QUALITY EVALUATION OF DIGITAL HOLOGRAPHIC DATA ENCODED ON THE OBJECT PLANE USING STATE OF THE ART CODECS

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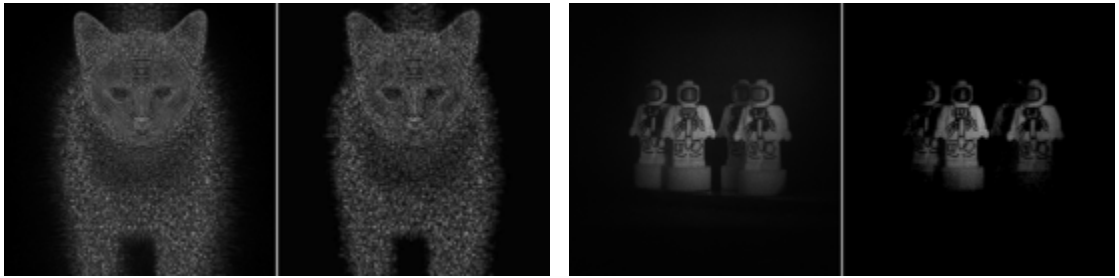
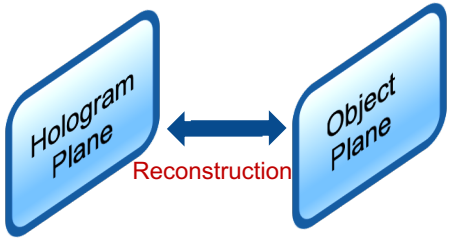
Overview of the presentation

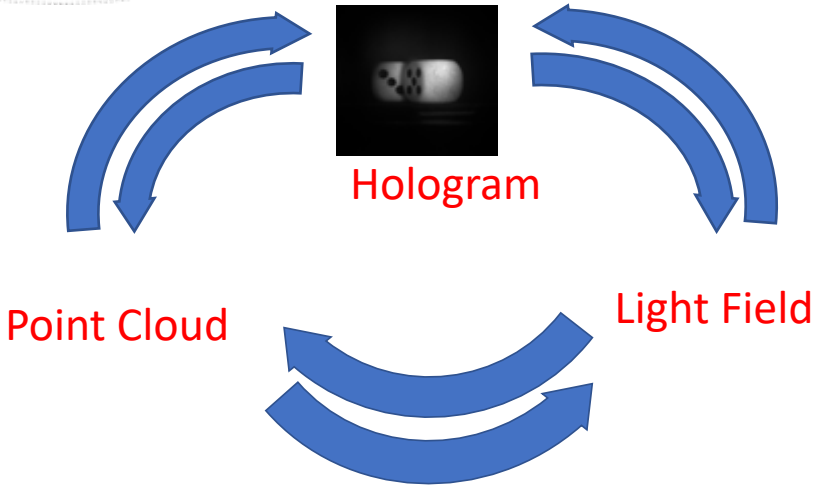
- Introduction
- Objectives of this study
- **Subjective Evaluation**
- Objective Evaluation
- Conclusions
- Future Work



Introduction

- Digital Holography is one of the plenoptic modalities and provides a volumetric representation
- Used in digital holographic microscopy (DHM), particle analysis, deformation measurements…
- Can be obtained from rendering other Plenoptic representations:
  Point clouds, Light fields
- Can be used to store/represent other formats
- Its importance is recognized on JPEG Pleno standardization activity

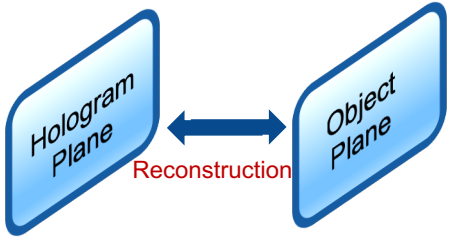


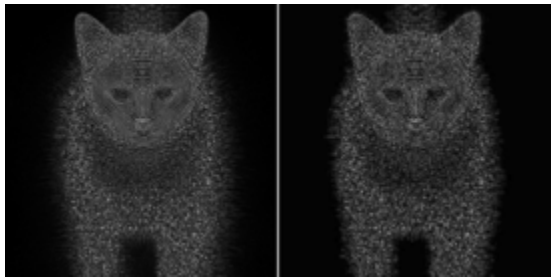


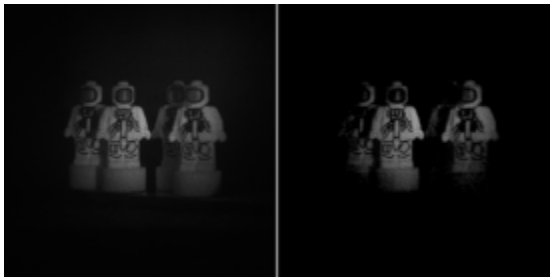
Objectives of this study

Quality Assessment of compressed holograms

- Subjective evaluation
  - Holograms compressed by state of the art codecs
  - Holograms represented on the object plane
  - Compression of Real and Imaginary components
  - Visualization of the Amplitude







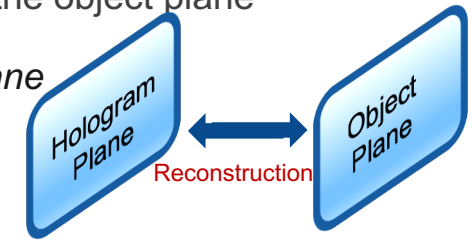
- Validation of Objective Metrics

Subjective evaluation

Subjective evaluation of state of the art codecs

- Compression on the object plane

  Previous work revealed the better efficiency of current codecs in the object plane (when compared with the hologram plane)
  - Compression of *real* + *imaginary* represented in the *object plane*
  - *Amplitude* provides a direct 2D visualization



- Tested codecs:
  - JPEG 2000
  - HEVC (Intra)
  - AV1 (Intra)

