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In-service Real-time and Continuous Objective Video Quality Assessment for DTV Broadcasting

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ABSTRACT

This article presents a simple and reasonable in-service, real-time, and continuous single-ended objective video quality assessment model for DTV broadcasting using a multiburst signal at the bottom of the transient effect area, similar to Vertical Interval Test Signals. The issue of in-service video-quality monitoring in DTV broadcasting is addressed, and an effective method of quality monitoring is presented. The proposed method is also implemented and tested in a range of situations using a simulated HDTV broadcasting network.

Key words: Objective quality assessment, In-service, Single-ended, DTV broadcasting, Video compression

1. INTRODUCTION

DTV services have been rapidly developing over the last few years, based on advances in digital signal-compression technology. However, in-service, single-ended QoS issues -often the most critical parameter for evaluating a DTV system -have not developed at the same pace. Thus, there is an urgent need to develop appropriate methods and tools to ensure the QoS provided to the end-user [1][2]. Quality assessment and control of images and videos, from the input (capture device) to the final output (display and its environment) presented to the human viewer, are essential for DTV applications and services. As a result, various objective video quality assessment (VQA) methods with different criteria have been proposed, where depending on the application and accessible information, these VQA methods can be classified into three types: double-ended systems, double-ended systems using reduced reference, and single-ended systems. The standardization of these visual quality metrics is now being considered by various groups, including the Video Quality Experts Group (VQEG) for video [3]. However, QoS remains one of the highest priorities, requiring urgent attention from broadcasters, for whom single-ended systems are more important than reduced-reference and double-ended systems as regards in-service, real time, and continuous monitoring of QoS [4].

Accordingly, this paper proposes a simple and reasonable in-service, real time, and continuous single-ended objective VQA method using a multiburst signal at the bottom of the Transient Effect Area (TEA), similar to Vertical Interval Test Signals (VITS).

2. IN-SERVICE VQTS USING TATS

In standards like SMPTE 274M, the production aperture defines the active picture area produced by the signal sources, such as cameras, telecines, digital videotape recorders, and computer-generated pictures. Plus, the production aperture con-

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sists of the TEA and a clean aperture [5]. Since modifying the signals in the TEA has no effect on the displayed picture, as this region is not generally displayed on the monitor, the proposed method replaces the signals in this region with transient effect area test signals (TATS) in every frame in a video sequence to facilitate objective VQA. In effect, these TATS signals are similar to the VITS signals in an analog television system [6].

A simple and typical configuration for the proposed objective VQA method is shown in Fig. 1, which consists of a multiburst signal generator and time code inserter, line switcher, and quality assessment block.

To evaluate the frequency response characteristics of a DTV compression performance, a multiburst is extremely useful as an "in-service" test, since the signal can be included as a designated line in the TEA, allowing tests to be conducted without interfering with the program material. Fig. 2 shows the proposed multiburst waveform that contains a calibration square wave to the left of

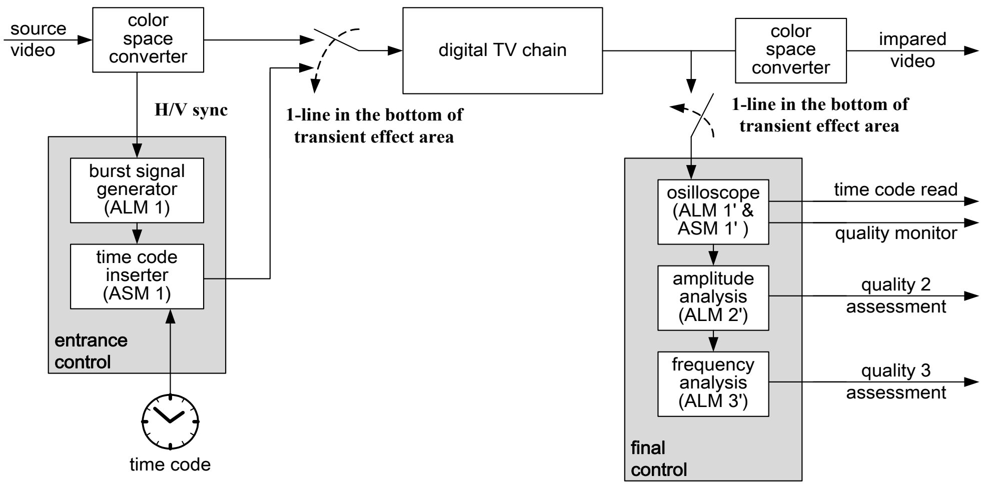


Fig. 1. Proposed simple and typical in-service, real-time, and continuous single-ended objective VQA structure for DTV service.

