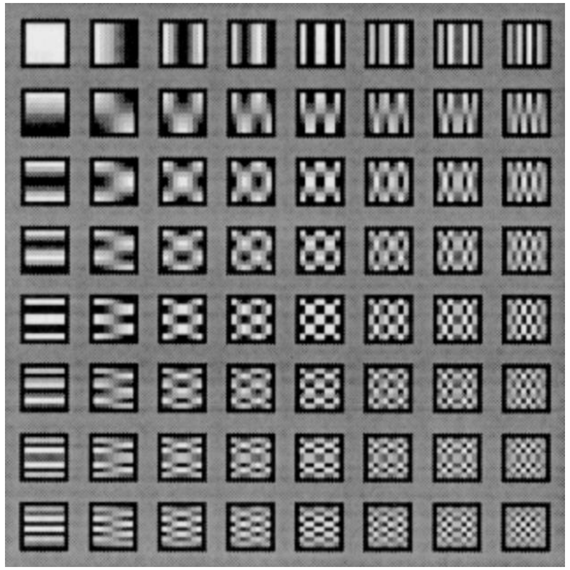
DCT COEFFICENTS

239	32	27	-12	3	-5	3	1
34	-3	-19	6	3	0	-1	1
-70	2	8	23	9	6	-1	-1
5	0	-6	11	-2	0	-1	1
-17	-3	6	6	3	-1	0	0
2	4	2	2	1	-2	0	1
-3	0	0	-1	-1	-1	0	0
1	-1	3	1	0	0	0	0

Basic compression methods

- DCT(Discrete Cosine Transformation)
  - DCT represents an image as a sum of sinusoids of varying magnitudes and frequencies.
  - DCT helps separate the image into parts of differing importance (with respect to the image's visual quality).
    - For example, the DCT is used in JPEG

Spatial Domain $\xrightarrow{\text{DCT}}$ Frequency Domain



DCT

- Distribution of coefficients in DCT

DC AC

1	2	6	7	15	16	28	29
3	5	8	14	17	27	30	43
4	9	13	18	26	31	42	44
10	12	19	25	32	41	45	54
11	20	24	33	40	46	53	55
21	23	34	39	47	52	56	61
22	35	38	48	51	57	60	62
36	37	49	50	58	59	63	64

AC AC

- DC coefficient
- Low-frequency
- Mid-frequency
- High-frequency

Quantization

- Quantization is the process of reducing the number of bits needed to store an integer value by reducing the precision of the integer.
  - Given a matrix of DCT coefficients, we can generally reduce the precision of the coefficients more and more as we move away from the DC coefficient.

$$Q_{50} = \begin{bmatrix} 16 & 11 & 10 & 16 & 24 & 40 & 51 & 61 \\ 12 & 12 & 14 & 19 & 26 & 58 & 60 & 55 \\ 14 & 13 & 16 & 24 & 40 & 57 & 69 & 56 \\ 14 & 17 & 22 & 29 & 51 & 87 & 80 & 62 \\ 18 & 22 & 37 & 56 & 68 & 109 & 103 & 77 \\ 24 & 35 & 55 & 64 & 81 & 104 & 113 & 92 \\ 49 & 64 & 78 & 87 & 103 & 121 & 120 & 101 \\ 72 & 92 & 95 & 98 & 112 & 100 & 103 & 99 \end{bmatrix}$$

Quantization

- Quantization Process
  - Quantized value (i, j) $\frac{DCT(i,j)}{Quantum(i,j)}$ rounded to nearest the integer.

