Chapter 14
Green Video Compression for Portable and Low-Power Applications

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ABSTRACT

This chapter presents recent advances in the implementation of video compression that allow for energy efficiency and management. Algorithmic complexity reduction and complexity management are key to the implementation of video compression in a green computing environment. The authors concentrate on low-power applications (such as smartphones or autonomous cameras), in which the ability to manage algorithmic complexity (and thus energy consumption) to match battery conditions and the priority of other tasks is one of the key enablers for reduced energy consumption. First, a study of the state-of-the-art video coding standard H.264/AVC and an analysis of its encoder complexity will be presented. Secondly, low complexity H.264/AVC encoder implementations will be explored in two categories as: Low Complexity Motion Estimation Algorithms and Low Complexity Mode Decision Algorithms. Later, a discussion of Complexity Scalable Encoding Algorithms that can adaptively adjust their computational complexities will follow. During the discussions, the authors will also introduce a novel framework for managing the complexity of an H.264/AVC encoder in a processor or power constrained environment as well as a complexity reduction tool. The chapter will conclude with a discussion about the future of sustainable green computing in video compression, followed by summary and concluding remarks.

INTRODUCTION

Digital video technology has been recently finding its way in many portable and wireless applications. Advances in video compression and wireless communications have made it possible to transmit video streams over wireless networks. It is now common to record and watch video on portable devices such as cell phones, and wireless surveillance camera networks are being deployed.

Although video de-compression is a rather easy task, video compression remains a complex and power-hungry endeavor. In order to reduce the

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energy footprint of such ubiquitous applications (and hence their carbon footprint), it is necessary to harness and manage the complexity involved in the video compression process.

This chapter aims to describe algorithmic ways to control and manage the complexity of digital video encoding, in order to allow integration of video compression in an overall green computing design, which can help prolong battery life and/or allow running more applications concurrently on low-power processors with limited computational capabilities.

Over the years, video compression algorithms have improved in their compression efficiency. H.264/AVC is the state-of-the-art international video coding standard developed by the *Joint Video Team* (JVT) (Wiegand, Sullivan, Bjontegaard, & Luthra, 2003). JVT is a joint workforce established by two study groups, ITU-T Video Coding Experts Group (VCEG) and ISO/IEC Moving Pictures Experts Group (MPEG), with the vision of finalizing the new video coding standards. H.264/AVC adopts highly advanced and flexible encoding techniques to achieve high compression efficiency which significantly surpass previous standards. The high performance of the new standard renders it the prevalent compression algorithm in many applications and platforms. However, the encoding techniques employed in the standard come with a price of increased computational complexity. Although designs that are capable of performing such complex functions are realizable with the improved computational power of the IC chips, the increased computational complexity poses a great problem particularly for the battery operated portable devices with limited processing capabilities such as mobile phones and PDAs. In fact, it has been shown that the processing of even a QCIF (176×144) video for communication over a wireless network consumes 2/3 of the total power which exceeds by far the transmission in terms of power consumption (Agrawal, Chen, Kishore, Ramanathan, & Sivalingam, 1998).

An essential green computing objective is to improve energy efficiency while maintain a good quality of service. In the case of video compression, this involves hunting down the causes of complexity (and hence energy inefficiencies) in a compression algorithm, and finding ways to avoid them, but beyond this, it also means being able to maintain service (i.e. video compression), in cases where the battery life of the device might prevent the algorithm from running at full performance, which means that a complexity-adaptive scheme is necessary. Therefore, the design of computational complexity control algorithms for video coding has become a highly active research field. A complexity control structure should comprise of two distinct components, a low complexity component, and a complexity scalable component that can adapt the computational complexity of the system and operate under variable resource constraints. In the recent years, different techniques have been developed which are either low complexity or complexity scalable but only a few that joins the two notions together.

The purpose of this chapter is four-fold. We will first describe the computational complexity incurred by individual components of the H.264/AVC encoding process. Then, we will investigate the existing energy efficient encoding algorithms developed to operate at low and variable complexity levels. Subsequently, we will introduce a novel framework for managing adaptively the complexity of an H.264/AVC encoder. Lastly, we will consider the sustainability of green computing in the future directions of video compression.

The following section constitutes a short review of video compression principles as they are applied in a recent standard (namely H.264 AVC), to allow readers not familiar with the video compression domain to fruitfully read further sections. It is mainly inspired by review papers on the subject (such as Wiegand, Sullivan, Bjontegaard, & Luthra, 2003), and is by no means an exhaustive review of the topic.

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