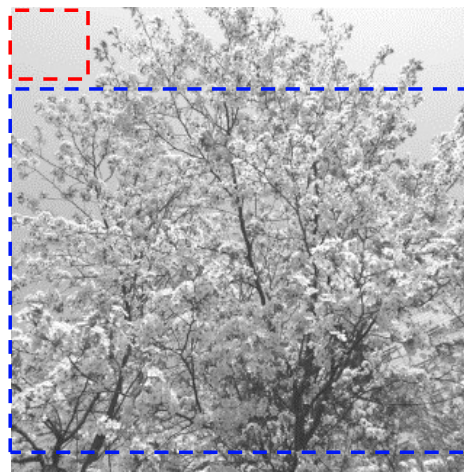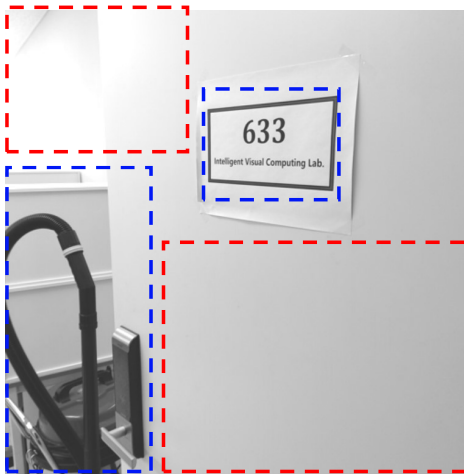# Spatial Correlation

이진영

Spatial Correlation

- Similarity of neighboring pixels

- Low correlation in object boundaries, but high correlation in background regions
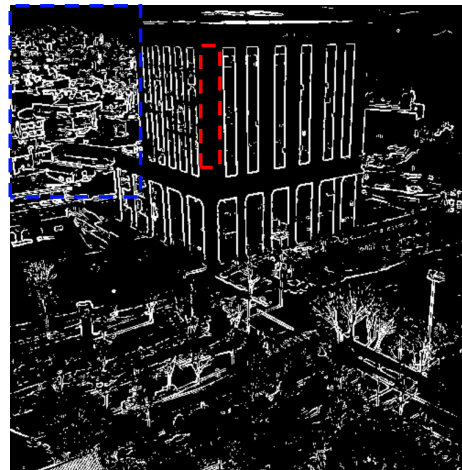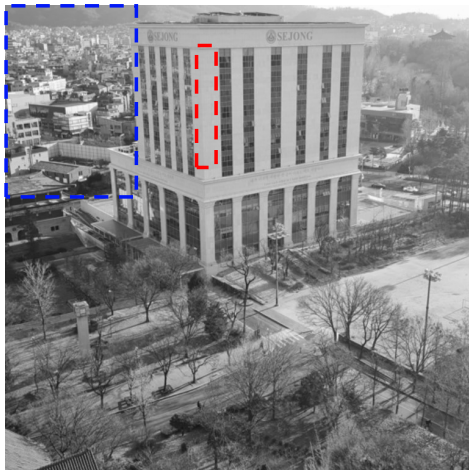

High Correlation

Low Correlation

Measurement

▪ Low correlation in regions with edges, high difference between adjacent pixels, high variance, …

▪ High correlation in regions with no edge, low difference between adjacent pixels, low variance, …
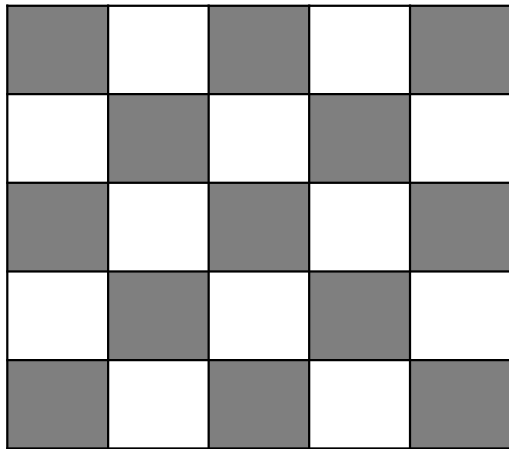

Edge Map

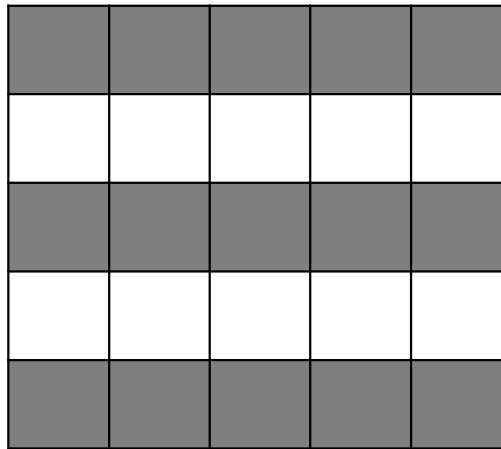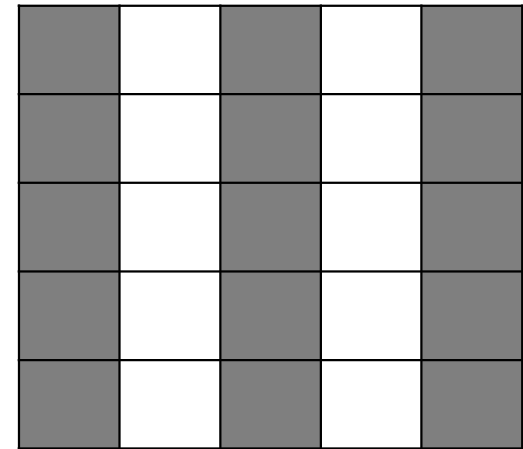$$var = \frac{\sum_{i=1}^{n}(x_i - \mu)^2}{n}$$

