

Depth Enhancement Tool & Rendering with Connection Information

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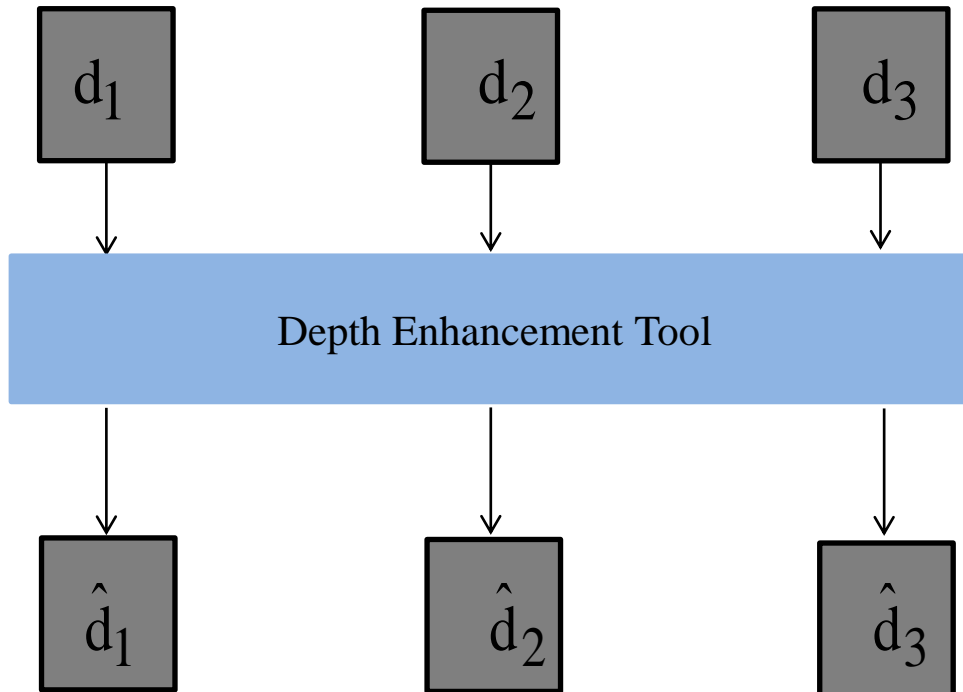
Outline

- Results
 - Depth Enhancement Tool
 - View Synthesis with Connection information
 - Rendering with Structured-Depth

Depth Enhancement Tool

Depth Enhancement Tool

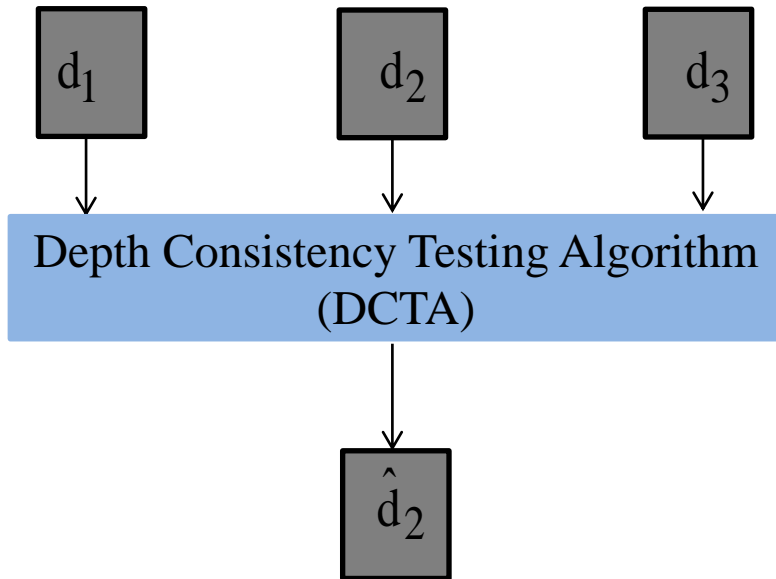
MPEG Depth Maps (MPEG/D)



Enhanced Depth Maps (ED)

