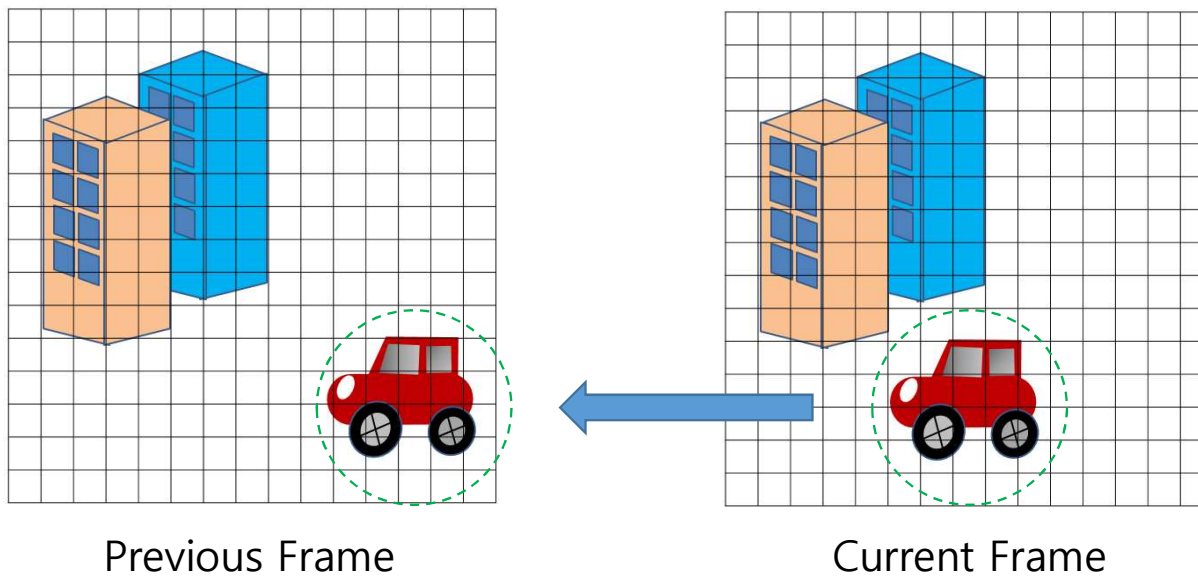# Temporal Correlation

이진영

Temporal Correlation

- Similarity of neighboring frames

- Low correlation in fast motions, but high correlation in slow motions

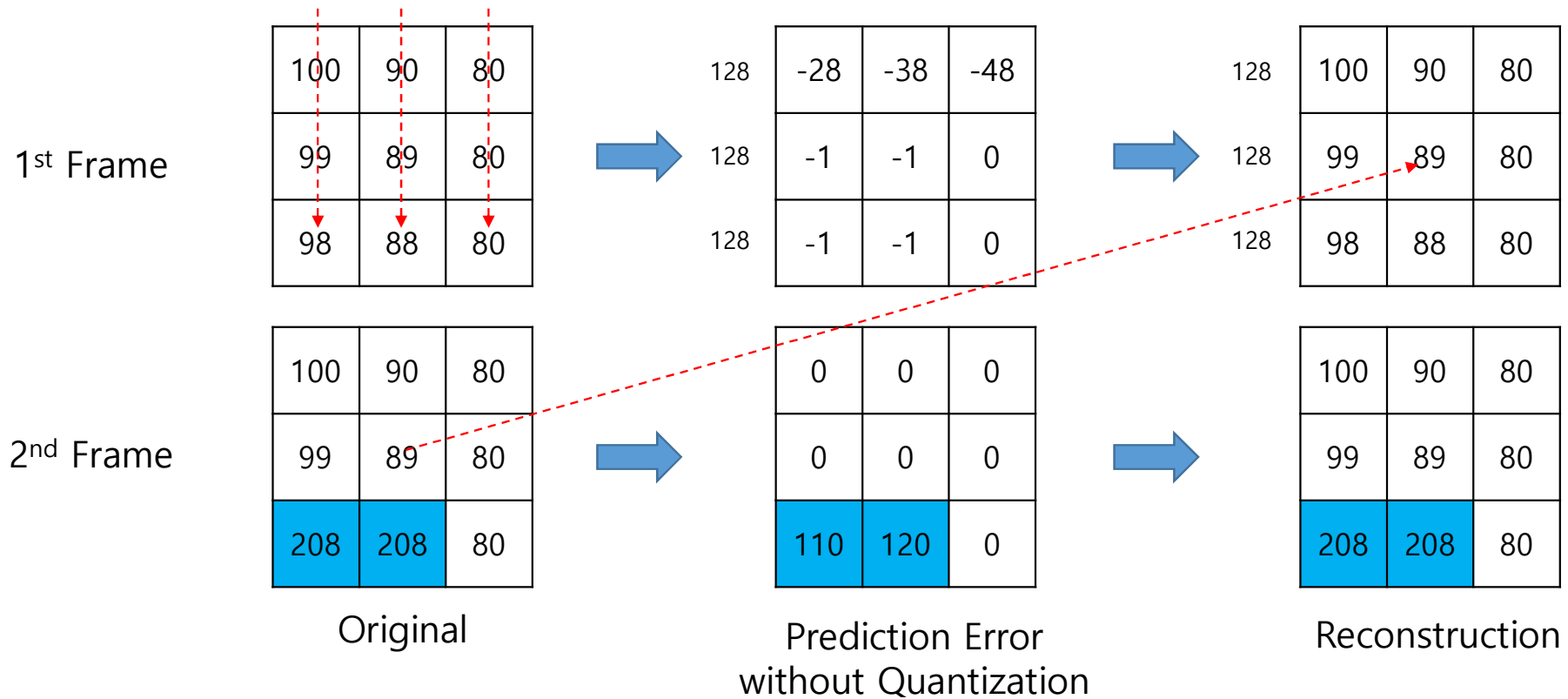Previous Frame   Current Frame

Correlation Direction

- Sometimes, spatially or temporally high correlation depending on characteristics of frames (images)

