

Effect of lossy networks on stereoscopic 3D-video streams

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Effect of Lossy Networks on Stereoscopic 3D-Video Streams

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Abstract—We present an experimental study of the sensitivity of stereoscopic 3D-Video streams to lossy networks. By means of a controlled network testbed, we impaired and assessed the quality of a broad range of 3D stereoscopic video sequences considering different content types, compression levels and packet loss rates. Our study and methodology are meant to provide service providers with the means to pinpoint the working boundaries of their videosets in face of different network conditions.

Index Terms—3D Video streaming services, quality of experience, network impairments

I. INTRODUCTION

3D video streaming application are booming to fulfill the demand of high-quality media. However, with their high quality and bandwidth requirements, come more stringent constraints on networks [1], [2]. In this situation, it is fundamental to understand how the network limitations impact quality[3]. In this work we study the non-linear distortion effects that lossy networks have onto 3D videos, and show how 3D streams are more sensitive than 2D videos [4].

The study of the relation between the quality of video content distribution and network condition can be performed following several approaches. For example, video sources can be synthetically simulated following a statistical model of the source [5], [6]. Nevertheless, when video quality measures are required, it is necessary to perform the experimental analysis on real high quality video sequences [7].

Video signal compression is a fundamental step for the transmission of a signal over band limited channels. At higher compression ratio the video signal is affected by different distortion effects [8]. Moreover, the quality of the signal can be severely affected when transmission over error prone channels [9]. Error recovery tools and error concealment tools can drastically reduce the effect of network impairments [10].

A model for video quality assessment considering packet loss for broadcast digital television coded in H.264 was proposed in [11]. They experimented with two different packet loss values: very low packet loss rate (0.1%) and high packet loss rate (10%).

In [12] we presented a method to assess quality of 2D video streams when subjected to real network impairments,

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specially derived from lossy networks. In [13] we sophisticated the methodology to add not only the effect of networks on 2D videos but also the compression. In this paper, we bring the knowledge learnt to the more complex arena of 3D video streaming services. We use an experimental set-up composed by a 3D streaming server, a 3D streaming client and a network emulator between the two to force network-derived distortions in a controlled manner. Video degradation is assessed by means of the Video Quality Metric (VQM), which has been demonstrated to correlate well to subjective studies, both in 2D [13] and in 3D video streaming services [4].

The relative quality of the videos is first assessed by means of degradation colormaps per video, compression and packet loss. The quantitative overall quality values are obtained, pinpointing the extreme cases of video degradation per video type and bitrate compression. Finally, psychometric curves have been shown to be the way in which human perception degrades with respect to an impairing parameter [14]. Thus, a psychometric curve is derived from each of the videos and compression. This type of analysis provides insights on the working limits of videos when subjected to stringent network conditions.

This type of analysis is meant to provide video streaming service providers a grasp of the effects that real-time network conditions have onto the video quality delivered. This can, in turn, help them anticipate problematic drops in quality and better dimension their systems [15], [16].

The reminder of this paper is organized as follows. The experimental evaluation methodology used for the proposed study is introduces and thoroughly described in Section II. Section III presents and discusses the experimental results. Finally, conclusions are drawn in Section IV

II. METHODOLOGY

This section presents the method used to perform our study, including the preparation of materials (3D video dataset), the emulation of network impairments, the distortion of 3D videos and, finally, the measurement of quality degradations in relation to network conditions. The experimental setup is depicted in Figure 1. This experimental set-up is an upgraded 3D video enabled version of the evaluation methodology used for 2D analysis in [17], [13]. A video server is connected to a video client through a commercial-rated network emulator.