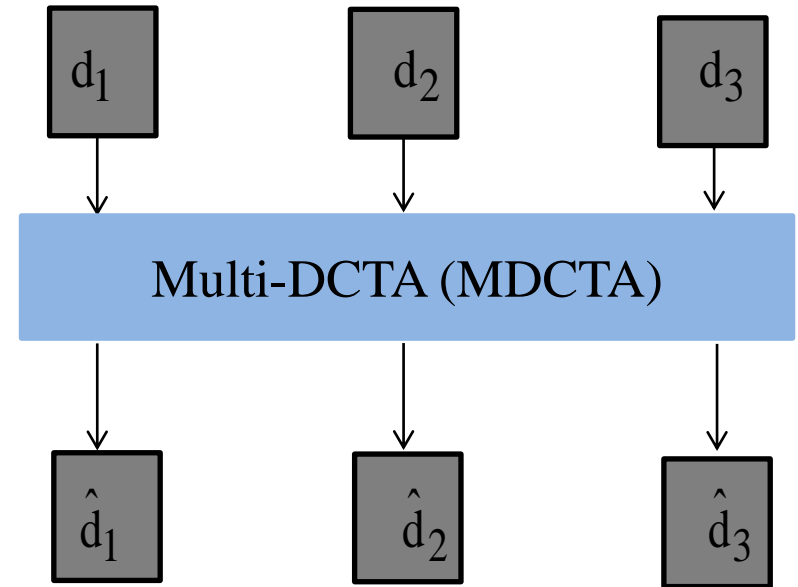
Depth Enhancement Tool

Depth Consistency Testing



Testing pixels in 2

Depth Enhancement Tool

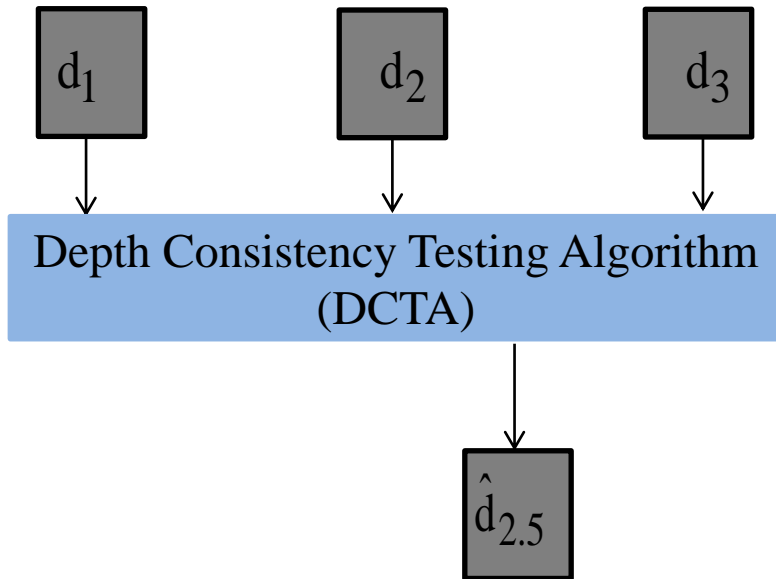


Testing pixels in 1, 2, and 3

MDCTA/ED

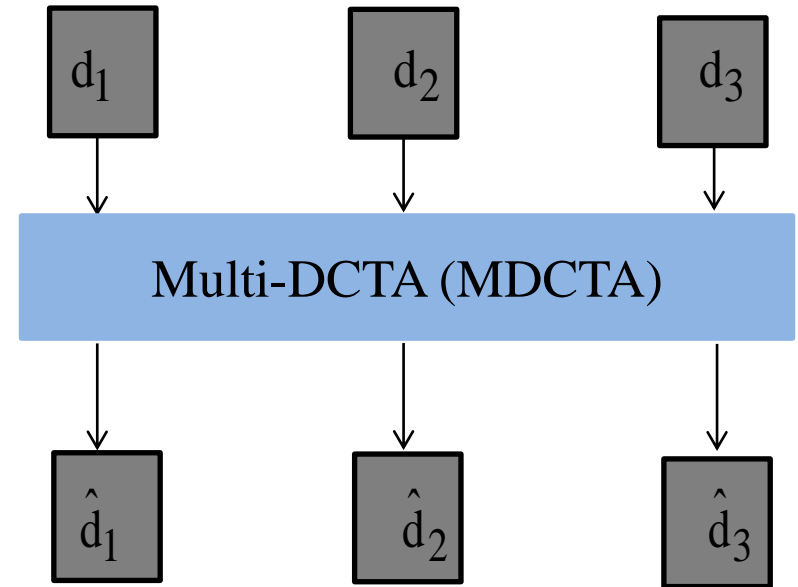
Depth Enhancement Tool

Depth Consistency Testing



Testing pixels in 2.5

Depth Enhancement Tool

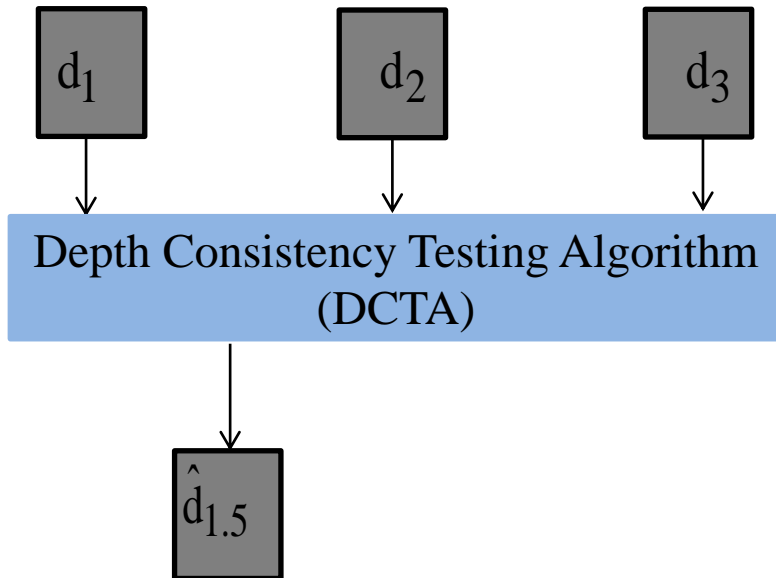


Testing pixels in 1, 2, and 3

MDCTA/ED

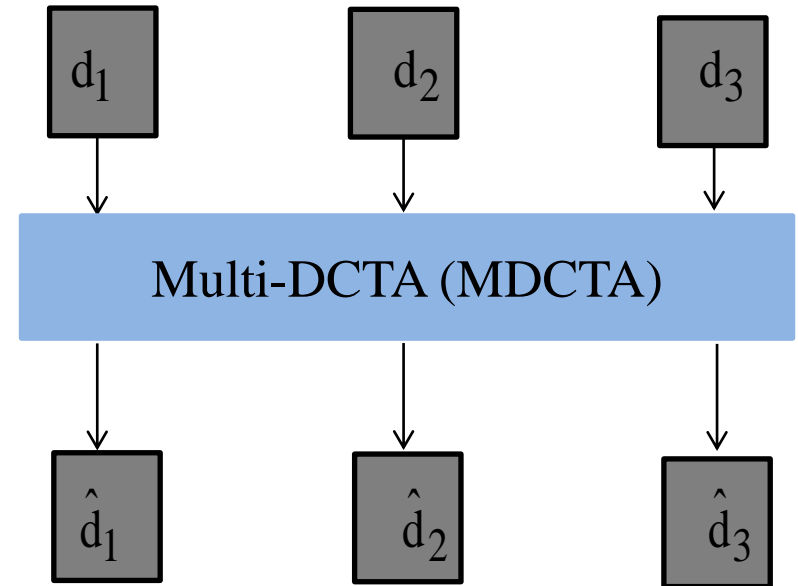
Depth Enhancement Tool

Depth Consistency Testing



Testing pixels in 1.5

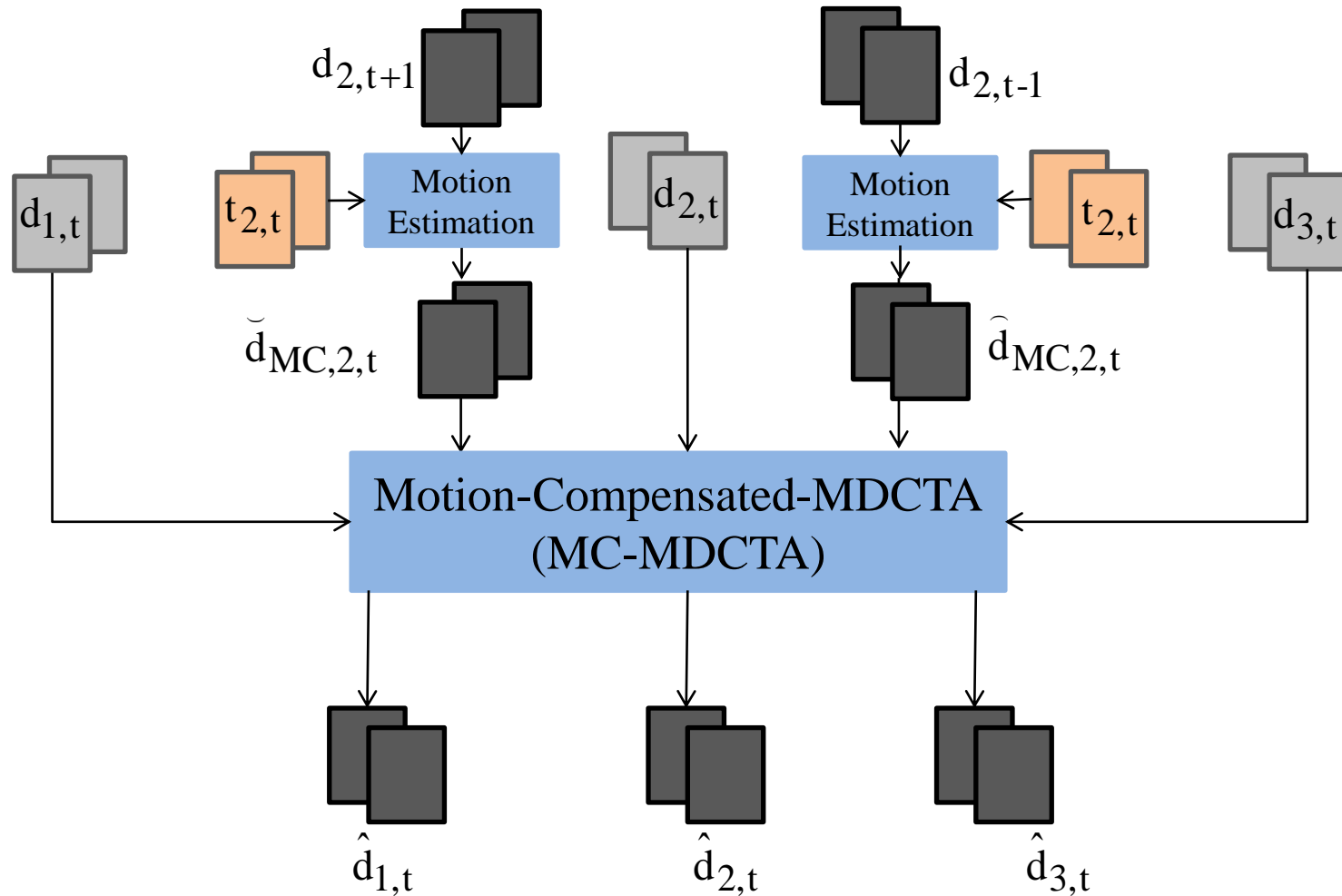
Depth Enhancement Tool



Testing pixels in 1, 2, and 3

MDCTA/ED

Depth Enhancement Tool



MC-MDCTA/ED

VSRS 3.5 Configuration file

The best VSRS parameters setting[1]:

- 1D Synthesis mode
- Boundary Noise Removal off
- View Blending off, not used in the 1D mode
- Half-pel precision
- Any setting for the Filter parameter

[1] Study of VSRS input parameters, Martin Pettersson, Ericsson AB, 2011-02-28

Results

MPEG/D → VSRS 3.5

Sequence ID	Test Sequence	Spatial Resolution	No. Frames	Virtual View	MPEG/D → VSRS 3.5 [dB]
S01	Poznan Hall 2	1920x1088	200	6.5	SE
S02	Poznan Street	1920x1088	250	3.5	SE
S03	Undo Dancer	1920x1080	250	03	38.50
S04	GT Fly	1920x1080	250	04	x
S03	Kendo	1024x768	300	04	37.66
S06	Balloons	1024x768	300	04	36.60
S07	Lovebird1	1024x768	240	07	28.68
S07*	Lovebird1	1024x768	240	07	30.37
S08	Newspaper	1024x768	300	05	32.35

Results

MPEG/D → MDCTA/ED → VSRS 3.5

Sequence ID	Test Sequence	Spatial Resolution	No. Frames	Virtual View	MPEG/D → VSRS 3.5 [dB]	MDCTA/ED → VSRS 3.5 [dB]
S01	Poznan Hall 2	1920x1088	200	6.5	SE	SE ⁽¹⁾
S02	Poznan Street	1920x1088	250	3.5	SE	SE
S03	Undo Dancer	1920x1080	250	03	38.50	38.11 ⁽²⁾
S04	GT Fly	1920x1080	250	04	x	x
S03	Kendo	1024x768	300	04	37.66	37.30 ⁽²⁾
S06	Balloons	1024x768	300	04	36.60	36.60
S07	Lovebird1	1024x768	240	07	28.68	28.72
S07*	Lovebird1	1024x768	240	07	30.37	30.00
S08	Newspaper	1024x768	300	05	32.35	32.40 ⁽²⁾

