LIGHT FIELD DATA MANAGEMENT AND TRANSMISSION FOR MEDIA PRODUCTION

Use Cases and Requirements

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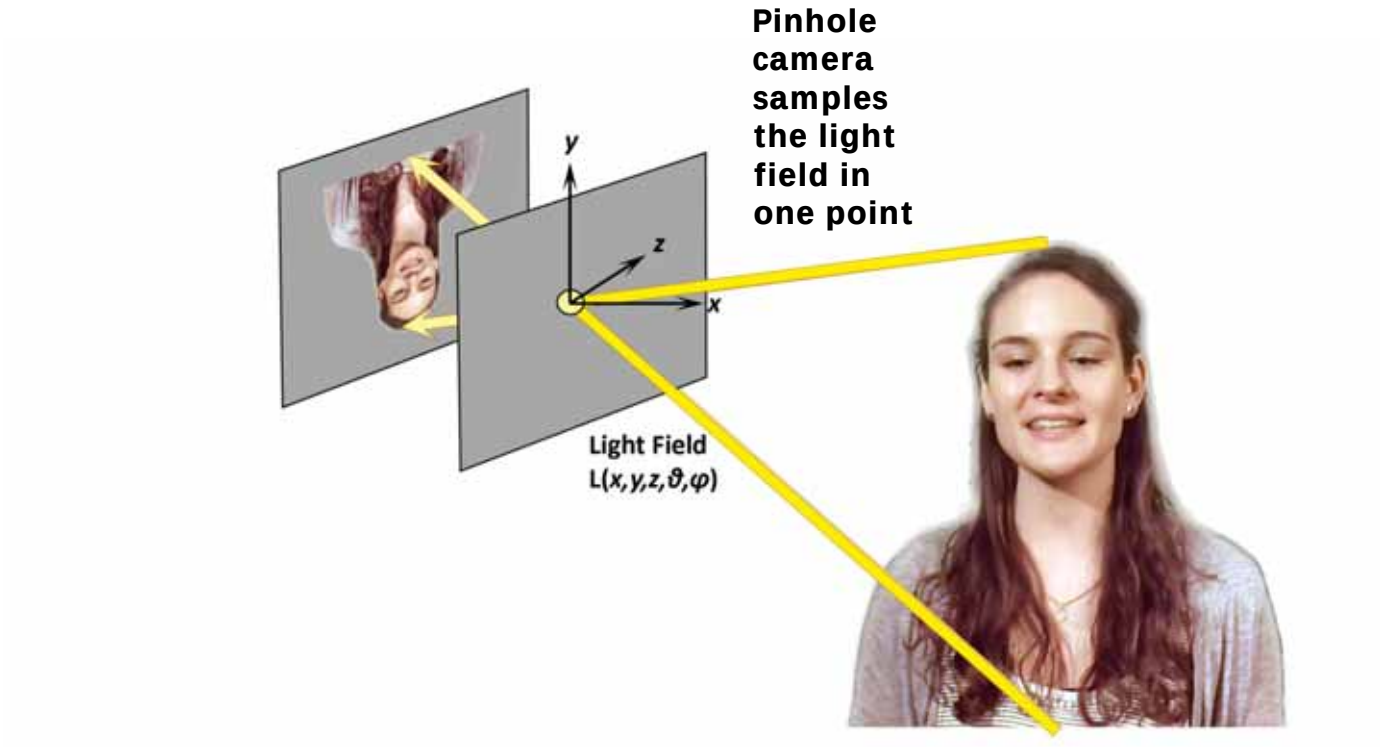
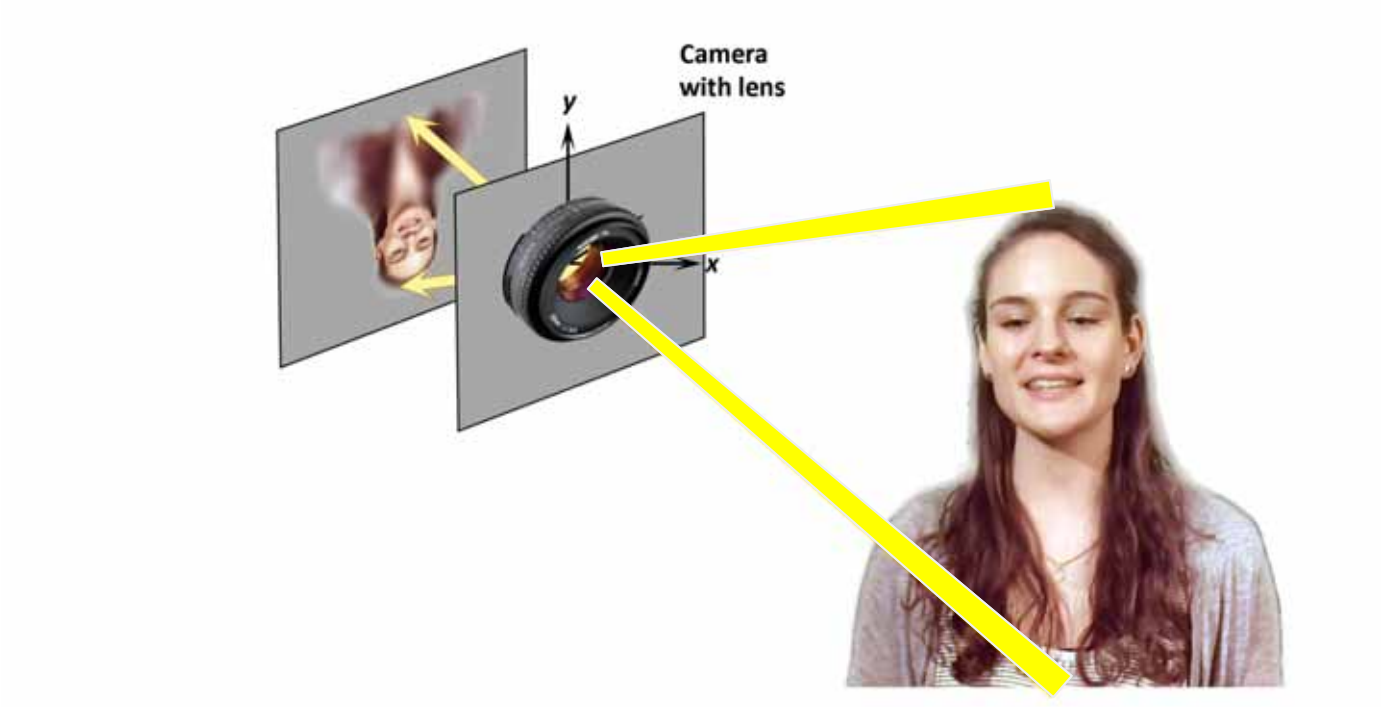
- Introduction
- Use cases and potential of lightfield based media production
- Processing Pipeline and Derived Requirements

