Objective evaluation and state-of-the-art video compression standard based solutions for plenoptic image content

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Outline

- Introduction

- Plenoptic imaging

- An extended signal pipeline

- Video compression applied to plenoptic images

- Objective evaluation methodology

- Summary

Plenoptic research at MIUN

Mittuniversitetet
MID SWEDEN UNIVERSITY

- Active in the field of plenoptics since 2005

- 4 senior researchers, 2-3 PhD students

- Research interests
  - Modeling of, and synthesis from, plenoptic systems
  - Compression of plenoptic image and video
  - Quality evaluation

- Plenoptic related projects
  - Plenocap – Plenoptic Capture and Computational Photography
    (2013-2015)
  - LIFE – Light Field Evaluation System
    (2015-2018)
  - Marie Sklodowska-Curie International Training Network Full Parallax
    Imaging (2015-2019)

2 PhD student
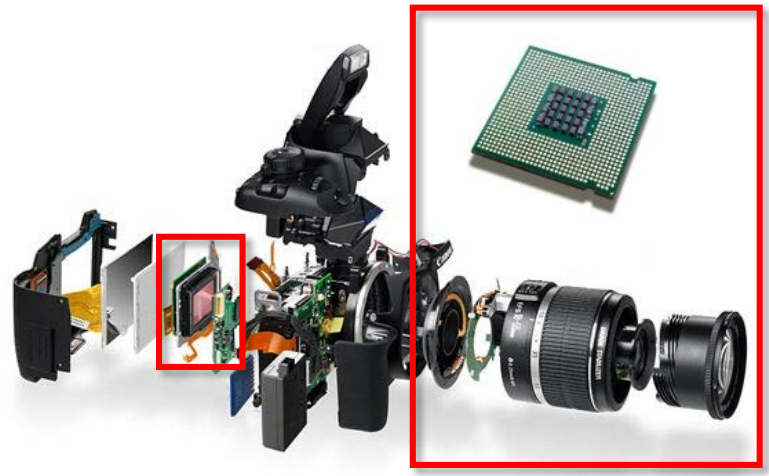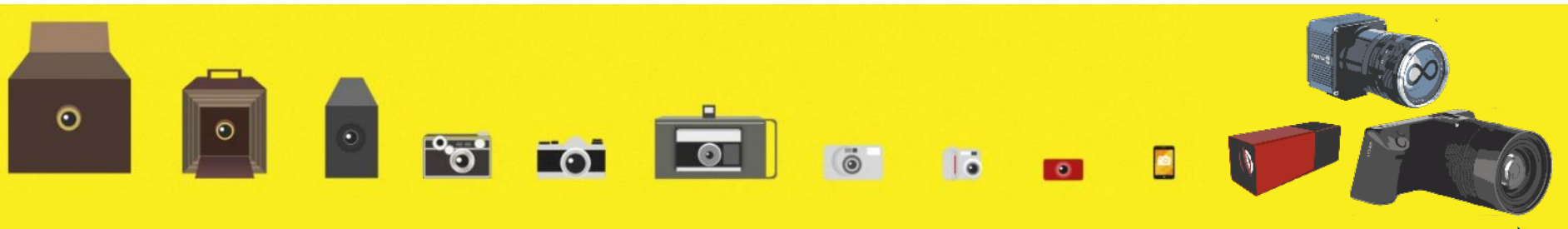positions open
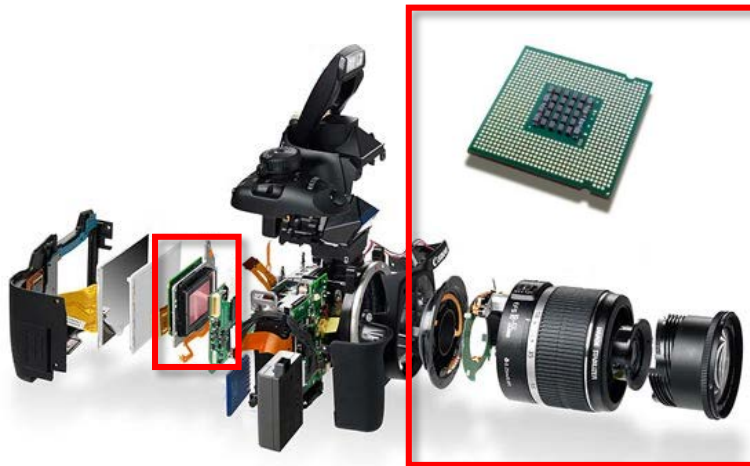
www.miun.se/stc/Realistic3D

Plenoptic imaging

Digitized film

Based on infographics from Optics Central Australia and Gregor Halenda, Popular Mechanics
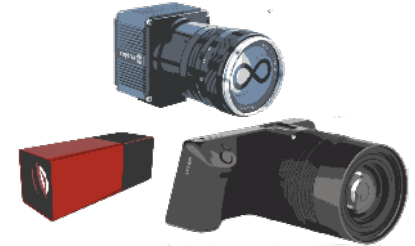
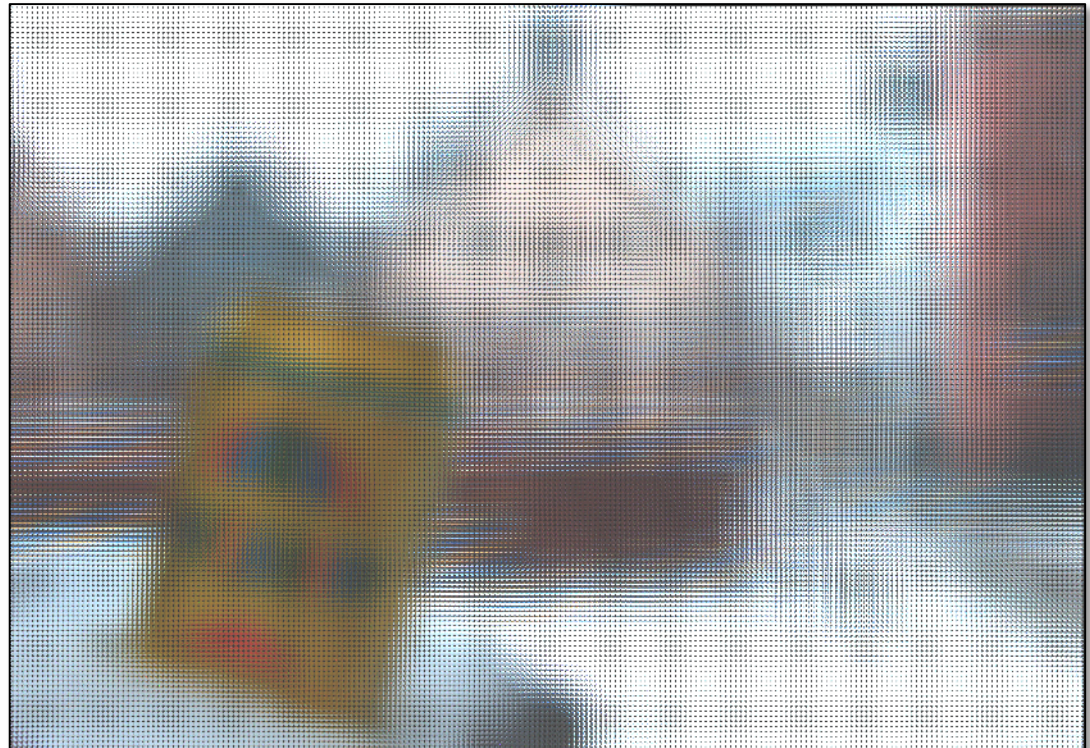# Plenoptic imaging