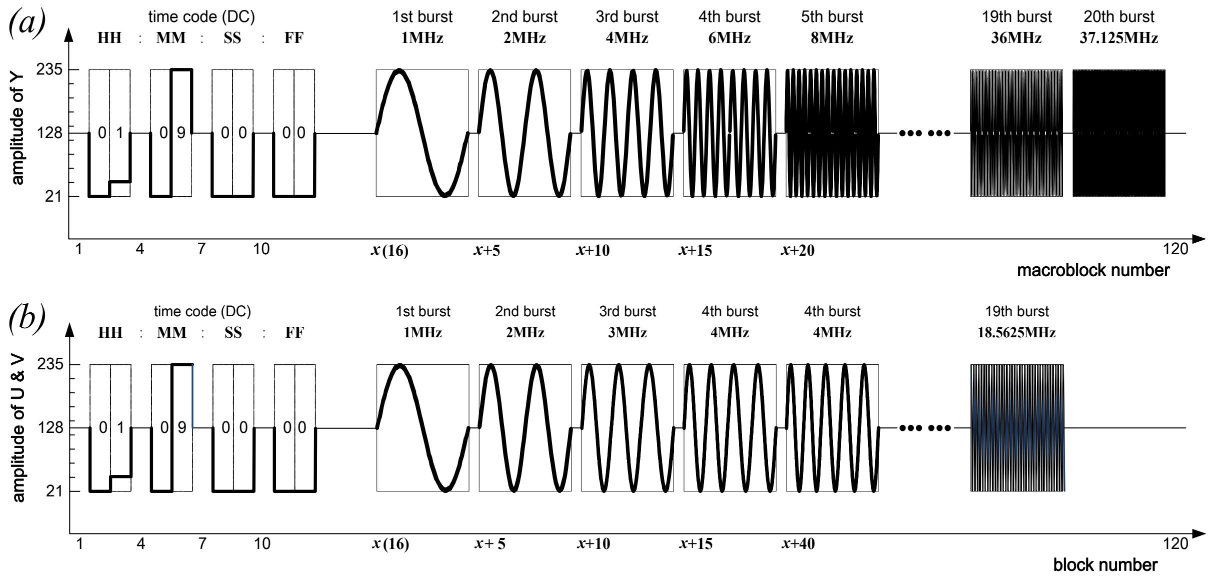


Fig. 2. Proposed 1-line (a)Y and (b)UV MPEG-2 MP@HL 4:2:0 format TATS for objective VQA including time code.

the first burst that functions as a calibrating reference using a time code. The luminance and chrominance bursts are composed of 20 and 19 different frequencies, respectively, from 1MHz to half the sampling frequency. Limited by the maximum luminance value 235, the proposed burst signals are horizontally and vertically symmetric, and may distort the waveform in the DTV encoder and decoder.

While the proposed method does not require synchronization, the quality of the DTV sequence can vary as regards time. Thus, a time code is inserted in front of the burst for a quality assessment of each frame. The level for each field in the time code is calculated using $n/9\times214+21$. Each field in the time code is separated by 1 macroblock to allow easy reading using an ordinary oscilloscope.

The proposed TATS are generated at the entrance of the DTV chain (entrance control) and reproduced at each measurement point (final control). A linear combination of the distortion usually provides the final objective quality evaluation.

For real-time quality assessment, the picture quality in the time domain is assessed based on the average burst amplitude distortion or average pixel difference in each burst, while the picture quality in the frequency domain is assessed based on the average burst amplitude using an FFT (Fast Fourier Transform).

3. EXPERIMENTAL RESULTS

The test configuration was composed of an S/W encoder, a stream generator, channel coder, RF modulator, and DTV receiver, as shown in Fig. 3, representing a simple simulated HDTV broadcasting monitoring system. The video output of the DTV receiver was watched using a monitor, plus the proposed multiburst was measured using an oscilloscope. The proposed quality assessment blocks in the time and frequency domains are also added. The source and decoded images are shown in Fig. 4.