- Old mpeg depth maps
- (1) Good subjective result
- (2) Subjective improvement

Results

MPEG/D → MC-MDCTA/ED → VSRS 3.5

Sequence ID	Test Sequence	Spatial Resolution	No. Frames	Virtual View	MPEG/D → VSRS 3.5 [dB]	MDCTA/ED → VSRS 3.5 [dB]	MC-MDCTA /ED → VSRS 3.5 [dB]
S01	Poznan Hall 2	1920x1088	200	6.5	SE	SE ⁽¹⁾	SE
S02	Poznan Street	1920x1088	250	3.5	SE	SE	SE
S03	Undo Dancer	1920x1080	250	03	38.50	38.11 ⁽²⁾	38.05
S04	GT Fly	1920x1080	250	04	x	x	x
S03	Kendo	1024x768	300	04	37.66	37.30 ⁽²⁾	37.65
S06	Balloons	1024x768	300	04	36.60	36.60	36.74
S07	Lovebird1	1024x768	240	07	28.68	28.72	28.72
S07*	Lovebird1	1024x768	240	07	30.37	30.00	30.30
S08	Newspaper	1024x768	300	05	32.35	32.40 ⁽²⁾	32.56

- Old mpeg depth maps
- (1) Good subjective result
- (2) Subjective improvement

Subjective Results



MPEG/D → VSRs 3.5

Poznan Hall2
Frame 157

MPEG/D → MDCTA/ED → VSRs 3.5



Subjective Results



Poznan Hall2
Frame 121

MPEG/D → VSRS 3.5



MPEG/D → MDCTA/ED → VSRS 3.5

Subjective Results



Original



MPEG/D \rightarrow VSRS 3.5



MPEG/D \rightarrow MDCTA/ED \rightarrow VSRS 3.5

Subjective Results



Original

Kendo 4
Frame 202



MPEG/D \rightarrow VSRS 3.5



MPEG/D \rightarrow MDCTA/ED \rightarrow VSRS 3.5

Subjective Results



Original

Kendo 4
Frame 204

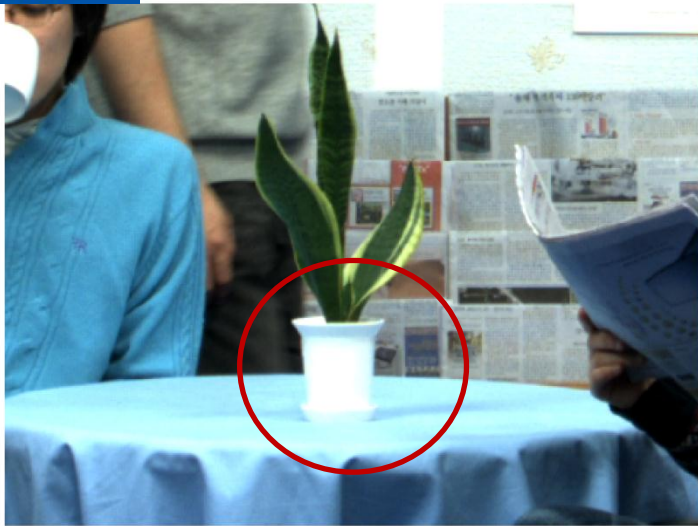


MPEG/D \rightarrow VSRS 3.5



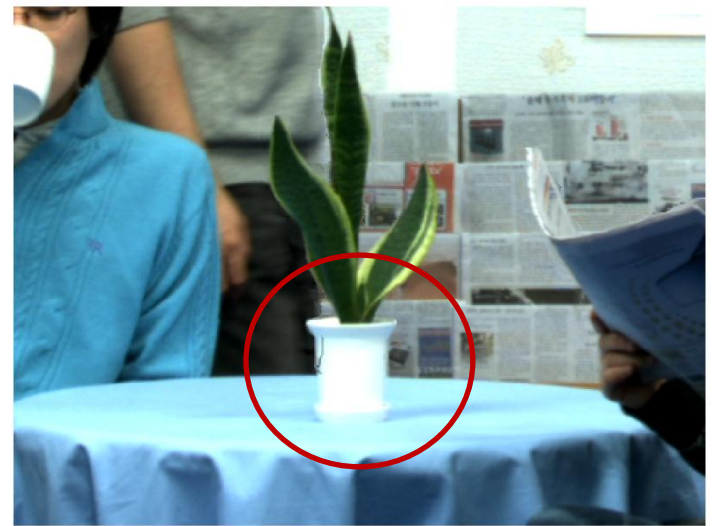
MPEG/D \rightarrow MDCTA/ED \rightarrow VSRS 3.5

Subjective Results

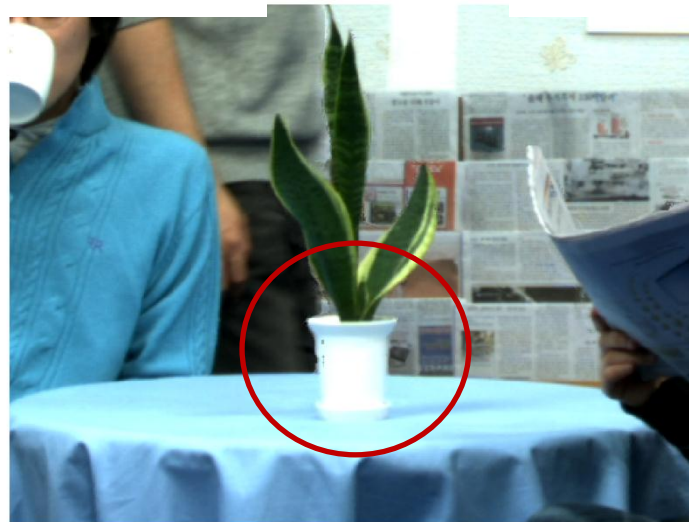


Original

Newspaper 5
Frame 85



MPEG/D \rightarrow VSRS 3.5



MPEG/D \rightarrow MDCTA/ED \rightarrow VSRS 3.5

Subjective Results



Original

Newspaper 5
Frame 217



MPEG/D \rightarrow VSRS 3.5

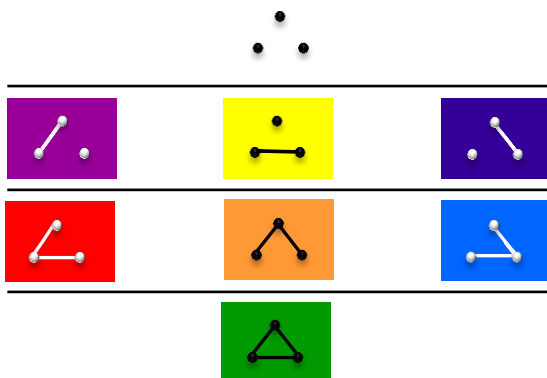


MPEG/D \rightarrow MDCTA/ED \rightarrow VSRS 3.5

View Synthesis with Connection Information

Inter-View Connection Information

Possible cases of inter-view connectivity for $n = 3$:

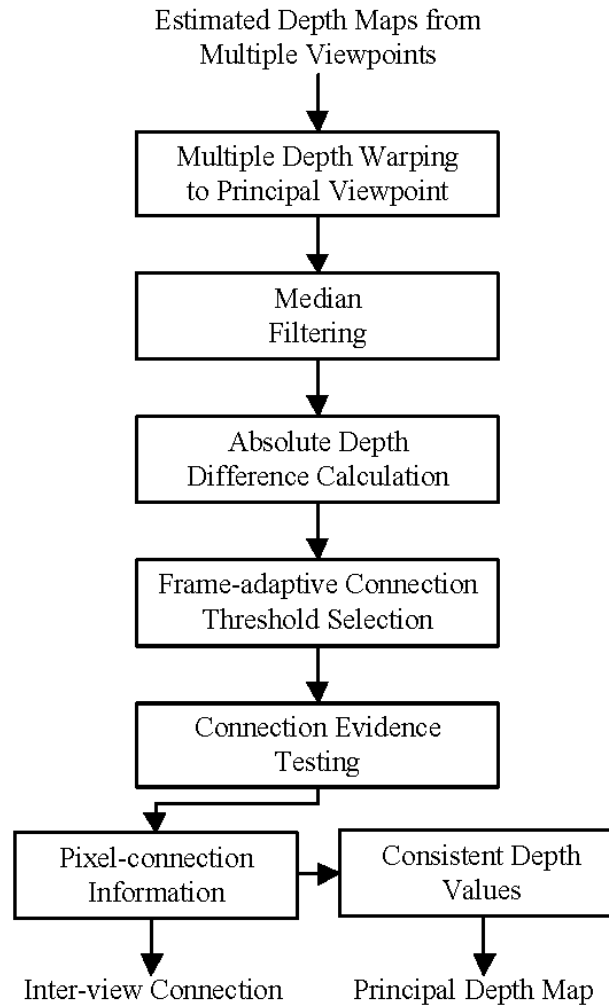


Use of Connection Information:

- *To obtain consistent depth values*
- *To combine texture pixels from multiple viewpoint reliably*