Digitized film

Digitized optics

Plenoptic imaging

Digitized film

Digitized optics

DOWNLOAD

*"Upgrade now!
Best Lens Award 2025"*

Based on infographics from Optics Central Australia and Gregor Halenda, Popular Mechanics
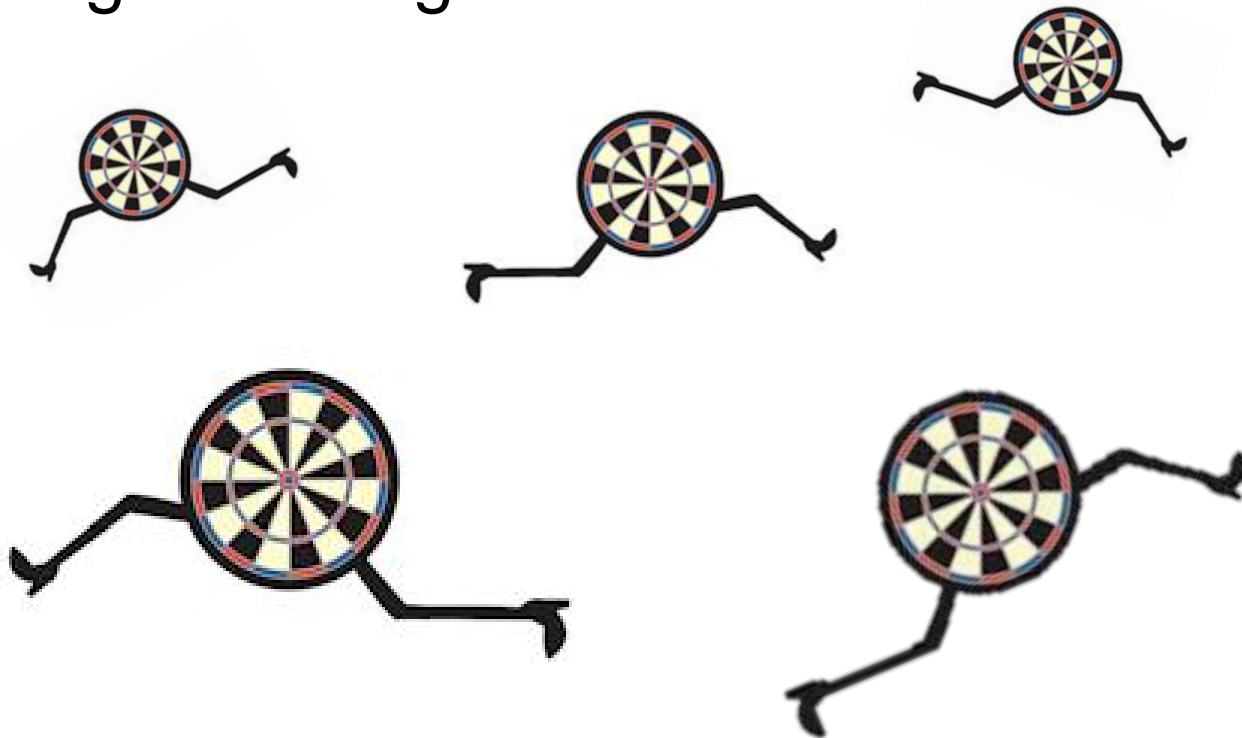
Plenoptic imaging

- 4D light field spatially multiplexed onto 2D sensor

- The spatial multiplexing properties are yet not fixed

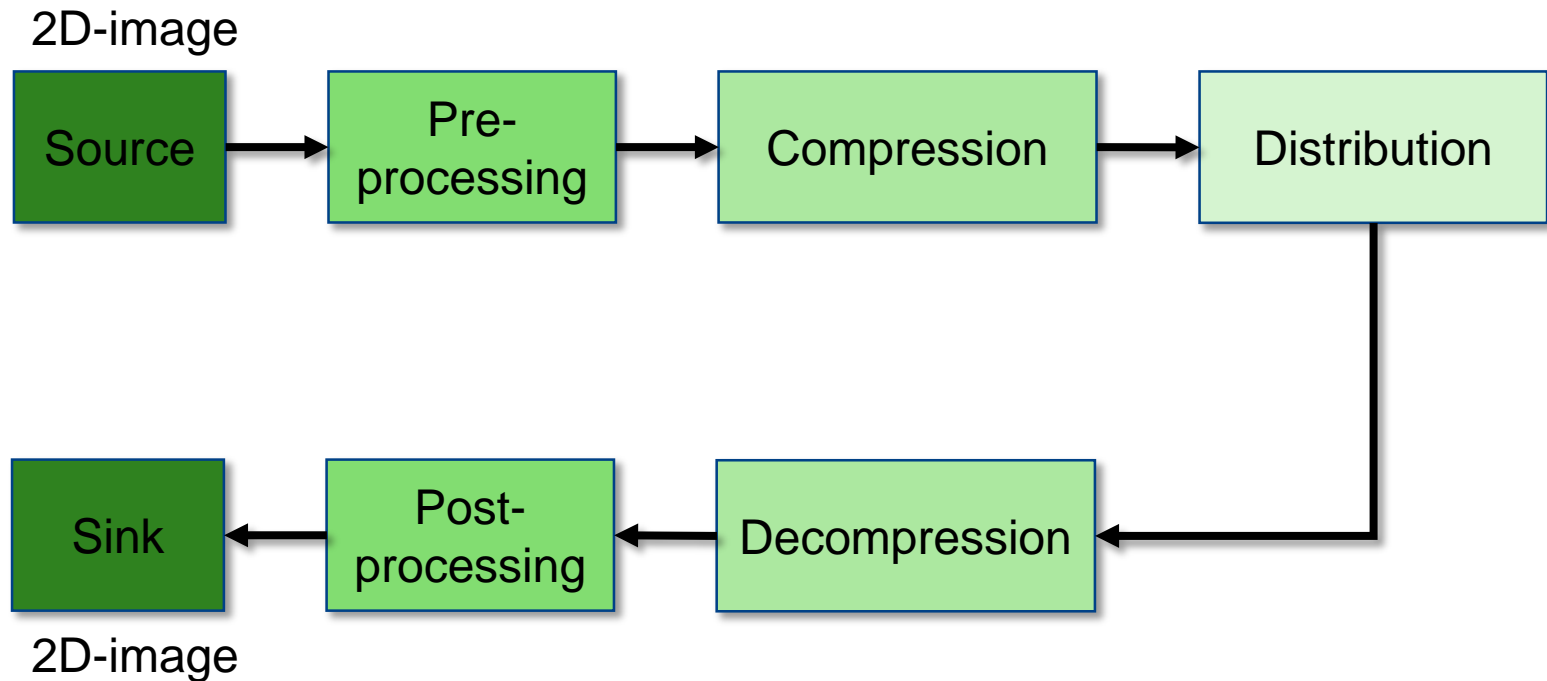- The statistical properties of the 2D sensor "image" varies

