JPEG

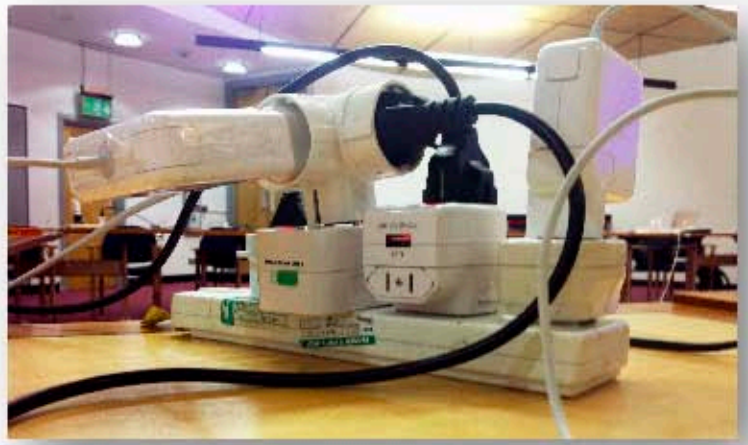
JPEG PLENO

Towards a New Standard for Plenoptic Image Compression

Touradj Ebrahimi

JPEG Convener

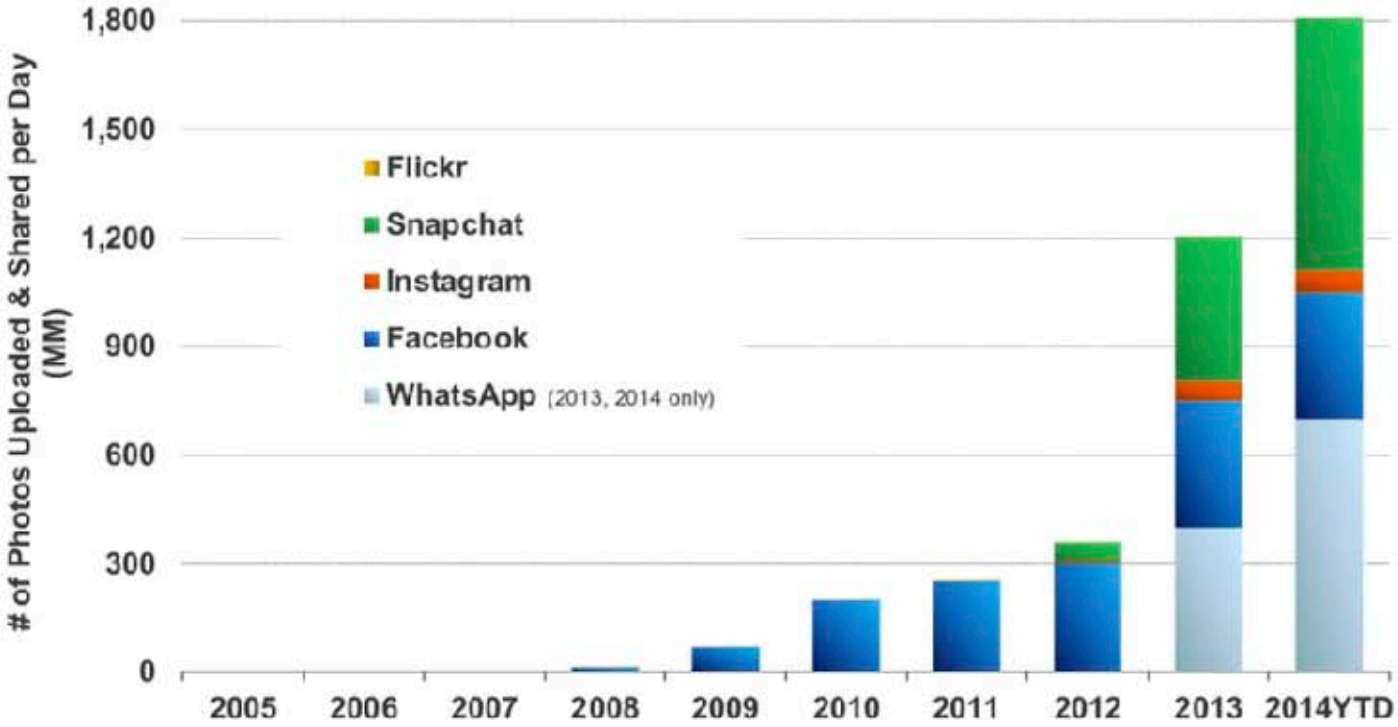
JPEG Committee



- Joint Photographic Experts Group
  - ISO/IEC JTC1/SC29/WG1
  - ITU-T SG16
- Standardization = Assuring INTEROPERABILITY

JPEG Family of Standards

JPEG still a rapidly growing ecosystem



Source: KPCB 2014 Internet Trends, estimates based on publicly disclosed company data.

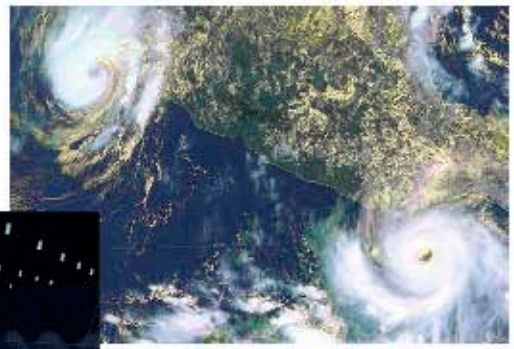
1995-96 Technology and Engineering Emmy award (together with MPEG-2)

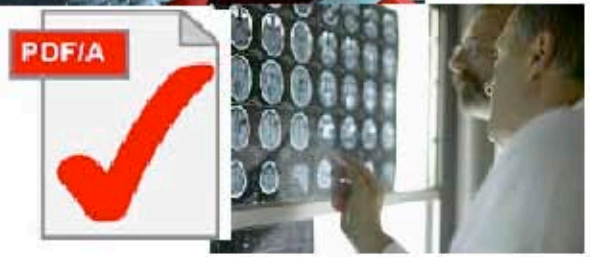
JPEG 2000 succeeded in professional markets

DICOM
Digital Imaging and Communications in Medicine

DCI
Digital Cinema Initiatives, LLC

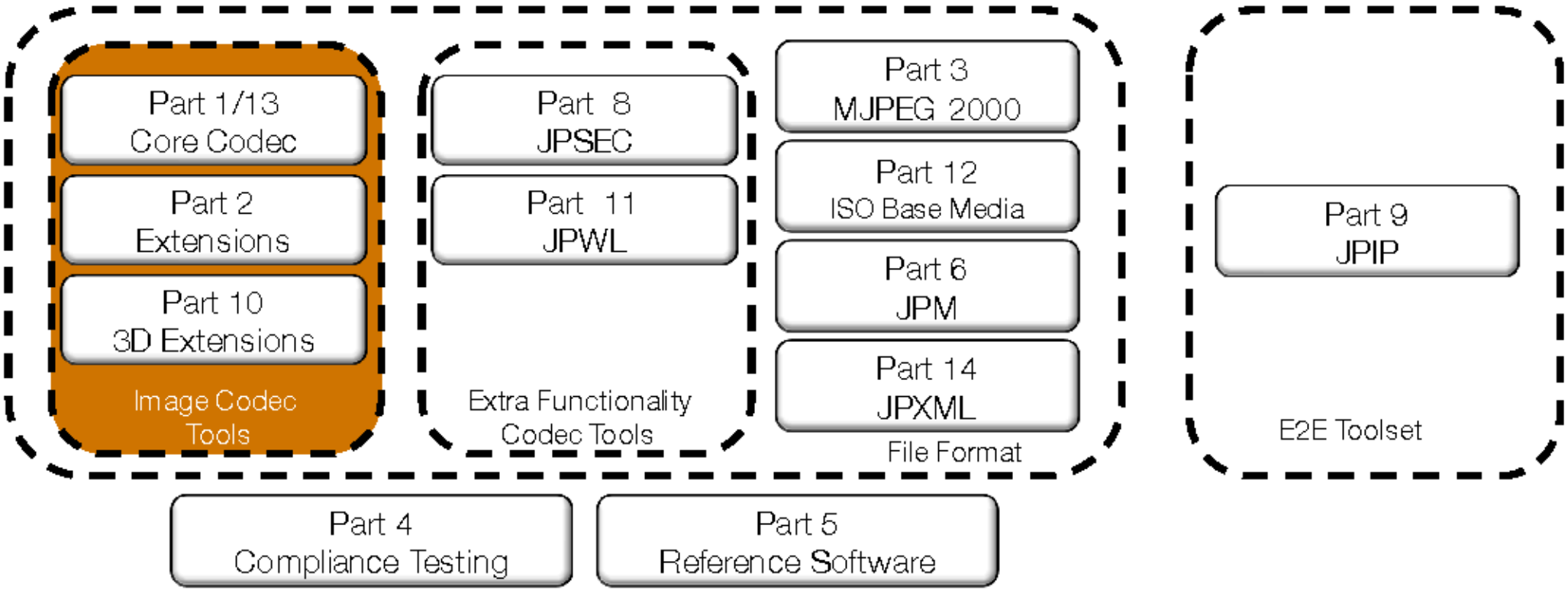
VSF
VIDEO SERVICES FORUM



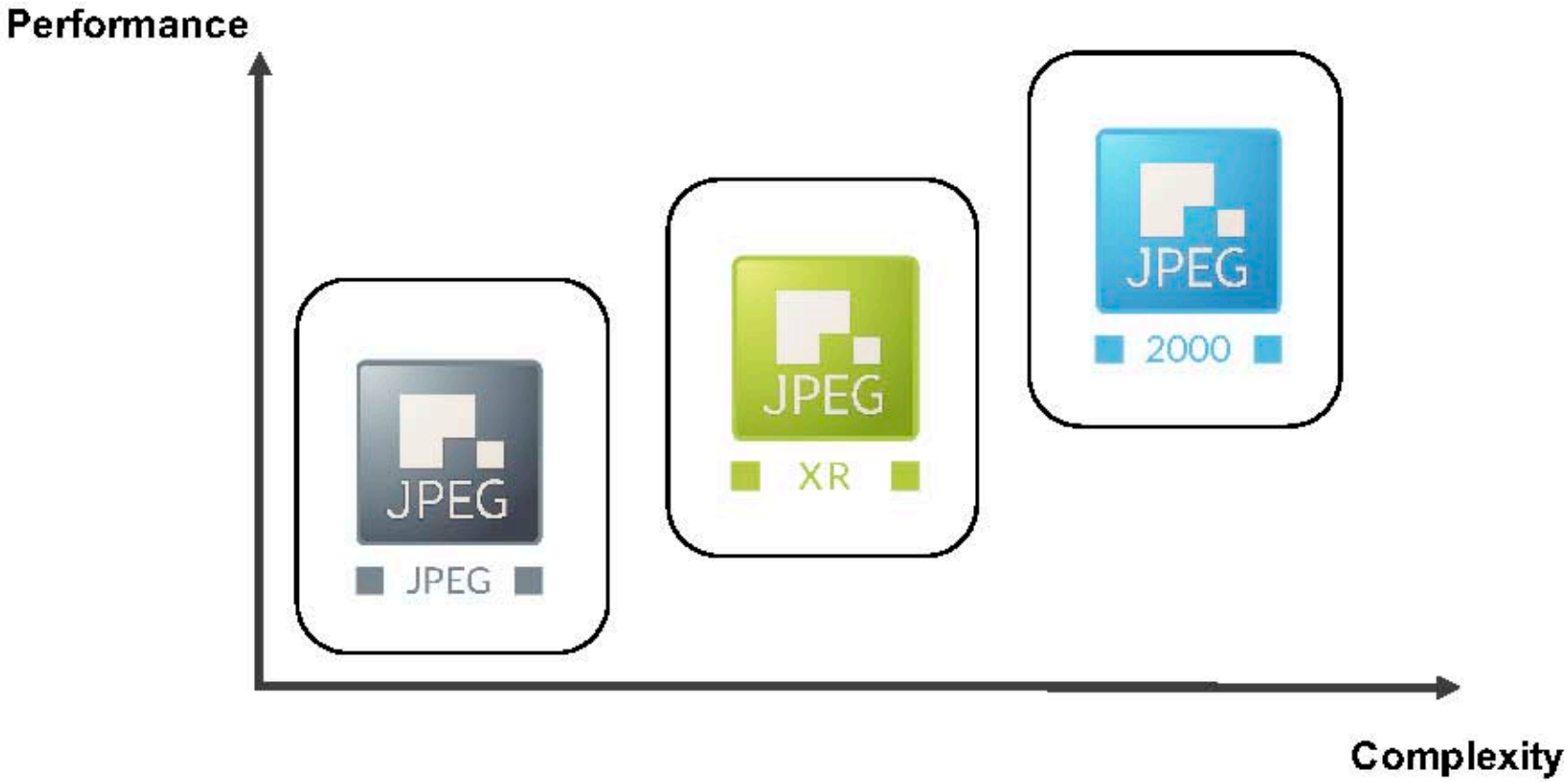


2015 Technology and Engineering Emmy award (JPEG 2000 interoperability)

JPEG 2000 framework



JPEG XR bridges gap



JPEG XR in many apps but not widely used

Some of the standards in progress

Advanced Image Coding (AIC)

- Evaluation methodologies and metrics

JPEG XT

- JPEG forward/backward compatible HDR compression

JPEG XS

- Light weight low latency compression system

Standards in Progress

Advanced Image Coding (AIC)

