AHG5/AHG8: RGB4:4:4 video coding using HEVC multi-view extensions

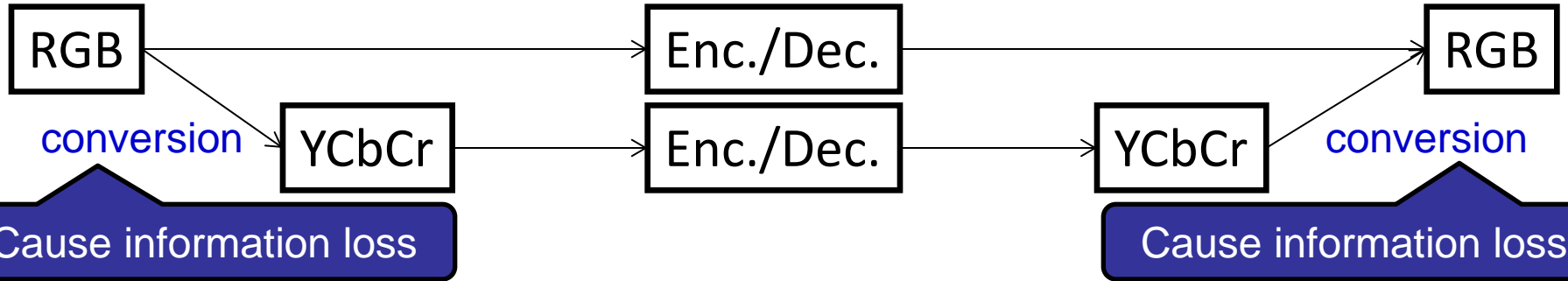Akira Minezawa, Shun-ichi Sekiguchi, Tokumichi Murakami

Mitsubishi Electric Corporation
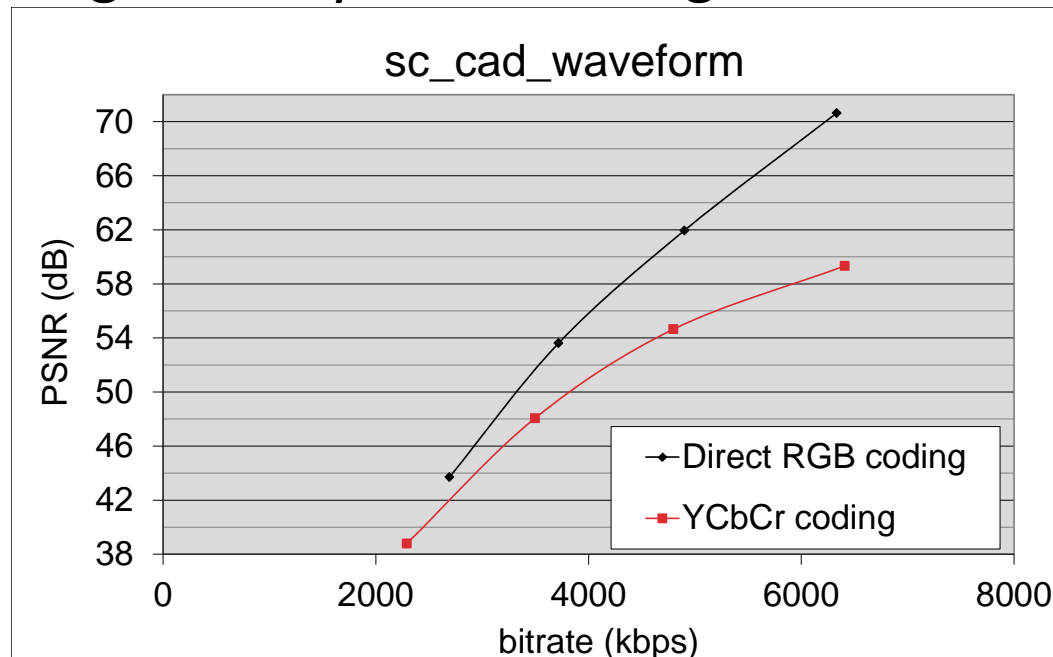
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Overall summary

- Propose a RGB domain coding architecture using HEVC multi-view extensions
  - Luma 4:0:0 coding for each color plane
  - G plane is used as one of reference pictures of inter prediction for corresponding R and B coding
  - No block-level changes from HEVC version 1

    (e.g., possibility of further performance improvements)

- The proposed scheme achieves 11-27% BD-rate gain compared with RExt anchor on average
  - With regard to screen contents, the proposed scheme has up to 33% average coding gain

- Recommend studying the proposed scheme in appropriate AHGs

RGB coding or YCbCr coding?

