Linear Optimization Approach for Depth Range Adaption of Stereoscopic Videos

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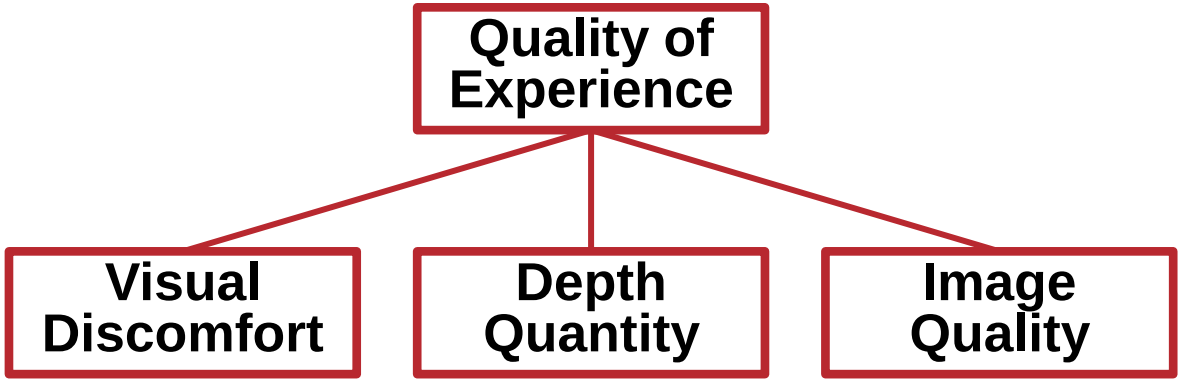
Linear Optimization Approach for Depth Range Adaption of Stereoscopic Videos

- Introduction
  - 3D Quality of Experience Model
- Approach
  - Optimization Problem
  - Comfort Zone
  - Human Visual Attention Data
- Experiments
  - Subjective Assessment and Reference Material

Quality of Experience Model for Stereoscopic Videos

[Chen2012]: Key aspects Visual Discomfort (VDC), Depth Quantity (DQ) and Image Quality (IQ)



Challenge of Stereoscopic Post-Production: Maximize DQ, minimize VDC and minimize Deterioration of IQ

Key Aspects of Quality of Experience

- **Visual Discomfort (VDC)**

  Depth distance of object of interest to screen increases ➔ Accommodation-vergence conflict increases ➔ VDC increases

