Characterization and selection of light field content for perceptual assessment

P. Paudyal[1], J. Gutiérrez[2], P. Le Callet[2], M. Carli[1], F. Battisti[1]

[1] Telecommunication Lab (COMLAB)
Università degli Studi Roma TRE

[2]Image, Interaction, Perception Group (IPI)
Laboratoire des Sciences du Numérique de Nantes (LS2N)
Université de Nantes

08/05/2017 - VQEG Meeting

Introduction and motivation

- Light field imaging provides two main applications to immersive media:

Changing View-point

Refocusing

Introduction and motivation

- Light field technology introduces novelties in the whole processing chain:

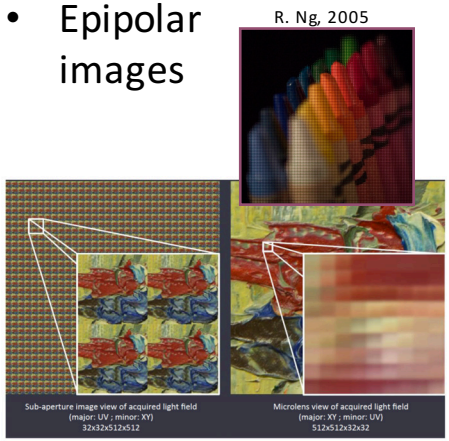
Content acquisition

- Camera arrays
- Plenoptic cameras

Lytro Immerge

Representation

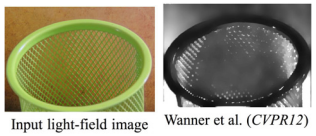
- Plenoptic image
- Elemental images
- Multiview
- Epipolar images



L. Baboulaz, 2014

Pre/post-processing

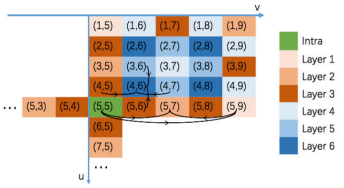
- Demosaicking, devigneting, rectification, …
- Depth map estimation.
- Super-resolution.
- View synthesis.



Input light-field image — Wanner et al. (*CVPR12*)

Coding

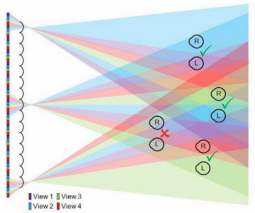
- DCT-based
- Wavelet-based
- Multiview-video-based
- Standard encoders: HEVC



D. Liu, ICME2016

Rendering

- Light Field Displays
- HMDs
- Applications in normal displays.



Introduction and motivation

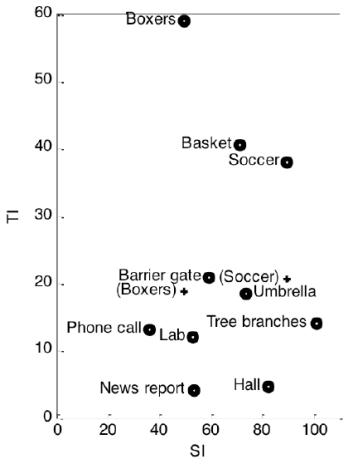
- New considerations are required to evaluate perceptual aspects with light field technologies:
  - Study of appropriate techniques to evaluate Quality of Experience (QoE).
    - Methodologies for **subjective evaluation**.
    - Development of **objective metrics**.
  - Evaluation of perceptual impact of **degradations**.
  - Generation of **datasets** for perceptual quality evaluation.
- 1st step: Proposed framework for light field content characterization and selection.
  - Paper in QoMEX 2017.

