Inactive Regions Padding Methods for Rotated Sphere Projection of 360 Video

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Abstract

In the workflow of 360 video coding of JVET (Joint Video Experts Team), firstly the 360 videos are projected onto the 2D plane with diverse projection formats, such as Equi-Rectangular Projection (ERP), Cubemap Projection (CMP), Rotated Sphere Projection (RSP), etc. The projection format of RSP has inactive regions in the converted 2D plane. The inactive regions may cause visual artifact as well as the reduction of the coding efficiency due to discontinuity at boundaries between active and inactive regions. In this paper, to overcome these problems, the inactive regions are padded by using two types of adjacent pixels. Then padded regions of RSP are blended with inactive regions padded by proposed method. The experimental results demonstrate that, in terms of end-to-end WS-PSNR-NN, the proposed method achieves 0.1% BD-rate reduction. In addition, the visual artifacts along the borders between discontinuous faces are noticeably reduced.

1. Introduction

In recent years, 360 videos have been attracting increasing attention as a new type of media that provides immersive experiences. In JVET, which commenced work on a new video coding standard to be known as Versatile Video Coding (VVC), 360 videos are included in the scope of standard along with SDR (Standard Dynamic Range) and HDR (High Dynamic Range) video.

In general, existing video codecs are designed considering conventional 2D videos. Therefore, in the workflow of 360 video coding of JVET, firstly the 360 videos are projected onto the 2D plane with a projection format, such as ERP, CMP, RSP, etc. Then it is packed into a 2D rectangular image to be coded. In this process, a converted 2D image has inactive regions as well as discontinuities between faces in some projection formats. Such discontinuities and inactive regions may degrade coding efficiency and cause visual artifacts in a generated viewport which includes face boundaries. To solve these drawbacks, various methods have been proposed [1].

2. Rotated Sphere Projection (RSP)

The basic RSP [2] is a typical projection in which inactive regions exist. As shown in Fig. 1, the RSP has two equal-sized segments and places them on the 2D plane in two rows. On a sphere, the combined two segments of the RSP are similar to a tennis ball. Both sides of each segments are represented by arcs, thereby forming inactive regions. Then the inactive regions which are the corners of two segments of RSP are filled with the default gray color. The inactive regions may cause the visual artifacts as well as reduction of coding efficiency due to discontinuity at inactive pixel boundaries around arcs. To efficiently overcome these drawbacks, a padding method has been proposed in JVET [3]. As shown in Fig. 2 (right), padding is applied around arcs boundaries where the padded areas are drawn on 16×16 grid which aligns inactive and active area border with CU boundaries. The padded samples are samples that should be geometrically located in the padding area, which called geometry padding. This method noticeably reduces the visual artifact and the BD-rate performance are also improved. However, since there are still inactive regions, further improvement may be possible. In this paper, methods of inactive regions padding (IRP) is presented to efficiently improve coding efficiency as well as reducing visual artifact.

3. Inactive Regions Padding (IRP) for RSP

If the inactive regions are filled with the adjacent pixels in the given sphere video, the high correlation between active and inactive regions could be kept in the projected 2D video. Therefore, in this paper, the inactive regions are filled with the pixels obtained by two ways. As shown in Fig. 3 (a) of Test 1, the averages of the pixels of the rectangular face, which are adjacent to the arcs, are used to pad the corresponding inactive regions. In the Fig. 3 (b) of Test 2, the inactive regions are padded using the average pixels values of the arcs boundaries corresponding to each arc. The correspondences between inactive regions and associated faces are indicated with the same colors and numbers in Fig. 3 (a) and (b), respectively. Then to reduce discontinuities between filled inactive regions and already padded areas, the blending is performed. Fig. 4 shows an example of IRP process.

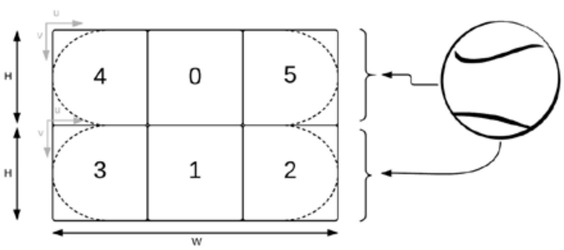


Fig. 1. Rotated Sphere Projection (RSP) [2]

