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IEEE P3333.1.4 Recommended Practice for the quality assessment of light field imaging

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IEEE P3333.1.4

Recommended practice for the Quality Assessment of Light Field Imaging

The "recommended practice" defines and covers:

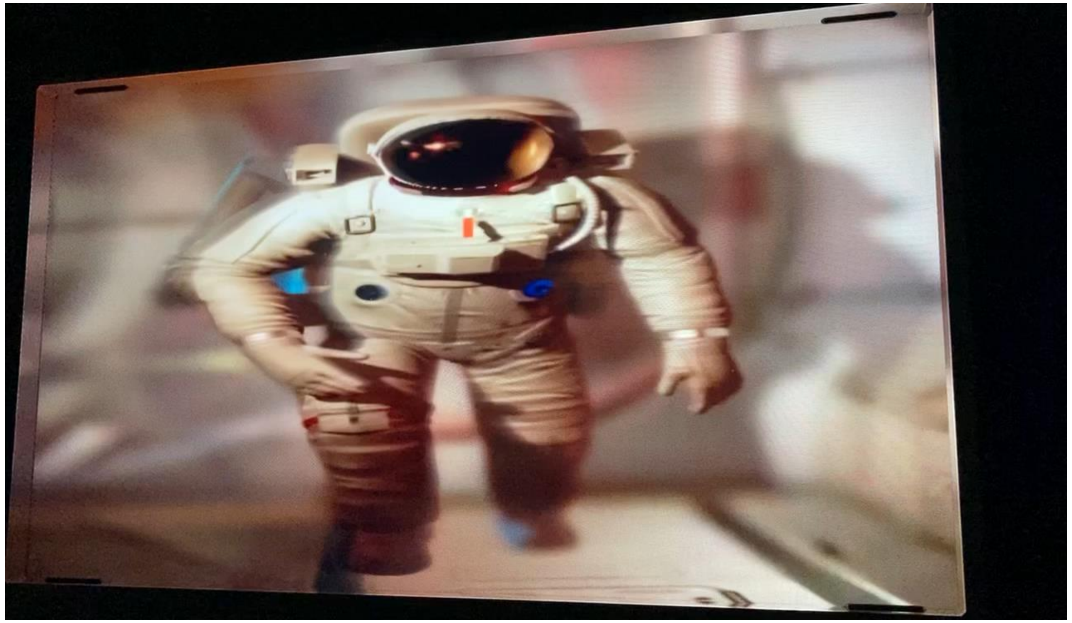
1) Use cases, acquisition, visualisation and content characterisation

2) Influencing factors and impairments for the quality of Light Field imaging

3) Subjective assessment of Light Field imaging

4) Objective assessment of Light Field imaging

5) Datasets



Introduction, considerations (including current limitations), guidelines and recommendations

https://standards.ieee.org/ieee/3333.1.4/10873/

IEEE Standardization

P3333.1.4 –Recommended practice for the quality assessment of light field imaging.

