OPTIMIZED INTER-VIEW PREDICTION BASED LIGHT FIELD IMAGE COMPRESSION WITH ADAPTIVE RECONSTRUCTION

ICIP 2017 LF Image Coding Grand Challenge

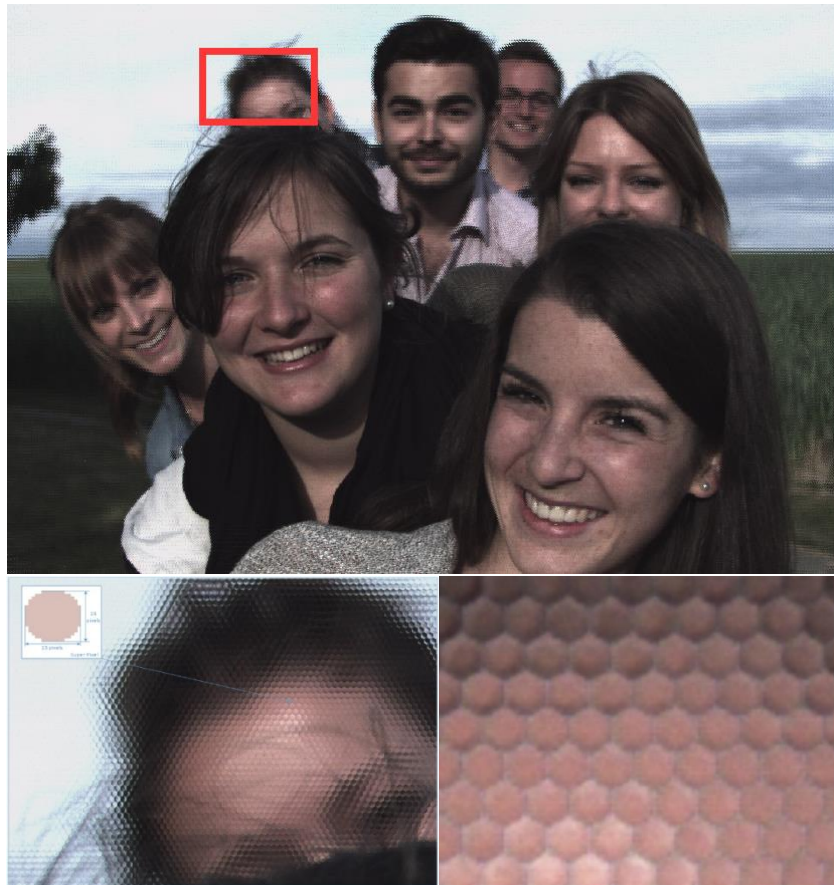[1]Chuanmin Jia,
cmjia@pku.edu.cn

Joint work with [1]Yekang Yang, [2]Xinfeng Zhang, [1]Xiang Zhang, [3]Shiqi Wang, [1]Shanshe Wang, [1]Siwei Ma
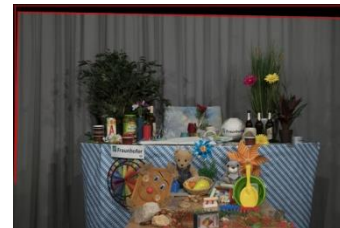
[1]Institute of Digital Media (IDM), PKU
[2]Rapid-Rich Object Search (ROSE) Lab, NTU
[3]CS Department, City University of Hong Kong

2017/9/18

Light Field Image
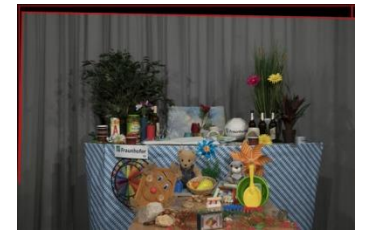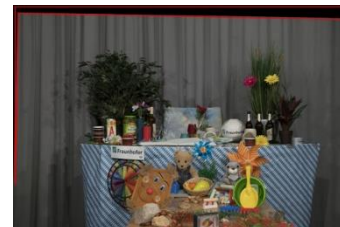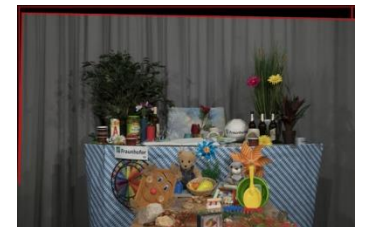
◆ Lenslet

◆ High Density Camera Array

LF Image Coding Standardization

◆ JPEG Pleno[1]

   ✓ Grand Challenge for LF image coding: ICME-2016, ICIP-2017
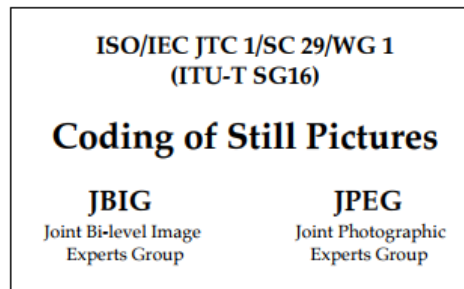
[1] https://jpeg.org/jpegpleno/workplan.html

