

# Evaluation of Quality in Imaging Systems Based on Psychovisual Attributes

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## Resumen

La calidad subjetiva de imágenes es un elemento clave en sistemas de multimedia. Este artículo trata acerca de dos partes básicas –calidad de evaluación de imagen y mejoramiento de calidad de imagen. Presentamos nuestros resultados en este campo.

## Palabras clave

Calidad de imagen, sistemas de multimedia, modelos visuales humanos, tests subjetivos.

## Abstract

The subjective image quality is a key issue in multimedia systems. The paper deals with two basic parts - image quality evaluation and image quality improvement. We present our results of in this recent field.

## Keyword

Image quality, multimedia systems, human visual models, subjective tests

## I. Introduction

In the past our research activities have been focused on the objectivization of subjective image quality metric. We have tested several different approaches including the Human Visual System

(HVS) modeling and we have compared the results with the standard subjective observer tests according to the ITU-R Rec. BT500. So far we have tested various image degradation mechanisms such as lossy image compression techniques. Recently we have started the study of selected image improving techniques. These image improving techniques are a standard part of almost all image and/or video processing software packages but the degree of correction is always set by an observer with no more objective approach. This paper summarizes first results of detail study of two fundamental image improving techniques – the edge sharpening and color saturation. The paper motivation is to develop an efficient tool for the image quality evaluation for the image compression and image enhancement software packages.

## II. Theoretical background

### 2.1 Sharpness

Sharpness is a sensation which gives information about the high-frequency content in a signal. The

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spectral envelope of the signal is one of the determinant factors in the perception of sharpness. The other factor is the centre-frequency of narrow-band signals [24].

The accepted model of sharpness is,

$$S = 0.11 \frac{\int_0^{24} N' g(z) z dz}{\int_0^{24} N' dz} \quad [\text{acum}] \quad (1)$$

where,

$$\left. \begin{aligned} z < 14, &\rightarrow g'(z) = 1, \\ z \geq 14, &\rightarrow g'(z) = 0.00012 \cdot z^4 - 0.0056 \cdot z^3 \\ &+ 0.1 \cdot z^2 - 0.81 \cdot z + 3.51 \end{aligned} \right\} \quad (2)$$

The upper integral is the first moment of specific loudness over critical-band rate, using  $g(z)$  as a critical band-rate dependent factor.

## 2.2 Roughness

Roughness is another sensation which is perceived in modulated signals at modulation frequencies higher than 20 Hz [24]. Two main factors influence roughness, the frequency resolution and the temporal resolution of the visual system. It is usually modeled by,

$$R \sim f_{\text{mod}} \Delta L. \quad (3)$$

## 2.3 Fluctuation strength

Fluctuation strength is another sensation which is perceived in modulated signals at low modulating frequencies up to a modulation frequency of 20 Hz. A model of fluctuation strength is accepted [24],

$$F \sim \frac{\Delta L}{(f_{\text{mod}}/4\text{Hz}) + (4\text{Hz}/f_{\text{mod}})} \quad (4)$$

where  $\Delta L$  is the temporal depth of the masking pattern, and  $f_{\text{mod}}$  is the modulation frequency.

## III. Subjective tests of image quality – methodology

The subjective test methodology is clearly defined by the ITU-R Rec. No 500-10 (2000) [1]. There is a vast variety of test images available from ITU, SMPTE, EBU and others. In this case we have followed the methodology but the selection of test images was original. We have chosen this approach because the standard tests are well and widely known and this fact can affect the experimental subjective results. We applied five different images in color and/or BW versions – see Figure1:



Figure 1. Test pictures Square, Fruit, Garden, Portrait, Posters.

The standardized workplace for a subjective quality evaluation by observers was created. In all cases the DSCQS (Double Stimulus Continuous Quality Scale) has been used but two different continuous scales have been applied. For the evaluation of image degradation the CQS from 0 to 100% (0 to 20% bad, 20 to 40% poor, 40 to 60% fair, 60 to 80% good, 80 to 100% excellent) has been used and for the evaluation of image quality enhancing the relative CQS from -3 to +3 (original image is 0, -3 much worse, -2 worse, -1 slightly worse, 0 same, +1 slightly better, +2 better, +3 much better) has been used. In this case finer evaluation by half degree is allowed.

