ISO/IEC JTC 1/SC 29/WG 1 (ITU-T SG16)

Coding of Still Pictures

JBIG
Joint Bi-level Image Experts Group

JPEG
Joint Photographic Experts Group

TITLE: JPEG Pleno Second Draft Call for Contributions on Subjective Light Field Quality Assessment

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PROJECT: JPEG Pleno

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JPEG Pleno Second Draft Call for Contributions on Subjective Light Field Quality Assessment

Summary

The scope of JPEG Pleno Quality Assessment is the creation of a quality assessment standard, defining a framework including subjective quality assessment protocols and objective quality assessment methods for lossy decoded data of plenoptic modalities in the context of multiple use cases.

This document contains the JPEG Pleno Second Draft Call for Contributions (CfC) on Subjective Light Field Quality Assessment. The scope of this call for contributions is to collect new procedures and best practices with regard to light field subjective quality assessment methodologies to assess the artefacts induced by coding algorithms. All contributions, which can be test procedures, datasets, and any additional information, will be considered to develop the standard by consensus among the JPEG experts following a collaborative process approach from the very beginning.

Subjectively-annotated light field databases will support the evaluation of the objective quality assessment methods in a second call.
1. JPEG Pleno standards

The JPEG Pleno standard tools provide a framework for coding new imaging modalities derived from representations inspired by the plenoptic function. The image modalities addressed by the current standardization activities are light field, holography, and point clouds, where these image modalities describe different sampled representations of the plenoptic function. Currently, four parts (Part 1: Framework, Part 2: Light field coding with Amendment 1: Profiles and levels for JPEG Pleno light field coding system, Part 3: Conformance testing and Part 4: Reference software) have been standardized [1, 2, 3, 4, 5]. JPEG Pleno Part 5: Holography [6] is under development, being the first standardization effort aspiring to a versatile solution for efficient compression of holograms for a wide range of applications.

In the context of the JPEG Pleno standardisation process with respect to light field coding (Part 2) [2], various subjective visual quality assessment procedures have been designed and used; thus, significant knowledge has been built-up with respect to challenges, good practice guidelines and methodological aspects. To further improve this task, JPEG has launched a new standardisation effort known as JPEG Pleno Quality Assessment. It aims at providing a quality assessment standard, defining a framework including subjective quality assessment protocols and objective quality assessment procedures for lossy decoded data of plenoptic modalities in the context of multiple use cases. The first phase of this effort will address the light field modality and should build on the light field quality assessment tools developed by JPEG in recent years.

2. Scope

The scope of this call for contributions is to collect new methodologies and best practices with regard to light field subjective quality assessment procedures to assess artefacts induced by coding algorithms. All contributions will be considered to develop the standard by consensus among the JPEG experts following a collaborative process approach from the very beginning. Subjectively-annotated light field databases will support the evaluation of the objective quality assessment methods in a second call.

3. Use cases and requirements

JPEG issued a document “Use Cases and Requirements for Light Field Quality Assessment” [7] to assist this standardization effort, defining use cases and requirements to support the development of a light field quality assessment standard both for subjective and objective assessment.

The use cases refer primarily to static light fields, corresponding to a single time sample, where spatial and angular information of a tri-dimensional scene are simultaneously captured. However, non-static light field use cases may be addressed in the future.

4. Test materials

The currently available test materials are provided in the JPEG Pleno database [8]. These light field images present different scene geometries and spatio-view geometry diversity and is composed of the following data:

- **Lenslets**: Bikes, Danger de Mort, Fountain&Vincent2 and Stone Pillars Outside;
- **HDCA** (High Definition Camera Array): Lab1 and Tarot; and
- **Synthetic**: Greek and Sideboard.

Table I includes a summary of the selected datasets from the JPEG Pleno database [8], with their example views depicted in Figures 1 to 3.
<table>
<thead>
<tr>
<th>Dataset</th>
<th>Number of views</th>
<th>Spatial resolution (pixels)</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bikes</td>
<td>13 × 13</td>
<td>625 × 434</td>
<td>Lenslets</td>
</tr>
<tr>
<td>Danger de Mort</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fountain&amp;Vincent2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stone Pillars Outside</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laboratory1</td>
<td>31 × 31</td>
<td>1936 × 1288</td>
<td>HDCA</td>
</tr>
<tr>
<td>Tarot</td>
<td>17 × 17</td>
<td>1024 × 1024</td>
<td>HDCA</td>
</tr>
<tr>
<td>Greek</td>
<td>9 × 9</td>
<td>512 × 512</td>
<td>Synthetic</td>
</tr>
<tr>
<td>Sideboard</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Fig 1. From left to right and from top to bottom: Bikes, Danger de Mort, Stone Pillars Outside and Fountain&Vincent 2 example views.
The JPEG Pleno light field dataset is diverse in terms of:

- Acquisition/creation technology, notably:
  - Lenslet Lytro Illum camera;
  - High Density Camera Array (HDCA);
  - Synthetic creation.
- Scene geometry;
- Spatial resolution;
- Number of views/perspectives;
- Bit-depth;
- Structure of texture.