LF Image Coding Standardization

◆ **JPEG Pleno**

  ✓ Grand Challenge for LF image coding: ICME-2016, ICIP-2017

  ✓ Call for Proposal (CfP) in 74th WG1 meeting in Geneva (2017.2)[1]

ISO/IEC JTC 1/SC29/WG1 N74014
74th Meeting, Geneva, Switzerland, January 15-20, 2017

ISO/IEC JTC 1/SC 29/WG 1
(ITU-T SG16)

Coding of Still Pictures

JBIG
Joint Bi-level Image
Experts Group

JPEG
Joint Photographic
Experts Group

[1] https://jpeg.org/downloads/
jpegpleno/wg1n74014_pleno_final_cfp.pdf

TITLE: JPEG Pleno Call for Proposals on Light Field Coding

Proposed Coding Tools

◆ Sub-aperture Rearrangement Mechanism

◆ Enhanced Illuminance Compensation

◆ Adaptive Lenslet Reconstruction
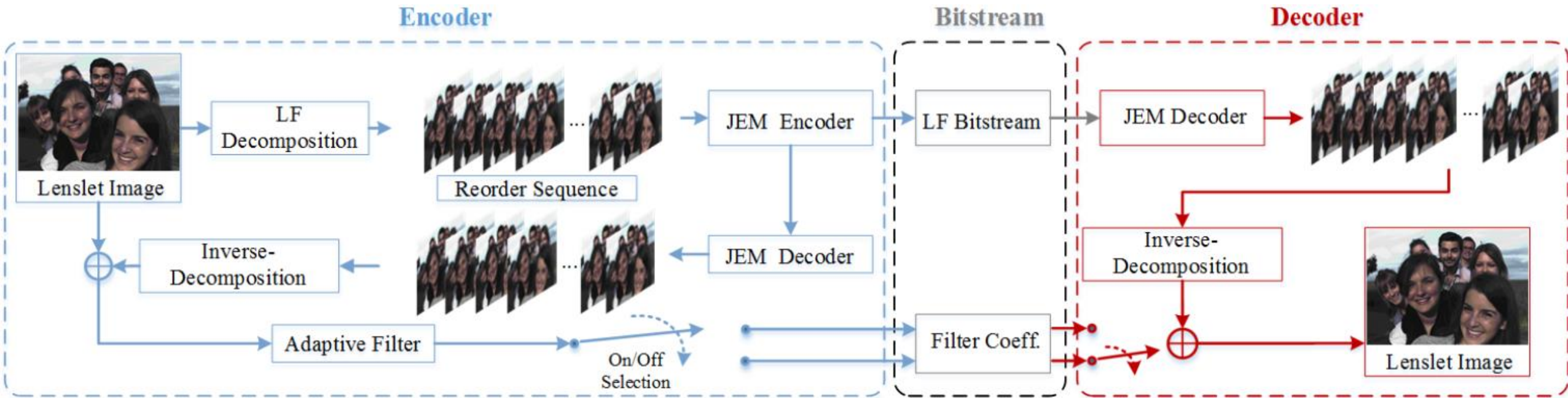
Flowchart

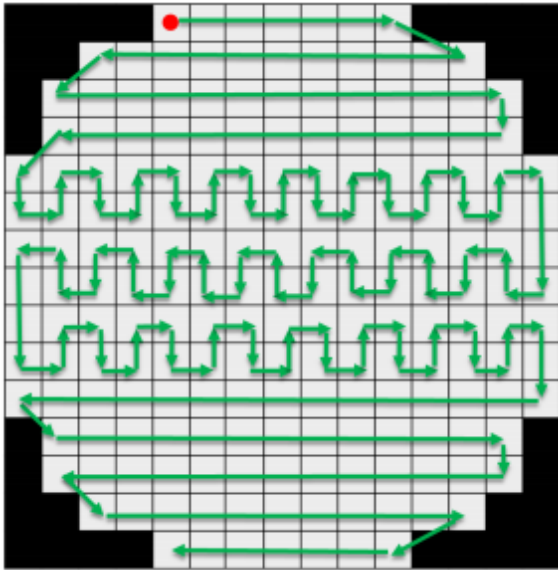◆ Processing chain: YCbCr-444, bit-depth: 10 bit

Proposed Coding Tools

◆ Sub-aperture Rearrangement Mechanism

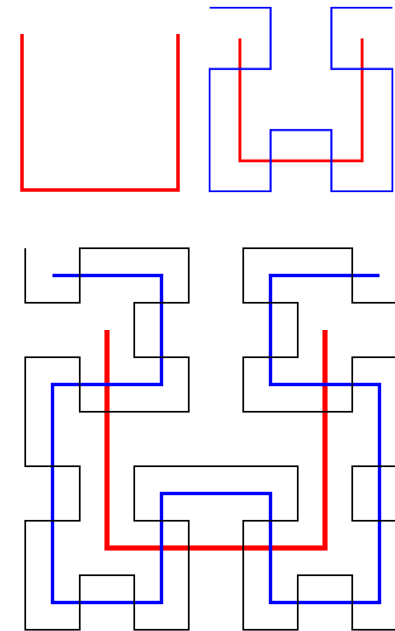◆ Enhanced Illuminance Compensation

◆ Adaptive Lenslet Reconstruction

Sub-aperture Reorder

◆ Inspired by.

