# The Web-based Subjective Quality Assessment of an Adaptive Image Compression Plug-in

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Abstract: Images are a key element for conveying information about visual systems. However, image-based representation and communication require large information bandwidth. Image compression is currently the leading methodology for reducing bandwidth/load problems thus improving User Experience. Synthetic objective metrics are often used to assess the quality of image compression models, but they often do not reliably predict subjective ratings. This work shows the end-users' quality evaluation of a new compression plug-in fully compliant with all on-going image formats. The subjective quality assessment of jpeg pictures compressed by the plug-in followed a new Web-based Single Stimulus Continuous Quality Scale method, whose validity and reliability have been described in a previously published study. The results of this study show that pictures compressed by the proposed adaptive image compression plug-in have a 55% compression gain compared to jpeg images compressed by Facebook Mobile, with no loss in perceived image quality.

## 1 INTRODUCTION

Images are often used as a representation method to convey information in Web-based systems. Visual content is cognitively processed in a non-propositional way, that is to say, no decoding is necessary to process the depicted data complexity and its inner relations, since images keep the perceptual structure of what they represent (Sternberg and Sternberg 2015).

Given the importance of using images for Web-based information and communication, reducing the bandwidth usage due to a massive quantity of images is a goal for practitioners, especially for smartphones and other mobile devices. As Jakob Nielsen highlights when describing his Law of Internet Bandwidth, "bandwidth will remain the gating factor in the experienced quality of using the Internet medium" (Nielsen 1998).

Lossy image compression is still the primary solution for reducing bandwidth and saving storage space (Vidhya et al. 2016). The State of the Art shows many new compression algorithms, which are effective in reducing the size of the original representation with no loss in image quality (Sarode et al. 2016). Nevertheless, the jpeg file format, which was released in 1991, is still the predominant image format, because shifting into different file formats files can result in compatibility issues with systems. Indeed, many new compression algorithms require format shifting and end-users might encounter compatibility problems with their software or devices.

Another problem with compression methods is that their optimizations are driven by synthetic objective quality evaluation metrics, which are often not efficiently predictive of subjective evaluations. Even though synthetic objective metrics are fast, repeatable and do not have high costs, they are not always able to reliably predict subjective image quality ratings assigned by human participants. The reason for this is that these objective metrics are derived from subjective quality datasets, which are subsets by definition. Instead, the proper method is to be driven by the subjective quality evaluation tests (Winkler et al. 2012).

Subjective quality evaluation is still a key process in image or video compression methods because low perceived quality contributes directly to a poor user experience (Pedram et al. 2014).

This paper describes the subjective quality assessment of a compression plug-in developed by an engineering company called Cogisen (www.cogisen.com). The compression method is based on a new visual saliency algorithm, which, for



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each image, calculates a map of the perception threshold beyond which users might perceive any reduction in quality. The system has been developed to be compatible with any kind of image compression models and flexible to all current image formats. The system also has a minimal impact on mobile processor usage.

The subjective evaluation of the Cogisen compression plug-in followed an image quality assessment method, which adapts the Single Stimulus Continuous Quality Scale method described by the ITU-R BT.500-8 recommendations (ITU Telecom 2002) to a Web-based procedure using an online testing tool and a crowdsourcing Web platform for recruiting participants. Both validity and reliability of the Web-based procedure have been investigated in a previous study, which compares the results obtained using the Web-based method to data obtained with laboratory methods (Mele et al. 2016).

This paper describes the subjective quality evaluation of images compressed by two methods: Facebook Mobile's jpeg compression algorithm (which represents the optimized maximum compression level of commonly used jpeg compression), and The Cogisen plug-in, which reduces information in non-salient parts of jpeg images.

# 2 SUBJECTIVE QUALITY EVALUATION OF THE IMAGE COMPRESSION PLUG-IN

## 2.1 Method

The subjective quality assessment procedure used in this study was validated using a data set of images whose quality has been previously ranked by participants (Mele et al. 2016). We compared the Cogisen's compression algorithm with the Facebook Mobile's one because Facebook is a public service by definition and its compression model complies with the State of the Art.

## 2.2 Material

The stimuli used for this study were obtained from a selection of six high quality reference pictures (800x800 pixels) provided by the Colourlab Image Database: Image Quality (CIDIQ) (Liu et al. 2014).

