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Error Resilient Video Coding for Wireless Visual Sensor Network

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Abstract: This work proposes an error-resilient video coding scheme for improving the ecosystem of Wireless Visual Sensor Network (WVSN). In order to optimize the video information communication over WVSN, this work first provides a discussion on ecology technology model of video transmission in the WVSNs. And then proposes a Distributed Video Parallel Coding scheme, which make use of the correlation of video information in the decoder side, to cope with the loss of video data over wireless error-prone channel. Specifically, this work proposes a Partition Irregular Repeat Accumulate codec, which exhibits better error resilience performance and obtain the same compression ratio with traditional video coding method. The experimental results indicate that the performance of the proposed Distributed Video Parallel Coding scheme is promising and can better optimize the ecosystem of video communication over WVSN.

Keywords: Wireless Visual Sensor Network; Error Resilient; Distributed Video Coding

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1. Introduction

Wireless Visual Sensor Network (WVSN) improve the quality of human daily life like ubiquitous city and healthcare services [1], which may be deployed in failure-prone environments, and video transmission code easily fail. The reliable visual information communication is one of the most important factors in the ecological chain of WVSN, i.e. "Visual Sensing- Compression- Transmission- Decompression- Monitoring/Decision". Information ecosystem has been widely used, and applied as a mature theory in the education construction or an improved understanding of modern health information [2-3]. But few researcher have study the ecosystem of video transmission. Jannis Kallinikos took the video as digital object and studied the production and distribution of video content in the internet media ecosystem [4]. Tiwari A proposed method and apparatus to provide an ecosystem for mobile video [5]. However, most of the existing works for multimedia divide the information communication tasks into isolated episodes of "compression", "power consumption" and "error resilience", without considering the interaction between them. In order to optimize the ecosystem of video information communication over WVSN, this work first provides a discussion on ecology technology model of video transmission in the WVSNs. And then make use of an error-resilient video coding scheme, Distributed Video Coding (DVC), for improving the ecosystem of WVSN. In order to jointly consider the "compression", "power consumption" and "error resilience", this paper first proposes a Distributed Video Parallel Coding (DVPC), which make use of the correlation of video information in the decoder side, to cope with the loss of video data over wireless error-prone channel. Then a Partition Irregular Repeat Accumulate (PIRA) codec for distributed joint source-channel coding (DJSCC) scheme has been proposed for better error resilience performance, while remain the power consumption constrained.

This paper is organized as follows: Section 2 describes the proposed DVPC and the DJSCC based on the proposed PIRA. The experimental results and discussion are located in Section 3.

2. The proposed error resilience video coding

This work provides an ecosystem model of video coding and transmission in the WVSNs, which is shown in Figure 1. For the WVSN nodes, the video capture devices may not have enough computer power and resources, thus the encoder needs the lower complexity. Meanwhile, there is channel loss in the video transmission part, which affects the decoding quality. The error resilience of video coding scheme plays an important role in improving the decoded video quality. In summary, the traditional video coding schemes, such as HEVC, are based on high complexity and power consumption of encoders, which are not applicable in the WVSN. On the other hand, DVC is an innovative paradigm which shifts the processing complexity from encoder to decoder, and has better error resilience in the video transmission [6]. According to the methodology of information ecology, this work proposes a balance video coding scheme between "complexity", "compression", "power consumption", "error resilience" and "decoding quality", which is named DVPC.