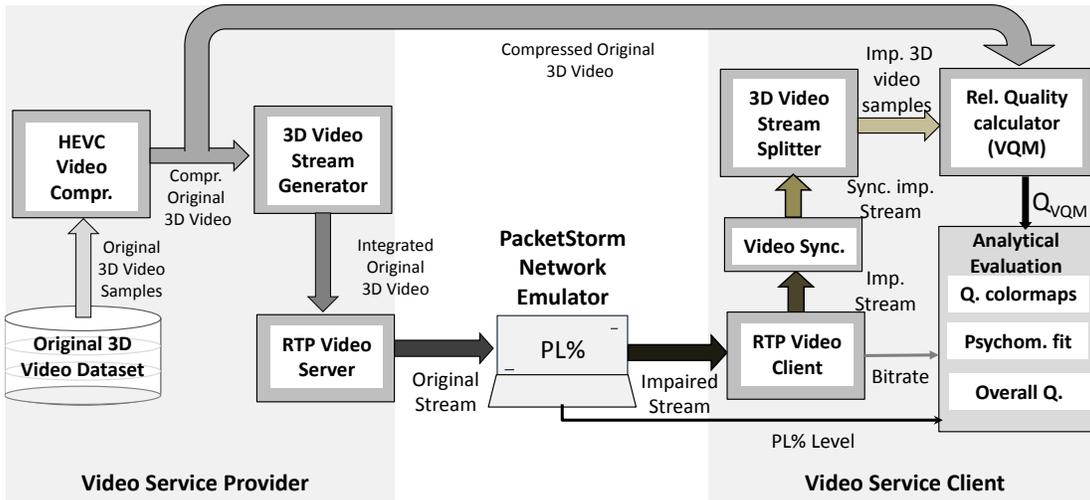


Fig. 1: Stereoscopic 3D video analysis experimental evaluation set-up.

We used PacketStorm Hurricane II [18], which is capable of emulating real-time network impairments such as packet loss, delay, jitter, and force bandwidth constraints. We focused on packet loss, which causes by far the most severe video distortion [12], [17].

On the server side, original Stereoscopic 3D sequences are obtained from a 3D Video dataset [7]. These are then compressed at different quality levels using H.265/HEVC [19]. H.265/HEVC provides view scalability at the bitstream level. Furthermore, it allows the transmission of multiview video (e.g., video with 2 views suitable for viewing on a stereo display) in an efficient and backward compatible way. This process provided us with three dimensions of analysis. First the different original video sequences give a broad range of testing characteristics. In addition, compressing the original sequences at different levels provides a second dimension of analysis. In it, not only video types but also the influence of compression are put to test. Finally, a third dimension comes from network distortions. The compressed sequences are integrated in a single stream to be sent over the network through an RTP server. The RTP/UDP transmission protocol was chosen in order to get a full understanding of the effect of packet loss.

In the client, an RTP client receives the video stream and outputs the H.265/HEVC received video stream and the overall received bitrate. This is then resynchronized to the original counterpart. In our first tests we observed, that the HEVC decoder was only losing the first two seconds, thus the synchronization basically consisted on shifting the data by two seconds. In this way, the impaired video sequences can be compared directly to their original counterpart, using VQM to assess the relative loss of quality. The latter is analysed in three different ways: (1) VQM value colormaps per video type, compression bitrate and packet loss level; (2) relative quality quantitative analysis of videos versus packet loss and bitrate (3) psychometric curve fit per video type, bitrate.