Six of 23 high-quality pictures were selected to represent a wide range of photographic subjects (Figure 1). The selected stimuli include the following pictures: one outdoor panorama, one indoor panorama, one man-made object picture, one picture with distinct foreground/background configurations, one picture without any main specific object of interest, one close-up shot.

The reference pictures were compressed by two compression methods:

1. The Facebook Mobile compression algorithm.
2. The Cogisen plug-in, according to the following compression gains over Facebook Mobile: 25%, 35%, 45%, 55%. Four distorted pictures (not belonging to the experimental database) were placed twice into the test in order to control subjects' attention.

The test consisted of a total of 49 trials presented in a randomized order, in order to avoid that two identical pictures are presented consecutively.

## 2.3 Procedure

Participants were asked about visual acuity, contrast sensitivity, colour vision, light condition and prior experience with video display systems or devices, by a questionnaire shown before the test. Participants were also asked to check the physical dimensions of their display and to regulate it to the maximum brightness. If participants met the preliminary requirements (no vision impairments, only desktop devices, no devices less than 13-inches wide, maximum brightness on) test instructions were displayed.

Each image was presented for 7 seconds, then a 1-100 integer quality scale, numerically marked and divided in three parts by the "Bad", "Fair", and "Excellent" labels, was displayed for at least 3 seconds. Subjects were asked to assess the quality of each picture by dragging the slider on the quality scale. This Single Stimulus Continuous Quality Scale (SSCQS) evaluation method follows the ITU-R BT.500-8 recommendations (ITU Telecom 2002). The test has been developed by using an online survey software tool, i.e., SurveyGizmo (www.surveygizmo.com).

To prevent errors due to subjects' fatigue and loss of attention, the testing session lasted a maximum 20 minutes. The subjective quality assessment consisted in one single session with participants recruited by means of a crowdsourcing platform for psychological research called Prolific Academic (www.prolific.ac). All participants were first time users of such a quality assessment procedure, and they were remunerated with a £1.25 payment.

## 2.4 Subjects

Sixty-three subjects (mean age= 32.6 years old, 50.7% male, 100% English speakers), eight expert users (mean age= 34.87, 87.5% male) and 28 non-expert viewers (mean age= 32.3, 45.4% male) were recruited. All the tests were completed in a single session on March 10, 2016. Expertise was classified according to the participants' employment as reported in a preliminary questionnaire.

Since five outliers were excluded after the descriptive analysis, the screened subjective database included the scores provided by a total of 58 subjects, mean age= 37.2 years old, 48.3% male, 44.8% in-door with natural lights; 55.2% indoor with artificial lights.

## 2.5 Results

The basic data analysis included:

- Mean opinion score (MOS): Opinion scores were integers in the range 1-100;
- Difference mean opinion score (DMOS): The raw opinion scores were converted to quality difference scores:

$$d_{ij} = r_i ref(j) - r_{ij}$$

where $r_{ij}$ is the raw score for the i-th subject and j-th image, and $r_i ref(j)$ denotes the raw quality score assigned by the i-th subject to the reference image corresponding to the j-th distorted image (Sheikh et al. 2006). Difference Mean Opinion Scores (DMOS) were therefore obtained by calculating the difference between the Mean Opinion Scores (MOS) (range 1-100) assigned to high quality reference images and those assigned to the compressed images (Table 1).

Table 1: Subjects' Mean Opinion Scores and Difference Mean Opinion Scores assigned to both Cogisen compressed pictures and Facebook Mobile compressed pictures.

| | **COG 25% gain** | **COG 35% gain** | **COG 45% gain** | **COG 55% gain** | **FB Mobile** |
|---|---|---|---|---|---|
| **MOS** | 76.96 | 77.68 | 74.83 | 72.62 | 74.30 |
| **DMOS** | -2.54 | -3.27 | -0.41 | 1.79 | 0.11 |

The Pearson linear correlation between the DMOS assigned to the pictures compressed by the plug-in and the jpeg pictures show high correlation coefficients, which means that the perceived quality of the Cogisen pictures is greatly correlated with the perceived quality of Facebook Mobile pictures (Table 2).