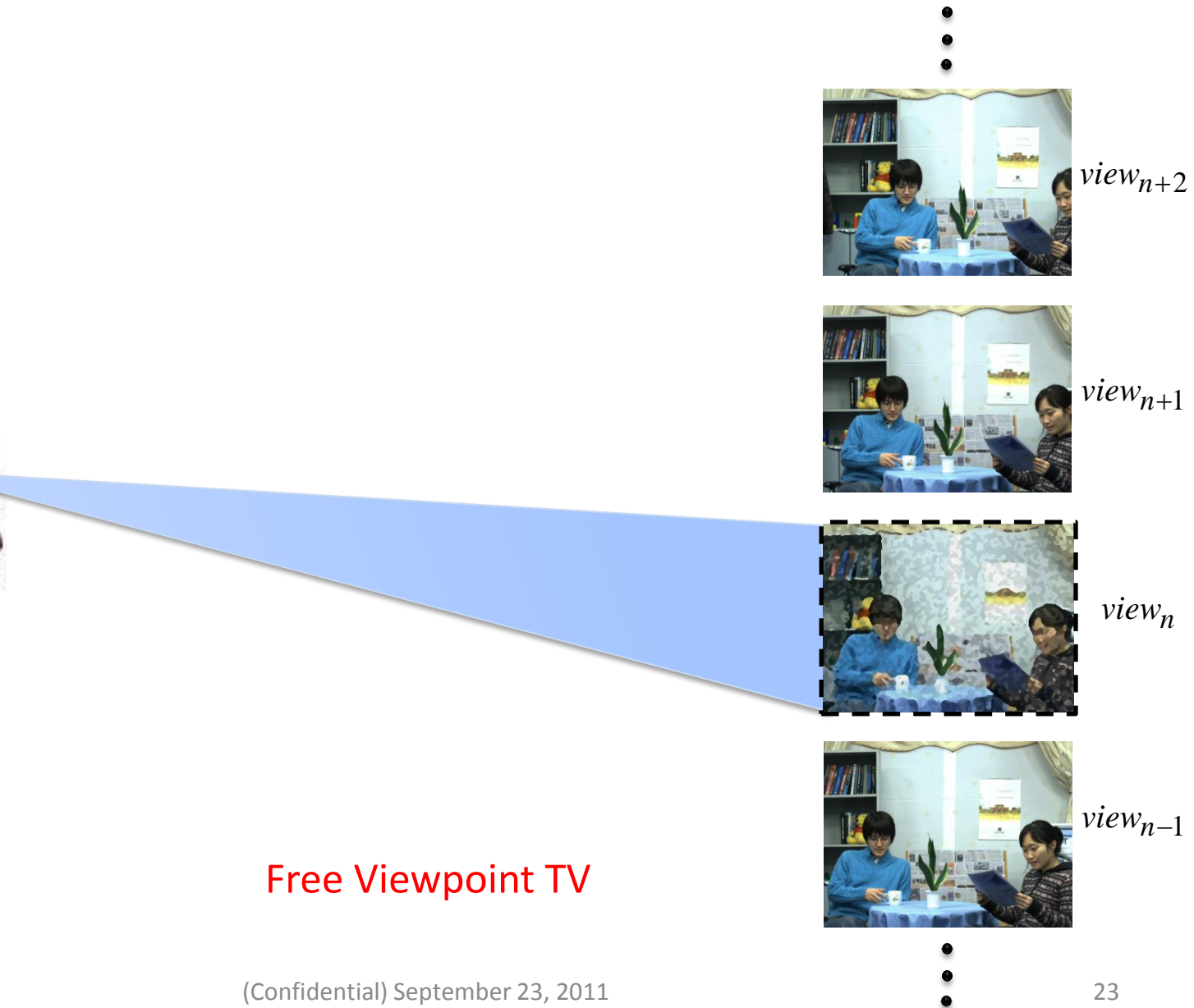
Depth Consistency Testing



Virtual View Rendering



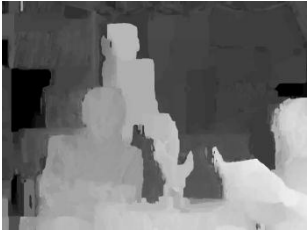
User



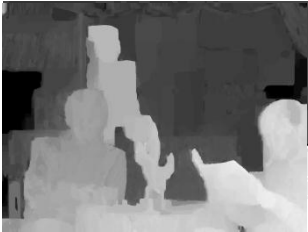
Free Viewpoint TV

Virtual View Synthesis (VSRS+)

$view_{n+2}$



$view_{n+1} = p$



$view_{n-1}$



Enhanced depth maps

VSRS+

$view_{n+2}$



$view_{n+1} = p$



$view_{n-1}$



Multiview Texture

VSRS+

$view_{n+2}$



Warping



*Warped views
at virtual viewpoint n*

$view_{n+1} = p$



Warping



$view_{n-1}$



Warping



VSRS+

$view_{n+2}$



Warping



*Warped views
at virtual viewpoint n*

$view_{n+1} = p$



Warping



*Masked Inter-view
Connection Information*



$view_{n-1}$



Warping



VSRS+

$view_{n+2}$



Warping

*Warped views
at virtual viewpoint n*



$view_{n+1} = p$



Warping



$view_{n-1}$



Warping



*Masked Inter-view
Connection Information*

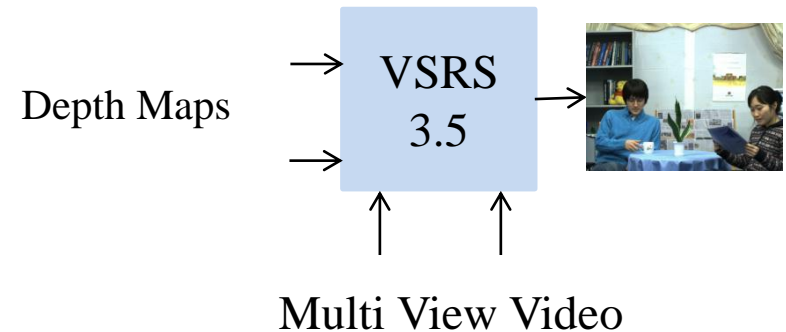
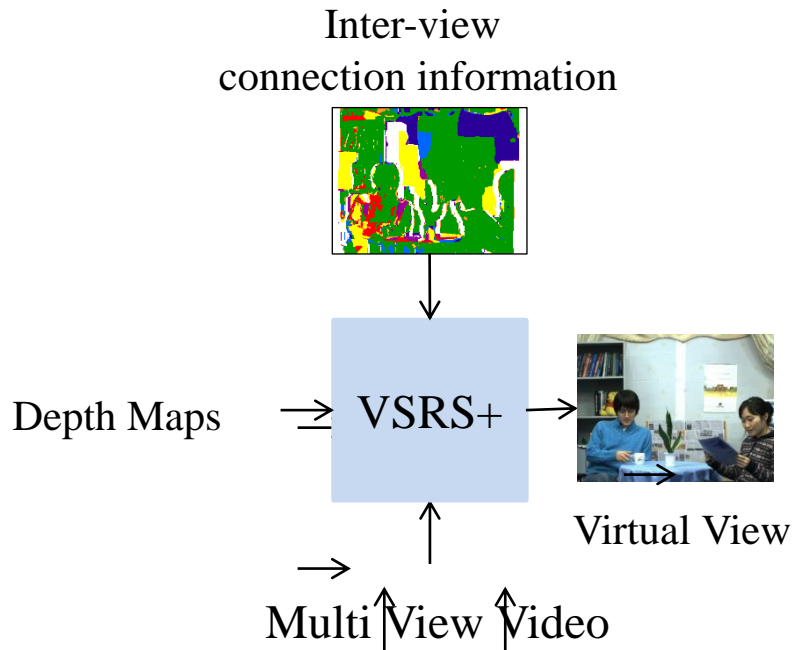


*Connection-
Adaptive
Pixel Intensity
Estimation*

virtual view $_n$



Rendering with Connection Information



Results

MPEG/D → VSRS+

Sequence ID	Test Sequence	Spatial Resolution	No. Frames	Virtual View	MPEG/D → VSRS 3.5 [dB]	MPEG/D → VSRS+
						Adaptive Conn.
S01	Poznan Hall 2	1920x1088	200	6.5	SE	SE
S02	Poznan Street	1920x1088	250	3.5	SE	SE
S03	Undo Dancer	1920x1080	250	03	38.50	39.46
S04	GT Fly	1920x1080	250	04	SE	x
S03	Kendo	1024x768	300	04	37.66	38.13
S06	Balloons	1024x768	300	04	36.63	37.00
S07	Lovebird1	1024x768	240	07	28.68	29.60
S07*	Lovebird1	1024x768	240	07	30.37	30.70
S08	Newspaper	1024x768	300	05	32.35	33.50

Results

MDCTA/ED → VSRS+

Sequence ID	Test Sequence	Spatial Resolution	No. Frames	Virtual View	MPEG/D → VSRS 3.5 [dB]	MPEG/D → VSRS+	MDCTA/ED → VSRS+	
						Adaptive Conn.	Adaptive Conn.	Fixed Conn.
S01	Poznan Hall 2	1920x1088	200	6.5	SE	SE	SE	SE
S02	Poznan Street	1920x1088	250	3.5	SE	SE	SE	SE
S03	Undo Dancer	1920x1080	250	03	38.50	39.46	38.84	38.84
S04	GT Fly	1920x1080	250	04	SE	x	x	x
S03	Kendo	1024x768	300	04	37.66	38.13	37.96	38.10
S06	Balloons	1024x768	300	04	36.63	37.00	36.88	36.89
S07	Lovebird1	1024x768	240	07	28.68	29.60	29.37	29.85
S07*	Lovebird1	1024x768	240	07	30.37	30.70	30.50	30.81
S08	Newspaper	1024x768	300	05	32.35	33.50	34.10	34.43

