INTERNATIONAL ORGANISATION FOR STANDARDISATION
ORGANISATION INTERNATIONALE DE NORMALISATION
ISO/IEC JTC1/SC29/WG07 MPEG 3DGH

ISO/IEC JTC1/SC29/WG07/M73364
Jul. 2025, Daejeon, KR

Title	**[GSC] Three-component rotation for video-based GSC**
Source	**Poznan University of Technology**
	Electronics and Telecommunications Research Institute
Author	**Adrian Dziembowski, Błażej Szydełko, Gwangsoon Lee, Jun Young Jeong**

1 Abstract

This document proposes an approach of reducing the number of components needed to represent quaternions from 4 to 3 without a need to use Euler angles.

2 Algorithm

The simplest solution to reduce the number of components needed to represent rotation is to convert quaternions to Euler angles. The equations are commonly known and easy to use. However, while conversion to Euler angles works and provides similar quality when no video compression is performed, it is slightly worse for video encoding, as in some borderline cases pixels change their value from very bright to very dark resulting in temporal flickering.

Therefore, we propose to keep the quaternion representation, but to reduce the number of components by getting rid of the W component. Such a reduction is possible as the quaternions representing rotation are redundant and changing their scale does not change the rotation. So the quaternion [X,Y,Z,W] = [1,2,3,4] represents the same rotation as [2,4,6,8] and so on.

The idea is to normalize all the quaternions - and to divide all the components by W: [X/W, Y/W, Z/W, W/W], basically setting W = 1 for all the splats. In this case the decoder assumes W = 1 and needs only three components per splat.

Such an approach works fine, unless W is very close to zero (or zero – then it does not work at all).

The solution to such a problem is to rotate the splats by 90 degrees around one of the X, Y, Z axes. The rotation changes the quaternion (including W), and among four rotations (no rotation, rotation around X, Y, and Z) we choose the one which gives us the biggest absolute value of W. Then we can do the normalization [X/W, Y/W, Z/W, W/W] without any problems.

The 90-degree rotation of the splat is performed by exchanging the scale components. For example, when the splat is rotated around X axis, SX and SZ are exchanged.

3 Results

The results presented below were obtained for Bartender sequence, QP = 4.

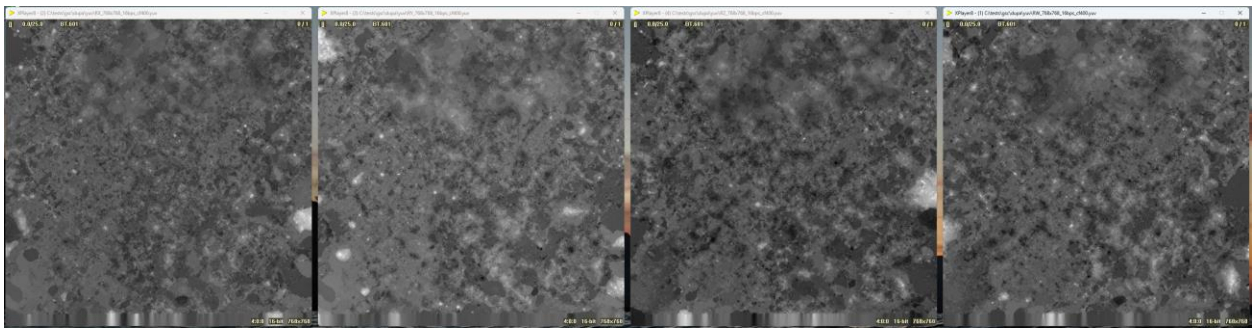

Fig. 1. Original, 4-component quaternions.