✓ Hybrid Scan order Zhao et al[1]

✓ Hilbert Space Filling

[1] Zhao S, Chen Z, Yang K, et al. Light field image coding with hybrid scan order[C]//Visual Communications and Image Processing (VCIP), 2016. IEEE, 2016: 1-4.

Sub aperture Rearrangement

◆ Optimized rearrangement algorithm (13 × 13)

Anchor

Propose

Performance

◆ Anchor: Zhao et al. [1]

Test Image Name	BD-Rate
I01 Bikes	-0.6%
I02 Danger de Mort	-0.8%
I04 Stone Pillars Outside	-1.8%
I09 Fountain Vincent	-1.7%
I10 Friends	-0.8%
Average	**-1.1%**

[1] Zhao S, Chen Z, Yang K, et al. Light field image coding with hybrid scan order[C]//Visual Communications and Image Processing (VCIP), 2016. IEEE, 2016: 1-4.
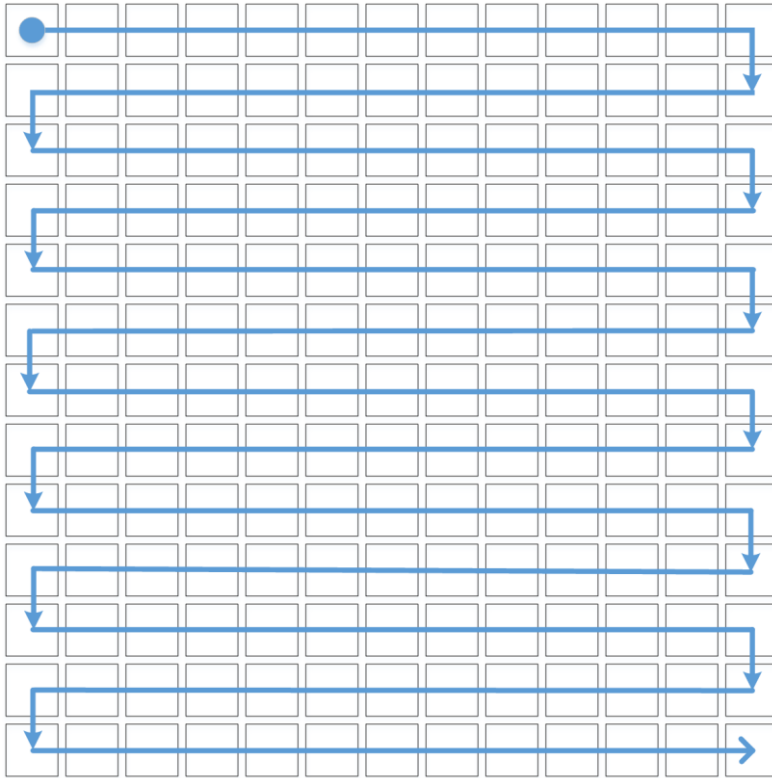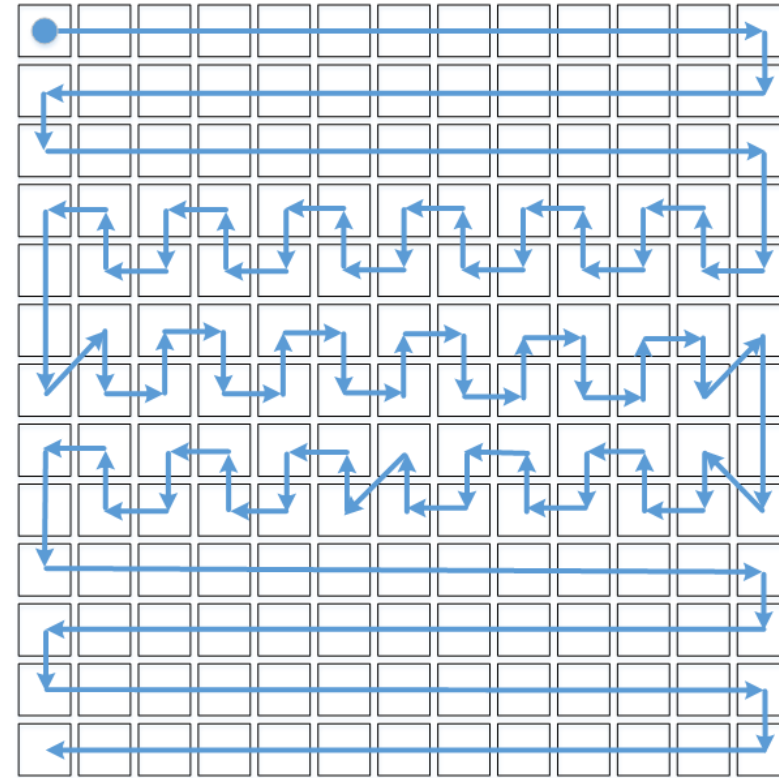
Performance