Content characterization

- Appropriate selection of content for QoE evaluation is crucial:
  - Image/Video characteristics
  - Application under study
  - Purpose of the evaluation

2D content

- Type of content:
  - Natural vs. animation
  - Realistic application (e.g., movies, sports, …) vs. system-performance evaluation (standard tests).
- Coding complexity:
  - Spatial, temporal, and color properties: SI, TI, …
- Duration, resolution, framerate…



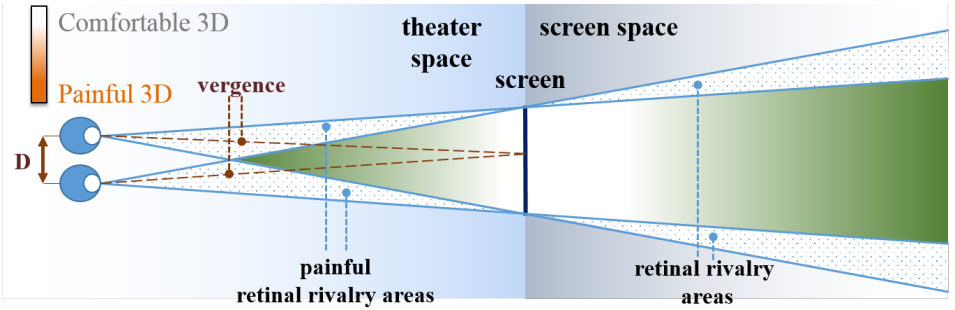
M. Pinson, M. Barkowsky, and P. Le Callet, "Selecting scenes for 2D and 3D subjective video quality tests," *EURASIP J. Image Video Process.*, vol. 2013, no. 1, pp. 50–61, Aug. 2013..

Content characterization

- Appropriate selection of content for QoE evaluation is crucial:
  - Image/Video characteristics
  - Application under study
  - Purpose of the evaluation

3D content added:

- Horizontal disparities.
- Depth budget.
- Visual comfort and fatigue.
- Motion in depth plane.
- Disparity changes (e.g., DTI).
- Occlusions.



[1] S. Winkler, "Efficient measurement of stereoscopic 3D video content issues", *Electronic Imaging*, Jan. 2014.

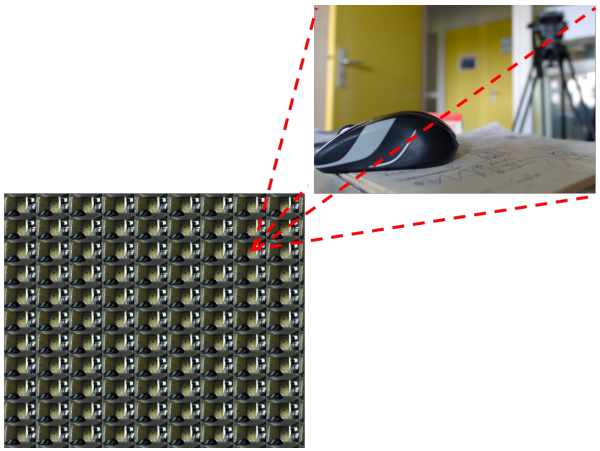
[2] M. Urvoy, J. Gutiérrez, M. Barkowsky, R. Cousseau, Y. Koudota, N. García, V. Ricordel, and P. Le Callet, "NAMA3DS1-COSPAD1: Subjective video quality assessment database on coding conditions introducing freely available high quality 3D stereoscopic sequences", *International Workshop on Quality of Multimedia Experience*, pp. 109–114, Yarra Valley, Australia, Jul. 2012.

Content characterization

- Appropriate selection of content for QoE evaluation is crucial:
  - Image/Video characteristics
  - Application under study
  - Purpose of the evaluation

Light Field content added:

- Vertical disparities.
- Refocusing possibilities.



Content characterization

- Proposed characterization for light field content: **2D features**
  - **Spatial Indicator** (SI) — ITU-T, "Recommendation P.910, Subjective video quality assessment methods for multimedia applications", Apr. 2008
  - **Colorfulness** — D. Hasler and S. E. Suesstrunk, "Measuring colorfulness in natural images", *Electronic Imaging*, 2003.
  - **Contrast** — R. M. Haralick, K. Shanmugam et al., "Textural features for image classification", *IEEE Trans. on systems, man, and cybernetics*, vol. 3, no. 6, pp. 610–621, Nov. 1973.