3	5	7	9	11	13	15	17
5	7	9	11	13	15	17	19
7	9	11	13	15	17	19	21
9	11	13	15	17	19	21	23
11	13	15	17	19	21	23	25
13	15	17	19	21	23	25	27
15	17	19	21	23	25	27	29
17	19	21	23	25	27	29	31

A Sample Quantization Matrix

92	3	-9	-7	3	-1	0	2
-39	-58	12	17	-2	2	4	2
-84	62	1	-18	3	4	-5	5
-52	-36	-10	14	-10	4	-2	0
-86	-40	49	-7	17	-6	-2	5
-62	65	-12	-2	3	-8	-2	0
-17	14	-36	17	-11	3	3	-1
-54	32	-9	-9	22	0	1	3

DCT Matrix (Before Quantization)

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Quantization

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9	11	13	15	17	19	21	23
11	13	15	17	19	21	23	25
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13	15	17	19	21	23	25	27
15	17	19	21	23	25	27	29
17	19	21	23	25	27	29	31

A Sample Quantization Matrix

30	0	-1	0	0	0	0	0
-7	-8	1	1	0	0	0	0
-12	6	0	-1	0	0	0	0
-5	-3	0	0	0	0	0	0
-7	-3	3	0	0	0	0	0
-4	4	0	0	0	0	0	0
-1	0	-1	0	0	0	0	0
-3	1	0	0	0	0	0	0

DCT Matrix (After Quantization)

Quantization

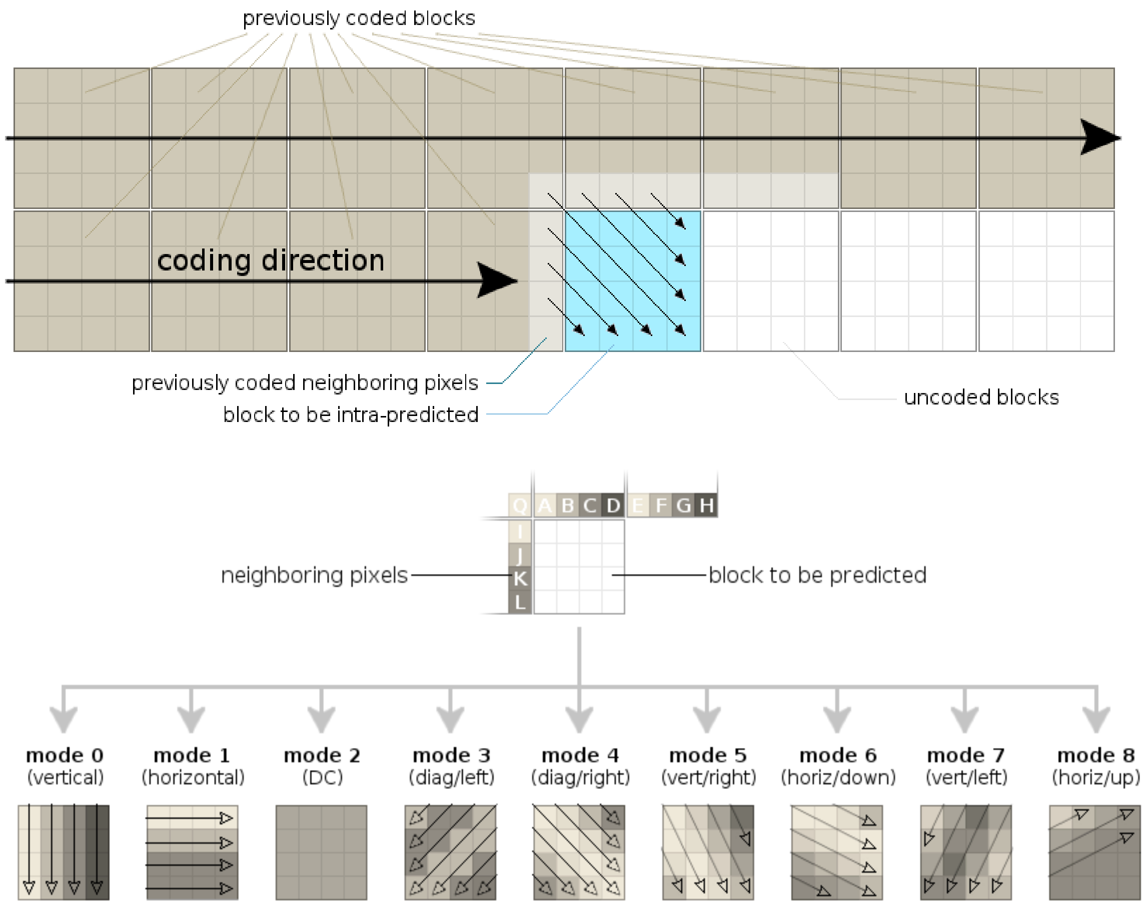
- Quantization Process
  - The low-frequency elements near the DC coefficient have been modified, but only by small amounts.
  - The high-frequency areas of the matrix have, for the most part, been reduced to zero.
  - In this sense, insignificant data has been discarded and the image information has been compressed.