Results

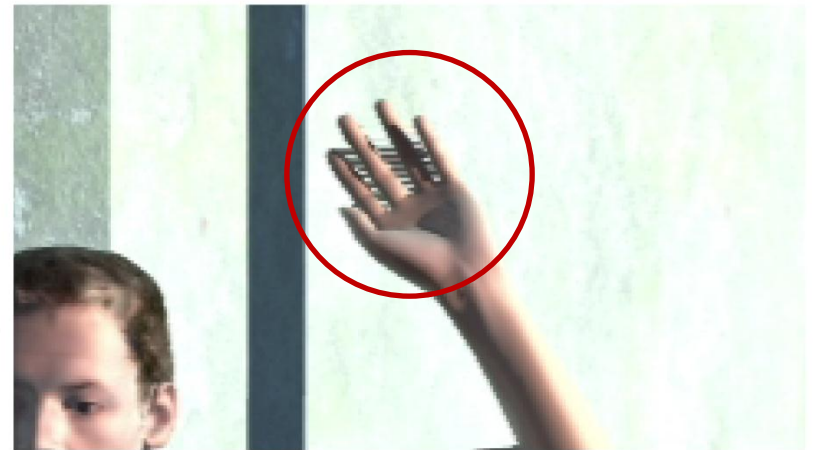
MC-MDCTA/ED → VSRS+

Sequence ID	Test Sequence	Spatial Resolution	No. Frames	Virtual View	MPEG/D → VSRS 3.5 [dB]	MPEG/D → VSRS+	MDCTA/ED → VSRS+		MC-MDCTA/ED → VSRS+	
						Adaptive Conn.	Adaptive Conn.	Fixed Conn.	Adaptive Conn.	Fixed Conn.
S01	Poznan Hall 2	1920x1088	200	6.5	SE	SE	SE	SE	SE	SE
S02	Poznan Street	1920x1088	250	3.5	SE	SE	SE	SE	SE	SE
S03	Undo Dancer	1920x1080	250	03	38.50	39.46	38.84	38.84	38.58	38.58
S04	GT Fly	1920x1080	250	04	SE	x	x	x	x	x
S03	Kendo	1024x768	300	04	37.66	38.13	37.96	38.10	38.11	38.29
S06	Balloons	1024x768	300	04	36.63	37.00	36.88	36.89	36.88	37.04
S07	Lovebird1	1024x768	240	07	28.68	29.60	29.37	29.85	29.38	29.80
S07*	Lovebird1	1024x768	240	07	30.37	30.70	30.50	30.81	30.55	31.20
S08	Newspaper	1024x768	300	05	32.35	33.50	34.10	34.43	34.04	34.30

Subjective Results



Original



MPEG/D → VSRS 3.5



MPEG/D → MDCTA/ED → VSRS+



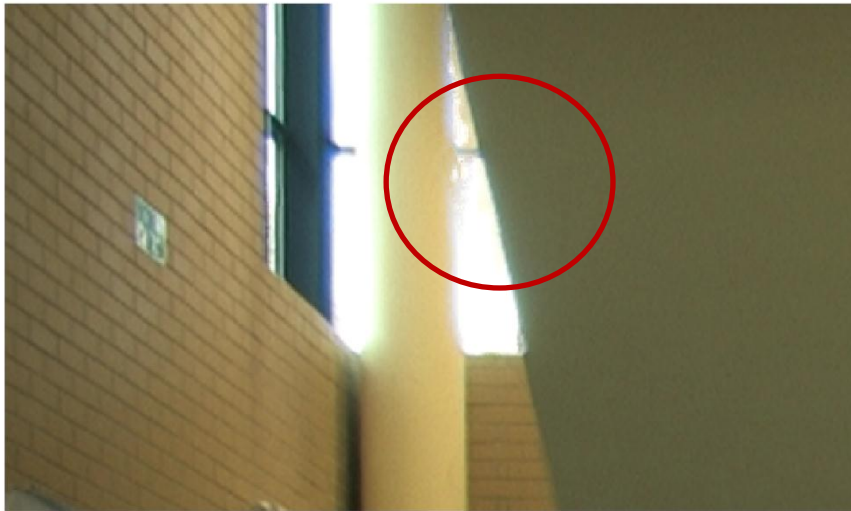
MPEG/D → VSRS+

Subjective Results

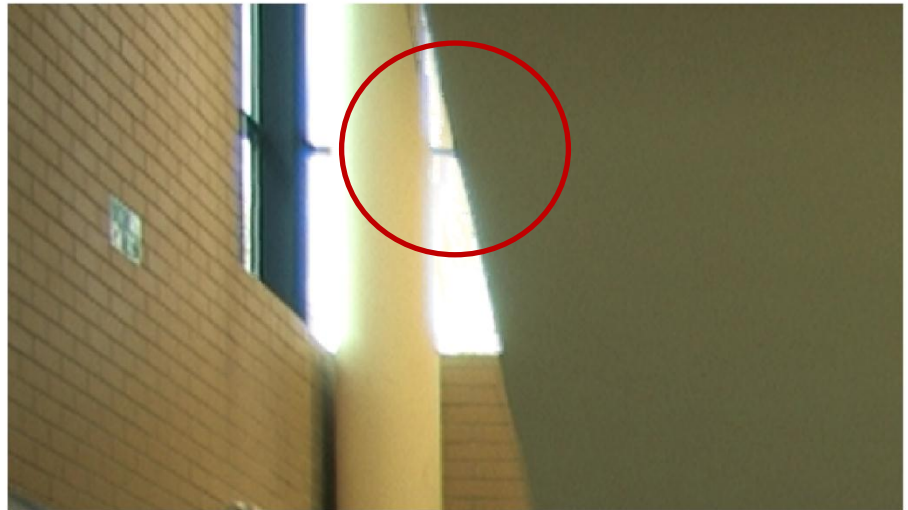
MPEG/D → VSRS 3.5



Poznan Hall2
Frame 159



MPEG/D → MDCTA/ED → VSRS+



MPEG/D → VSRS+

Subjective Results

MPEG/D \rightarrow VSRS 3.5



Poznan Street
Frame 121



MPEG/D \rightarrow MDCTA/ED \rightarrow VSRS+



MPEG/D \rightarrow VSRS+

Subjective Results

MPEG/D \rightarrow VSRS 3.5



Poznan Hall2
Frame 122



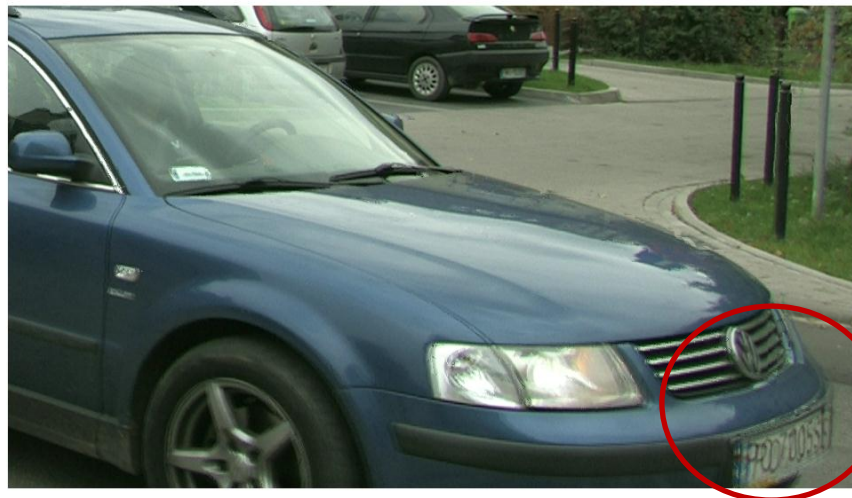
MPEG/D \rightarrow MDCTA/ED \rightarrow VSRS+