Light Field Principles

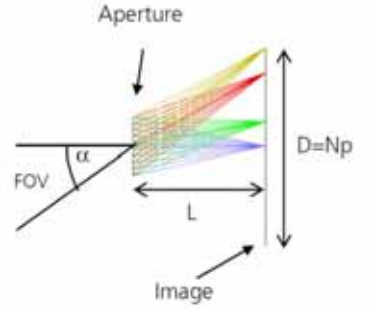


Light Field Principles



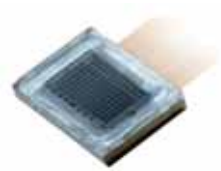
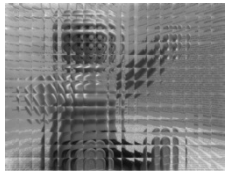
Light Field Principles

- Standard cameras capture light rays dependent on
  - Iris (Aperture)
  - focal length (FOV)
  - exposure time
- and rebundle the light rays based on the
  - focal point

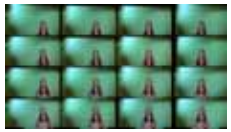


Light Field Principles

- Microlens-Array with one sensor (Insect-Eye)
- Main lens with multiple sensors and microlensarrays


- Cameraarrays in fixed arrangements
- Freely positioned cameras


Light Field Principles

- Compromise between captured space of light field, density of sampling and necessary computation
- Dense sampling (camera with microlenses) allows
  - Easy data processing without depth map calculation by combining of light rays from different shots
  - Avoiding of artefacts as no light rays are missing
- Sparse Sampling (camera arrays) allows
  - Larger space to be captured
  - Enables more flexibility for visual effects