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for a greener tomorrow eco Changes

```
RGB ────────────────────────────────────→ Enc./Dec. ─────────────────────────────→ RGB
   conversion ↘                                                              ↗ conversion
              YCbCr ──────→ Enc./Dec. ──────→ YCbCr
```

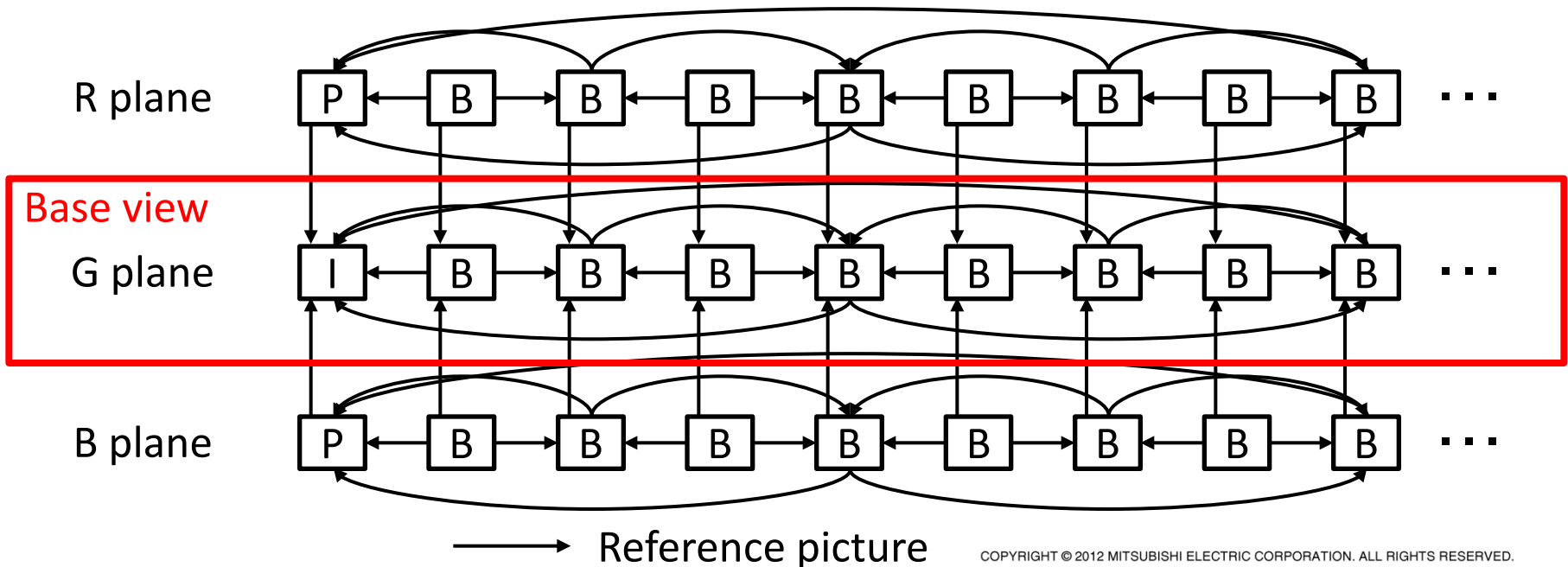**Cause information loss**   **Cause information loss**

- Color space conversion from RGB to YCbCr and back to RGB causes information loss in the original RGB color space

- Direct RGB domain coding is preferable to YCbCr domain coding for high fidelity video coding

sc_cad_waveform

Legend:
- Direct RGB coding
- YCbCr coding

X-axis: bitrate (kbps)
Y-axis: PSNR (dB)

Proposed RGB coding

- Propose a new architecture for direct RGB video coding by using MV-HEVC
  - Apply each color plane into a monochrome view source
  - G plane is used as one of reference pictures of inter prediction for corresponding R and B plane
- MV-HEVC is a high-level syntax extension of HEVC version 1
  - The proposed 4:4:4 coding requires no block-level changes from HEVC version 1 specification

R plane: P B B B B B B B B ···

Base view
G plane: I B B B B B B B B ···

B plane: P B B B B B B B B ···

⟶ Reference picture

Simulation Results

- Test conditions
  - Anchor: HM10.1_RExt3.0
  - PSNR:
    $$PSNR_{GBR} = \frac{4 \cdot PSNR_G + PSNR_B + PSNR_R}{6}, \qquad PSNR_{GBR^m} = \frac{PSNR_G + PSNR_B + PSNR_R}{3}$$
- Achieve 9.5% to 25.3% and 11.2% to 26.9% average BD-rate gains for $PSNR_{GBR}$ and $PSNR_{GBR}{}^m$ based measurement
  - With regard to screen contents, up to 33% average coding gains are achieved

