M-010

無線 LAN マルチカメラサーベイランスシステムにおける ROI に基づくビデオ送信システム

ROI-based Video Transmission System For Wireless Multi-camera Surveillance Systems

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ABSTRACT

This paper analyzes the performance of two popular video coding standards, MJPEG and MJPEG2000, in terms of ROI-based video transmission for wireless multi-camera surveillance systems. In this work, ROI-based MJPEG video transmission is proposed and speed improvement is successfully demonstrated. MJPEG2000 provides better compression quality over MJPEG. However, higher execution speed of MJPEG is an advantage for real-time processing. This paper investigates compression-transmission time and overall performance for different ROI sizes and different number of multi-camera nodes. It is observed that MJPEG demonstrates better time-optimal performance, yielding significant improvement for time-critic multi-camera video surveillance transmission. However after some threshold, with the increasing number of nodes, it is demonstrated that JPEG2000 transmission yields shorter transmission time due to the smaller video stream.

1. INTRODUCTION

Nowadays, video surveillance systems are being widely employed in public areas despite many privacy discussions. Outdoor surveillance systems with multiple cameras, observing wide areas, depend on wireless communication because of the ease of deployment and mobility. However, wireless transmission suffers from error-resilient, time-varying channels and low-bandwidth conditions. In case of multi-camera systems, these conditions become more severe with increasing network-congestion and decreasing bandwidth rate per camera node. Hence, achieving real-time transmission of huge video data from camera nodes to observation rooms under scarce network and low computational power conditions is a challenging task and a crucial issue for surveillance.

To overcome the drawbacks of wireless channels and accomplish real-time video transmission for time-critic applications, there are various on-going researches by many communities. While video coding communities pursue the development of new standards, the most recent and well-known approach is content-aware video transmission to provide full utilization of the limited resources. A group of researchers study the rate-allocation and scheduling based on the priority of the video content [1-2]. Another major group of researchers apply content-awareness concept at the encoding stage of video transmission [3-6]. These are generally called Region-of-Interest (ROI)-based approaches, extracting important regions of each frame, giving priority to those regions by allocating higher bit-rates and replenishment rates. ROI-based video transmission approaches achieve effective usage of available bandwidth while providing flexibility to visualization of video data.

The aim of our work in this paper is to investigate the ROI-based video transmission performance of two widely used video coding standards, MJPEG and MJPEG2000 and to show the advantageous cases depending on the number of nodes for each standard. Although there are more advanced video coding standards, like MPEG2, MPEG4, AVC, these are computationally complex and weak to transmission errors of wireless communication. This work is unique in two-folds. First, we give the detailed performance analysis of MJPEG and MJPEG2000 in terms of wireless multi-camera video streaming focusing on ROI-based content-aware transmission. Second, we propose a new approach, ROI-based MJPEG video transmission. Considering the time-critic applications, most of the time, MJPEG provides speed-optimal solutions with significant improvement due to low-computational complexity.

2. SYSTEM OVERVIEW AND ROI TRANSMISSION

In this work, experiments are conducted in a wireless multi-camera outdoor surveillance system installed on a public road in front of the university campus. In this system, there are 12 nodes constructed along 25 m distance in 300 m length and one central control server. Each node has three cameras (36 cameras in total), a processing unit (a PC), and a wireless LAN interface IEEE 802.11b, whose effective bandwidth is about 1 Mbps. Processing units at the capture nodes are Intel Pentium M 1.6 GHz machines with 0.97GB RAM. PC used as a control server is a Intel Pentium 1.06GHz dual core machine with 1.99GB RAM. In this research, Kakadu JPEG2000 Software is employed, which is one of the fastest implementation of JPEG2000 compression standard. For JPEG compression Intel Performance Primitives (IPP) is used. MJPEG and MJPEG2000 video streams can be explained as successive transmissions of video frames encoded in JPEG and JPEG2000. Data transmission is achieved over TCP protocol.

Fig. 1 explains ROI-based video transmission proposed in this work. Instead of transmitting entire frame each time, background frame is transmitted at first and only regions-of-interest (ROI) including change in the scene are extracted, encoded and transmitted for successive frames. Then, background frame is updated regular basis.

3. EXPERIMENTAL RESULTS AND DISCUSSION

In our experiments, we assume that ROI is properly detected by a certain method. Major evaluation criteria in our experiments are processing times for the same input and same resultant PSNR. To achieve this, a preliminary test input sequence is prepared and stored. For each experiment, input is read from this sequence frame by frame. There are three main steps for streaming of one frame from a camera node to the observer room: reading input, encoding and transmission. Processing time is measured in two ways. During these steps processing time is constant for MJPEG and MJPEG2000 for input read and encoding, however transmission

