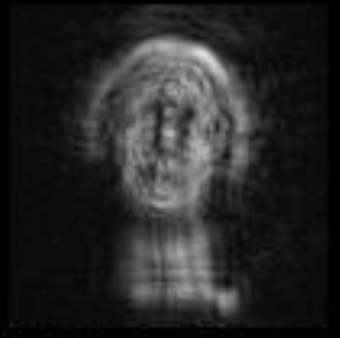
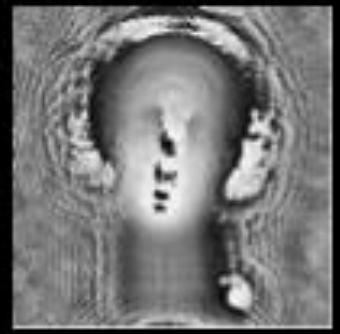
JPEG Pleno

Peter Schelkens

Vrije Universiteit Brussel - imec

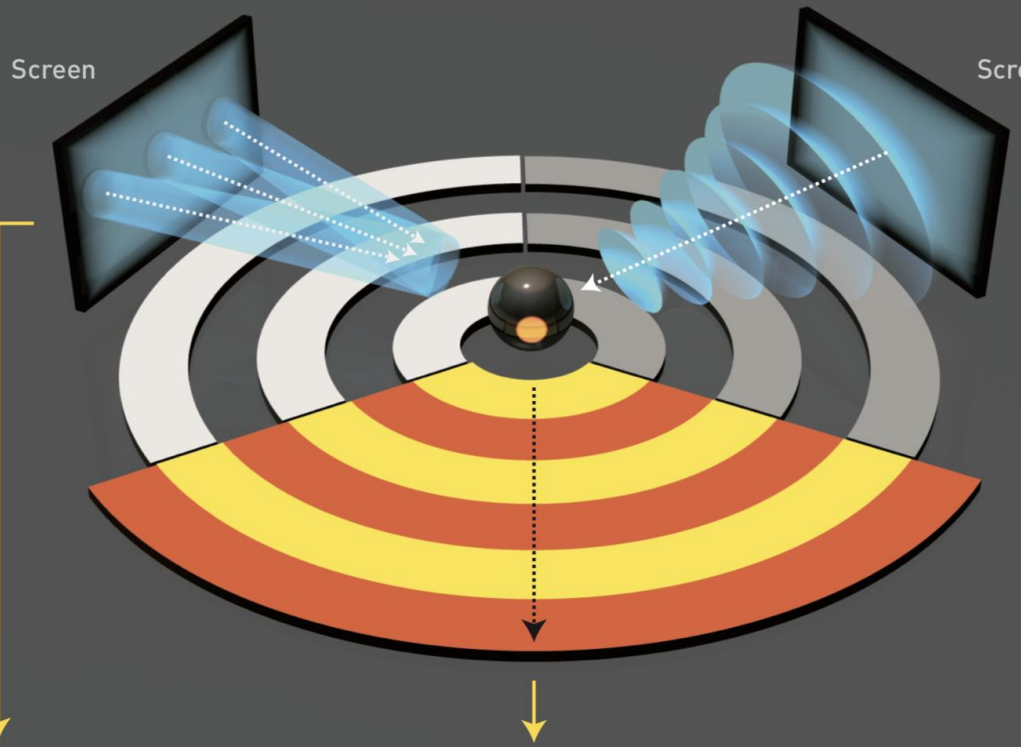
Content of this talk





- Introduction
- JPEG Pleno Framework
- JPEG Pleno Light Field
- JPEG Pleno Point Cloud
- JPEG Pleno Holography
- Timeline

3-D display families



Ray (lightfield)

Parallax : easy
Accommodation : hard
Occlusion : easy
View angle : moderate
Virtual image formation : easy

Point (volumetric)

Parallax : easy
Accommodation : trivial
Occlusion : difficult
View angle : easy
Virtual image formation : impossible?

Wave (holographic)

Parallax : easy
Accommodation : easy
Occlusion : easy
View angle : hard
Virtual image formation : easy

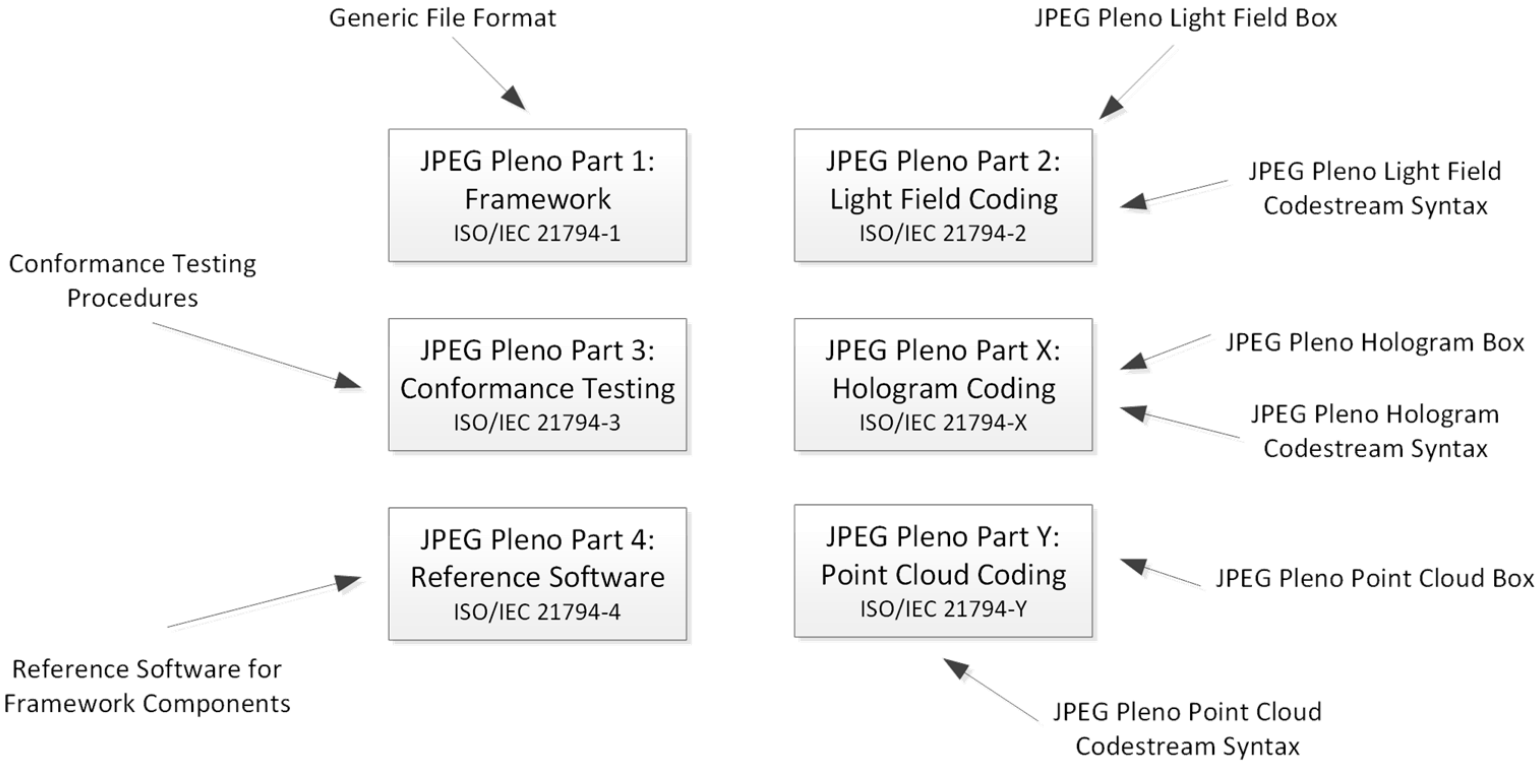
JPEG Pleno

Goal

- Standard framework that will facilitate capture, representation and exchange of light field, point cloud and holographic data.