	All Intra					
	Main-tier		**High-tier**		**Super High-tier**	
	$psnr_{GBR}$	$psnr_{GBR}{}^{m}$	$psnr_{GBR}$	$psnr_{GBR}{}^{m}$	$psnr_{GBR}$	$psnr_{GBR}{}^{m}$
RExt	-17.9%	-20.1%	-14.1%	-16.3%	-10.8%	-12.9%
SC	-32.0%	-33.0%	-28.8%	-29.8%	-26.1%	-26.9%
All	**-25.3%**	**-26.9%**	**-21.9%**	**-23.5%**	**-18.9%**	**-20.3%**

	Random Access					
	Main-tier		**High-tier**		**Super High-tier**	
	$psnr_{GBR}$	$psnr_{GBR}{}^{m}$	$psnr_{GBR}$	$psnr_{GBR}{}^{m}$	$psnr_{GBR}$	$psnr_{GBR}{}^{m}$
RExt	-5.3%	-7.9%	-6.2%	-8.1%	-5.8%	-6.9%
SC	-28.0%	-28.3%	-25.1%	-25.5%	-22.7%	-23.0%
All	**-17.3%**	**-18.7%**	**-16.2%**	**-17.3%**	**-14.7%**	**-15.4%**

	Low Delay B					
	Main-tier		**High-tier**		**Super High-tier**	
	$psnr_{GBR}$	$psnr_{GBR}{}^{m}$	$psnr_{GBR}$	$psnr_{GBR}{}^{m}$	$psnr_{GBR}$	$psnr_{GBR}{}^{m}$
RExt	5.1%	2.0%	-0.4%	-2.2%	-2.8%	-3.6%
SC	-22.5%	-22.9%	-20.6%	-20.9%	-19.2%	-19.3%
All	**-9.5%**	**-11.2%**	**-11.1%**	**-12.1%**	**-11.5%**	**-12.0%**

Additional Results

- Test under applying the OP offset for B and R plane
  - QP_B and QP_R are set to $QP_G + 6$
  - Anchor: HM10.1_RExt3.0 with and without QP offset
- Results
  - Achieve up to 43% BD-rate gain on average compared with RExt3.0
  - When applying QP offset, degree of coding improvement of the proposed scheme is enlarged relative to no QP offset condition

vs RExt3.0						vs RExt3.0 with QP offset					
All Intra						All Intra					
Main-tier		High-tier		Super High-tier		Main-tier		High-tier		Super High-tier	
$psnr_{GBR}$	$psnr_{GBR}^{m}$	$psnr_{GBR}$	$psnr_{GBR}^{m}$	$psnr_{GBR}$	$psnr_{GBR}^{m}$	$psnr_{GBR}$	$psnr_{GBR}^{m}$	$psnr_{GBR}$	$psnr_{GBR}^{m}$	$psnr_{GBR}$	$psnr_{GBR}^{m}$
-44.1%	-31.5%	-37.8%	-23.1%	-30.8%	-16.7%	-27.1%	-33.2%	-21.2%	-25.8%	-15.9%	-19.7%
-42.2%	-37.9%	-37.5%	-33.2%	-33.9%	-29.8%	-36.7%	-39.3%	-32.6%	-34.8%	-29.2%	-31.1%
-43.1%	**-34.9%**	**-37.6%**	**-28.5%**	**-32.4%**	**-23.7%**	**-32.2%**	**-36.4%**	**-27.2%**	**-30.6%**	**-22.9%**	**-25.7%**
Random Access						Random Access					
Main-tier		High-tier		Super High-tier		Main-tier		High-tier		Super High-tier	
$psnr_{GBR}$	$psnr_{GBR}^{m}$	$psnr_{GBR}$	$psnr_{GBR}^{m}$	$psnr_{GBR}$	$psnr_{GBR}^{m}$	$psnr_{GBR}$	$psnr_{GBR}^{m}$	$psnr_{GBR}$	$psnr_{GBR}^{m}$	$psnr_{GBR}$	$psnr_{GBR}^{m}$
-40.5%	-24.1%	-42.0%	-19.0%	-37.5%	-11.2%	-13.3%	-19.0%	-14.0%	-16.3%	-12.2%	-12.7%
-39.2%	-32.8%	-35.1%	-28.5%	-31.7%	-25.4%	-32.1%	-34.1%	-29.0%	-30.4%	-25.9%	-27.0%
-39.8%	**-28.7%**	**-38.3%**	**-24.0%**	**-34.4%**	**-18.7%**	**-23.2%**	**-27.0%**	**-21.9%**	**-23.8%**	**-19.4%**	**-20.3%**
Low Delay B						Low Delay B					
Main-tier		High-tier		Super High-tier		Main-tier		High-tier		Super High-tier	
$psnr_{GBR}$	$psnr_{GBR}^{m}$	$psnr_{GBR}$	$psnr_{GBR}^{m}$	$psnr_{GBR}$	$psnr_{GBR}^{m}$	$psnr_{GBR}$	$psnr_{GBR}^{m}$	$psnr_{GBR}$	$psnr_{GBR}^{m}$	$psnr_{GBR}$	$psnr_{GBR}^{m}$
-38.0%	-18.8%	-41.3%	-16.2%	-36.4%	-9.5%	-2.8%	-10.6%	-7.5%	-11.2%	-8.1%	-9.9%
-35.9%	-28.7%	-32.2%	-24.8%	-28.9%	-21.9%	-27.3%	-29.7%	-24.6%	-26.2%	-22.0%	-23.2%
-36.9%	**-24.1%**	**-36.5%**	**-20.7%**	**-32.5%**	**-16.0%**	**-15.8%**	**-20.7%**	**-16.5%**	**-19.1%**	**-15.4%**	**-17.0%**