- Test data
  - 3 holograms of emergimg database (optically generated hologram)
  - 3 holograms of interfere database (computer generated holograms)

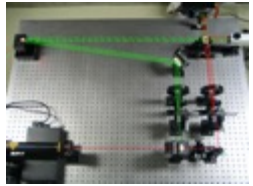
Test Data

Optically generated holograms (OGH) EmergIMG holograms database

http://emergimg.di.ubi.pt/downloads.html

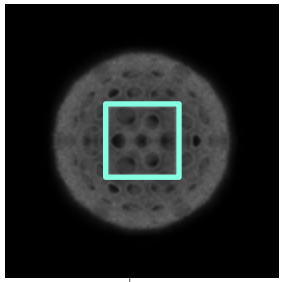
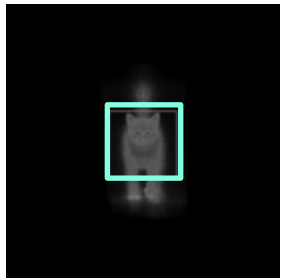
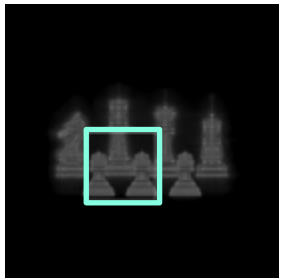
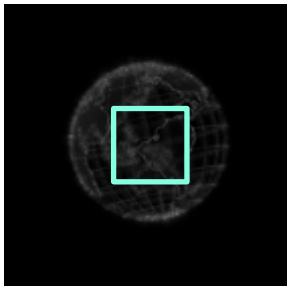






Computer generated holograms (CGH) Interfere-I database

http://www.erc-interfere.eu/downloads.html

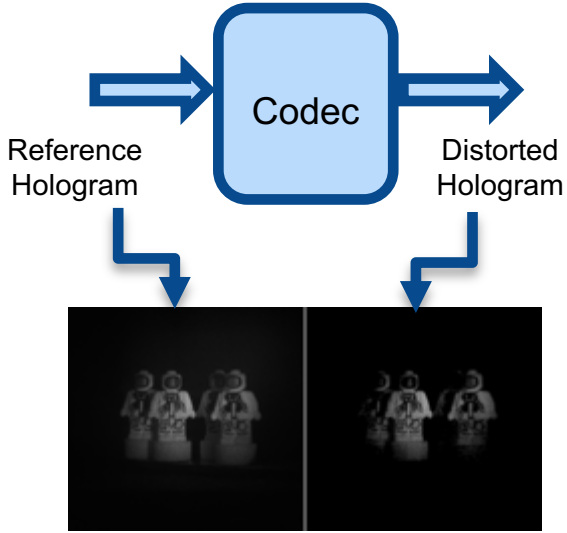





used for training

Subjective evaluation

- EIZO CG318 4K

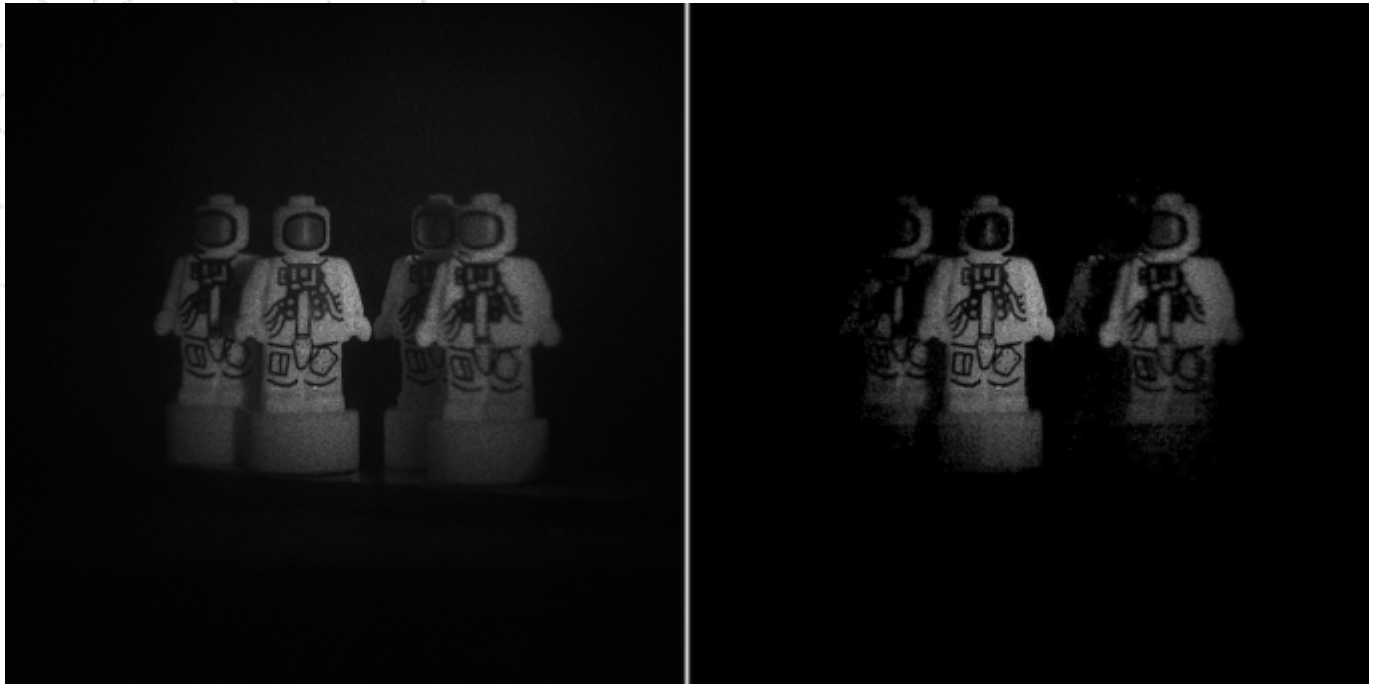
- Reference and Distorted images side by side
- 4 bit-rates were tested for each codec
- 5 quality levels
  1 - *very annoying*,
  2 - *annoying*,
  3 - *slightly annoying*,
  4 - *perceptible, but not annoying*,
  5 - *imperceptible*