- Aims
  - tools for improved compression while providing advanced functionalities at system level and;
  - supporting data and metadata manipulation, editing, scalability, random access and interaction, protection of privacy and ownership rights as well as other security mechanisms.

JPEG Pleno
Framework



JPEG Pleno Part 1

Generic File Format

identifies the file as being part of the JPEG Pleno family of files

file type, version and compatibility information

catalog of JPEG Pleno file

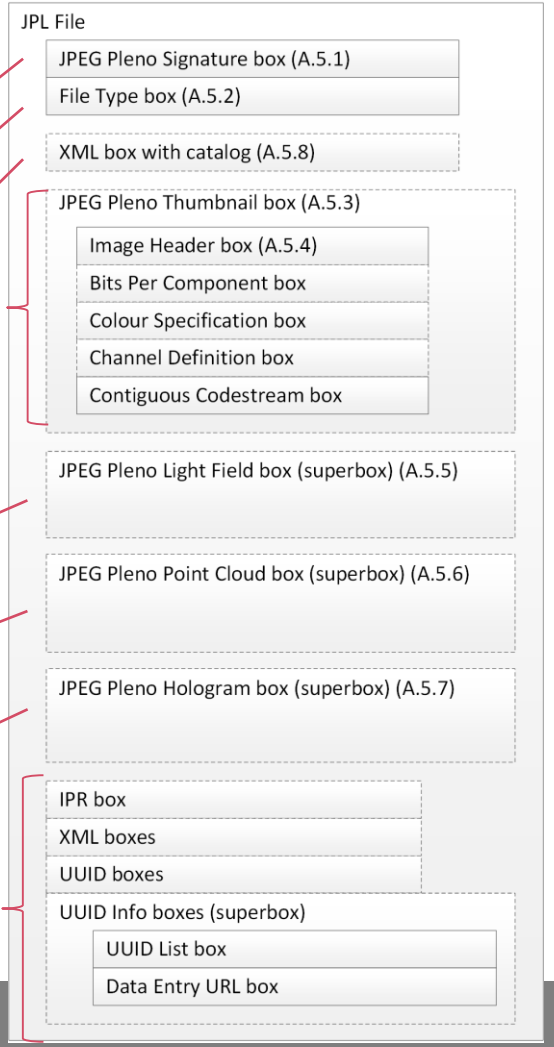
contains number of boxes that allow the signaling of a thumbnail image that represents the carried plenoptic content, the size of the image and other related fields

contains the encoded light field, its parameterization and associated metadata

contains the encoded point could, its parameterization and associated metadata

contains the encoded hologram, its parameterization and associated metadata

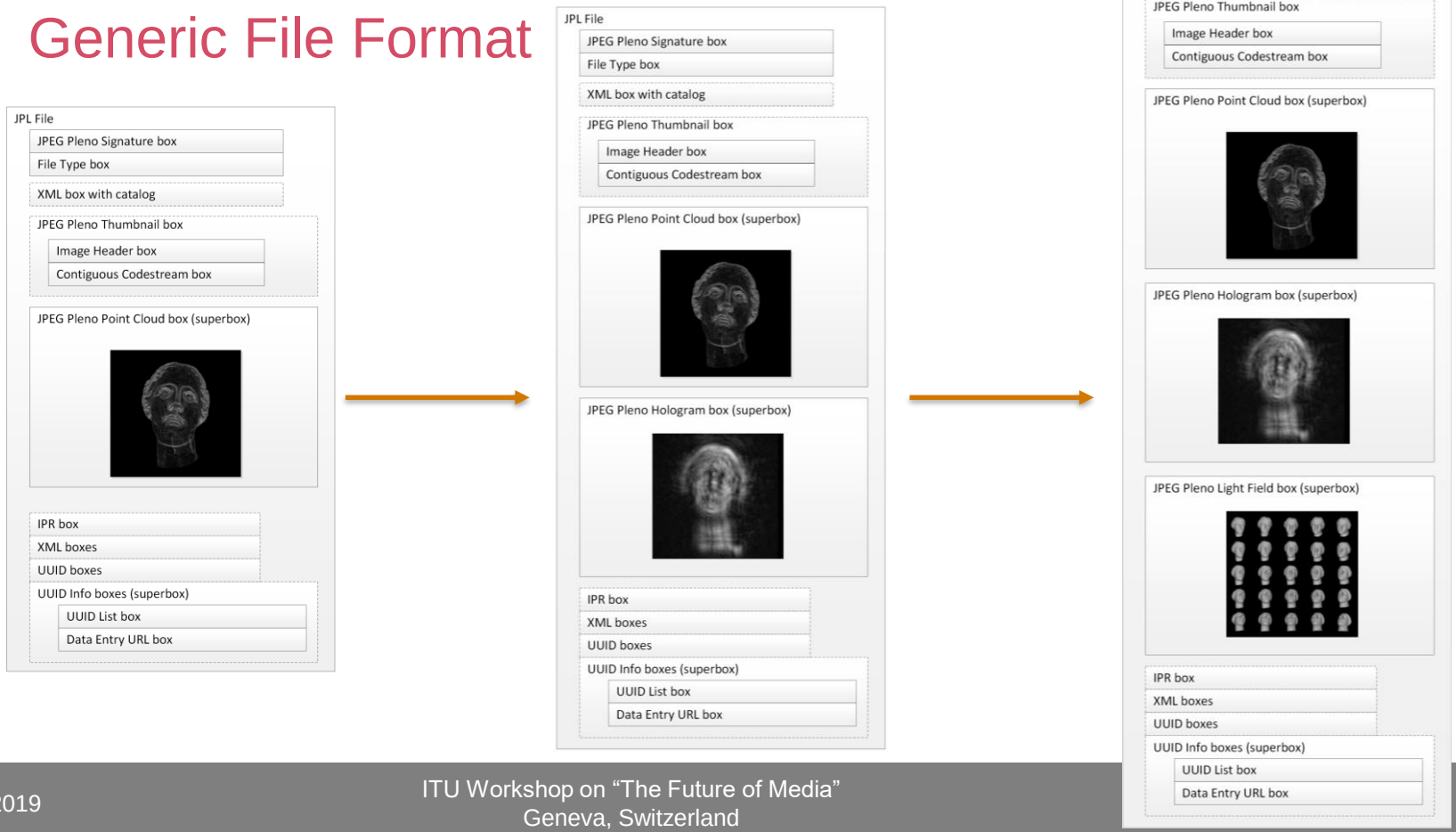
additional metadata



P. Schelkens et al., "JPEG Pleno light field coding technologies,"
Proc. SPIE 11137, Applications of Digital Image Processing XLII, 2019.