The test sequence of images has been formed as a sequence of 10 seconds presentation of reference image (original) and 10 seconds presentation of test image. These 10 seconds blocks have been separated by a 5 seconds presentation of gray field with the identification label and finally displayed as a slide-show. As an introductory sequence an uninterrupted

sequence of images from the worst quality to the best quality and back has been displayed in order to set a proper scale for observers. The recommended viewing distance has been set as 5 times the image height.

The previous results related to the subjective image quality have been published in [2, 3, 4, 5].

## IV. Examples of image quality degradation

The first step we in the field of image quality evaluation we have tested the dependencies of subjective quality vs compression rate for selected image compression techniques and standards. Figs 2, 3 demonstrate these dependencies. Even during the compression procedure we have found some examples (for low compression rates) that the subjective image quality is improved with higher compression rate (Figure 3).

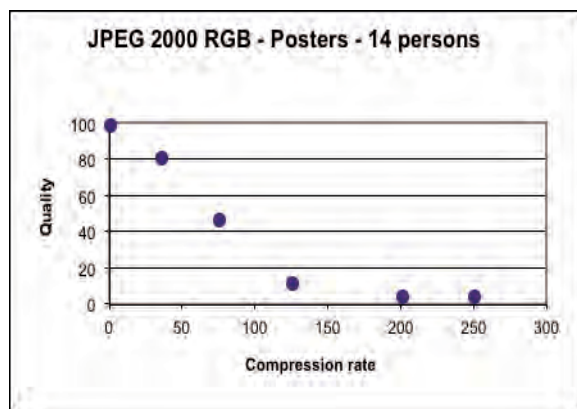


Figure 2. JPEG 2000 compression.

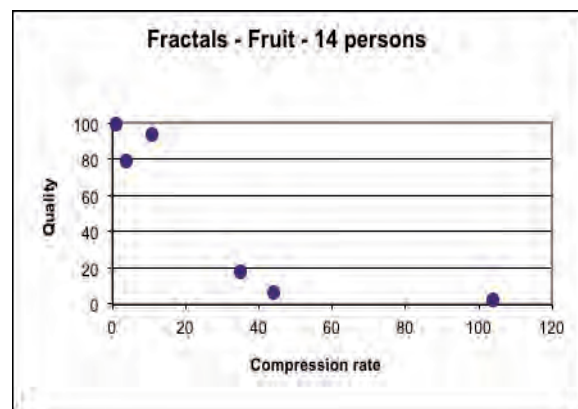


Figure 3. Fractal compression.

## V. Examples of quality improvement mechanisms and their testing

The first image quality improving tool we have applied a standard edge enhancement procedure

(sharpening) implemented in the open-source image processing package GIMP. This tool allows set the degree of sharpening from 0 to 100. Final responses have been measured with BW versions of images. The perceptual sharpening originates at the receptive fields in our retina and we can find tens of different operators in the literature e.g. [6].

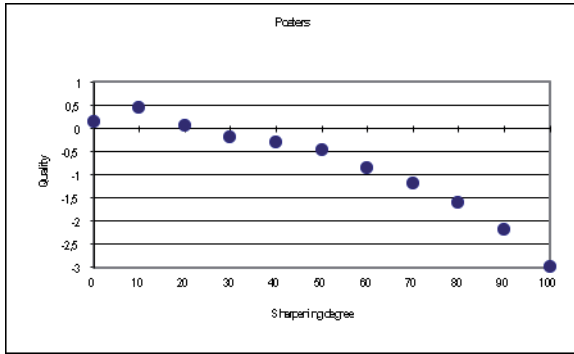


Figure 4: Sharpening – example 1.