30	0	-1	0	0	0	0	0
-7	-8	1	1	0	0	0	0
-12	6	0	-1	0	0	0	0
-5	-3	0	0	0	0	0	0
-7	-3	3	0	0	0	0	0
-4	4	0	0	0	0	0	0
-1	0	-1	0	0	0	0	0
-3	1	0	0	0	0	0	0

DCT Matrix (After Quantization)

Basic compression methods

- Intra prediction

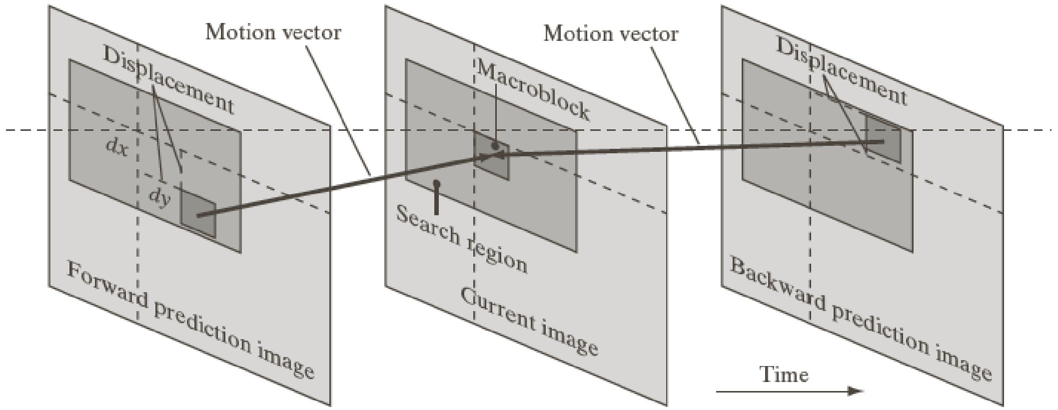


AVC/H.264 intra prediction modes

https://xiph.org/~xiphmont/demo/daala/demo2.shtml

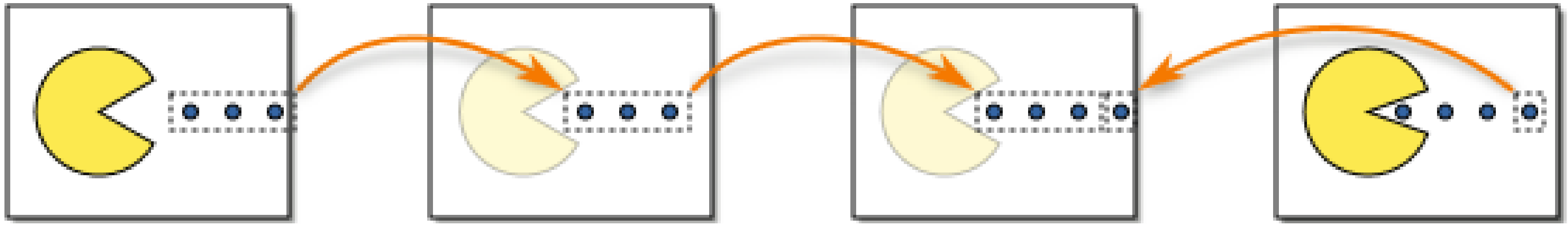
Basic compression methods

- Inter prediction(motion compensation)



  - Currently, Block Matching Algorithm is used for motion estimation
  - It is not exactly the motion!

- Forward/Backward prediction



forward

backward