Plenoptic imaging compression

The signal target has become targets and they are all moving in terms of properties as new technologies emerge
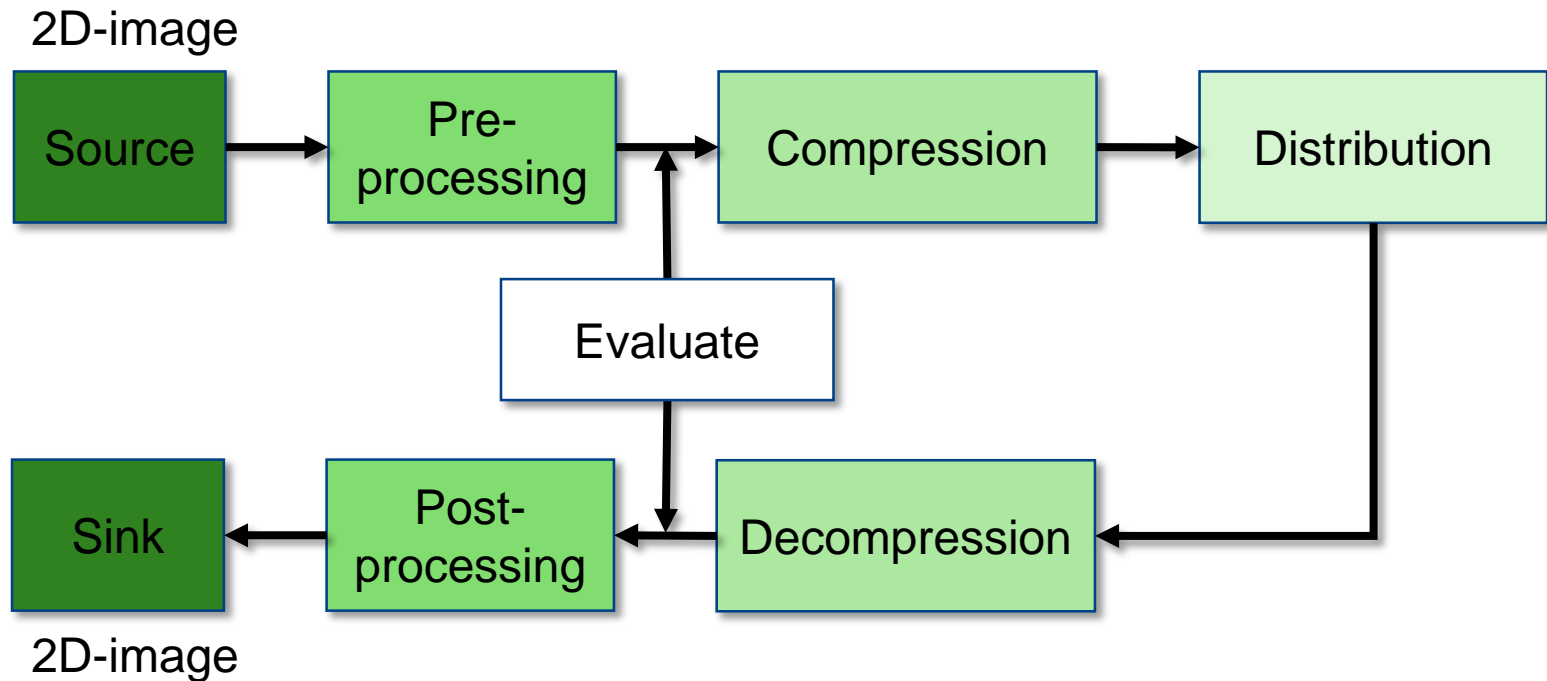
Signal processing chain conventional imaging