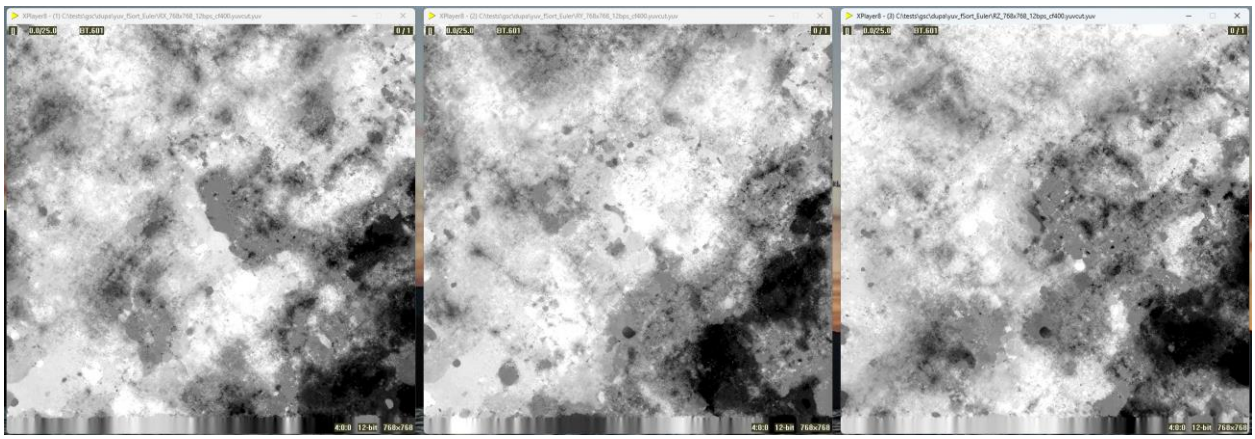

Fig. 2. Euler angles.

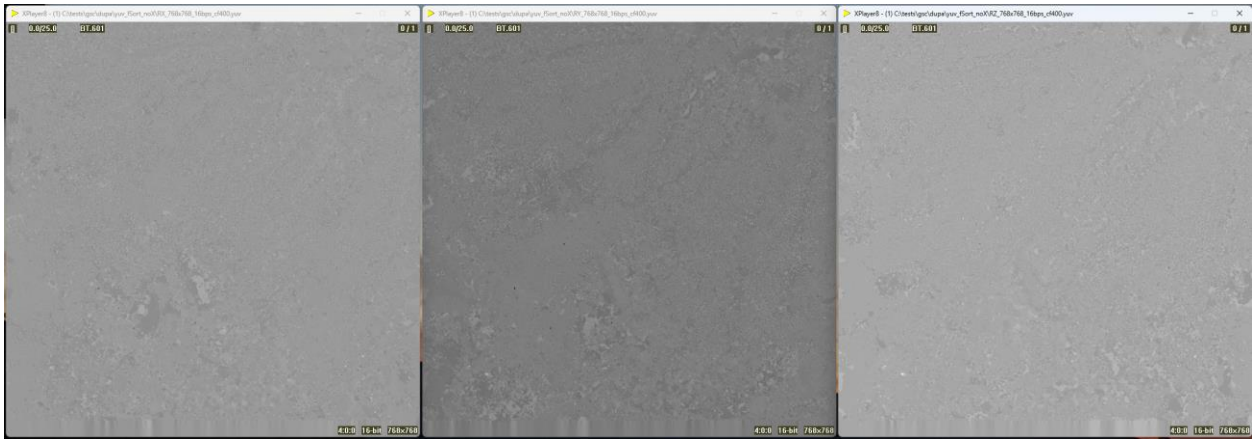

Fig. 3. Proposed 3-component quaternions.

Table 1. Bytes needed to store a single frame of the Bartender scene, frame 0, QP = 4.

	3-component Q	4-component Q	Euler angles
RX	266645	292639	334364
RY	279148	294671	334487
RZ	271027	296322	335330
RW		296339	
Total	816820	1179971	1004181

The proposed approach allows for removing ~1/4 of the bits required for representing rotation using the 4-component quaternions. When compared to Euler angles, the major gain comes from the temporal domain. The Euler angles tend to flicker, while proposed approach is stable as 4-component quaternions.

