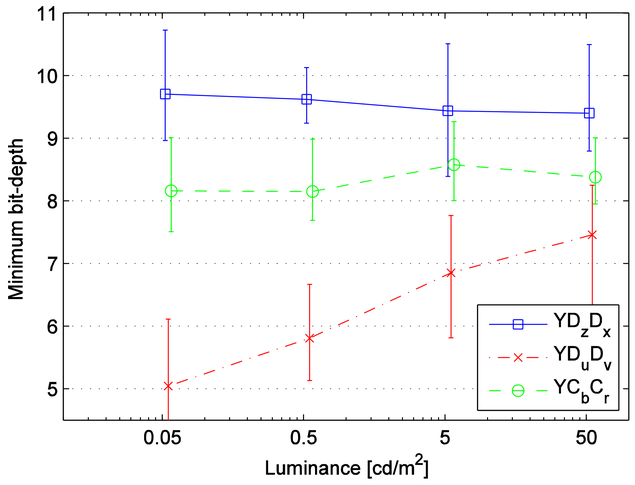
CHROMA SCALING FOR HIGH DYNAMIC RANGE VIDEO COMPRESSION

Ronan Boitard[1], Mahsa T. Pourazad[1,2], Panos Nasiopoulos[1]
[1]University of British Columbia
[2]TELUS Communications Inc.

Introduction

■ **Perceptual encoding: preserve visual information on limited bit-depth**

- **Standard Dynamic Range (SDR):**
  - 8 bits
  - $Y'C_bC_r$
- **High Dynamic Range (HDR):**
  - 10 bits
  - $Y'C_bC_r$? $Y'D_zD_x$? $Y'D_uD_v$?
  - Do chroma channels need 10 bits? [1]



- **$Y'C_bC_r$ requires 9 to 10 bits**
- **$Y'D_uD_v$ requires 6 to 9 bits:** (Luminance dependent)

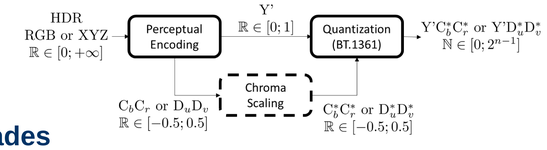
■ **Why use $Y'D_uD_v$?**

- **Better decorrelation between luma and chroma**
- **Color space more perceptually uniform than $Y'C_bC_r$**
- **Can represent the full color gamut**
- **Representation independent from color primaries (e.g,. BT.709, BT.2020)**
- **Chroma downsampling generates color artifacts in Y'CbCr**

Chroma Scaling

■ **Chroma Scaling?**

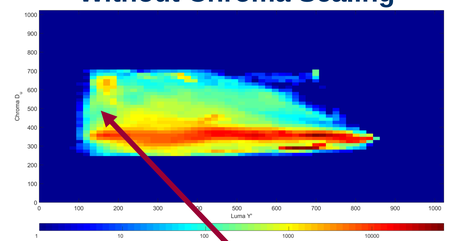
- **Optimize usage of code words with respect to the Human Visual System (HVS) properties**



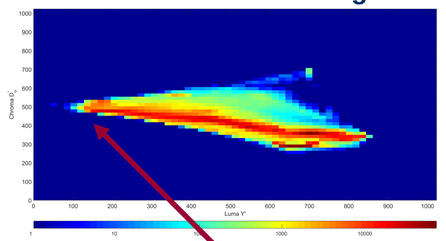
■ **Benefits?**

- **Remove invisible color shades**
- **Signal easier to predict**
- **Increase compression efficiency!**

Without Chroma Scaling



With Chroma Scaling



HVS cannot differentiate color shades at low luminance

Our method uses fewer code words where the HVS is less sensitive

Chroma Scaling & Compression Efficiency

■ **Proposed Scaling:**

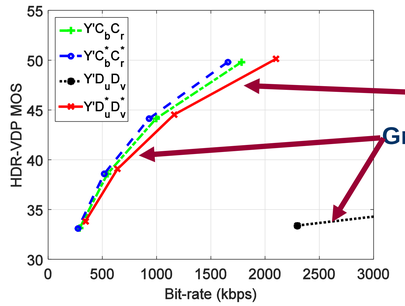
- **$Y'C_bC_r$ 10 bits chroma (Green)**
- **$Y'C_b^*C_r^*$ 9 bits chroma (Blue)**

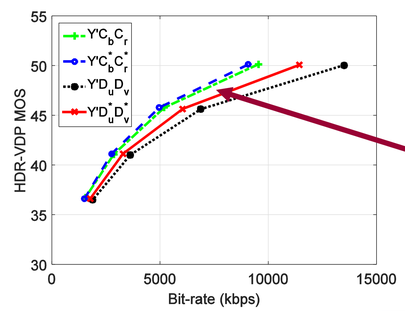
$$\mathbf{C}^* = 2^{9-n}\mathbf{C},$$

- **$Y'D_uD_v$ 10 bits Chroma (Black)**
- **$Y'D_u^*D_v^*$ 6 to 9 bits chroma (Yellow)**

$$\mathbf{C}^* = 2^{\frac{p(50)-p(0.05)}{log(50/0.05)}log(\mathbf{Y})+b-n}\mathbf{C},$$

p(50): bit-depth at 50 cd/m²= 9,
p(0.05): bit-depth at 0.05 cd/m²= 6,
b: offset =7.301
n: targetted bit-depth = 10



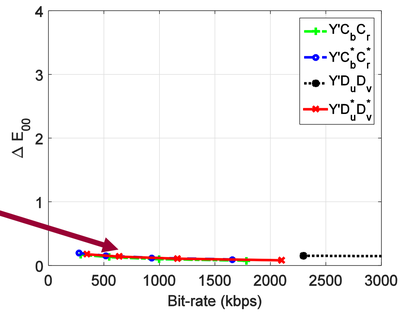


Night scene (FireEater2)

Lower bit-rates for same VDP MOS

Great gain for $Y'D_u^*D_v^*$ compared to $Y'D_uD_v$

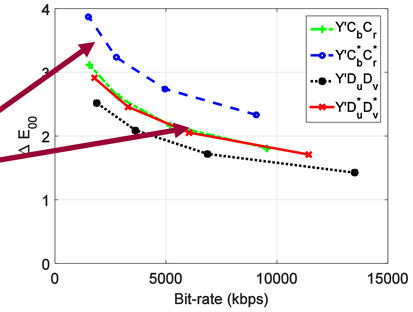
No impact on color accuracy



Day scene (Market3)

Loss of color accuracy using $Y'C_b^*C_r^*$

$Y'C_bC_r$ outperforms $Y'D_u^*D_v^*$



Conclusion

■ **Our method allows $Y'D_uD_v$ to handle well night scenes**
■ **Our method can be adapted to any color representation IC_tC_p, $Y'D_zD_x$, etc.**
■ **Our method does not seem to increase $Y'C_bC_r$ compression efficiency on 10 bits**

Reference

[1] R. Boitard et al., "Evaluation of color encodings for high dynamic range pixels," in *Proc. SPIE 9394, Human Vision and Electronic Imaging XX*, 2015

a place of mind
THE UNIVERSITY OF BRITISH COLUMBIA