- Subjects had a training step with two holograms on levels 1,3 and 5

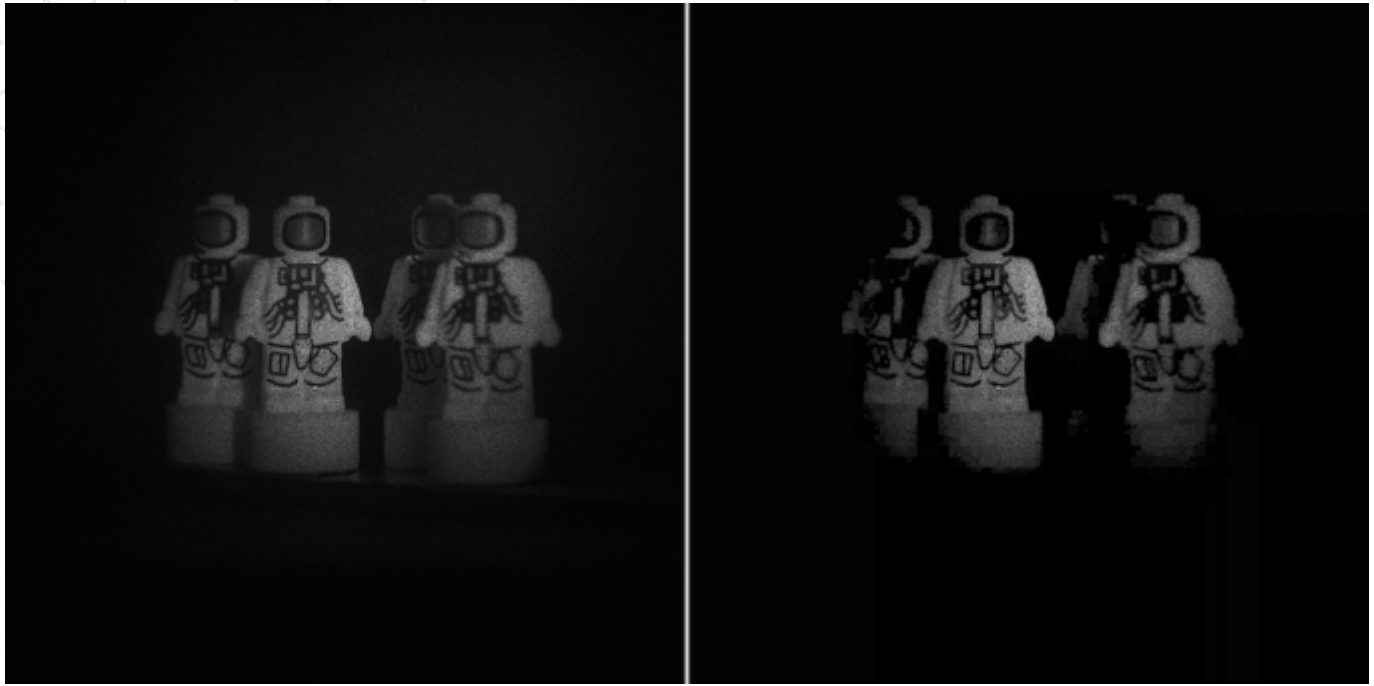
Test Data

JPEG 2000 lower bit rate



Test Data

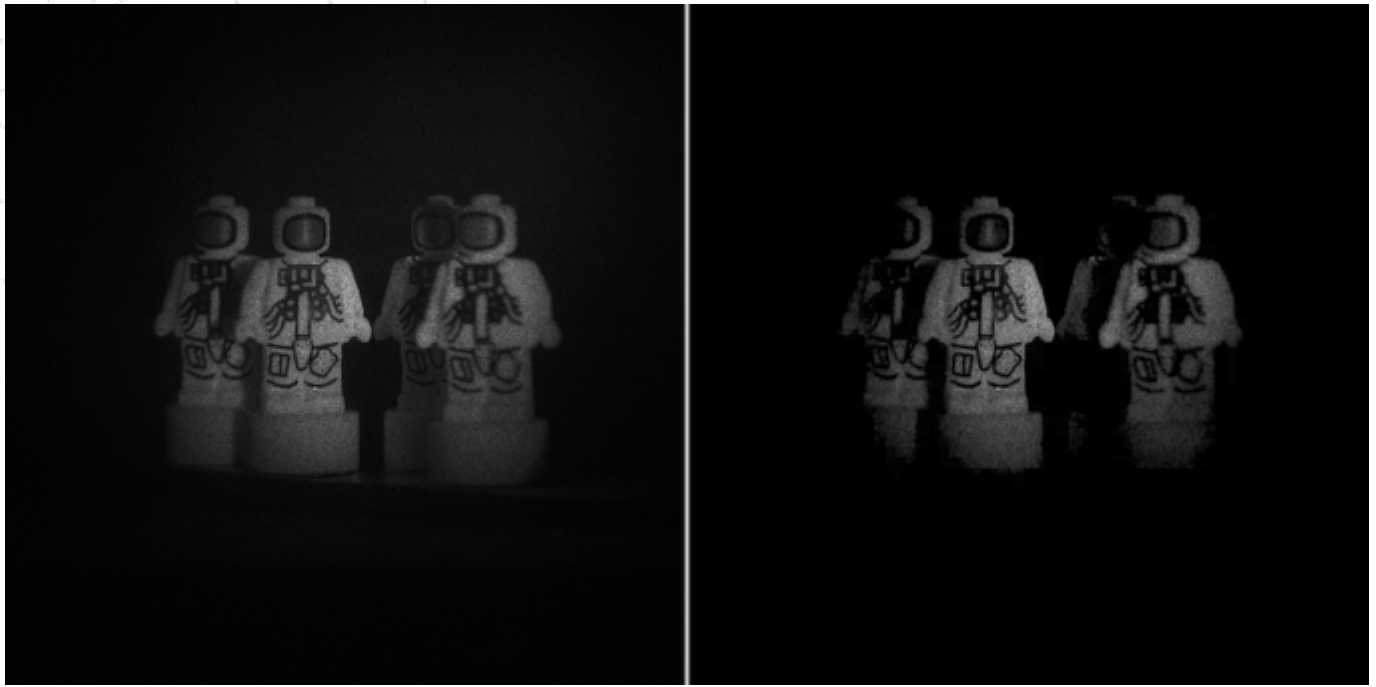
HEVC lower bit rate



Test Data

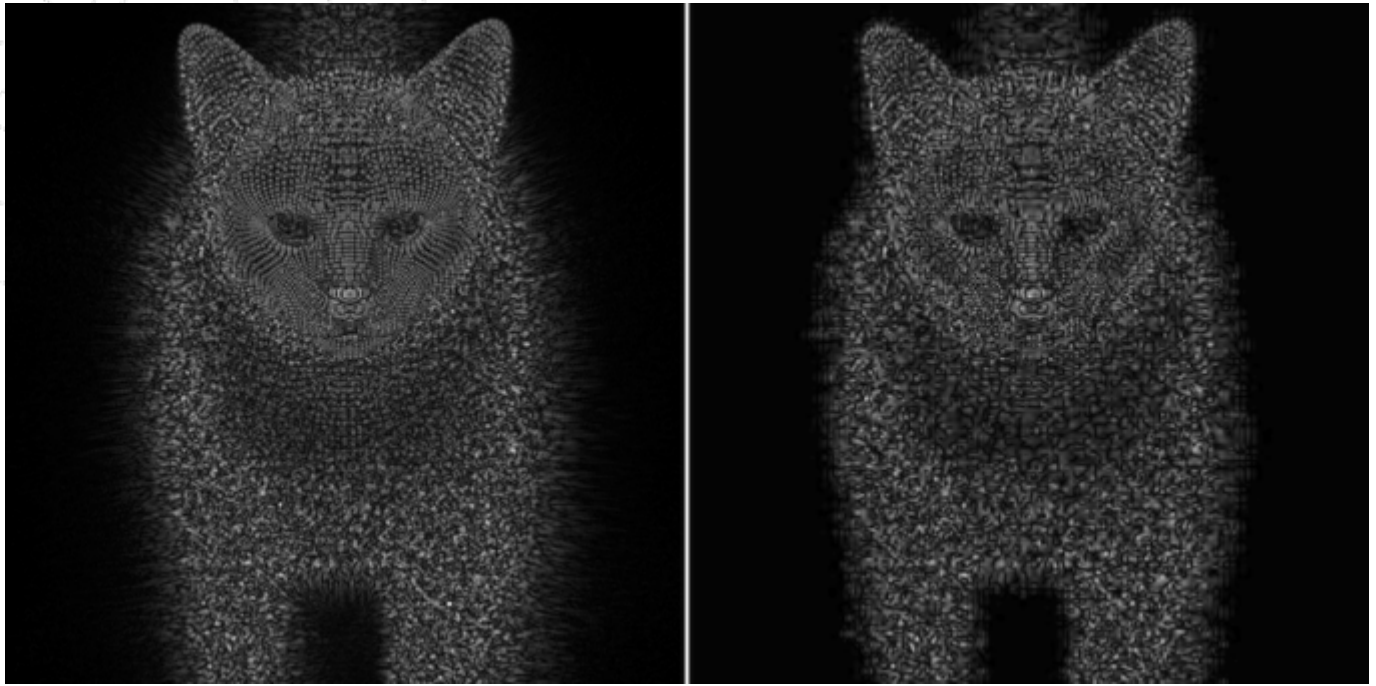
AV1 lower bit rate

