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A Survey on Video Coding in Wireless Multimedia Sensor Network Environment using Compressed Sensing Technique

Mr. C.S.Deshmukh
M.E.(scholar), Department of Information Technology,
P.R.M.I.T.& R, Badnera,
Amravati, India
chetan.deshmukh00@gmail.com

Prof. S.V.Dhopte
Department of Information Technology,
P.R.M.I.T.& R, Badnera,
Amravati, India
sanjaydhopte@gmail.com

Abstract— **This article presents the design of a networked system for compression, rate control and error correction of video in Wireless Multimedia Sensor Network Environment on the theory of compressed sensing. The objective of this work is to study a cross-layer system that jointly controls the video encoding rate, the transmission rate, and the channel coding rate to maximize the received video quality. First, compressed sensing based video encoding for transmission over wireless multimedia sensor networks (WMSNs) is studied. It is shown that compressed sensing can overcome many of the current problems of video over WMSNs, primarily encoder complexity and low resiliency to channel errors. It is shown that the rate of compressed sensed video can be predictably controlled by varying only the compressed sensing sampling rate.**

Keywords—Compressed Sensing, Sensor Network, Video Compression.

I.INTRODUCTION

A Wireless Sensor Network is a network of devices, known as nodes, which can sense the environment and communicate the information gathered from the monitored field through wireless links. The data is forwarded to a sink that can use it locally or is connected to other networks (e.g., the Internet) through a gateway. The nodes can be stationary or moving as well as they can be aware of their location or not. Wireless sensor networks (WSNs) can be used to gather scalar information from sensors in a monitored field such as humidity, pressure, temperature, etc. Nodes in WSNs are electronic devices commonly equipped with a transreceiver, a limited energy supply, a sensing unit, memory, processing resources and additional modules can be found, such as a Global Positioning System (GPS). When inexpensive low-resolution CMOS cameras and microphones are embedded in wireless sensors, multimedia and scalar data can be retrieved from the environment. This resulting Wireless Multimedia Sensor Networks (WMSNs) enhance applications like surveillance, disaster monitoring, wildlife observation, automated assistance for elderly and disabled people, traffic avoidance, industrial process control and localization services[1].

The wireless sensor network consist of node and sink in which, the visual data sensed by source nodes have to be digitalized and transmitted to the sink over the sensor network. The energy and processing constraints of the sensor nodes, as well as the nature of the wireless links that interconnect them, restrict the bandwidth of the communication path and impose a considerable packet loss rate. Among the solutions, multimedia coding techniques are used to compress the original data, reducing the required transmission rate and potentially saving energy of the source node over the entire path toward the sink. Some multimedia coding provides error resilience, which may sustain the minimum acceptable end-to-end quality of the application, even when some packets are lost while transmitted over error-prone wireless links[1][2].

A new cross layer wireless system based on Compressed Sensing (CS) can offer a convincing solution to various video streaming problems. It is an alternative to traditional video encoders that sense and compress data simultaneously at very low computational complexity for the encoder. Image coding and decoding based on CS has recently been explored [3]. A single-pixel cameras can operate efficiently across a much broader spectral range than conventional silicon-based cameras. For transmission of CS images and video streaming in wireless networks, we have to use the Compressive Distortion- Minimizing Rate Control (C-DMRC), a new distributed cross-layer control algorithm that jointly regulates the CS sampling rate, the data rate injected in the network and the rate of a simple parity-based channel encoder to maximize the received video quality over a multihop wireless network[4][5].

II.RELETED WORK

Video coding standards has drowned a lot of research interest and number of techniques. The basic design of all major video coding standards follows the same block-based hybrid video coding approach. Each block of a picture is either intra-picture coded, with-out referring to other pictures of the video sequence, or it is inter-picture coded, where the prediction signal is formed by a displaced block of an already coded picture. The latter technique is also referred to as motion-compensated prediction and represents the key concept for utilizing the large amount of temporal redundancy in video sequences [5][6].

In a Research Article by ISO/IEC JTC 1, "Coding of Audio-Visual Objects"(2000), The next generation of MPEG i.e. MPEG-4, is based upon the same technique as its previous techniques. The most important new features of MPEG-4, concerning video compression are the support of even lower bandwidth consuming applications,e.g. mobile devices like cell phones and on the other hand applications with extremely high quality and almost unlimited bandwidth. In general the MPEG-4 standard is a lot wider than the previous standards. It also allows for any frame rate, while MPEG- 2 was locked to 25 to 30 frames per second. This is the classic MPEG-4 video streaming standard, MPEG-4 Visual[7].

