

Chapter 8

Resilient Video Coding via Improved Motion Compensated Prediction

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ABSTRACT

Motion compensated prediction (MCP) is at the heart of modern video compression standard because of its ability to remove temporal redundancies. However, MCP is responsible for temporal error propagation, which can result in severe quality degradation in lossy environments. In this chapter, the authors present two innovative methods of improving MCP to be more resilient to packet losses. In the first method, the motion trajectory is used to develop a novel distortion weighting technique, and the second method exploits the presence of Intra macroblocks in previously coded frames to develop increase robustness.

INTRODUCTION

Digital video communication is a rapidly growing industry accelerated by increased consumer mobility. Robust video compression that potentially withstands varied network conditions has been at the forefront of research in both academia and industry. H.264/AVC is the latest international video coding standard (Wiegand, Sullivan, Bjontegaard, & Luthra, 2003; Richardson, 2003). It has

achieved a significant improvement in compression performance compared to the previous standards (up to 50% higher compression efficiency) and provides a network friendly representation of video for a variety of applications including, video telephony, broadcasting and storage. When transmitting H.264/AVC compressed bitstreams through unreliable channels, a mismatch between the encoder and decoder predictions caused by packet losses results in errors spreading both spatially and temporally due to Motion Compensated Prediction (MCP). Error resilient tools are

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therefore necessary to mitigate the effects of the spatio-temporal error spread.

In this chapter we study the behavior of a motion-compensated predictive video encoder, with the aim of improving its error resilience. After reviewing the principles of error resilience in video communications over lossy networks as well as some existing techniques, we will suggest two methods of improving the performance of compressed video in error prone environments. The first method is a procedure for weighting the distortion used in rate-distortion optimized video coding and the second method alters the reference frames used in predictive coding to generate a bitstream that is robust to transmission errors. Through simulations, we demonstrate that the weighted distortion technique is able to achieve performance comparable to current state of the art techniques, but without the assumptions made by existing schemes. Our second method improves on the performance of current reference frame altering techniques by up to 1.0 dB and also presents subjective video quality improvements.

BACKGROUND

Error Resilient (ER) video coding approaches can be classified into 3 broad categories: encoder, decoder and encoder/decoder co-operation techniques, which are summarized below,

1. **Encoder:** These methods involve adding redundancy at source coder, channel coder or both. Bitstream prioritization (Turletti & Huitema, 1996; Zhu, 1997; Sun & Zdepsky, 1994), and Forward Error Correction (FEC) (Chou, Mohr, Wang, & Mehrotra, 2001; Tan & Zakhor, 2001; R. Zhang, Regunathan, & Rose, 2001) fall into this category. Also some interesting work has been done on error resilient techniques that exploit channel characteristics. The main technologies are based on path diversity (Apostolopoulos,

Wong, Tan, & Wee, 2002; Nguyen & Zakhor, 2002; Padmanabhan, Wang, & Chou, 2003), network coding (Chou, Wu, & Jain, 2003; Wu, Chou, & Kung, 2005) and cross-layer design/optimization (Wu, Chou, Zhang, et al., 2005; Setton, Yoo, Zhu, Goldsmith, & Girod, 2005).

2. **Decoder:** These methods are also known as error concealment. Despite the use of encoder techniques to protect the video bitstream, some errors or losses may escape/penetrate encoder protections and cause a perceptual degradation of received video quality. Hence it is necessary for the decoder to perform error concealment. Most of these techniques exploit either spatial (Aign & Fazel, 1995; Wang, Zhu, & Shaw, 1993; Sun & Kwok, 1995) or temporal correlations (Aravind, Civanlar, & Reibman, 1996; Wang & Zhu, 1998; Wang, Wenger, Wen, & Katsaggelos, 2000; Lam, Reibman, & Liu, 1993; Lu, Lieu, Letaief, & Chuang, 1998) in order to predict the erroneous pixels.
3. **Encoder/Decoder:** ARQ methods fall into this category (Podolsky, McCanne, & Vetterli, 2001; Chou & Miao, 2006; Miao & Ortega, 2002). A better approach adjusts the encoder prediction upon receiving channel feedback to send a correcting signal that is able to update the decoder prediction to match that in the encoder (Girod & Farber, 1999; Chang & Lee, 2000). These methods may not be suitable for low delay applications such as video telephony.

This chapter is focused on improved source coding, which falls in the “Encoder” category defined above. Therefore, we now highlight the error resilient tools present in the H.264/AVC standard, followed by a discussion of rate distortion optimized (RDO) video coding, along with an exploration of current state-of-the-art end-to-end RDO techniques.

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