Alliance for Open Media



Test Data

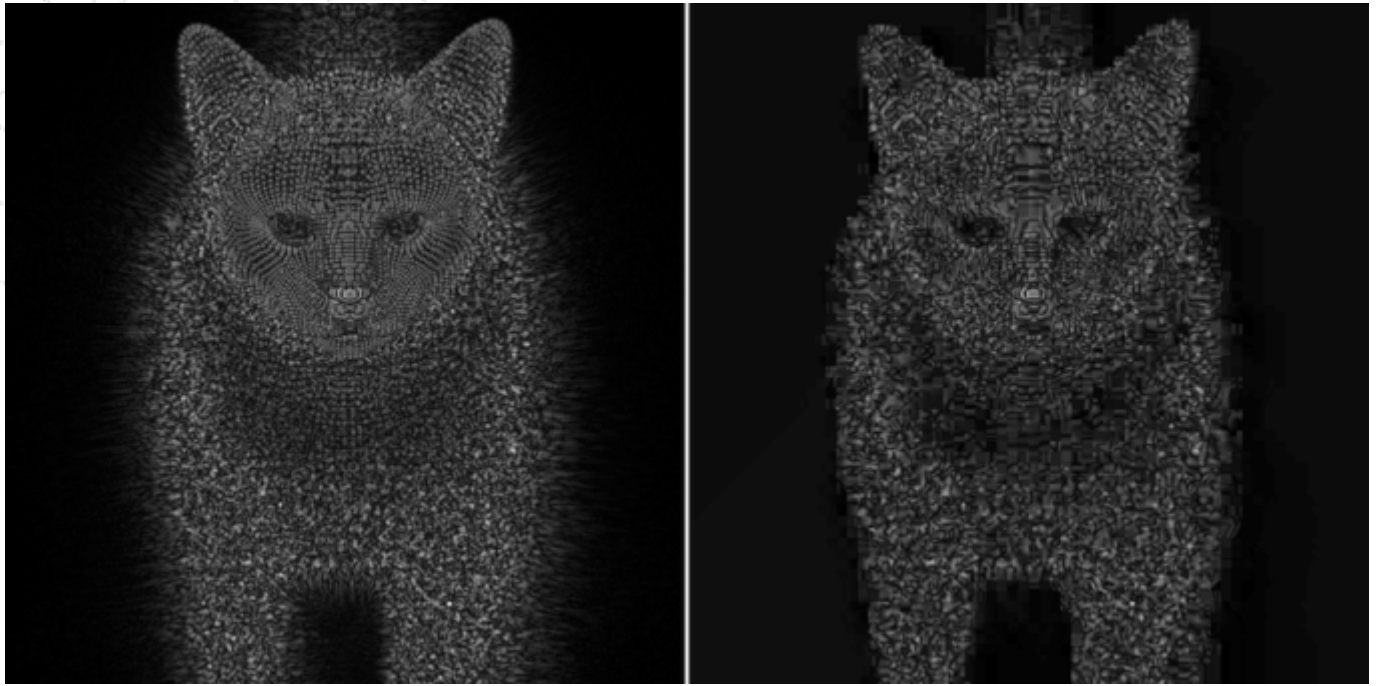
JPEG 2000 lower bit rate



- Generated from Point Clouds
- Real resolution allow visualization of its point made nature

Test Data

HEVC lower bit rate



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AV1 lower bit rate