Conclusions

- Propose a direct RGB coding architecture using MV-HEVC
  - Apply each color plane into a monochrome view source
  - No block-level changes from HEVC version 1 specification

- The proposed scheme achieves 11-27% BD-rate gains compared with RExt3.0 on average
  - Achieve up to 33% average coding gain for screen contents
  - In the condition of using QP offset for B and R plane, further coding gains are obtained

- Recommend studying the proposed scheme in appropriate AHGs
  - Consider the proposed scheme as base coding architecture for further improvement of direct RGB coding based on HEVC
  - The proposed architecture can easily apply for future extensions on multi-spectrum video/image signals

Supplemental slides

vs separate color plane coding

- Anchor: Separate RGB color plane coding using 4:0:0 coding of HM10.1_RExt3.0

- Results
  - Achieve coding improvement for all test sequences
  - 12.7% to 26.2% and 12.5% to 26.8% average BD-rate gains for $PSNR_{GBR}$ and $PSNR_{GBR}^{m}$ based measurement

	All Intra					
	Main-tier		**High-tier**		**Super High-tier**	
	$psnr_{GBR}$	$psnr_{GBR}^{m}$	$psnr_{GBR}$	$psnr_{GBR}^{m}$	$psnr_{GBR}$	$psnr_{GBR}^{m}$
RExt	-19.1%	-20.0%	-13.9%	-14.9%	-9.8%	-10.7%
SC	-32.6%	-32.8%	-28.8%	-28.9%	-25.6%	-25.6%
All	**-26.2%**	**-26.8%**	**-21.8%**	**-22.3%**	**-18.2%**	**-18.6%**

	Random Access					
	Main-tier		**High-tier**		**Super High-tier**	
	$psnr_{GBR}$	$psnr_{GBR}^{m}$	$psnr_{GBR}$	$psnr_{GBR}^{m}$	$psnr_{GBR}$	$psnr_{GBR}^{m}$
RExt	-17.3%	-16.8%	-11.4%	-11.1%	-7.2%	-7.0%
SC	-31.1%	-30.4%	-27.0%	-26.4%	-23.7%	-23.1%
All	**-24.6%**	**-24.0%**	**-19.7%**	**-19.2%**	**-16.0%**	**-15.5%**

	Low delay B					
	Main-tier		**High-tier**		**Super High-tier**	
	$psnr_{GBR}$	$psnr_{GBR}^{m}$	$psnr_{GBR}$	$psnr_{GBR}^{m}$	$psnr_{GBR}$	$psnr_{GBR}^{m}$
RExt	-8.9%	-8.8%	-5.6%	-5.5%	-3.6%	-3.5%
SC	-27.5%	-27.3%	-23.8%	-23.5%	-20.9%	-20.5%
All	**-18.8%**	**-18.6%**	**-15.2%**	**-15.0%**	**-12.7%**	**-12.5%**