2D-image

| Source | → | Pre-processing | → | Compression | → | Distribution |

| Sink | ← | Post-processing | ← | Decompression | ← |

2D-image

Signal processing chain conventional imaging

2D-image

| Source | → | Pre-processing | → | Compression | → | Distribution |

Evaluate

| Sink | ← | Post-processing | ← | Decompression | ← |

2D-image

HVS properties highly relevant

Signal processing chain conventional imaging

2D-image

```
┌──────────┐      ┌──────────────┐      ┌──────────────┐      ┌──────────────┐
│  Source  │ ───► │     Pre-     │ ───► │ Compression  │ ───► │ Distribution │
│          │      │  processing  │      │              │      │              │
└──────────┘      └──────────────┘      └──────────────┘      └──────────────┘
      ▲
      │
┌──────────┐
│ Evaluate │
└──────────┘
      │
      ▼
┌──────────┐      ┌──────────────┐      ┌──────────────┐
│   Sink   │ ◄─── │    Post-     │ ◄─── │ Decompression│ ◄───
│          │      │  processing  │      │              │
└──────────┘      └──────────────┘      └──────────────┘
```
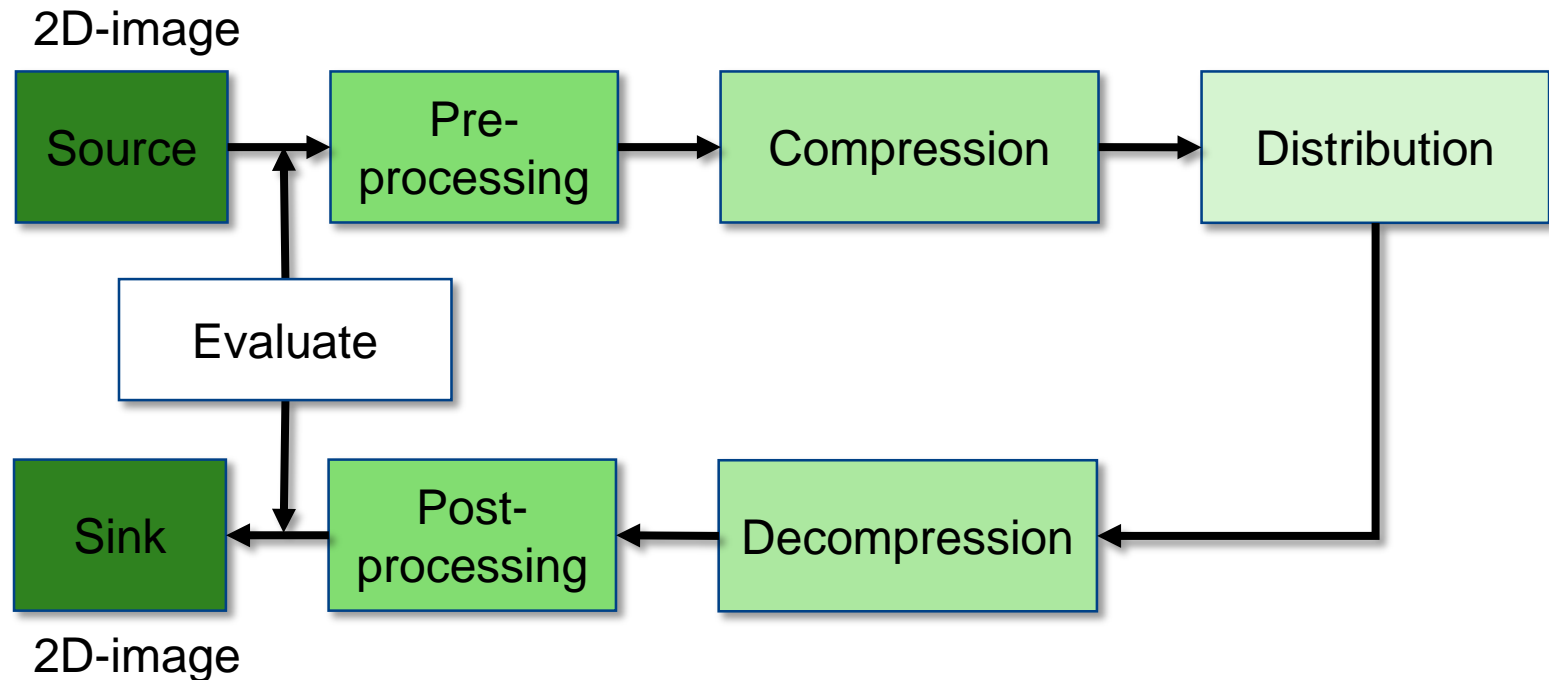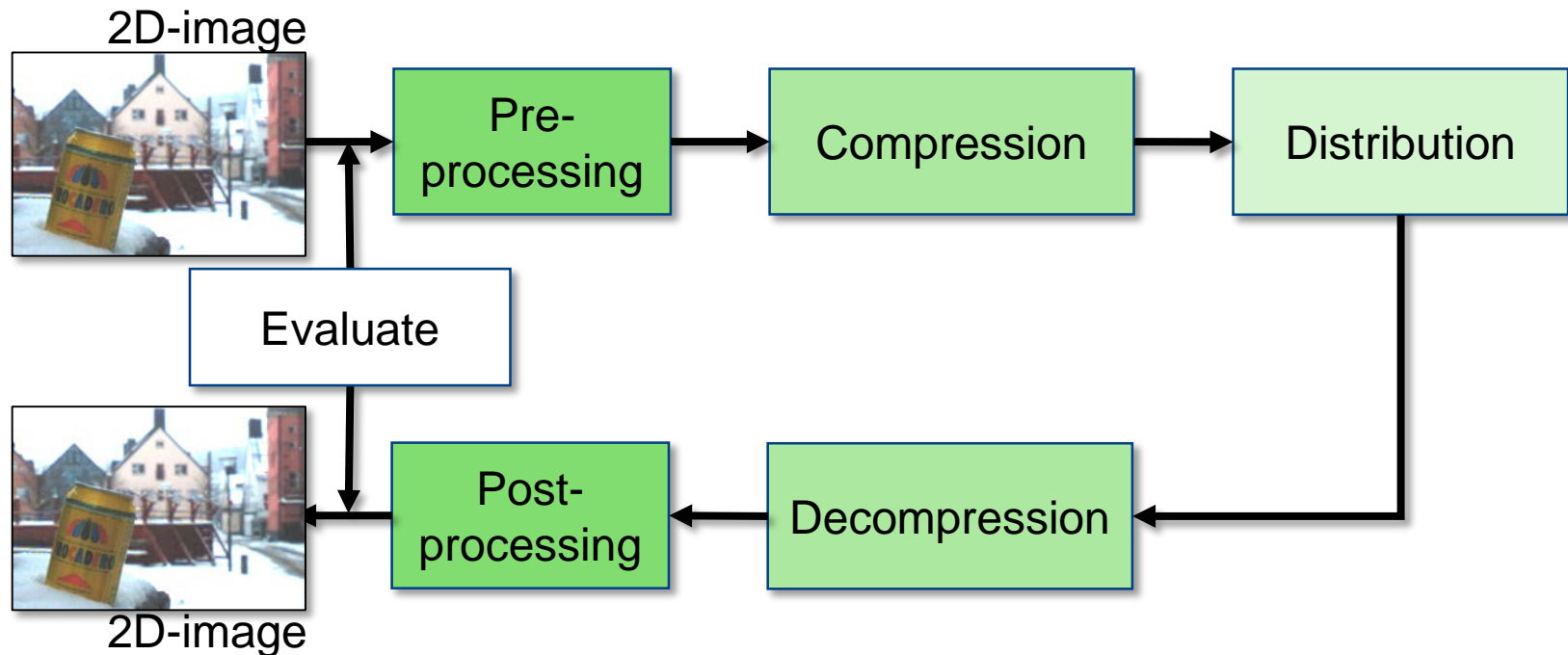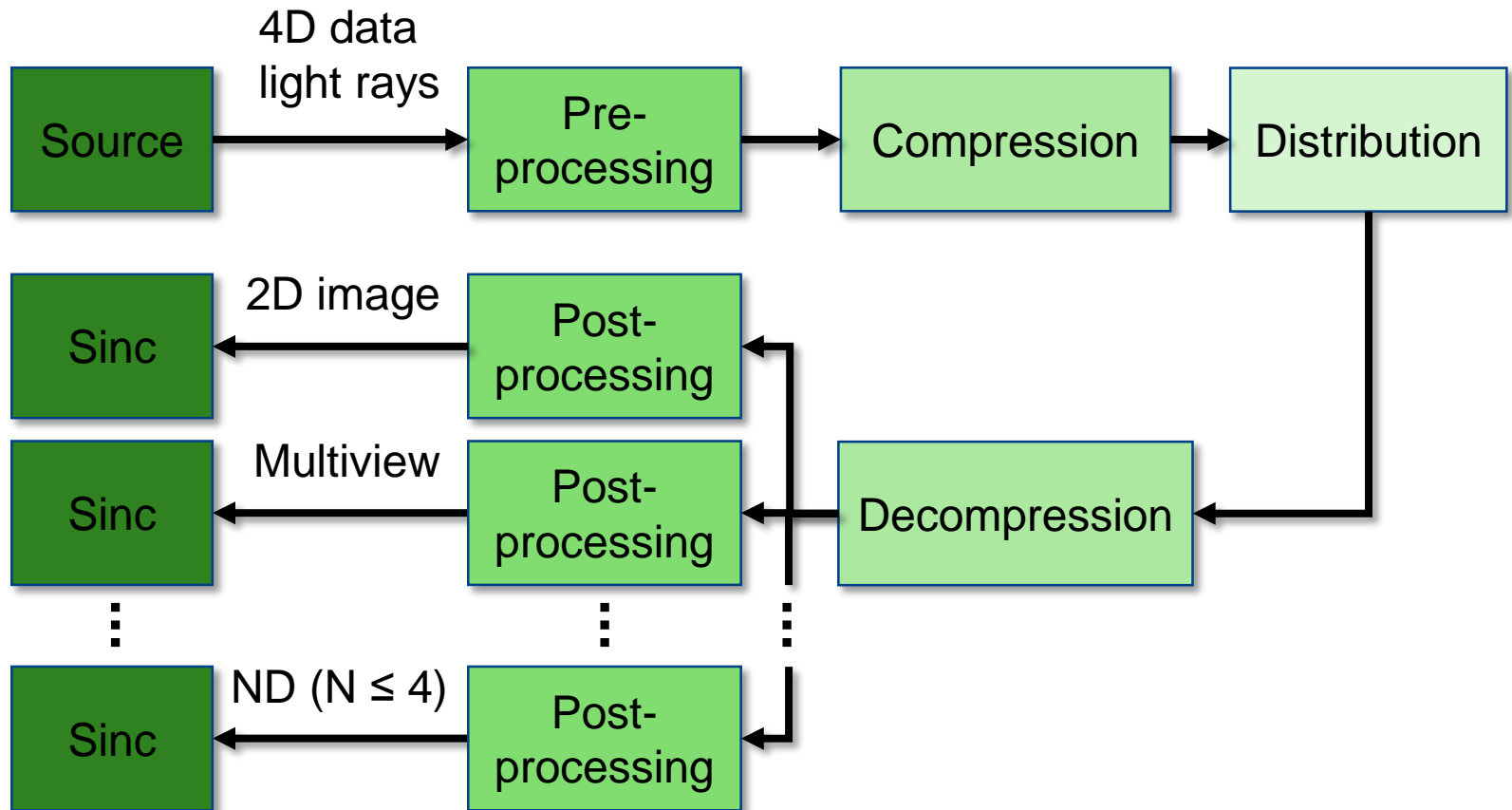
2D-image