JPEG Pleno Part 1

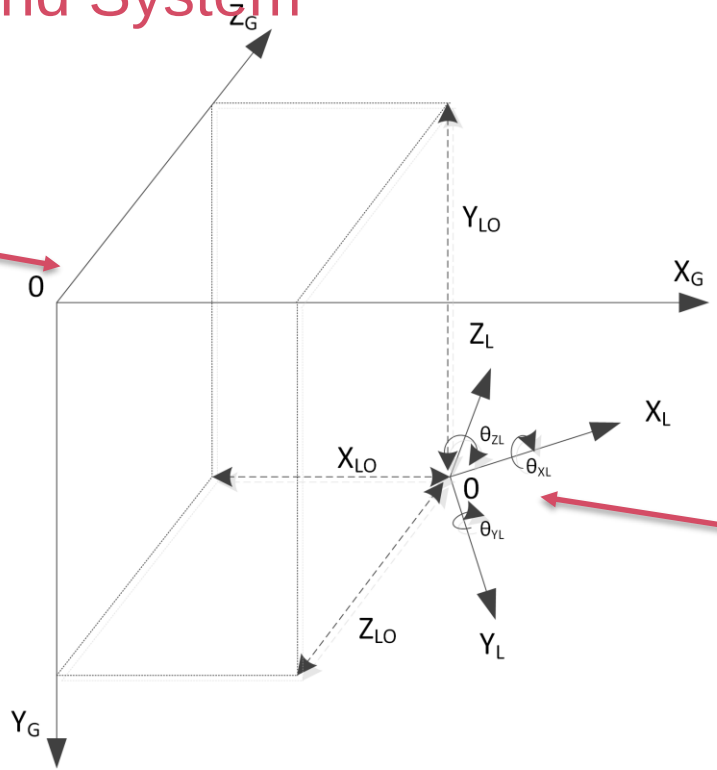
Generic File Format



JPEG Pleno Part 1

Reference Grid System

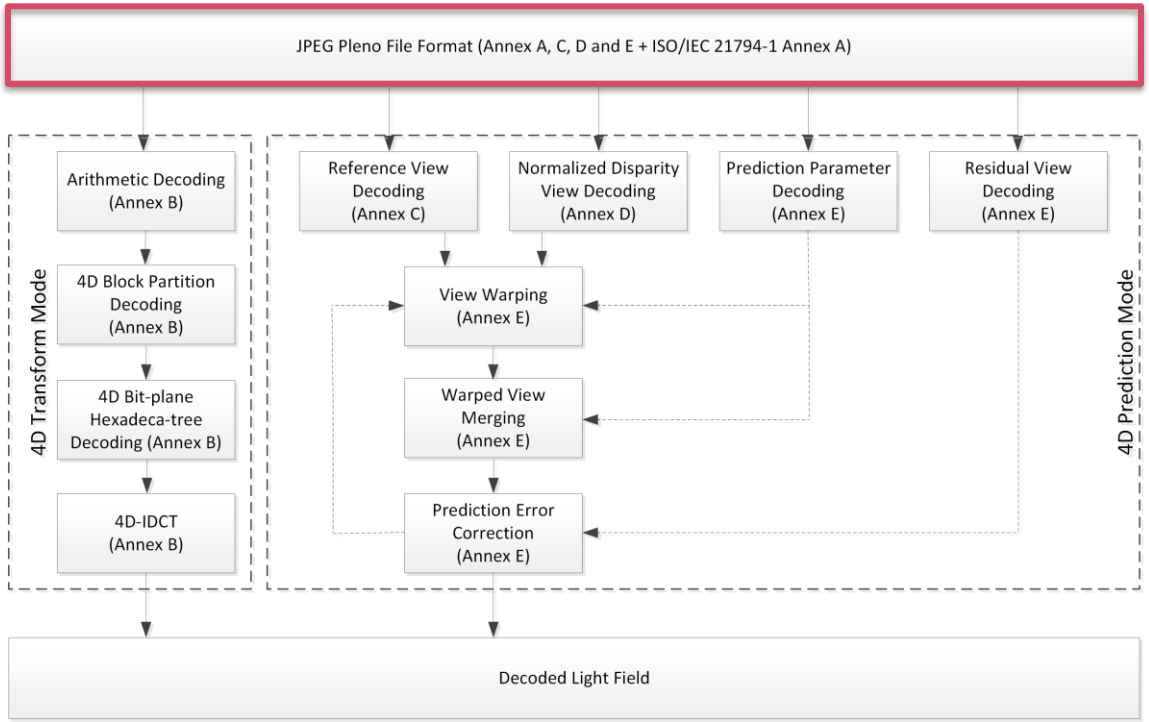
Global Reference Grid



Local Reference Grid

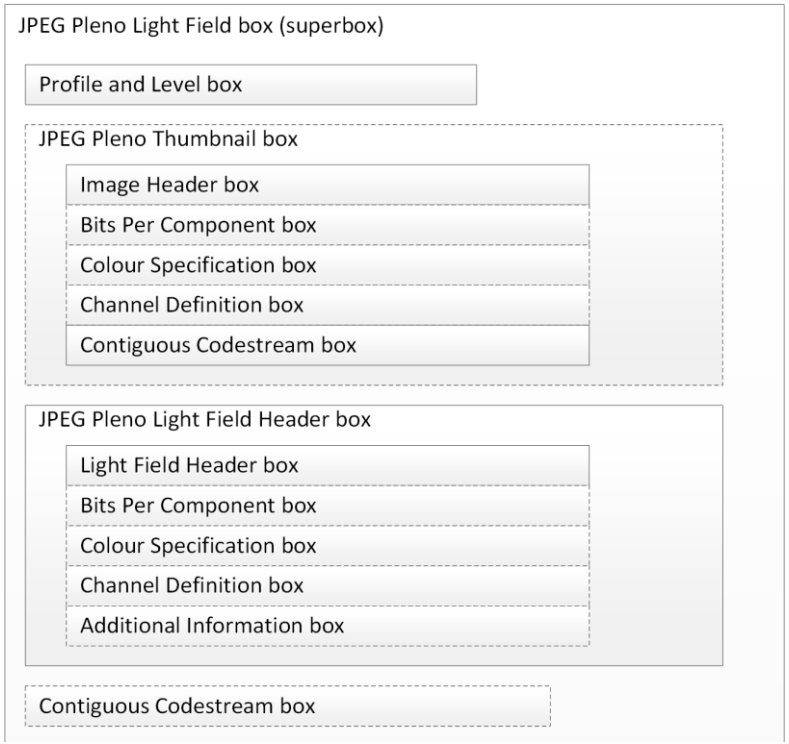
JPEG Pleno Light Field

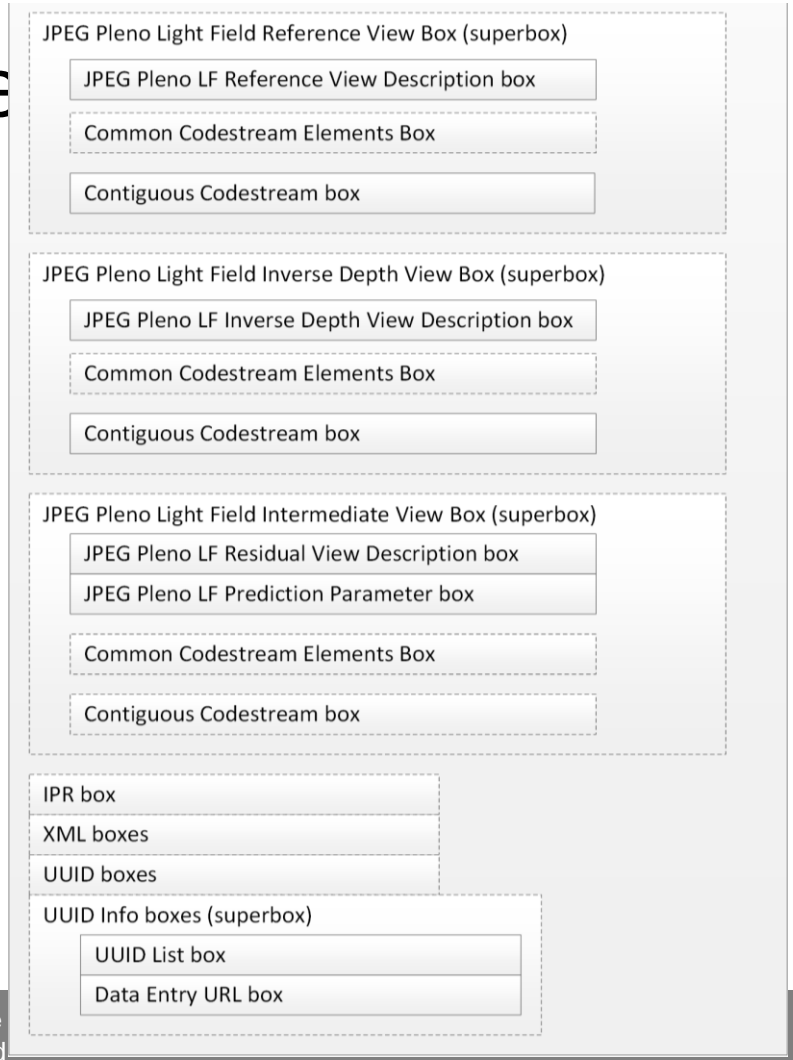
Generic Light Field Coding Architecture



JPEG Pleno Light Fie

File Format





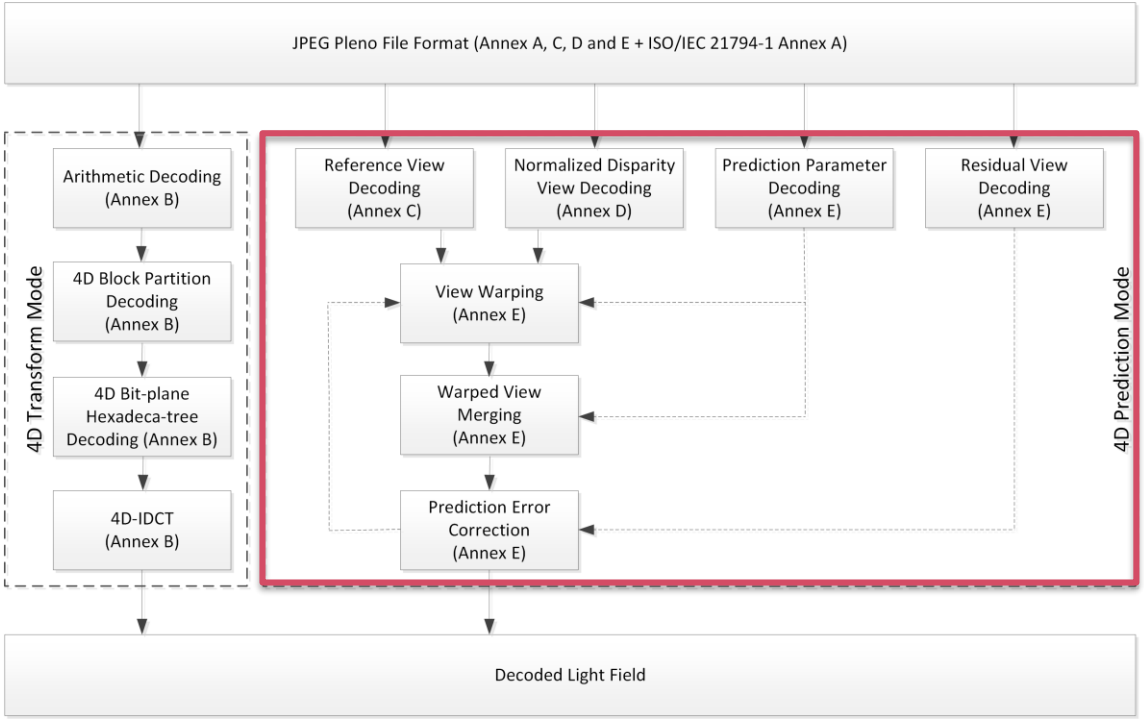
JPEG Pleno Light Field

Calibration Data

PP	Precision of coordinates. (Precision Prec = 16*2^PP) This number indicates the IEEE floating-point precision issued for the coordinates. The IEEE 754 / ISO/IEC/IEEE 60559 floating point representation is utilized.
X_{LO}	Position of the origin of the local reference grid in the global reference system along the X_G coordinate axis. This field is utilizing the chosen floating-point precision.
Y_{LO}	Position of the origin of the local reference grid in the global reference system along the Y_G coordinate axis. This field is utilizing the chosen floating-point precision.
Z_{LO}	Position of the origin of the local reference grid in the global reference system along the Z_G coordinate axis. This field is utilizing the chosen floating-point precision.
θ_{XL}	Rotation offset around the X_L axis (in rad). This field is utilizing the chosen floating-point precision.
θ_{YL}	Rotation offset around the Y_L axis (in rad). This field is utilizing the chosen floating-point precision.
θ_{ZL}	Rotation offset around the Z_L axis (in rad). This field is utilizing the chosen floating-point precision.
CalTab	Calibration Table. This field indicates which calibration parameters are signalled.