- Evaluation methodologies and metrics

JPEG Systems

- Consolidated system layer structure

JPEG XT

- JPEG forward/backward compatible HDR compression

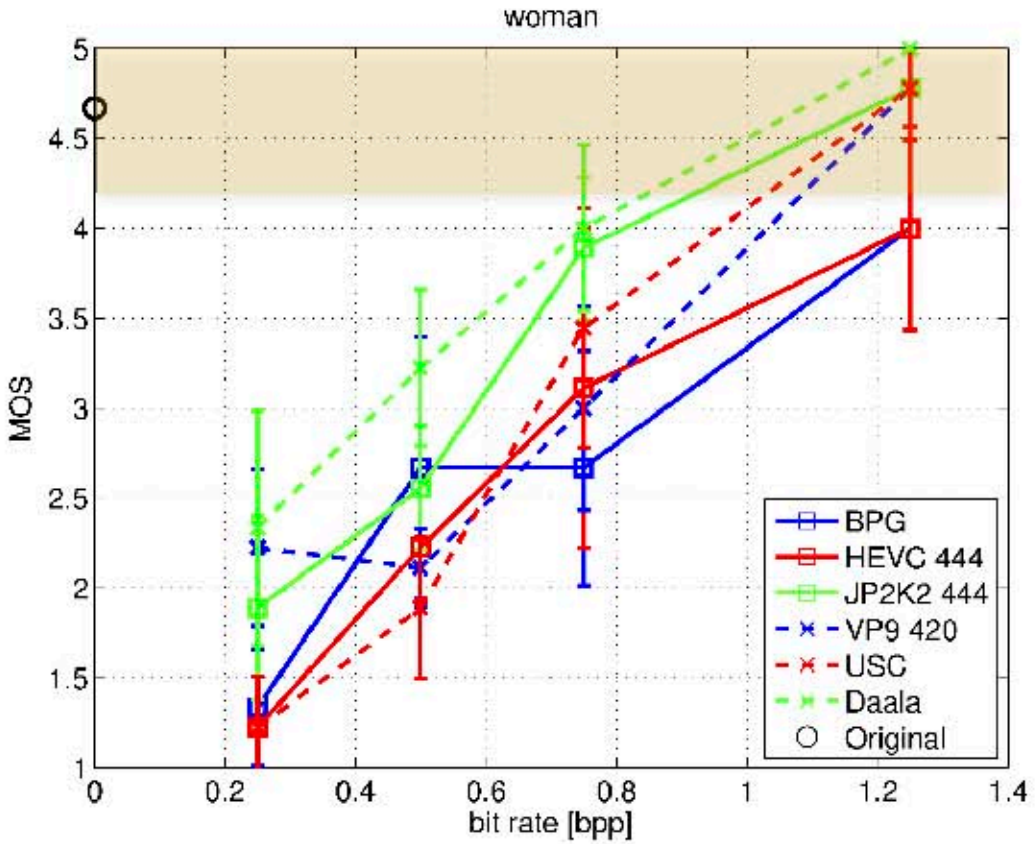
JPEG XS

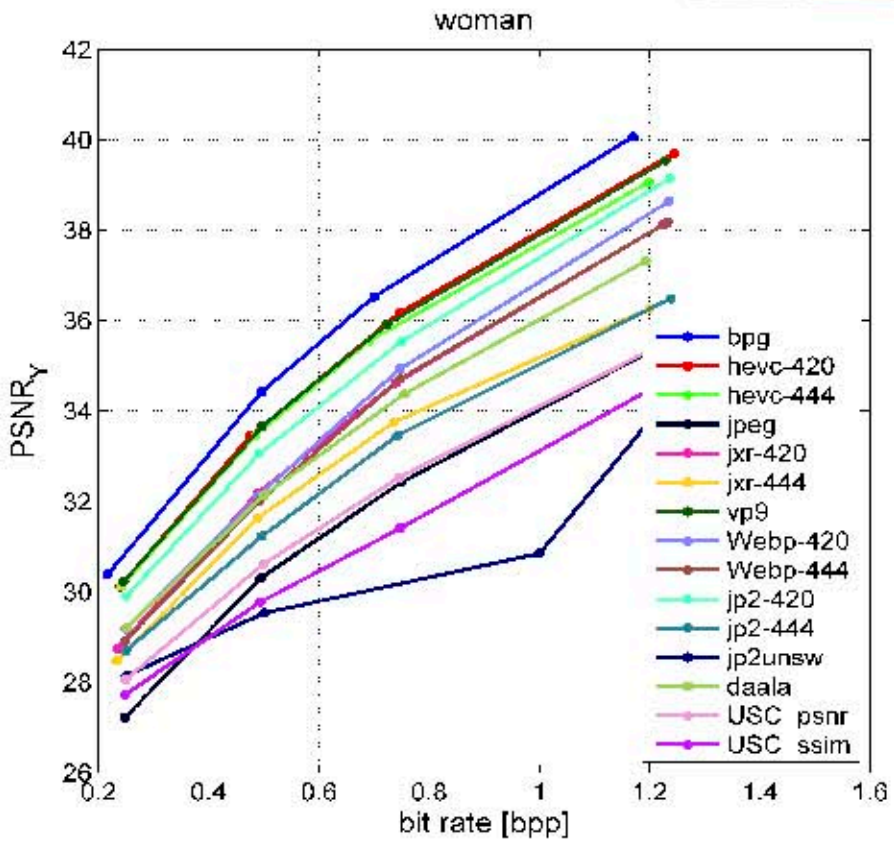
- Light weight low latency compression system

Advanced Image Coding (AIC)

- Advanced Image Coding
  - Part 1: Guidelines for codec evaluation
  - Part 2: Evaluation procedure for assessing visually lossless coding
  - Part 2 AMD1: Evaluation of high dynamic range content
  - Part 2 AMD2: Evaluation of image sequences
- Call for information issued in February 2015 to receive information on next generation still image compression with superior compression efficiency, as well as other useful features needed in future multimedia applications
- PCS 2015 Feature Event - Evaluation of current and future image compression technologies
- ICIP 2016 Image Compression Grand Challenge - Evaluation of innovative ideas for image compression technologies when compared to existing standards.

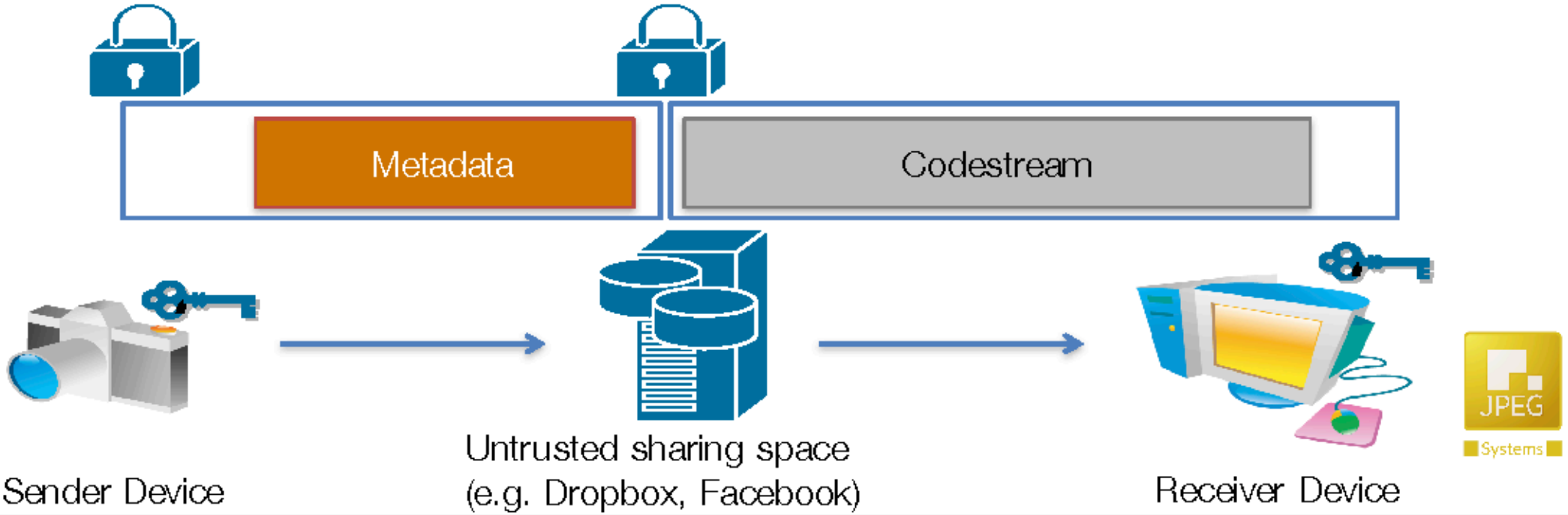
Advanced Image Coding (AIC)



