Blind Quality Assessment for 3D-Synthesized Images by Measuring Geometric Distortions and Image Complexity

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Introduction

Free viewpoint video (FVV), due to its comprehensive applications in television entertainment, remote surveillance, medical applications and remote education, has been perceived as the development direction of next generation video technologies. FVV images are synthesized via a depth image-based rendering (DIBR) procedure in the "blind" environment. Therefore, a real-time reliable blind quality metric is urgently required. However, existing state-of-art quality metrics are limited to predict FVV images mainly because geometric distortions are generated by DIBR. In this paper, a novel blind quality metric, measuring Geometric Distortions and Image Complexity (GDIC), is proposed for DIBR-synthesized images.

Method Description

Overview

(a) clean image (b) geometric distorted image

Fig. 1

Fig. 1 shows that geometric distortions have a remarkable destructive effect on naturalness attribute of an DIBR-synthesized image. Compared to clean mages, the human visual system can easily observe geometric distortions in distorted images, which are marked by red boxes. In the research, a blind quality assessment metric for DIBR-synthesized images is proposed via measuring geometric distortions and image complexity. Our proposed metric contains three steps, including geometric distortion evaluation, image complexity estimation and a pooling stragety. The overview of the proposed quality model is shown in fig. 2.

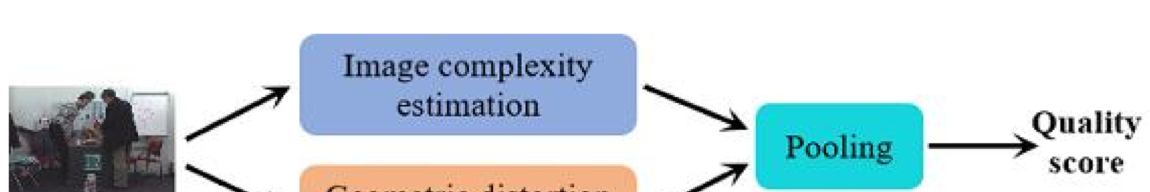


Fig. 2

Geometric Distortion and Image Complexity (GDIC)

➢ *Geometric Distortion Quantization*

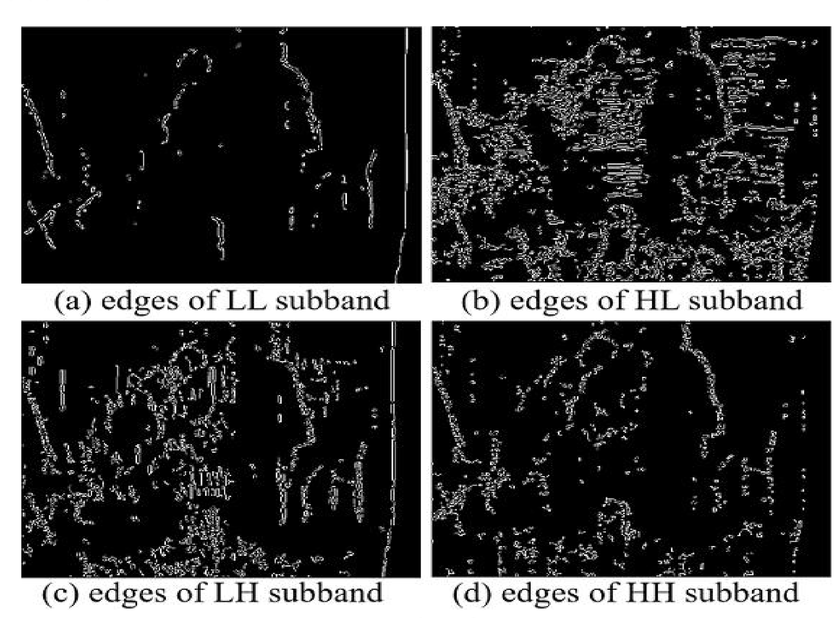
The geometric distortions are quantified by computing the edge structural similarities between low and high-frequency subbands

$$S_H = \frac{1}{L}\sum_{l=1}^{L}\left(\frac{2C_{LL}(l)\cdot C_{HL}(l)+\varepsilon}{C_{LL}(l)^2+C_{HL}(l)^2+\varepsilon}\right)$$

$$S_V = \frac{1}{L}\sum_{l=1}^{L}\left(\frac{2C_{LL}(l)\cdot C_{LH}(l)+\varepsilon}{C_{LL}(l)^2+C_{LH}(l)^2+\varepsilon}\right)$$

$$S_D = \frac{1}{L}\sum_{l=1}^{L}\left(\frac{2C_{LL}(l)\cdot C_{HH}(l)+\varepsilon}{C_{LL}(l)^2+C_{HH}(l)^2+\varepsilon}\right)$$

where C_{LL}, C_{HL}, C_{LH} and C_{HH} denote the edge maps of low-frequency (LL) and high-frequency (HL,LH and HH) subbands of a given DIBR-synthesized view. Fig. 3 shows an example of the edge maps of LL, HL, LH and HH subbands.



(a) edges of LL subband (b) edges of HL subband

(c) edges of LH subband (d) edges of HH subband

Fig. 3

➢ *Image Complexity Estimation*

A hybrid filter combining the Autoregressive (AR) and bilateral (BL) filter is employed to depict the texture and edge regions of DIBR-synthesized views, and its expression is as follows:

$$\hat{y}_q = \frac{Q^n(x_q)\hat{a} + kQ^n(x_q)b}{1+k}$$

where x_q is the pixel location in a synthesized view; $Q^n(x_q)$ is composed of the n neighboring pixels of x_q ; k adjusts the relative strength of the responses of $\hat{a}$ and b, which represent the coefficients of AR and BL filter respectively. Then, the image complexity is estimated by $F=-\int H'_{(\rho)}\log H'_{(\rho)}d_\rho$, where $H'_{(\rho)}$ represents the probability density of grayscale ρ in the error map between the given DIBR-synthesized view and its associated filtered result, i.e., $\Delta y_q = y_q - \hat{y}_q$; y_q is the value of a pixel at location x_q .