Motivation
Displays Today

Motivation
Displays Tomorrow

Need for „reacting" content

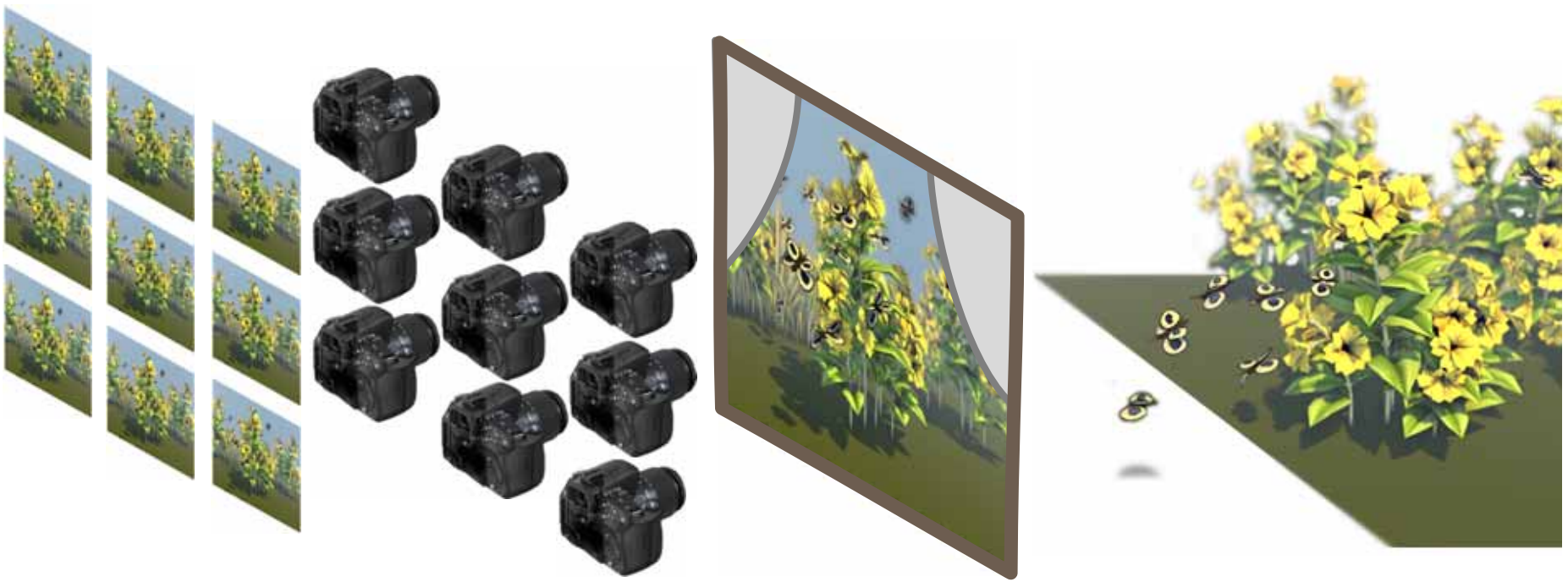
Motivation

The very same needs in media production!

- Continuously increasing amount of computer generated special effects using 3D modeling software
- Best description of reality by natural content
- Natural content does not provide this editing flexibility
- Hampers intuitive story telling

The solution: Lightfields

- Different views permit to react to user movements



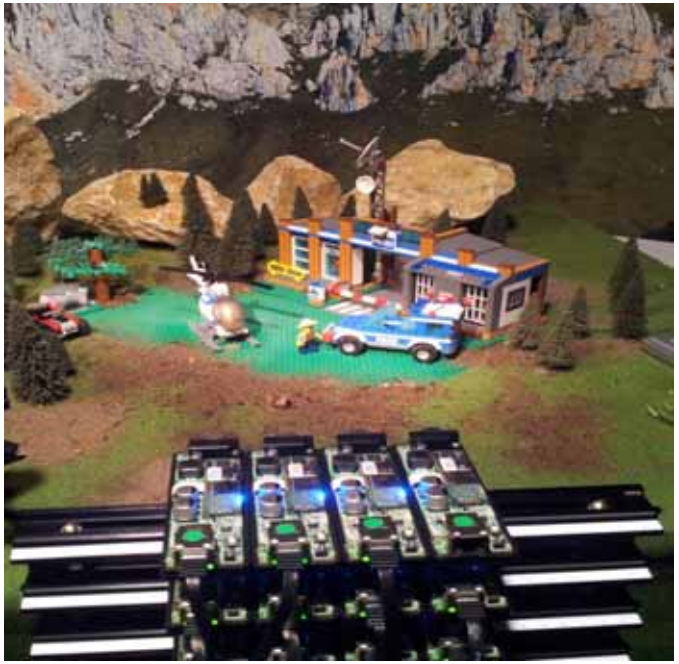
Sensor Projection Window World

Lightfield Visual Effects

- Virtually reposition the camera
  - Rendering in X,Y,Z-Direction
  - Create “Vertigo-Effect” / Dolly-Zoom
  - Create „Matrix-Effect“ / Camera path in freeze frame
  - Create stereo pairs, choose inter-axial distance in post
- Reposition the Depth-of-Field
  - Change position and width of DOF
- Depth-based relighting

Lightfield Visual Effects

Example Stop-Motion Production with 16 Cameras



Lightfield Visual Effects
Output of One Individual Camera

Lightfield Visual Effects
Output After Lightfield Rendering

More Lightfield Visual Effects
Relighting

Lightfield Processing Pipeline

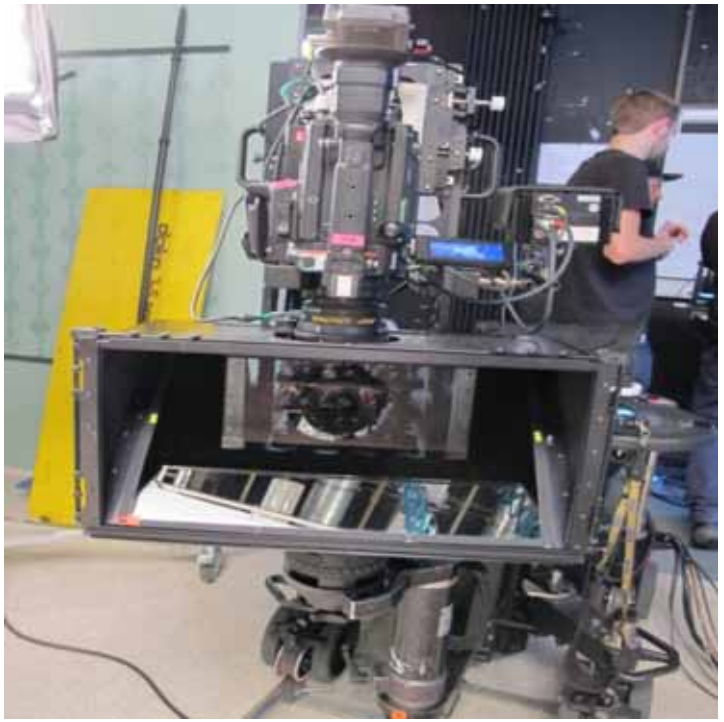
Capture → Rectification → Disparity → Rendering