- Selection of the best prediction direction, based on the correlation analysis

High Temporal
Correlation

(Horizontally) High
Spatial Correlation

Previous Frame
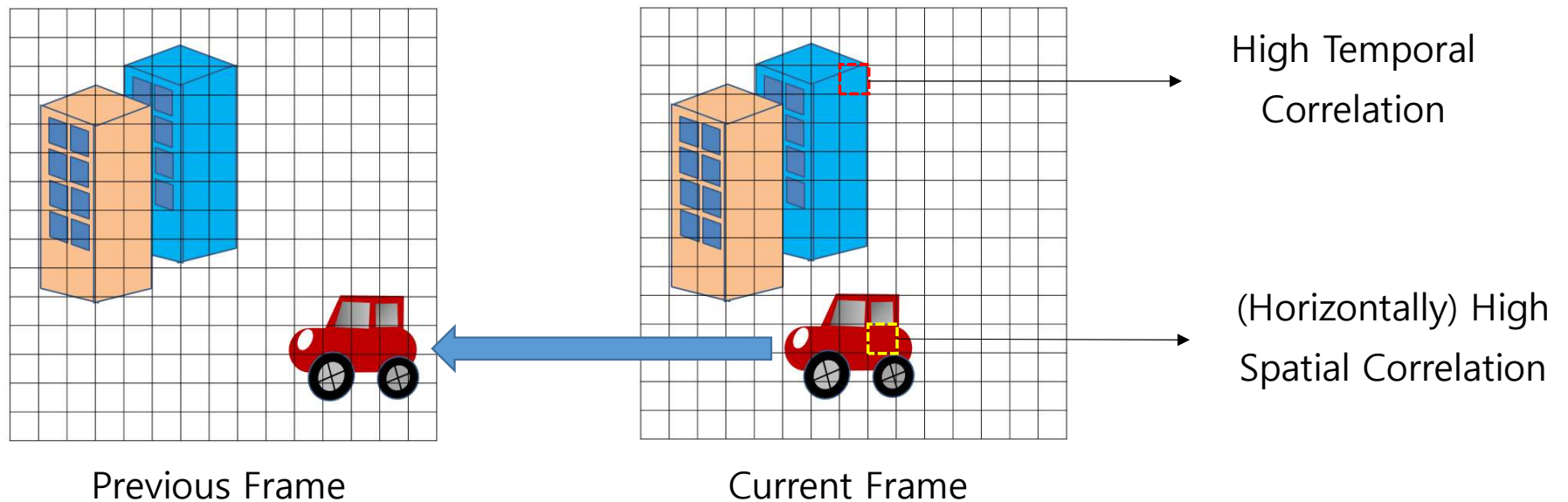
Current Frame

Temporal Prediction

- Prediction of a current frame from a previously reconstructed frame

1st Frame

100	90	80
99	89	80
98	88	80

➡️

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

➡️

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

2nd Frame

100	90	80
99	89	80
208	208	80

➡️

0	0	0
0	0	0
110	120	0

➡️

100	90	80
99	89	80
208	208	80

Original   Prediction Error without Quantization   Reconstruction

Various Predictions

- Selection of the best prediction method among various prediction candidates

- However, more bit, according to the number of prediction candidates

- For example, 0 or temporal prediction, 10 for horizontally spatial prediction, 11 for vertically spatial prediction (Depending on correlation analysis)
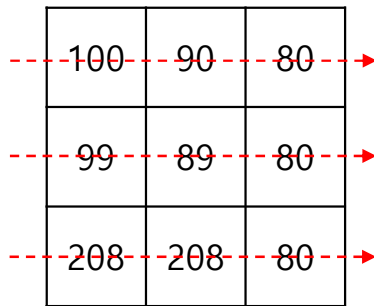
Example of Vertical Prediction (1st Frame)

First

Original			Prediction Error			Quantization $(e \div 5)$			Inverse Quantization $(e \times 5)$			Reconstruction		
100	90	80	-28	-38	-48	-5	-7	-9	-25	-35	-45	103	93	83
99	89	80												
98	88	80												

Final

Original			Prediction Error			Quantization $(e \div 5)$			Inverse Quantization $(e \times 5)$			Reconstruction		
100	90	80	-28	-38	-48	-5	-7	-9	-25	-35	-45	103	93	83
99	89	80	-4	-4	-3	0	0	0	0	0	0	103	93	83
98	88	80	-5	-5	-3	-1	-1	0	-5	-5	0	98	88	83

