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Mobile video communications based on cloud transcoding †

Song Rong [1], Linbo Qing [1,*], Yinhao Xu [1], Xiaohai He [1], and Yonghong Peng [2]

1 College of Electronics and Information Engineering, Sichuan University, No.24 South Section 1, Yihuan Road, Chengdu, China; rongsong1993@stu.scu.edu.cn (S. R.); qing_lb@scu.edu.cn (L. Q.); 1152396036@qq.com (Y.X.); hxh@scu.edu.cn (X. H.)

2 Faculty of Computer Science, University of Sunderland, Chester Road, Sunderland, SR1 3SD, UK; Yonghong.Peng@sunderland.ac.uk (Y.P.)

* Correspondence: qing_lb@scu.edu.cn (L. Q.); Tel.: +86-028-8546-3466

† Presented at the IS4SI 2017 Summit DIGITALISATION FOR A SUSTAINABLE SOCIETY, Gothenburg, Sweden, 12-16 June 2017.

Published: date: 9 June 2017

Abstract: In the ecological chain of mobile video communication, most of the existing video coding schemes are focusing on the compression performance while sacrificing the computational complexity. For mobile-to-mobile video communication, both the transmitter and receiver devices may have limited computing resources. Consequently, the unbalance between the power consumption and compression efficiency is critical for the video communication ecosystem. Based on the advantages of the cloud computing, this study proposes a low complexity end-to-end video communication system based on the cloud transcoding. A distributed video coding (DVC) to high efficiency video coding (HEVC) transcoder is proposed for implementation on cloud, while the user ends are computational light-weighted.

Keywords: mobile video communication; DVC; HEVC; cloud transcoding

1. Introduction

The rapid development of mobile communication technology (e.g. 5G communication) has contributed a lot to video transmission [1]. However, the issue about energy consumption of traditional video coding standard is still challenging due to the complicated encoding paradigm. In the existing mobile video communication, great efforts are made to study "Encoding-Transmission-Decoding" in order to reduce the bandwidth requirement. In other word, most of the existing video coding schemes focusing on the compression performance while sacrificing the computational complexity, obviously, these methods often focus only on the compression part, but ignores the power consumption that is also critical for practical scenarios, which would lead to the unbalance of the video communication ecosystem. Information ecosystem theory has been widely used in recent years [2], and applied as a mature theory in the healthy ecology systems of hospital information and agricultural domain [3-4]. All of these studies have employed the "Ecological Methodology" to understand the information process deeply, but few researchers have studied the ecosystem of video transmission. So, this work presents a mobile video communication ecosystem based on cloud transcoding to solve the unbalanced relation between the power consumption and compression efficiency.

2. Problem analysis

For mobile-to-mobile video communication, both the transmitter and receiver devices may not have enough computer power and resources. Meanwhile, most of the traditional video coding schemes for mobile devices divide the information communication tasks into isolated episodes of "compression performance" and "power consumption" etc., without considering the interaction of those tasks. Therefore, how to find a more effective method to meet the requirement of the mobile communication devices is an urgent problem. On the one hand, traditional video codecs, such as HEVC are based on the frameworks which have encoders of higher complexity than decoders [5]. On the other hand, DVC is an innovative paradigm which shifts the processing complexity from encoder to decoder [6]. In order to provide a mobile video communication framework of low complexity at both end-user devices by combining the characteristics of two video coding schemes, this paper proposes an improved DVC to HEVC video transcoder based on cloud computing. As shown in Figure 1, the computational complexity can be taken over by the transcoder which has powerful processing capacity, so that the problem of this unbalanced relation between the power consumption and compression efficiency in mobile video communication ecosystem could be effectively solved.

