Reference Model for Quality Meter Description

Jamal Baïna, Pierre Brétillon and Gabriel Goudezeune

TDF-C2R, Broadcasting and Wireless Research Center of TDF,
1 rue Marconi, 57070 Metz, France
jamal.baina@tdf.fr

ABSTRACT

The goal of this paper is to present a methodology and method for the monitoring of digital television broadcasting network. The proposition is a conceptual model for the description of perceptual objective assessment methods for signal quality. This will lead to find common agreement and consensus around this generic approach well adapted to cover a large set of solutions. On the other hand, this proposition will bring to the comparison of algorithmic and associated modules in the right way. In deed, a comparison of basic functions specified by their input and output and their internal operations is much easier than trying to compare the results obtained by the whole measurement methods from signal representation to quality notation providing. This simplification is imposed by the complexity of the techniques and by the difficulty to identify a unique winner trough a comparison tests procedure.

Keywords: Digital Television, video quality, monitoring, objective model, broadcasting network

1. MEASUREMENT STRATEGIES

In the context of a broadcasting network, the key point is to consider the practical way in which a given method can be applied. Most picture quality assessment methods rely on measures of the distortion between the pictures at some point of the network and the pictures at the entrance. This configuration demands to transmit some information about the reference picture to the distant measurement point in the broadcasting network. Thus, the amount of reference information is of primary importance. Three classes representing different measurement strategies for the assessment of the quality of video signals have been defined by ITU-T SG9.

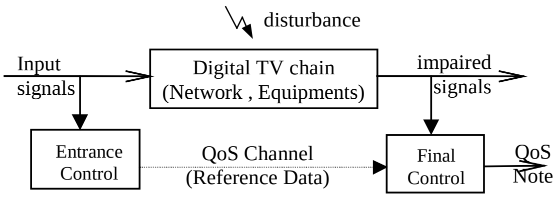

Figure 1: Methodology with reduced reference data

The *reduced reference* class id based on the comparison is carried out on a small set of parameters only (Figure 1). Those are designed to highlight specific impairments of encoding algorithms. A linear combination of the parameters usually provides the final objective evaluation. The combination model is adjusted to maximize correlation with subjective test results. Methods in this class may be less accurate than the full image comparison approach, and are tuned to specific impairments, but are also less complex. Real-time implementations are affordable, although the synchronization of original and impaired data is still necessary. This strategy offers the advantage of surveying the transparency of transmission links. Furthermore, the bit rate of the reference data is very limited. Consequently, this second strategy is well adapted for an automatic and continuous monitoring of the quality of signals on DTV networks.

In the class *without reference* information, this constraint is particularly challenging in the field of quality assessment, so much work has focused on the only characteristic impairments, that is blocking artifacts for JPEG and MPEG pictures, and often in the perspective of applying post-decoding processing. As far as we know, the results of such features have rarely been correlated to subjective data. This strategy is quite the most simple to implement, since a measurement can be obtained at any point with standalone equipment. However, the major drawback is that the quality evaluation is necessarily limited since the measured picture degradation is mainly blocking effect.

The methodology that we propose is the monitoring of video quality over DTV network is "Double-ended with reduced reference information", with an optional configuration without any need for reference.

2. REFERENCE MODEL

The variety of available quality assessment methods makes the comparison of their design difficult. Recent activities in normalization bodies have led to propose a generic model to serve as a general structure to describe any measurement method, in order to go further in the normalization of one measurement method. This generic model is designed for in-service video quality monitoring applications over digital networks. It will be proposed to other standardization bodies such as ITU-T SG9 and VQEG.