Draft submitted in December 2021

Editorial comments addressed

Approved via ballot in August 2022

Approved for publication in final form in November

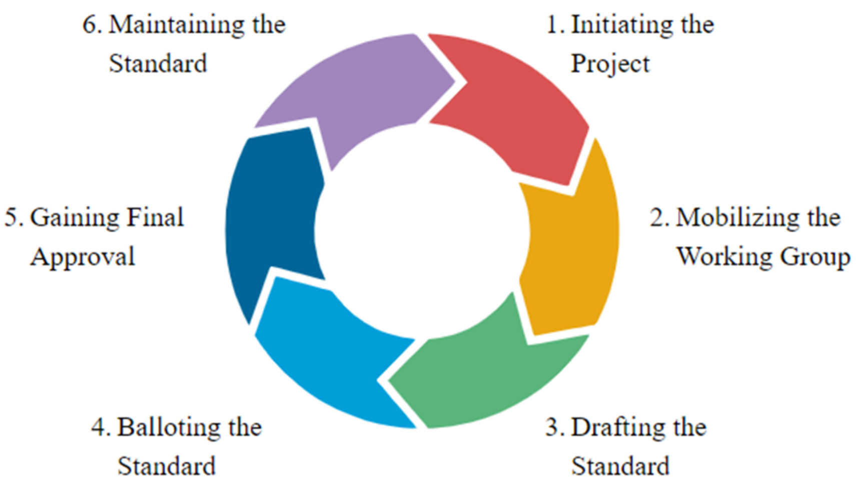


Figure: IEEE standardization process

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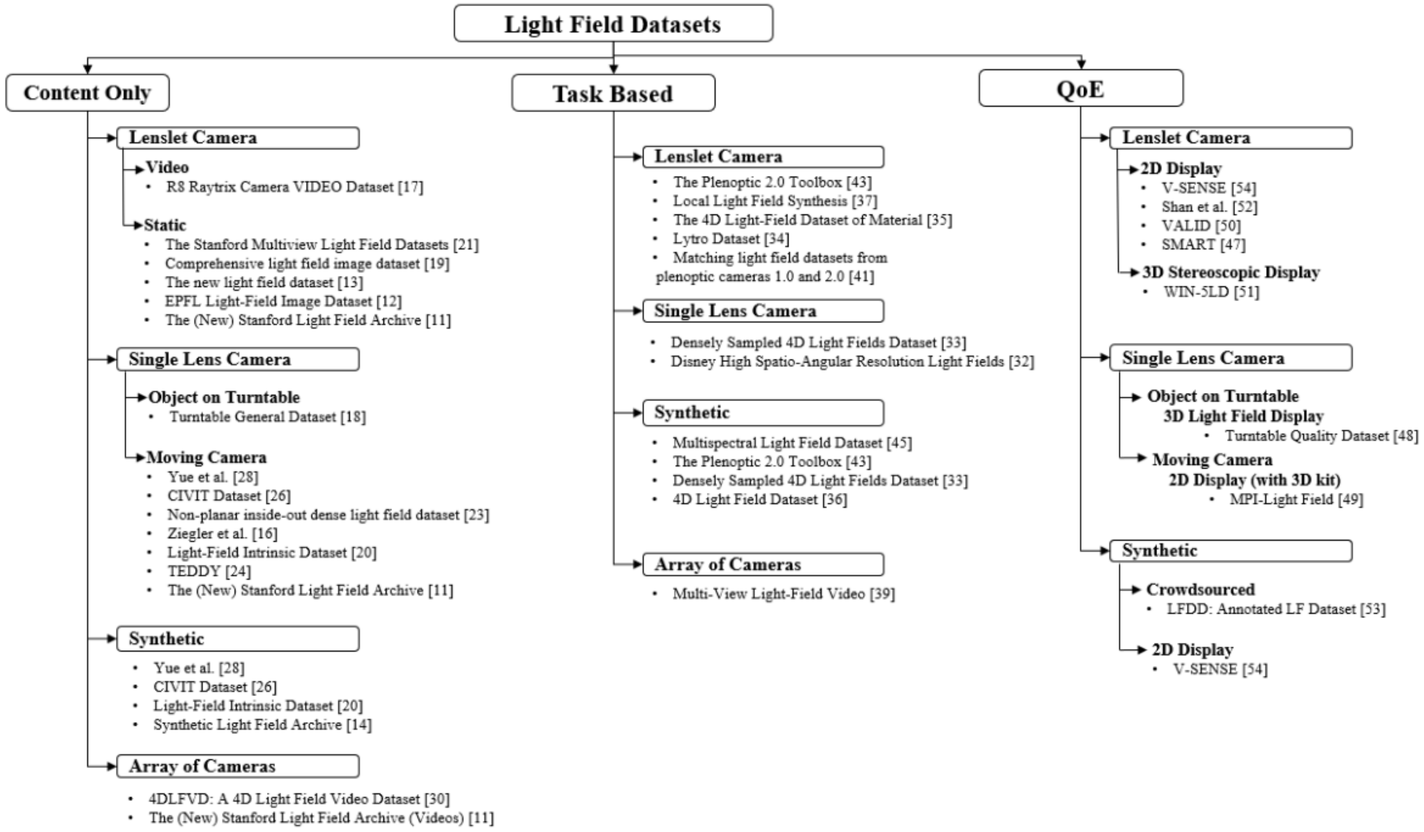
Datasets for Light field imaging – what is missing

