

# CE7: Removal of texture-to-depth resolution ratio restrictions

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# Introduction

- Current 3D-AVC supports two texture to depth resolutions
  - 1:1 (texture and depth are coded at equal spatial resolution)
  - 1:0.5 (depth at half spatial resolution in horizontally and vertically)
- In-loop resampling has been removed  
→ no reason for restricting to only these two depth resolutions
- The contribution shows that
  - A lower depth resolution can provide better RD performance for synthesized views
  - Depth maps at very low resolution can be coded as side information to improve the performance of texture coding

# Simulations

ATM v8.1 software with a modification to support different ratios between spatial resolution of texture and depth

## Tested resolutions

- 1/2, 1/4, 1/8, and 1/16 in both directions
- GDV: Single depth value per each depth view component

## Considered use cases

1. Best depth resolution for RD performance of synthesized views (CTC)
  - Results against MVC+D, i.e. HP anchor bitstreams according to the CTC
2. Best depth resolution for multiview texture coding
  - Coded depth maps are used only as side information to enhance the RD performance of texture views
  - Results against MVC, i.e. extracted texture views of HP anchor

# Simulations: tested resolutions

| Experiment | Depth/Texture resolution ratio<br>(vertical x horizontal) | How to derive the lower<br>resolution depth map |
|------------|---|---|
| Anchor     | 0.5x0.5   | JSVM Downsampled                                |
| 1/2        | 0.5x0.5   | JSVM Downsampled                                |
| 1/4        | 0.25x0.25   | JSVM Downsampled                                |
| 1/8        | 0.125x0.125   | Max Downsampled*                                |
| 1/16       | 0.0625x0.0625   | Max Downsampled                                 |
| GDV        | Only one value  | Mean value of frame selected                    |

\* Max value of each block with size NxN is used as the downsampled respective value of that block

# Results, Use Case 1: Best depth resolution for RD performance of synthesized views (CTC)

|         | Texture Coding |          | Depth Coding |          | Total (Coded PSNR) |          | Total Vs. anchor without depth |          | Total (Synthesed PSNR) |          |
|---------|----------------|----------|--------------|----------|--------------------|----------|--------------------------------|----------|------------------------|----------|
|         | dBR, %         | dPSNR,dB | dBR, %       | dPSNR,dB | dBR, %             | dPSNR,dB | dBR, %                         | dPSNR,dB | dBR, %                 | dPSNR,dB |
| S01     | -30.96         | 1.15     | -53.75       | 4.01     | -32.27             | 1.22     | -24.78                         | 0.89     | -22.95                 | 0.73     |
| S02     | -12.49         | 0.38     | -47.44       | 2.60     | -16.13             | 0.52     | -7.28                          | 0.22     | -9.66                  | 0.29     |
| S03     | -19.14         | 0.73     | -29.43       | 2.78     | -18.91             | 0.74     | -12.48                         | 0.47     | -11.22                 | 0.38     |
| S04     | -19.24         | 0.76     | -76.59       | 8.21     | -23.47             | 0.97     | -17.03                         | 0.67     | -21.03                 | 0.74     |
| S05     | -23.17         | 1.26     | -49.40       | 3.31     | -25.37             | 1.38     | -9.03                          | 0.43     | -19.34                 | 0.88     |
| S06     | -27.51         | 1.62     | -44.51       | 2.70     | -29.16             | 1.72     | -19.19                         | 1.07     | -23.49                 | 1.20     |
| S08     | -15.09         | 0.69     | -2.50        | 0.10     | -15.73             | 0.72     | 1.95                           | -0.08    | -7.80                  | 0.28     |
| Average | -21.09         | 0.94     | -43.37       | 3.39     | -23.00             | 1.04     | -12.55                         | 0.52     | -16.50                 | 0.64     |

|         | Difference = Proposed - 3D-AVC (EHP with 1/2 resolution depth) |              |                    |                                |                        |
|---------|--|--------------|--------------------|--------------------------------|------------------------|
|         | Texture Coding   | Depth Coding | Total (Coded PSNR) | Total Vs. anchor without depth | Total (Synthesed PSNR) |
|         | dBR, %   | dBR, %       | dBR, %             | dBR, %                         | dBR, %                 |
| S01     | 0.13   | -35.53       | -6.93              | -7.70                          | -1.81                  |
| S02     | 0.53   | -33.33       | -6.83              | -7.55                          | -2.78                  |
| S03     | 0.00   | 0.00         | 0.00               | 0.00                           | 0.00                   |
| S04     | 5.21   | -36.49       | -3.04              | -3.29                          | -1.41                  |
| S05     | 0.46   | -28.08       | -15.90             | -19.38                         | -10.43                 |
| S06     | 0.30   | -26.31       | -10.29             | -11.73                         | -6.50                  |
| S08     | 0.00   | 0.00         | 0.00               | 0.00                           | 0.00                   |
| Average | 0.95   | -22.82       | -6.14              | -7.09                          | -3.28                  |

|     | Best resolution |
|-----|-----------------|
| S01 | 1/4             |
| S02 | 1/4             |
| S03 | 1/2             |
| S04 | 1/8             |
| S05 | 1/4             |
| S06 | 1/4             |
| S08 | 1/2             |