The captured waveforms from the DTV receiver output are shown in Fig. 5, where channels 1, 2, and 3 are the luminance(Y) and chrominance (U & V) signals, respectively. Here, the trigger was set to channel 1 video line 1123 and normal mode.

As shown in Fig. 5, the burst distortion varied with the time code according to the complexity of the source image. When increasing the transmission rate the distortions decreased and the picture quality became more acceptable. Therefore, the results confirmed the effectiveness of proposed method as an in-service, real-time, and continuous single-ended DTV picture quality monitor.

For the time domain and frequency domain, simple quality assessment methods using the average burst amplitude for real-time and continuous VQA

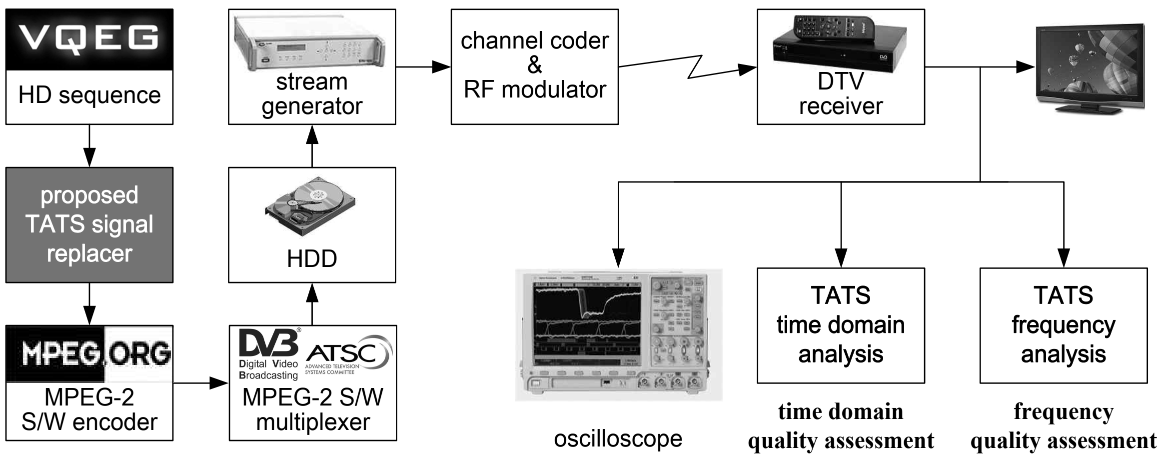
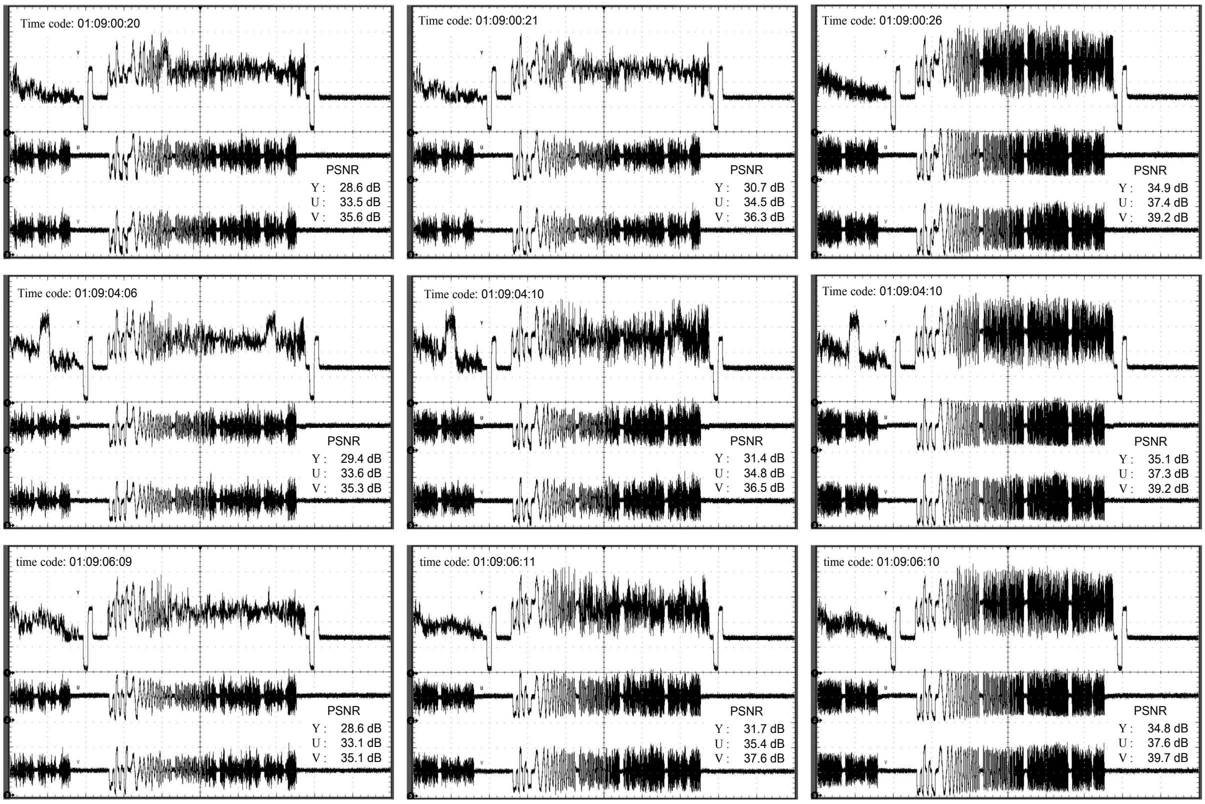


