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 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 emerging 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
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

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

AV1 lower bit rate

- 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**

<table>
<thead>
<tr>
<th></th>
<th>PCC</th>
<th>SRCC</th>
<th>RMSE</th>
<th>OR</th>
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<tbody>
<tr>
<td>PSNR</td>
<td>0.9276</td>
<td><strong>0.9349</strong></td>
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<td><strong>0.36124</strong></td>
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</table>
Objective Evaluation

MOS

VIFp

MOS

VIFp

MOS
Correlation of Objective metrics with Subjective results

**CGH – Computer Generated Holograms**

<table>
<thead>
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**Tables 2 and 3 show the performance of five selected metrics for all testing cases.**
Objective Evaluation
Correlation of Objective metrics with Subjective results

### All tested Holograms

<table>
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<tr>
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<th>RMSE</th>
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</table>

### Results

- **PSNR**: 0.66511
- **SSIM**: 0.54524
- **MS-SIM**: 0.57951
- **FSIM**: 0.51222
- **VIFP**: 0.71726

**Objective metrics** for all testing holograms are shown in the table above. The table includes PCC, SRCC, RMSE, and OR values for each metric. The table also shows the correlation between the objective metrics and subjective scores, as indicated by the MOS values.

**Graphs**

The graphs illustrate the correlation between subjective MOS scores and objective metric values for different models (JPEG2000, HEVC, AV1). Each graph represents a different metric (PSNR, SSIM, MS-SIM, FSIM) and shows how MOS scores change with varying values of the objective metric.

**Conclusion**

- For all metrics, the objective scores show a strong correlation with subjective MOS scores, indicating that these metrics can be used to evaluate the quality of holographic images.
- The table and graphs together provide a comprehensive analysis of the performance of different encoding algorithms on holographic images, highlighting the effectiveness of the VIFP metric in representing holographic image quality.

**Acknowledgments**

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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)