Newsletter No. 24
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Hybrid Distributed Video Coding with Frame Level Coding Mode Selection

Foreword

In a machine-to-machine (M2M) network, distributed video sensors/cameras collect video data which then is analyzed and processed on aggregation nodes or by cloud servers. Two concerns involve here: the hardware costs of sensor nodes and the requirement of long sustaining time for low power dissipation. One of our SIGGSP teams aims to develop a technique to measure the energy consumption/complexity of the sensors and aggregation nodes. A hybrid coding structure is proposed to increase the efficiency of current distributed video coding (DVC) codecs. The hybrid DVC framework performs comparably to H.264 No Motion with much lower encoding complexity.

—From Editorial

In a machine-to-machine (M2M) network with video sensors, distributed video sensors/cameras capture video sequences and communicate with the aggregation nodes, as shown in Fig. 1. The video data are then analyzed and processed on the aggregation nodes or by the cloud servers. Since the number of distributed sensor nodes is more than that of the aggregation nodes, the hardware costs of sensor nodes are mainly concerned. Furthermore, long sustaining time is usually required, making low power dissipation another key requirement for the distributed video sensors. Our team at National Taiwan University aims to develop coding and analysis subsystems of distributed video sensors that employ distributed video coding techniques to scale with the energy consumption/complexity of the sensor and aggregation nodes. This report demonstrates one of our research outputs about distributed video coding.

Congratulations!

- Associate Director, Professor Bing-Yu Chen and his research team won the Best Paper Award of ACM CHI 2013, “NailDisplay: Bringing an Always Available Visual Display to Fingertips.” The team is interviewed by Reuters, a famous American media.
- SIGCAM Co-PI Mi-Yen Yeh won the Best Paper Award at the 28th Annual ACM Symposium on Applied Computing, "MLC-Flash-Friendly Logging and Recovery for Databases." It is one of the 5 best papers among 1063 paper submissions, where the acceptance rate is 24% for ACM SAC of this year.
- One of our SIGSSA teams, PI Professor Joe-Air Jiang and Co-PI Dr. Cheng-Long Chuang are interviewed by BBC news for their contributions on Taiwan’s agricultural revolution!

Events

- M2M Project Monthly Presentation on April 24—"M-CHESS: M2M-based Context-aware Home Energy Saving System" of SIG Smart Service and Applications Group
- [Invited Talk] Fuchun Joseph Lin, Professor of Department of Computer Science of NCTU and Associate Chief Director of Microelectronics and Information Systems Research Center at NCTU, talks about "Cloud and Big Data Computing Platforms for M2M Communications Systems" on March 29th, 2013
- [Invited Talk] Jure Leskovec, Assistant Professor of Computer Science of Stanford University, talks about "Data Mining in Massive Online Social Networks" on March 29th, 2013

Distributed video coding (DVC), a new video coding paradigm based on Slepian-Wolf and Wyner-Ziv theories, is a promising solution for implementing low-power and low-cost distributed wireless video sensors since most of the computation load is moved from the encoder to the decoder, compared with conventional video coding systems, such MPEG standards. However, it has been shown that there is still room to improve the coding efficiency of the current DVC codecs. A hybrid coding structure with frame-level coding mode selection (CMS) is proposed in this project. As shown in Fig. 2, we propose to combine three coding techniques used by the conventional video codecs, residual coding, skip mode, and entropy coding, into the DVC system. The coding mode selection block refers to the quantized coefficients of different discrete cosine transform (DCT) bands of the difference frame to select between several coding modes, including skip, channel coding, entropy coding, and hybrid coding modes for each band, to improve the coding performance.

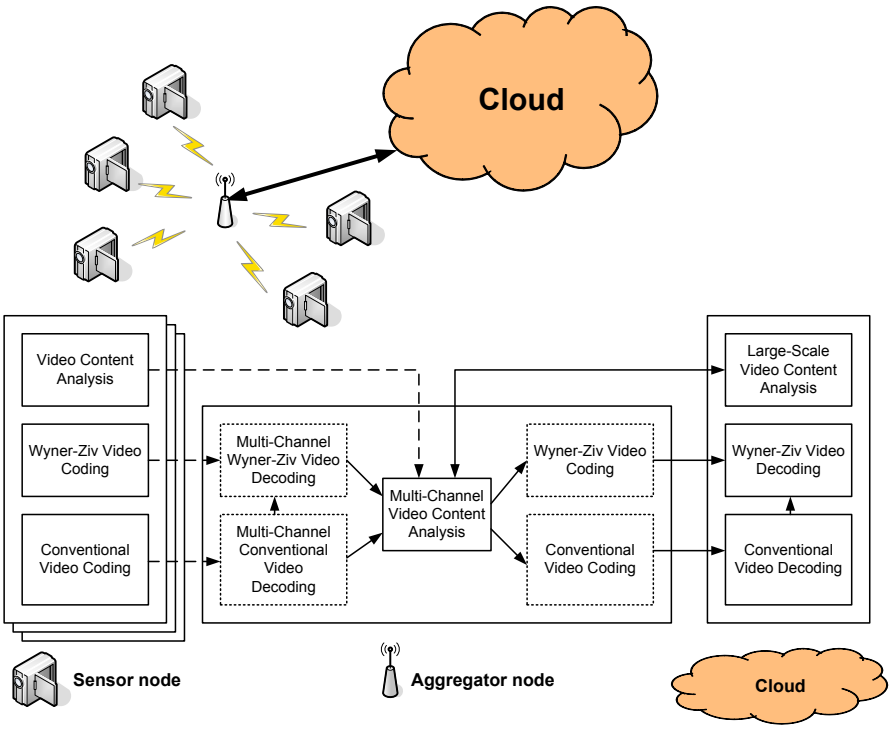


Fig. 1. Distributed video sensors in M2M network.