2.1. General concepts

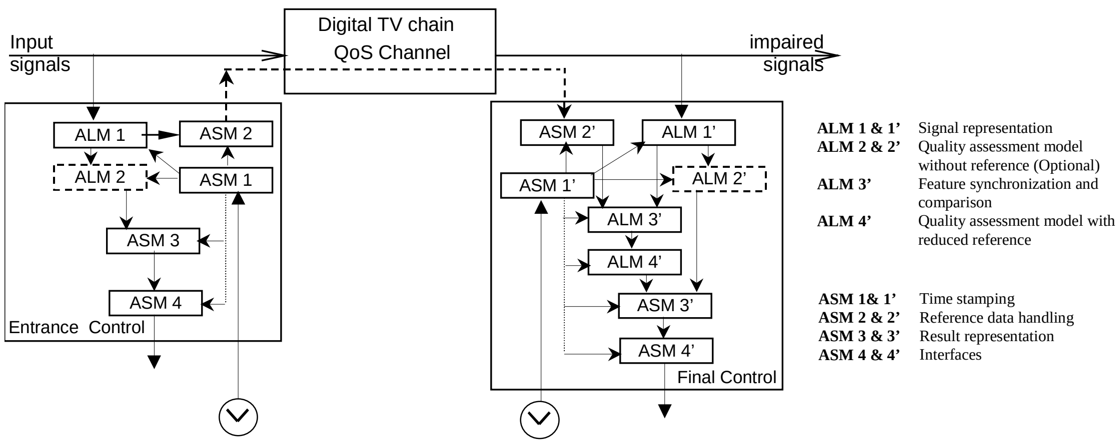

Figure 2: Detailed structure of the generic measurement method

The approaches presented in section 1 can be resumed in a theoretical concept under study at ITU-R JWP 10/11Q. The design and the development of a video quality meter bring to consider a general structure of the measurement procedure. Several layers compose this structure.

- **Measurement methodology** defines the class or the strategy relative to the application requirement,
- **Measurement Method** is composed of a set of modules, algorithmic and associated ones, implemented to process inputs such as original signals or processed reference data, and provide output results such as processed reference data, level of impairment or final quality notation,
- **Algorithmic module(s)** is the basic block of signal processing functions composing the method. It composes the core of the method from which the final objective qualification is delivered,
- **Associated module(s)** is an additional function that aids the algorithmic module(s) in its operation by addressing such issues as dating, synchronization, presentation of data, etc.

2.2. Measurement Method

A typical configuration for method is the structure shown hereafter in **Erreur! Source du renvoi introuvable.**.
A measurement method is composed by algorithmic (**ALM**) and associated modules (**ASM**).

(ALM and ASM are respectively the *Algorithmic* and the *Associated* modules composing the measurement method. The indexes **N** and **N'** indicate that the module is located at entrance control for **N** or at final control measurement point for **N'**).

2.3. Algorithmic modules

2.3.1. ALM 1 & 1': Signal representation

The ALM 1 & 1' concern modules where specific features are extracted from the signal. This is operated at the entrance control and at final control depending on the position of the measurement point or on the retained measurement methodology. The extracted features will be used by subsequent modules to measure the impact of the impairments introduced by pieces of equipment or by transmission link on the video signal: a comparison between the input and output features will provide an indicator of the video quality.

Signal representation is one or a set of transformations applied to the video in order to change its representation from values of pixel matrix to another domain. This latter domain can be a new matrix of transformed values, or a vector of features obtained on the initial domain or even after a mathematical transformation or filtering.

The performance of the signal representation algorithmic modules depends not only on the relevance of the representation, but also on the amount of extracted information to be transmitted. The limitation of the assigned bit rate of the reference data channel imposes the choice of the technique.

2.3.2. ALM 3': Feature synchronization and comparison

In order to evaluate the impact of video systems on original signals and to measure the quality of the final video, a synchronization and the comparison between features are operated on the representation of input signals and output ones. The result is considered as a diagnostic measurement.

The proposed quality assessment method is a comparative one. Then, in order to evaluate measure the quality of signals over one or several links of the network, it requires the realization of the comparison of two signal representations operated at different points. This approach imposes a precise synchronization between measurements done at entrance control point and those realized at final control ones. It is mandatory to ascertain the veracity of the time stamping information concerning each measurement. This insures that the synchronization between the input representation and the output one can be conducted successfully. After the synchronization, the comparison result is computed on a sample by sample, frame by frame or component by component basis depending of the signal representation (matrix or vector).