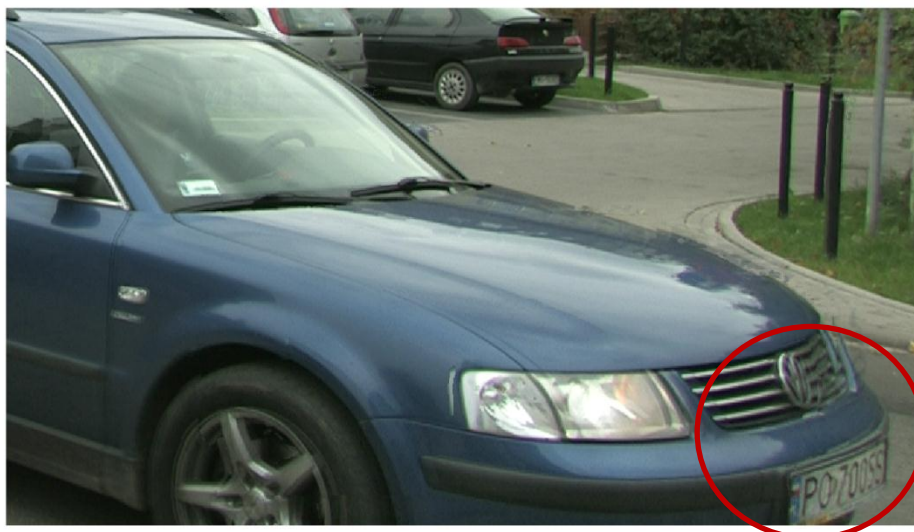
MPEG/D \rightarrow VSRS+

Subjective Results

MPEG/D → VSRS 3.5



Poznan Street
Frame 250



MPEG/D → MDCTA/ED → VSRS+



MPEG/D → VSRS+

Subjective Results



Original

Kendo 4
Frame 202



MPEG/D \rightarrow VSRS 3.5



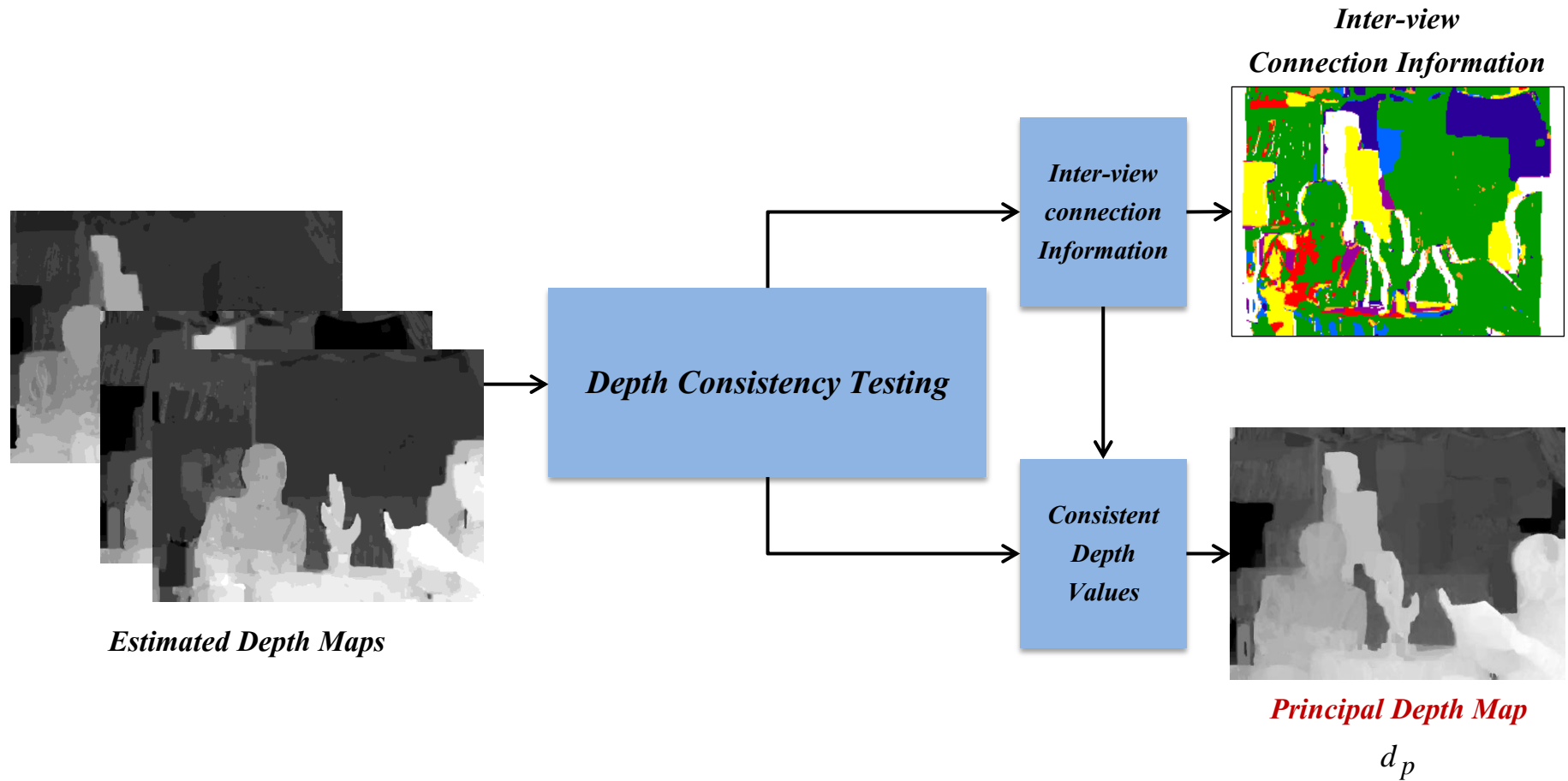
MPEG/D \rightarrow MDCTA/ED \rightarrow VSRS+



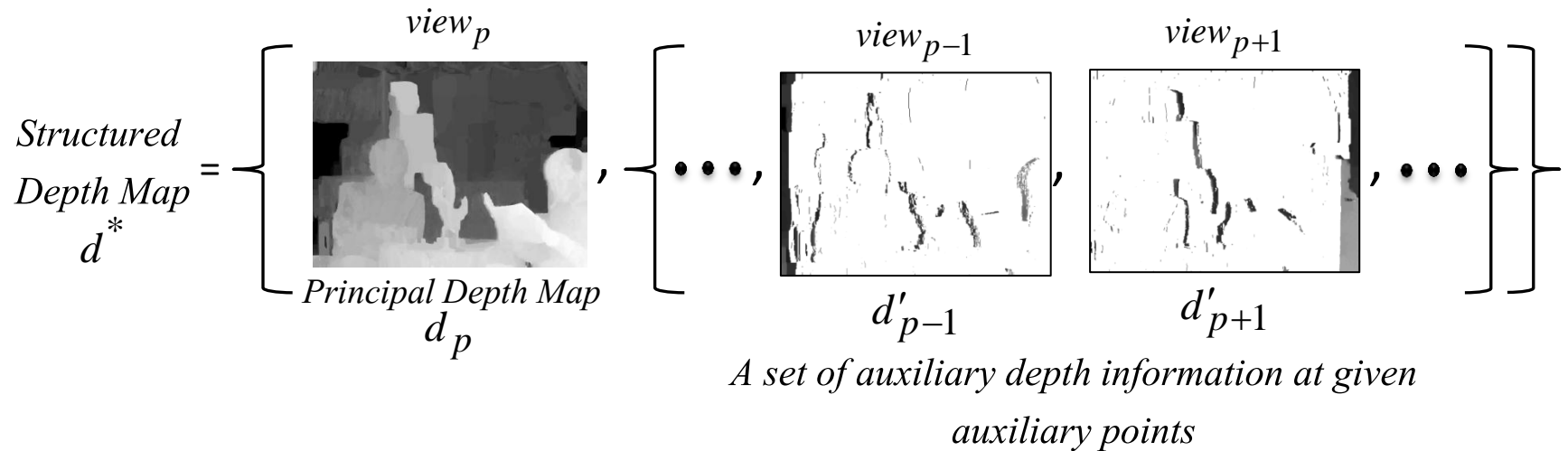
MPEG/D \rightarrow VSRS+

Rendering with Structured-Depth

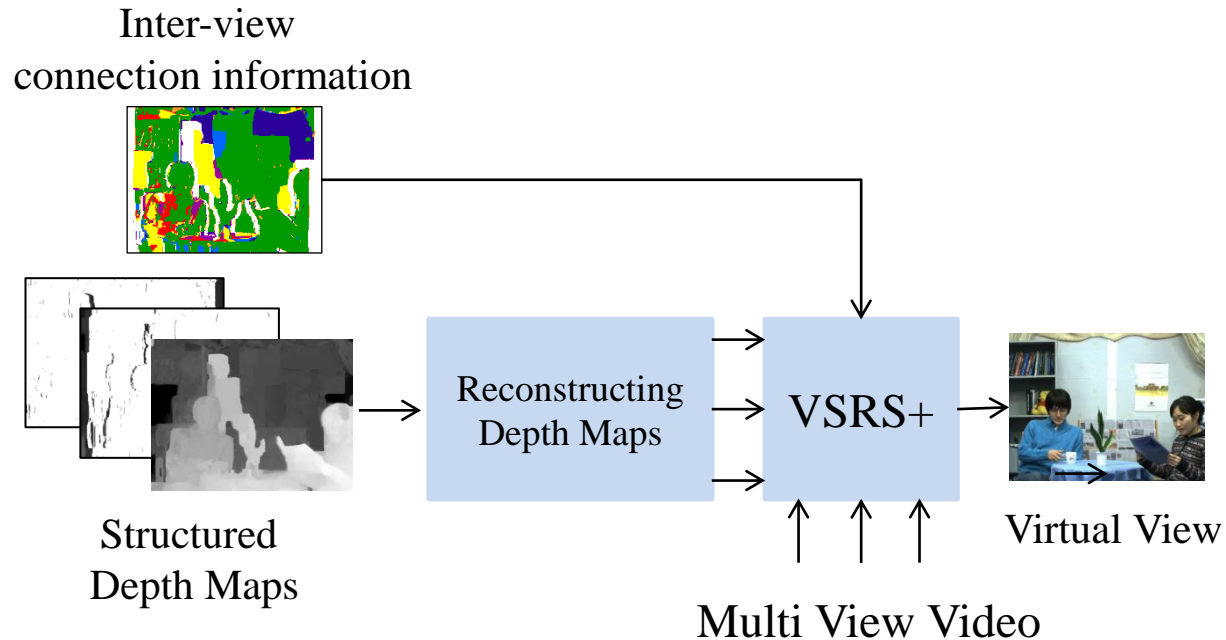
Principal Depth Map



Structured Depth Maps



Rendering with Structured Depth Maps



Results

MPEG/D → S/D → VSRS+

Sequence ID	Test Sequence	Spatial Resolution	No. Frames	Virtual View	MPEG/D → VSRS 3.5 [dB]	MPEG/D → S/D → VSRS+	
						Adaptive Connection	Fixed Connection
S01	Poznan Hall 2	1920x1088	200	6.5	SE	SE	SE
S02	Poznan Street	1920x1088	250	3.5	SE	SE	SE
S03	Undo Dancer	1920x1080	250	03	38.50	38.86	38.86
S04	GT Fly	1920x1080	250	04	SE	x	x
S03	Kendo	1024x768	300	04	37.66	37.79	37.82
S06	Balloons	1024x768	300	04	36.63	36.60	36.56
S07	Lovebird1	1024x768	240	07	28.68	29.50	30.00
S07*	Lovebird1	1024x768	240	07	30.37	30.32	30.34
S08	Newspaper	1024x768	300	05	32.35	33.60	33.90