Lightfield Processing Pipeline
Support of Varying Array Architectures

Portable Camera-Array	Camera robots for highest quality
	

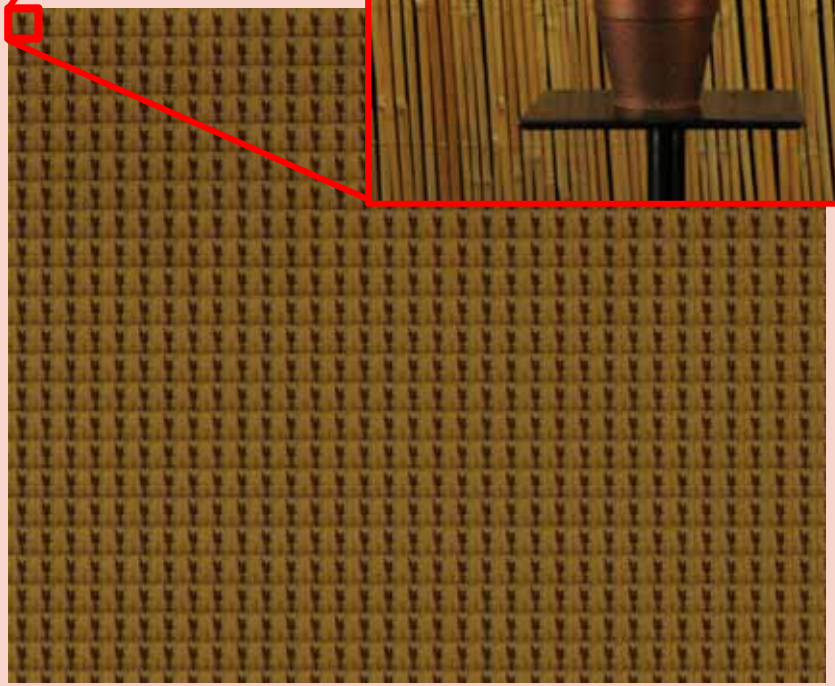
Lightfield Processing Pipeline
Support of Varying Array Architectures

Capture → Rectification → Disparity → Rendering



Lightfield Processing Pipeline

Support of Varying Array Architectures

Portable Camera-Array	Cam for hig
	

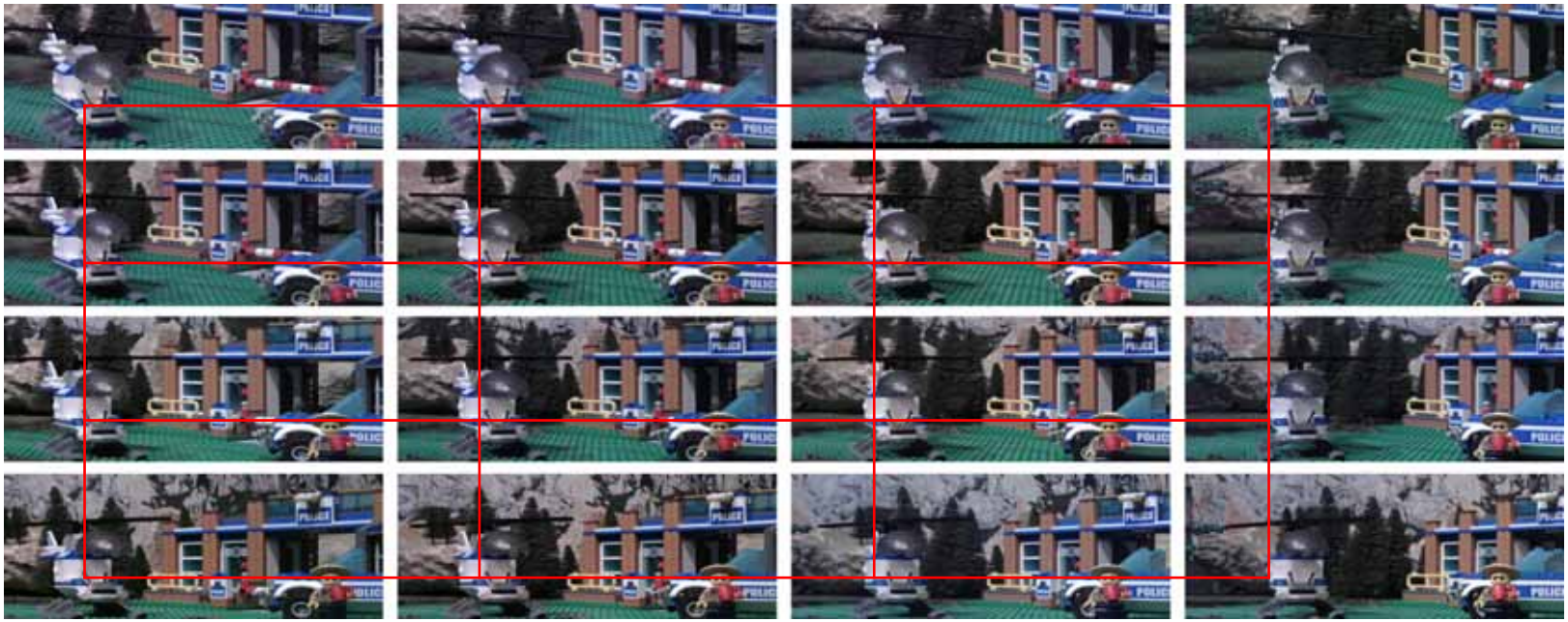
Lightfield Processing Pipeline
Support of Varying Array Architectures