The comparison is defined as the difference or absolute difference between the signals or their representations. The amplitude of the comparison signal and its statistical properties carries information about the characteristics of the generated distortions. Many different parameters are commonly extracted from the error signal. Several comparison functions have been used for this issue. Some are very close to error signal calculations *SNR*, *MSE*, *PSNR*. They consist of a general comparison of signal values. Other types of comparison functions have been introduced to be more adapted to the comparison of feature components: log*_ratio*, *error* and *error_ratio*. The mean and the maximum value applied on the previous functions allow having six different parameters obtained from features. A large set of objective parameters can be derived from spatial and temporal parameters and impairment parameters. The results are a representation of the degradation between two video sequences. This output will feed to the next module that is the perceptual model.

2.3.3. ALM 2, 2' & 4': Quality assessment model

The quality assessment model ALM 2, 2' or 4' merges the previously defined features into a single quality prediction value, since several impairment types can occur simultaneously and influence the subjective judgment. The aim of the model is to compute a perceptual quality score. The most relevant measurements of individual impairments must be jointly used to predict perceptually objective quality by a single value. To this end, a combination model is set up.

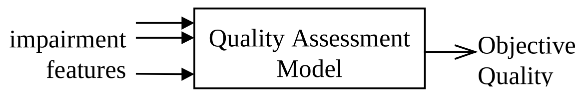

Figure 3: Synoptics of the quality assessment algorithmic module

The model combines the relevance of the preceding video impairment features to predict global quality. To this end, an optimization procedure carried out with subjective data, obtained by the standard SSCQE (Single Stimulus Continuous Quality Evaluation) is used to set up the model.

2.4. Associated modules

2.4.1. ASM 1 & 1': Time stamping

The measurement points need a reference time in order to synchronize the processed quality parameters.

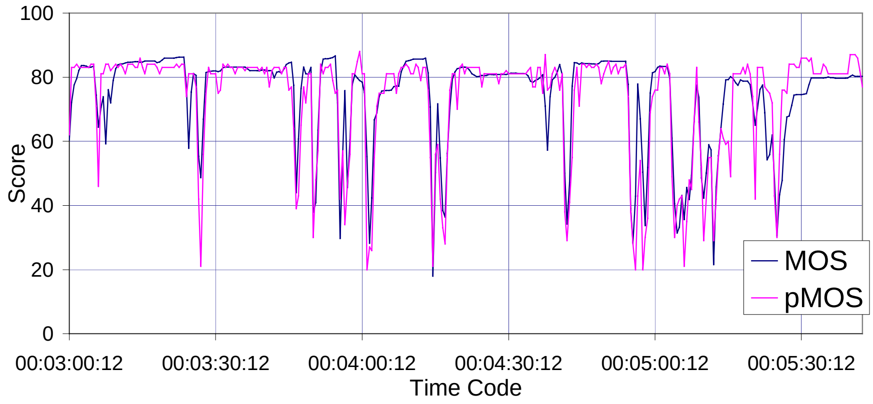

Figure 4: Objective quality of a sequence affected by transmission errors.

The comparison obtained between the parameters has to be calculated for the same time stamp.

The ASM 1 & 1’, are the pilots of the quality meters at the measurement points. They represent the schedulers of the whole system. The time stamping modules launch all measurement the processes. They, also, provide time stamps for the formatting of, on one hand, the reference data transmitted through the QoS Channel with ASM 2 & 2’; on the other hand, the QoS information transmitted to the supervision system with ASM 4 & 4’. The time stamping modules have to use a common unified clock retrievable all over the network chain. One example of a unified time reference is MPEG-2 internal system time clock (STC). It is useful to be used as a reference time for the generation of the time stamps for the quality meter. This internal MPEG-2 reference clock is available at each measurement point localized everywhere onto the network. The operations achieved at input and output equipment are then synchronous, to carry out the comparison of the parameters.