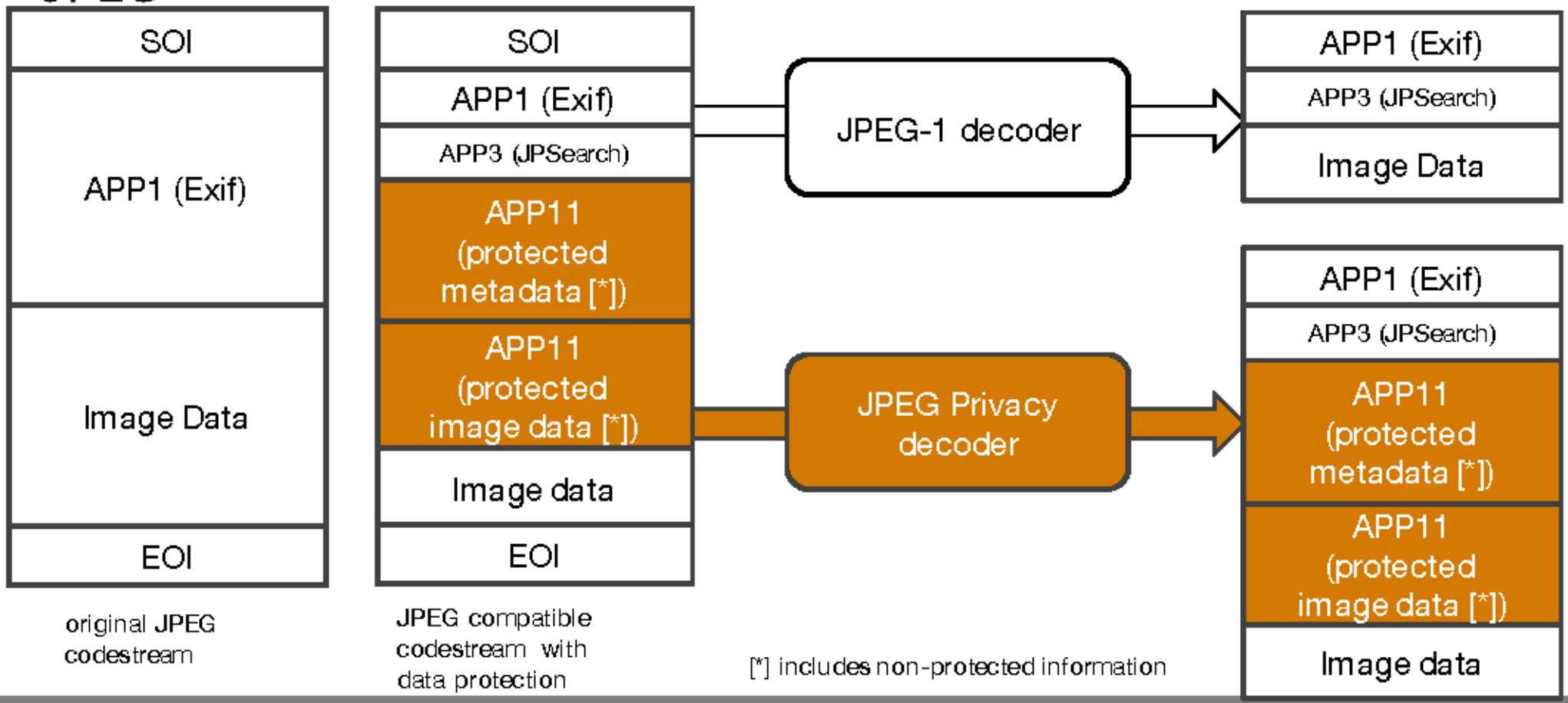


JPEG Privacy

- Solutions to provide privacy protection and security solutions to legacy JPEG

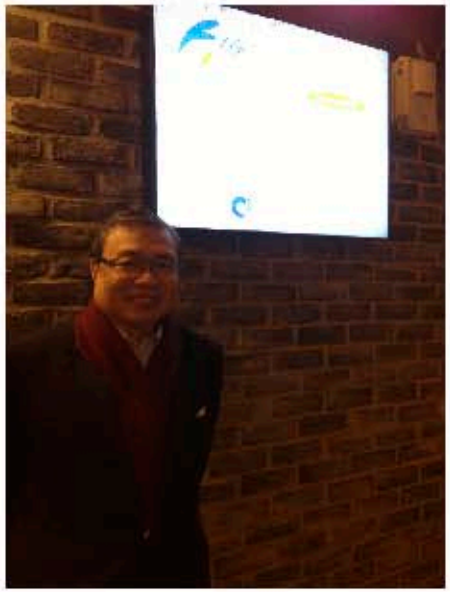


JPEG Privacy App11



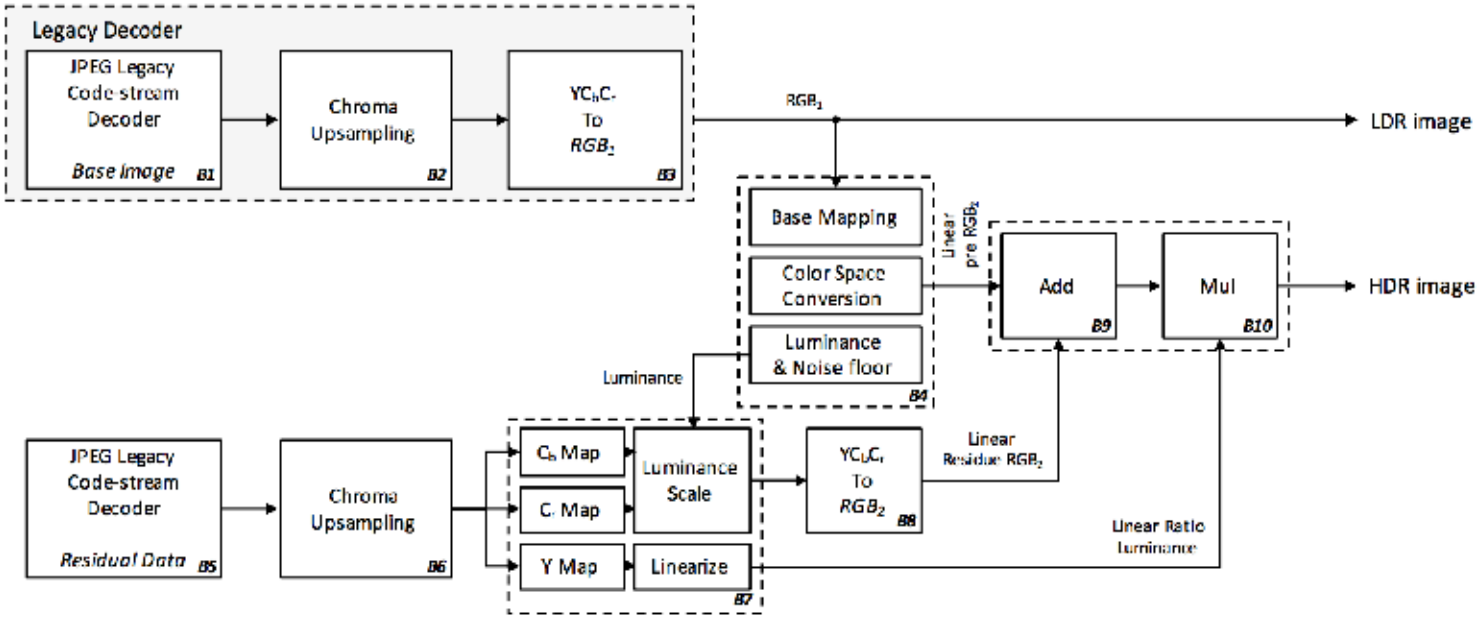
JPEG XT backward compatible HDR

- A JPEG legacy compatible HDR image compression standard

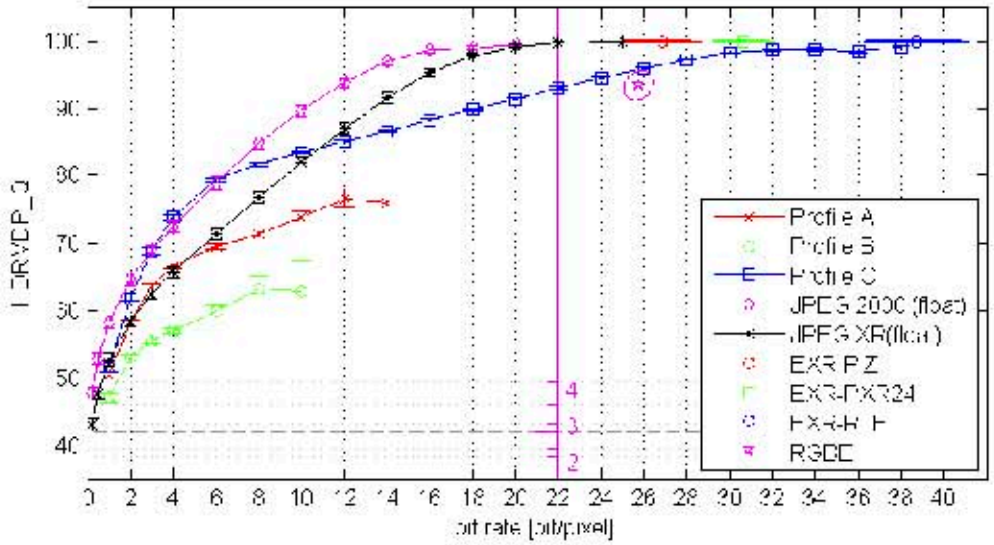


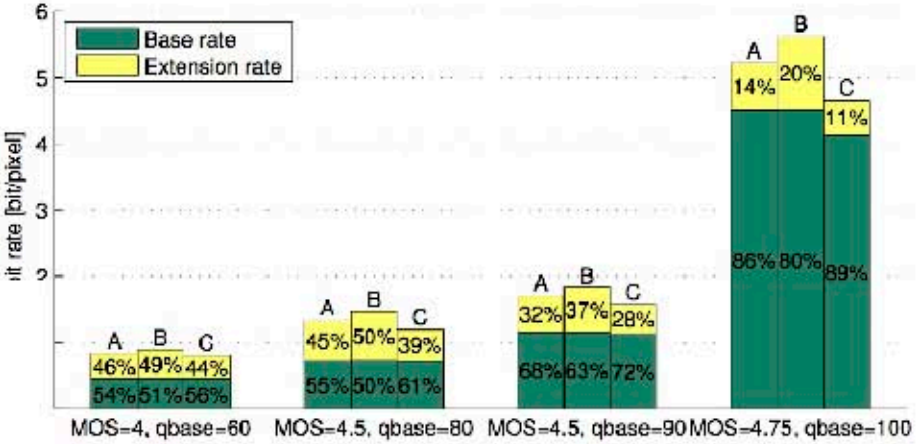
JPEG XT design principles

- Two-layer coding, with **base layer a legacy JPEG coded LDR** and enhancement layer the residual to produce the HDR
- Enhancement layer uses as much as possible JPEG Legacy coding tools



JPEG XT compression efficiency



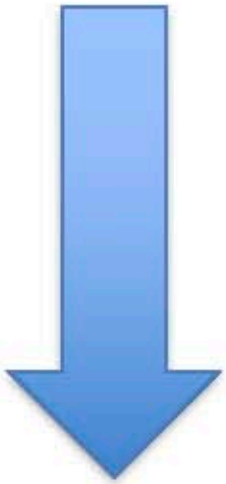


JPEG XT Parts

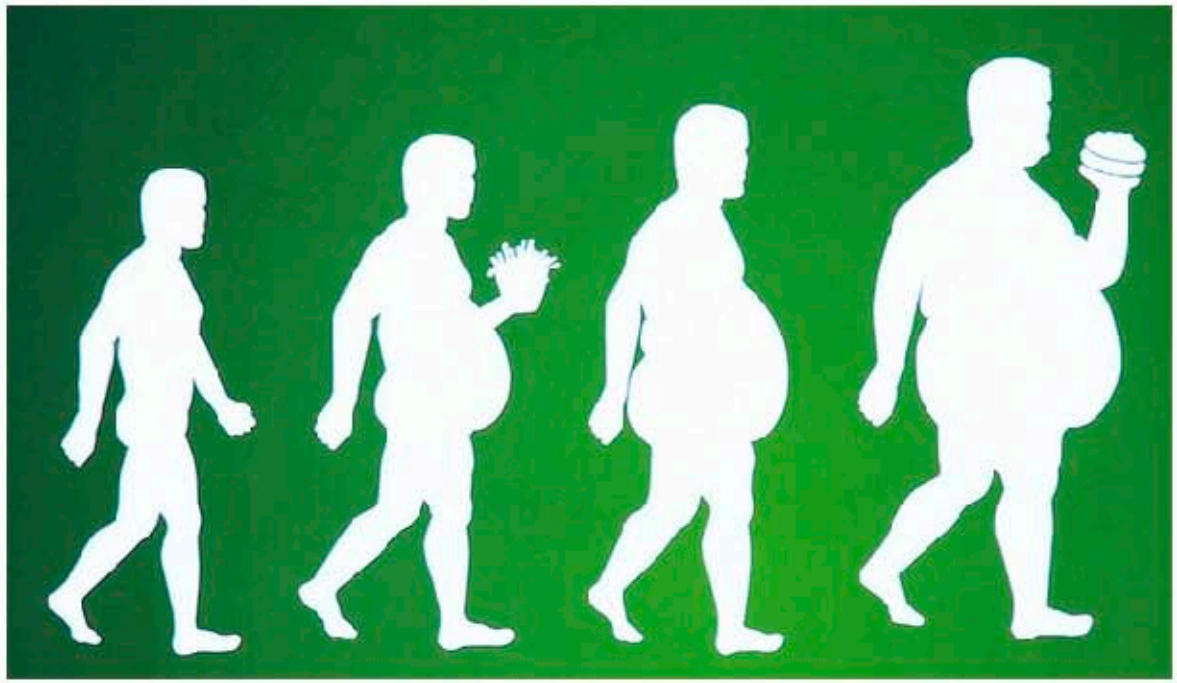
Part	Title	WD	CD	DIS	FDIS	IS
1	Core Coding System	13/01	13/07	14/01	-	14/10
2	Coding of High Dynamic Range Images	13/10	14/01	14/04	-	14/10
3	Box File Format	14/05	14/07	15/02	-	15/06
4	Conformance Testing	15/02	16/02	**16/06**	-	**17/02**
5	Reference Software	14/07	16/02	**16/06**	-	**17/02**
6	IDR Integer Coding	14/05	14/07	15/02	15/06	16/02
7	HDR Floating-Point Coding	14/05	14/07	15/02	15/06	16/02
8	Lossless and Near-lossless Coding	14/07	15/02	15/06	16/02	**16/06**
9	Alpha Channel Coding	14/10	15/02	15/06	16/02	**16/06**

Compression game in the last 3 decades

Increase complexity



Get better compression

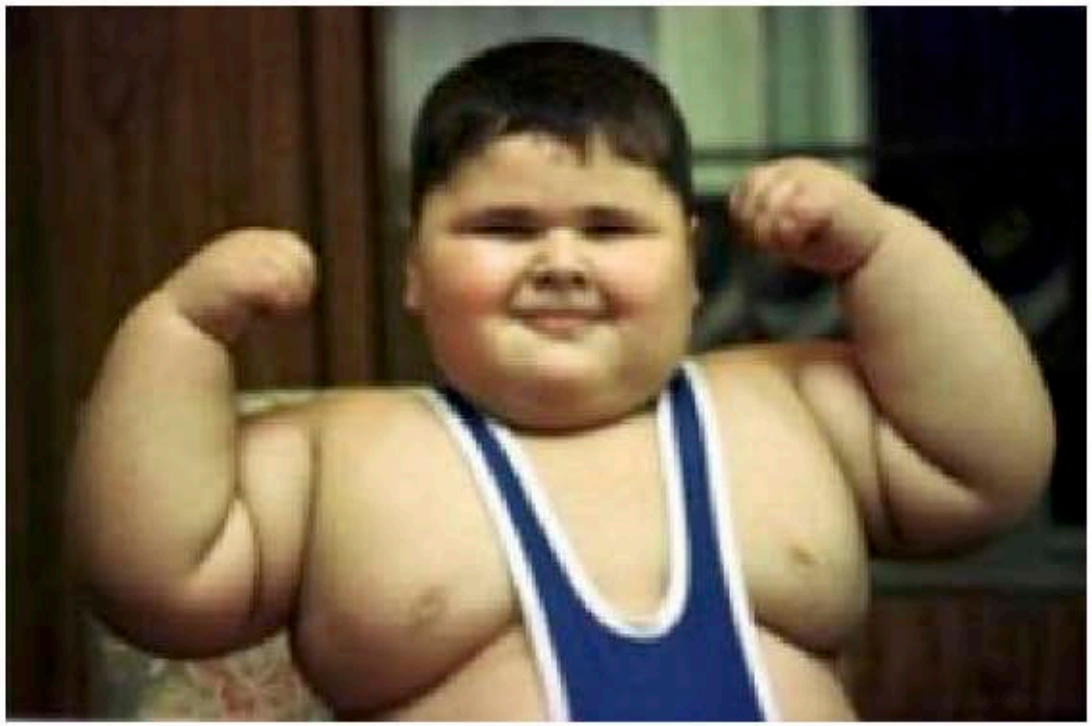


Result of this compression game …

Increasingly complex systems

…

But we seem to be happy about it and continue on this trend exclusively!