# Results, Use Case 2: Best depth resolution for multiview texture coding

|         | Texture Coding |          | Depth Coding |          | Total (Coded PSNR) |          | Total Vs. anchor without depth |          |
|---------|----------------|----------|--------------|----------|--------------------|----------|--------------------------------|----------|
|         | dBR, %         | dPSNR,dB | dBR, %       | dPSNR,dB | dBR, %             | dPSNR,dB | dBR, %                         | dPSNR,dB |
| S01     | -30.36         | 1.13     | -63.55       | 6.01     | -34.19             | 1.33     | -26.91                         | 0.99     |
| S02     | -12.49         | 0.38     | -47.44       | 2.60     | -16.13             | 0.52     | -7.28                          | 0.22     |
| S03     | -18.62         | 0.71     | -60.73       | 7.46     | -21.99             | 0.87     | -15.80                         | 0.60     |
| S04     | -23.58         | 0.98     | -71.19       | 7.29     | -25.83             | 1.10     | -19.60                         | 0.80     |
| S05     | -20.67         | 1.14     | -63.90       | 4.82     | -31.97             | 1.89     | -17.08                         | 0.92     |
| S06     | -25.86         | 1.53     | -53.39       | 4.28     | -32.65             | 2.03     | -23.18                         | 1.36     |
| S08     | -14.20         | 0.66     | -48.75       | 8.19     | -26.70             | 1.35     | -11.33                         | 0.53     |
| Average | -20.82         | 0.93     | -58.42       | 5.81     | -27.07             | 1.30     | -17.31                         | 0.77     |

|         | Difference = Proposed - 3D-AVC (EHP with 1/2 resolution depth) |              |                    |                               |
|---------|--|--------------|--------------------|-------------------------------|
|         | Texture Coding   | Depth Coding | Total (Coded PSNR) | total Vs. anchor without dept |
|         | dBR, %   | dBR, %       | dBR, %             | dBR, %                        |
| S01     | 0.73   | -45.34       | -8.85              | -9.83                         |
| S02     | 0.53   | -33.33       | -6.83              | -7.55                         |
| S03     | 0.52   | -31.30       | -3.08              | -3.33                         |
| S04     | 0.87   | -31.10       | -5.40              | -5.86                         |
| S05     | 2.96   | -42.59       | -22.50             | -27.43                        |
| S06     | 1.95   | -35.19       | -13.78             | -15.72                        |
| S08     | 0.89   | -46.24       | -10.98             | -13.28                        |
| Average | 1.21   | -37.87       | -10.20             | -11.86                        |

|     | Best resolution |
|-----|-----------------|
| S01 | 1/8             |
| S02 | 1/4             |
| S03 | 1/4             |
| S04 | 1/4             |
| S05 | 1/16            |
| S06 | 1/16            |
| S08 | 1/16            |

# Specification text changes, background

In current 3D-AVC depth view components used only for disparity derivation:

Max out of 4 corners:

A: top-left, B: top-right, C: bottom-left and D: bottom-right

$$A = d(Cb)_{x,y}$$

$$B = d(Cb)_{x+size\_h>>mixed\_res,y}$$

$$C = d(Cb)_{x,y+size\_v>>mixed\_res}$$

$$D = d(Cb)_{x+size\_h>>mixed\_res,y+size\_h>>mixed\_res}$$

$$d = \max(A,B,C,D)$$

# Specification text changes, overview

Proposal: in SPS integer multiplier and an integer divisor for horizontal and vertical resolution ratios: dHM, dHD, dVM, and dVD

$$A = d(Cb)_{dL,dT}$$

$$B = d(Cb)_{dR,dT}$$

$$A = d(Cb)_{dL,dB}$$

$$B = d(Cb)_{dR,dB}$$

$$d = \max(A,B,C,D)$$

Options:

1) Unconstrained depth resolution

$$dL = x * dHM / dHD$$

$$dT = y * dVM / dVD$$

$$dR = (x + size\_h) * dHM / dHD$$

$$dB = (y + size\_v) * dVM / dVD$$

2) Power-of-2 divisor

$$dL = x * dHM \gg \log2(dHD)$$

$$dT = y * dVM \gg \log2(dVD)$$

$$dR = (x + size\_h) * dHM \gg \log2(dHD)$$

$$dB = (y + size\_v) * dVM \gg \log2(dVD)$$

3) Dyadic depth-to-texture resolution ratio

$$dL = x \gg \log2(dHD)$$

$$dT = y \gg \log2(dVD)$$

$$dR = (x + size\_h) \gg \log2(dHD)$$

$$_8 dB = (y + size\_v) \gg \log2(dVD)$$



# Conclusions

- Best-performing depth resolutions:

|     | Synthesized views | Coded texture |
|-----|-------------------|---------------|
| S01 | 1/4               | 1/8           |
| S02 | 1/4               | 1/4           |
| S03 | 1/2               | 1/4           |
| S04 | 1/8               | 1/4           |
| S05 | 1/4               | 1/16          |
| S06 | 1/4               | 1/16          |
| S08 | 1/2               | 1/16          |

- Additional gains of depth resolution optimized for RD performance of synthesized views:

| Difference = Proposed - 3D-AVC (EHP with 1/2 resolution depth) |                    |                          |
|--|--------------------|--------------------------|
|  | Total (Coded PSNR) | Total (Synthesized PSNR) |
|  | dBR, %-unit        | dBR, %-unit              |
| Average  | -6.14              | -3.28                    |

- Additional gains of depth resolution optimized for multiview texture coding:

| Difference = Proposed - 3D-AVC (EHP with 1/2 resolution depth) |             |
|--|-------------|
| Total Vs. anchor without depth                                 |             |
|  | dBR, %-unit |
| Average  | -11.86      |

# Thank you

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