Content characterization

- Proposed characterization for light field content: **3D features**
  - **Depth map and depth histogram**
    - Various alternatives for dense and sparse light fields: multiview correspondence, epipolar images, etc.
    - For Lytro images: *Lytro Desktop SW*.
  - **Disparity range**

    S. Wanner, S. Meister, and B. Goldluecke, "Datasets and Benchmarks for Densely Sampled 4D Light Fields," in *Annual Workshop on Vision, Modeling and Visualization*, 2013, pp. 225–226.
  - **Occlusions**

    T. Wang, A. Efros, and R. Ramamoorthi, "Depth estimation with occlusion modeling using light-field cameras", *IEEE Transactions On Pattern Analysis And Machine Intelligence, 2016*.

Content characterization

- Proposed characterization for light field content: **Refocusing**
  - Focus metrics

    W. Wu, P. Llull, I. Tosic, N. Bedard, K. Berkner, and N. Balram, "Content-adaptive focus configuration for near-eye multi-focal displays," *IEEE Int. Conf. on Multimedia and Expo*, pp. 1–6, Jul. 2016
  - *Focusness* and *objectness* measures

    N. Li, J. Ye, Y. Ji, H. Ling, and J. Yu, "Saliency Detection on Light Field," *IEEE Conf. on Computer Vision and Pattern Recognition*, Jun. 2014, pp. 2806–2813.
  - **"Shift & sum"**:
    - "Refocused images can be obtained by adding shifted sub-aperture images" (Ng. *et al.*)
    - Algorithm implemented in Matlab toolbox:

      D. G. Dansereau, O. Pizarro, and S. B.Williams, "Decoding, Calibration and Rectification for Lenselet-Based Plenoptic Cameras," *IEEE Conf. on Computer Vision and Pattern Recognition,* Jun. 2013, pp. 1027–1034.
    - **Refocusing range** → Slope parameters to obtain images refocused on the nearest and furthest objects of the scene.

Datasets

- Existing datasets:
  - Stanford LF dataset [1]
  - Densely sampled 4D light fields [2]
  - EPFL [3]
  - SMART [4]
  - IRISA [5]

[1] V. Vaish and A. Adams, "The (new) stanford light field archive," 2008. Available: http://lightfield.stanford.edu/

[2] S. Wanner and B. Goldluecke, "Variational Light Field Analysis for Disparity Estimation and Super-Resolution," *IEEE Trans. on Pattern Analysis and Machine Intelligence*, vol. 36, no. 3, pp. 606–619, Mar. 2014.

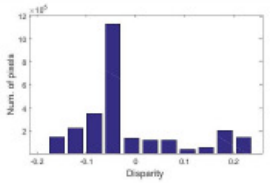
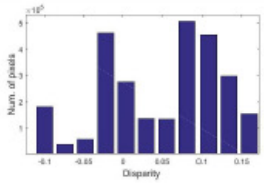
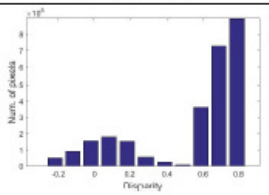
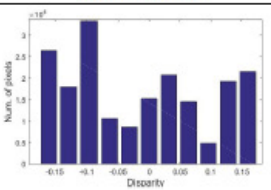
[3] M. Rerabek and T. Ebrahimi, "New light field image dataset," *Int. Conf. on Quality of Multimedia Experience*, Lisbon, Portugal, Jun. 2016.

[4] P. Paudyal, R. Olsson, M. Sj¬ostr¬om, F. Battisti, and M. Carli, "Smart: a light field image quality dataset," *Int. Conference on Multimedia Systems*, May 2016.