Henrique Edouardo Vittorio Carlos (265 pounds)

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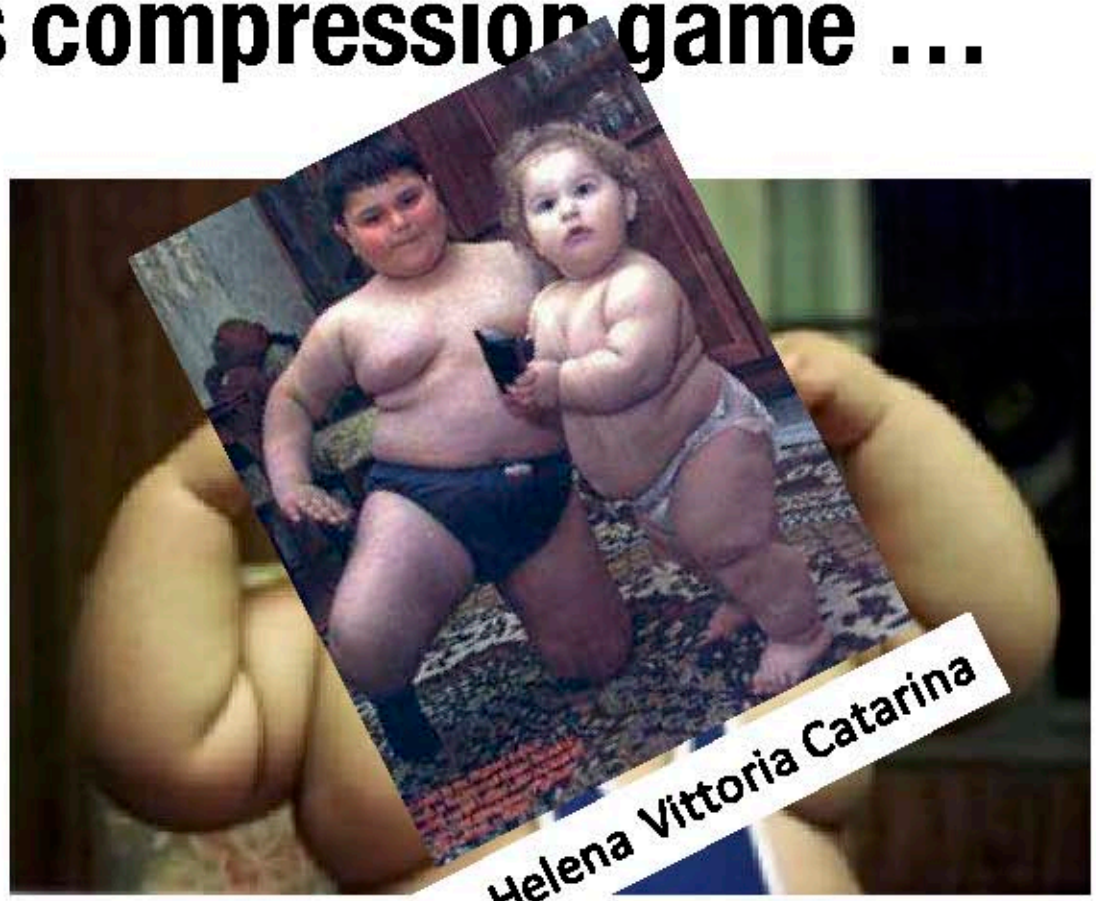


Henrique Edou… Vittorio Carlos (265 pounds)

JPEG XS Light weight / Low Latency Image Coding

- Modest compression
- Transparent quality
- Low complexity
- Low latency

JPEG XS Light weight / Low Latency Image Coding

- Several applications identified:
  - Broadcast applications and live production
  - Live-production
  - Digital Cinema
  - Industrial vision
  - Professional audio visual systems
  - Consumer TV
  - Mobile video
  - Camera array based recordings
  - Ultra high frame rate cameras
  - Medical Imaging
  - Video Surveillance and security
  - Automotive Infotainment
  - Camera manufacturers
  - Set-top boxes
  - Low-cost visual sensors in Internet of Things (IoT)
  - HMD displays for VR and AR
- From the above a set of requirements and optional features extracted

New Work Item

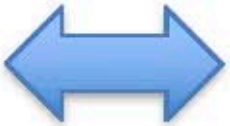
JPEG XS Transport over video links and IP network

Format	Throughput	Physical link	Capacity	Compression
2K / 60p / 422 / 10 bits	2.7 Gbps	HD-SDI	1.33 Gbps	~ 2
2K / 120p / 422 / 10 bits	5.4 Gbps	HD-SDI	1.33 Gbps	~ 4
4K / 60p / 422 / 10 bits	10.8 Gbps	3G-SDI	2.65 Gbps	~ 4
2K / 60p / 422 / 10 bits	2.7 Gbps	1G Ethernet (SMPTE2022 1/2)	0.85 Gbps	~ 3
2K / 60p / 444 / 12 bits	4.8 Gbps	1G Ethernet (SMPTE 2022 6)	0.85 Gbps	~ 6
4K / 60p / 422 / 10 bits	10.8 Gbps	10G Ethernet (SMPTE2022 1/2)	8.5 Gbps	~ 1.3
3x [4K / 60p / 422 / 10 bits]	32.4 Gbps	10G Ethernet (SMPTE2022 6)	7.96 Gbps	~ 4
4K / 60p / 444 / 12 bits	19 Gbps	10G Ethernet (SMPTE2022 1/2)	8.5 Gbps	~ 2.2
2x [4K / 60p / 444 / 12 bits]	37.9 Gbps	10G Ethernet (SMPTE2022 6)	7.96 Gbps	~ 5
8K / 120p / 422 / 10 bits	85 Gbps	25G Ethernet	21,25 Gbps	~ 4

JPEG XS work plan and schedule

Meeting	Status	Date
71st JPEG meeting	CfP	16/02
72nd JPEG meeting	Submission of proposals	16/06-16/10
73rd JPEG meeting	WD1	16/10
74th JPEG meeting	WD2	17/02
75th JPEG meeting	CD	17/06
76th JPEG meeting	DIS	17/10
78th JPEG meeting	IS	18/06

Should pictures be flat?



3D again?

- Isn't 3D dead?

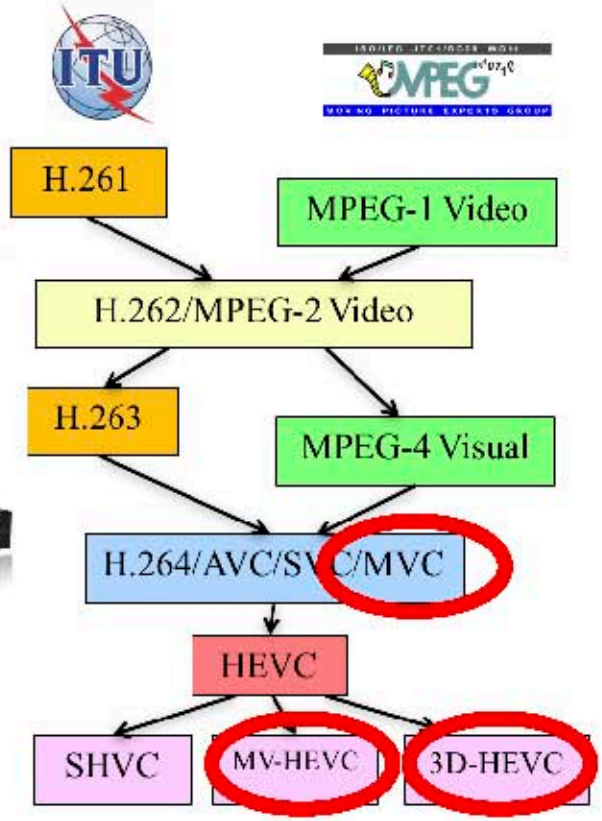
Quick history of 3D …

Wheatstone explains "stereopsis"	First stereo film camera	Boom year for 3D movies		First compression standard: MPEG-2 develops Multi-View Profile		MPEG-4 Multi-View Coding
1838	1851	1890	1915	1953	1990s	1995	2005-2009	2009
	Queen Victoria starts stereoscope rage		First red/blue 3D movies shown		3D starts to gain popularity with IMAX 3D		Expansion of 3D movies	

3D has been a hit for a while…but…

MPO

JPS



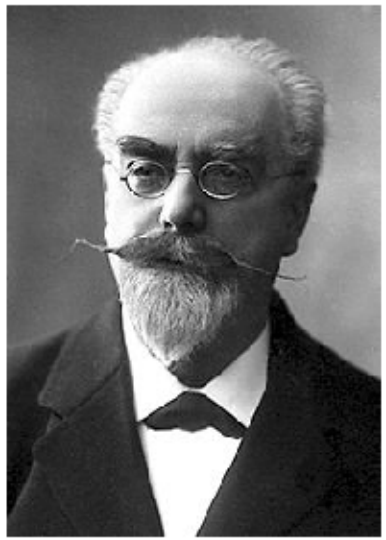
What happened to 3D?

- It has not delivered the quality of experience users expect!

The real world around us is 3D!

"The most perfect photograph currently shows only one aspect of reality; it reduces to a unique image fixed on a plane, as a drawing or a painting would be traced by hand."

"Can we ask photography to render all the richness that the direct view of an object offers ?"

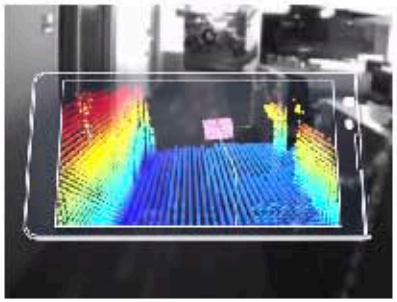


Gabriel Lippmann (1845 – 1921)

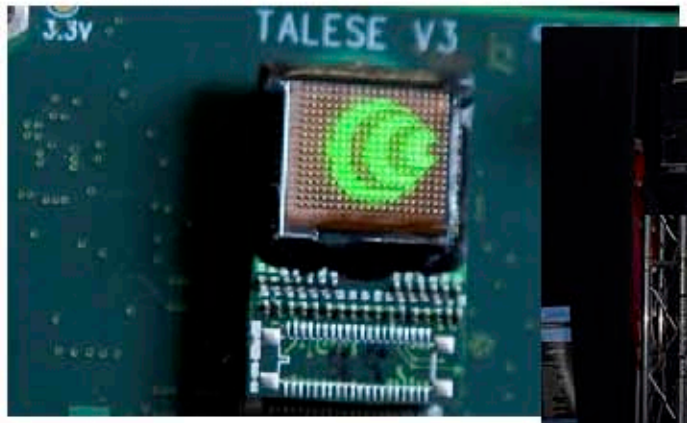
Lippmann is remembered as the inventor of a method for reproducing colors by photography, based on the interference phenomenon.

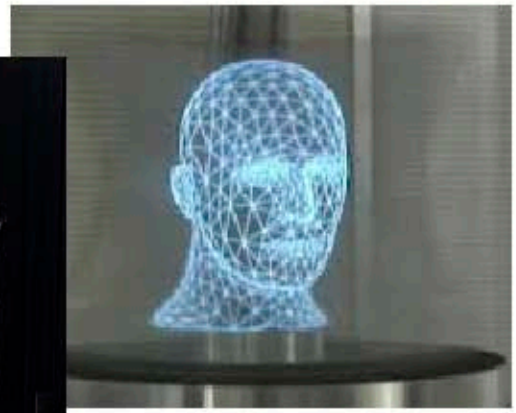
1908 Nobel Prize in Physics

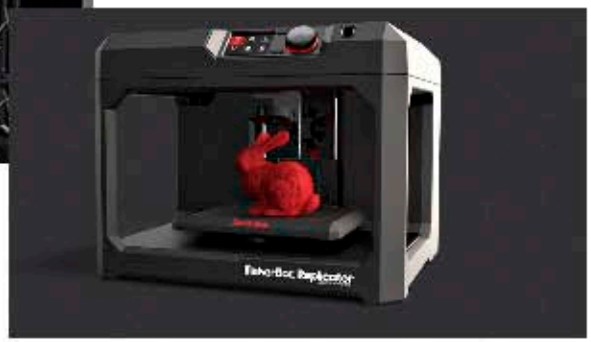
Capturing reality



Rendering/synthetizing reality





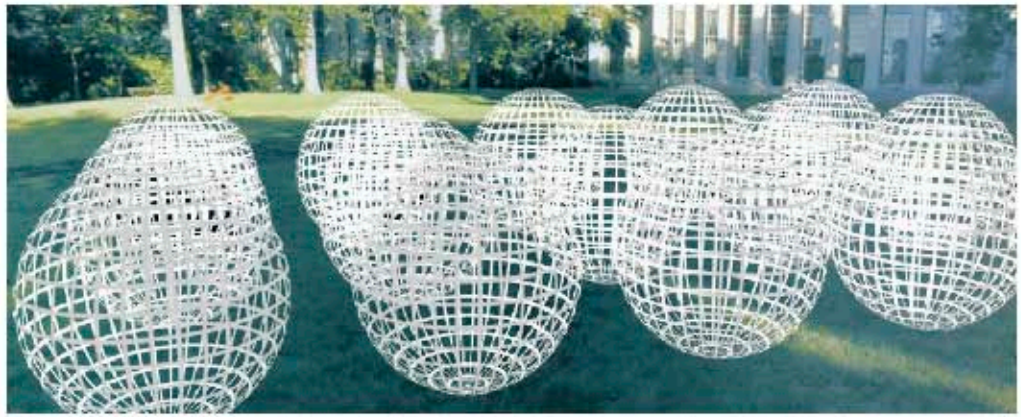


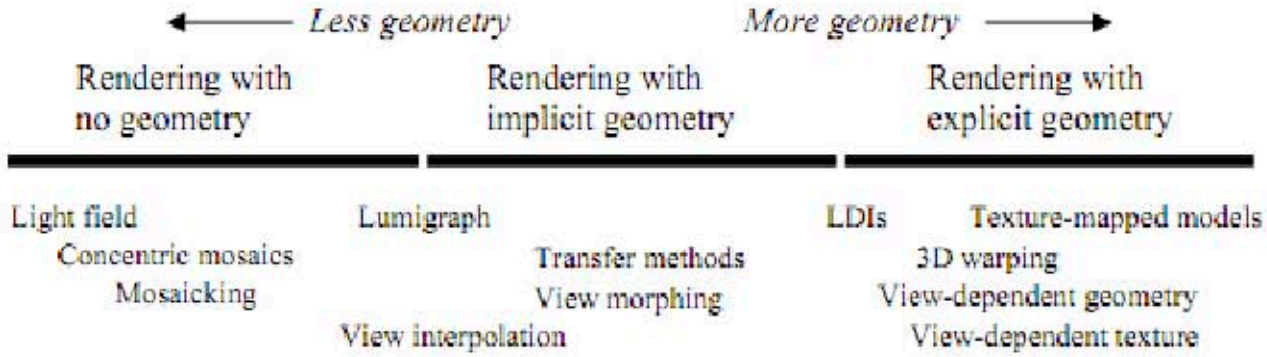
JPEG PLENO

JPEG PLENO targets a standard framework for the representation and exchange of new imaging modalities such as light-field, point-cloud and holographic imaging.