III. EXPERIMENTAL RESULTS

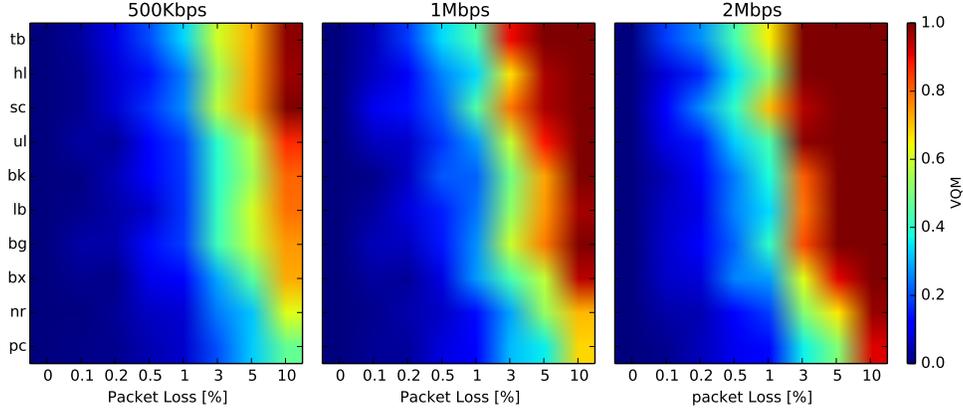
In order to study the effect of lossy networks on 3D-Stereoscopic video sequences, we selected the original (unimpaired) videos of the NAMA3DS1-COSPAD1 dataset presented by Urvoy et al. in [7]. This original dataset consist of 10 high quality Full-HD stereoscopic sequences shot with a semi-professional camera at a resolution of 1920x1080, chroma format 4:2:2 and 25fps. Nine of these videos have a duration of 16 seconds, while the remaining one (Umbrella) has a duration of 13 seconds. We compressed each of the 10 sequences at three compression levels (500Kbps, 1000Kbps and 2000Kbps) with a GOP of 15 frames (1 I, 3 P, 11 B). Subsequently we integrated each of the compressed sequences into a single stream per bitrate. These 3 different streams of 2 minutes and 37 seconds were sent over the emulated network at 8 levels of packet loss (24 testing conditions). This makes a total of 73 long videos or 730 video sequences in which to study the effects of losses in stereoscopic 3D-videos. The characteristics of the video dataset and testing conditions are summarized in Table I.

Figure 2a shows the colormap of the average, aggregated-VQM results of the 10 video sequences (y-axis), 8 levels of loss (x-axis) and 3 bitrates (500Kbps, 1Mbps and 2Mbps from left to right, respectively). In addition, Table II gives the overall quantitative relative quality values for the whole dataset. As a general conclusion, the videos tend to maintain high quality values for very low packet loss up to approximately 1%. After that point, degradation starts occurring in all the videos.

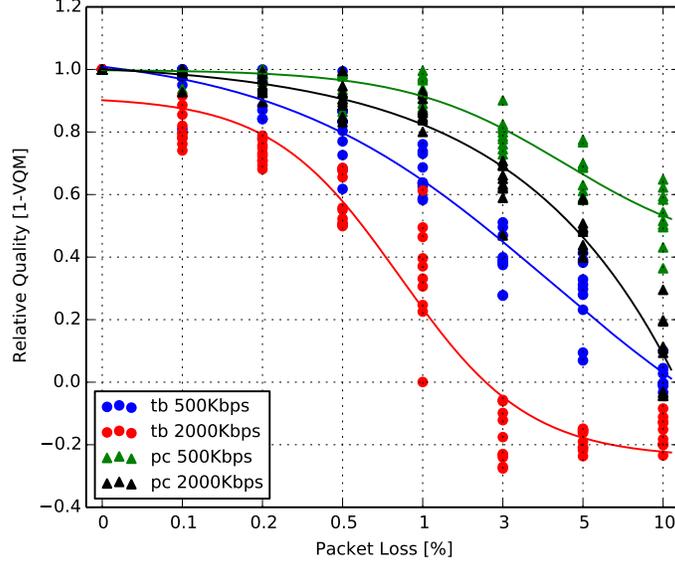
It is worth noticing that as the videos' compression bitrate increases, the degradation starts earlier and it is more dramatic. At 500Kbps all the videos keep low degradations (0-0.15%) up to 1%. Furthermore, most of them are still not suffering heavy degradation with 3% and 5%. The same videos, compressed at 2000kbps suffer degradation already at 0.5% packet loss. Moreover, all of them are dramatically impaired from the 3% packet loss rate on.