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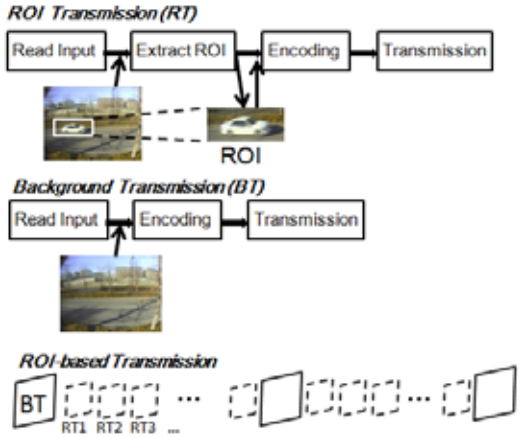

Fig. 1. ROI-based Video Transmission

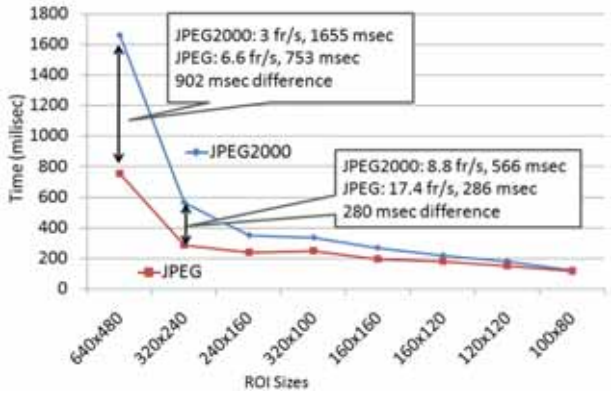

Fig. 2. Video transmission for various image sizes

time, hence overall time are highly affected by network conditions. Fig. 2 shows experimental results conducted for 5 frames for different image sizes. Encoding time for JPEG2000 is much larger than JPEG. As a result overall processing time is longer. With the decreasing ROI size, encoding time difference also decreases and the difference of overall performance decreases as well.

Next, multiple surveillance camera nodes are studied. Experiments for ROI-based MJPEG and ROI-based MJPEG2000 video streaming are conducted for simultaneous transmission from multiple nodes and results are given in Fig. 3 and 4. In case of multiple nodes, overall performance highly depends on the network conditions. For the same input and PSNR conditions, compression time for MJPEG is much shorter than MJPEG2000 while resultant compressed stream size is larger. As a result, in case of small number of nodes, MJPEG demonstrates better time-optimal performance, since time spent during compression is more important. MJPEG yields significant improvement over MJPEG2000 for time-critic video surveillance applications for this case. On the other hand, when the number of nodes increases, the number of video data being tried to sent simultaneously to the same control node over wireless network increases and required transmission time increases. From various experiments conducted in this work, it is observed that JPEG based video transmission is affected more by network conditions and results are much variable. Although JPEG2000 based video transmission is longer in most of the cases, transmission time is more stable.

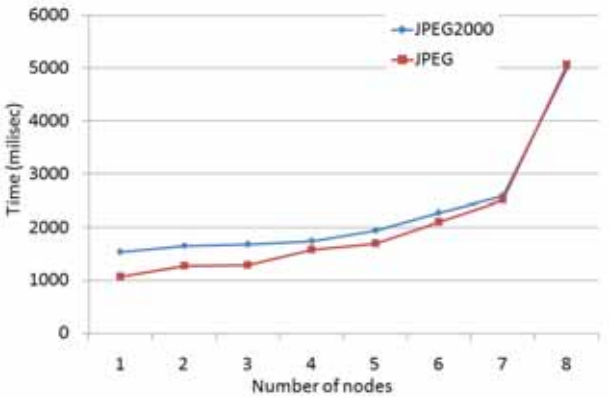

Fig. 3. Video transmission for various node numbers. (41 frames of 160x120)

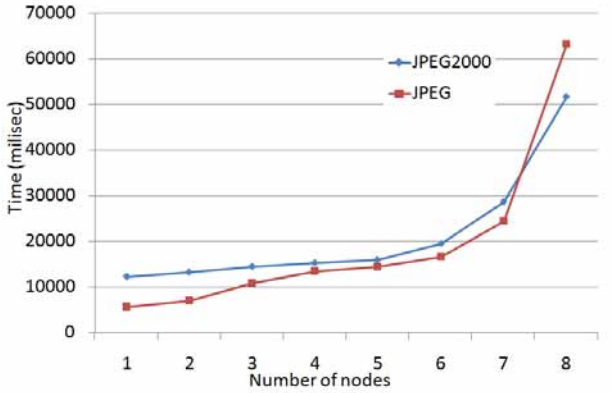

Fig. 4. Video transmission for various node numbers. (41 frames of 640x480)

4. CONCLUSIONS

In this work, ROI-based video transmission is analyzed for MJPEG and MJPEG2000. Since resultant data size is smaller for MJPEG2000, transmission time is faster compared to MJPEG. MJPEG2000 produces gradually improved results with the increasing number of camera nodes. The number of nodes, where MJPEG2000 overcomes MJPEG depends on the system specifications like bandwidth, processing power, network conditions. In the experiments presented here, after seven nodes transmission at the same time, MJPEG2000 starts to become advantageous.

5. REFERENCES

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