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Quality perception when streaming video on tablet devices ☆

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ABSTRACT

The proposed work aims at analyzing the quality perceived by the user when streaming video on tablet devices. The contributions of this paper are: (i) to analyze the results of subjective quality assessments to determine which Quality of Service (QoS) parameters mainly affect the users' Quality of Experience (QoE) in video streaming over tablet devices; (ii) to define a parametric quality model useful in system control and optimization for the considered scenarios; (iii) to compare the performance of the proposed model with subjective quality results obtained in alternative state-of-the-art studies and investigate whether other models could be applied to our case and vice versa.

1. Introduction

Reliable real-time evaluation of the Quality of Experience (QoE) plays a fundamental role in video streaming scenarios, as it is needed for a number of purposes, ranging from the monitoring of the streaming sessions to the control of the source and channel rates, from the setting of the network parameters to the adaptation of the interaction experience the user is provided with.

Although it is well-known that subjective assessment is the most reliable way of evaluating the perceived quality, it is obvious that such methodology cannot be applied in a real-time video streaming scenario. Furthermore, over the past years, streaming of videos over the Internet has become increasingly common on handheld devices, such as smartphones and tablets. In such systems the end-user has no access to the original video frames; therefore, even objective Full-Reference (FR) approaches are not practicable at the receiver-side. As an alternative, No-Reference (NR) approaches can be used, which allow for estimating the perceived quality from the decoded video or from parameters extracted from the received bitstream or characterizing the streaming environment at both the user-side and the network. However, in order to reliably estimate the quality perceived by the end-user, NR objective quality metrics must be highly correlated with human quality perception.

In this work we are interested in analyzing the perception of quality in this application scenario, specifically when the video sequences are transmitted over lossy wireless channels and the videos are played back on tablet devices. In a real video streaming transmission over lossy wireless channel, the received video sequences are degraded versions of the original ones, due to the lossy coding and the channel transmission errors. Then, the annoyance caused by various distortion effects on the received video sequences may vary greatly depending on the introduced distortion. For instance, playback interruptions can be more annoying than the degradation due to low-rate video compression, whereas presenting High Definition (HD) quality video at the expenses of some frame freezing occurrences can be generally advantageous for the overall QoE.

To reach our goal, a subjective quality assessment has been conducted with the help of 40 subjects that were asked to rate several video sequences affected by various types of distortions. The analysis has been conducted by recording the subjective video quality in a real video streaming scenario. Several issues related to the fruition chain have been considered, from the impairments imputable to the coding algorithms, to those caused by the network. Given such application scenario, one of the objectives of the proposed study is to determine which Quality of Service (QoS) parameters mainly affect the users' QoE in multimedia video consumption on tablet devices, in terms of correlation with subjective quality results. Then, a QoE index is proposed, as a function of the relevant QoS parameters. The proposed quality model is extensively tested by comparing its performance with that of other state-of-the-art objective quality metrics defined in different video streaming scenarios, as there are no other assessments performed in the past related to video playback on tablet devices.

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Section 2 presents related works. Section 3 illustrates the test material used for the assessment and describes the subjective video quality assessment procedure. Section 4 discusses the assessment results, whereas Section 5 analyses the performance of the proposed quality index. Finally, Section 6 draws final conclusions.

2. Related works

There are extensive studies that have been carried out in the recent past which focus on subjective video quality assessment. They differ on the considered applications, on the methodology followed to collect and evaluate the perceived quality, on the system parameters have been varied during the experiments to evaluate the impact on the quality, and whether they propose a final parametric model or not. Some of these papers are briefly reviewed in this section and summarized in Table 1.

The following papers have collected and analyzed subjective results without proposing any objective quality model. In [1], forty subjects were asked to rate 78 video sequences generated from 6 different videos at CIF spatial resolution and affected by different packet loss rate (PLR), ranging from 0.1% to 10%. The scores assigned by the observers were averaged to obtain the Mean Opinion Score (MOS) and then collected in a public database. In [2], the authors present MintMOS, a lightweight, NR, loadable kernel module to infer the QoE of a video stream and offer suggestions to improve it. Thirteen video samples were generated from an original video sequence using three parameters: loss, delay and encoding bitrate. Then, 49 subjects were asked to assign a perceptual rating to the video samples. Finally, the MOS values were compared to the MintMOSs projections, demonstrating a high degree of correlation with the human perception. In [3], extensive subjective tests are conducted for assessing the perceptual quality of low bitrate videos, which cover 150 test scenarios and include five distinctive dimensions: encoder type, video content, bit rate, frame size, and frame rate. Based on the subjective scores, a statistical analysis is performed in order to study the influence of each dimension on the perceptual quality. All previous papers present subjective results, in terms of MOS, related to streaming video sequences transmitted over a lossy channel.