Correlation Direction

▪ Sometimes, horizontally or vertically high correlation depending on characteristics of an image

▪ Based on the correlation analysis, different compression, restoration, ... , upsampling strategies

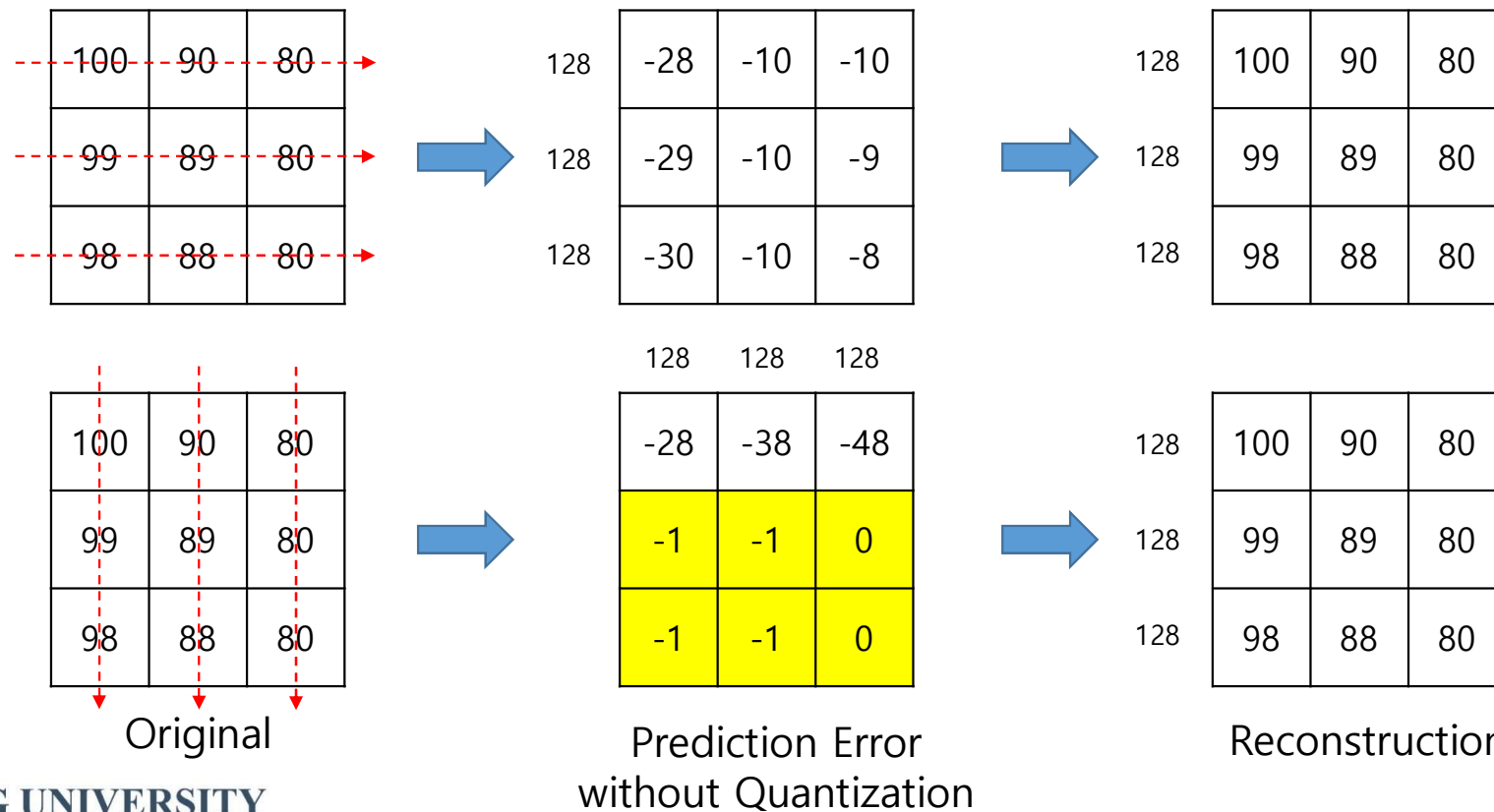Low Correlation   Horizontally High Correlation   Vertically High Correlation
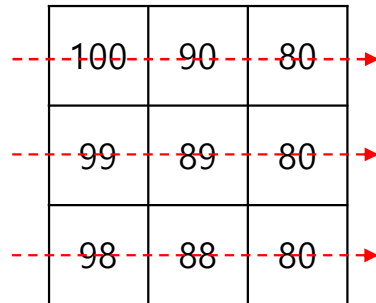
Spatial Prediction