- **Depth Quantity (DQ)**

  Depth range increases ➔ DQ increases

- **Deterioration of Image Quality (DIQ)**

  More complex depth mapping operators ➔ DIQ increases

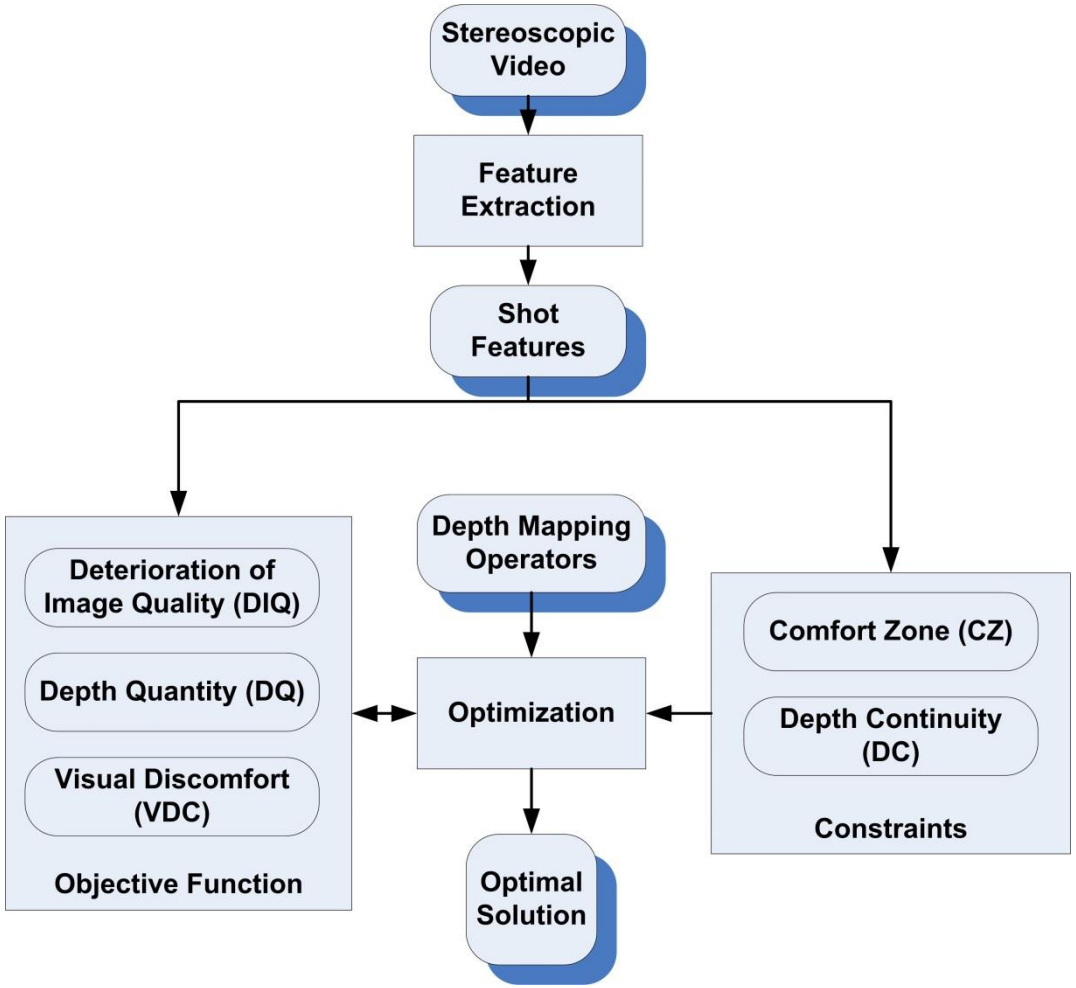
- **Comfort Zone (CZ)**

  Best practice design pattern for depth range limits (w.r.t. display system)

- **Depth Continuity of attracting image parts (DC)**

  Particularly at shot transitions

Optimization of Quality of Experience



Approach

Objective Function

- Measures for $A \in \{\mathrm{DQ}, \mathrm{VDC}, \mathrm{DIQ}\}$ as function of the depth mapping operators $\phi_{p_1,\ldots,p_n}$ and the shot s:

$$\mu_A = \mu_A(\phi_{p_1,\ldots,p_n}, s)$$

- Maximize Depth Quantity (DQ), minimize Visual Discomfort (VDC), minimize Deterioration of Image Quality (DIQ)

$$\mu_{\mathrm{QoE}} = \mu_{\mathrm{DQ}} - \mu_{\mathrm{VDC}} - \mu_{\mathrm{DIQ}}$$

Optimization of Quality of Experience

Constraints:

- Comfort Zone

$$d(\phi(f)) \in [D_m(s), D_M(s)]$$

- Depth Continuity of objects of interest

$$|d_{ooi}(\phi(f_i^+)) - d_{ooi}(\phi(f_{i+1}^-))| \leq \lambda$$

Optimization of Quality of Experience

- Linear optimization problem; solved by Simplex-Algorithm [Nelder1965]

$$\max_{p_1,\ldots,p_n} \frac{1}{N} \sum_{i=1}^{N} \mu_{\mathrm{QoE}}(\phi_{p_1,\ldots,p_n}, s_i)$$