[5] R. Daudt and C. Guillemot, "Lytro Illum Light Field Dataset," 2016. Available: https://www.irisa.fr/temics/demos/IllumDatasetLF/index.html

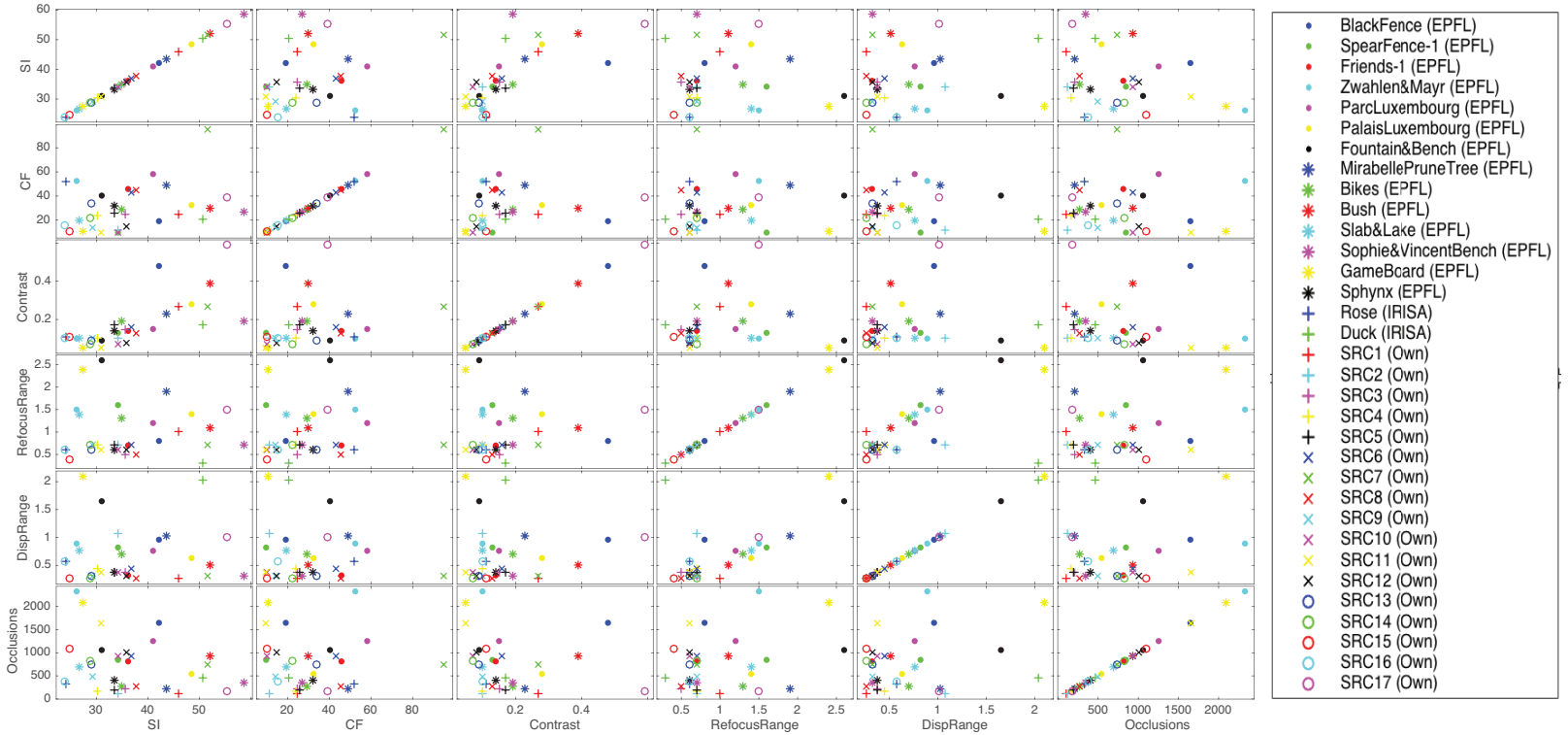
- Generation of a **new dataset** according to this characterization:

