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TESTING OF NEW MODELS OF THE HUMAN VISUAL SYSTEM FOR IMAGE QUALITY EVALUATION

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ABSTRACT

This article deals with evaluation of image quality by various methods and comparison of their results. Generally, there are several ways how to assess image quality. Three main approaches are: subjective testing, objective testing and image quality evaluation using a human visual system model (HVS). The subjective testing is based on human perception, the objective testing on a mathematical computing and the human vision models on mathematical modelling of the human vision with respecting the human perception properties. Then, the described methods and two nocel designed HVS models are used for image quality evaluation using a set of images. The results of modelling were compared with results of the subjective and objective methods.

1 INTRODUCTION

One of the main reasons of image quality evaluation is introduction and employment of the image compression.

The first approach to the image quality evaluation is subjective quality testing (e.g. DSIS–Double Stimulus Impairment Scale, DSCQS–Double Stimulus Continuous Quality Scale, SCM–Stimulus Comparison Method, SSM–Single Stimulus Method, SSCQM–Single Stimulus Continuous Quality Evaluation), which is based on many observers that evaluate image quality. These tests have a very strict definition of observational conditions [1].

The second approach is the objective image quality testing (e.g. SNR–Signal to Noise Ratio, MSE–Mean Square Error, MAE–Mean Absolute Error) based on mathematical calculations. The objective quality evaluation is easier and faster then the subjective one because observers are not needed [2], but generally these testing have bad correlation (ρ = 0.4–0.7) with objective criteria.

The third way how to assess the image quality is use of a human visal model (HVS) [3, 4]. Human visual models combine and use both the objective and subjective methods. These visual models can model only some parts of the human vision that we need (e.g. spatial resolution, temporal motion, colour fidelity, colour resolution, etc.) [3]. A majority of these models requires a tested image and its corresponding matching reference in order to determine the perceptual difference between them. The human visual models can be divided into two groups. The first group comprises one-channel models [2, 3] that can be characterised by computing with the entire image. In the second group there are multi-channel models [2, 3, 4] that simulate the neuron response of the brain cortex. The response is selective to spatial frequencies and orientations. These models decompose the image into the many spatial frequency bands and/or orientations. Then, separate thresholds are set for each channel. At the end of the processing the channels are weighted and summed in order to get a number that represents the overall image quality.

The aim of this study is comparison of two designed models with both the subjective and the objective methods for the image quality evaluation. Tests are carried out using a group of standardised test images.

2 METHODOLOGY

2.1 Subjective quality testing

For the subjective testing we established a subjective testing laboratory fulfilling ITU-R recommendations (BT.500-10) for subjective image quality testing. The scheme of the laboratory is presented in Fig. 1.

General viewing conditions for subjective assessments are:

- The ratio of initial luminance to peak luminance should be less than 0.02.
- Maximum observation angle should be less than 30°.
- Peak luminance 200 cd/m^2.
- Monitor without digital processing.
- Surroundings illuminance at the position of the screen 200 lux.

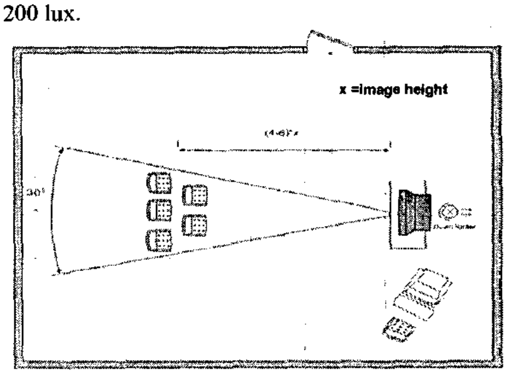

Figure 1. Setup of the subjective quality testing lab.

Test method DSCQS
(Double Stimulus Continuous Quality Scale)

DSCQS test method has been chosen because it is especially suitable for evaluation of perceived differences between the original and compressed images with a wild range of compression ratios and methods. The observers is asked to observe a pair of pictures, each from the same source, one is the reference image (in our case of 100 % picture quality), and the second one is distorted by a compression. The reference image is first in order. The evaluating sessions last 30 minutes in which the picture pairs are presented in a random order and random impairment levels covering all required combinations of compressions. Each pair were switched each 10 seconds. The continuous scale from 0 to 100 was used for quality assessment. The range is covered by the word expressions for the picture quality as Excellent, Good, Fair, Poor and Bad. According to recommendation at least 15 observers should be used. They should not be experts on assessment of the picture quality. We have used only students as observers, it is not ideal covering a spectrum of ages, but on the other hand they have prerequisite for quite good eyesight. The eyesight was tested by Snell's optotype test fat a viewing distance of 5 meters.

2.2 Objective quality testing

MSE and MAE were chosen as the objective quality testing methods. They are defined as follows:

$$MSE = \frac{1}{MN}\sum_{i=0}^{M-1}\sum_{j=0}^{N-1}\left(x_{ij} - y_{ij}\right)^2 [-]$$

$$MAE = \frac{1}{MN}\sum_{i=0}^{M-1}\sum_{j=0}^{N-1}\left|x_{ij} - y_{ij}\right| [-]$$

2.3 Human visual system model testing

We tested quality of the pictures using two models of human visual system.

The first designed model (HVS1) has been derived from characteristics of the existing models [2, 3, 4]. The model comprises colour transformation (pictures are transformed from R, G, B to the CIE Lab colour space *L, a, b),* four-level Gaussian pyramidal decomposition (filtering with 2D Gaussian core and decimation by 2 is repeated step by step three times), contrast channels computation and quatization, oriented channels computation and quatization (oriented channels are computed parallel with the contrast channels), computation of distance metrics and final weighting. It involves 5 levels of computing in L, a, b channels, 10 levels in each L, a, b contrast channels and 5 levels in each L, a, b oriented channels. Together there are 60 channels. To get one value that describes the overall image quality we use weighting of selected channel distances.

The second designed model (HVS2) simulates function of the optical part, retina and the brain cortex transform functions. This modelling respects theory and practical experiences with image quality testing. That helped researchers to discover some basic properties of the human visual system (e.g. sensitivity to some frequency bands and edge detection). The most important edge orientations are 0° and 90°. Important frequencies bands are: the base band, which represents information of scene brightness, and some higher bands, which represent information about important details (edges) in the image. Combinations of frequency bands and orientations create a model of visual perception. The last step of this processing employes computing of a difference metric as a Just Noticeable Difference (JND) map.

The outputs of all methods are normalised so that the image quality evaluation algorithms can be compared.

3 RESULTS

Results of the subjective, objective and HVS testing conducted with JPEG compressed LENA testing image are presented Fig. 2.

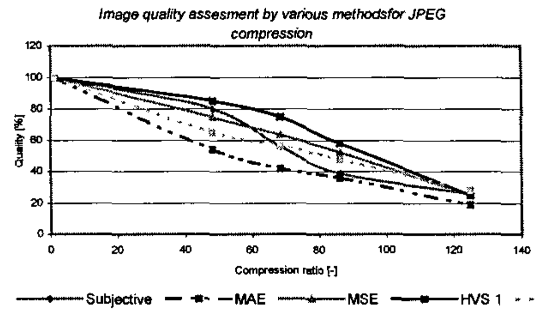

Figure 2. Image quality testing by various methods.

4 CONCLUSIONS

According to results presented in Fig. 2 the second model is more suitable for image quality evaluation than the first HVS model, MSE or MAE. The second HVS model better simulates the human visual system becouse it better respects features of the human image perception process. The main criterion of image quality assessment is a good correspondance with results of the subjective image quality testing.

5 ACKNOWLEDGEMENT

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