Capture → Rectification → Disparity → Rendering

- Heterogeneous Architectures
  - Different image sizes
  - Different bit depths and color spaces
  - Support of RGB and RAW capture
  - 2D grids with different layouts, but not necessarily regular

Lightfield Processing Pipeline
Need of Dedicated Meta Data

Capture → Rectification → Disparity → Rendering

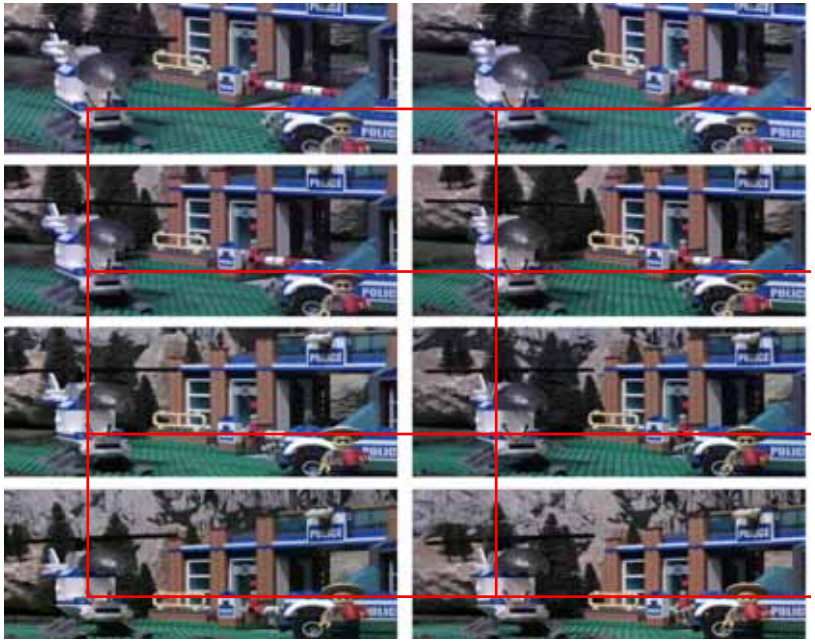


- Corresponding pixels are in the same row or column

Lightfield Processing Pipeline
Need of Dedicated Meta Data

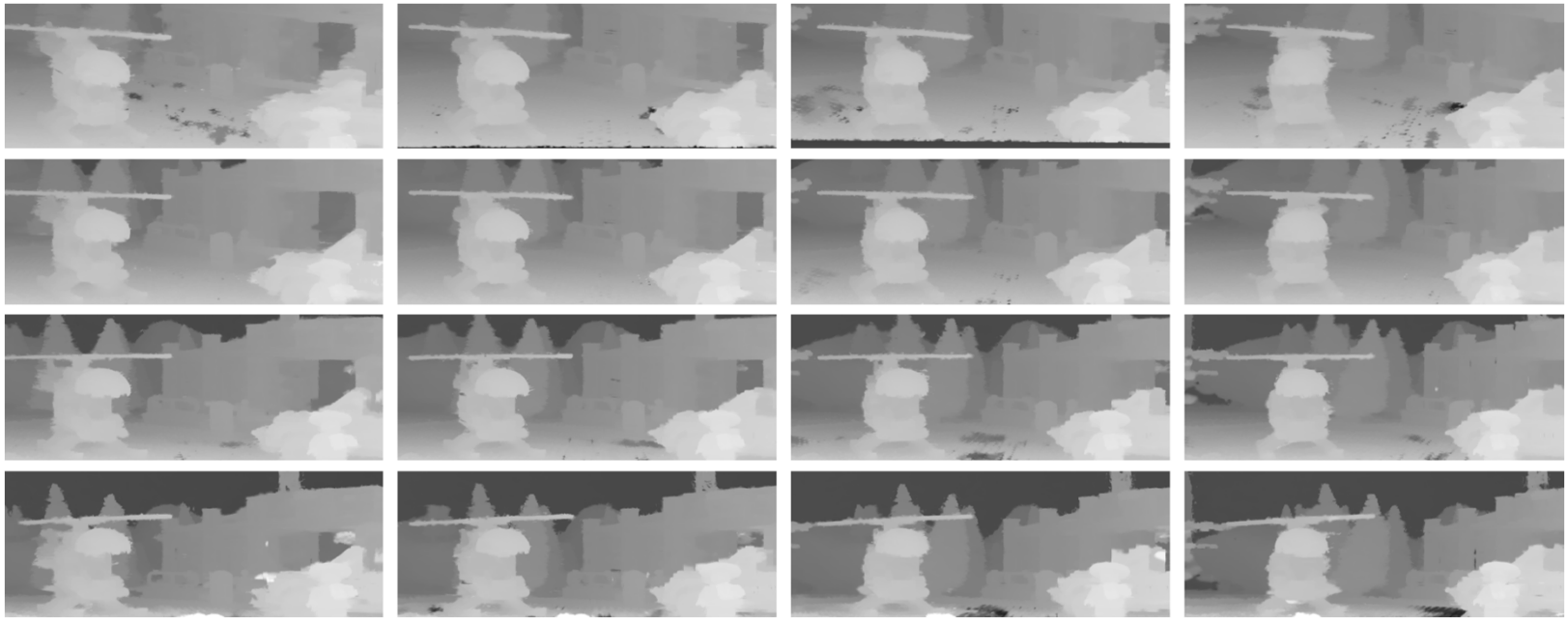
Capture → Rectification → Disparity → Rendering