Encoder

Decoder
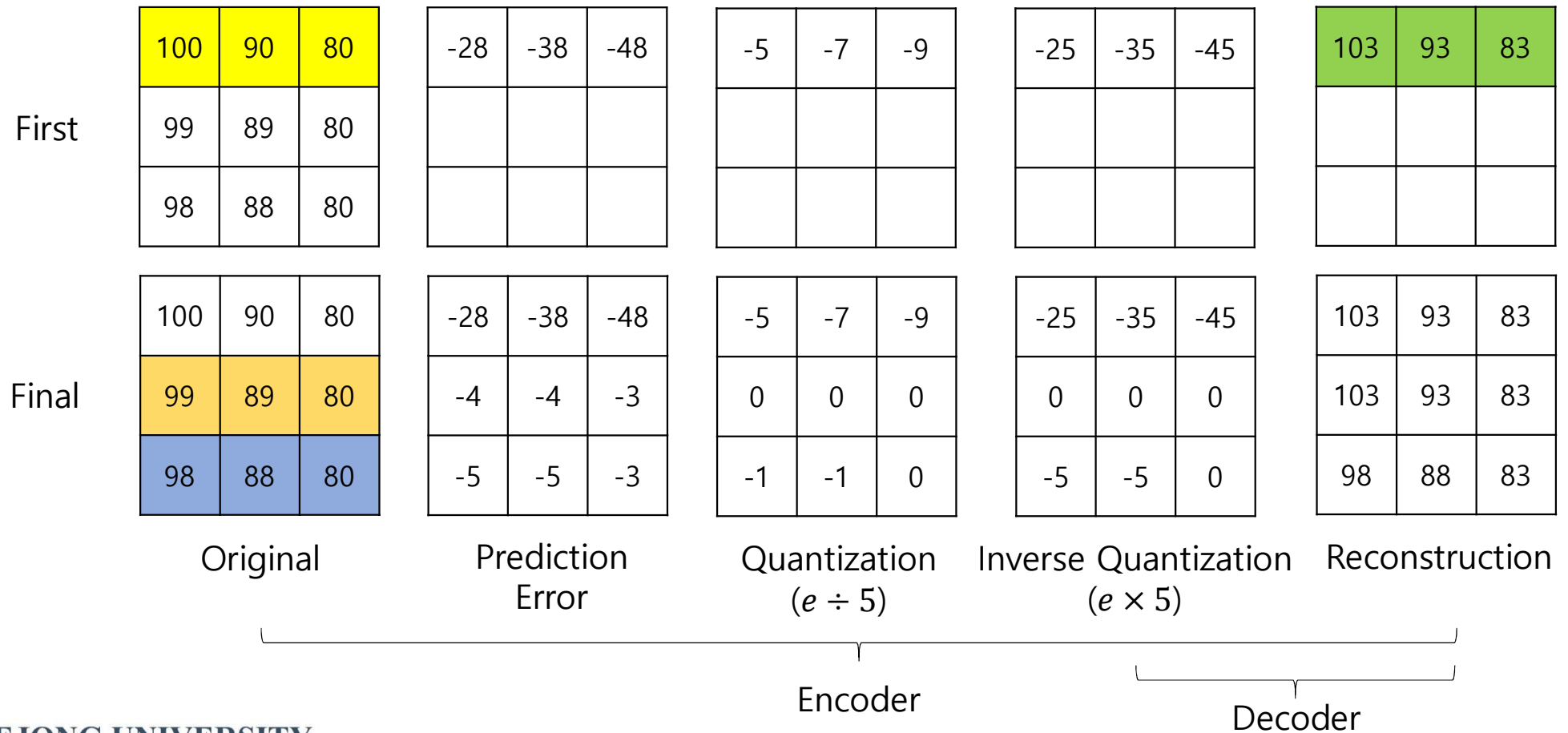
Example of Temporal Prediction (2nd Frame)

①
103	93	83
103	93	83
98	88	83

Reconstruction
(1st Frame)

100	90	80
99	89	80
255	255	80

Original
(2nd Frame)

-3	-3	-3
-4	-4	-3
157	157	-3

Prediction
Error

0	0	0
0	0	0
31	31	0

Quantization
($e \div 5$)

0	0	0
0	0	0
155	155	0

Inverse Quantization
($e \times 5$)