Maria Martini and Edris Shafiee

Taxonomy of existing datasets



QoE LF datasets

Dataset	Representative Artifacts	Distortions Methods	Reconstruction Methods	Subjective evaluation method	Scores provided [All subject scores + MOS / MOS only]	Display Type	Display Make/Model
SMART [48]	Compression	JPEG, JPEG2000 HEVC Intra SSDC	NA	Pairwise Comparison Matrix (PCM), using Bradley-Terry (BT) model to convert discrete rating data in matrix to continuous rating scale	All subject scores + MOS	2D	Dell U2413f
VALID [51]	Compression Refocusing	HEVC, VP9 3 Other Methods	NA	DSIS, 5 points scale for 8-bit Output Depth CB-ACJ	All subject scores + MOS	2D	Eizo ColorEdge CG318-4K Samsung SyncMaster2443
Turntable Quality Dataset [49]	Compression, blur, additive noise	Additive Gaussian Noise JPEG compression Gaussian blur	NA	SSCQE, 5 points scale at 5 different locations within display's FOV	All subject scores + MOS	3D Light field	Holografika's Holovizio HV721RC
LFDD: Annotated LF Dataset [54]	Compression Noise Geometric Distortion Contrast Enhancement	JPEG, JPEG2000, BPG VP9, AV1, AVC, HEVC, noise, Geometric Distortions	NA	DSIS, points between 1 to 5 with one decimal precision	MOS only	NA	Crowdsourced
WIN-5LD [52]	Compression Reconstruction Refocussing	JPEG2000 HEVC	Linear Interpolation Nearest Neighbour 2 CNN based methods	DSCQS, 5 points scale	MOS only	3D Stereoscopic	55" Samsung 3D TV
MPI-Light Field [50]	Compression Reconstruction	3D-HEVC Nearest Neighbour [NN] Image wraping OPT Quantised Depth Maps (DQ) Display: Gaussian Blur in angular domain	Linear Nearest Neighbour [NN] Optical Flow Estimation [OPT]	JND and JOD, scale between 0 to -9 based on severity of distortion	All subject scores + MOS	2D (used with active shutter glasses)	ASUS VG278 27" FULL HD LCD desktop monitor together with NVIDIA 3D glasses
Shan et al. [53]	Compression, blur, additive noise	Gaussian Blur JPEG JPEG2000 White Noise	NA	DSCQS, 5 points scale	All subject scores + MOS	2D	Dell E2211Hb
V-SENSE [55]	NA	NA	Refocusing	Eye Tracking, recording events, saccades, fixations and blinks of left eye only	NA	2D	Dell P2415Q 23.8" Monitor

QoE LF datasets

SMART [48]	Battisti et al.	2016	QoE	Lytro Illum	16	16	Real Scenes	S
Turntable Quality Dataset [49]	Tamboli et al.	2016	QoE	Basler's ACE 1300gc	3	3	Real Objects	S
MPI-Light Field [50]	Adhikarla et al.	2017	QoE	Canon EOS 5D Mark II	14	350	9 Synthetis Scenes 5 Real Scenes	S
VALID [51]	Viola et al.	2018	QoE	Lytro Illum	5	5	Real Scenes from [14]	S
Win5-LID [52]	Shi et al.	2018	QoE	Lytro Illum	10	220	6 Real Scenes from [14] 4 Synthetic Scenes from [37]	S
Shan et al. [53]	Shan et al.	2018	QoE	Lytro Illum	6	6	Real Scenes from [13]	S
LFDD: Annotated LF Display [54]	Zizen et al.	2020	QoE	Synthetic	10	10	Synthetic Scenes	S
V-SENSE [55]	Gill et al.	2020	QoE	Synthetic and Lytro Illum	20	20	Real Scenes from [12], [14], [33] and Synthetic Images from [37]	S

Subjective quality assessment of LF imaging

– Most existing open access datasets report results with 2D displays (or stereoscopic 3D).

[see IEEE P3333.1.4 and Shafiee, Martini 2022]

– Different experience w.r.t. light field displays

– Differences in subjective test methodology

- User position/motion
- Multiple users
- Training

[Kara, P. A., Tamboli, R. R., Shafiee, E., Martini, M. G., Simon, A., & Guindy, M. (2022). Beyond perceptual thresholds and personal preference: towards novel research questions and methodologies of quality of experience studies on light field visualization. *Electronics*, *11*(6), 953.]

Other limitations of existing datasets

- **Video content**: very few datasets provide video data (complex acquisition), with most of them focusing on static scenes.
  - More datasets with video data should be produced and made public to advance video-related research and testing.
- **Natural scene content vs. synthetic content**: in many of the available datasets synthetic content is generated.
  - This enables controlling parameters in the content and does not require acquisition equipment, but more natural scene contents, in particular video, is required.
- Presentation of subjective results in quality assessment datasets: most of the existing quality datasets report the **aggregated scores from subjects**, via MOS.
  - However, the value of including scores from all subjects and not only MOS has been recently established (e.g., Pezzulli, Martini, Barman, IEEE T. Multimedia. 2020)