In research article by ThomasWiegand, Gary J. Sullivan, Gisle Bjontegaard, and Ajay Luthra, "Overview of the H.264/AVC Video Coding Standard"(2003), The H.264 is the latest generation standard for video encoding. This initiative has many goals. It should provide good video quality at substantially lower bit rates than previous standards and with better error robustness or better video quality at an unchanged bit rate. The standard is further designed to give lower latency as well as better quality for higher latency. In addition, all these improvements compared to previous standards were to come without increasing the complexity of design so much that it would be impractical or expensive to build applications and systems. An additional goal was to provide enough flexibility to allow the standard to be applied to a wide variety of applications: for both low and high bit rates, for low and high resolution video, and with high and low demands on latency[8][9].

A number of applications with different requirements have been identified for H.264:

- Entertainment video including broadcast, satellite, cable, DVD, etc (1-10 Mbps,high latency)
- Telecom services (<1Mbps, low latency)
- Streaming services (low bit-rate, high latency)

In research article by M. Allman, V. Paxson, and W. Stevens, "TCP Congestion Control,"(2010).The most common rate control scheme is the well-known Transmission Control Protocol (TCP), because of algorithm used in TCP. The variation in the rate determined by TCP can be very distracting for an end user which results in poor end user perception of the video quality. TCP assumes that the main cause of packet loss is congestion and thus misinterprets losses caused by channel errors as signs of congestion. The equation-based rate control schemes regulate the transmission rate of a node based on measured parameters such as the number of lost packets and the round trip time of the data packets[10][11].

In research article by K. Stuhlmuller, N. Farber, M. Link, and B. Girod, "Analysis of Video Transmission over Lossy Channels," (2000), investigate the effects of packet loss and compression on video quality as well as the video distortion over lossy channels of MPEG encoded video with both interframe coding and intraframe coding. A factor β is defined as the percentage of frames that are an intraframe, or I frame, i.e. a frame that is independently coded. The authors then derive the value β that minimizes distortion at the receiver. In investigate optimal strategies to transmit video with minimal distortion. However, the authors assume that I frames are received correctly, and that the only loss is caused by the intercoded frames. Quality of Service (QoS) for video over the Internet using TCP or a TCP Friendly rate controller. In general, a WMSN will not be directly connected to the Internet, so requiring fairness to TCP may result in significant underestimation of the achievable video quality[12].

III. WSN AND WMSN BACKGROUND

A Wireless Sensor Network (WSN) is a network of devices known as nodes, which can sense the environment and transmit information gathered from the monitored field through wireless links. The data is forwarded via multiple hops to a sink also known as controller or monitor. The Sink can use the information either locally or it can be connected to other networks (e.g., the Internet) through a gateway. The nodes can be stationary or moving also they can be aware of their location or not. This single-sink scenario suffers from the lack of scalability due to increasing the number of nodes, the amount of data gathered by the sink increases. Once its capacity is reached, the network size cannot be expand. A multiple-sink WSN can be scalable (i.e., the same performance can be achieved even by increasing the number of nodes), while this is clearly not true for a single-sink network. However, a multi-sink WSN does not represent a extension of a single-sink case for the network engineer. In many cases nodes send the data collected to one of the sinks which forward the data to the gateway, toward the final user. From the protocol viewpoint, this means that a selection can be done, based on a suitable criterion that could be minimum delay, maximum throughput, minimum number of hops, etc. Therefore, the presence of multiple sinks ensures better network performance with respect to the single-sink case , but the communication protocols must be more complex and should be designed according to suitable criteria[1].

A Wireless Multimedia Sensor Networks (WMSN) is a network of wireless embedded devices that allow retrieving video and audio streams, Still Images and Scaler data from physical environment. The WMSN is a concept of wireless sensor networks and distributed smart cameras. A WMSN is a distributed wireless system that interacts with the physical environment by observing it through multiple media. It also have a capability to store and perform online processing of the retrieved information. With rapid improvement in hardware, a single embedded device can be equipped with audio video collection modules[1].