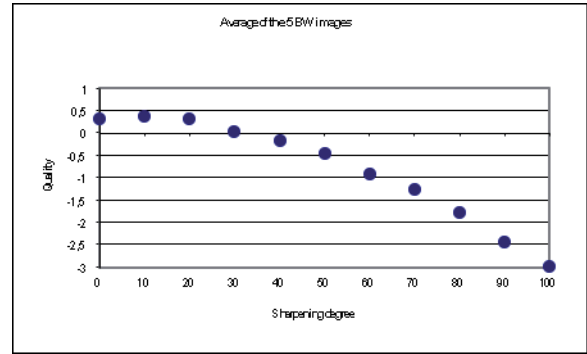


Figure 3: Sharpening – example 2.

The second quality improvement tool has been the color saturation manipulation and the procedure has been implemented in the MATLAB. The test images represented in the

RGB color space have been converted into the Y, R-Y, B-Y versions and the chrominance components have been increased by a multiplication factor  $k$ .

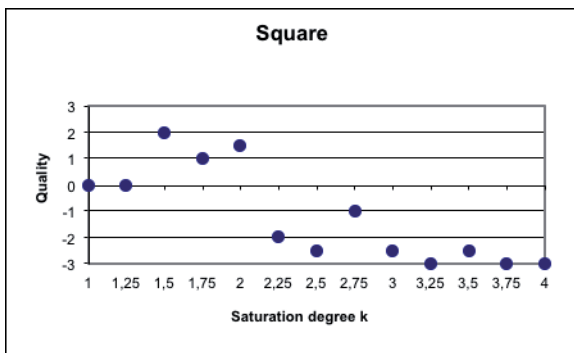


Figure 6: Saturation – example 1.

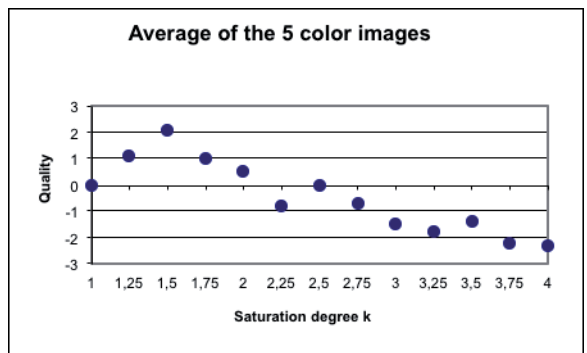


Figure 7: Saturation – example 2.

Two examples are demonstrated on Figs 6. and 7. Fig.6. shows the evaluation of the test SQUARE and Fig.7 averaged values over the whole set of 5 test images. Both these cases have shown that the responses are not necessarily flat and uniform as it was apparent in the sharpening case on Figs 4. and 5. It indicates that the perception of color saturation is strongly affected by higher-order processes in the HVS and it cannot be described by a simple law with a monotonous response.

upon the maximum fidelity. We can define the coefficient of goodness (perceptual quality) as a measure of observer impression improvement and evaluate various types of distortions increasing the coefficient of goodness.

The coefficient of goodness (perceptual quality) is a metric-based measurement close to QoS (Quality of Service), which enables us to rate a transmission system, and to state its overall performance.

## VI. Coefficient of goodness (perceptual quality)

Based upon these examples we can define a different approach to the traditional one based

Video, audio and image compression systems dedicated to High-end Transmission purposes encounter as the final element of the communication chain the recipient or the observer, which criteria give us the subjective quality of the system, based on perceptual cues.

The maximization of perceptual image quality or coefficient of goodness seems to be a crucial item for most of multimedia imaging system. So far there was no other reasonable approach or criterion for such an optimization. The measured curves can be taken as an initial data for the formulation of a mathematical modeling of index of goodness dependencies.

## VII. Conclusion

The paper has experimentally demonstrated selected abnormalities in the image subjective quality related to the classical maximum fidelity approach. Three fundamental operation over the image have been tested – compression, sharpening and color saturation. These subjective-quality-improvement methods are extensively applied in general still picture and/or vídeo enhancement and we have done more exact approach.

In future we would like to compare various image sharpening techniques (HP, 2nd order operators, L

vs uv etc.) and the impact of denoising operators. The denoising operators are among the image enhancement tools affecting the original image quality because the denoising effect is always accompanied with image degradation.

## VIII. References

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