◆ Optimized rearrangement for sub apertures:

✓ Anchor: JPEG CfP

Test Image Name	BD-Rate
I01 Bikes	-1.6%
I02 Danger de Mort	-3.6%
I04 Stone Pillars Outside	-5.1%
I09 Fountain Vincent	-5.9%
I10 Friends	-0.0%
Average	**-3.2%**
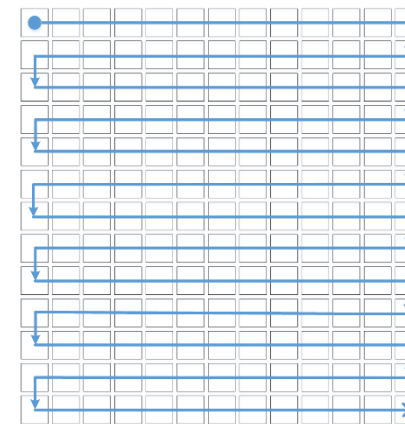
Anchor
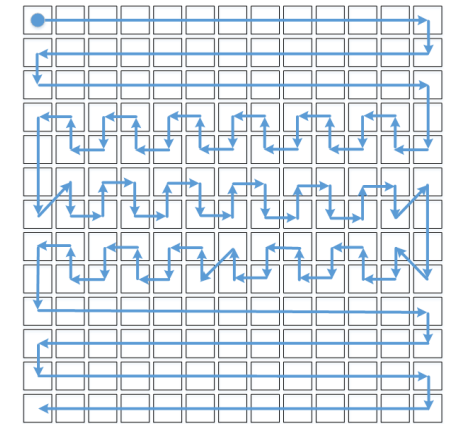
Propose
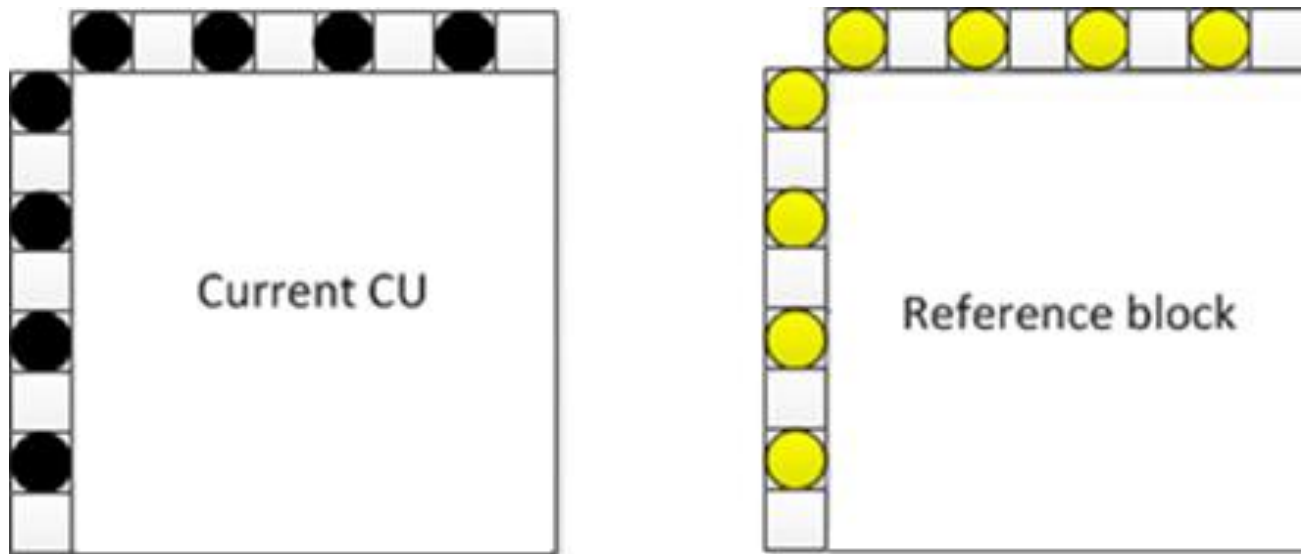
Proposed Coding Tools