HVS properties highly relevant

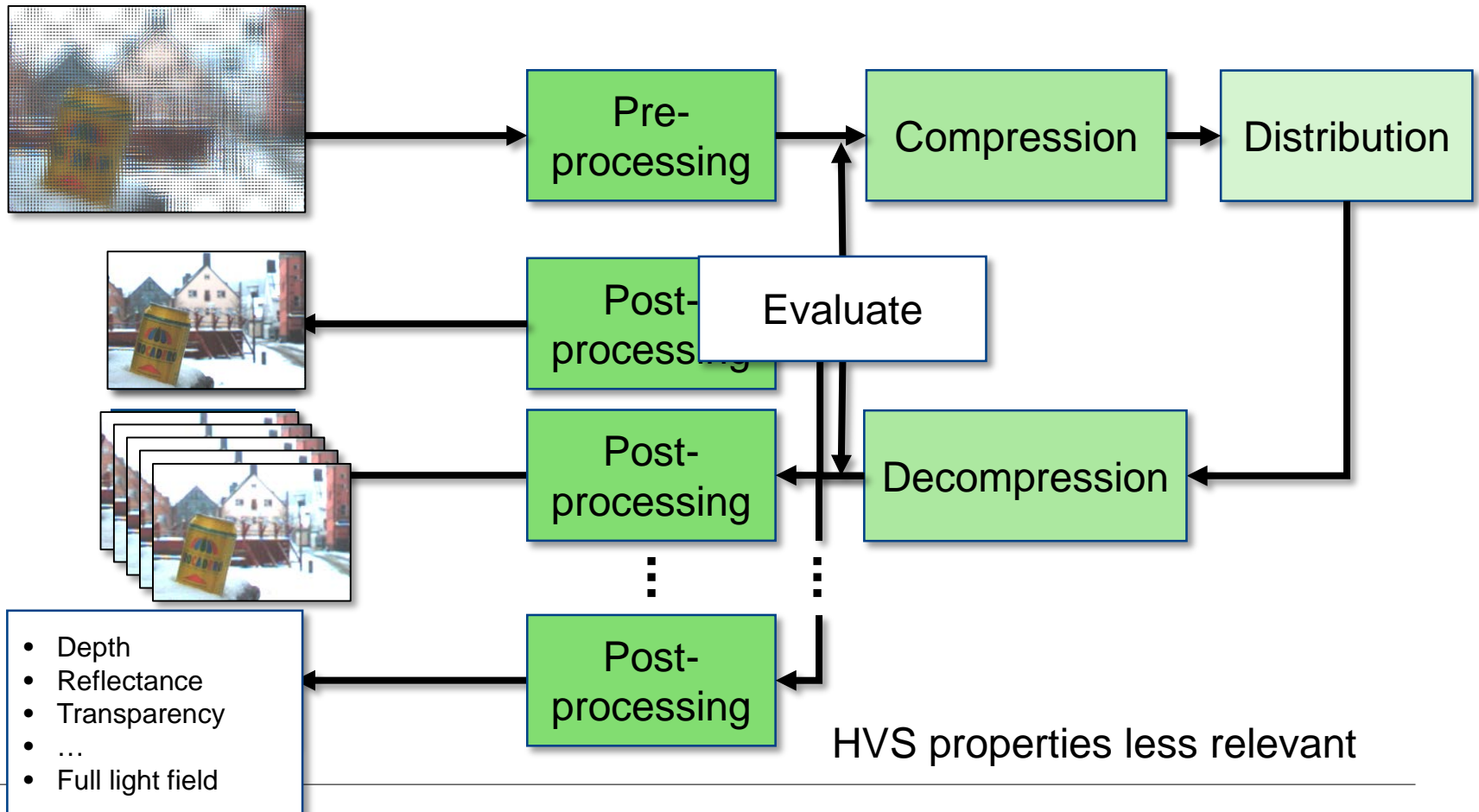# Signal processing chain conventional imaging

