

PhD dissertation

Analysis, extensions, and optimizations of high-efficiency video compression techniques

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Abstract

This PhD dissertation presents a comprehensive investigation into the analysis, optimization, and extension of hybrid video coding (HVC) techniques, primarily (but not exclusively) focused on the High Efficiency Video Coding (HEVC) standard. As video content accounts for approximately 80% of global network traffic, the development of efficient representation and protection methods is critical for modern telecommunication infrastructure.

In Chapter 1, the analysis of video coding efficiency and statistical properties of data in the encoder has been discussed, along with practical applications of the obtained statistical knowledge.

In Chapter 2, the video encoder optimizations have been discussed. Especially, the improved Rate-Distortion Optimized Quantization (RDOQ) algorithm and optimized motion estimation method have been proposed.

Chapter 3 describes an extension of the HEVC standard to support 3D video and multiview content, particularly for Free-Viewpoint Television (FTV) systems with arbitrary camera configurations.

Chapter 4 summarizes the proposal of fast, energy-efficient watermarking algorithms that operate directly in the compressed bitstream domain for both AVC and HEVC standards.

The findings demonstrate that a deep understanding of bitstream statistics enables the creation of faster, more robust encoders and more versatile video systems. Although the experimental results mainly focus on HEVC, the methodologies and conclusions are universal to hybrid coding schemes and have been actively applied to the development of next-generation technologies like the Enhanced Compression Model (ECM) – the successor of Versatile Video Coding (VVC).

The dissertation takes the form of a collection of published, thematically related scientific articles, in accordance with Article 187, paragraph 3, of the Law on Higher Education and Science.