◆ Sub-aperture Rearrangement Mechanism

◆ Enhanced Illuminance Compensation

◆ Adaptive Lenslet Reconstruction

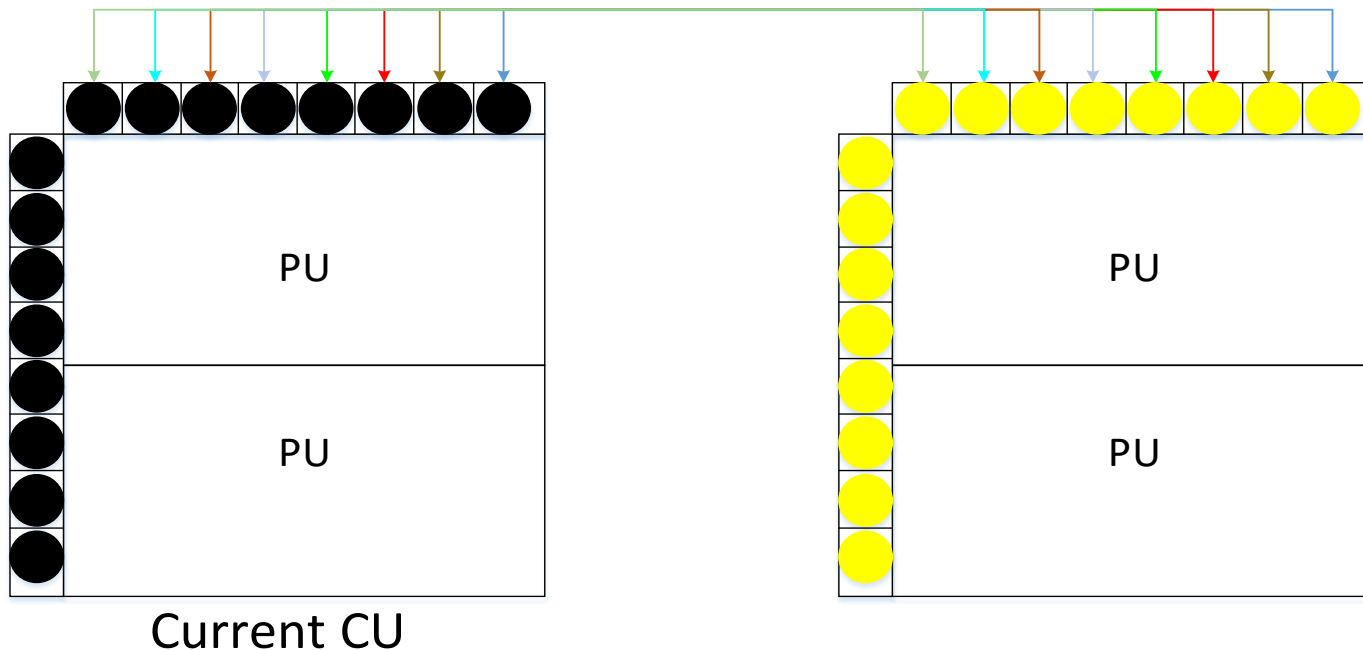# Local Illuminance Compensation in JEM

◆ Conventional LIC in JEM.

$$y = \alpha x + \beta$$

Linear Regression by 2:1 reference samples down-sampling

● Neighboring samples of current CU

● Neighboring samples of the reference block

Enhanced Illuminance Compensation

◆ Reference pixel selection algorithm.

Current CU

Reference CU in List0

● Neighboring samples of current CU

● Neighboring samples of reference Block

$$SAD = \sum_{i=0}^{CUWidth-1} abs(pix[i] - ref[i])$$

$$AvgSAD = \frac{SAD}{CUWidth}$$

$$Selected\_Flag\_Each\_Pix[i] = abs(pix[i] - ref[i])$$
$$< AvgSAD\ ?\ True: False$$

Enhanced Illuminance Compensation

◆ Syntax Element

  ✓ Picture Level Flag

    ➢ CU flag to denote each CU applied or not

  ✓ Merge mode CU: derivate from neighboring CU

◆ Rate-distortion Optimization

  ✓ Whether apply enhance IC

  ✓ SAD: integer pixel motion search

  ✓ SATD: frac pixel motion search

Performance

◆ Enhanced IC vs Original LIC (JEM-2.0)

Test Image Name	BD-Rate
I01 Bikes	-0.5%
I02 Danger de Mort	-0.1%
I04 Stone Pillars Outside	-0.5%
I09 Fountain Vincent	-0.1%
I10 Friends	-0.2%
Average	**-0.3%**

Proposed Coding Tools

◆ Sub-aperture Rearrangement Mechanism

◆ Enhanced Illuminance Compensation
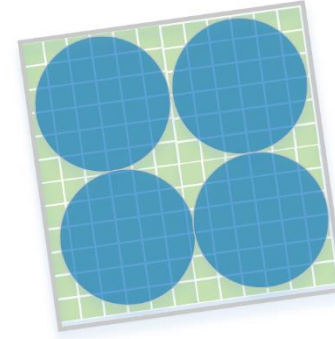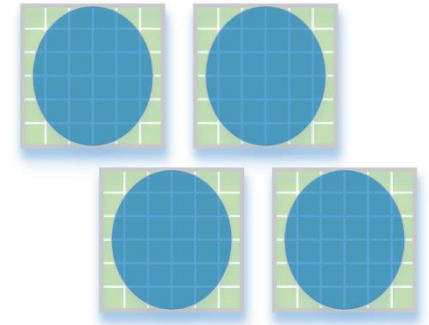
◆ Adaptive Lenslet Reconstruction