S_{GLX}	Scaling of local reference grid system with respect to global reference grid system for the X-axes before rotation. This field is utilizing the chosen floating-point precision.
S_{GLY}	Scaling of local reference grid system with respect to global reference grid system for the Y-axes before rotation. This field is utilizing the chosen floating-point precision.
S_{GLZ}	Scaling of local reference grid system with respect to global reference grid system for the Z-axes before rotation. This field is utilizing the chosen floating-point precision.
XCC(t, s)	Camera centre of subaperture view (t, s) in local reference grid along X_L coordinate axis. This quantity is used in warping process for intermediate view prediction. This field is utilizing the chosen floating-point precision.
YCC(t, s)	Camera centre of subaperture view (t, s) in local reference grid along Y_L coordinate axis. This quantity is used in warping process for intermediate view prediction. This field is utilizing the chosen floating-point precision.
ZCC(t, s)	Camera centre of subaperture view (t, s) in local reference grid along Z_L coordinate axis. This quantity is used in warping process for intermediate view prediction. This field is utilizing the chosen floating-point precision.
$\theta_{Xcam}(t, s)$	Camera rotation offset around the X_{CAM} axis (in rad). This field is utilizing the chosen floating-point precision.
$\theta_{Ycam}(t, s)$	Camera rotation offset around the Y_{CAM} axis (in rad). This field is utilizing the chosen floating-point precision.
$\theta_{Zcam}(t, s)$	Camera rotation offset around the Z_{CAM} axis (in rad). This field is stored as a 4-byte signed integer.
$M_{int}(t,s)$	Matrix of intrinsic camera parameters (see table B.X)