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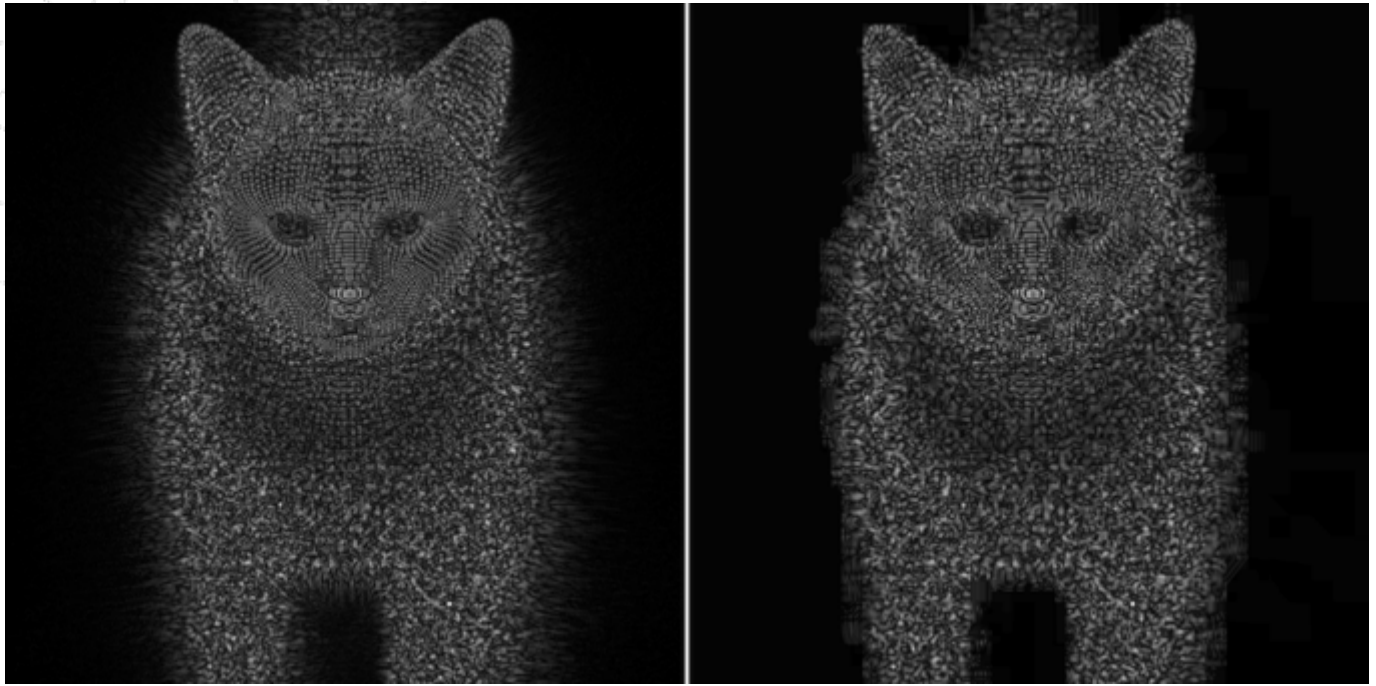
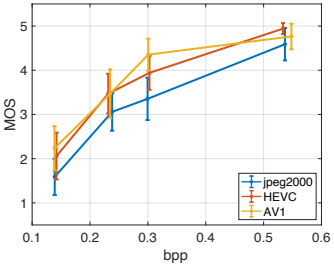
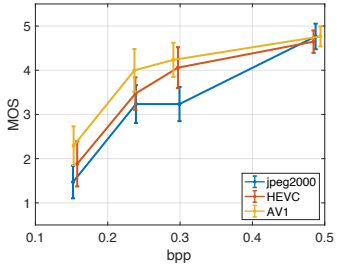


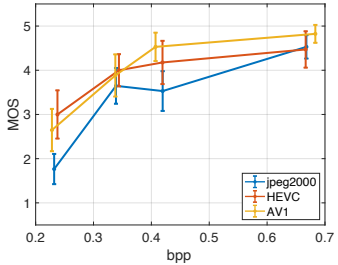
- Generated from Point Clouds
- Real resolution allow visualization of its point made nature