➢ *Pooling Stragety*

In order to eliminate the effect of image content diversity on NR IQA metric, the image complexity is used to normalize the quantized geometric distortions, so the overall quality score Q is computed as:

$$Q = \frac{\sum \omega_i S_i}{F}$$

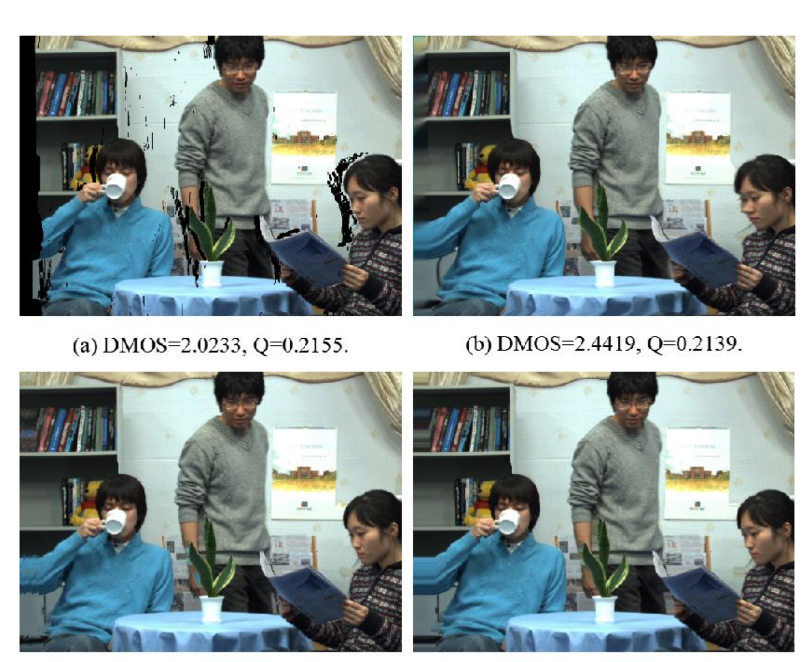
where *i = H,V and D*; Adjusting the weight coefficient of ω_i can improve the performance of the quality evaluation metric.

Results

Evaluation

Metric	PLCC	SRCC	RMSE	Designed for	Category
PSNR	0.3976	0.3095	0.6109	Natural Images	Full-Reference
SSIM [13]	0.4850	0.4368	0.5823	Natural Images	Full-Reference
VSNR [14]	0.4370	0.3851	0.5989	Natural Images	Full-Reference
IW-SSIM[15]	**0.5831**	0.4053	**0.5409**	Natural Images	Full-Reference
FSIM [16]	0.5828	0.4148	0.5411	Natural Images	Full-Reference
PSIM [17]	0.5315	0.4576	0.5640	Natural Images	Full-Reference
NIQE[18]	0.4374	0.3739	0.5987	Natural Images	No-Reference
QAC [19]	0.3519	0.3108	0.6232	Natural Images	No-Reference
SIQE [10]	0.3219	0.0739	0.6304	Natural Images	No-Reference
ILNIQE [20]	0.4998	**0.5348**	0.5767	Natural Images	No-Reference
3D-SWIM [2]	0.6584	0.6156	0.5011	DIBR-Synthesized Images	Full-Reference
MW-PSNR [3]	0.5622	0.5757	0.5506	DIBR-Synthesized Images	Full-Reference
MP-PSNR [4]	0.6174	0.6227	0.5238	DIBR-Synthesized Images	Full-Reference
MP-PSNR-reduce [5]	0.6772	0.6634	0.4899	DIBR-Synthesized Images	Reduce-Reference
Vinit [7]	0.7145	0.6293	0.4659	DIBR-Synthesized Images	Reduce-Reference
Yue [6]	0.6750	0.6520	0.4620	DIBR-Synthesized Images	No-Reference
APT [8]	**0.7307**	**0.7157**	**0.4546**	DIBR-Synthesized Images	No-Reference
Proposed GDIC	**0.7332**	**0.7551**	**0.4528**	DIBR-Synthesized Images	No-Reference

Table 1



(a) DMOS=2.0233, Q=0.2155. (b) DMOS=2.4419, Q=0.2139.

(c) DMOS=2.9070, Q=0.2099. (d) DMOS=2.9535, Q=0.2091.

Fig. 4

- ❖ Performance comparisons are conducted on the newly released IRCCyN/IVC database, which contains 12 original images and their associated 84 synthesized views
- ❖ PLCC, SRCC and RMSE are used to measure the competing IQA metrics for DIBR-synthesized views. We report the performance indices in the Table 1. The proposed metric achieves inspiring results, comparable to recently developed IQA methods
- ❖ Fig. 4 show four DIBR-synthesized views with different distortion levels. Obviously, with the increase of subjective scores (DMOS), the objective scores (Q) predicted by our GDIC decreases gradually. So our GDIC are highly consist- ent with subjective ratings

Conclusion

In this research, we have proposed a blind quality assessment metric of DIBR-synthesized images. The metric contains two parts, including geometric distortions quantization and image complexity estimation model. The first part is conducted to detect and quantify the geometric distortions. In the second part, image complexity is used to eliminate the impact of image content diversity on IQA metrics. Experiments conducted on IRCCyN/IVC DIBR image database denote the superiority of our blind quality algorithm as compared with prevailing existing FR, RR and NR methods, which include two types of IQA metrics designed for natural scene and 3D-synthesized images.

Acknowledgement

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