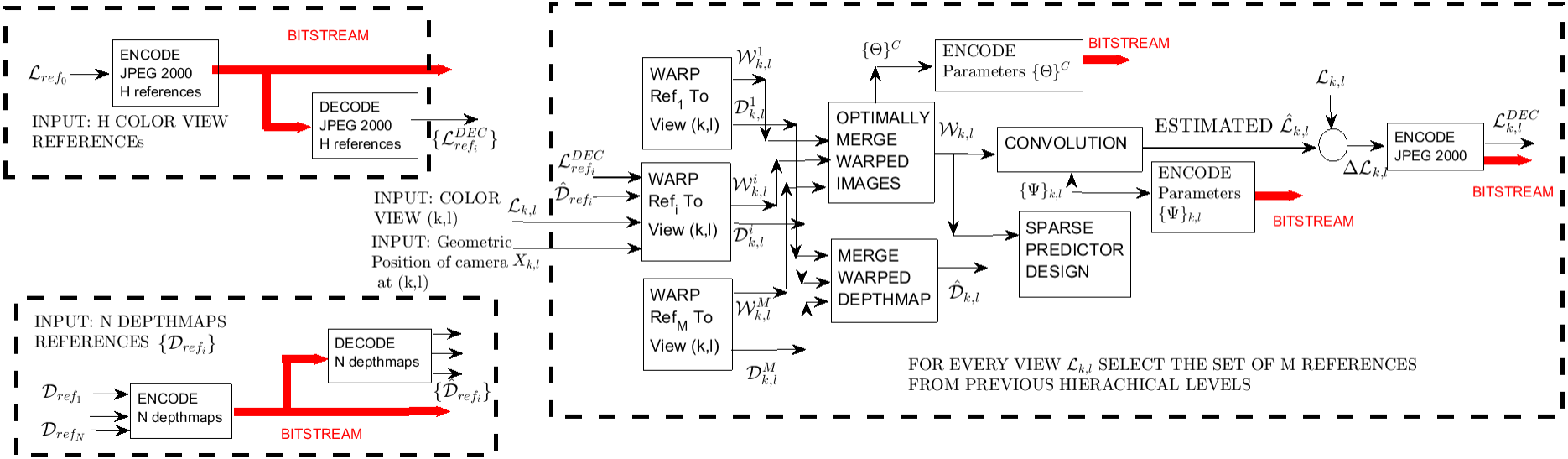
JPEG Pleno Light Field

Generic Light Field Coding Architecture



JPEG Pleno Light Field

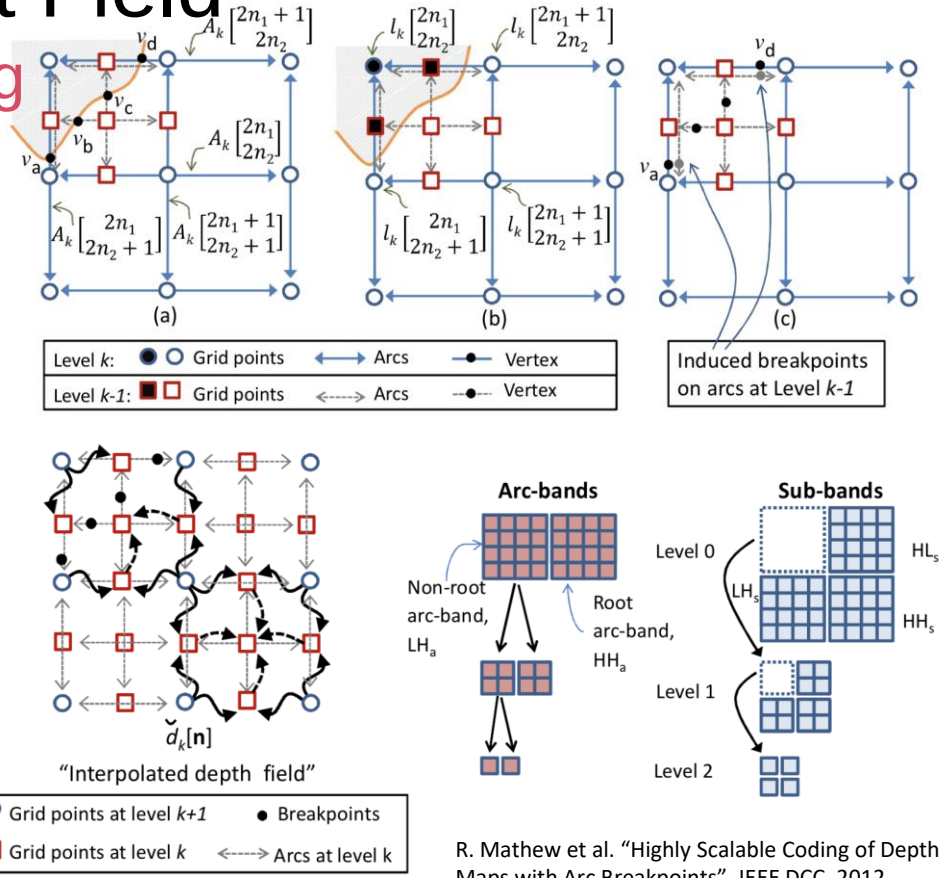
4D Prediction encoder architecture



JPEG Pleno Light Field

Inverse Depth Encoding

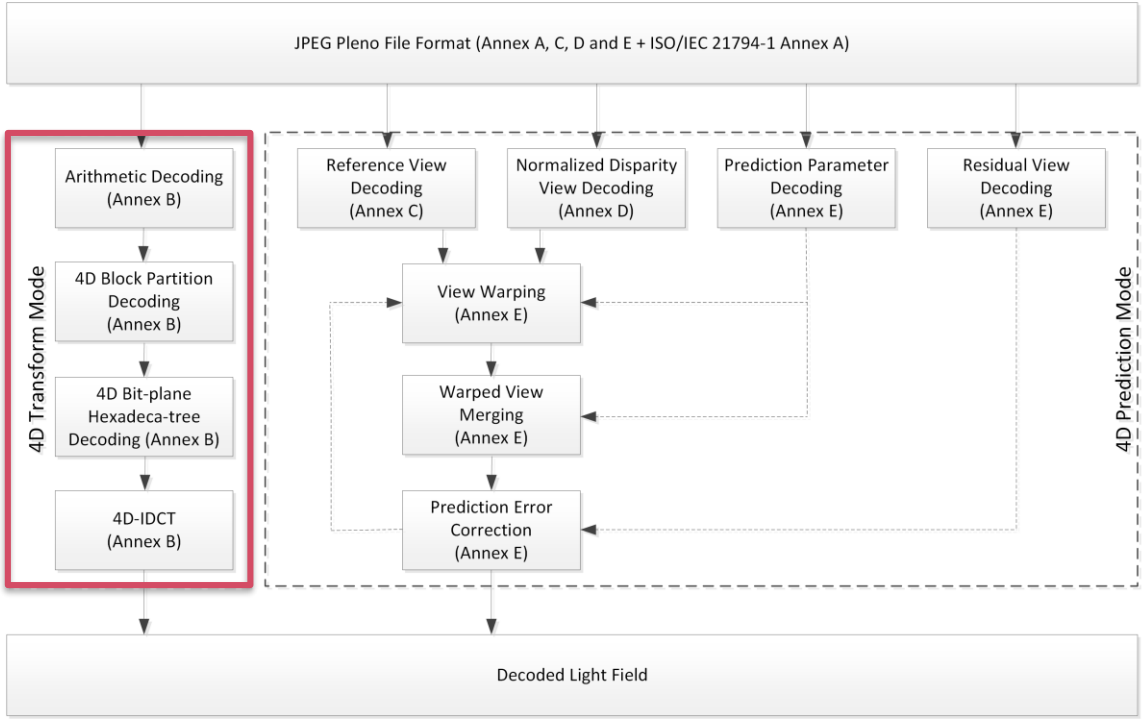
- JPEG 2000 (default)
- New part 17 of JPEG 2000: extensions for coding of discontinuous media
  - Also suitable for e.g. optical flow data
- Specifies “breakpoint-dependent” spatial wavelet transforms



