Paper

Videotoms in Objective and Subjective Quality Tests of Video

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Abstract—This paper proposes idea of videotoms usage in quality tests of video signals. This concept simplifies parametric model creation for television services such as IPTV (Internet Protocol Television), VoD (Video on Demand) and others. Videotom is simple, well-defined video sequence in the context of video quality tests. Presented idea was used in both objective and subjective tests of influence selected network parameters: jitter of delay, packet loss and packet corrupt on the video quality measured using Mean Square Error (MSE) and Mean Opinion Score (MOS) metrics. Results showed that proposed method is useful especially for subjective tests and it can reduce costs and time for them.

Keywords—Digital Television, IPTV, Quality of Service, Videotoms, VoD.

1. Introduction

In recent years, strong and dynamic evaluation of multimedia services in the telecommunication networks can be observed. In addition to standard terrestrial television occurs IPTV and also others interactive TV services created in broadband networks based on IP protocol usage. Their attractiveness from customer point of view is not only measured by the price but also by the quality. Service provider looks at the quality from the perspective of network parameters, whereas from user side much more important is his satisfaction with the service provided. Defining relationship between those two different approaches to quality is a real challenge. Evidence of this is the fact that amount of work researches carried out by ITU and VQEG have not yet led to creation of parametric model similar to those for telephony and videotelephony (ITU-T recommendation G.107 [1], ITU-T recommendation G.1070 [2]). Nothing surprising, since TV services are very complicated and very difficult in a proper modeling in context of quality assessment.

Most of the studies done so far keep focus on quality tests a few selected “television sequences” varying volatility (high motion, low motion) and level of details. Those video signal representations are used to show the impact of the changes like broadcasting, encoding, transmission or reception conditions on objective or subjective quality. That approach is not without drawbacks and weaknesses, because the same tests for different set of video sequences caused that received results will be significantly different. Identification all possible cases is not possible and the creation of quality model that would be reflected in the actual systems requires a lot of testing and analysis [3]–[7]. For that reason, purposeful is to move research on simplified model in which “television sequences” will be replaced with videotoms – video samples which content is clearly defined. This approach allows on significant simplification not only for costly subjective tests but also for the whole process of analysis relationship between objective and subjective quality.

2. Videotoms Concept and Visual Human Perception

The mechanisms of visual human perception are very complex and their in-depth analysis is still the subject of research engineers, doctors and psychologists. In greatly simplified the process of seeing can be summarized as follows. First, the human eye captures light reflections associated with the observed object and then it is converted and transferred by nerve cells to the brain, which interprets received information and creates final impression. Various properties of that process as well as additional conditions such as emotional state, tiredness, past experiences can influence how the image will be interpreted and in result received. It is also really important how effects are presented as an object of observation. In case of video sequences can say that significant role in their creation process should not be fitting them to TV conditions, but rather adapting the image to the general nature of human perception. Considering that in video samples creation process it’s needed to take into account a number of dependencies related to that. Pictures used in this process should have continuous and constant form and structure. Removed should be any excess, irrelevant information that disturbs in unambiguous interpretation, because the human ability to perceive is more limited when the images are abstract or inconsistent. Apart from that there are many other important elements that necessarily need to be taken into account in the process of creating video sequences from pictures such as contrast, brightness, details and diversity. If we add that the knowledge of the picture that we see speeds up interpretation process we can create appropriate test sequences. Presented approach author called the concept of videotoms – creation of simple, well-defined video pictures that are known to user. Videotom name comes from logatom word defined in speech audiometry, but newly introduced concept is related only to video, not audio signals. The definition refers to simple, well-defined video sequences. It’s worth

Table 1
Reference video sequences

Name	Blue cube	Green rectangle	Red balls
Description	Spinning blue cube	Moving green rectangle from the left side to right side	Red balls falling down at the different speed
Characteristic	High motion sequence with small number of details	Low motion sequence with small number of details	Average/high motion sequence with large number of details
Duration	10 s		
Codec	MPEG4 AVC		
Resolution	544 × 396 pixels		
Maximum bit rate	1662 kbit/s	158 kbit/s	1885 kbit/s

to noting that videotoms suit perfectly to subjective quality tests, because observer always notice distortion in observed video picture – in case of normal "television sequences" distortions can be unnoticed. The use of such video sequences should allow receiving more reliable results, reducing the number of tests and simplifying analysis process for them.