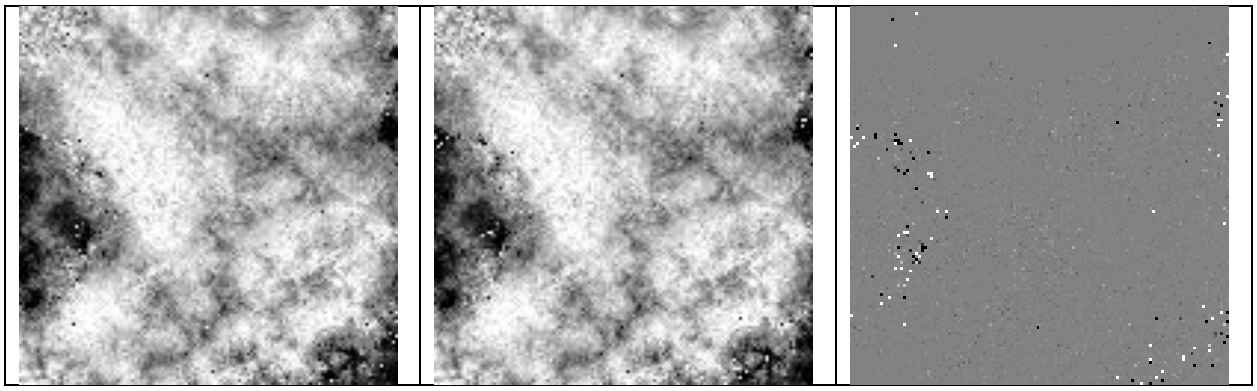

Fig. 4. Euler angles (RX) in temporal domain. From left: frame 0, frame 1, difference.

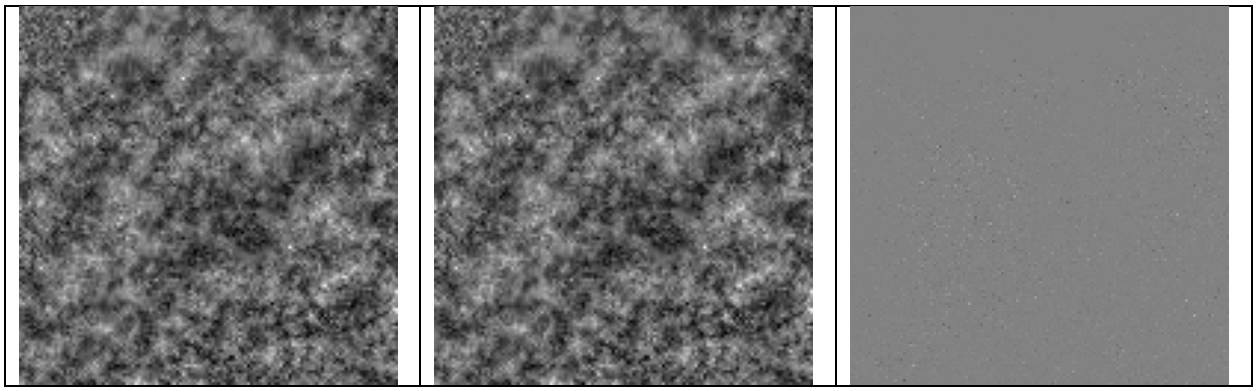

Fig. 5. 4-component quaternion (RX) in temporal domain. From left: frame 0, frame 1, difference.

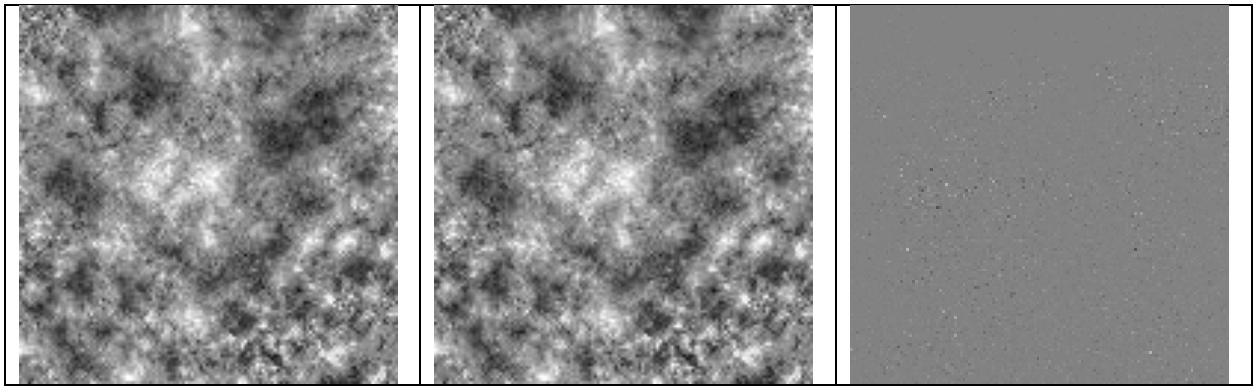

Fig. 6. 3-component quaternion (RX) in temporal domain. From left: frame 0, frame 1, difference.

4 Recommendations

We recommend to explore the approach of 3-component quaternions further.

5 Acknowledgment

This work was supported by Institute of Information & Communications Technology Planning & Evaluation (IITP) grant funded by the Korea government (MSIT) (No. 2018-0-00207, Immersive Media Research Laboratory).