R. Mathew et al. “Highly Scalable Coding of Depth Maps with Arc Breakpoints”, IEEE DCC, 2012.

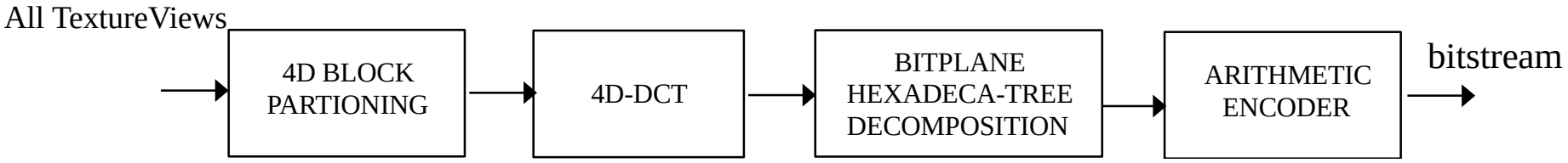
JPEG Pleno Light Field

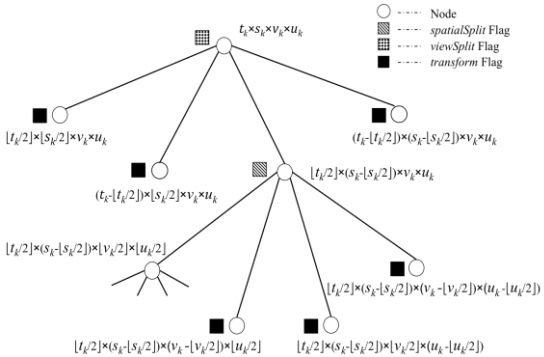
Generic Light Field Coding Architecture

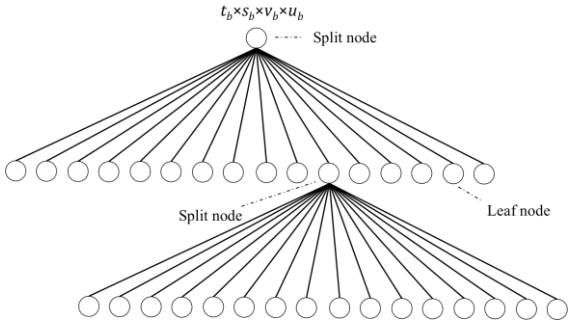


JPEG Pleno Light Field

4D Transform – Encoder Architecture





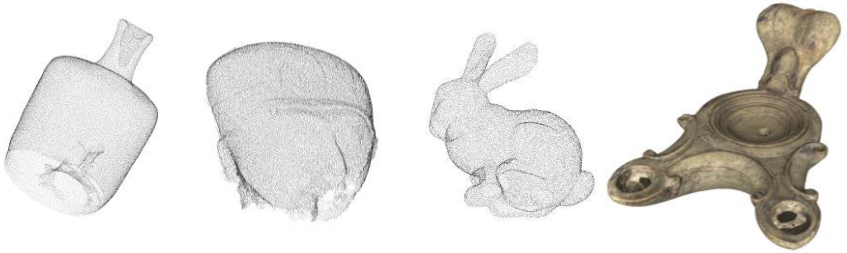


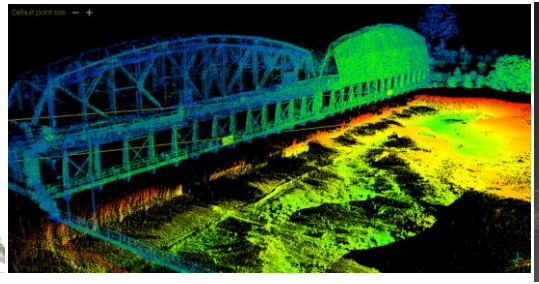
JPEG Pleno Point Cloud

Introduction

Point clouds are a promising 3D technology

- Strong interest from consumer market and developers
- Accurate 3D representation
- Several acquisition solutions available nowadays





JPEG Pleno Point Cloud

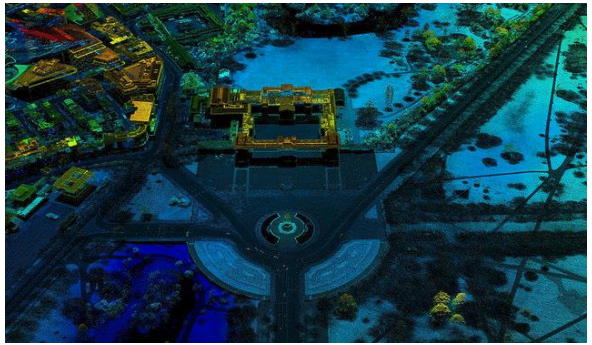
Current Mandate

- Consult with industry and academia to determine use cases and requirements for static point cloud coding
- Collect a database of point clouds for testing and evaluation
- Design subjective and objective testing protocols for point cloud quality evaluation
- Solicit proposals for point cloud encoding and evaluate proposals

JPEG Pleno Point Cloud

Requirements

- Key Identified Requirements
  - Support for coding and compression of both local and global attributes as well as geometric information
  - Tuneable quality
  - Scalability of geometry and attributes
  - Different degrees of precision, resolution and range
  - Random access – selective decoding of a portion of the point cloud independently of the rest



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JPEG Pleno Holography

Nano- to Macroscale Applications

© 2019 www.ultimate-holography.com

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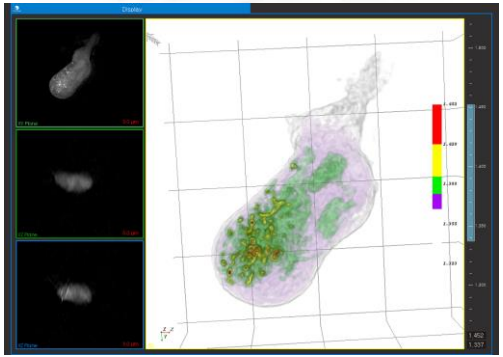

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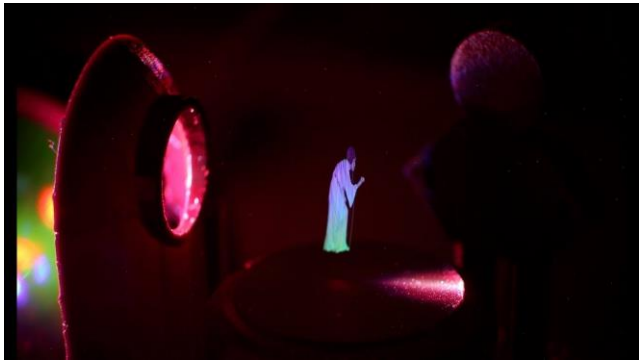