Lenslet Decomposition

◆ Affine Transform for lenslet $\vec{f}: \mathcal{A} \longrightarrow \mathcal{B}$.

$$\begin{bmatrix} \vec{y} \\ 1 \end{bmatrix} = \begin{bmatrix} \mathcal{A} & | & \vec{b} \\ 0 \cdots 0 & | & 1 \end{bmatrix}$$
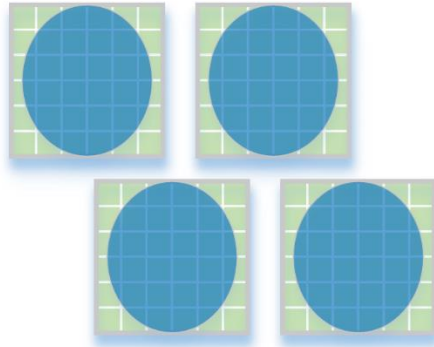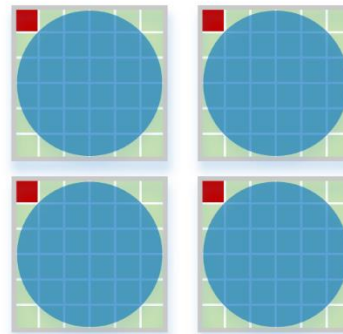
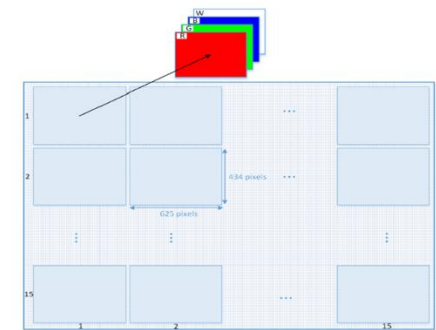Calibration Information of Lytro LF Camera

Affine

Super-pixel

◆ Interpolation and re-sampling[1]: subapertures.

Interpolation

Re-sampling

[1] Dansereau D G, Pizarro O, Williams S B. Decoding, calibration and rectification for lenslet-based plenoptic cameras[C]//Proceedings of the IEEE conference on computer vision and pattern recognition. 2013: 1027-1034.

Lenslet Reconstruction

◆ From sub apertures to lenslet

   ✓ Irreversible transform

      ➤ Interpolation & shift noise

   ✓ Inspired by ALF in JEM

      ➤ Objective:
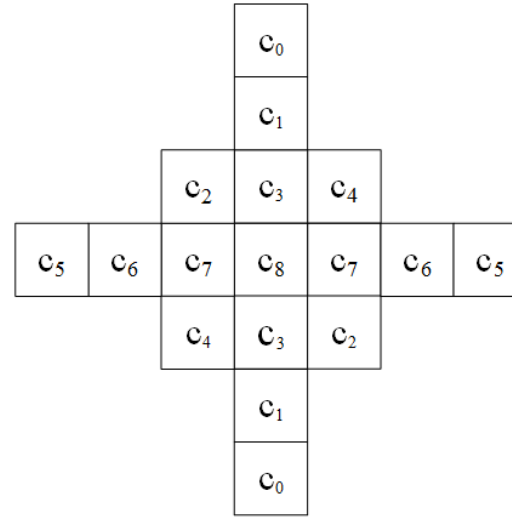

Affine
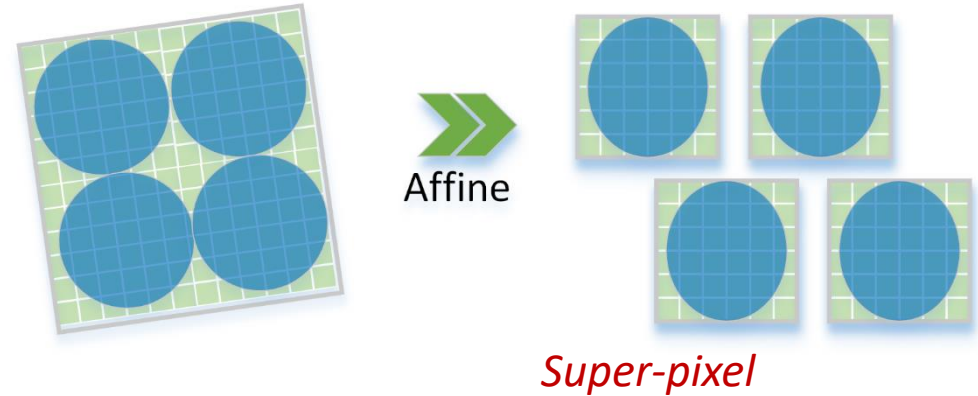
Super-pixel

$$\min_{\boldsymbol{c}_k} \sum_{t \in C_k} \sum_{n=0}^{N-1} \|\boldsymbol{c}_k(n)\boldsymbol{y}(t + p_n) - \boldsymbol{x}(t)\|_2^2$$

$$\hat{\boldsymbol{x}}[r] = \sum_{n=0}^{N-1} \boldsymbol{c}(n)\boldsymbol{y}[r + p_n]$$