Large-scale and rich-diversity datasets play an important role in developing subjective and objective quality assessment methods. Hence, within the context of this CfC, the JPEG committee also probes for additional datasets, as defined in section 8.1[C3] and [C8], depicting additional features as listed below in the set of requirements for additional datasets:

- Synthetic generated LF, lenslets and HDCA;
- Different angular samplings (from narrow to wide baseline);
Different parallax levels;
- Different spatial resolutions;
- Different/complex scene geometries;
- Different colour gamut;
- Different degrees of texture;
- Different bit-depths;
- Different number of views/perspectives;
- Test data with specularity and transparency;
- Content type diversity.


5. Coding conditions
This section lists the codecs for the experiments performed with the selected light fields from the JPEG Pleno dataset [8]. The original datasets will be made available to the proponents. The associated bitrates will be determined along the collaborative process.

1. JPEG Pleno Part 2 coding modes [2]
2. HEVC [9]
3. VVC [10]

6. Evaluation conditions and processes
This call is asking for contribution as inputs to the standardization process that will be a collaborative process from the very beginning. In practice, this means that there will be no related call for proposals. In this context, all received contributions will be considered to develop the standard by consensus among the JPEG experts. Contributions may address a subset of the requirements and not necessarily all the requirements as defined in the document “Use Cases and Requirements for Light Field Quality Assessment” [7]. During the collaborative phase, elements of complementary contributions may be combined into a single coherent specification.

Contributors are not required to be accredited JPEG members at the time of submission. Contributors are expected to present their contributions at the 99th JPEG Meeting, April 2023, and to participate in the following discussion. Contributors are expected to engage with JPEG as a part of the collaborative development of the standard.

6.1. Contributions assessment
The methods submitted as a contribution to this CfC will be reviewed by implementing and testing them in the laboratories of the proponents. Statistical analysis will be employed to analyze and compare quantitatively the results of the proposed methodologies. The test may include, but not limited to: Absolute prediction error (RMSE), Pearson correlation coefficient, Spearman's rank correlation coefficient and Outlier ratio will be computed for accuracy, linearity, monotonicity and consistency, respectively. The
quantitative evaluation criteria aim to assess the Repeatability, Reliability, and Efficiency of the contributions according to the subjective quality assessment requirements identified in [7].

- **Correlation**: the correlation between the scores obtained in different laboratories may be computed, for example using the Pearson linear correlation coefficient (PLCC) and the Spearman rank order correlation coefficient (SROCC). Additionally, the root-mean-square error (RMSE) and the outlier ratio (OR) may be computed.

- **CE, UE, OE**: the correct estimation (CE), over-estimation (OE), under-estimation (UE) may be computed to see if the scores are statistically distinguishable across the different experiments proposed in the different labs.

- **CD, FR, FD, FT**: correct decision (CD), false ranking (FR), false differentiation (FD), or false tie (FT) may also be computed.

- **Student's t-test or Welch’s t-test**: may be used to assess whether the means of the collected scores differ significantly.

- **ANOVA**: a multi-way ANOVA will be performed on the scores obtained in different laboratories with the goal of verifying whether the obtained scores are statistically equivalent.

- **Size of confidence intervals (CI)**: the size of CI of subjective scores of each stimulus will be computed for each test and may be compared across multiple experiments (Reliability and Repeatability [7]).

- **Significance test**: a two-sample t-test or Wilcoxon test will be performed between subjective scores of multiple experiments (Reliability and Repeatability).

- **Discriminability score**: a more accurate method should result in more pairs of images whose quality can be said to be different under a statistical test. Significance tests between scores of each possible pair of stimuli will be performed and the percentage of stimuli pairs with a significant difference will be obtained (Reliability and Repeatability [7]).

To assess the Efficiency requirement [7], the above criteria will be used for a various number of subjects. Subjective tests will be conducted with a sufficiently large number of subjects which can be compared with a subset of scores or a separate test with a smaller number of subjects:

- What is the minimum number of participants required to achieve statistically comparable outcomes to the test with all participants. (Using correlation and significance tests)

- Comparison of plots of the number of subjects versus the discriminability score.

- Comparison of plots of the number of subjects in method A versus method B to reach the same discriminability score.
7. **Timeline**

The following schedule is planned for the JPEG Pleno Light Field Quality Assessment.