HVS properties highly relevant
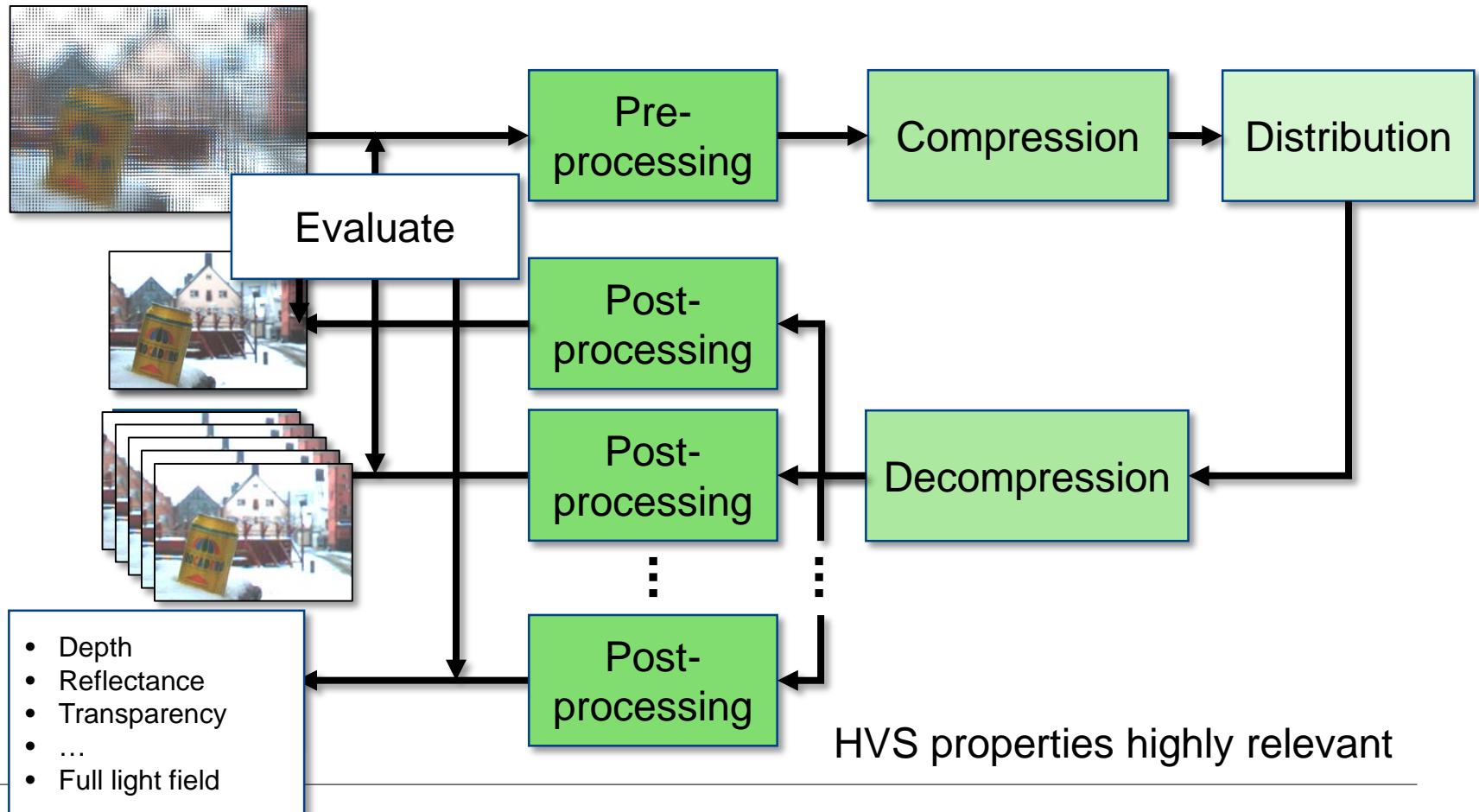
Signal processing chain plenoptic imaging

