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A Cross-Layer System for Joint Compression, Rate Control and Error Correction of Video over Resource Constrained Wireless Multimedia Sensor Networks

Mr.A.Ravi Kumar
Assoc Prof,
Head of the Department,
Department of CSE,
SSJ Engineering College.

Dr.M.Ashok
B.Tech, M.Tech, Ph.D, MISTE,
Principal,
SSJ Engineering College.

Dr.Praveen Sam
Prof. CSE Department,
G.Pulla Reddy Engineering
College.

Abstract:

With the availability of low-cost small-scale imaging sensors, CMOS cameras, microphones, which may ubiquitously capture multimedia content from the field, Wireless Multimedia Sensor Networks (WMSN) have been proposed and drawn the immediate attention of the research community. WMSN applications, e.g., multimedia surveillance networks, target tracking, environmental monitoring, and traffic management systems, require effective harvesting and communication of event features in the form of multimedia such as audio, image, and video.

To this end, additional challenges for energy-efficient multimedia processing and communication in WMSN, i.e., heterogeneous multimedia reliability definitions, tight QoS expectations, and high bandwidth demands, must be addressed as well. In this paper, we have studied and implemented a system which maximizes the video quality in wireless multimedia sensor networks. There is a problem of encoding rate, compression rate and channel encoding rate in compressed sensing based on video transmission over wireless sensor networks.

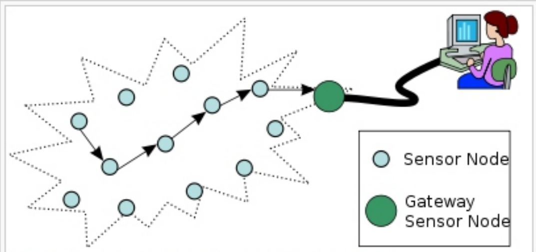
It leads to encoder complexity and recovery errors. To overcome the problems we propose the rate controller which is designed for predicting the rate of compressed sensed video and adjust the sampling rate of compressed videos. And also detect and correct the recovery error when transmitting the video in wireless multimedia sensor networks. Comparative analysis shows that when rate controller based MWSN systems have higher energy efficiency along with improved video quality.

Keywords:

WMSNs, Video Streaming, Quality, Compression, Encoding, Transmission.

Introduction:

Wireless Sensor Networks (WSN) have recently been the focus of a significant amount of attention and effort of the research community. The main motivation has been to address the challenges posed by the WSN paradigm, i.e., limited node power, processing, and communication capabilities, dense network deployment, multi-hop communications, and heterogeneous application-specific requirements. The vast majority of these studies applies to conventional WSN applications which need reliable and efficient communication of scalar event features and sensor data such as temperature, pressure, humidity.The development of wireless sensor networks was motivated by military applications such as battlefield surveillance; today such networks are used in many industrial and consumer applications, such as industrial process monitoring and control, machine health monitoring, and so on.



Typical multi-hop wireless sensor network architecture

The WSN is built of “nodes” – from a few to several hundreds or even thousands, where each node is connected to one (or sometimes several) sensors.

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Each such sensor network node has typically several parts: a radio transceiver with an internal antenna or connection to an external antenna, a microcontroller, an electronic circuit for interfacing with the sensors and an energy source, usually a battery or an embedded form of energy harvesting. A sensor node might vary in size from that of a shoebox down to the size of a grain of dust, although functioning "motes" of genuine microscopic dimensions have yet to be created. The cost of sensor nodes is similarly variable, ranging from a few to hundreds of dollars, depending on the complexity of the individual sensor nodes. Size and cost constraints on sensor nodes result in corresponding constraints on resources such as energy, memory, computational speed and communications bandwidth. The topology of the WSNs can vary from a simple star network to an advanced multi-hop wireless mesh network. The propagation technique between the hops of the network can be routing or flooding.

The main characteristics of a WSN include:

- Power consumption constraints for nodes using batteries or energy harvesting
- Ability to cope with node failures (resilience)
- Mobility of nodes
- Heterogeneity of nodes
- Scalability to large scale of deployment
- Ability to withstand harsh environmental conditions
- Ease of use
- Cross-layer design

The availability of inexpensive hardware such as CMOS cameras and microphones has fostered the development of Wireless Multimedia Sensor Networks (WMSNs), i.e., networks of wirelessly interconnected devices that are able to ubiquitously retrieve multimedia content such as video and audio streams, still images, and scalar sensor data from the environment. In this project, we shall first survey the state of the art in algorithms, protocols, and hardware for wireless multimedia sensor networks and identify open research issues.

In the course of this process, we shall evaluate existing solutions and open research issues at the application, transport, network, link, and physical layers of the communication stack, along with possible cross-layer synergies and optimizations. This ultimately forms the groundwork for our interest in developing an optimally efficient suite of multimedia communication protocols. We envisage a cross-layered approach that may combine, under one umbrella, recent advances in coding, multi-channel MAC protocols, emerging technologies like UWB, amongst others.In addition to the ability to retrieve multimedia data, WMSNs will also be able to store, process in real time, correlate and fuse multimedia data originated from heterogeneous sources. Wireless multimedia sensor networks will not only enhance existing sensor network applications such as tracking, home automation, and environmental monitoring, but they will also enable several new applications such as:

Multimedia Surveillance Sensor Networks. Video and audio sensors will be used to enhance and complement existing surveillance systems against crime and terrorist attacks. Large scale networks of video sensors can extend the ability of law enforcement agencies to monitor areas, public events, private properties and borders.Traffic Congestion Avoidance Systems. It will be possible to monitor car traffic in big cities or highways and deploy services that offer traffic routing advice to avoid congestion. Automated parking assistance is another possible related application. Advanced Health Care Delivery. Telemedicine sensor networks can be integrated with 3G multimedia networks to provide ubiquitous health care services. Patients will carry medical sensors to monitor parameters such as body temperature, blood pressure, pulse oximetry, ECG, breathing activity. Similarly, elderly and family monitors will help in providing timely and essential support to the less able sections of society.