②
103	93	83
103	93	83
253	243	83

Reconstruction

Encoder

Decoder
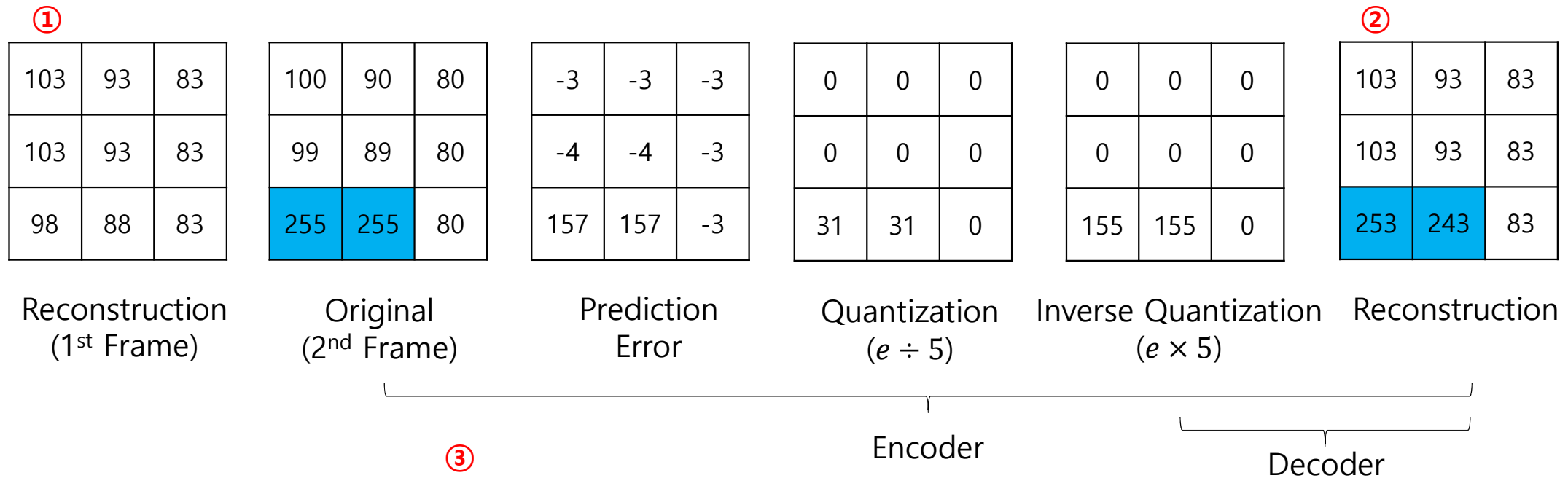