- Need of dedicated meta data
  - Approx. camera positions
  - Approx. camera distances
  - Time codes
    (in case capture start times differed)
- Sometimes need
  - Focal length, pixel size, …



Lightfield Processing Pipeline
Storage of Disparity Maps

Capture → Rectification → Disparity → Rendering

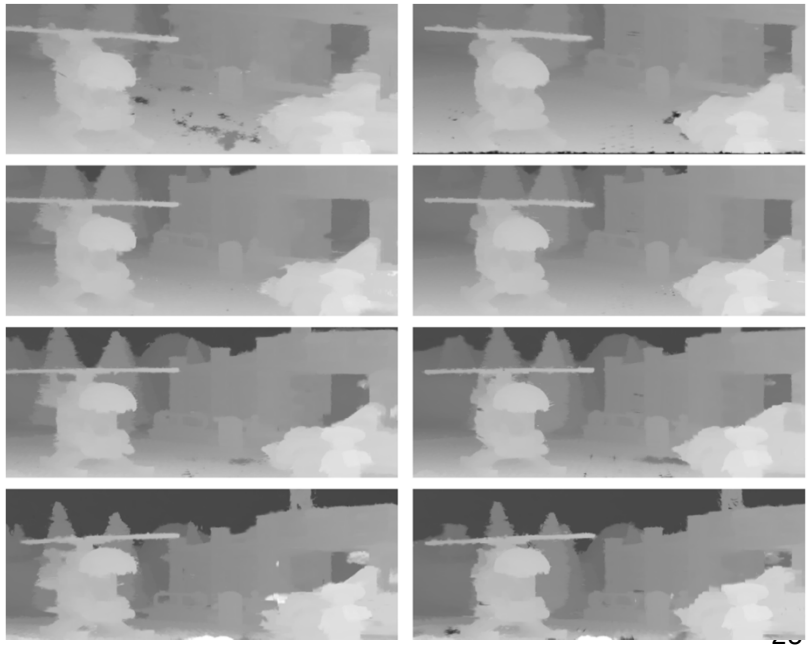


- Helps to interpolate a sparse lightfield into a dense one

Lightfield Processing Pipeline
Storage of Disparity Maps

Capture → Rectification → Disparity → Rendering

- Takes a lot of time, error prone
- Need for direct storage
- Subpixel accuracy
- Associated meta data for interpretation (base line)
- Positive and negative signs
- Min. value range: -8k .. 8k
- Mixed pixels -> Multiple values