Industrial Process Control. Multimedia content such as imaging, temperature, or pressure amongst others, may be used for time-critical industrial process control. The integration of machine vision systems with WMSNs can simplify and add flexibility to systems for visual inspections and automated actions that require high-speed, high-magnification, and continuous operation.Many of the above applications require the sensor network paradigm to be re-thought in view of the need for mechanisms to deliver multimedia content with a certain level of quality of service (QoS).

Since the need to minimize the energy consumption has driven most of the research in sensor networks so far, mechanisms to efficiently deliver application-level QoS, and to map these requirements to network-layer metrics such as latency and jitter, have not been primary concerns in mainstream research on sensor networks.

EXISTING SYSTEM:

In existing layered protocol stacks based on the IEEE 802.11 and 802.15.4 standards, frames are split into multiple packets. If even a single bit is flipped due to channel errors, after a cyclic redundancy check, the entire packet is dropped at a final or intermediate receiver. This can cause the video decoder to be unable to decode an independently coded (I) frame, thus leading to loss of the entire sequence of video frames.

Disadvantages:

Instead, ideally, when one bit is in error, the effect on the reconstructed video should be unperceivable, with minimal overhead. In addition, the perceived video quality should gracefully and proportionally degrade with decreasing channel quality.

PROPOSED SYSTEM:

With the proposed controller, nodes adapt the rate of change of their transmitted video quality based on an estimate of the impact that a change in the transmission rate will have on the received video quality. While the proposed method is general, it works particularly well for security videos. In addition, all of these techniques require that the encoder has access to the entire video frame (or even multiple frames) before encoding the video.

Advantages:

The proposed CSV encoder is designed to: i) encode video at low complexity for the encoder; ii) take advantage of the temporal correlation between frames.

MODULES:

1. CS Video Encoder (CSV):

The CSV video encoder uses compressed sensing to encode video by exploiting the spatial and temporal redundancy within the individual frames and between adjacent frames, respectively.Sensing the channel: those that have the cost of sensing channel have higher energy consumption and so they are not suitable for WMSNs.

using extra packets: Using retransmission time of dropped packets includes not only retransmission request but also transmission of dropped packet. These methods waste a great amount of energy for congestionDetection in sensor nodes.Low cost: Some methods do not necessitate extra cost for congestion detection. These methods are the most suitable for congestion detection in WMSNs.

2. Rate Change Aggressiveness Based on Video Quality:

With the proposed controller, nodes adapt the rate of change of their transmitted video quality based on an estimate of the impact that a change in the transmission rate will have on the received video quality. The rate controller uses the information about the estimated received video quality directly in the rate control decision.

If the sending node estimates that the received video quality is high, and round trip time measurements indicate that current network congestionCondition would allow a rate increase; the node will increase the rate less aggressively than a node estimating lower video quality and the same round trip time. Conversely, if a node is sending low quality video, it will gracefully decrease its data rate, even if the RT T indicates a congested network. This is obtained by basing the rate control decision on the marginal distortion factor, i.e., a measure of the effect of a rate change on video distortion.

3.Video Transmission Using Compressed Sensing:

We develop a video encoder based on compressed sensing. We show that, 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 without using motion vectors.

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4. Adaptive Parity-Based Transmission:

For a fixed number of bits per frame, the perceptual quality of video streams can be further improved by dropping error samples that would contribute to image reconstruction with incorrect information. Which shows the reconstructed image quality both with and without including samples containing errors? It assume that the receiver knows which samples have errors, the demonstrate that there is a very large possible gain in received image quality if those samples containing errors can be removed.

We studied adaptive parity with compressed sensing for image transmission, where we showed that since the transmitted samples constitute an Unstructured, random, incoherent combination of the original image pixels, in CS, unlike traditional wireless imaging systems, no individual sample is more important for image reconstruction than any other sample. Instead, the number of correctly received samples is the only main factor in determining the quality of the received image.

Conclusions and Future enhancements:

The compression measurement and reconstruction of the video sequence sparse signal was taken as main line, introduced the theory of compressive sensing framework and the traditional video codec model, analyzed the sparsity of residual image frames, designed the measurement matrix and the reconstruction algorithms, and implemented the video codec scheme based on the compressive sensing theory. Here we have proposed a scheme for wireless video multicast based on compressed sensing which does not suffer from a cliff–effect.

The system consists of a video encoder, distributed rate controller, and an adaptive parity channel encoding scheme that take advantage of the properties of compressed sensed video to provide high-quality video to the receiver using a low- complexity video sensor node. This Video Compressed Sensing Framework can be used in WSN environment where memory and energy are the major constraints. The Future work is to design hardware for CS framework from which the measurements are obtained directly instead of total samples.

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