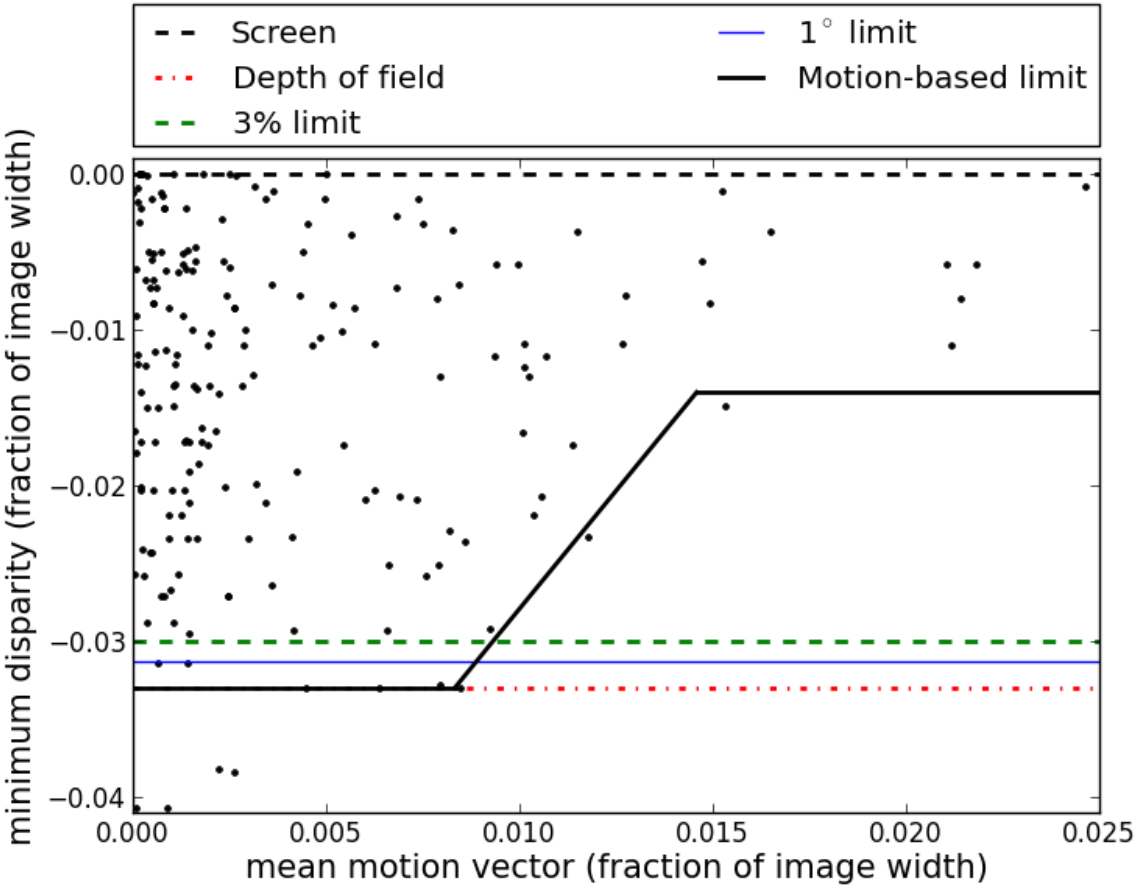
subject to

$$d(\phi(f)) \in [D_m(s_i), D_M(s_i)] \qquad \forall f \in s_i$$

$$|d_{ooi}(\phi(f_i^+)) - d_{ooi}(\phi(f_{i+1}^-))| \leq \lambda \quad \forall f_i^+, f_{i+1}^-$$

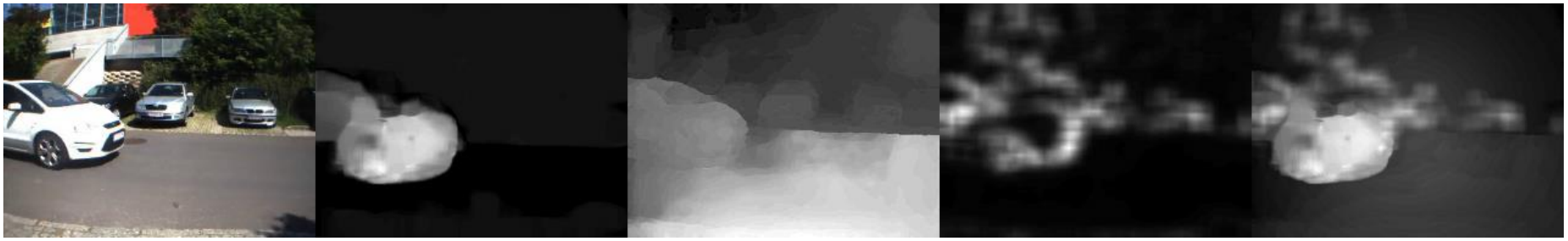
Analysis and Parameterization of Comfort Zones

- Dependency on motion-characteristics of the scene



Depth Continuity of Objects of Interest

- by means of a S3D human visual attention model



Maximum pooling of

- Motion map [Farneback2003]
- Disparity map [emotion3D]
- Spectral residual saliency map [Hou2007]
- Center Bias

Experimental Evaluation and Reference Material

- 17 subjects
- 12 videos
  - 5 High-motion self-captured
  - 4 High-quality from [MmspgDB]
  - 3 Anaglyph from [Yan2013]
- Questions: Depth Quantity, Visual Comfort and Image Quality
- Set-up after [ITU-R]
- http://www.scch.at/en/id-3d-visual-discomfort-database

Experimental Evaluation: Comparison to [Yan2013]

- Improvement of Visual Comfort is significant

(t = 3.606; p = 0.0004)

<u>Top bars:</u> mean level of DQ, IQ and Visual Comfort for videos of [Yan2013]

<u>Bottom bars:</u> Our results

Experimental Evaluation: Overall

- 24 videos
- Subjective assessment results combined in two sets
  - Set A: original videos
  - Set B: mapped videos

Result:

The mean level of Visual Comfort is significantly higher for the mapped videos (set B) than for the original videos (set A).

The level of Image Quality and Depth Quantity could not be observed for being statistically significantly different.

References

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[Nelder1965] Nelder, John A., and Roger Mead. "A simplex method for function minimization." The computer journal 7.4 (1965): 308-313.

Database: http://www.scch.at/en/id-3d-visual-discomfort-database

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Thank You!

Questions?