Preliminary study on objective measurement and assessment of video quality using wavelet transform

1 Introduction

As follow up to the contribution 6Q/42-E (13 September 2001): “A new method for objective measurement of video quality using wavelet transform,” Project Leader for IEC PT 62251 has been made studies on the method independent on the proposer Korean Republic.

The studies in the framework of objective video quality assessment with double-ended full reference assumption were conducted at Multimedia Systems Lab. in Faculty of Engineering, Chiba University. The video test sequences of the VQEG, converted to linear sRGB data defined by IEC 61966-2-1: 2001 to be a frame composition of 320 x 240 pixels were used for wavelet transform within a frame and over the frames. A set of DMOS values corresponding to each of the test sequences reported in the document 10-11Q/56-E (21 January 2000) were also referred to in order to study the feasibility of capability of the proposed method for getting optimized correlation between the objective Video Quality Rating (VQR) and the subjective difference mean opinion score (DMOS).

2 Study results

2.1 Optimization by the multiple regression analysis

2.1.1 Formulation and method of optimisation

The video quality rating (VQR) was defined here as a function of differences between every possible corresponding metric physically measurable at the transmitting and receiving ends of a video as in equation (1).

$$VQR = f(m_1, m_2, \cdots, m_{\mathrm{N}}) \qquad (1)$$

where m_n is the n-th objective metric which may contribute to account a given set of the difference of the mean opinion scores (DMOS) and N is the number of available metrics in assessment of video quality.

In this study, a simple weighted sum as in equation (2) was adopted as the function in equation (1).

$$VQR_j = w_0 + \sum_{n=1}^{N} w_n m_{nj} \qquad \text{for } 1 \le j \le M \qquad (2)$$

where w_n is a degree of contribution or a weight corresponding to the metric m_n, and w_0 is an offset term in order for the VQR to be optimally fit to given pairs of the videos, the reference and deteriorated, whose DMOS values are known.

The weight w_n was decided by minimising Euclidian norm in equation (3).

$$\|\mathbf{Mw} - \mathbf{d}\|_2^2 \rightarrow \min \qquad (3)$$

where $\mathbf{w} = (w_0, w_1, \cdots, w_{\mathrm{N}})^T$ is the $\mathrm{N}+1$ dimensional vector; $\mathbf{M} = (\mathbf{m}_1, \mathbf{m}_2, \cdots, \mathbf{m}_{\mathrm{M}})^T$ is the $\mathrm{M} \times \mathrm{N}$ matrix, in which the value $\mathrm{M} > \mathrm{N}$ is the number of the given DMOS’s, i.e., the number of the reference and deteriorated video pairs in which $\mathbf{m}_i = (1, m_{i,1}, m_{i,2}, \cdots, m_{i,N})$ is a vector of measurable values; and $\mathbf{d} = (d_1, d_2, \cdots, d_M)^T$ is the vector of the DMOS's.

Optimisation (minimisation) of the Euclidian norm was conducted by multiple regression analysis for 160 video pairs SRC13…22 (M=160) and also for 320 video pairs SRC1…10 and SRC13…22 (M=320). Namely,

$$\|VQR - DMOS\|^2 \to \min .$$

2.1.2 Results of optimisation

Degrees of optimisation depend on how many independent accounting valuables (N) are incorporated. Figure 1 shows an example of optimisation for M=160 and N=121. Figure 2 is an example for M=320 and N=240.

