Chapter 2
Compression Artifacts in Modern Video Coding and State-of-the-Art Means of Compensation

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ABSTRACT

This chapter describes and explains common as well as less common distortions in modern video coding, ranging from artifacts appearing in MPEG-2 Video, MPEG-4 Part 2, H.264, and VC-1 to scalable and multi-view video coding based distortions, including the proposals for next generation video coding (NVC). In addition to a discussion about avoiding these artifacts through encoder-side measures, a state-of-the-art overview of their compensation at the decoder side is given. Finally, artifacts emerging from new sophisticated coding tools in current and upcoming video coding standards are discussed.

INTRODUCTION

As the coding tools used in modern video coding advanced in the last decades, new compression artifacts emerged, creating the need for sophisticated means of compensation. As the human eye is eventually the final recipient of the coded video, including distortions, artifact compensation based on human visual perception is an important research field, which is faced with new challenges due to new coding tools and the respective new artifacts induced by them.

It is important to be aware of these new artifacts and to analyze their sources in order to be able to compensate for them. As new coding tools are developed, most prominently represented by the current contributions to NVC, a basic understanding of the effects of the artifacts caused by these coding tools as well as their effect on the overall video quality is crucial. Although most of the

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current research is focused on the compensation of blocking, blurring and ringing artifacts and the development of new coding tools, this book chapter gives an overview of the artifacts caused by existing and new coding tools, focusing on mainstream block-based video coding represented by MPEG-2 Video, MPEG-4 Part 2, H.264, VC-1 and the amendments to H.264 for scalable and multi-view video coding. The interested reader may additionally find an overview of Wavelet-based compression artifacts appearing in Motion JPEG 2000 and others in Watson (1997) and Ramos (2001). Literature on non-mainstream video coding formats like Ogg Theora (Xiph. Org Foundation, 2011) is sparse (Crop, 2010) and therefore out of the scope of this book chapter.

The description of artifacts herein includes a discussion on the impact of new coding tools on artifacts in general and suggestions on how to minimize the appearance of these artifacts, thus eliminating the requirement for compensating them at the decoder side. After summarizing the properties and causes of commonly appearing artifacts such as blocking, blurring and ringing, including a number of artifacts originating from new coding tools, a short outlook on the perception of new artifacts and their connection to quality metrics concludes this chapter.

BACKGROUND

The origins of artifacts in block based transform video coding are, in most cases, directly or indirectly related to quantization errors in the transform domain, which are inevitable when lossily compressing images or sequences thereof. Since the first coding standards of this kind, e.g. JPEG for still image coding and H.261 for video coding, various related visual artifacts have been discussed throughout the literature.

Blocking Artifacts

Perhaps the most "famous" and most widely studied artifacts in today's block based video coding are blocking artifacts which occur due to the division of frames into macroblocks of rectangular shape. All blocks are coded separately from one another despite a possibly existing spatial correlation between them, yielding visible edges at macroblock borders. Due to the equidistant distribution of macroblock borders in JPEG, MPEG-2 Video and MPEG-4 Part 2 which is caused by the constant transform size of 8x8 samples, blocking artifacts are, in most cases, easily spotted by the Human Visual System (HVS) as a regular structure which does not belong to the image (Wu, 2006).

Due to the intense research concerning blocking artifacts, a number of possibilities for their compensation is available, e.g. (Oosa, 1998) and (Triantafyllidis, 2002). As both MPEG-2 Video and MPEG-4 Part 2 do not have an integrated deblocking filter, the artifact compensation has to be performed at the decoder side. In order not to cause a drift between encoder and decoder, deblocking has to be performed as a form of post processing on the decoded pictures which are displayed, but must not be applied to reference pictures which are used for motion compensated prediction.

Simple forms of deblocking involve low pass filtering at or around all macroblock borders, which causes blurring artifacts at borders which do not expose blocking artifacts (see below), whereas advanced approaches use edge detection algorithms to identify visually prominent edges or adaptively adjust the filter strength and/or area of influence, i.e. the number of samples around the macroblock border, based on image properties, quantizers, coding modes etc. The latter approach is incorporated in both H.264 and VC-1 in the form of an in-loop deblocking filter which is applied to all coded pictures before storing them in the reference buffers, yielding filtered references which are used for motion compensation. As experiments