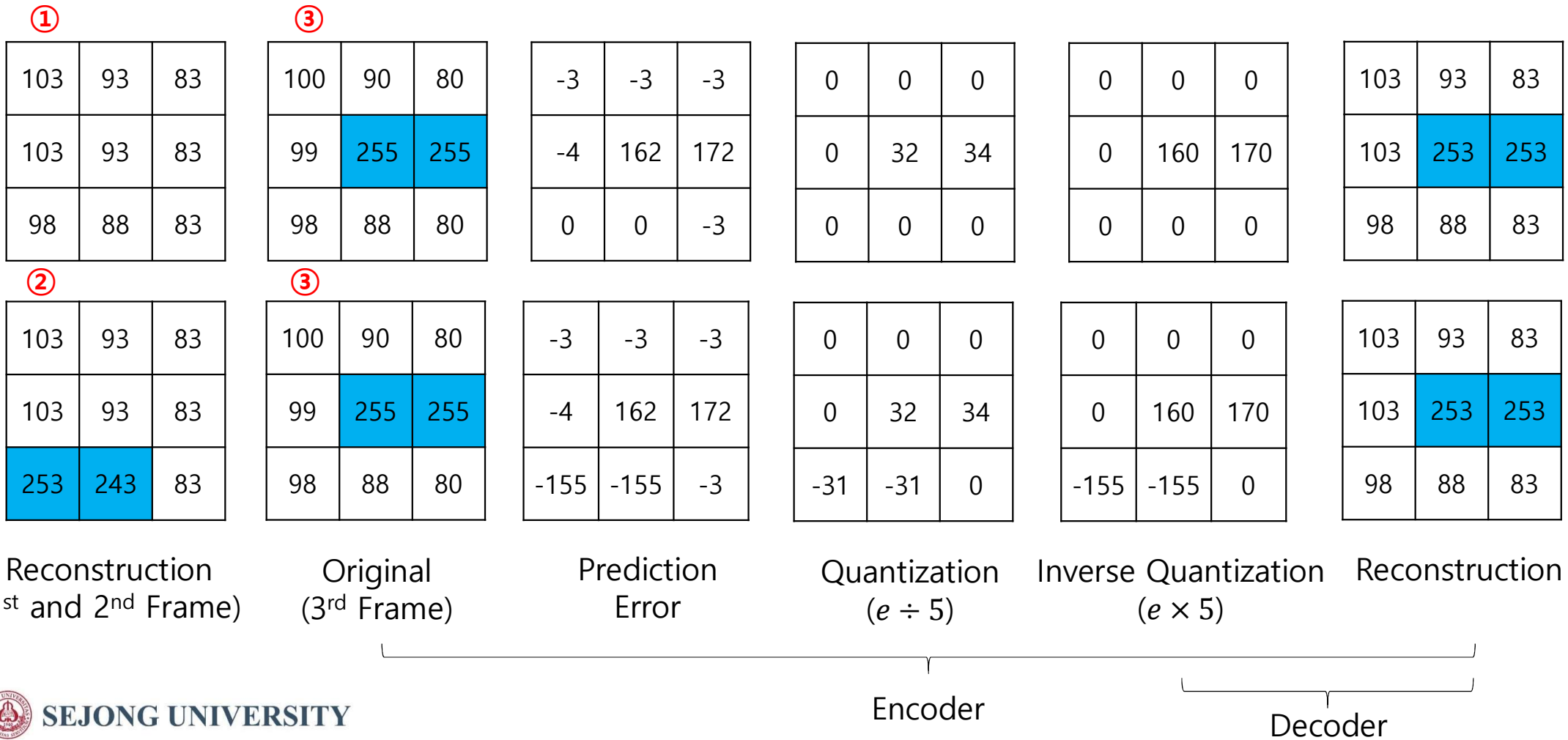③
100	90	80
99	255	255
98	88	80