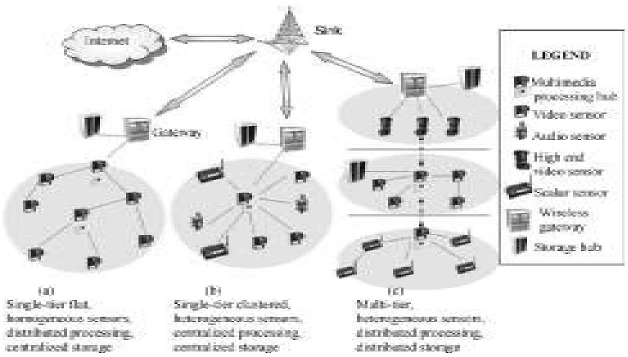

Figure 1- Wireless Multimedia Sensor Network

IV. COMPRESSED SENSING

Compressed Sensing(CS) is a technique that can overcome many problem like encoder complexity and low resiliency to channel error regarding to video over WMSNs. The rate of Compressed Sensed Video(CSV) can be control by varying the compressed sensing sampling rate. CS can offer an alternative to traditional video encoders by enabling imaging systems that sense and compress data Simultaneously at very low computational complexity for the encoder. In conventional digital image or video capturing the large amount of raw data acquired which need immediate compression in order to store or transmit. This process has two main disadvantages. First, acquiring large amount of raw image or video data can be expensive particularly at wavelength where CMOS/CCD technology is limited. Second compressing raw data can be computationally complex in case of video. The process of sample , process, keep important information, and throw away the rest, is known as Compressed Sensing(CS).

Compressive Sensing (CS) is able to processed many signals that could be difficult to capture or encode using conventional methods. From a relatively small number of random measurements, a high-dimensional signal can be recovered. Standard video capture systems require a complete set of samples to be obtained for each frame, at which point a compression algorithm may be applied. In some applications, such as imaging at non-visible (e.g. infrared) wavelengths, it may be difficult or expensive to obtain these raw samples.

In other applications, such as multi-image capture in camera networks, implementing a compression algorithm may In other applications, such as multi-image capture in camera networks, implementing a compression algorithm may itself be a challenge. These burdens may be reduced by using compressive imaging hardware such as the single-pixel camera where random measurements are collected independently from each frame and no additional compression protocol is needed[3][12].

V. NETWORK ARCHITECTURE

The C-DMRC is a new distributed cross-layer control algorithm that jointly regulates the CS sampling rate, the data rate in the network, and the rate of a simple parity-based channel encoder to maximize the received video quality over a multi-hop wireless network. By jointly controlling the compressive video coding at the application layer, the rate at the transport layer, and the adaptive parity at the physical layer, we can use information at all three layers to develop an integrated congestion-avoiding and distortion-minimizing system[2]. The cross-layer architecture of integrated congestion control and video transmission scheme is shown in Fig 2.

- **Distortion-Based Rate Control-** C-DMRC uses the received video quality for rate control decision. The transmitting node alters the quality of the transmitted video directly rather than controlling the data rate. By controlling congestion, the fairness in the quality of the received videos is maintained even over videos with very different compression ratios.