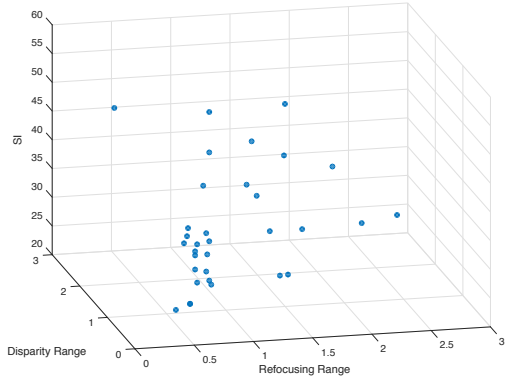
Results

Preview				
Dataset	Own	Own	Own	EPFL
Main application	Viewpoint changing	Refocusing	Viewpoint changing & Refocusing	Refocusing
Spatial Indicator	34.10	24.83	55.21	36.14
Colorfulness	10.12	10.37	38.97	45.85
Contrast	0.07	0.11	0.59	0.14
Refocusing Range	[-0.4, 0.2]	[-0.3, 0.1]	[-1.4, 0.1]	[-0.3, 0.4]
Occluded pixels	930	1091	171	813
Disparity range	[-0.16, 0.22]	[-0.1, 0.16]	[-0.22, 0.79]	[-0.16, 0.16]
Depth Distribution				

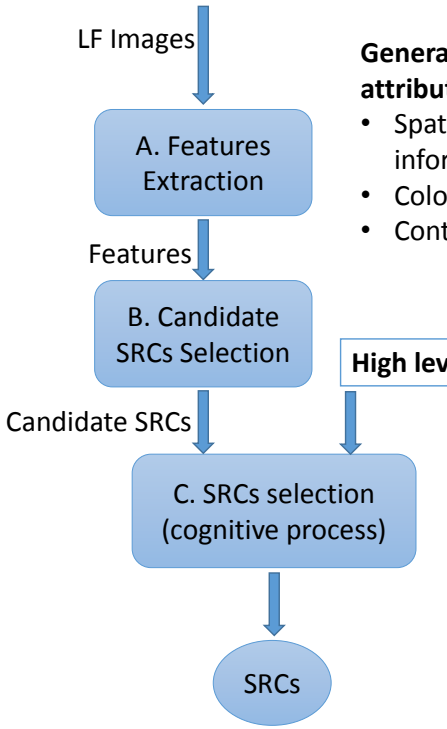
Results

- Examples of data representation





Content selection



High level Features

General visual quality attributes

- Spatial perceptual information
- Colorfulness
- Contrast, etc.

LF imaging specific attributes

- Depth properties (depth map, depth histogram, diversity rage, occlusion)
- Refocusing features: Depth of Fields, etc.

General categories

- Indoor/outdoor
- Peoples, nature, landscape, buildings, grid, light, etc.

LF imaging capabilities

- complex scenes with transparency, reflections, high occluded area, etc.

Future work

- Subjective assessment tests:
  - Coding artifacts.
  - View-synthesis.
  - Performance of refocusing and changing viewpoint.

- Publication of a new annotated dataset:
  - Features from the characterization.
  - Subjective results.

Characterization and selection of light field content for perceptual assessment

P. Paudyal[1], J. Gutiérrez[2], P. Le Callet[2], M. Carli[1], F. Battisti[1]

[1] Telecommunication Lab (COMLAB)
Università degli Studi Roma TRE

[2]Image, Interaction, Perception Group (IPI)
Laboratoire des Sciences du Numérique de Nantes (LS2N)
Université de Nantes

08/05/2017 - VQEG Meeting