Users prefer Guetzli JPEG over same-sized libjpeg

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Abstract

We report on pairwise comparisons by human raters of JPEG images from libjpeg and our new Guetzli encoder. Although both files are size-matched, 75% of ratings are in favor of Guetzli. This implies the Butteraugli psychovisual image similarity metric which guides Guetzli is reasonably close to human perception at high quality levels. We provide access to the raw ratings and source images for further analysis and study.

1 Introduction

Guetzli is a new JPEG encoder that uses the recently introduced Butteraugli psychovisual similarity metric to make rate/distortion decisions. Thus, Guetzli produces images that Butteraugli believes to be 'better' than standard libjpeg. We undertook an experiment to see whether humans agree with this assessment. The settings are very simple: we have pairwise comparisons between size-matched images, both in standard JPEG format, and see whether human raters prefer one or the other.

2 Materials and Methods

2.1 Source images

To ensure a meaningful evaluation of compressor quality and output size, we create a 31-image dataset with known source and processing. The images are publicly available [1].
We reduce JPEG artifacts by capturing images at the highest JPEG quality level using a Canon EOS 600d camera and downsampling the resulting images by 4x4 using Lanczos resampling, as implemented in GIMP. Photographers often apply unsharp masking to compensate for downsampling, so we also apply it in most of the images before downsampling. The degree of unsharp masking is chosen arbitrarily, but before any compression experiments. The images are chosen to cover a wide range of contents, including nature, humans, smooth gradients, high-frequency detail, with relatively thorough coverage of the sRGB gamut.

2.2 Image degradation method

We are testing two compressors which offer a distortion vs size trade-off via a single quality parameter. Guetzli is designed for high-quality, visually lossless compression, so we choose its quality parameter to be 94, which results in a rate of approximately 2.6 bits per pixel. For each guetzli-compressed image, we generate a JPEG image for comparison by invoking ImageMagick 6.7 via `convert -sampling-factor 1x1` with decreasing quality parameter until the libjpeg output is smaller than the guetzli JPEG. The final libjpeg JPEG file is generated at the next higher quality level, which guarantees it is at least as large as (and typically larger than) the Guetzli file. Note that the scale of the resulting libjpeg quality parameters is slightly different; we see a minimum of 83, maximum 93, average 89.4 and median 90. Both compressors produce a standard-conformant JPEG bitstream.

Before display, we upsample both images by a factor of two using nearest neighbor sampling (i.e. pixel replication) and crop them to 900x900 pixels starting at the top-left corner so that the images fit on our screen.

2.3 Viewing environment

To reduce the variability of the comparison results, e.g. due to differences in monitor gamut, panel bit depth and processing/LUTs, we perform all tests on a single monitor. A calibrated 27” NEC PA272 includes a 10-bit panel while still being reasonably commercially available. We choose viewing conditions that match a typical office environment.

2.4 Experiment design

We choose a pairwise comparison model. To avoid the need for a break, we present the 31 images once in a single session, typically 20 to 30 minutes. We provide a custom OpenGL viewer that alternates between the two compressed images.
variants on the right half of the screen, while displaying the uncompressed original image on the left side. The presentation order of each image is chosen randomly, and we swap between them at a fixed rate of 0.44 Hz. To reset perception between the two images, we fade the screen to mid-gray over 250 ms and hold it at gray for 600 ms. Our instructions are to click upon the less preferable image, at the location of the most visible artifact. To reduce the likelihood of random guesses, we leave open the option of skipping images when there is no discernible difference.

Subjects are asked to sit at a distance of 3-4 picture heights from the screen in order to reduce eye movements when comparing with the original image. We provide a brief explanation and training, including the example of clicking on a location.

2.5 Subjects

23 raters participated in our experiment. Their age range spans 25-46 years (median 31). 56.5% (13) are women. All but three subjects report corrected-to-normal vision; one is red-green color blind, one has slightly higher visual acuity and one has slightly lower acuity. Subjects are recruited via convenience sampling from Google employees working nearby, or known to us. We attempt to equalize the gender ratio and include several experienced photographers, but most subjects are not experienced in the field of image compression and only informed that they are comparing two compressors.

3 Results

Each subject generated 11 to 31 answers, with a mean of 26 and median of 29. The raw ratings are listed below. Overall, 75% of decisions were in favor of Guetzli, i.e. the rater decided that the corresponding libjpeg image was worse. There was only moderate variation among images; the interquartile range is 85%-68%. In one extreme, only 22% preferred the Guetzli encoding of the ‘cloth’ image, apparently due to loss of detail in the pink goggles. Conversely, raters unanimously preferred the Guetzli encoding of ‘bees’.

The number of ratings for each image was relatively consistent (quartiles 19, 20, 21), which implies raters skipped different images. Assuming image preferences are ‘uncertain’ if the image was in the lower quartile of number of ratings, discarding those images raises the median preference for Guetzli to 80%. Note that this analysis method was devised after the data was collected, so it is possible the sampling method is biased towards a particular outcome. Although discarding images that received the fewest ratings seems reasonable,
we must ignore this conclusion and only report the 75% preference from the full dataset, listed below for completeness.