Fig. 3. Test configuration of simulated HDTV broadcasting network.

Fig. 4 urce image replacing proposed TATS at marked(▶) line (a) and displayed image (b).



(a) 5Mbps (b) 10Mbps (c) 15Mbps

Fig. 5 Captured proposed TATS waveform according to bitrate: (a) 5Mbps, (b) 10Mbps, and (c) 15Mbps.

are shown in Fig. 6 and in Fig. 7, respectively. Using the methods, the quality variations for the whole sequence are shown in Fig. 8. The quality assessed in the time domain was similar to that in the frequency domain and to conventional PSNR evaluations.

Consequently, the results indicate that the proposed method may be useful for in-service objective VQA and monitoring DTV broadcasting systems.

4. CONCLUSION

In-service and real-time quality assessment and control of videos, from the input to the final output, are essential for DTV applications and services. Thus a simple and reasonable in-service, real-time, and continuous single-ended objective VQA method was presented for DTV broadcasting using a TATS multiburst to replace 1-line signal at the bottom of the TEA. The proposed method

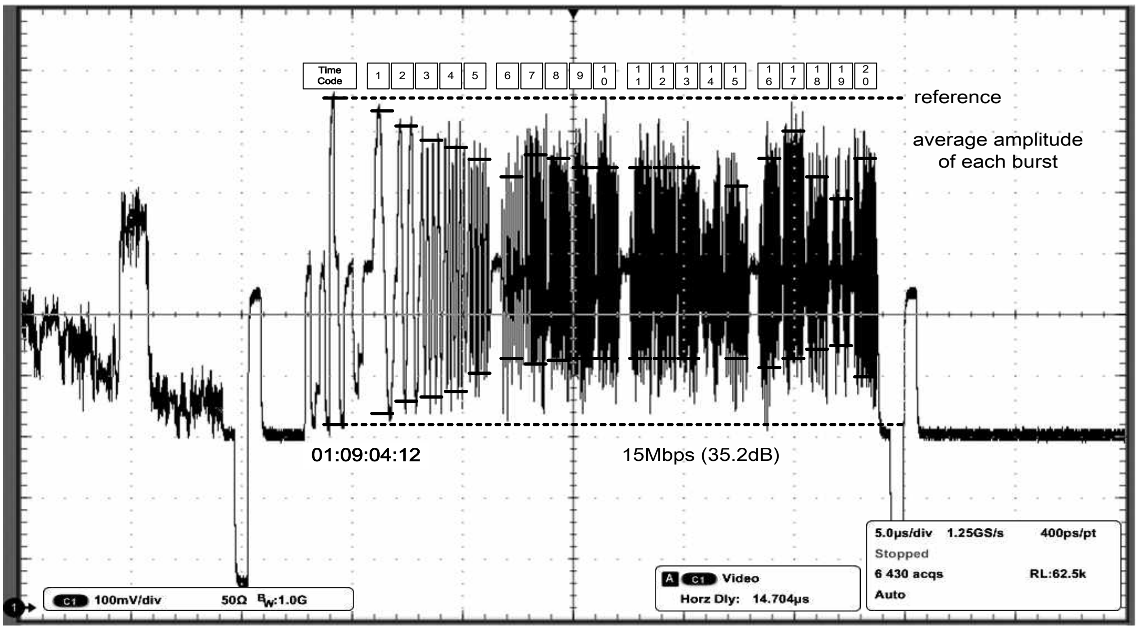


Fig. 6 Average burst amplitude for time domain quality assessment.