Plenoptic representation of visual information

- 7D function $P_f(x,y,z,\theta,\phi,\lambda,t)$
  - spatial position *(x,y,z)*
  - viewing direction (θ,ϕ)
  - wavelength (λ)
  - time *(t)*





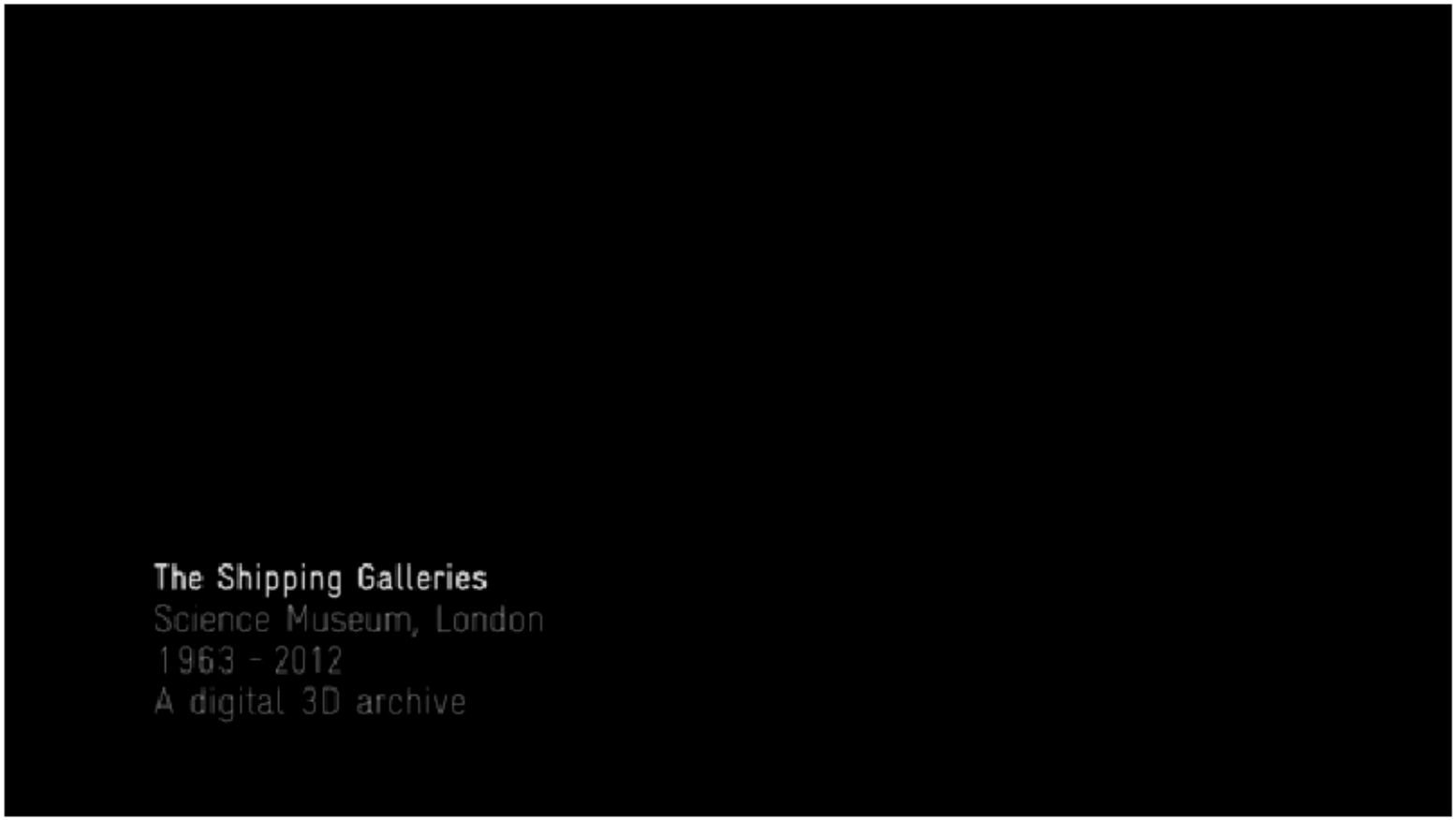
JPEG PLENO design principles

- One or limited number of representation models
- Well defined, specific and useful milestones
- Where needed, backward compatible with legacy JPEG

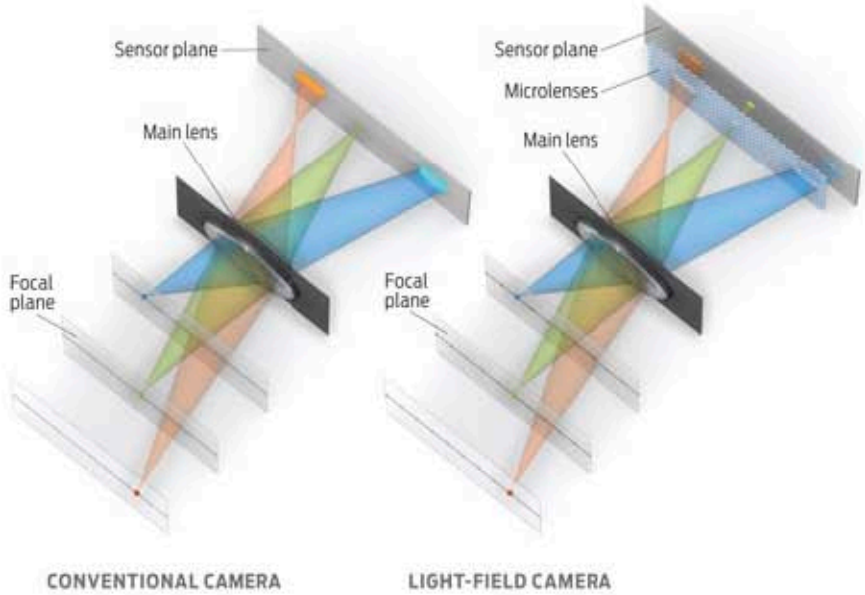
Spatial Photography

- Motion parallax

Point-cloud Photography



Light-field Photography



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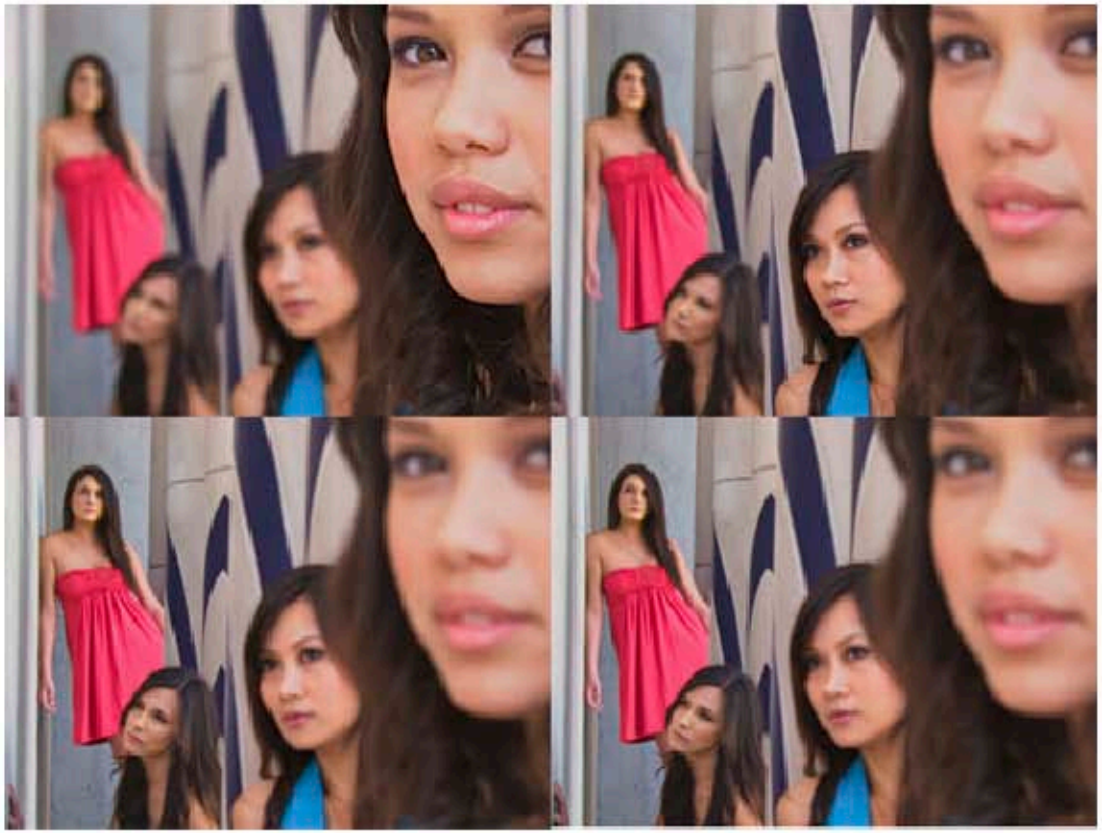


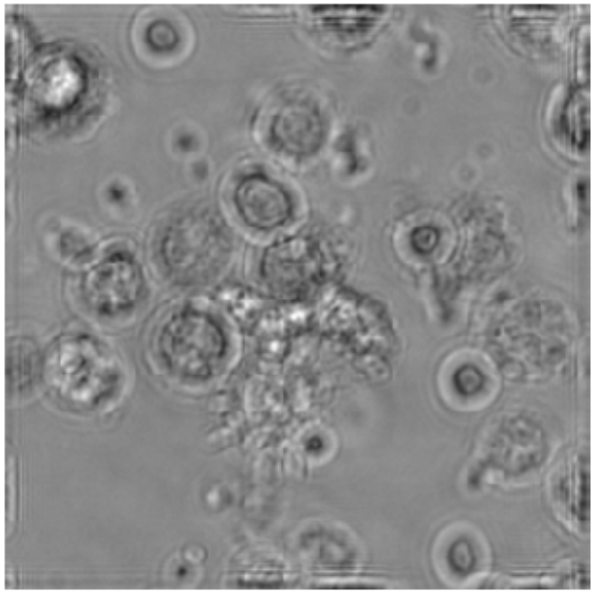
- Refocusing capability after capture
- Change of perspective (view point)
- and many more desirable features

LYTRO

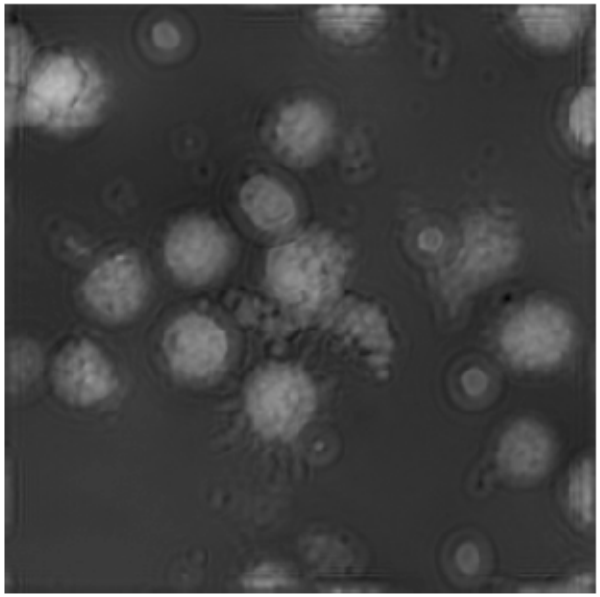
Light-field Photography

LYTRO

Holography



amplitude



phase

Holographic Microscopy

JPEG PLENO Workshop

Warsaw, Poland – June 23rd, 2015

14:00 Touradj Ebrahimi (JPEG Convenor - EPFL): "*JPEG PLENO - Introduction and Scope*"

Light-fields

14:15 Christian Perwaß (Raytrix GmbH, Germany): "*Metrically Calibrated Multi-focus Plenoptic Camera and its Applications*"

14:40 Joachim Keinert (Fraunhofer IIS, Germany): "*Lightfield media production using camera arrays - use cases and requirements*"

14:55 Peter Kovacs (Holografika, Hungary): "*Light Field Displays*"