Table 2: Correlations between scores assigned to Facebook Mobile compressed pictures and those compressed by the Cogisen Plug-in. The star "*" marks the mean differences that are significant at the 0.01 level. Two stars "**" mark the mean differences that are significant at the 0.05 level.

| | *DMOS* | **COG 25% gain** | **COG 35% gain** | **COG 45% gain** | **COG 55% gain** |
|---|---|---|---|---|---|
| **FB Mobile** | ***Pearson Corr.*** | 0.343* | 0.262** | 0.497* | 0.404 |
| | ***Sig. (p value)*** | *0.008* | *0.047* | *0.000* | *0.002* |

It was investigated whether the participants' performance has been affected by (1) their expertise with video display systems or devices (expert, non expert) (2) the lighting condition of the setting (natural light, artificial light; indoor, outdoor), and (3) the order in which pictures are shown in the testing sequence (first half of the test, second half of the test).

1. Expertise. The one-way ANOVA shows no effect of expertise on difference mean opinion scores ($F(1,57)= 2.332$; $p > 0.05$).
2. Lighting condition. The one-way ANOVA shows no significant difference in the DMOS assigned in two different lighting conditions (indoor with natural lights, indoor with artificial lights), ($F(1,57)= 2.386$; $p > 0.05$).
3. Order effect. Multiple linear regression analysis showed that the order of the stimuli into the test (first half, second half) was not able to predict the subjects' answers ($R^2= 0.041$, $F(1,57)= 2.386$, $p > 0.05$; $\beta= 0.202$, $p>0.05$).

The effect of compression method (Facebook Mobile, Cogisen) on subjects' performance was investigated. The repeated measures ANOVA shows an overall significant difference in DMOS assigned to stimuli compressed by the Cogisen plug-in compared to those assigned to jpeg pictures compressed by the Facebook Mobile application

(Multivariate test; Wilks' Lambda $F(4,54)= 7.635$; $p=0.000$).

Pairwise comparisons among compression levels and Facebook Mobile compression (adjustment for multiple comparisons: Bonferroni) show significant difference between both 25% and 35% compressed pictures and Facebook Mobile pictures. No difference between both 45% and 55% compressed pictures and jpeg images was found (Table 3).

Table 3: Pairwise Comparisons. Table shows the mean difference between the DMOS assigned to the Facebook Mobile's picture values and the DMOS assigned to the Cogisen's compressed pictures. Positive mean difference values denote higher mean opinion scores assigned to Cogisen pictures compared to Facebook pictures. A p value >0.05 denotes that the mean difference is not significant. The star "*" marks the mean differences that are significant at the 0.01 level.

| (I) Compression | (J) Compression | Mean Diff. (I-J) | Std. Error | Sig. (p value) |
|---|---|---|---|---|
| **FB Mobile** | **COG 25%** | 2.664* | 0.719 | 0.005 |
| **FB Mobile** | **COG 35%** | 3.397* | 0.794 | 0.001 |
| **FB Mobile** | **COG 45%** | 0.534 | 0.571 | 1.000 |
| **FB Mobile** | **COG 55%** | -1.681 | 0.736 | 0.261 |

## 2.6 Discussion

The main results show that the difference mean opinion scores assigned to both 25% and 35% Cogisen compressed pictures were significantly higher than those assigned to jpeg stimuli. These results mean that Cogisen's compression method is able to reduce image file size in a way that better manages the information that affects perceived quality. It confirms that Cogisen's adaptive image compression model is more effective than currently common image compression methods in preserving the most salient aspects of images, with a 35% file size gain over jpeg images compressed by Facebook Mobile while also maintaining a higher perceived image quality.

No difference between the perceived quality scores assigned to both 45% and 55% Cogisen compressed pictures and those assigned to Facebook Mobile pictures means that the Cogisen plug-in achieves similar results than the Facebook Mobile compression algorithm with a 55% gain over it.

The authors of this paper are working on further studies focusing on the design and the assessment of the Cogisen plug-in for video compression applications.

# 3 CONCLUSIONS

This work investigated the subjective quality perception of images compressed by the Cogisen plug-in, which can be integrated into the compression settings of mobile and desktop applications. Sixty-three participants assessed the perceived quality of jpeg pictures compressed by the Facebook Mobile application and by the Cogisen compression plug-in.

The Single Stimulus Continuous Quality Scale method was used to compare the quality score. The quality scores assigned to compressed pictures were compared to those assigned to high quality reference pictures, which were randomly shown during the test (as recommended the ITU suggestions). The presentation used a Web-based administration procedure validated in a previous study (Mele et al. 2016). The results obtained in this study show that the compression plug-in does not significantly affect the subjective perceived quality of previously jpeg compressed pictures up to a gain of 55% file size reduction.

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