TABLE I: Video dataset parameters range in terms of video types (acronym, name and description), compression and network packet loss ratio.

Video type			Compression	Packet loss
Acronym	Name	Description	500Kbps 1000Kbps 2000kbps	PL0% PL0.1% PL0.2% PL0.5% PL1% PL3% PL5% PL10%
bg	Barrier gate	Still on parking gate. Barrier stands as car passes.		
bk	Basket	Still on basketball game; Pan as action goes from one side to the other.		
bx	Boxers	Still on boxer training;still on two boxers fighting.		
hl	Hall	Still on hotel hall from ceiling;two people meet in one corner.		
lb	Lab	Still on two scientists working on a lab.		
nr	News Report	Still on two men sitting behind table, reading the news.		
pc	Phone Call	Still on man behind a table picking up the phone.		
sc	Soccer	Still from behind the soccer goal; men scoring.		
tb	Tree Branches	Still on tree branches; leaves moved by the wind.		
ul	Umbrella	Still; man opens umbrella and starts turning it.		



(a) VQM Colormaps of the whole dataset per video type, packet loss and bitrate.



(b) Psychometric fit of the best and worst performing videos in their low and high quality variants.

Fig. 2: Quality results of the Stereoscopic 3D videos under lossy networks (per packet loss).

In addition, as it was to be expected, video types suffer degradation differently. These different behavioral patterns can be easily spotted by means of the psychometric curve fitting. Figure 2b shows the fitted curves of the extreme video types (Tree branches, tb, and phone call, pc).

On the one hand, pc, the video type least affected by

network loss, shows very flat curves (low degradation) until roughly 1% packet loss. On the other hand, tb, the most affected one, suffers from high degradation already with low network losses (0.2-0.5%).

This type of analysis and curve fitting could provide the service providers with insights of its videosets and act ac-

TABLE II: Relative quality values averaged per video iterations, bitrate and packet loss. Cell colors give qualitative relative quality for all video types in terms of bitrate and packet loss level: green (best); orange (median); and red (worst).