Lenslet Reconstruction

◆ Filter shape

✓ 3×3 square
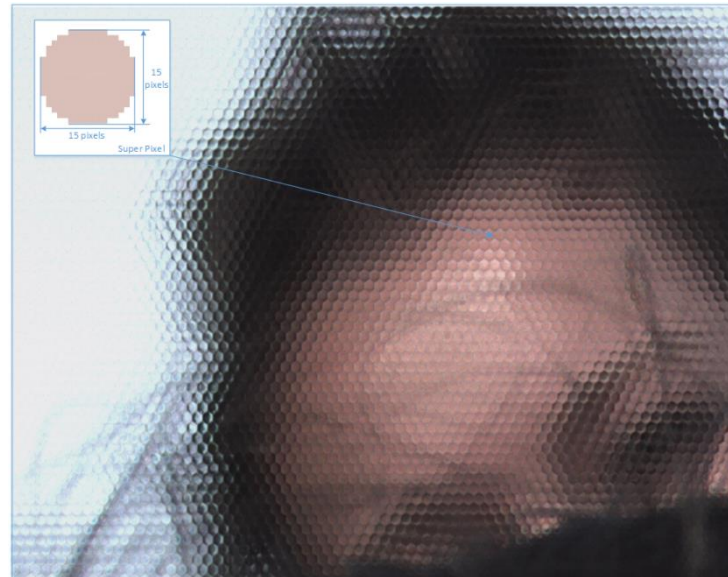
✓ 7×7 cross

◆ Sample Classification

✓ in each super pixel

✓ re-use filter coefficient

Performance

◆ Adaptive Recon VS. no Adaptive Recon

Test Image Name	BD-Rate
I01 Bikes	-3.0%
I02 Danger de Mort	-1.4%
I04 Stone Pillars Outside	-1.1%
I09 Fountain Vincent	-2.9%
I10 Friends	0.0%
Average	**-1.7%**

Performance (Re-Scan & Enhance IC)

	Re-Scan	Enhance IC	Re-Scan+Enhance IC
I01 Bikes	-1.6%	-0.5%	-2.1%
I02 Danger de Mort	-3.6%	-0.1%	-3.7%
I04 Stone Pillars Outside	-5.1%	-0.5%	-5.4%
I09 Fountain Vincent	-5.9%	-0.1%	-6.0%
I10 Friends	-0.0%	-0.2%	-0.2%
Average	**-3.2%**	**-0.3%**	**-3.5%**

Total Performance

	vs HEVC Intra	vs JEM Intra
I01 Bikes	-41.0%	-23.1%
I02 Danger de Mort	-33.8%	-32.8%
I04 Stone Pillars Outside	-54.8%	-32.7%
I09 Fountain Vincent	-53.7%	-34.8%
I10 Friends	-29.4%	-15.2%
Average	**-42.5%**	**-27.7%**