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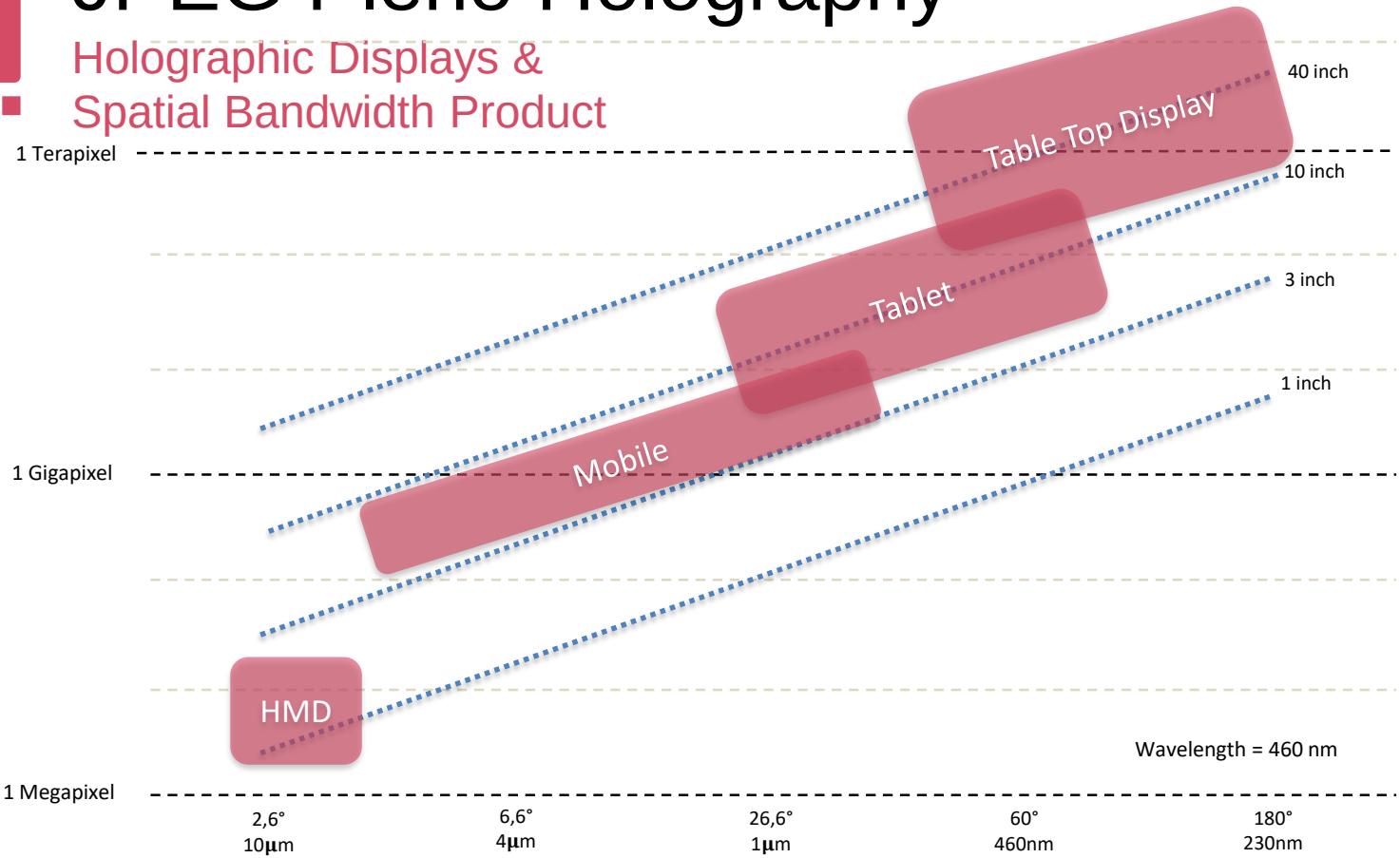
www.youtube.com/watch?v=qUSiw87mQck

JPEG Pleno Holography

Holographic Displays & Spatial Bandwidth Product

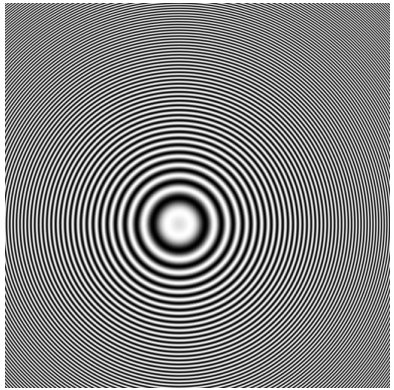


JPEG Pleno Holography

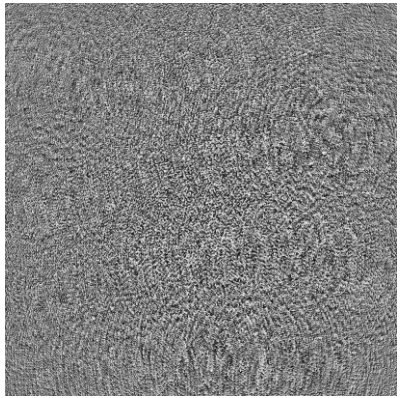
Signal Properties of Holograms

- Huygens-Fresnel principle

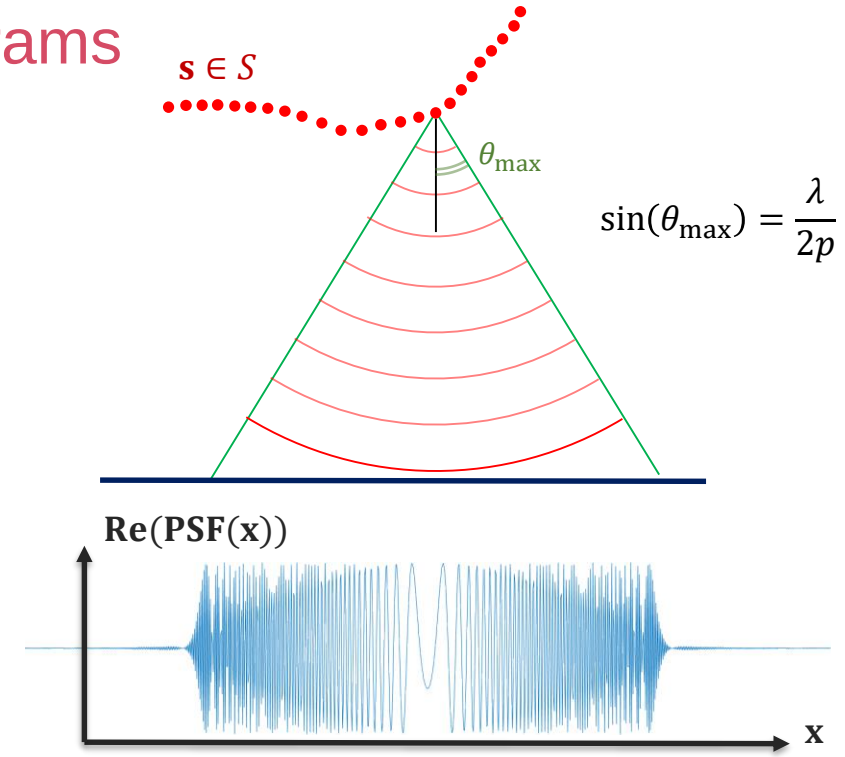
$$u'(\mathbf{x}) = \frac{1}{i\lambda}\iint_S u(\mathbf{x})\frac{\exp\left(\frac{2\pi i}{\lambda}\|\mathbf{s}-\mathbf{x}\|\right)}{\|\mathbf{s}-\mathbf{x}\|^2}\mathbf{n}\cdot(\mathbf{s}-\mathbf{x})d\mathbf{x}$$



Single point-spread function
(real part)



Hologram
(real part)



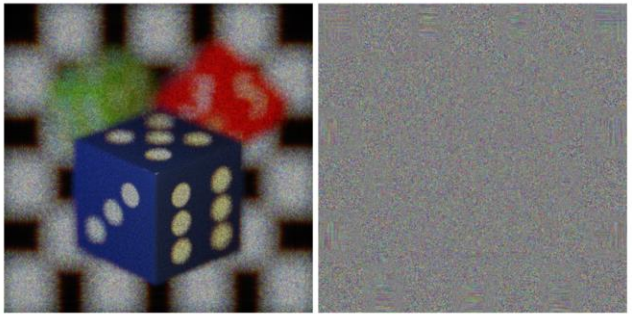
D. Blinder et al., "Signal processing challenges for digital holographic video display systems," Signal Processing: Image Communication, vol. 70, pp. 114–130, 2019.