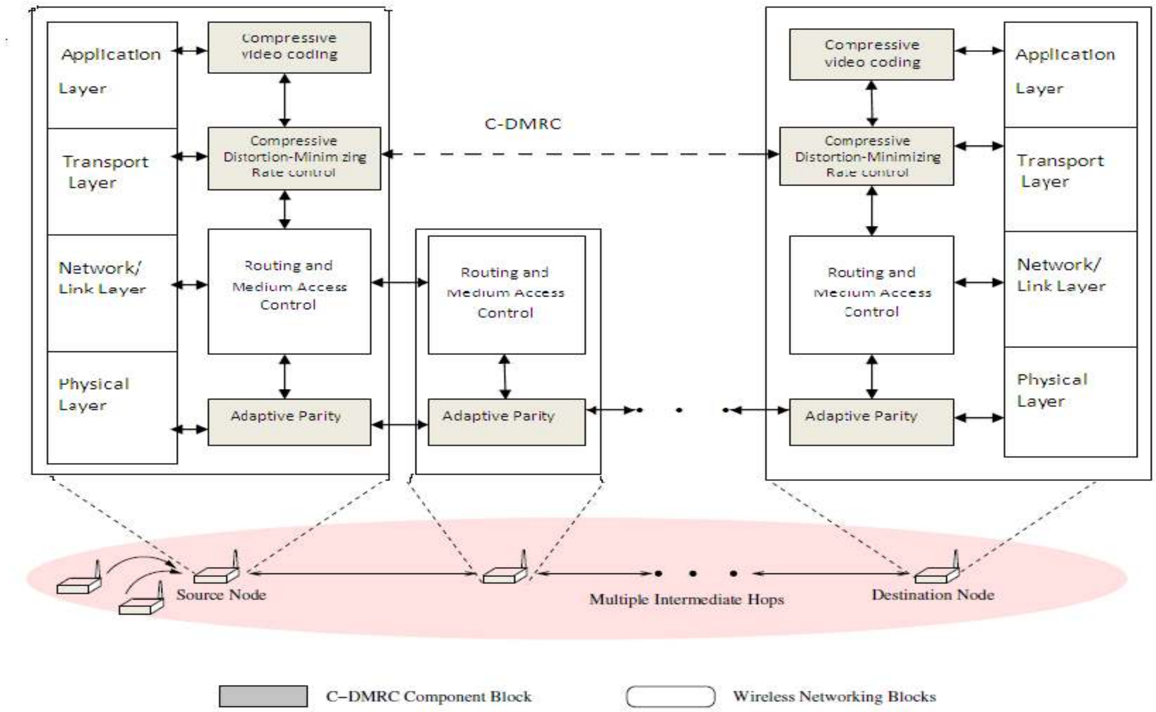

Figure 2- Cross-Layer Architecture

- **Rate Change Based on Video Quality-** The system is based on this CS architecture, where transmission rate is depend on the received video quality. This means that the rate controller uses the information about the estimated received video quality directly in the rate control decision. If the sending node found that the received video quality is very high, it will be decrease to increase the rate. If a node is sending poor-quality video, it will decrease its data rate, to improve quality of video.
- **Video Transmission Using Compressive Sampling-** The video encoder can be develope based on compressed sensing. By using the difference between the CS samples of two frames, we can capture and compress the frames based on the temporal correlation at low complexity.

VI. C-DMRC

The overall architecture of compressive distortion-minimizing rate controller (C-DMRC) is shown in figure 2. The system takes a sequence of images at a user-defined number of frames per second where the encoding is done using compressed sensing and transmits an encoded video in wireless environment. The end-to-end Round Trip Time (RTT) is measured to perform congestion control for the video within the network, and the Bit Error Rate (BER) is measured to provide protection against channel losses. This system combines functionalities of the application layer, the transport layer and the physical layer to deliver video through a wireless network to maximize the received video qualitywhile accounting for network congestion and lossy channels[4][13].

CS Video Encoder: - The CSV video encoder takes the raw samples from the camera and generates compressed video frames. The compression is based on the temporal correlation between frames.

Rate Controller :- The C-DMRC block takes the end-to-end RTT of the previous packets as input and the calculate sample loss rate to determine the optimal sampling rate for the video encoder.

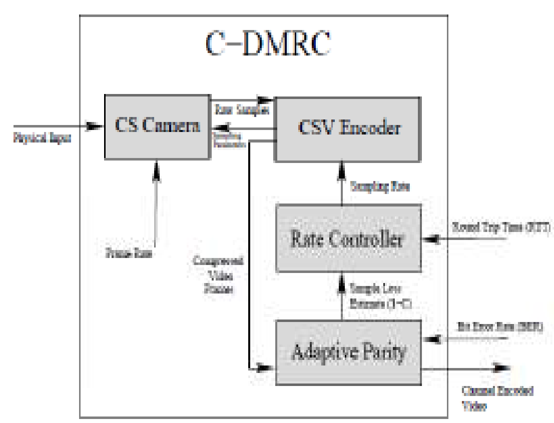

Figure 3. Architecture of the C-DMRC video rate control system.

Adaptive Parity:- The Adaptive Parity block uses the measured or estimated sample error rate of the channel in order to determine a parity scheme for encoding the samples, which are input directly from the video encoder.

VII. CONCLUSION

We have proposed a wireless video transmission system based on compress sensing. The system consist of video encoder, distributed rate controller and adaptive parity channel encoding scheme to take the advantage of compressed sensed video to provide high quality video to the receiver. Compressed Sensing can overcome many problem like encoder complexity and low resiliency to channel error regarding to video over WMSNs. System use C-DMRC is a new distributed cross-layer control algorithm that jointly regulates the CS sampling rate, the data rate in the network, and the rate of a simple parity-based channel encoder to maximize the received video quality over a multi-hop wireless network.

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