V.T.	Bitrate	0.1%	0.2%	0.5%	1%	3%	5%	10%
tb	500Kbps	0.972±0.06	0.909±0.07	0.8±0.1	0.662±0.06	0.396±0.075	0.28±0.11	0.015±0.04
	1000Kbps	0.949±0.04	0.818±0.06	0.658±0.067	0.562±0.055	0.1±0.113	0±0.07	0±0.033
	2000Kbps	0.813±0.05	0.73±0.033	0.566±0.07	0.345±0.16	0±0.081	0±0.03	0±0.045
hl	500Kbps	0.981±0.016	0.92±0.064	0.859±0.074	0.752±0.09	0.462±0.2	0.267±0.12	0.025±0.05
	1000Kbps	0.94±0.05	0.894±0.07	0.746±0.1	0.663±0.1	0.329±0.15	0.043±0.1	0±0.015
	2000Kbps	0.918±0.05	0.84±0.074	0.65±0.072	0.488±0.075	0±0.07	0±0.05	0±0.02
sc	500Kbps	0.965±0.06	0.979±0.03	0.87±0.08	0.81±0.06	0.59±0.072	0.423±0.05	0.135±0.06
	1000Kbps	0.902±0.06	0.86±0.04	0.776±0.06	0.552±0.07	0.211±0.21	0.042±0.06	0±0.006
	2000Kbps	0.886±0.045	0.734±0.09	0.591±0.075	0.29±0.09	0.049±0.1	0±0.05	0±0.03
ul	500Kbps	0.982±0.02	0.927±0.066	0.825±0.07	0.736±0.064	0.421±0.07	0.259±0.063	0±0.03
	1000Kbps	0.944±0.06	0.935±0.063	0.82±0.05	0.725±0.05	0.411±0.12	0.113±0.154	0±0.08
	2000Kbps	0.91±0.065	0.854±0.03	0.671±0.07	0.563±0.1	0.0138±0.085	0±0.075	0±0.07
bk	500Kbps	0.993±0.009	0.952±0.044	0.882±0.06	0.818±0.093	0.6±0.05	0.457±0.025	0.196±0.131
	1000Kbps	0.989±0.014	0.94±0.08	0.79±0.06	0.777±0.06	0.511±0.054	0.262±0.145	0±0.033
	2000Kbps	0.952±0.03	0.882±0.052	0.751±0.066	0.616±0.07	0.191±0.182	0±0.032	0±0.03
lb	500Kbps	0.987±0.013	0.963±0.043	0.933±0.053	0.824±0.072	0.582±0.087	0.395±0.061	0.21±0.13
	1000Kbps	0.9711±0.037	0.92±0.055	0.8472±0.07	0.76±0.09	0.473±0.07	0.25±0.05	0.033±0.135
	2000Kbps	0.936±0.05	0.91±0.075	0.746±0.073	0.657±0.063	0.211±0.2	0±0.1	0±0.06
bg	500Kbps	0.964±0.042	0.962±0.06	0.866±0.092	0.814±0.07	0.57±0.075	0.42±0.1	0.25±0.077
	1000Kbps	0.948±0.06	0.943±0.03	0.854±0.082	0.731±0.05	0.41±0.061	0.22±0.09	0±0.022
	2000Kbps	0.932±0.03	0.878±0.06	0.774±0.055	0.593±0.05	0.17±0.206	0±0.05	0±0.034
bx	500Kbps	0.983±0.036	0.99±0.011	0.9±0.07	0.875±0.043	0.71±0.08	0.54±0.07	0.272±0.12
	1000Kbps	0.972±0.031	0.98±0.023	0.91±0.06	0.726±0.06	0.563±0.074	0.416±0.115	0.052±0.076
	2000Kbps	0.935±0.067	0.92±0.046	0.745±0.284	0.722±0.057	0.378±0.113	0.086±0.11	0±0.04
nr	500Kbps	0.996±0.006	0.978±0.03	0.941±0.033	0.93±0.057	0.751±0.084	0.682±0.064	0.377±0.122
	1000Kbps	0.989±0.02	0.96±0.043	0.93±0.046	0.866±0.077	0.712±0.078	0.47±0.054	0.286±0.1
	2000Kbps	0.965±0.04	0.956±0.055	0.881±0.034	0.815±0.06	0.49±0.091	0.34±0.1	0.022±0.097
pc	500Kbps	0.992±0.018	0.988±0.014	0.955±0.043	0.933±0.049	0.795±0.046	0.673±0.0641	0.53±0.083
	1000Kbps	0.978±0.033	0.974±0.026	0.917±0.043	0.881±0.0527	0.689±0.086	0.64±0.052	0.317±0.148
	2000Kbps	0.986±0.021	0.947±0.0284	0.9±0.05	0.87±0.04	0.634±0.065	0.49±0.059	0.085±0.114

cordingly. For example, in the presence of high losses, a service provider could decide streaming video type tb with high compression (low bitrate) instead of a low compression (high bitrate) version of it, to avoid quality drops.

IV. CONCLUSIONS

In this work we have explored the effect of lossy networks on 3D video streaming services. By means of an experimental test-bed, we have impaired and assessed the quality of a broad range of 3D stereoscopic video sequences in terms of content type, compression level and network loss rate. We have thus shown the non-linearities involved in 3D streaming, pinpointing how compression-before-transmission should be exploited to trade-off network and video quality.