Subjective quality assessment of LF imaging on LF displays

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Publication	Content	Test Variable	Rating Scale	Viewing Dist.	Movement	Display
Adhikarla et al. [16,17]	interactive	HCI modes	NASA TLX, UEQ	50 cm	none	prototype
Ahar et al. [18]	image	spatial distortion	5-pt. DCR	5 m	none	722RC
Cserkaszky et al. [19]	image	angular res., interpolation	7-pt. PC	4.6 m	sideways	C80
Cserkaszky et al. [20]	image	angular res., light field format	3-pt. PC	4.6–6.5 m	both directions	C80
Cserkaszky et al. [21]	image	angular res., light field format	bin., 5-pt. ACR, 7-pt. PC	4.6–6.5 m	both directions	C80
Darukumalli et al. [22]	image	zoom level	5-pt. ACR, 7-pt. PC	4.6 m	none	C80
Darukumalli et al. [23]	image	zoom level, content alignment	5-pt. ACR, 5-pt. DCR	4.6 m	none	C80
Dricot et al. [24]	video	compression	5-pt. DCR	6 m	none	C80
Kara et al. [25]	image	FOV	10-pt. ACR	up to 5 m	both directions	80WLT
Kara et al. [26]	image	angular res., reconstruction	10-pt. ACR	4.6 m	sideways	C80
Kara et al. [27]	image	angular res.	10-pt. ACR	4.6 m	sideways	C80
Kara et al. [28]	image	spatial res.	5-pt. DCR	4.6–6.6 m	both directions	C80
Kara et al. [29]	image	angular res.	bin., 25-pt. QC	4.6–5.6 m	none	C80
Kara et al. [30]	image	angular res., spatial res.	7-pt. PC	4.6 m	sideways	C80
Kara et al. [31]	image	angular res., reconstruction	10-pt. ACR	4.6 m	sideways	C80
Kara et al. [32]	video	angular res., spatial res.	5-pt. PC	4.6 m	sideways	C80
Kara et al. [33]	video	angular res., spatial res.	5-pt. DCR, 7-pt. PC	4.6 m	sideways	C80
Kara et al. [34]	video	angular res., spatial res.	5-pt. DCR	4.6 m	sideways	C80
Kara et al. [35]	image	viewing distance	7-pt. PC	4.5–7.5 m	none	C80
Kara et al. [36]	image	viewing distance	n/a	0.25–8 m	back and forth	80WLT, C80
Kovacs et al. [37]	image	symbol size	n/a	5 m	none	C80
Kovacs et al. [38]	image	grating density	bin.	5 m	both directions	C80
Kovacs et al. [39]	image	symbol size	n/a	80 cm	none	80WLT
Tamboli et al. [40,41]	image	spatial distortion	5-pt. ACR	2.44 m	none	721RC
Tamboli et al. [42]	image	angular distortion	5-pt. ACR	2.44 m	none	721RC
Tamboli et al. [43]	interactive	content orientation	n/a	4.6 m	sideways	C80
Zhang et al. [44]	live video	n/a	n/a	1.2–3.6 m	both directions	prototype

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A new Dataset for Light field imaging

Kamran Javidi, Edris Shafiee, Maria Martini

KULF dataset

Wireless and Multimedia Networking Research Group laboratory at Kingston University London

Acquisition:

- Plenoptic camera
- Camera rig

Exchangeable optics	Max. frame rate (in fps)	Lateral resolution (in MP)	Typical standard focal lengths (in mm)	MLA Aperture F/Number
C-Mount	30	2	(8, 12, 16), 25, 35, 50, 75	2.8 / 4 / 5.66

While earlier datasets acquired via plenoptic cameras only included static scenes or objects on a turntable, this dataset includes scenes with different types of motion.

Dataset acquired with plenoptic camera with a 35mm lens. The camera used can precisely capture a scene included in a 10cm × 10cm × 10cm volume, hence the captured scenes are included in such a volume.

Images acquired from 25 angles of view for each frame.

All the videos were recorded at 30 fps, with each frame at a 1920 × 1080 pixel resolution.

The dataset will be publicly available upon publication of standard and relevant paper

Dataset content

Content	Scene	Camera Motion	Duration	Frame rate (fps)
Video	Swinging magician	Fixed	10 s	30
Video	Hourglass	Fixed	10 s	30
Video	Marbles	Fixed	10 s	30
Video	Rolling marbles	Fixed	10 s	30
Video	Drop	Fixed	10 s	30
Static scene	Edris	Fixed	NA	NA
Static scene	Monument model	Fixed	NA	NA
Static scene	Marbles	Fixed	NA	NA
Static scene	Anatomy model (kidney)	Fixed	NA	NA

Note: first release content only

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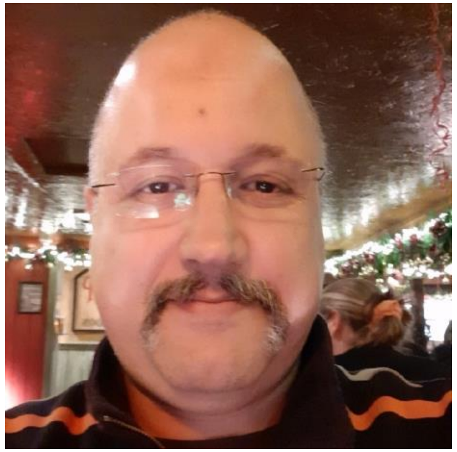
– Kamran Javidi
– Edris Shafiee



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