360-Degree VR Video Watermarking Based on Spherical Wavelet Transform

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Similar to conventional video, the increasingly popular 360° virtual reality (VR) video requires copyright protection mechanisms. The classic approach for copyright protection is the introduction of a digital watermark into the video sequence. Due to the nature of spherical panorama, traditional watermarking schemes that are dedicated to planar media cannot work efficiently for 360° VR video. In this article, we propose a spherical wavelet watermarking scheme to accommodate 360° VR video. With our scheme, the watermark is first embedded into the spherical wavelet transform domain of the 360° VR video. The spherical geometry of the 360° VR video is used as the host space for the watermark so that the proposed watermarking scheme is compatible with the multiple projection formats of 360° VR video. Second, the just noticeable difference model, suitable for head-mounted displays (HMDs), is used to control the imperceptibility of the watermark on the viewport. Third, besides detecting the watermark from the spherical projection, the proposed watermarking scheme also supports detecting watermarks robustly from the viewport projection. The watermark in the spherical domain can protect not only the 360° VR video but also its corresponding viewports. The experimental results show that the embedded watermarks are reliably extracted both from the spherical and the viewport projections of the 360° VR video, and the robustness of the proposed scheme to various copyright attacks is significantly better than that of the competing planar-domain approaches when detecting the watermark from viewport projection.

CCS Concepts: • **Security and privacy** → *Digital rights management*;

Additional Key Words and Phrases: 360° VR video, watermarking, spherical wavelet, just noticeable difference

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