The system labels all measurements with specific time stamps, which are present in the MPEG-2 stream.

2.4.2. ASM 2 & 2’: Reference data handling

The quality meter has to manage the QoS channel for reference information transmission. In order to make available signal reference information all over digital television networks, it must be transmitted to the final control stations. For this purpose, inserter and extractor means have to be implemented as Associated Modules at entrance and final measurement points ASM 2 & 2’. An example of implementation has been proposed.

One solution is to transmit input parameters in-band with the digital TV programs, in a dedicated quality of service channel multiplexed into the MPEG-2 Transport Stream. The bit-rate required to transmit the parameters is in the order of a few kbits/s, to be affordable. In this way, the parameters are easily broadcast to all final control measurement points. For this purpose, the creation of QoS channel was suggested and standardized in DVB. The multiplexing of the QoS channel into the MPEG-2 TS was proposed. DVB has edited the recommendations for the use of specific MPEG-2 packet Identification number (PID) reserved to the QoS channel. Several other applications are given to use this QoS channel.

One example of implementation proposed describe how to set up the test-data-section with information about QoS. It concerns the PID of elementary stream for which the measurement values are valid; the description of the content is in clear text, the processed measurement values and time stamps. This reference information is multiplexed at entrance control point and handled through the network until provided to the final control point[0].

2.4.3. *ASM 3 & 3': Result representation*

The ASM 3 module is needed to propose different types of measurement representation: graphical charts, plots. It also concerns the issue of short term and long term representation with the problems of time collapsing and statistical representation of objective quality measurement.

2.4.4. *ASM 4 & 4': Interfaces*

About the interface (ASM 4), several solutions are possible for connecting the quality meter to the supervision system. This will allow gathering quality information for the monitoring of the network and providing it if it's requested. To achieve the interfacing, HTML page server with JAVA applets is one possible solution. The other one is to use SNMP (simple Network Management Protocol) agents or specific external PROXY's. The agents allow to connect the pieces of equipment to the Management Information database (MIB) and consequently to the supervision system.

CONCLUSION

The proposition of the Reference Description Model is re-enforced by the current standards ITU-T and DVB. This in order to outcome with a coherent solution with a consideration to the standardization bodies.

REFERENCES

[1] P. Brétillon, J. Baïna, M. Jourlin, G. Goudezeune "Method for image quality monitoring on digital television networks". SPIE, Vol. °3845, pp 298-305, sept. 99.

[2] J. Baïna, G. Goudezeune, "Equipment and Stategies for Signal Quality Monitoring for Digital Television Networks", Proc. SMPTE Journal, september 1999.

[3] Recommandation UIT-R Bt. 654, « Qualité subjective des images de télévision en relation avec les principales dégradations du signal de télévision composite analogique », 1986.

[4] Manuel « Méthodes d'évaluation subjective en télévision », UIT, Genève, 1996.

[5] W. Xu, G. Hauske, « Picture quality evaluation based on error segmentation », SPIE Vol. 2308, pp. 1454-1465.

[6] K. Kotani, M. Katayama, T. Murai, M. Miyahara, « Objective Picture Quality Scale for color image coding », ICIP'95, Washington, DC, Vol.3 1995, pp. 133-136.

[7] Recommendation for the usage of a user defined signaling channel embedded in a MPEG-2 Transport Stream under the Packet Identifier PID 0x001D », DVB Document: TM1957Rev.3, May 98.

[8] Recommendation ITU-R BT 500-7, "Methodology for the subjective assessment of the quality of the television picture".

[9] "Method for in-service video quality monitoring over DTV broadcasting networks", contribution to ITU-R Joint Working Party 10-11 Q, Doc. R10-11 Q/057, 25 jan. 2000.

[10] "Methodologies For Video Quality Assessment On Networks In Operation", ITU-T SG9 J.ovq, Temporary Document 36, April 99.