15:20 Atanas Gotchev (Tampere University of Technology): "*Content creation for light-field displays*"

15:35 Roger Olsson (Mid Sweden University): "*Objective evaluation and SotA compression solutions for plenoptic image content*"

15:50 Discussion on compression of light field data (Requirements, use cases, technologies)

Point-clouds

16:30 Rufael Mekuria (CWI Netherlands): "*Point Cloud Compression*"

16:45 Discussion on compression of point cloud data (Requirements, use cases, technologies)

Holography

16:55 Małgorzata Kujawinska (Warsaw University of technology): "*Holographic capturing and rendering systems, suitable data representations for phase and amplitude*"

17:10 Frederic Dufaux (TELECOM ParisTech, France): "*Digital Holography Compression*"

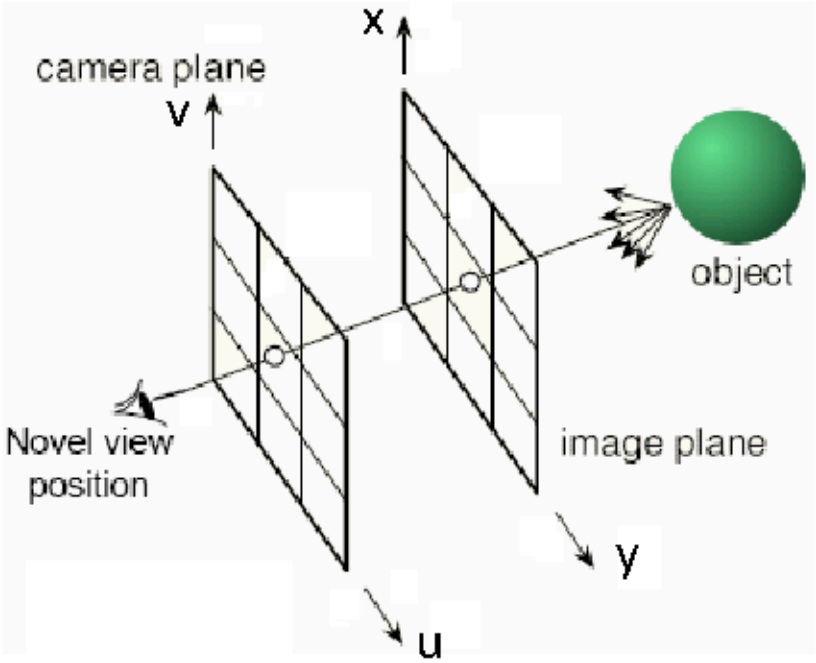
17:35 Discussion on compression of holographic data (Requirements, use cases, technologies)

17:50 Conclusions

Simplification of plenoptic function

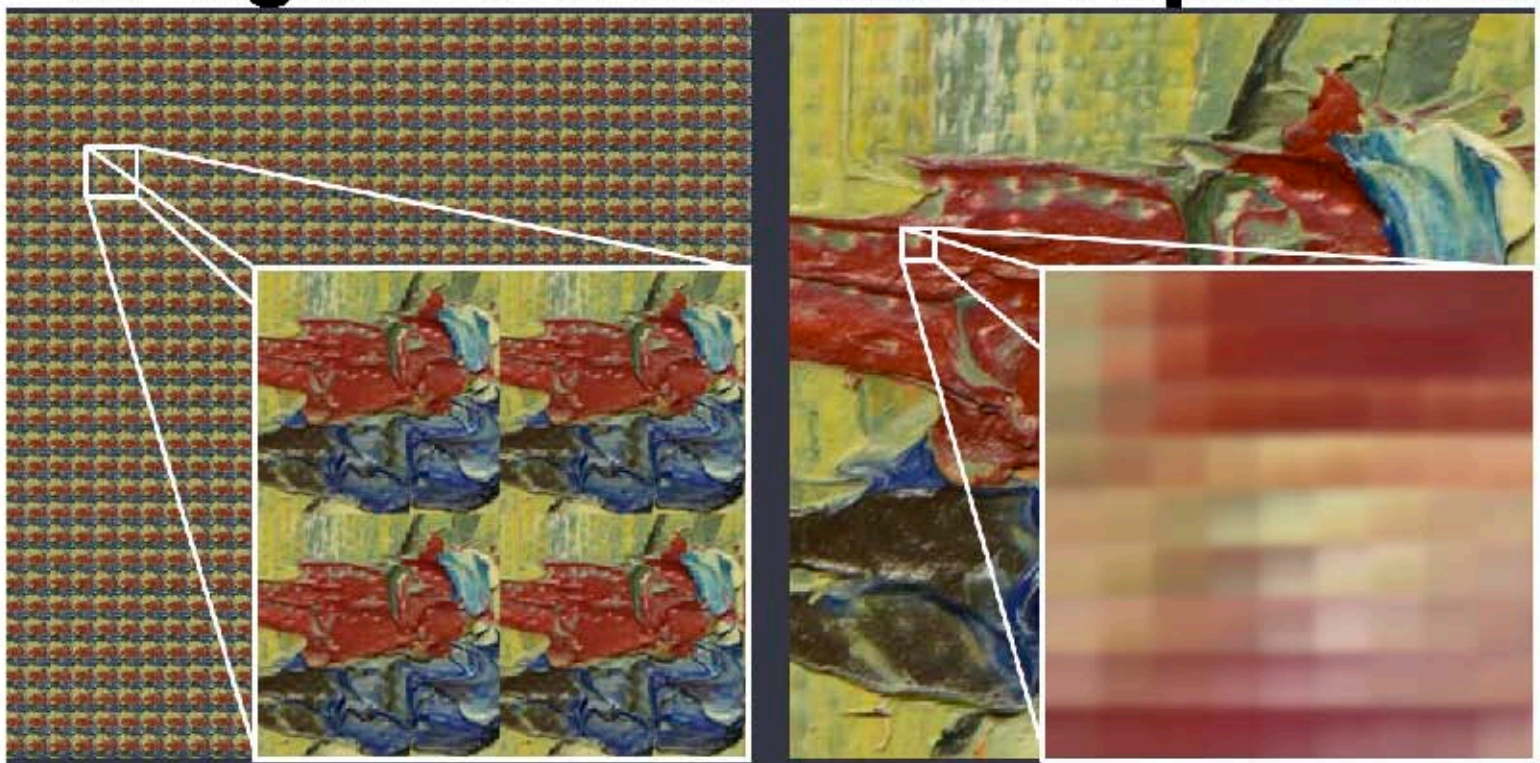
4D light field

- λ represented by R, G, and B components
- Static scene (no t)
- Assume intensity constant along a ray of light



from Atanas Gotchev

4D light field canonical representations

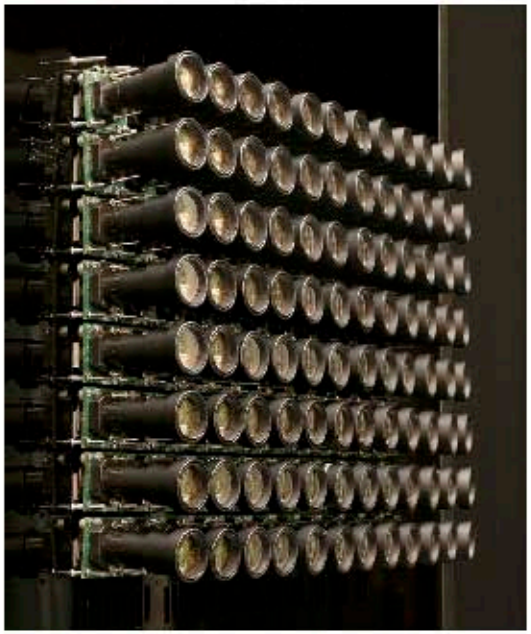


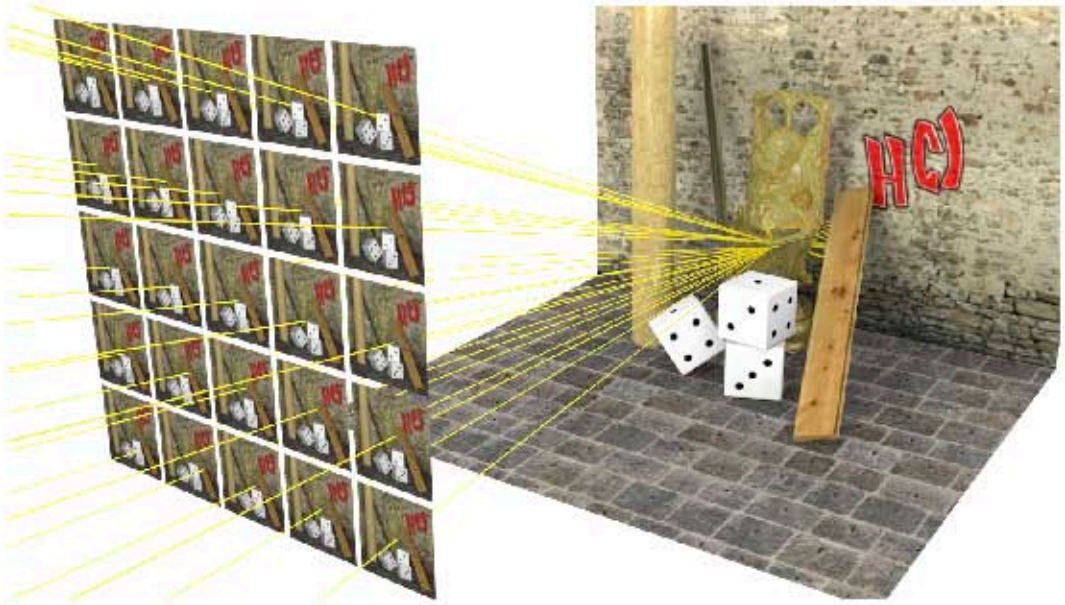
Sub-aperture image view of acquired light field
(major: UV ; minor: XY)
32x32x512x512

Microlens view of acquired light field
(major: XY ; minor: UV)
512x512x32x32

from Loïc Baboulaz

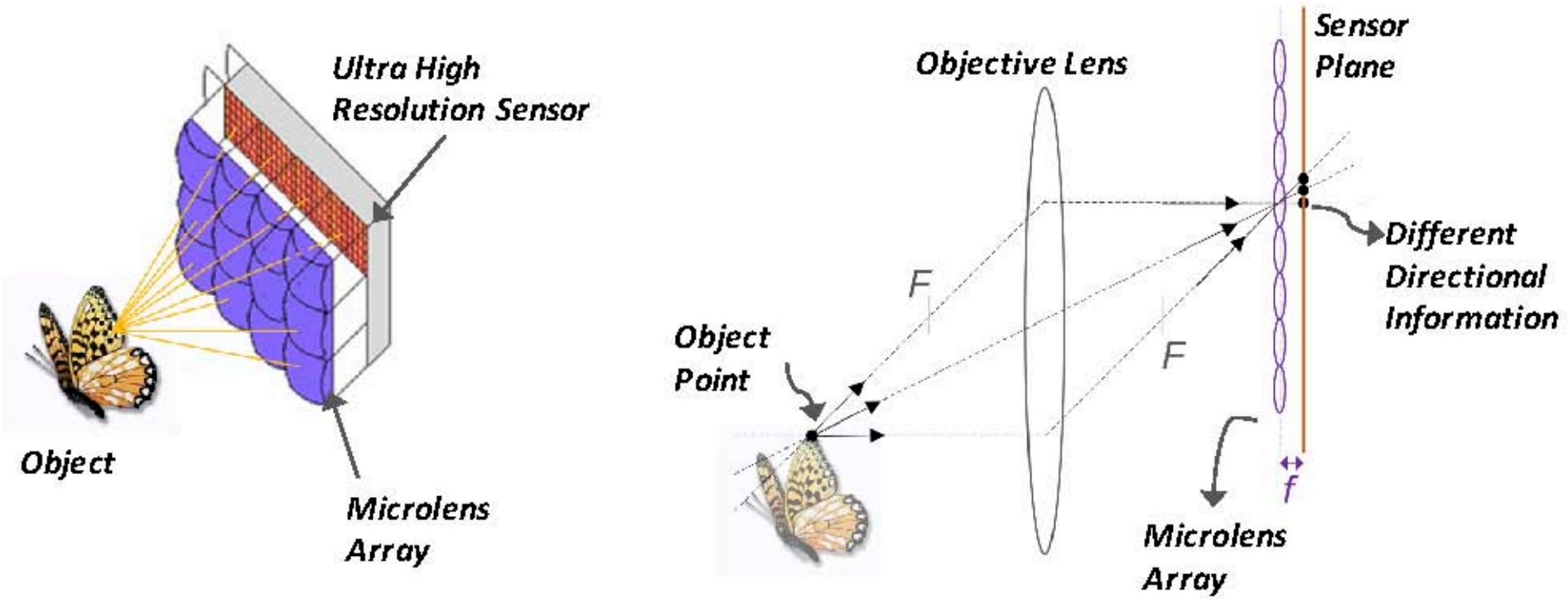
4D light field from multiple cameras





Super Multiview

4D light field with Microlens Array



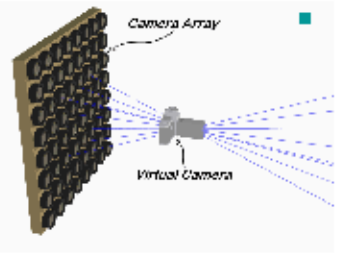
Lenslet light field

from C. Conti

Super Multiview versus Lenslet light field

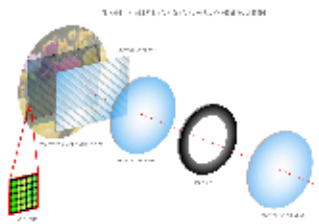
Super Multiview

- Tens or hundreds of cameras
- Expensive, camera rig with many cameras
- Wider baseline
- Horizontal or full parallax
- Full resolution for each view
- Sparser sampling of the light field
- Linear, arc or sparse camera arrangements
- Less compact devices
- Outcome is several viewpoints with horizontal and vertical disparities