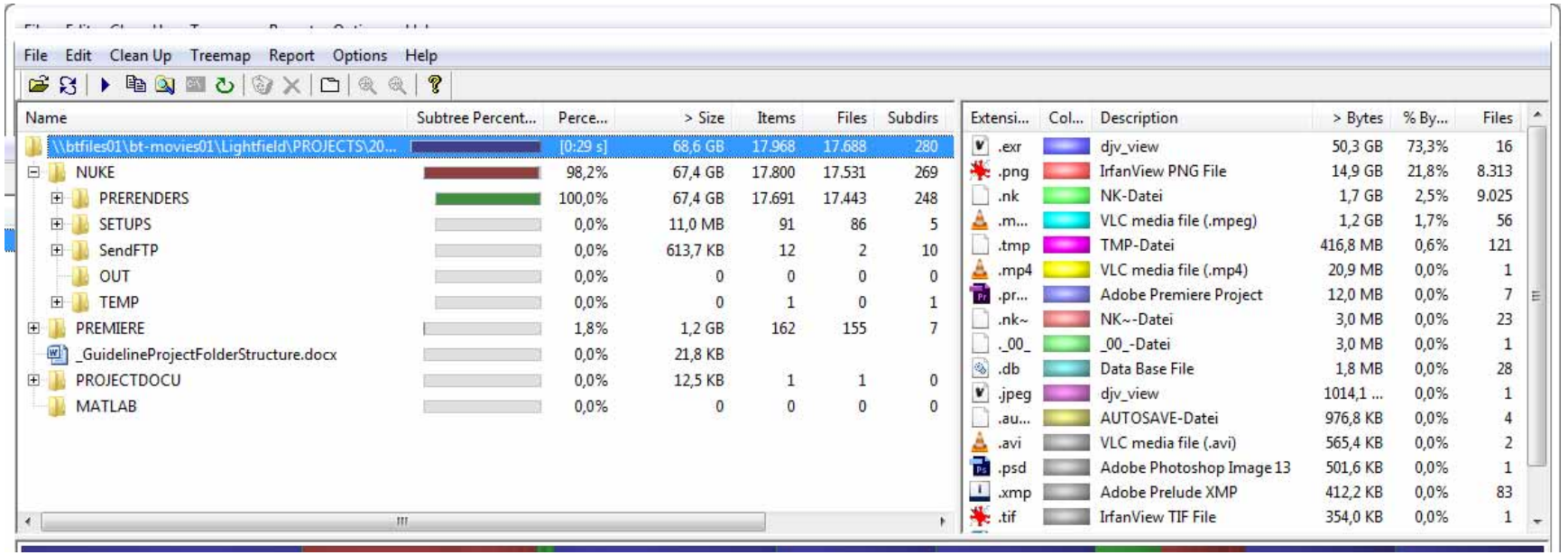


Lightfield Processing Pipeline
NUKE Data Management

- Post production requirements
  - Storage of intermediate results for time efficient reprocessing of parameter changes
  - Individual images for random access
- High data quality
  - Capture: 10-16 bit (integer)
  - Rectification and following steps: 16 bit or even 32 bit float
- High resolutions (2k-4k)

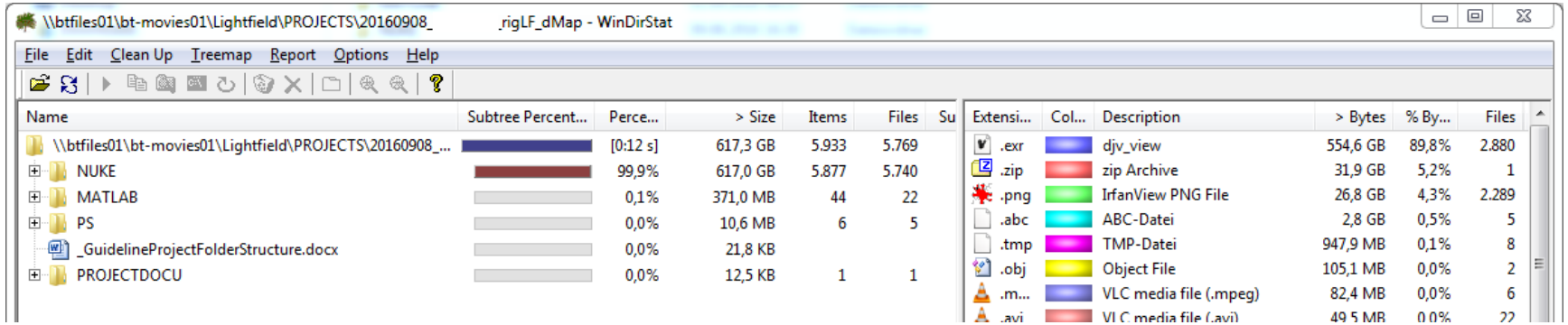
Lightfield Processing Pipeline
NUKE Data Management

- Example project for a 5x5 still frame
  - 5k material



Lightfield Processing Pipeline
NUKE Data Management

- Example project for a 2x3 array sequence with 100 frames
  - 5k material



6*100*81.5 MByte = 45.9 Gbyte (exr)	1.5*100 Gbyte 150 Gbyte	1.56*100 Gbyte 156 Gbyte	3.5 Mbyte PNG (HD)
Capture	Rectification	Disparity	Rendering

Lightfield Processing Pipeline
Random Access for Rendering

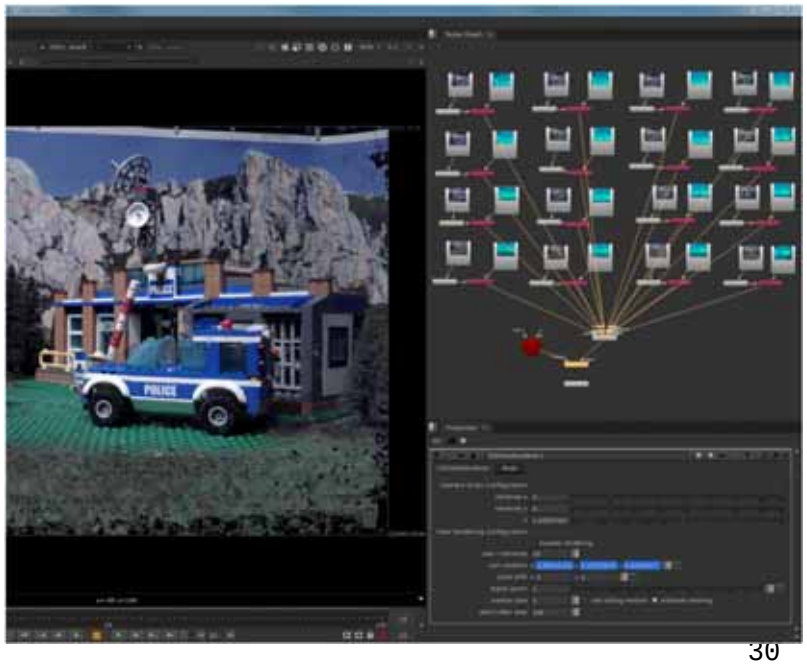
Capture → Rectification → Disparity → Rendering

- Vertigo Effect

Lightfield Processing Pipeline
Random Access for Rendering

Capture → Rectification → Disparity → Rendering

- Different Strategies
  - **Depth based**
  - Image based
- Depth based rendering leads to significant data reduction
- Compatible with post production environments
- High dynamic range and bit depth for good quality (i.p. relighting)