Original
(3rd Frame)

- Horizontally and vertically spatial prediction

- Temporal prediction from ① and ② frames

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Example of Temporal Prediction (3rd Frame)

①

103	93	83
103	93	83
98	88	83

③

100	90	80
99	255	255
98	88	80

-3	-3	-3
-4	162	172
0	0	-3

0	0	0
0	32	34
0	0	0

0	0	0
0	160	170
0	0	0

103	93	83
103	253	253
98	88	83

②

103	93	83
103	93	83
253	243	83

③

100	90	80
99	255	255
98	88	80

-3	-3	-3
-4	162	172
-155	-155	-3

0	0	0
0	32	34
-31	-31	0

0	0	0
0	160	170
-155	-155	0

103	93	83
103	253	253
98	88	83

Reconstruction
(1st and 2nd Frame)

Original
(3rd Frame)

Prediction
Error

Quantization
($e \div 5$)

Inverse Quantization
($e \times 5$)

Reconstruction

Encoder

Decoder

Compression Result

- Please choose the best reference for the temporal prediction

Original

100	90	80
99	255	255
98	88	80

Quantization
$(e \div 5)$

0	0	0
0	32	34
0	0	0

Reconstruction
(39.89dB)

103	93	83
103	253	253
98	88	83

Quantization
$(e \div 5)$

0	0	0
0	32	34
-31	-31	0

Reconstruction
(39.89dB)

103	93	83
103	253	253
98	88	83

Temporal Prediction from ①

Temporal Prediction from ②

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Experiment

- Video compression using spatial and temporal predictions for first.bmp and second.bmp

- Quantization ($e \div \alpha$), and then binarization for quantized prediction error

- Binarization for prediction direction, for example, 0 for horizontally spatial prediction and 1 for vertically spatial prediction in first.bmp, and then 0 for temporal prediction using the reconstructed image of first.bmp, 10 for horizontally spatial prediction, and 11 for vertically spatial prediction in second.bmp, respectively

Motion Vector (MV)

- Temporal prediction with motion vectors, which indicate motions between two frames (images)