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REFERENCES

- [1] A. Liotta, "The cognitive NET is coming," *IEEE Spectrum*, vol. 50, no. 8, pp. 26–31, Aug. 2013.
- [2] F. Agboma and A. Liotta, "Quality of Experience management in mobile content delivery system," *Telecommunication Systems*, vol. 49, no. 1, 2012.
- [3] M. Torres Vega, S. Zou, D. C. Mocanu, E. Tangdiongga, A. M. J. Koonen, and A. Liotta, "End-to-end performance evaluation in high-speed wireless networks," in *The Int. Conf. on Network and Service Management (CNSM)*, 2014.
- [4] C. T. Hewage and M. G. Martini, "Quality of experience for 3D video streaming," *IEEE Communications Magazine*, vol. 51, no. 5, pp. 101–107, 2013. [Online]. Available: <http://dx.doi.org/10.1109/MCOM.2013.6515053>
- [5] C. Perra, "Comparing gamma and weibull as frame size distributions for high efficient video coding," *Elektronika ir Elektrotechnika*, vol. 20, no. 8, pp. 44–48, 2014.

- [6] M. Fadda, M. Murrone, C. Perra, and V. Popescu, "Tv white spaces exploitation for multimedia signal distribution," *Signal Processing: Image Communication*, vol. 27, no. 8, pp. 893–899, 2012.
- [7] M. Urvoy, M. Barkowsky, R. Cousseau, Y. Koudota, V. Ricordel, P. L. Callet, J. Gutierrez, and N. N. García, "NAMA3DS1-COSPAD1: Subjective video quality assessment database on coding conditions introducing freely available high quality 3D stereoscopic sequences," in *QoMEX*, I. S. Burnett, Ed. IEEE, 2012, pp. 109–114. [Online]. Available: <http://dblp.uni-trier.de/db/conf/qomex/qomex2012.html#UrvoyBCKRCGG12>
- [8] C. Perra, "A low computational complexity blockiness estimation based on spatial analysis," 2014, pp. 1130–1133.
- [9] B. Saba, C. Perra, and D. Giusto, "Image transmission over error-prone channels," 2011, pp. 1195–1198.
- [10] C. Perra, P. Pes, and D. Giusto, "High-frequency error recovery in jpeg xr coded images," 2011, pp. 2217–2220.
- [11] J. Joskowicz and R. Sotelo, "A model for video quality assessment considering packet loss for broadcast digital television coded in h.264," *International Journal of Digital Multimedia Broadcasting*, vol. 2014, 2014.
- [12] D. Mocanu, A. Liotta, A. Ricci, M. Torres Vega, and G. Exarchakos, "When does lower bitrate give higher quality in modern video services?" in *Network Operations and Management Symposium (NOMS)*, 2014 IEEE, May 2014, pp. 1–5.
- [13] M. Torres Vega, V. Sguazzo, D. C. Mocanu, and A. Liotta, "An experimental survey of no-reference video quality assessment methods," *Int. J. Pervasive Computing and Communications*, vol. 12, no. 1, pp. 66–86, 2016.
- [14] S. Winkler, *Digital Video Quality: Vision Models and Metrics*, 1st ed. Wiley, Mar. 2005.
- [15] V. Menkovski and A. Liotta, "Intelligent control for adaptive video streaming," in *Consumer Electronics (ICCE)*, 2013 IEEE International Conference on, Jan 2013, pp. 127–128.
- [16] V. Menkovski, G. Exarchakos, and A. Liotta, "The value of relative quality in video delivery," *J. Mob. Multimed.*, vol. 7, no. 3, pp. 151–162, Sep. 2011.
- [17] M. Torres Vega, D. C. Mocanu, S. Stavrou, and A. Liotta, "Predictive no-reference assessment of video quality," *Signal Processing: Image Communication*, vol. 52, pp. 20 – 32, 2017. [Online]. Available: <http://www.sciencedirect.com/science/article/pii/S092359651630176X>
- [18] PacketStorm, "Packetstorm hurricane II network emulator," Available at <http://packetstorm.com/packetstorm-products/hurricane-ii-software/>.
- [19] x265, "HEVC/H.265," Available at <http://x265.org/hevc-h265/>.