Lightfield Processing Pipeline
Offline Rendering

Capture → Rectification → Disparity → Rendering

- Different Strategies
  - **Depth based**
  - Image based
- High dynamic range and bit depth for good quality (i.p. relighting)

Lightfield Processing Pipeline
Online Rendering

- Real-time processing possible with simplified rendering algorithm
- Currently only still image
- Problem of handling the large data volumes

- Much higher computation power

Lightfield Processing Pipeline
Oculus Rift Demo

Captured by a portable system -> Still lower quality

Lightfield Processing Pipeline
Demo System

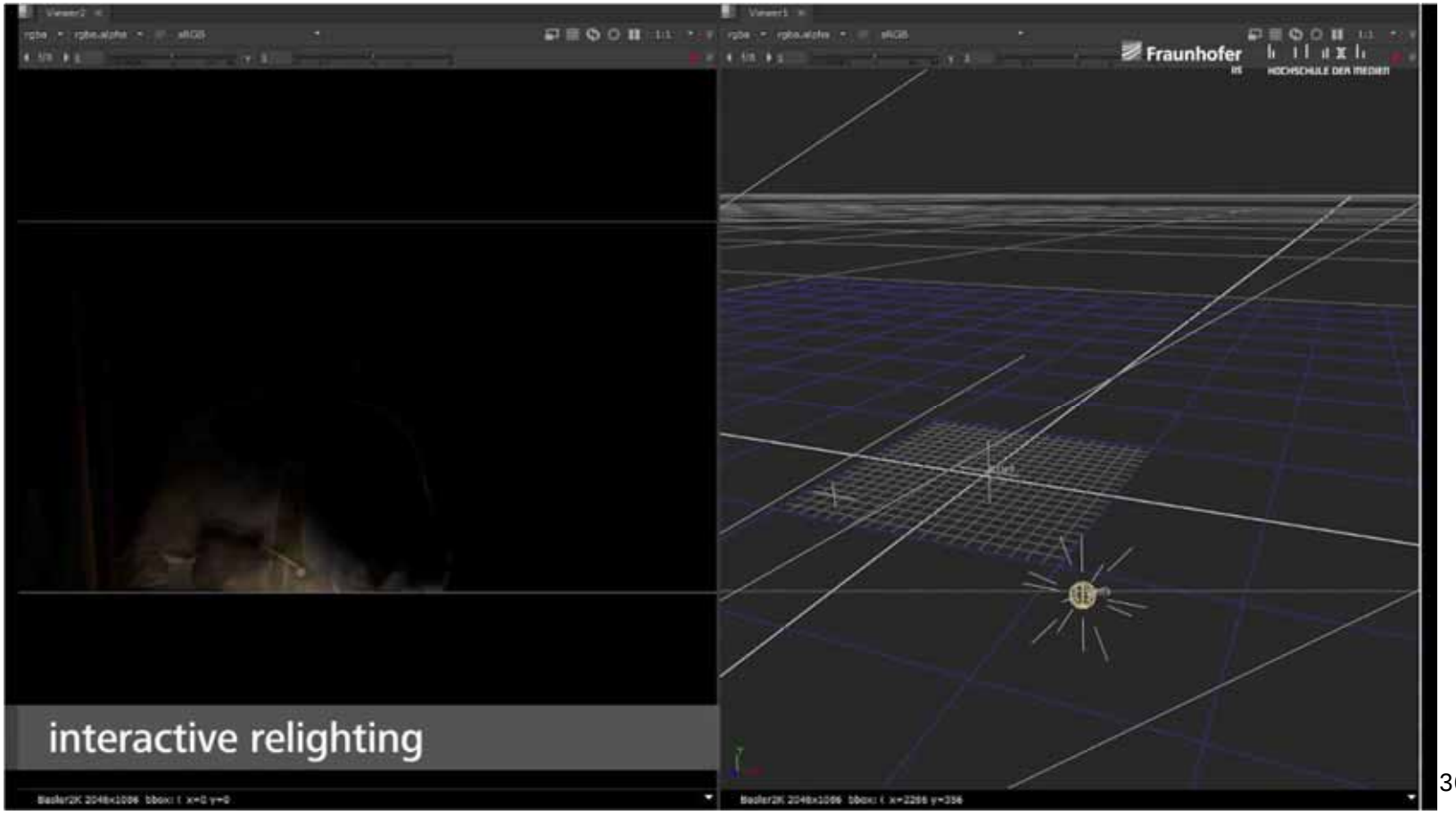
- Input data
  - RGB 9x1920x1080x3x25=1.3 Gbytes/s
  - Disparity: Same size (Subpixel accuracy)
- PCIe 3 capacity with 4 lanes: 4GByte/s (brut)
- More interactivity requires more images in the array
- Hard disk is the limiting factor

Time Frame

Future Has Started … (Making Of “Coming Home”)

Time Frame

Future Has Started … (Making Of “Coming Home”)



Conclusion about Lightfield in Media Production

- Novel visual effects in post production for natural content
- Requires multiview capture
  - Heterogenous architectures
  - Dedicated meta data
  - Disparity data
  - High dynamic range
- Proof of concept films available
- Several technology building bricks still missing
- Need of appropriate storage format for post production

Thank you for your attention!

Have a nice day!

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