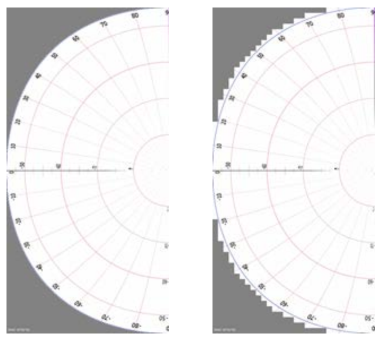
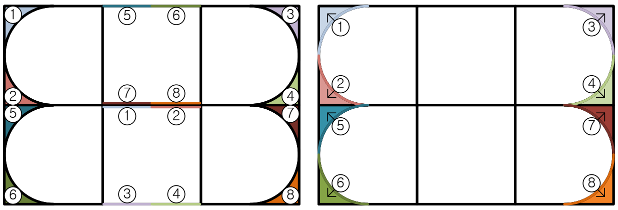


Fig. 2. A padding method of JVET-H0056 [3]



(a) Test 1 (b) Test 2

Fig. 3. Proposed inactive regions padding methods

Original Padding Inactive Region Blending

Fig. 4. Inactive regions padding process

4. Experimental Results

The proposed method was implemented on the 360Lib-5.0 and the HM -16.16 and evaluated according to the JVET common test conditions and the evaluation procedures for 360 videos [4].

4.1. Objective quality

The two tests were compared with the RSP of the last 360Lib software [5]. TABLE 1 shows the average BD-rate reduction on Y component in the five JVET – Call for Proposal test sequences with various quality metrics.

As a result, Test 2 of the proposed padding methods obtained the average BD-rate gain of 0.1% compared to the RSP.

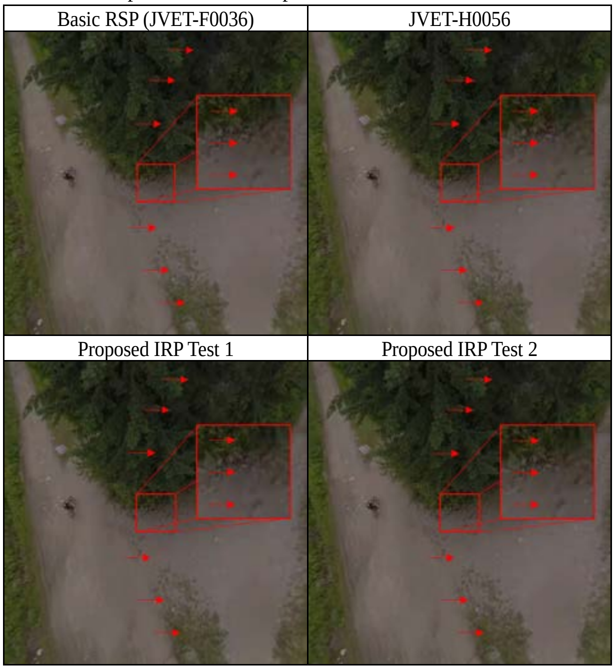
4.2. Subjective quality

The evil viewport [6], [7] are provided for the quality comparison in terms of the visual artifact. The two evil viewports are indicated by two vertexes on the RSP layout, which are (yaw, pitch) equal to (-135, 0) and (0, -45), as their centers. Accordingly, for each sequence, there are four decoded evil viewports for subjective quality comparison: (1) static viewport 1 centered at vertex 1, (2) static viewport 1 centered at vertex 2, (3) static viewport 2 centered at vertex 1, and (4) static viewport 2 centered at vertex 2. In TABLE 2, the decoded evil viewports of static viewport 2 centered at vertex 2 for the sequence *"ChairliftRide"* are shown for the quality comparison of four tests. The illustrated viewport frames are coded under a constant QP of 37.

TABLE 1. Experimental Results (Anchor: RSP)

Anchor: RSP	Test 1 E2E-WS-PSNR			Test 2 E2E-WS-PSNR		
	Y	U	V	Y	U	V
Trolley	0.1%	0.1%	0.2%	-0.1%	0.2%	0.1%
ChairliftRide	-0.2%	-0.4%	-0.2%	-0.3%	-0.5%	-0.5%
KiteFlite	-0.1%	-0.1%	0.1%	-0.2%	-0.2%	0.1%
Harbor	-0.1%	0.1%	0.0%	-0.2%	0.3%	-0.3%
Balboa	0.3%	0.9%	0.5%	0.2%	0.6%	0.1%
Total	**0.0%**	**0.1%**	**0.1%**	**-0.1%**	**0.1%**	**-0.1%**

TABLE 2. Viewport of static viewport 2 centered at vertex 2



5. Conclusions

In this paper, methods of padding inactive regions are proposed to improve coding efficiency and reduce visual artifact in RSP. The experimental results show that the average 0.1 % BD-rate reduction is obtained in Test 2. In addition, the visual artifact can be noticeably reduced by padding inactive regions with the proposed methods.

Acknowledgement

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References

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