Subjective Evaluation

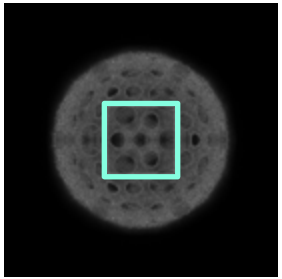
Optically generated holograms (OGH) EmergIMG holograms database

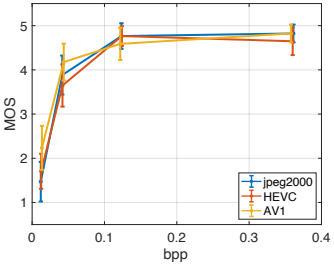


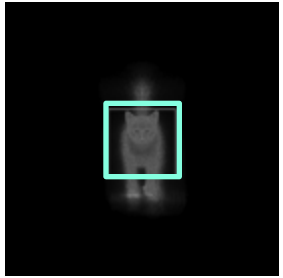


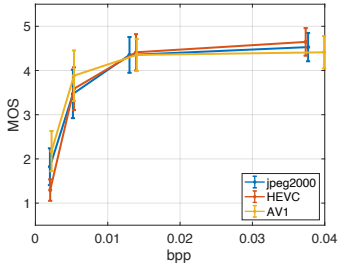


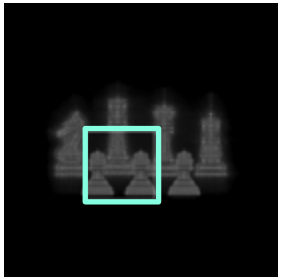
Computer generated holograms (CGH) Interfere-I database

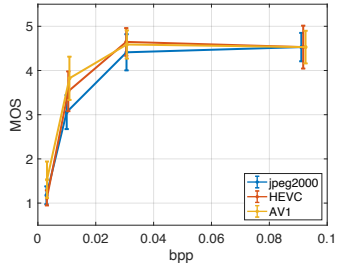








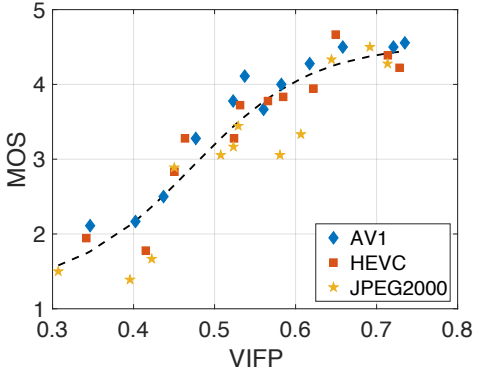


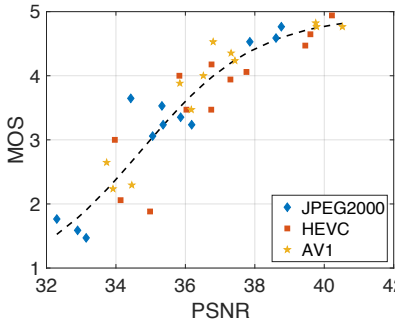


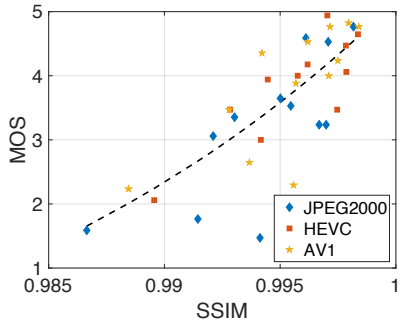
Correlation of Objective metrics with Subjective results

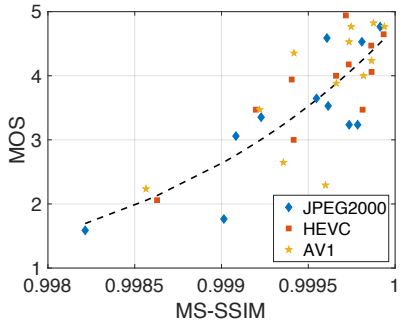
OGH – Optically Generated Holograms

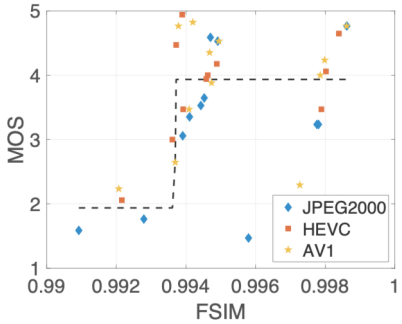
	PCC	SRCC	RMSE	OR
PSNR	0.9276	**0.9349**	0.37749	**0.19444**
SSIM	0.72117	0.74222	0.70655	0.5
MS-SIM	0.73327	0.72999	0.69072	0.47222
FSIM	0.60892	0.49451	0.80767	0.66667
VIFP	**0.93448**	0.93039	**0.36124**	**0.19444**