- Generally, high MV correlation between neighboring pixels

| 1st Frame | 2nd Frame | 3rd Frame | 4th Frame |
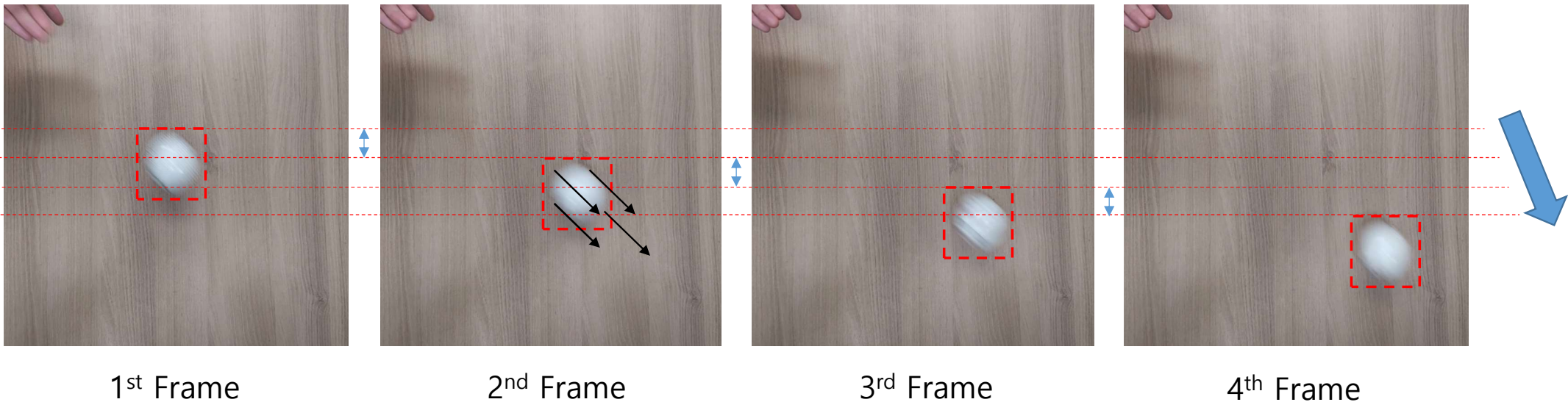
Block Matching

- Determination of displacements of each block between two consecutive frames

- Motion estimation that finds the optimum MV and reference block

1st Frame

MV

2nd Frame
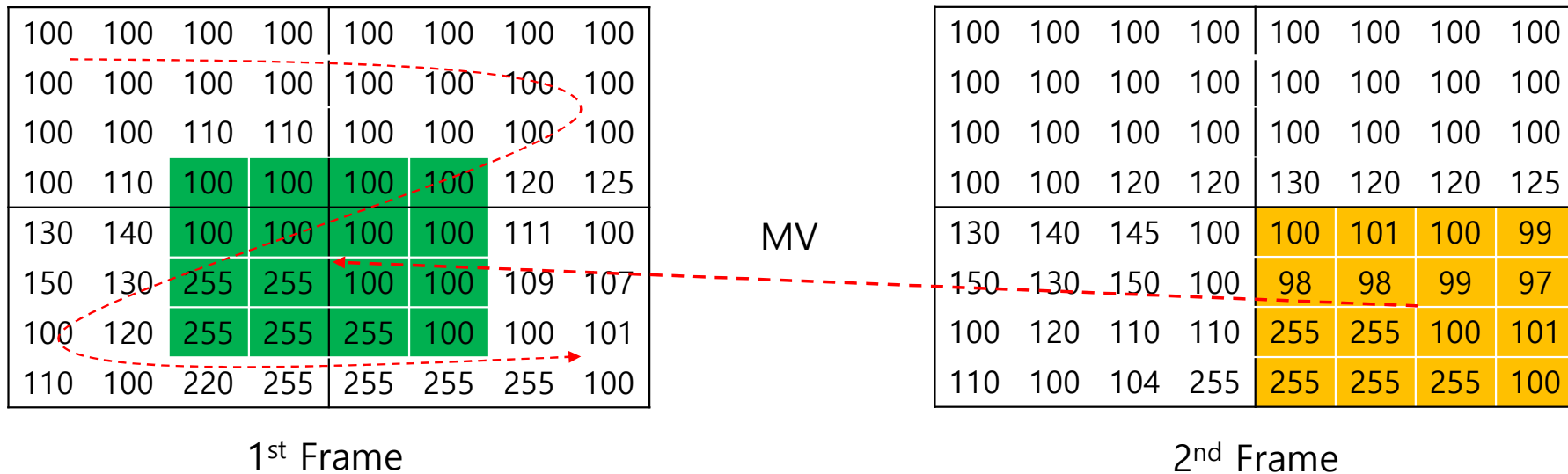
Temporal Resolution

- …

- 30fps

- 60fps

- 120fps

- …

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Frame Rate Up Conversion (FRUC)

- Generation of higher frame-rate videos from low frame-rate videos through frame interpolation

- Smooth continuity of motions across frames

MV

1st Frame   2nd Frame   3rd Frame