Video Compression for Wireless Transmission: Reducing the Power Consumption of the WPAN Hi-Speed Systems

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Abstract. In this paper, we consider the power consumption aspects of video over wireless transmission in wireless personal area networks. We show that lossless and lossy compression always gives power consumption gains if we consider joint power consumption of transmission and compression units.

Keywords: wireless video transmission, compression, power saving, HDTV, WPAN, NGmS, 802.15.3c, wireless display.

1 Introduction

Video transmission in wireless personal networks (WPAN) has become a hot topic in the modern industry. The ability to use 60GHz spectrum led to new communication standards development to cover short range video delivery tasks. The standards like WirelessHD [1], IEEE 802.15.3c [2] and NGmS (Next Generation millimeter-wave Systems) are designed especially to transmit the uncompressed high-definition video (HD video) over wireless for video cable replacements in home or office use, to exchange multimedia data in WPAN networks using the handheld devices or to connect the handhelds to the remote display panels. Traditionally the compression (lossless or lossy) was aimed to decrease the data size to be transmitted, and everyone understands that if the channel bandwidth may become smaller that the uncompressed data size, then using of compression is the only solution. But if the channel bandwidth is always high enough to fit the uncompressed data the question is: do we need a compression in the transmission chain? Regarding the mobile devices such as handhelds the one of the most interesting questions is the battery power consumption and battery live time. When the device also has a capability to use the remote display connected with wireless protocol like NGmS or other the question is: how much will affected the total power consumption of the handheld by the video over wireless transmission? And is there any possibility to decrease the power consumption and to save battery?

In this paper, we show that even if we have a very high bandwidth channel that can fit all raw HD video data, it is always better to use lossless or lossy video compression

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before transmission to decrease the power consumption. It is clear that the compression scheme will also consume the battery power, but we show that it is possible to develop a very small and power efficient compression scheme based on JPEG-LS [3] or H.264/AVC [4] standards that allows to minimize the total power consumption of transmission and compression comparing to the uncompressed video transmission power consumption.

The paper is organized as follows.

In section 2 we formally define the problem of selecting an efficient video compression method while minimizing the total power consumption of the whole system. We also suggest the simple power-rate model introducing the overall power consumption at the transmitter as a function of the input data rate. In section 3, we present the compression schemes based on JPEG-LS and H.264/AVC standards showing what set of options we select to be used. Then we estimate the compression efficiency (simulation results for rate-distortion functions) considering HD video of three types: computer screen graphics, synthetic movie and natural movie. In section 4, we apply the power-rate model to estimate the power consumption of the real video compression/transmission system taking NGmS networking as an example. Section 5 concludes the paper.

2 Problem Statement

The goal of this work is to estimate the efficiency and advisability of compression in wireless video cable replacement from the power consumption point of view for the overall system. The main estimation criteria are the total power consumption at the transmitter side and the quality of the reconstructed video sequence at the receiver after transmission.

Therefore first of all we should find a relation between these criteria and define a power-distortion model connecting energy consumption for video processing/transmission and quality (PSNR) of the received frames. Such a model consists of several parts.

Firstly we introduce analytical power-rate function that refers to the overall power consumption at the transmitter required to support different compression rates. Models that use Shannon bound for power-rate approximation such as [5] are absolutely unsuitable here for WPAN systems due to much smaller WPAN rates for the given power consumption level. Therefore below we present and describe new wireless-oriented linear power-rate model.

Secondly real rate-distortion function is estimated for different video compression algorithms. For that we implemented the compared encoders in RTL. So the results obtained are well correlated with practice and our final goal – designing of the hardware low-complexity video transmission system. Existing complexity-rate models like in [6] are unfortunately quite inaccurate and provide very rough estimates only.

Summarizing the described two stages i.e. basing on analytical power-rate function and experimental rate-distortion function it is possible to estimate the required power-distortion function for the selected encoder and video transmission system.

In this work we assume the following scenario: the maximum channel bandwidth is high enough to fit all possible compressed video data (even if it is compressed with compression ratio 1, i.e. uncompressed). We want to compare the power consumption