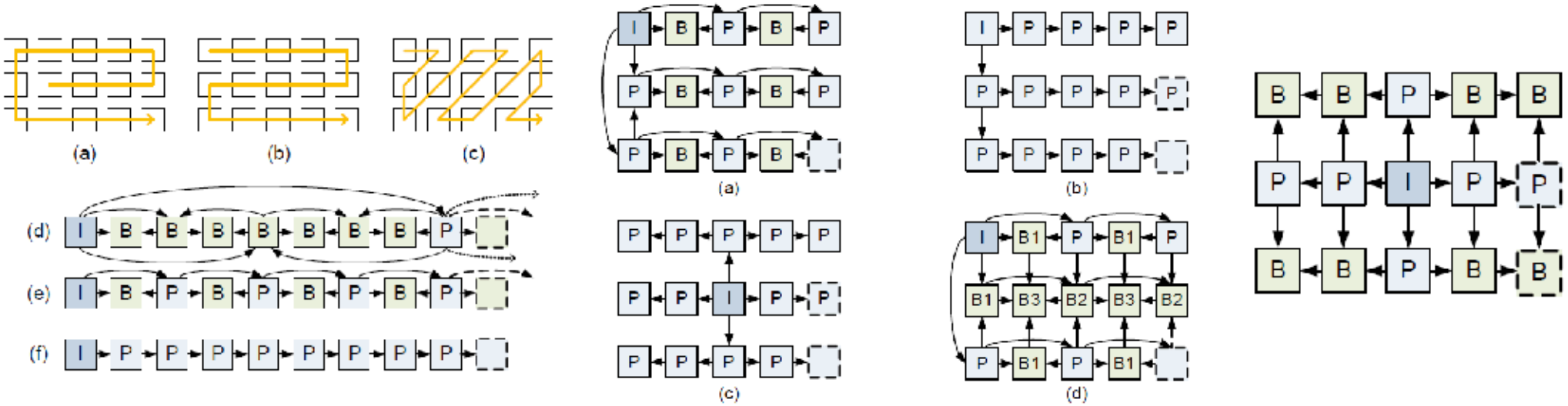


Lenslet Light field

- Single camera, no need for camera synchronization
- Lenticular array composed of a large number of micro-lenses (ML)
- Baseline limited by size of ML array
- Full parallax
- Full resolution shared by ML
- Denser sampling of the light field
- Trade-off between spatial and angular information
- Outcome is array of Micro-images each associate to a ML with light coming from several view angles



Super Multiview compression

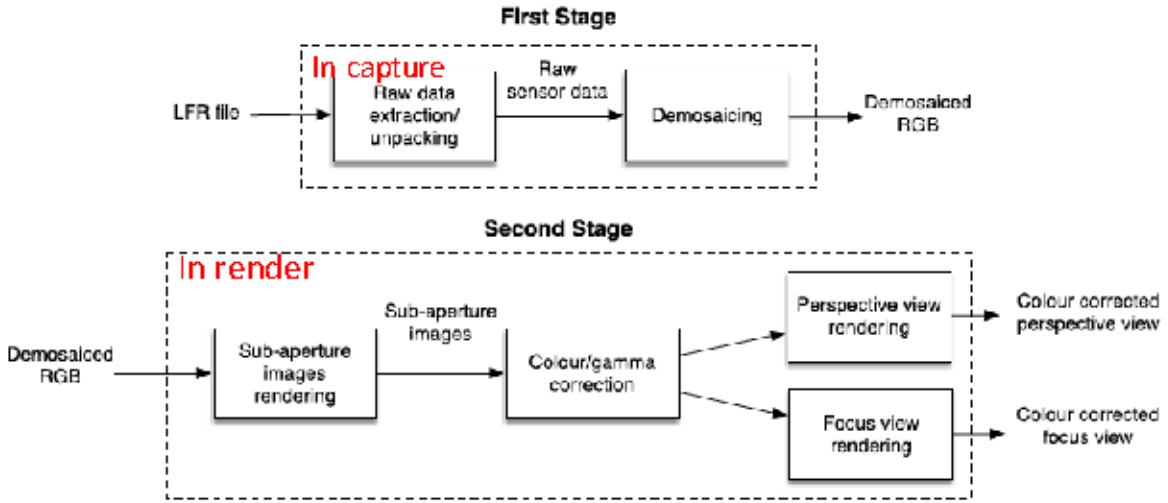


Based on MVC video compression approach

from F. Dufaux

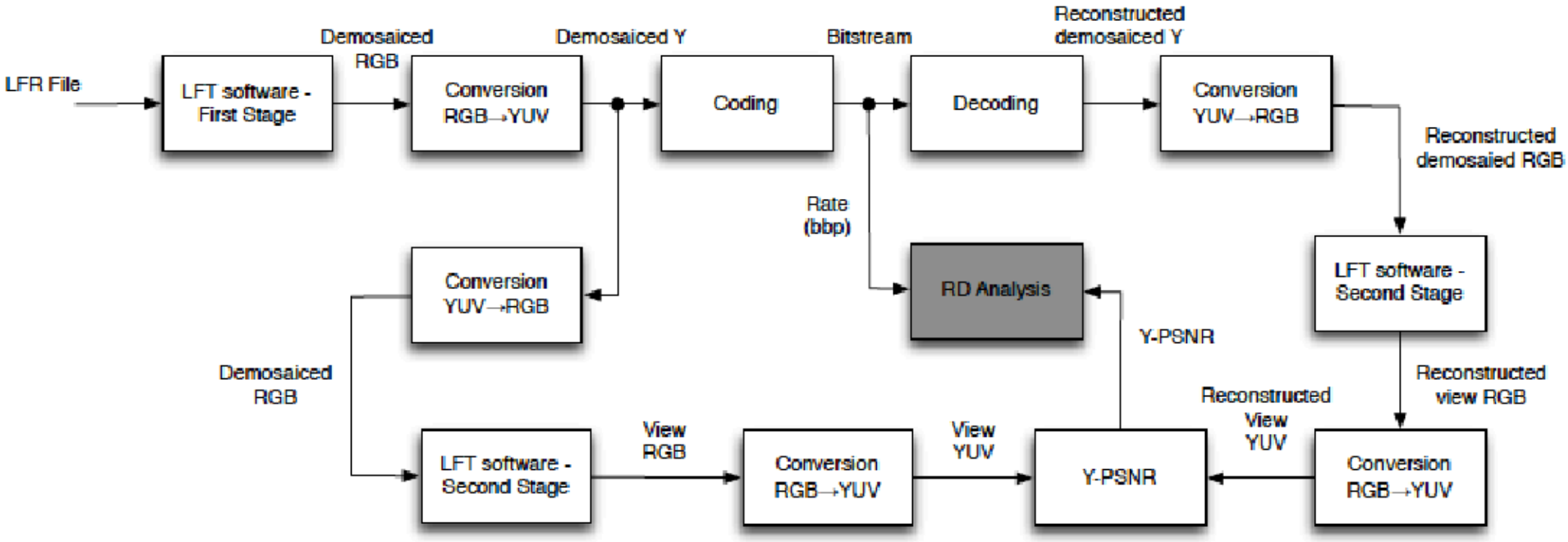
Computational imaging in lenslet light field

- First Stage : Demosaicing is needed to prepare sensor output for compression by conventional image compression algorithms
- Second stage: As sensor in lenslet light field gathers richer information than a conventional camera, further processing is required in order to render data to a regular 2D display.



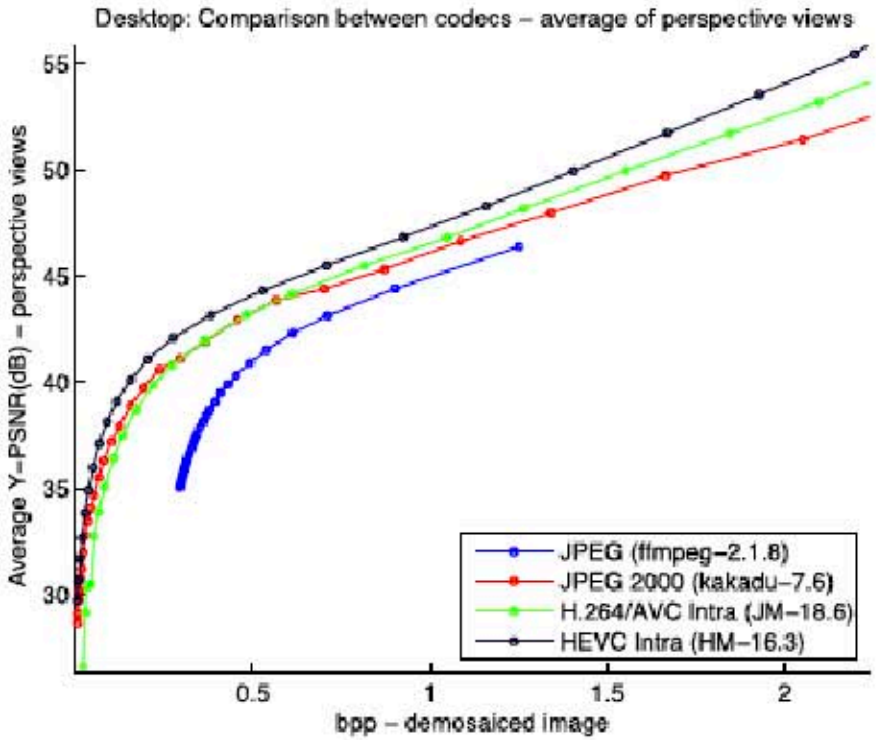
from F. Pereira

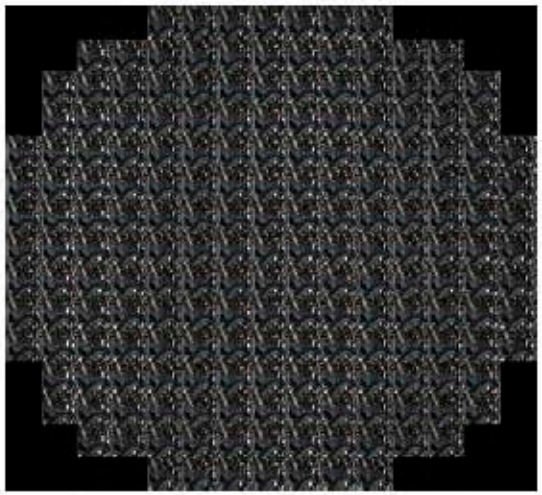
Lenslet light field compression assessment

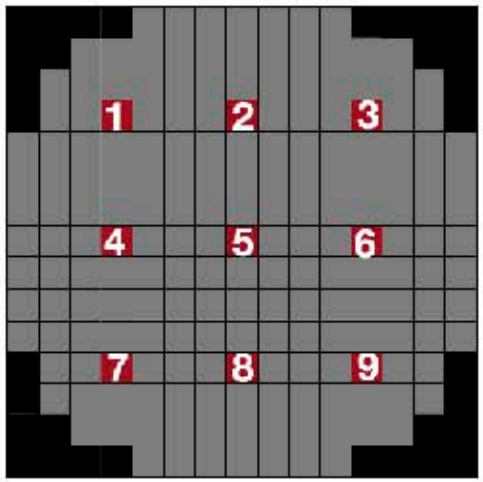


from F. Pereira

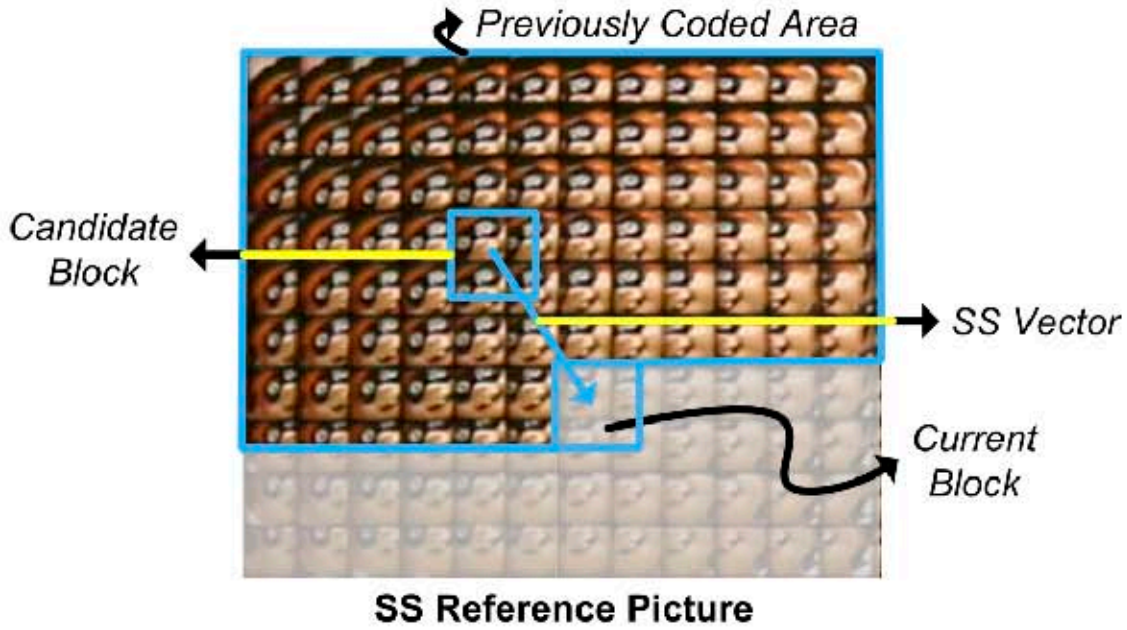
Lenslet light field compression assessment