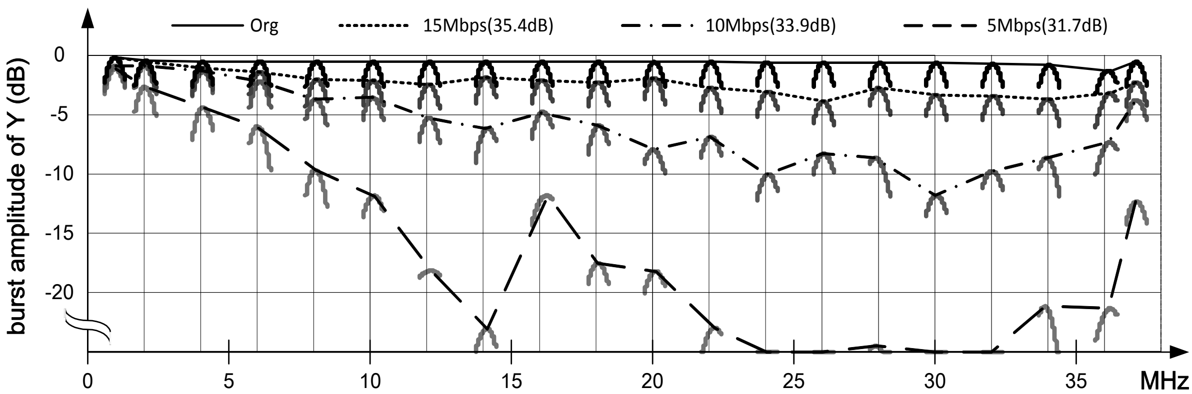


Fig. 7 Average burst amplitude for frequency domain quality assessment.

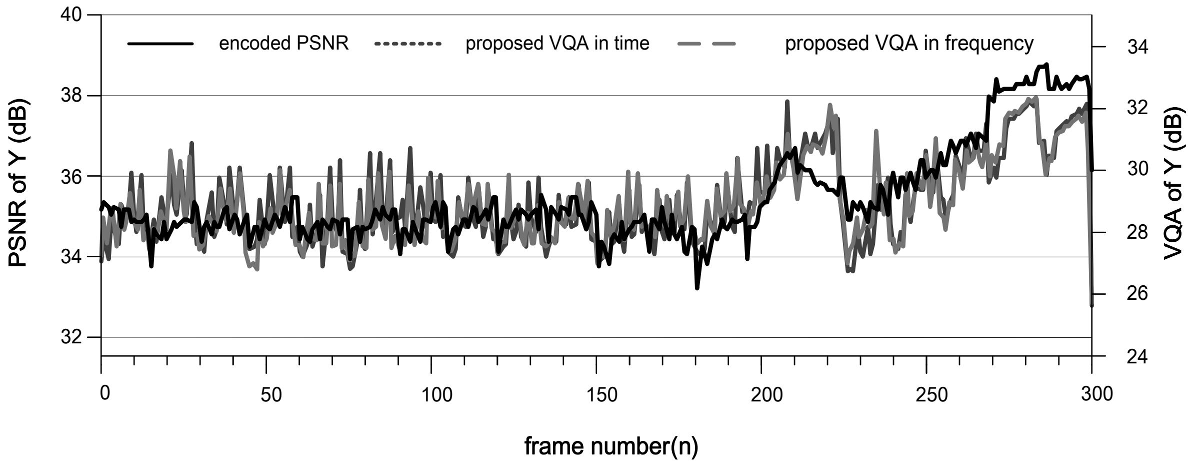


Fig. 8 Video quality assessment for whole sequence.

was also shown to be effective for a range of situations using a simulated HDTV broadcasting network. Further work is planned for hardware implementation using an FPGA adapted sophisticated burst combination and precise quality assessment algorithm.

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