The ratings are listed in matrix form, one row per image, in decreasing order of total rating decisions. Each column (corresponding to the rater’s index) indicates which is worse: L for libjpeg, G for Guetzli or blank if the image was skipped.

out-of-focus: LLLLLLGLLLLLLLLLLGG LLLL
white-yellow: LLLGLGLL LLLLLG LLLLLG
brake-light: LLLLLLLLGLGLGGGL L L
pink-flower: LLLLLLLL LGLGG GLLLLL
wollerau: LLLLLGLGLGLLLLLLLLLLLLLL
red-flowers: LLGGGLGLL LLLL LLLL LLLG
geranium2: LLLLGL LLLLLGLGLLLLLLLL
green-rose: LGLLLLGGL LLLG G LLLL
bicycles: LLLLLLLLLGLGG GLLLL
blue-rose: LLLLLLGLLGL LLLL LLLL
pimpinelli: LLGGGL LL LLLLLL
minerology: LLLLL LLLG LLLLLG
red-room: LLLLLLGLGL LL LL GLLLL
yellow2: LLLLL LLLGLGLL GLLLL
stp2: LLLLLLLLLLLLLLLLLLLLL
vflower: LLLLLLLLLLLLLGLGG LLLLLG
port: LLLLLGLGLGLGLLLLL LLLL
station: LGLGLGGLGLGL G LLLL
yellow: LGLGLLGLGLL LLLLLL
bench2: LGLGLGLL GGL LGLGG
red-rose: LLGGL LGL GGGGG L GL
geranium: LGLLGL LLGG G L LGL
stp: LGLGLLGLGGLGGLLL LLLLLL
rainbow: GGGLG LGL G LL G GGLG
bench: LLLLLLLGL GLGL L LLGG
rgb: LLLLLLLGLLGLGL LLLLLL
cloth: GLGGGGGLLG G G GG G
lichen: LGLGLGLL GLG L LGL
bees: LLLLLLLLL LLL LL LLLLL
green: LLLLL LL LLLLL LLCG
hand: GGL GL LL LGLLGLL GL LL
4 Discussion

Our headline result is that 75% of mostly naive users (with no explicit instructions about what kind of artifacts to look for) preferred the Guetzli output over libjpeg, although both are in standard JPEG format and size-matched (as far as possible using the JPEG quality parameter).

We created and published a new image dataset because the Kodak images are low-resolution (512 × 768 pixels) and scanned from film [2]. This leads to differences in color gamut, correlation, saturation level and noise distribution versus today’s digital cameras. The IMAX/McMaster images are higher resolution, but apparently also scanned from film [3].

Our results are only valid for high-bitrate compression, which is useful for long-term photo storage. Note that the recent ICIP 2016 Grand Challenge [4] included a subjective codec comparison using bitrates of up to 1.5 bits per pixel, whereas our quality settings lead to about 2.6 bpp. ITU P910 [5] recommends a darkened viewing environment to maximize detection of artifacts, but we used normal office viewing conditions. This more closely matches expected use, but may make artifacts harder to see. However, we expect this to affect both codecs equally. Absolute or degradation category ratings are unsuitable measures because most of our subjects are naive, and the compression artifacts are too minor to capture on a 5-point scale. Similarly, a Mean Opinion Score may result in higher variability due to interpretation and/or language differences [6]. Hence, we only gathered pairwise comparisons.

Note that user preferences differ - some will be more sensitive to certain kinds of artifacts, but the percentage of raters preferring Guetzli were relatively consistent across images (±5% from the median after discarding the 25% images with the fewest ratings).

In future studies of this kind, we suggest allowing users to toggle the two compressor outputs at their discretion, because many felt that the current rate was too fast. However, there should still be a certain upper bound on the flicker rate to avoid highlighting compression artifacts via “motion detection”. Also, the statistical power would have been increased if we had established rules prior to the data collection for discarding ratings. Although “outlier” raters were not expected nor observed, most were untrained and apparently struggled initially to detect compression artifacts. This leads to some near-random ratings. One reasonable way to reduce these is to discard images with the fewest votes. It would also be interesting to measure the repeatability of observer ratings (i.e. noise level), and Type I errors (false alarms, i.e. detections of artifacts where none exist) by inserting some
identical image pairs.

In this study, we compared size-matched images. It might also be interesting to determine how far Guetzli file sizes can be reduced until the rater preference for Guetzli decreases to 50%. This would indicate a “compression factor” versus libjpeg, but reliably obtaining such a threshold would be challenging given potentially noisy results.

5 Conclusion

In a pairwise comparison by 23 human raters of size-matched Guetzli vs libjpeg encodings of 31 publicly available images, 75% of all 614 comparisons were in favor of Guetzli. We conclude that Guetzli generates higher quality images (at considerable encoding cost).

This is due to the action of Butteraugli, which guides Guetzli. We conclude that at very high qualities, the Butteraugli metric is a reasonable proxy for human rater preference.

References

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