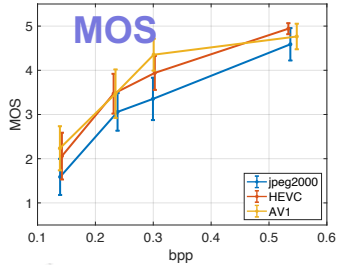


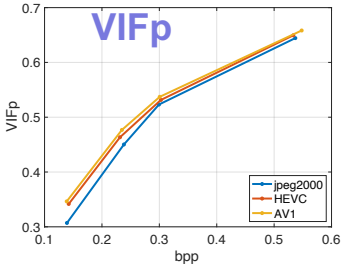


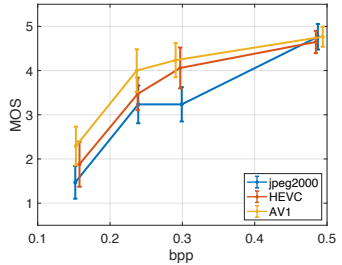


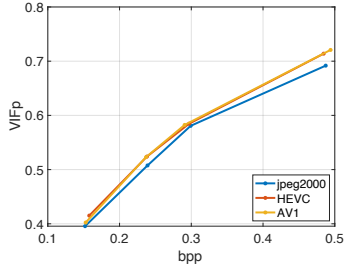


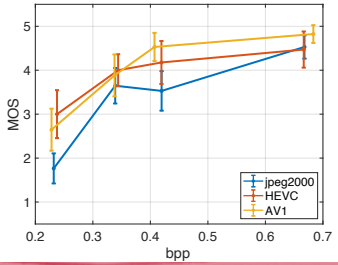
Objective Evaluation

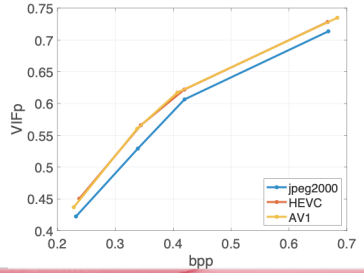


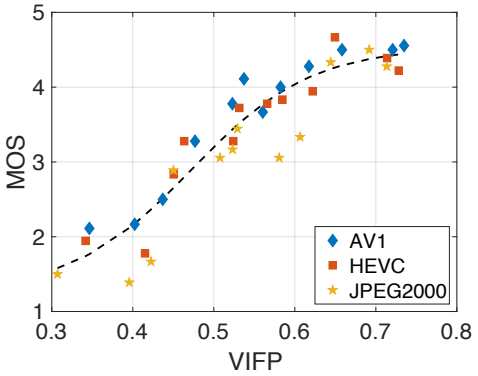








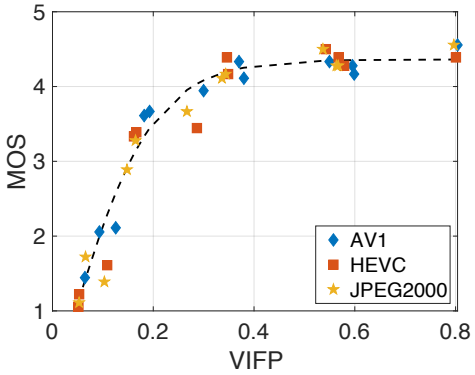


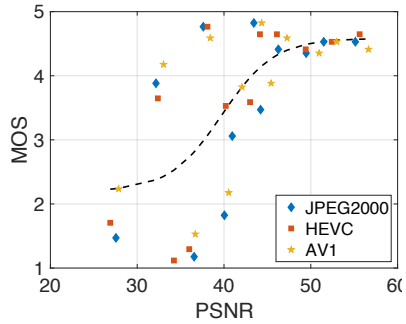


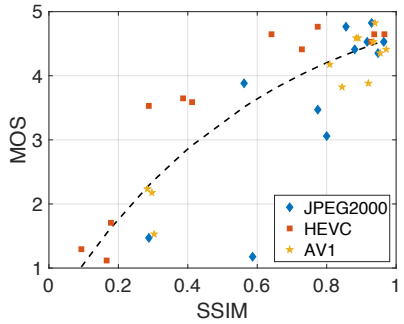
Correlation of Objective metrics with Subjective results

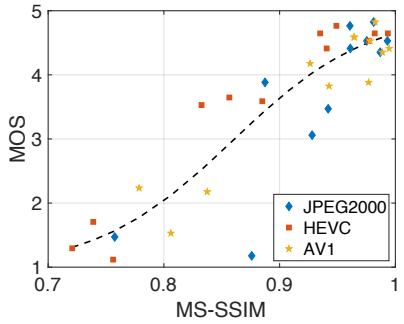
CGH – Computer Generated Holograms

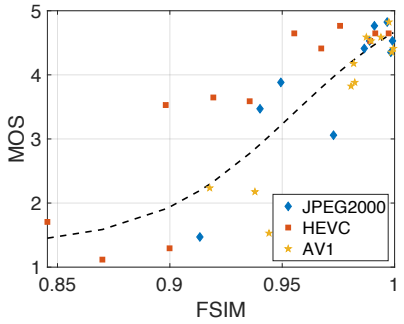
	PCC	SRCC	RMSE	OR
PSNR	0.65555	0.5639	0.93539	0.52778
SSIM	0.81498	0.72514	0.72201	0.33333
MS-SIM	0.86648	0.77502	0.62309	0.25
FSIM	0.7861	0.75569	0.76666	0.41667
VIFP	**0.97635**	**0.92866**	**0.2715**	**0.083333**