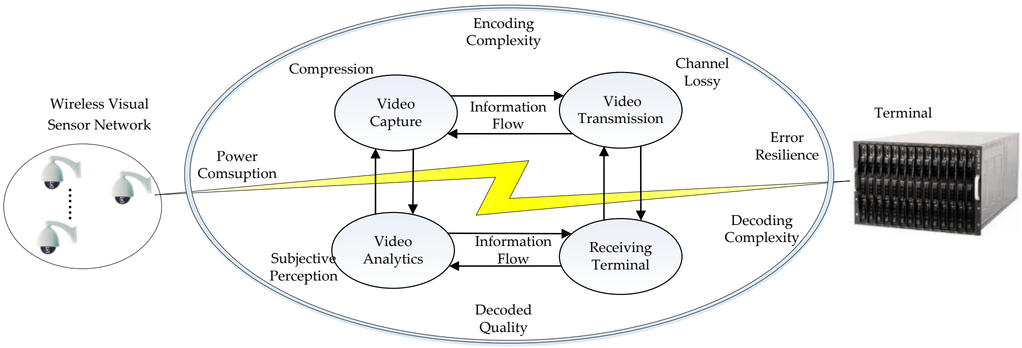

Figure 1. The ecosystem of video coding and transmission

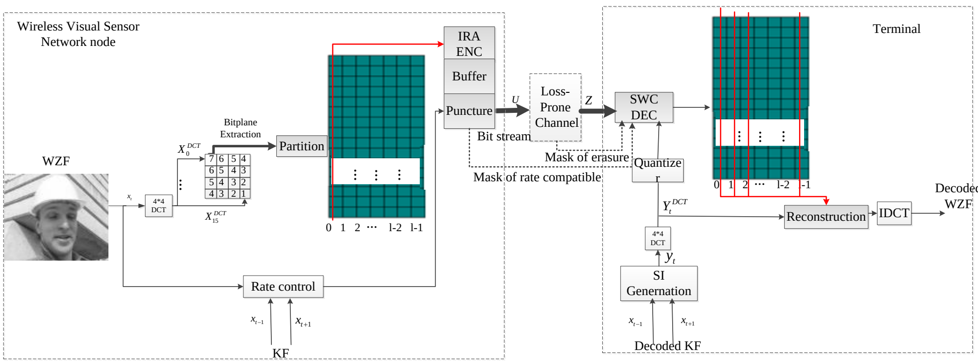

Figure 2. The proposed DVPC architecture

The DVPC is shown in Figure 2. All of the frames are divided into Key Frames (KF) and Wyner-Ziv Frames (WZF) according to the GOP size and the WZF are encoded using WZ codec. The pixels are grouped into 4×4 blocks, and DCT is applied to each block in order to compute the coefficients. Each DCT coefficient is quantized according to a quantization parameter, which is decided by the chosen quantization matrix [6]. Then, each coefficient was extracted into bit planes. Then, they were encoded using the proposed PIRA encoder. In the proposed PIRA, the side information, Channel error-prone condition, and the received parity bits are used to calculate the initial LLR of the iterative decoding.

The DJSCC encoder based on PIRA is comprised of three steps: (1) Source partition: Divide the information bits into k_0 groups of n bits. (2) Encoding: The bits are encoded. (3) Rate Compatibility:

Generate a random sequence to be the transmission mask, which is known by the encoder and decoder.

3. Results and Discussion

In order to validate the error resilience of the proposed DVPC, the Rate Distortion (RD) performance was tested over wireless channels. A PIRA code was designed in a rate of 1/2 and length of 1584, firstly. In all of the experiments, the luminance of the standard video tested sequence ('Foreman') was encoded at 15-fps. The transmission channel for different erasure ratios was evaluated. Figure 3 shows that the PSNR decreased as the α increased. The PSNR of the DVPC decreased less than that of the LDPC-based DVC [7] by approximately 0.15 dB in the 'Foreman'.

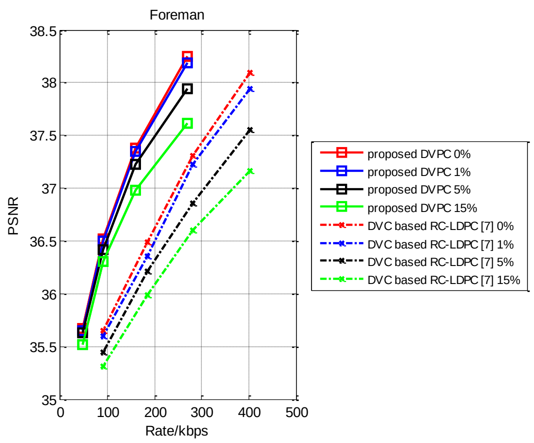

Figure 3. RD of *WZF* over wireless channel without FC for '*foreman'* sequence

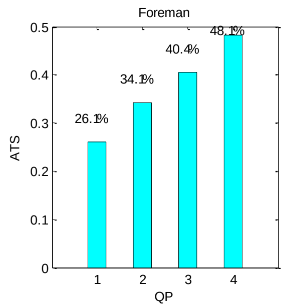

Figure 4. RD of *WZF* over wireless channel without FC for '*foreman'* sequence

In order to compare the time complexity based on different channel codes with no loss, we calculated the Average Time Save (ATS) ratios between the LDPC-based DVC [7] and the DVPC scheme.

And the results are given by Figure 4, in which four QP matrix {1,2,3,4} [7] for the tested sequences result in different bit rates. With the higher bit rates, the more time saved by the DVPC scheme. Sometimes saved about half of codec time. Thus the PIRA is a low delay channel codec and is suitable for practical DVPC.

As shown in these experimental results, the proposed DVPC scheme exhibits a better error resilience and lower time complexity than the LDPC-based DVC. In a word, the proposed DVPC scheme achieves an ecology balance between "complexity", "compression", "power consumption", "error resilience" and "decoding quality", and is very effective for video transmission over wireless channels.

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Conflicts of Interest: No conflict of interest exits in the submission of this manuscript, and manuscript is approved by all authors for publication. I would like to declare on behalf of my co-authors that the work described was original research that has not been published previously, and not under consideration for publication elsewhere, in whole or in part. All the authors listed have approved the manuscript that is enclosed.

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