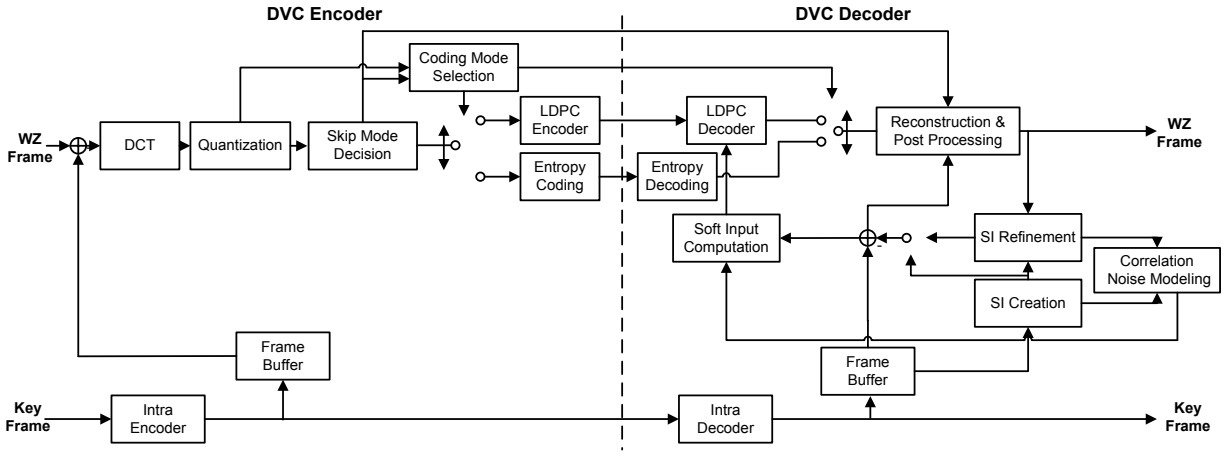


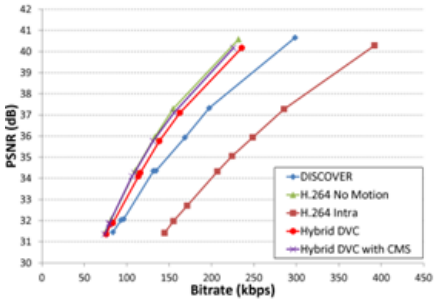
Fig. 2. The proposed hybrid DVC framework.

The test conditions for this system are set as follows:

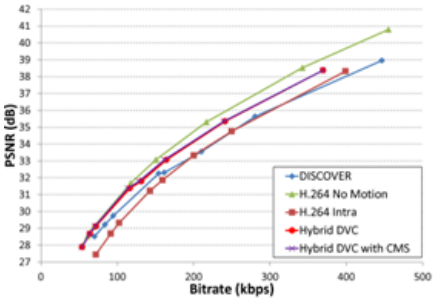
- Test sequences: Foreman, Coastguard, and Hall Monitor. Each sequence has different characteristics.
- Resolution and frame rate: QCIF (176x144) at 15 Hz.
- Benchmark codecs: H.264/AVC Intra, H.264/AVC No Motion, and DISCOVER DVC codec.
- GOP size: 2.

The R-D performance evaluation results in Fig. 3 show that the proposed hybrid DVC codec achieves higher compression ratio than the DISCOVER codec, a widely-used DVC codec: we have up to 2 dB gain in PSNR for the Hall sequence and 1 dB gain for the Foreman sequence. Although the R-D performance of our DVC system is still a little worse than that of H.264 No Motion for the Foreman sequence, the hybrid DVC with coding mode selection is as good as H.264 No Motion for the Hall sequence and is better for the Coastguard sequence. The proposed DVC system performs comparably to H.264 No Motion with much lower encoding complexity.

In the future, besides continuously improving the coding performance, the hardware DVC engine design is also one of the targets of this project. Moreover, the video analysis engine will be taken into consideration to further improve the power efficiency while maintaining the performance of context inferring.



(a)



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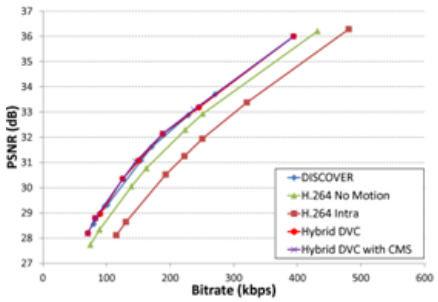

(c)

Fig. 3. Rate-Distortion performance comparison for the sequences (a) Hall, (b) Foreman, and (c) Coastguard.

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This project is being conducted in partnership with Intel Research, through the Intel-NTU Connected Context Computer Center at National Taiwan University. The Intel Champions of the team are Dr. V Srinivasa Somayazulu and Dr. Yen-Kuang Chen, where the principle investigator is Prof. Shao-Yi Chien with co-PI Dr. Chia-Han Lee (Academic Sinica). The team members are Teng-Yuan Cheng, Hsing-Min Chen, Pei-Kuei Tsung, Pin-Hong Kuo, Chieh-Chuan Chiu, Hsin-Fang Wu, Shun-Hsing Ou, Ssu-Lu Hsu, Yu-Chun Wang, Ting-Yu Chen, and Yueh-Ying Lee.

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