Signal processing chain plenoptic imaging

Signal processing chain plenoptic imaging

Evaluate

Pre-processing

Compression

Distribution

Post-processing

Post-processing

Decompression

Post-processing

- Depth
- Reflectance
- Transparency
- ...
- Full light field

HVS properties highly relevant

Rendering to 3D

Uncompressed 24 bpp   Uncompressed 24 bpp

JPEG 2000 0.22 bpp   JPEG 2000 0.22 bpp

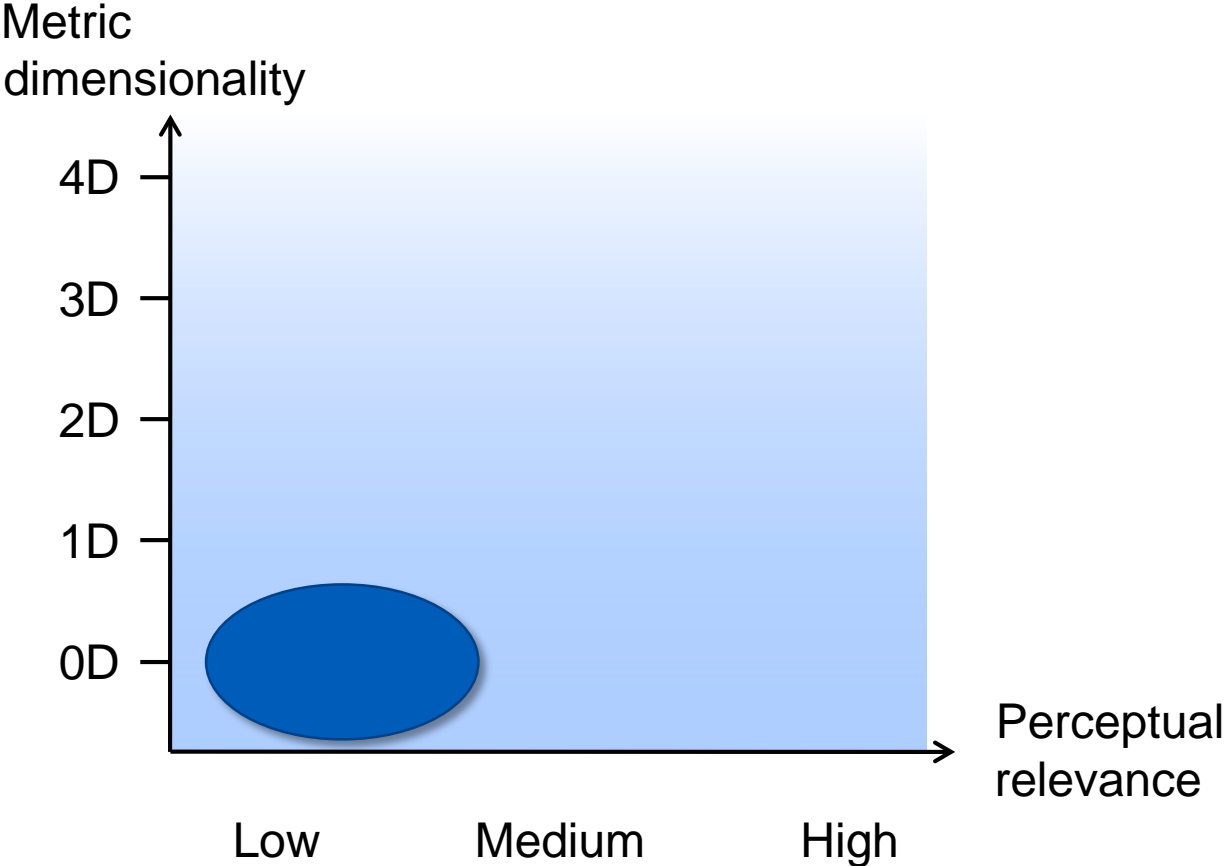MPEG-4 AVC 0.22 bpp   MPEG-4 AVC 0.22 bpp
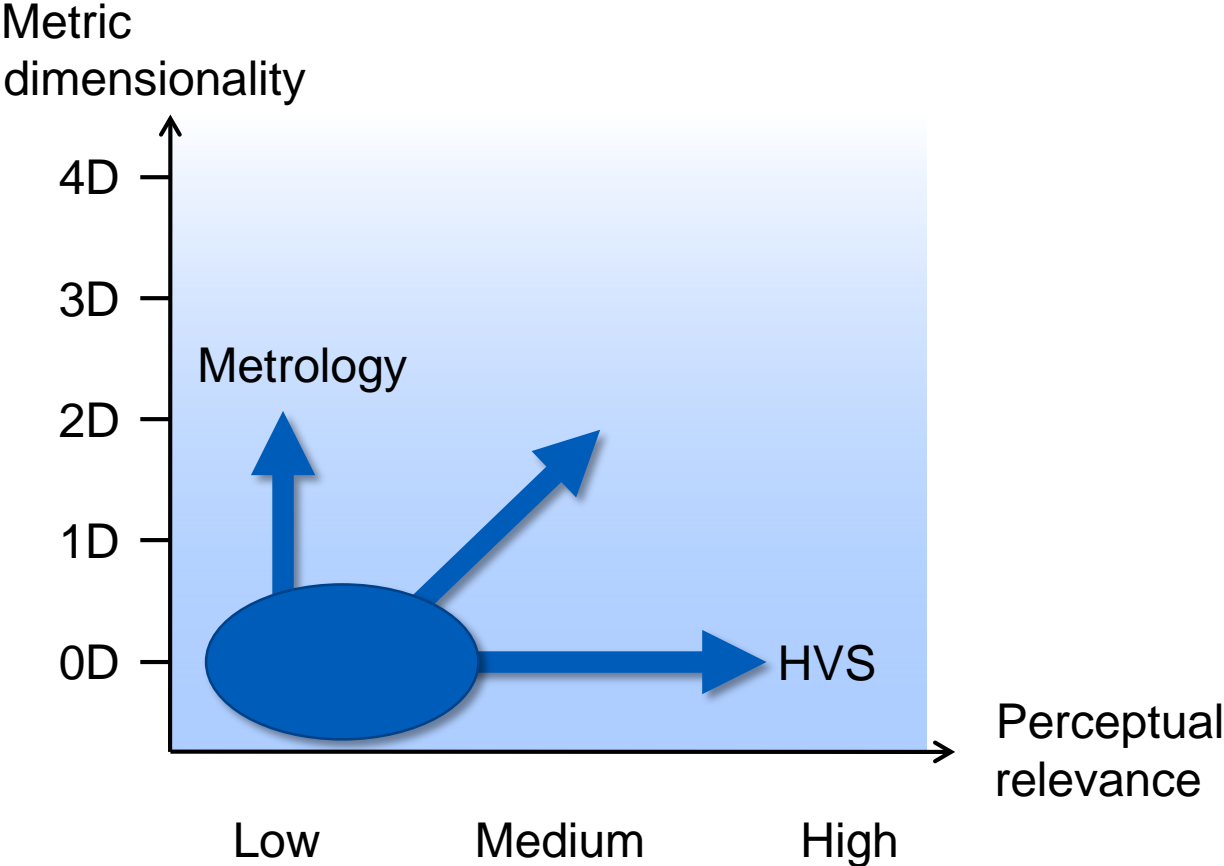
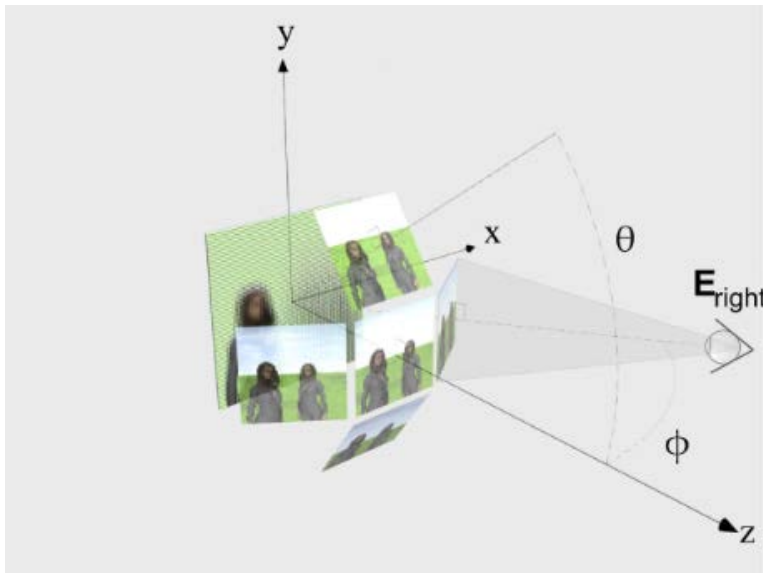Right view   Left view