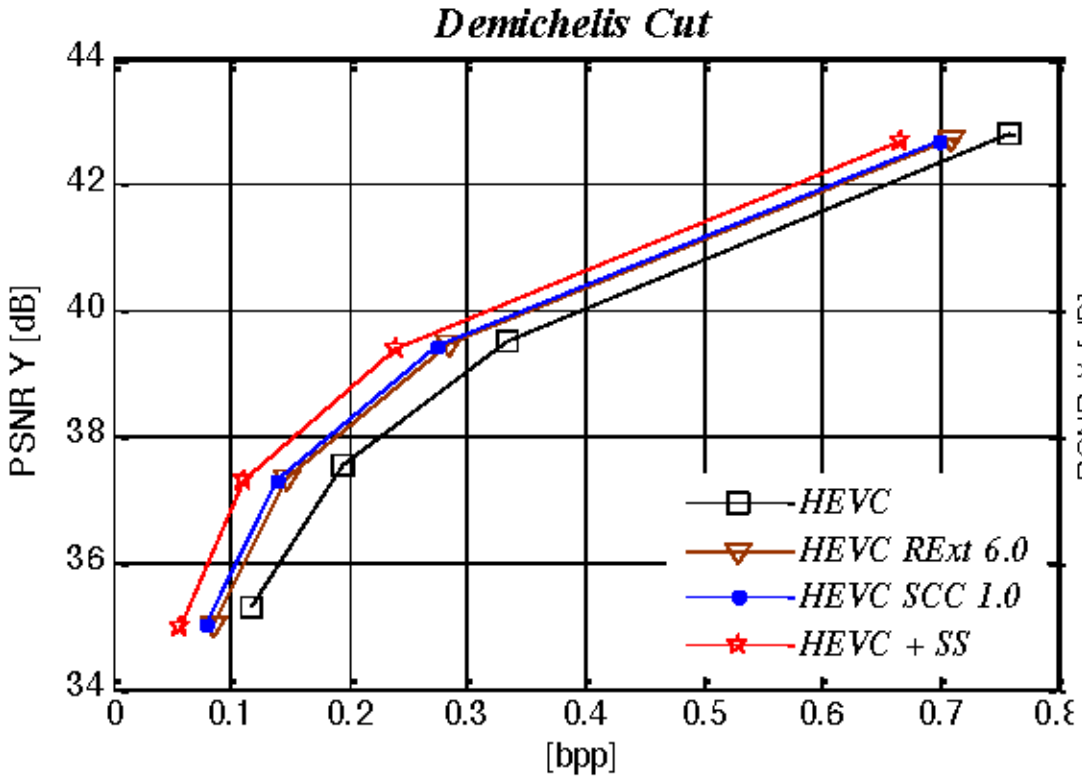


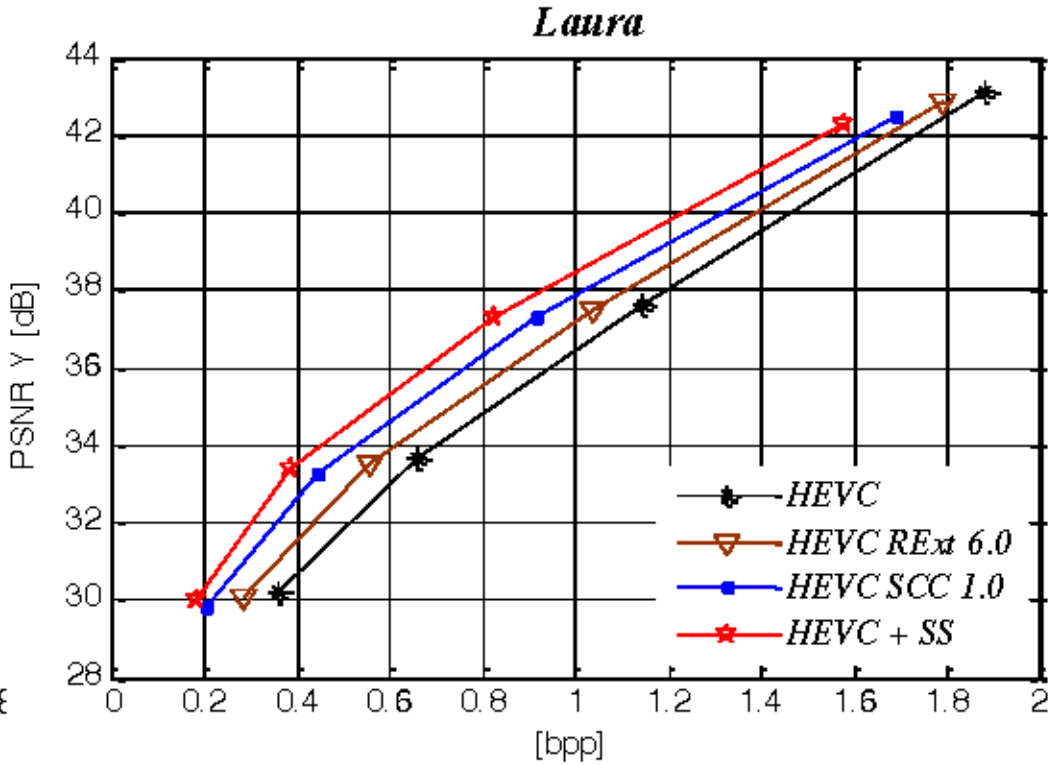
Self-Similarity (SS) Compensated Prediction



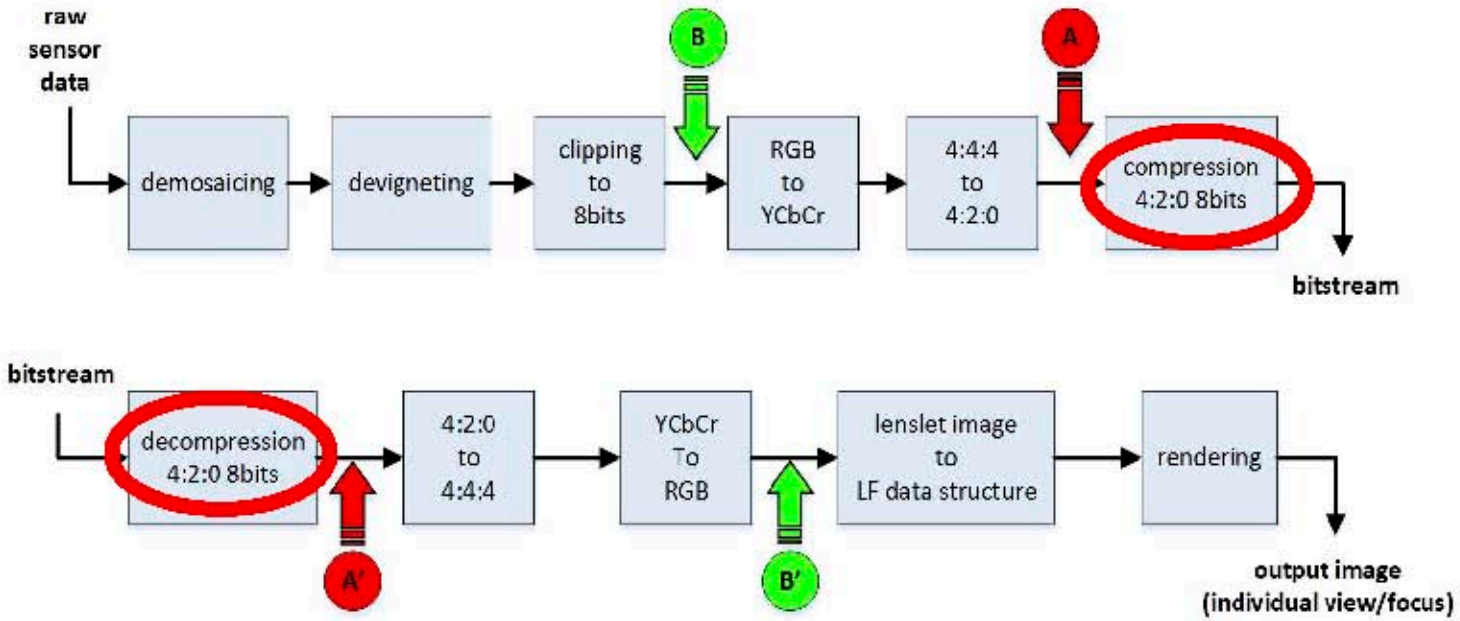
from C. Conti

Self-Similarity (SS) Compensated Prediction

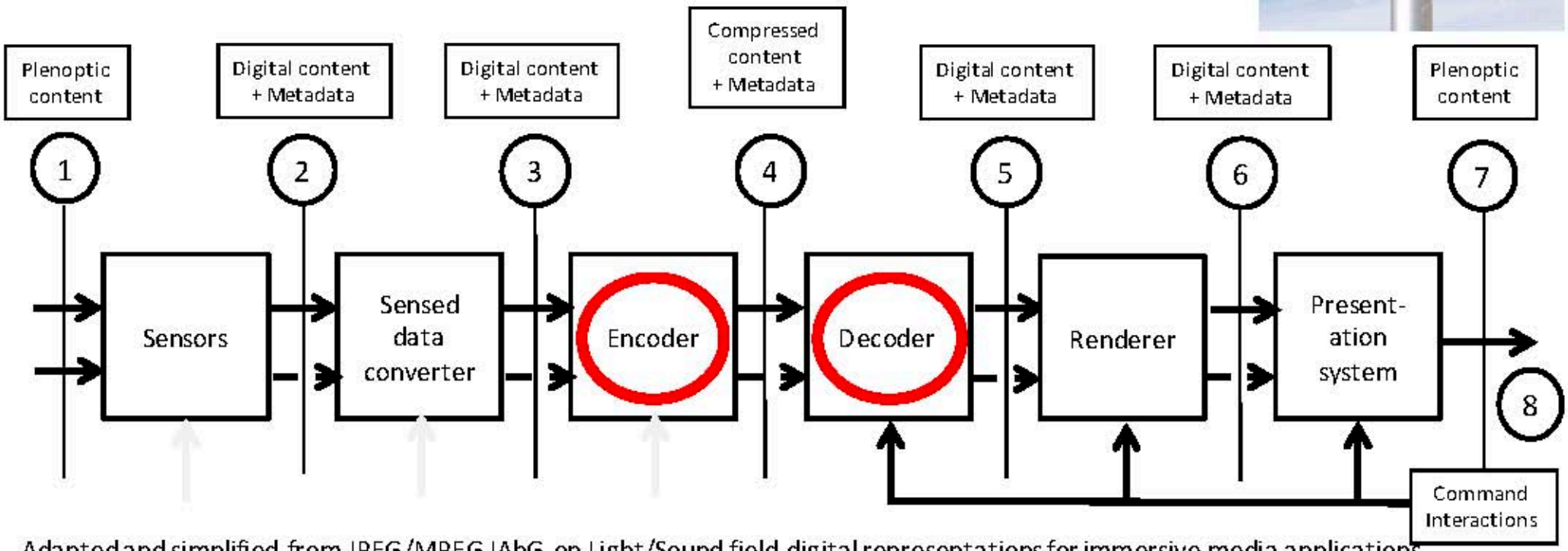




ICME 2016 Light-field image compression Grand Challenge



Plenoptic content compression



Adapted and simplified from JPEG/MPEG JAhG on Light/Sound field digital representations for immersive media applications

Conclusions

- JPEG is exploring several paths to serve future imaging needs
  - Advanced Image Coding
  - JPEG XT
  - JPEG XS
  - JPEG PLENO
- JPEG PLENO activities have started since 2015 and will span beyond 2020
  - Well defined milestones and standards will be defined shortly
  - Joint AhG between JPEG and MPEG to better understand light/sound field digital representations, use cases and requirements
- Standardization committees do not do research but respond to needs and when interoperability is desired
  - Consider joining JPEG if any of the above is of interest, either from potential applications perspective or if you have potential technologies to propose.

Conclusions

- JPEG is exploring several paths to serve future imaging needs
  - Advanced Image Coding
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  - JPEG Privacy & Security
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More information

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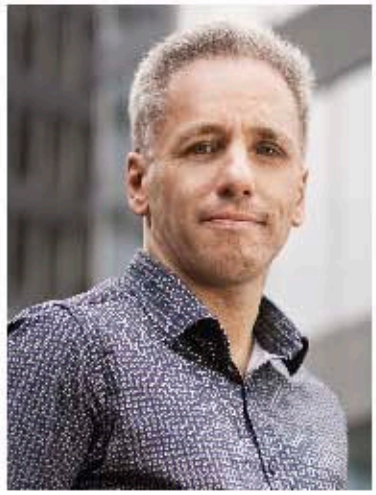

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