Results

MPEG/D → MDCTA/ED → S/D → VSRS+

Sequence ID	Test Sequence	Spatial Resolution	No. Frames	Virtual View	MPEG/D → VSRS 3.5 [dB]	MPEG/D → S/D → VSRS +		MDCTA/D → S/D → VSRS+	
						Adaptive Connection	Fixed Connection	Adaptive Conn.	Fixed Conn
S01	Poznan Hall 2	1920x1088	200	6.5	SE	SE	SE	SE	SE
S02	Poznan Street	1920x1088	250	3.5	SE	SE	SE	SE	SE
S03	Undo Dancer	1920x1080	250	03	38.50	38.86	38.86	38.70	38.70
S04	GT Fly	1920x1080	250	04	SE	x	x	x	x
S03	Kendo	1024x768	300	04	37.66	37.79	37.82	37.67	37.76
S06	Balloons	1024x768	300	04	36.63	36.60	36.56	36.50	36.50
S07	Lovebird1	1024x768	240	07	28.68	29.50	30.00	29.44	29.84
S07*	Lovebird1	1024x768	240	07	30.37	30.32	30.34	30.17	30.24
S08	Newspaper	1024x768	300	05	32.35	33.60	33.90	34.12	34.20

Results

MPEG/D → MC-MDCTA/ED → S/D → VSRS+

Sequence ID	Test Sequence	Spatial Resolution	No. Frames	Virtual View	MPEG/D → VSRS 3.5 [dB]	MPEG/D→S/D→VSRS +		MDCTA/D→S/D →VSRS+		MC-MDCTA/D→S/D →VSRS+	
						Adaptive Connection	Fixed Connection	Adaptive Conn.	Fixed Conn	Adaptive Conn.	Fixed Conn
S01	Poznan Hall 2	1920x1088	200	6.5	SE	SE	SE	SE	SE	SE	SE
S02	Poznan Street	1920x1088	250	3.5	SE	SE	SE	SE	SE	SE	SE
S03	Undo Dancer	1920x1080	250	03	38.50	38.86	38.86	38.70	38.70	38.50	38.50
S04	GT Fly	1920x1080	250	04	SE	x	x	x	x	x	x
S03	Kendo	1024x768	300	04	37.66	37.79	37.82	37.67	37.76	37.79	37.83
S06	Balloons	1024x768	300	04	36.63	36.60	36.56	36.50	36.50	36.66	36.62
S07	Lovebird1	1024x768	240	07	28.68	29.50	30.00	29.44	29.84	29.24	29.81
S07*	Lovebird1	1024x768	240	07	30.37	30.32	30.34	30.17	30.24	30.13	30.20
S08	Newspaper	1024x768	300	05	32.35	33.60	33.90	34.12	34.20	34.00	34.28