Total Performance

◆ RD Curves
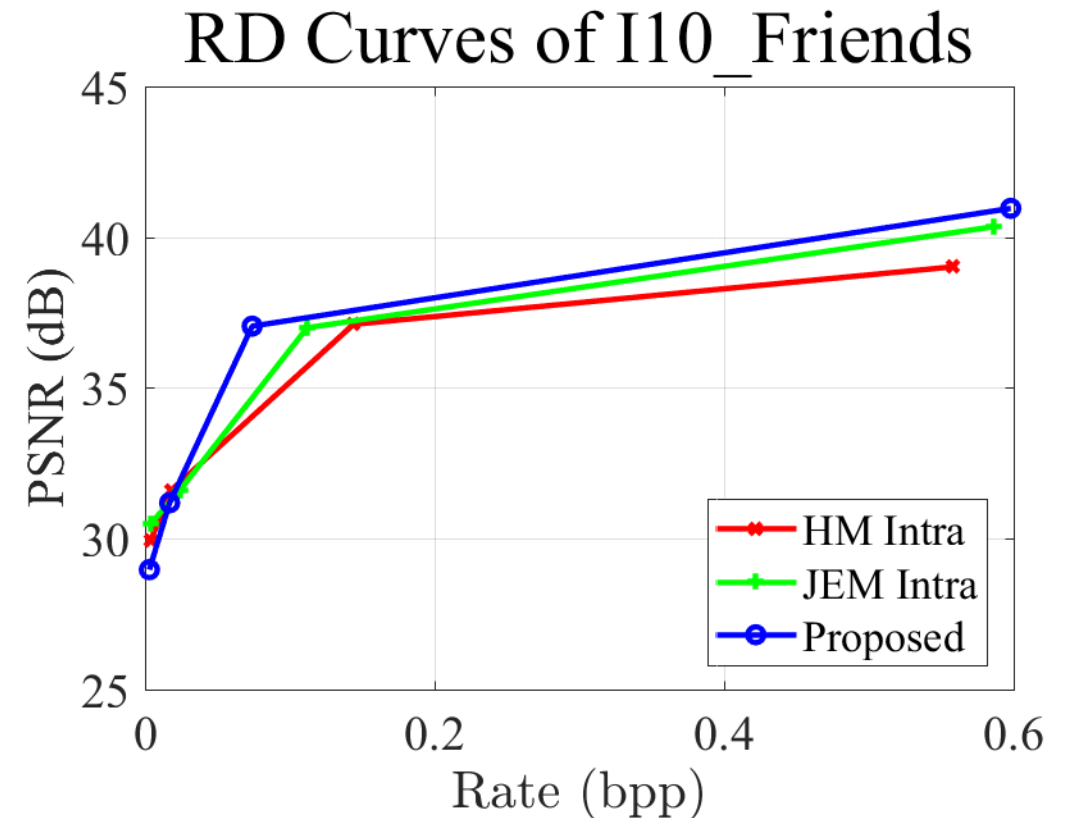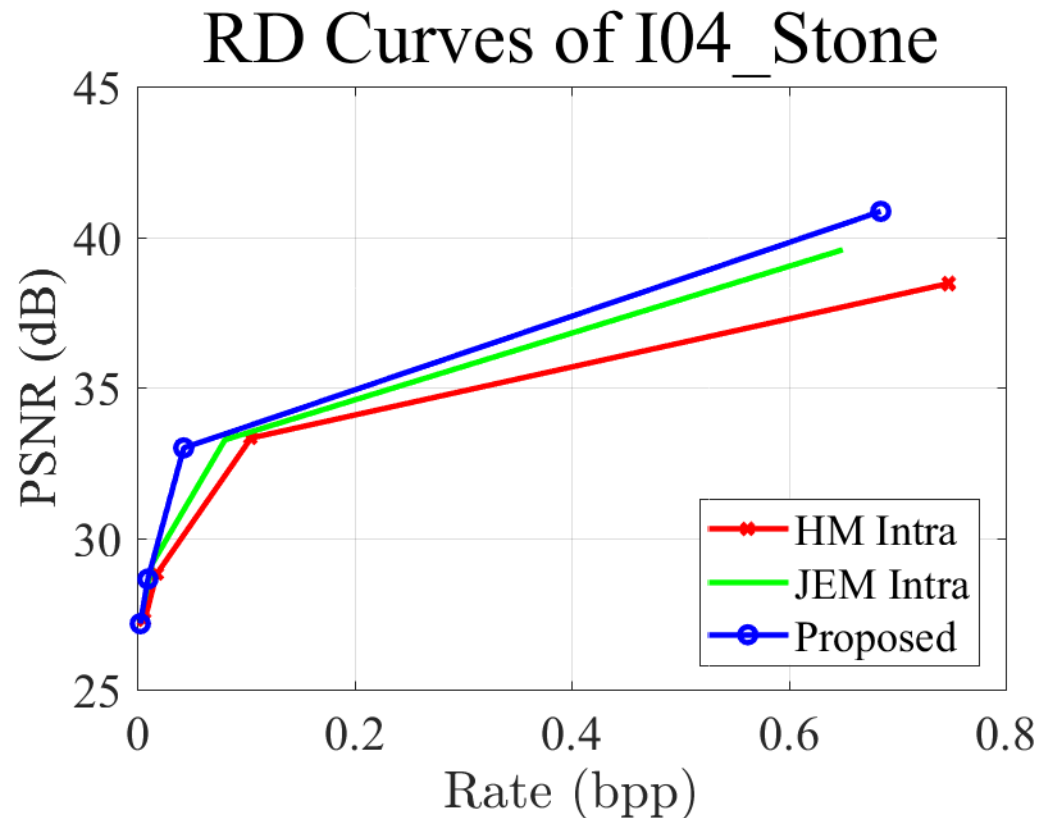
Conclusion

Goal: High Efficiency Light Field image Compression Algorithm.

◆ **Solution1:** Sub aperture Rearrangement Mechanism.

◆ **Solution2:** Enhanced Illuminance Compensation.

◆ **Solution3:** Adaptive Reconstruction Lenslet.

◆ **Results:** Achieving 3.2%, 0.3% bit-rate reduction respectively. The total bit-rate reduction is over 40% when comparing with HEVC Intra Coding.

Thanks

Q & A