<table>
<thead>
<tr>
<th>Date</th>
<th>Task</th>
</tr>
</thead>
<tbody>
<tr>
<td>April 2022</td>
<td>95th WG1 meeting: Draft Call for Contributions on Subjective Light Field Quality Assessment</td>
</tr>
<tr>
<td>July 2022</td>
<td>96th WG1 meeting: Second Draft Call for Contributions on Subjective Light Field Quality Assessment</td>
</tr>
<tr>
<td>September 2022</td>
<td>Workshop: Subjective Light Field Quality Assessment</td>
</tr>
<tr>
<td>October 2022</td>
<td>97th WG1 meeting: Final Call for Contributions on Subjective Light Field Quality Assessment</td>
</tr>
<tr>
<td>January 2023</td>
<td>98th WG1 meeting: status evaluation of the Final Call for Contributions on Subjective Light Field Quality Assessment</td>
</tr>
<tr>
<td>1st April 2023</td>
<td>Deadline for submission of contributions</td>
</tr>
<tr>
<td>April 2023</td>
<td>99th WG1 meeting: study of the contributions and start of the collaborative process</td>
</tr>
</tbody>
</table>

The intended timeline for the standardization process is as follows:

<table>
<thead>
<tr>
<th>Date</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>October 2023</td>
<td>Working Draft (WD)</td>
</tr>
<tr>
<td>April 2024</td>
<td>Committee Draft (CD)</td>
</tr>
<tr>
<td>October 2024</td>
<td>Draft International Standard (DIS)</td>
</tr>
<tr>
<td>January 2026</td>
<td>International Standard (IS)</td>
</tr>
</tbody>
</table>

Once the specification for subjective quality assessment procedure has reached a mature status the Call for Proposals for Objective Light Field Quality Assessment will be launched.

8. **Contribution composition and requirements**

8.1. **Contribution elements**

A contribution may consist of one or more of the following elements:

[C1] Subjective assessment methodology addressing one or more requirements defined in [7].

[C1.1] Description of the methodologies

[C1.2] Detailed explanation of how the requirements are addressed.
[C2] Any supporting evidence for the methods above including a detailed description of the performed experiments and associated results.

[C3] Selection of test materials that includes original and/or decoded light fields associated or not with the relevant experiments above.

[C4] Interchange format solutions and considerations addressing the requirements defined in [7].

[C5] Software implementation of methods and protocols, e.g., test subject screening, score screening, score analysis, etc.


[C7] Additional relevant use cases and requirements.

[C8] Additional relevant datasets, including licensing conditions if not publicly available.

[C9] Any other relevant evidence or literature.

8.2. Contribution registration and delivery

No pre-registration is required. Proponents who wish to contribute to this CfC are encouraged to send an email to all experts listed in Section 12 expressing their intent to participate.

All documents to be submitted should be uploaded before the submission deadline to the WG1 document registry. Those proponents without access to the registry should contact the WG1 members listed in Section 12.

The title of the contribution documents should start with “PlenoLF_SA_Contribution_<ContributionID>_”.

Proponents are also expected to provide JPEG with sufficient rights to allow usage of the provided software/tools for the purpose of evaluation. Instructions or/and software header for the submitted software package should include information about usage rights.

Proponents should give to JPEG enough rights to use the selected datasets in the standardization process. If they are not public, include the licensing conditions in the proposal submission.

8.3. IPR conditions (ISO/IEC Directives)

Contributors are advised that this call is being made in the framework and subject to the common patent policy of ITU-T/ITU-R/ISO/IEC and other established policies of these standardization organizations. The persons named below as contacts (Section 12) can assist potential contributors in identifying the relevant policy information.

8.4. Contribution to standardization

Contributors are informed that based on the submitted contributions, a standard specification will be created. If they submit a contribution and (part of) the proposed technology is accepted for inclusion in the standard, they will be expected to attend subsequent JPEG meetings and contribute to the creation of the different standard documents. Within this process, evolution and changes are possible as several technologies may be combined to obtain a better performing solution.
9. Free and open source encouragement

Contributors are welcome and encouraged to develop and provide free and open source implementations as well as tools (frontend, backend, test set generation, etc.) to conduct evaluation experiments and data analysis specified in the standard.

10. Royalty-free goal

The royalty-free patent licensing commitments made by contributors to previous standards, e.g. JPEG 2000 Part 1, have arguably been instrumental to their success. JPEG expects that similar commitments would be helpful for the adoption of new standards.

11. Participation

The Ad Hoc Group (AhG) on JPEG Pleno Light Field was established to develop standards in relation to the light field imaging modality. All interested parties are encouraged to register to the email reflector of the AhG (Email reflector: jpeg-lightfield@jpeglists.org).

To subscribe to the email reflector, please visit http://listregistration.jpeg.org; in case of problems, please contact lists@jpeg.org.

12. Contacts

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Saeed Mahmoudpour (Ad Hoc Group on JPEG Pleno Light Field Co-Chair)
Email: Saeed.Mahmoudpour@vub.be

13. References


7. ISO/IEC JTC 1/SC 29/WG 1, “Use cases and requirements for light field quality assessment v4.1”, Online, N100255, July 2022


9. ISO/IEC JTC 1/SC 29/WG 1, CTQ "JPEG Pleno Light Field Common Test Conditions v3.3", 84th JPEG Meeting, Brussels, Belgium, N84049, July 2019