HV3D: Human Visual System Based 3D Video Quality Metric

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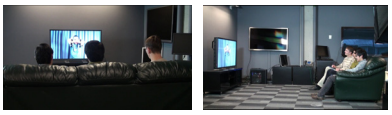
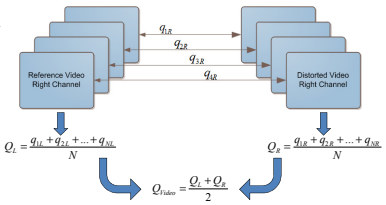
Introduction

- Subjective quality evaluation: not always practical, time-consuming
- No standard 3D Quality Metric (QM) available yet
- MPEG is looking for a QM for 3D video compression standard
- 2D metrics fail for 3D picture quality evaluation. They do not take into account:
  - depth perception
  - binocular properties of HVS (Human Visual System)
  - size of the screen (not important in 2D; 3D content has different depth effect on different 3D screen sizes)

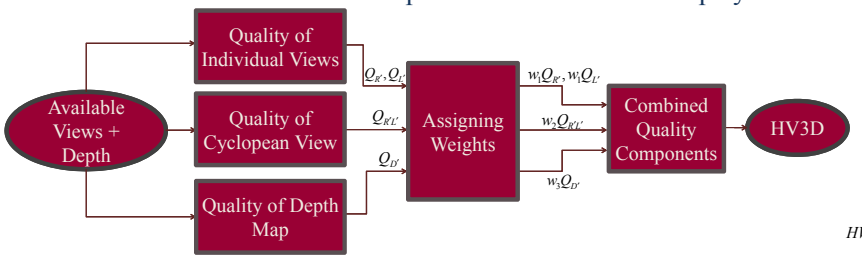


A widely used approach



Our proposed 3D quality metric: HV3D

- HV3D is a full reference metric, which is designed based on human visual 3D perception
- HV3D takes into account the specifications of the 3D display



$$HV3D = w_1Q_{R'} + w_1Q_{L'} + w_2Q_{R'L'} + w_3Q_{D'}$$

$$w_1Q_{R'} = [w_1VIF(Y_R, Y_{R'}) + w_4VIF(U_R, U_{R'}) + w_4VIF(V_R, V_{R'})$$

$$w_1Q_{L'} = w_1VIF(Y_L, Y_{L'}) + w_4VIF(U_L, U_{L'}) + w_4VIF(V_L, V_{L'})$$

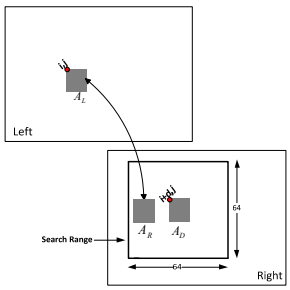
$$w_2Q_{R'L'} = w_2VIF(D, D')^{\beta} \cdot \sum_{i=1}^{N} \frac{SSIM(IDCT(XC_i), IDCT(XC_i'))}{N}$$

$$w_3Q_{D'} = w_3VIF(D, D')^{\beta} \cdot \sum_{i=1}^{N} \frac{\sigma_{d_i}^2}{N.\max(\sigma_{d_j}^2 \mid j=1,2,\ldots,N)}]$$

$$\hat{HV3D} = \frac{HV3D}{HV3D_{\max}} \qquad HV3D_{\max} = 2w_1 + 4w_4 + w_2 + w_3 \cdot \sum_{i=1}^{N} \frac{\sigma_{d_i}^2}{N \max\{\sigma_{d_j}^2 \mid j=1,2,\ldots,N\}}$$

Cyclopean view

- HVS fuses left & right views into a single cyclopean view.
- We model the cyclopean view:
  - Finding matching blocks
  - 3D-DCT transform
  - CSF (Contrast Sensitivity Function) mask modeling

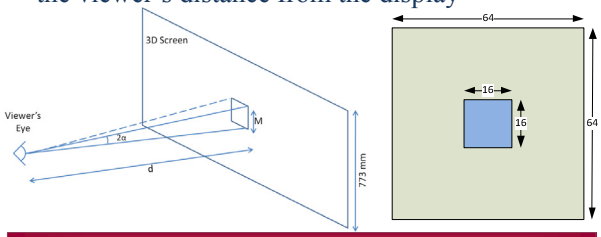


$$XC = \sum_{i=1}^{16}\sum_{j=1}^{16} C_{i,j}X_{i,j}$$

cyclopean view — CSF — low freq. coef. of 3D-DCT

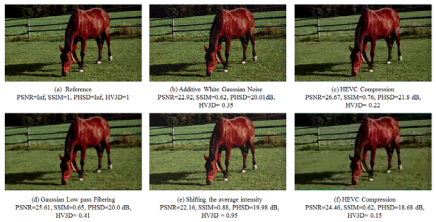
Quality of depth map

- The quality of depth map is measured over the projected picture area on the viewer's eye fovea
- The size of this picture area is measured based on the size and resolution of the display, as well as the viewer's distance from the display

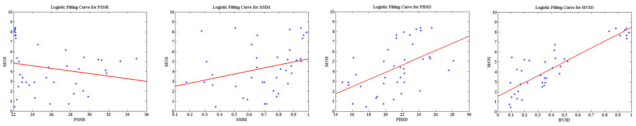


Experimental results

- Typical metric values (only left view is shown):



- Correlation with MOS (Mean Opinion Score):



Some applications of HV3D

Quality assessment of 3D videos on different sizes of 3D screens

Quality assessment of the 3D compressed videos