Subjective Results



MPEG/D → S/D → VSRS+: Fixed

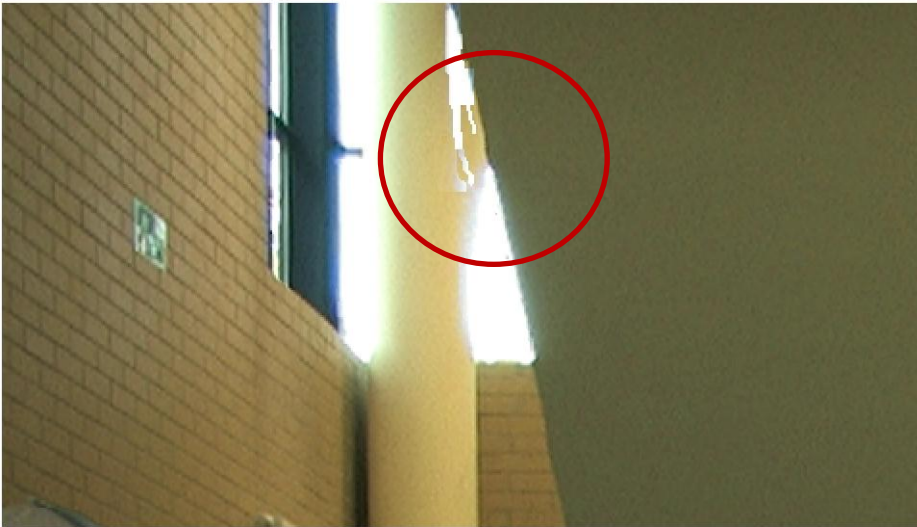
Newspaper 5
Frame 105

Adaptive VSRS+
vs.
Fixed VSRS+

MPEG/D → S/D → VSRS+: Adaptive



Subjective Results



Poznan Hall2
Frame 151

MPEG/D \rightarrow S/D \rightarrow VSRS+

MPEG/D \rightarrow VSRS 3.5



Subjective Results



Poznan Hall2
Frame 121

MPEG/D \rightarrow VSRS 3.5



MPEG/D \rightarrow S/D \rightarrow VSRS+

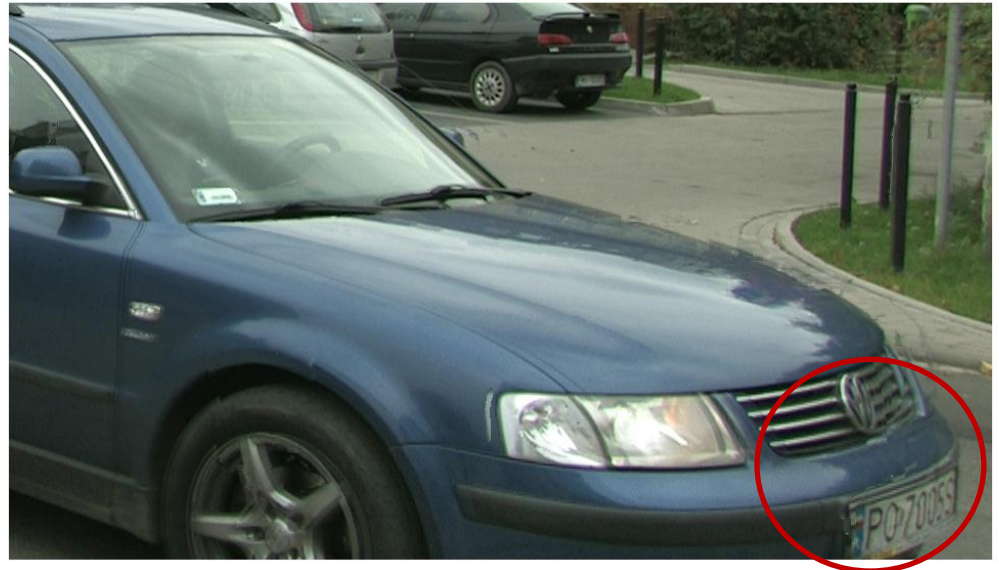
Subjective Results



Poznan Street
Frame 250

MPEG/D \rightarrow S/D \rightarrow VSRS+

MPEG/D \rightarrow VSRS 3.5



Subjective Results



Original



MPEG/D \rightarrow VSRS 3.5



MPEG/D \rightarrow S/D \rightarrow VSRS 3.5

Subjective Results



Original

Kendo 4
Frame 202



MPEG/D \rightarrow VSRS 3.5



MPEG/D \rightarrow S/D \rightarrow VSRS 3.5

Subjective Results



Original

Kendo 4
Frame 204



MPEG/D \rightarrow VSRS 3.5



MPEG/D \rightarrow S/D \rightarrow VSRS 3.5

Subjective Results



Original

Kendo 4
Frame 204



MPEG/D \rightarrow VSRS 3.5



MPEG/D \rightarrow S/D \rightarrow VSRS 3.5

Subjective Results



Original

Kendo 4
Frame 204

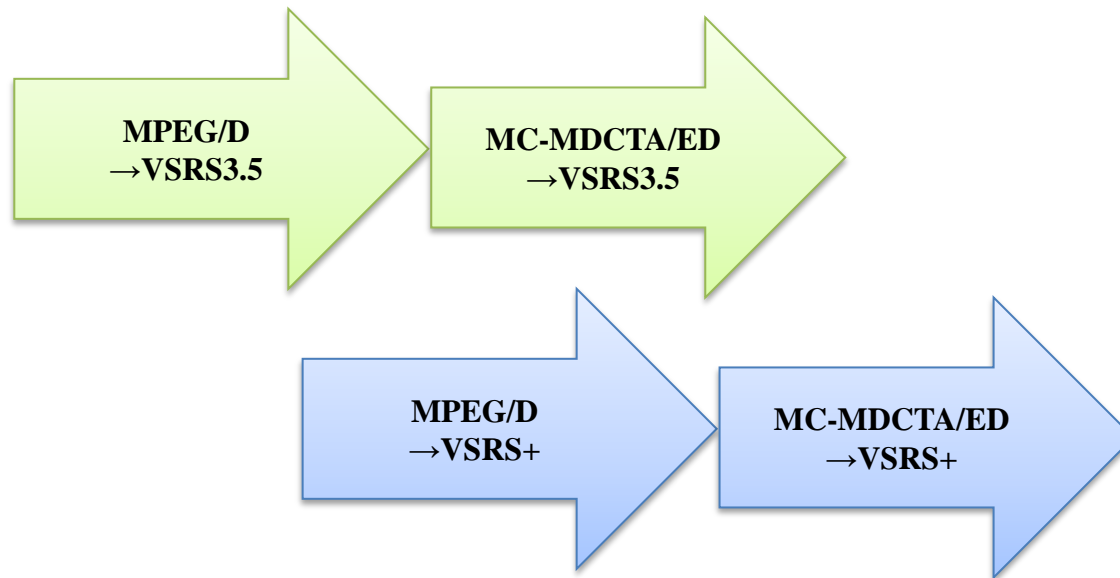


MPEG/D \rightarrow VSRS 3.5

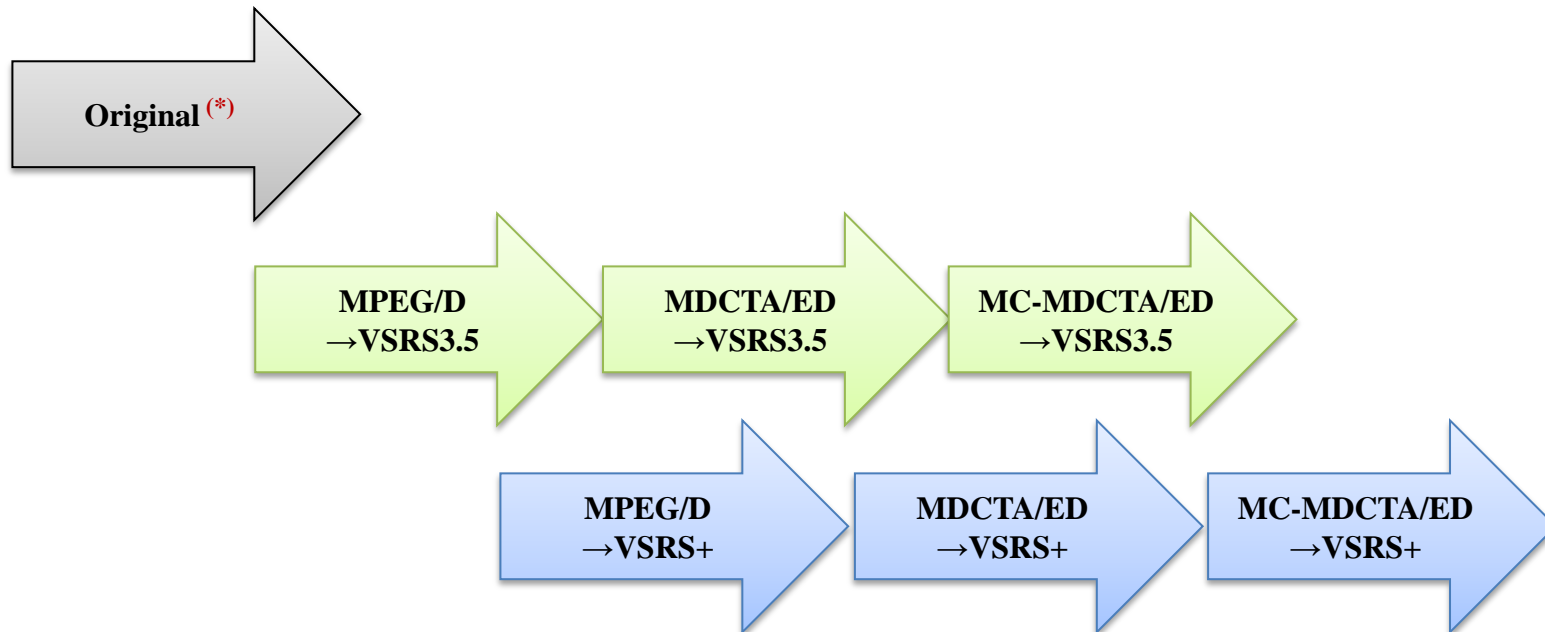


MPEG/D \rightarrow S/D \rightarrow VSRS 3.5

Sequence Viewing Order

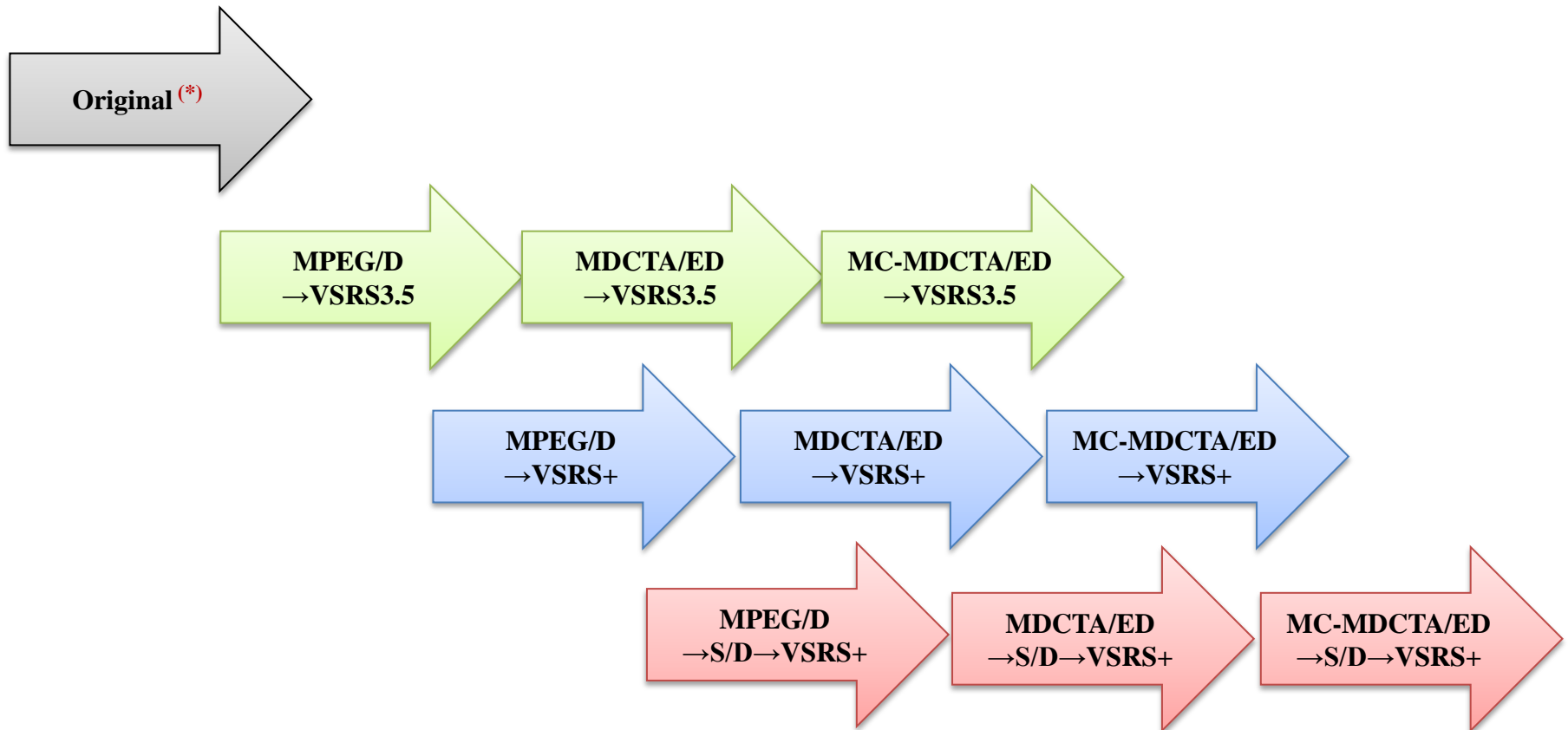


Sequence Viewing Order



*** Not available for the Poznan Street and the Poznan hall 2 test sequences**

Sequence Viewing Order



*** Not available for the Poznan Street and the Poznan hall 2 test sequences**

Thank You