3. Test Conditions and Reference Samples

To show videotoms usage in both subjective and objective quality tests according to Young-Helmholtz theory of trichromatic color vision and to engage three receptors: short-preferring (blue), middle-preferring (green) and long-

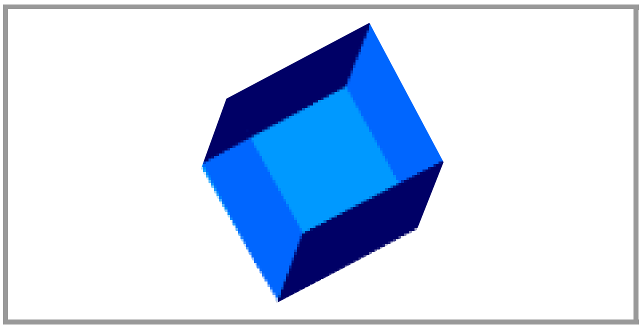

Fig. 1. Video sequence "Blue cube".

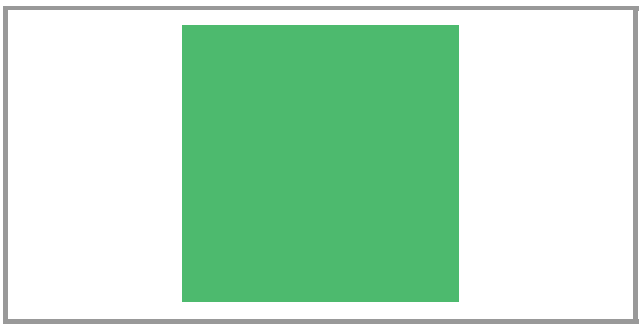

Fig. 2. Video sequence "Green rectangle".

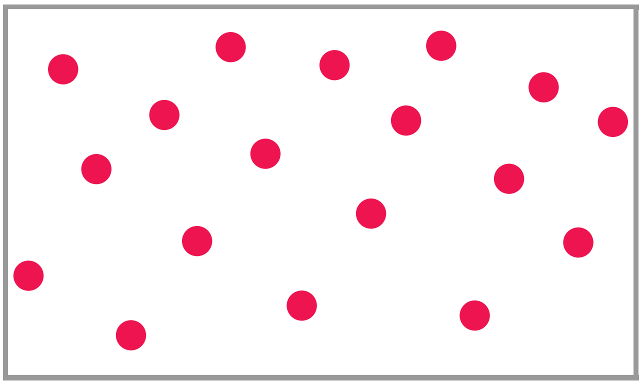

Fig. 3. Video sequence "Red balls".

preferring in the same way the three video sequences was created as shown in Figs. 1–3.

Reference video sequences presented in Table 1 were created by using Macromedia Flash Professional application and in the next step they were encoded in VirtualDub tool. The main aim of tests done in scope of this work was to verify impact of various network conditions in IP network on the quality. Based on video transmission properties the following parameters were chosen:

– jitter of delay [ms],

– packet loss [%],

– packet corrupt [%].

In objective tests quality metric was Mean Square Error (MSE). It was chosen because from the simplest measures this one best fits to distortions in the video pictures that are caused by network changes. For subjective tests standard MOS factor was used in standard 5th-stage and for measurements purposes Double-Stimulus Impairment Scale (DSIS) method was used [8]. Observers were 34 students (17 laboratory groups). To increase results reliability, they were trained about test procedures, used metrics, tools, etc. In calculation of average value for MOS metric 95% confidence level was chosen. Received results and their analysis allow to determine dependencies between network parameters and chosen quality measures. Presented earlier video sequences was used as reference probes from which sequences after processing was created. For that purpose the system as shown in Fig. 4 was created.

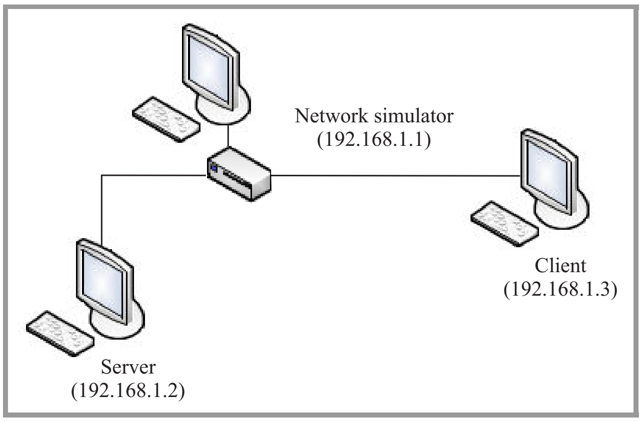

Fig. 4. System created for test probes preparing.