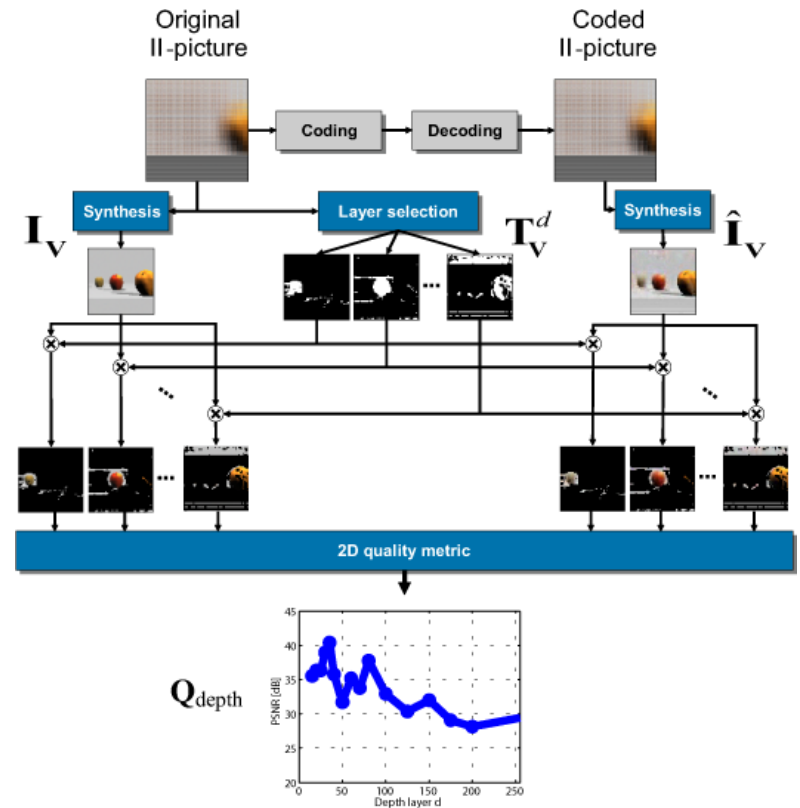# Objective evaluation

Objective evaluation

Objective evaluation

Extract signal components and evaluate those separately

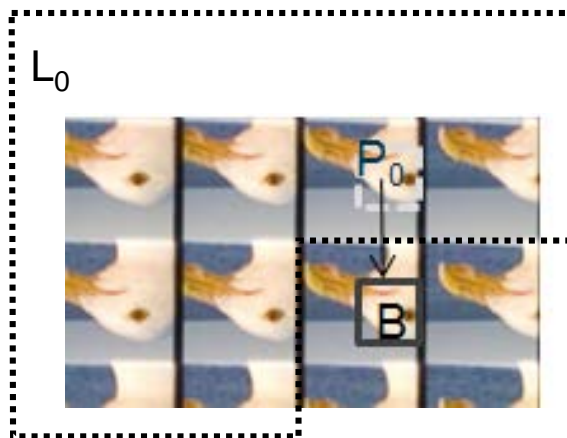Quality as a function of viewing angle

Quality as a function of scene depth

Olsson, R. & Sjöström, M. (2007). A depth dependent quality metric for evaluation of coded integral imaging based 3d-images. In *Proceedings of 3DTV Conference*. New York : . S. 403--406.
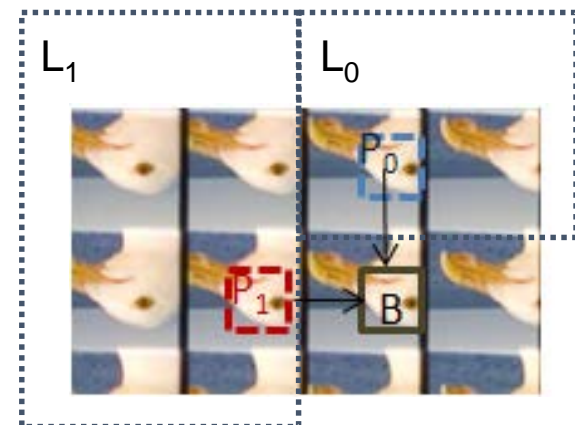
Video compression for plenoptic image content

- Extend HEVC to make temporal compression tools available for intra compression

- Multi-hypothesis prediction (Bi-directional prediction)

Time: ——————————→

B | Current frame being predicted

B | Current EIs being predicted

L_0

Prediction

L_1 L_0

Bi-directional prediction

Rendering to all-in-focus

Images rendered using light field from Todor Georgiev, Qualcomm

Li, Y. , Sjöström, M. , Olsson, R. & Jennehag, U. (2014). Efficient Intra Prediction Scheme For Light Field Image Compression. I
ICASSP, IEEE International Conference on Acoustics, Speech and Signal Processing - Proceedings.. S. Art. no. 6853654

Summary

- Plenoptic imaging with digitized optics is a paradigm shift

- Applications relying on plenoptic imaging will
    - produce and process a number of intermediate signals
    - generate outputs with different dimensionality

- Evaluating the performance of each processing step is necessary

- Perceptual relevant metrics, and signal property metrics, are both important

Thank you

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