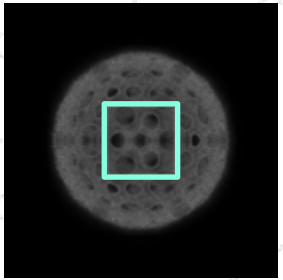


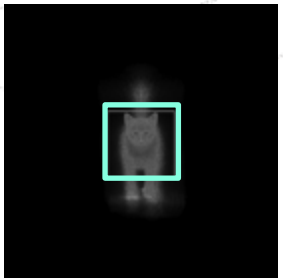


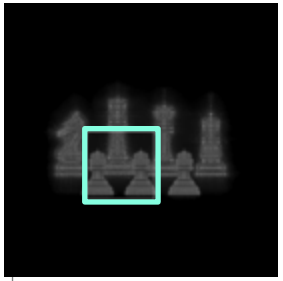


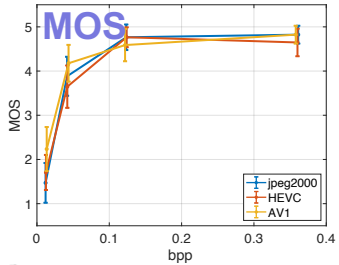


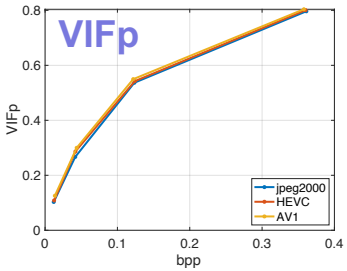
Objective Evaluation

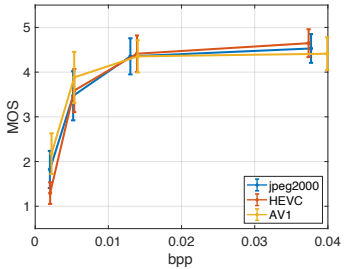


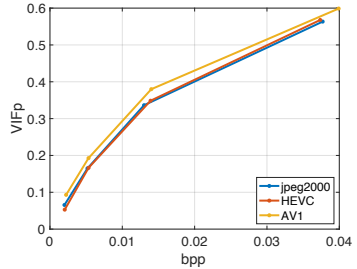


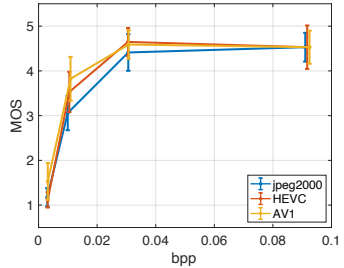


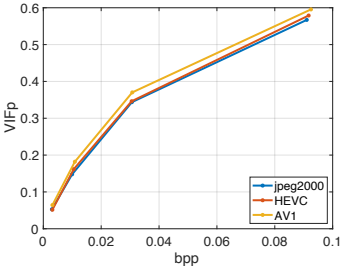


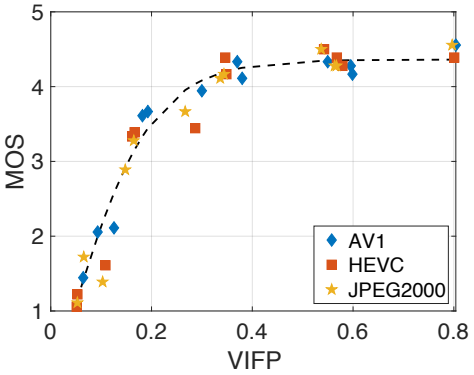








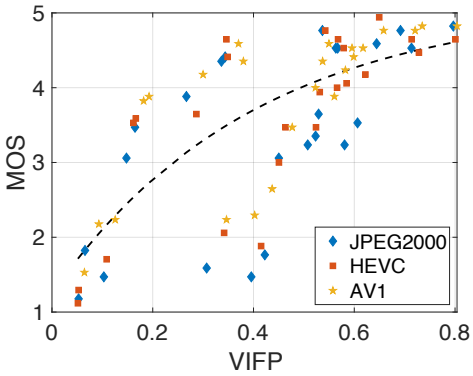


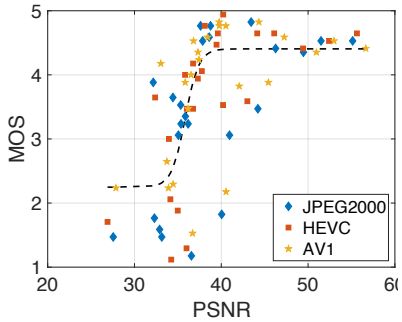


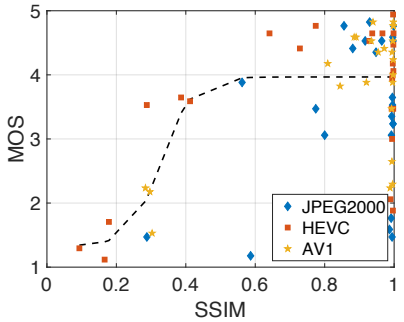
Correlation of Objective metrics with Subjective results

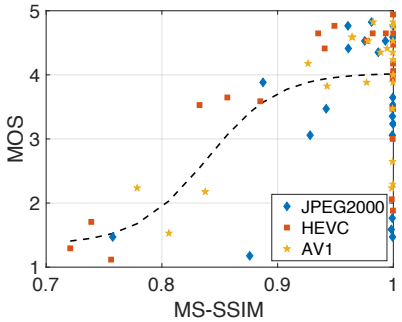
All tested Holograms

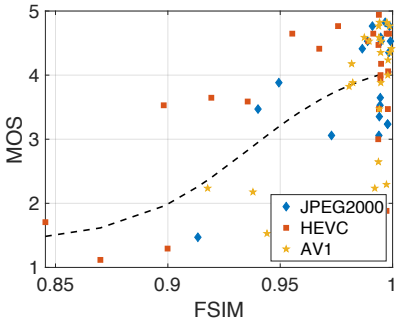
	PCC	SRCC	RMSE	OR
PSNR	0.66511	0.64712	0.8539	**0.5**
SSIM	0.54524	0.31798	0.95715	0.73611
MS-SIM	0.57951	0.32537	0.93088	0.79167
FSIM	0.51222	0.38364	0.97709	0.84722
VIFP	**0.71726**	**0.74283**	**0.7894**	0.59722











Conclusions

- ***Different data nature*** require **different quality models**
- Unnatural appearance of the Data creates problems on subjective evaluation
  - after appropriate training subjects manage to deal with the subjective test
- **VIFP** is the best performing metrics (from the studied ones)
  - However, the metric behaves differently, depending of the source of data.
- Further studies are needed to evaluate the volumetric nature of the holograms.

Future work

Video sequences with frames representing reconstructions with different viewing angle.

- Allows to evaluate the quality of the 3D information

(namely out of focus parts of the image during the reconstruction).

Acknowledgments

- EmergIMG project
  - Portuguese consortium UBI, IST, UC
  - Devoted to study Emerging Image Technologies
- JPEG Pleno development, standard for representation of:
  - Light Field, Point Cloud, Holography
- Project C4 - Cloud Computing Competence
- Project PLive (Internal Project of IT)