System consist three computers:

- Server (IP: 192.168.1.2) – streaming and sending reference probes to the Client computer,
- Client (IP: 192.168.1.3) – receiving test probes after changes caused by network conditions modification,
- Network Simulator (IP: 192.168.1.1) – modifying network conditions: jitter of delay, packet loss, packet corrupt using NETEM application.

4. Jitter of Delay

Jitter was modified by using NETEM tool. This parameter was changed from 0 to 5 ms with average delay set on 100 ms. Tested measure were MOS and MSE metrics. Figures 5–6 show results for all tested video sequences.

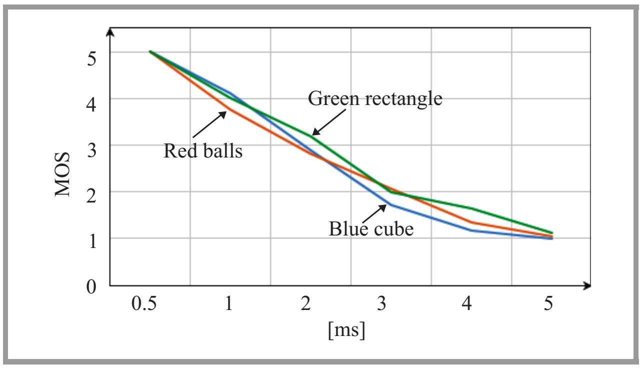

Fig. 5. MOS – jitter of delay (average delay 100 ms).

Tests showed that jitter has significant impact on the perceived quality especially when application buffer is set on small value. The most rushing declines were observed in the range of values from 1 to 3 ms. The charts intentionally omitted confidence intervals to keep it readable. Maximum standard deviations for MSE was 305.2583 where jitter of delay was set on 4 ms (Blue cube sequence). For MOS this statistics parameter gained 0.616945 by 3 ms jitter of delay (Blue cube sequence). Basically most of the distortions in the video pictures were related to blurring or to

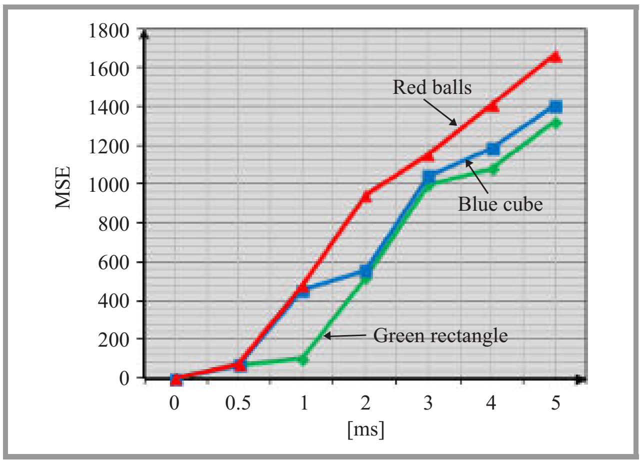

Fig. 6. MSE – jitter of delay (average delay 100 ms).

sharpening effects. Standard deviation for subjective tests was much smaller than in case of standard television sequences [9], but for objective tests results showed no difference. The limit of acceptability for jitter is 1 ms then MOS is above 4.

5. Packet Loss

Percentage of packet loss was modified by using proper mechanisms of NETEM tool from 0 to 10%. Packet were lost random (uniform distribution) without correlation. In this case the following quality metric were used: MOS for subjective (Fig. 7) and MSE for objective measurements (Fig. 8).

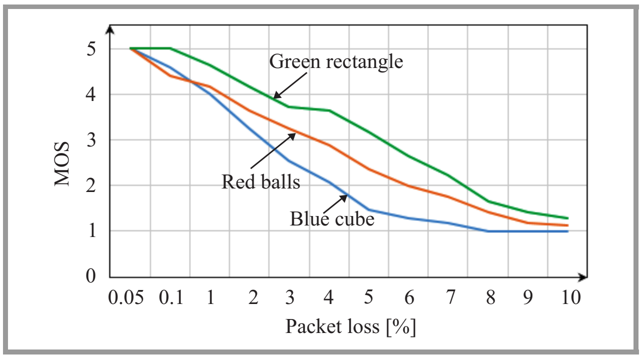

Fig. 7. MOS – packet loss.