- Prediction based on correlation direction, for example, horizontal or vertical direction

100	90	80
99	89	80
98	88	80

128	-28	-10	-10
128	-29	-10	-9
128	-30	-10	-8

128	100	90	80
128	99	89	80
128	98	88	80

100	90	80
99	89	80
98	88	80

Original

128	128	128
-28	-38	-48
-1	-1	0
-1	-1	0

**Prediction Error
without Quantization**

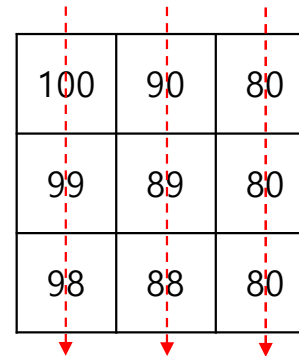| 128	100	90	80
128	99	89	80
128	98	88	80

Reconstruction

Prediction Information

- Transmission of prediction error and direction information in an encoder

- Reconstruction based on the prediction direction in a decoder

- Explicit signaling of the prediction direction, for example, 0 for horizontal prediction and 1 for vertical prediction

Example of Horizontal Prediction

First

Original			Prediction Error			Quantization ($e \div 5$)			Inverse Quantization ($e \times 5$)			Reconstruction		
100	90	80	-28			-5			-25			103		
99	89	80	-29			-5			-25			103		
98	88	80	-30			-6			-30			98		

Final

Original			Prediction Error			Quantization ($e \div 5$)			Inverse Quantization ($e \times 5$)			Reconstruction		
100	90	80	-28	-13	-13	-5	-2	-2	-25	-10	-10	103	93	83
99	89	80	-29	-14	-13	-5	-2	-2	-25	-10	-10	103	93	83
98	88	80	-30	-10	-8	-6	-2	-1	-30	-10	-5	98	88	83

Encoder

Decoder

SEJONG UNIVERSITY

Example of Vertical Prediction

First

100	90	80
99	89	80
98	88	80

-28	-38	-48

-5	-7	-9

-25	-35	-45

103	93	83

Final

100	90	80
99	89	80
98	88	80

-28	-38	-48
-4	-4	-3
-5	-5	-3

-5	-7	-9
0	0	0
-1	-1	0

-25	-35	-45
0	0	0
-5	-5	0

103	93	83
103	93	83
98	88	83

Original   Prediction Error   Quantization ($e \div 5$)   Inverse Quantization ($e \times 5$)   Reconstruction

Encoder

Decoder

Compression Result

- Please choose the best prediction in horizontal and vertical prediction methods

100	90	80
99	89	80
98	88	80

Original

-5	-2	-2
-5	-2	-2
-6	-2	-1

Quantization
($e \div 5$)

103	93	83
103	93	83
98	88	83

Reconstruction
(38.81dB)

Horizontal Prediction

-5	-7	-9
0	0	0
-1	-1	0

Quantization
($e \div 5$)

| 103	93	83
103	93	83
98	88	83

Reconstruction
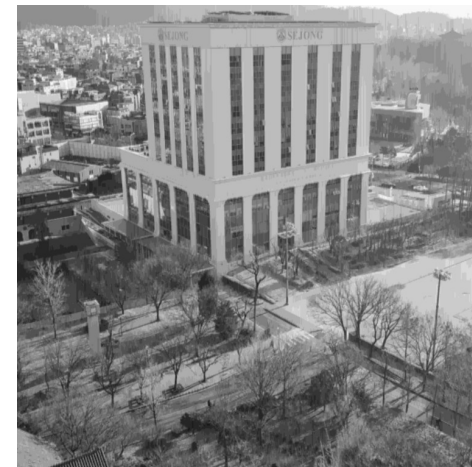(38.81dB)

Vertical Prediction

Experiment

- DPCM-based compression using horizontal and vertical predictions

- $e \div q$ for quantization

- Generation of bitstream with fixed-length or unary code (bitstream.txt)

- Binarization for the quantized prediction error, for example, <-3(000), -3(001), -2(010), -1(011), 0(100), 1(101), 2(110), >2(111), and then Inverse binarization with 000(-4), 001(-3), 010(-2), 011(-1), 100(0), 101(1), 110(2), 111(3)
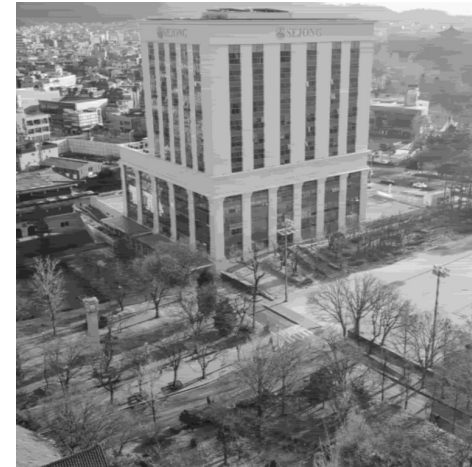
Horizontal Prediction

Vertical Prediction