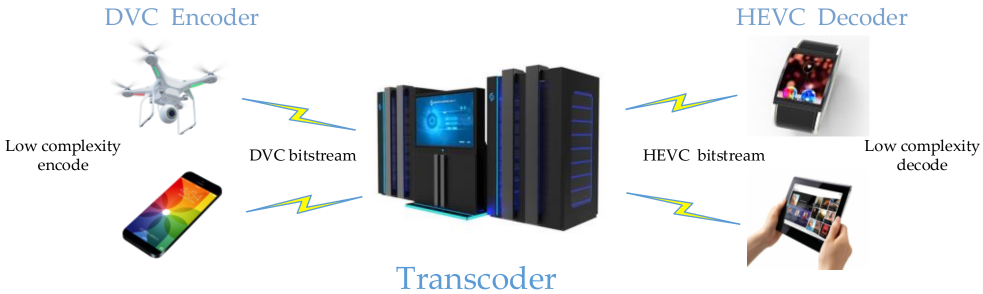

Figure 1. System using a DVC/HEVC transcoder

3. Proposed video transcoder

Figure 2 shows the proposed video transcoder, the main ideal of the proposal is to exploit the valuable information of the DVC decoding which can be used for the HEVC encoding algorithm, so that the more power resource can be saved during the transcoding process. It is well-know that the HEVC encoder adopts a recursive quad-tree partition to split CTUs into CUs through a complicated Rate Distortion Optimization (RDO) process, which brings the huge computational complexity. In this paper, the process of subdividing each CUs depth in HEVC could be accelerated by re-using the motion vectors (MVs) information of the DVC decoding stage.

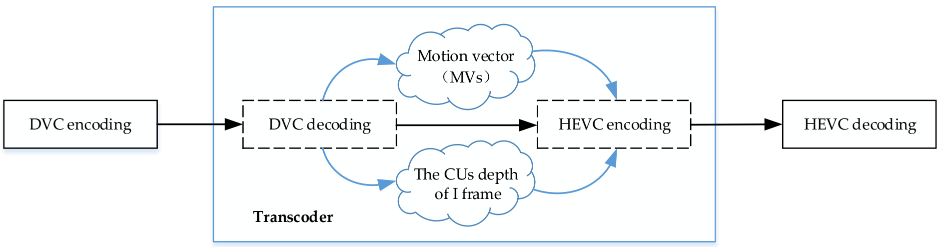

Figure 2. Proposed DVC to HEVC video transcoder

In DVC, the key frames are encoded using HEVC Intra, so they can be directly transmitted to the receiver without any transcoding conversion as I frames in the transcoder device. For the same GOP (Group of Pictures), it would be inter-frame correlation between the P frames and I frames. The partition modes of P frames could be on the basis of the partition modes of I frames, but the proportion of I frames CUs depth is 90% larger than P frames. To this phenomenon, a block merging method based on data statistic model is proposed to handle the problem to some degrees, e.g., every four '8×8' CUs and '16×16' CUs will be directly merged into one '16×16' CUs and '32×32' CUs respectively. After that, a rough CUs partition model of P frames may have a large difference with the original partition model of P frames in HEVC. Therefore, a block repartition algorithm for P frames is proposed based on the motion vectors (MVs) generated in DVC. For each CUs, we find five points which include four vertexes and one central point to calculate the mean and variance of the corresponding MVs to decide whether the CUs need to be divided. If both the mean and the variance are greater than a threshold, it indicates that the CUs exists some irregular movement areas, the current CUs will be split into four sub-CUs, or the CUs stays constant.

4. Results and discussion

In order to validate the effectiveness of the proposed fast transcoding algorithm from DVC to HEVC, the HEVC testing model HM16.1 are adopted for simulation bench. The reference transcoder consists of a full DVC decoder followed by a full HEVC encoder. The results are presented in Table 1. Experimental results show that compared with the reference transcoder, the proposed transcoder can achieve 60% to 50% total encoding time saving with negligible rate distortion drop.

Table 1. RD performance of the DVC/HEVC video transcoder

Sequences	∆PSNR(dB)	∆Bitrate(%)	∆Time(%)
FourPeople	-0.18	0.67	-57.83
Johnny	-0.01	0.70	-60.65
BQMall	-0.01	2.06	-55.64
BasketballDrill	-0.02	2.88	-56.68
Mean	**-0.06**	**1.58**	**-57.70**

In general, this paper demonstrated a result that the ecological methodology employed in mobile video communication system could achieve better performance in terms of the balance between compression efficiency and power consumption, compared with the traditional scheme where the design of compression efficiency and power consumption are carried on separately and isolated -- the typical scheme of "divide and conquer".

Acknowledgments: This project was supported by the Fundamental Research Funds for the Central Universities (No.2015SCU04A11), the National Natural Science Foundation of China Grant (No. 61471248).

Author Contributions: S.R. conceived the experiments and wrote the paper; L.Q. and Y.X. designed the experiments of the article; X.H. contributed the application of Information Ecology into video communication; Y.P. completed the final approval of the version to be published.

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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