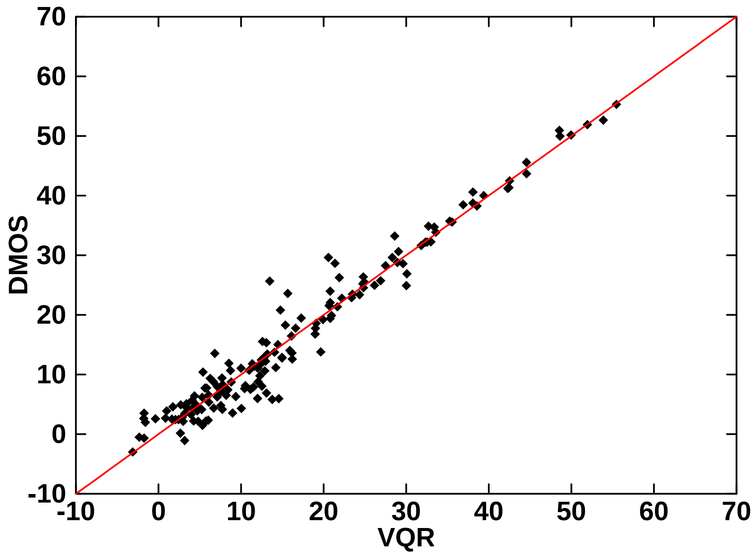

Figure 1 – An example of optimisation with M=160 and N=121

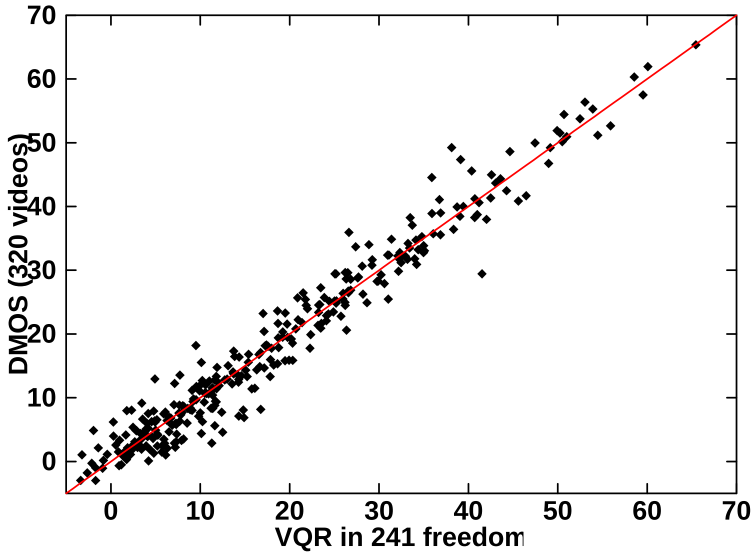

Figure 2 – An example of optimisation with M=320 and N=241

The examples showed that, independent of a set of video pairs and even of the size of the video pairs whose DMOS values are known, coefficients calculated by the wavelet transform provide enough power to account DMOS's using VQR's defined in equation (2). In this context, the use of the method of wavelet transform is excellent, because it provides enough and sufficient information to maximize the correlation between VQR and DMOS even to correlation of unity.

2.2 Accountability of the optimized result

In order to evaluate generalization capability of the method, the estimated weights were applied to an additional video pairs whose DMOS is known, but not used for estimation of the weights.

In a word, accountability of foreign video pairs is poor. In order to improve the accountability power, *forward selection method* is applied as first trial. Figure 3 was an example from the results of exhaustive examination.

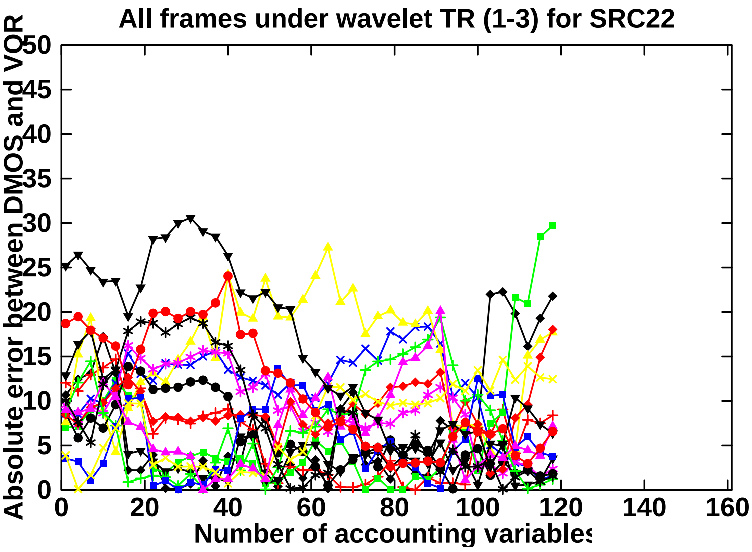

Figure 3 – An example of exhaustive examination of accountability

In figure 3, one of SRC22_HRCh_525 ($1 \le h \le 16$) is not included for optimization and decision of the weights. Thus, M=159. The VQR values for SRC22_HRCh_525 were calculated using the weights. The number of accounting variables up to 121 are used incrementally forward and corresponding absolute errors between DMOS and VQR are plotted.

The result showed optimum number of variables depends also what kind of processing (deterioration).

3 Preliminary conclusions

Wavelet transform within a frame and over the frames is powerful method to acquire (independent) measurable and objective parameters in spatial and frequency domain to characterize videos under test. It provides necessary amount of information to account subject metrics such as the DMOS in required precision on a given set of videos under test. In other words, degree of correlation between objective metric such as the VQR's and the MDOS's can be elevated to unity.

However, the weights obtained by optimization (partial regression coefficients) depend deeply on a given set of test video sequences. The higher the correlation, the poorer the DMOS accountability and predictability of an additional video that is not included in the given set.

Therefore, some kind of tradeoffs and optimum degree of correlation may exist, for which a method to determine should be sort in further study taking into account achievement in the field of multiple regression analysis as well as canonical correlation analysis.

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References

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(3) IEC 61966-2-1: 2001, Multimedia systems and equipment – Colour measurement and management – Part 2-1: Colour management – Default RGB colour space – sRGB, International Electrotechnical Commission, Geneva, Switzerland.

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