Clearly more damaged were high motion videotoms. Degradations was visible from 0.1% value, but they were rare. In this case also to keep charts more readable confidence intervals were omitted. Maximum value of stan-

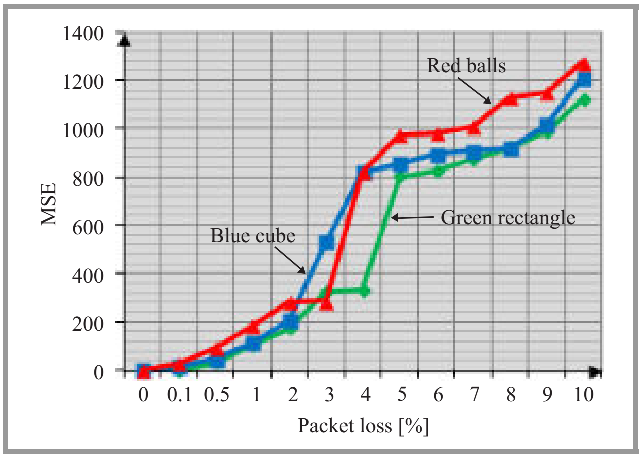

Fig. 8. MSE – packet loss.

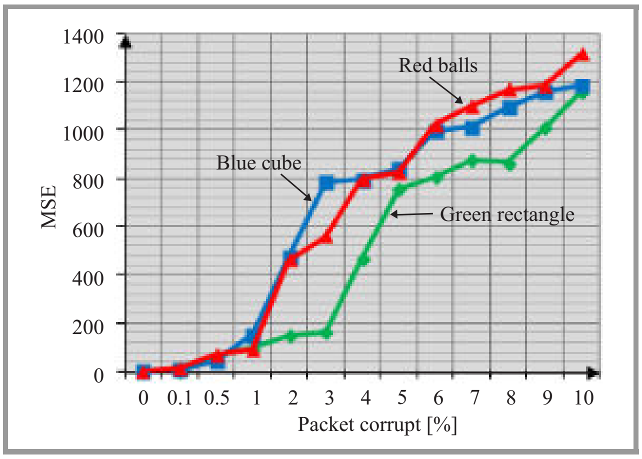

Fig. 10. MSE – packet corrupt.

dard deviation for MOS 0.6960094 occurred when packet loss was set on 4% (Red balls sequence) and for MSE 184.6932 by 6% of packet loss percentage. In this case received results are mainly the same for objective method and much lower than for television sequences for subjective method [9]. The most common distortions are individual artifacts and blurring effects. For larger values of packet loss it is possible to observe freezing effect.

6. Packet Corrupt

Percentage of packet corrupt was modified using NETEM application from 0 to 10%. Packet corrupt was done by introducing bit distortion in the packet body. Distortions were created random (uniform distribution) without any correlation.

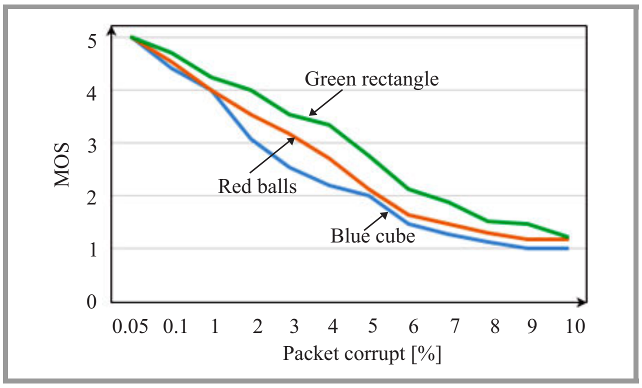

Fig. 9. MOS – packet corrupt.

The most sensitive sequences were Blue cube and Red balls (high motion sequence and sequence with large amount of details – see Figs. 9–10). Video picture deformities for this parameter were mainly the same as for packet loss – artifacts, blurring effects and sharpening effects. In the charter same as earlier confidence intervals were omitted – maximum value of standard deviation for MOS was 0.729981 (Red balls sequence) and for MSE it was 205.9 (Red balls). In comparison to similar tests done for normal television sequences received dispersion of values again are much smaller for subjective tests and mainly the same for objective tests. First distortions were visible when packet loss was set on 0.1%. Tests showed that video quality is acceptable when percentage packet corrupt is not greater than 1% then MOS is still above 4 (Fig. 9).

7. Conclusions

Presented test results showed how network parameters: jitter of delay, packet loss, packet corrupt affect video quality. All of them need to be preserve on proper level in real network in which television services are provided. The most critical parameter was jitter – even small changes in delay variation can have negative impact on quality in received video. Distortions and degradations caused by network parameters are mainly the same and they are associated with artifacts, blurring and sharping effects. Results showed that for objective methods videotoms do not give any special benefits as the results are not much better as for standard television sequences, but for subjective methods they are very useful. Received standard deviations and confidence intervals in each particular case were smaller than for television sequences. Videotoms used instead of television sequences makes it easier to capture distortion in received video pictures. It can reduce costs and effort needed to create quality model for video services.

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