JPEG Pleno Holography

Coding of holograms

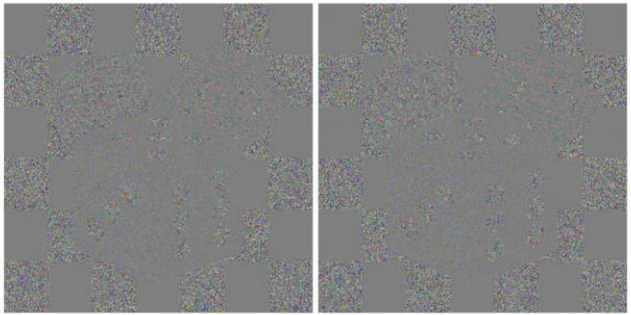
- Representation?
  - Amplitude holograms (real)
  - Phase holograms or kinoforms (real)
  - Amplitude-phase (complex)
  - Real-Imaginary (complex)
  - Shifted distance representation (complex)

- What to encode?
  - CGH source input
  - Hologram plane
  - Object plane
  - Content-aware coding



(a) Amplitude (b) Phase

FIGURE 3 Amplitude-Phase representation of hologram *Dices1080p*, selected from b<>com database.



(a) Real part (b) Imaginary part

FIGURE 4 Real-Imaginary representation of hologram *Dices1080p*, selected from b<>com database.

Schelkens et al. ,"JPEG Pleno: Providing Representation Interoperability for Holographic Applications and Devices", ETRI Journal, 2019.

JPEG Pleno Holography

Current Activities

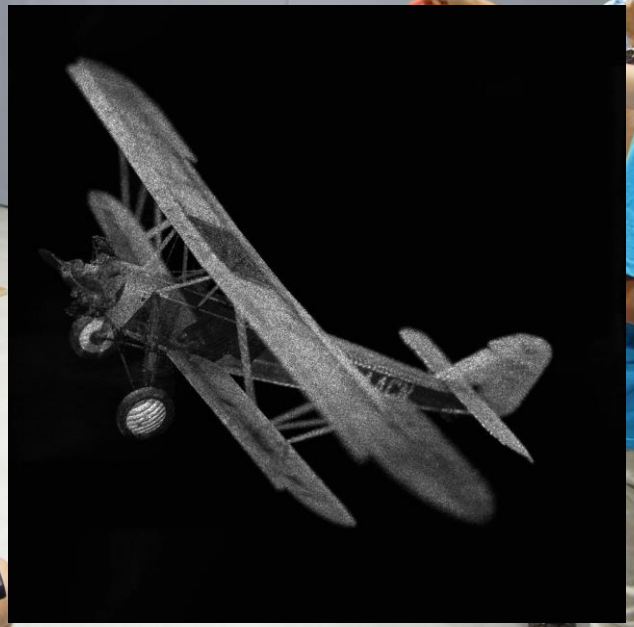
- The JPEG Pleno efforts in the context of holography aim at providing compression and quality testing solutions.

- Various holographic test data such as computer-generated holograms (CGH), microscopy/tomography images and interferometric data has been collected.
  - JPEG PlenoDB website: www.jpeg.org/jpegpleno

- Exploration studies to identify objective/subjective quality assessment and associated numerical reconstruction techniques for holography.

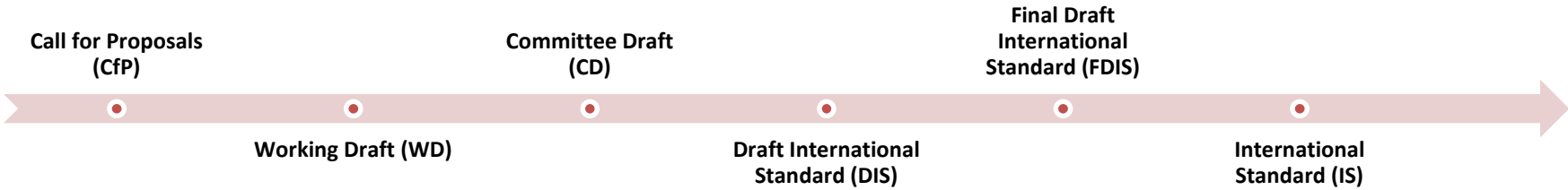
Quality Assessment

Objective & Subjective Quality Assessment



Timeline

- JPEG Pleno Part 1 Framework – DIS (Jul 2019)
- JPEG Pleno Part 2 Light Field Coding – DIS (Jul 2019)
- JPEG Pleno Part 3 Conformance Testing – CD (Jan 2020)
- JPEG Pleno Part 4 Reference Software – CD (Jan 2020)
- JPEG 2000 Part 17 Extensions for coding of discontinuous media – CD (Jan 2020)
- JPEG Pleno Holographic Coding – CfP (2020)
- JPEG Pleno Point Cloud Coding - TBD



JPEG Pleno

JPEG Pleno – Holography

Conclusions

Home | About JPEG | News & Press | Participation | Contact & Branding | ISO Members Area

JPEG Pleno

JPEG | JPEG XT | JPEG-LS | JPEG 2000 | JPEG XR | AIC | JPEG Systems | JPEG XS | JPEG Pleno | JPEG XL

Overview | Workplan & Specs | Documentation | Database | Light Field | Holography | Point Cloud

Overview of JPEG Pleno

JPEG Pleno aims to provide a standard framework for representing new imaging modalities, such as texture-plus-depth, light field, point cloud, and holographic imaging. Such imaging should be understood as light representations inspired by the plenoptic function, regardless of which model captured or created all or part of the content.

JPEG Pleno standard tools will be designed together to consider their synergies and dependencies for the whole to be effectively greater than the sum of its parts. To fully exploit this holistic approach, JPEG Pleno is not just a set of efficient coding tools addressing compression efficiency. It is a representation framework understood as a fully integrated system for providing advanced functionality support for image manipulation, metadata, random access and interaction, and various file formats. In addition, it should offer privacy protection, ownership rights, and security.

The JPEG Pleno framework is end-to-end-from the real or synthetized world to the replicated world-in its focus on harmoniously integrating all necessary tools into a single system to represent the same visual reality while considering different modalities, requirements, and functionalities.

Part 1, Framework

Specifies the JPEG Pleno framework and the interrelationsships between the different components of the standard, i.e. representation of light-field, point-cloud and holographic modalities and system related aspects.

Part 2, Light Field Coding

Specifies the coding technology for light field modalities

Part 3, Conformance testing

Defines conformance testing for the standardized technologies covered by the JPEG Pleno framework.

Part 4, Reference software

Provides reference implementations for the standardized technologies within the JPEG Pleno framework for purpose of reference for prospective implementers of the standard and compliance testing.

JPEG

About JPEG | News & Press | Participation | Contact & Branding

JPEG | JPEG XT | JPEG 2000

JPEG-LS | JPEG XR | JPEG XS

JBIG | JPSearch | JPEG Pleno

AIC | JPEG Systems | JPEG XL

ISO Members Area

Terms & Conditions

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