Among the works that focus on the development of video quality metric, Staelens et al. [4] proposes the use of a robust Machine Learning (ML) technique, called Symbolic Regression, to derive a new NR bitstream-based objective video quality metric for estimating perceived quality of HD H.264/AVC encoded videos. This technique allows to perform an automated selection of the most important variables that condition the perceived video quality. Only parameters that can be extracted or calculated from the received video bitstream, without the need for complete decoding, are considered. This set comprises 42 different parameters among which only 8 are considered as influential for modeling perceived video quality. The final objective quality model presents only four parameters for estimating video quality. Yamada and Nishitani [5] presents a NR video-quality estimation method for compressed videos which uses only pixel information for the quality estimation. Intra-coded frames are detected and a signal difference between the intra-coded frame and the adjacent non-intra-coded frame is calculated by using an activity value of every given-size pixel block. In addition, blockiness and blur levels are also estimated at every frame and are taken into account. In [6], a compressed domain NR metric is presented, which measures the video quality based on the information extracted from the bitstream during the decoding process. The proposed algorithm takes into account the quantization parameter, the motion, and the bit allocation factor. In contrast to conventional video quality assessment metrics which measure the video quality frame by frame, the video sequence is processed as a whole. Shi et al. [7] proposes a NR video quality assessment metric based on features extracted from the H.264/AVC encoded bitstream. Partial Least Squares Regression (PLSR) is used to calculate the weights relative to the extracted features. Then, a quality prediction model is also proposed. In [8], a low complexity NR video quality metric for H.264/AVC video transmissions in packet-based networks is presented. The proposed metric is based on several features extracted from the headers that encapsulate the compressed video data, such as the video distribution protocol stack or the network adaption level header. A piecewise linear model is used to estimate the correlation between the source and the decoded video for easy deployment in many network nodes. The evaluation shows that packet-header features allow for an accurate quality prediction when packet losses occur in video transmission. Romaniak et al. [9] proposes a NR metric to objectively assess the H.264/AVC video quality. The proposed model takes into account the typical artifacts introduced by hybrid block-based motion compensated predictive video codecs such as the H.264/AVC standard: blockiness and temporal flickering. A flickering metric for intra coded frames is also derived. Yamagishi and Hayashi [10] develops a model for estimating video quality for IPTV services. The proposed model is based on a quality-estimation unit for estimating how coded distortion and packet-loss degradations affect the video quality. In [11], the video quality is predicted through a combination of both application and network level parameters for all video content types. The proposed model is based on three objective parameters: bitrate, frame rate and PLR.

Although many works conducted subjective quality assessment and proposed video quality model related to streaming video over lossy channel and played back on PC, in the literature there are no works considering tablet devices as end devices. Then, no quality model and no subjective results exist within this specific scenario. Table 1 summarizes the primary characteristics of considered works about subjective quality assessment and video quality model proposal.

Table 1
Comparison of the primary characteristics of some state-of-the-art works conducting subjective video quality assessment and/or proposing video quality model.

	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]
Application											
Video on PC	X	X	X	X	X	X	X	X	X		X
IPTV										X	
Assessment methodology											
MOS	X	X	X	X	X			X	X	X	
DMOS						X					
Survey							X				
PSNR to MOS											X
Main experiment parameters											
Content			X	X							X
BER/ PLR	X	X		X				X		X	X
Bitrate	X	X	X		X	X	X		X	X	X
Frame size			X								
Frame rate			X								X
Delay		X									
Encoder type			X		X						
Others				X	X	X	X	X	X		X
New model											
No	X	X	X								
Yes				X	X	X	X	X	X	X	X

3. Subjective video quality assessment

The following two subsections present the selected video sequences used for the evaluation and the assessment procedure.