Energy Efficient Video Surveillance Approach for Multiple Camera in Wireless Sensor Networks

Juginder Pal Singh, Piyush Vashistha, Mohd. Aamir Khan, Manoj Kumar

Abstract*: The advances in the embedded system, computer vision, and wireless transmissions result in cost-effective wireless video surveillance. The digital camera is capable of detecting the moving target according to the control information. Video surveillance in the constrained environment of a wireless sensor network requires to be processed into three steps. Initially, the video is pre-processed after that compression is done and data is transmitted over the WMSN; at the last step, the analysis of the video is done at the receiver site. However, for wireless video-based sensor nodes transmitting a video stream is difficult using the traditional protocols. Camera-based Wireless Multimedia Sensor Network (WMSN) performs relatively in a different way from the traditional setups in the sense that it involves a directional sensing model, a complex in node processing and a need to transfer a large amount of data. In this paper, we suggest a new methodology which integrates the barrier coverage** *through* **multiple camera node models for object detection and transmission, instead of sending the complete frame, the objective is to achieve the trade-off between energy consumption and reliability of detection. Since blanket coverage generally results in high transmission time and the communication overhead is significant. To ensure the longevity of applications, reduction in energy consumption is of prime importance. However, the detection of the intruder and its success the rate ratio is highly dependent on the width of the barrier, the speed, and position of the entering event [1, 2, 6]

***Index Terms*: Energy Efficient, Wireless Multimedia Sensor Network, Video Surveillance**

I. INTRODUCTION

Wireless Video Surveillance System is considered as an application of Image Processing, computer vision and Wireless Multimedia Sensor Network (WMSN). Speedy developments and improvements in equipment affecting to CMOS, microphone, and camera have prepared them a key feature of WSN. A WSN contains inexpensive, low-power node, having the potential of grasping different categories of conditions related to environments like temperature, pressure, humidity, light, radiation, vibration, computation and wireless communication and other physical conditions [1, 2].

The structure, installation, and function of a WMSN necessitates the joining together of many fields that consist of signal processing, protocols, networking, the embedded systems, information management system and the distributed algorithms. These networks are mostly implemented in the environments where resources are limited for example with the battery operated nodes running un-tethered. These limitations define that WMSN problems are best described in a comprehensive manner by combining the physical, networking, application layers and devising major design modifications across the layers [7, 8]. The WMSN provides the strength of combined efforts to produce higher quality sense in time and space as compared to conventional stationery and stable sensors, which are implemented as per the following methodology:

- The WMSN can be fixed away from the actual approach, i.e. something known by perceiving the senses. In this method, the large WMSN that utilizes few critical methodologies to differentiate the target from the noise in the environment is definitely needed.
- Many WMSN which performs sensing only can also be implemented while keeping in mind that the position of WSN and the topology required for communication should be very carefully designed. These WMSN are used to transmit the time series of their sensing to the central system where the calculations are done and the data is combined [9, 12, 13].In this paper, the research work will significantly contribute to the field of WSN. The structure, installation, the function of a sensor network (wireless) necessitates the joining together of many fields that consist of signal dealing out, protocols, networking, the embedded systems, data management system and the distributed algorithms.This research work suggests the models which according to the demand are utilized to save the energy of WSNs. In this work we proposed a model where every node work on barrier coverage, as well as any object, detects on any camera node, it will active nearby all camera nodes to transmit the surveillance video to the server. These networks are mostly implemented in the environments where resources are limited, for example with the battery operated nodes running un-tethered. The proposed approach can be applied to any scenario without requiring any modifications.

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A. *The Scope of Video Surveillance System*

Video observation over WSNs broadly accepted development in the various cyber-physical applications targeted for traffic flow analysis, healthcare, public security, wildlife tracking, environment observing and weather forecasting. WSN inherits the critical problems related to data transfer and data transmission using wireless communication. These are:

- Data security
- Power limitations
- Signal attenuation and interference
- Channel bandwidth
- Line-of-sight obstruction

A huge amount of research effort has already been proposed to deal with issues, in addition, most of them are being successfully utilized in practice and have become the benchmark for the industries. Moreover, for the video surveillance applications with concurrent demand, the transmission and data transfer procedure at the individual wireless node generate a huge quantity of audio-visual data is still a matter of high concern. The key areas of research in video surveillance using WSN focus on video capture and pre-processing compression and transmission, and video analysis. Plenty of research effort has already been carried out in this arena because of the growing popularity in the surveillance applications.

B. *Motivation*

The inspiration for the present study has come from the reality about the WMSN's, as it is able to produce huge extent of data and its capability to deliver a distended, improved and greater view of the field of attention with very high resolution that too not at the price of dilapidation in the lifetime of the network and the superiority and excellence of the multimedia stuff. Also, very high energy is used up by the sensor nodes in wireless communication as paralleled to the data processing. This method of data transmission is a simplified method and is independent of root discovery and maintenance. Moreover, the power required by a node to transfer the data to the sink is directly proportional to some power greater than or equal to two of the distance. Therefore, it is obvious that the higher the distance of the nodes from the sink, the more the energy will be consumed and there will be a high probability of nodes dying out at a faster pace. Since it is undoubtedly very difficult to make a replacement or restore the power of batteries of the wireless sensor, therefore the energy so available should be used very wisely in demand to increase the life span and potential of the network. The primary objective of this research work is to increase the effectiveness of the Video Surveillance System in WSNs in order to minimize the extent of data generation & increasing the life span of the network by energy focusing on the aspects related to less energy consumption and also to produce higher quality sensing in time and space as compared to the conventional stationary sensors.

II. LITERATURE REVIEW

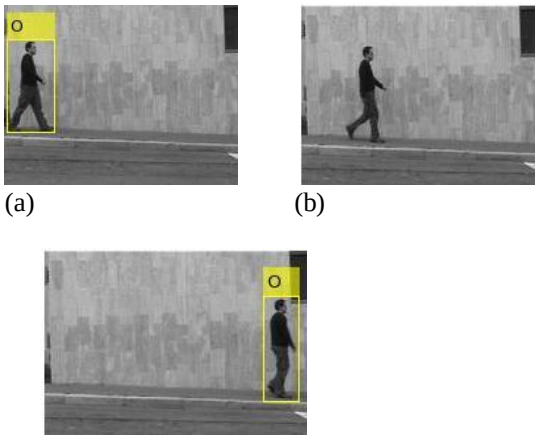
Many researchers have already concentrated on the challenges related to Wireless Sensors which have controlled resource potential of the hardware related to memory, processing power, bandwidth, and energy resources.

A lot of research is already being pursued in the following interest area that focuses on:

- Escalating network life span.
- Growing steadfastness of data transfer.
- Searching out the solutions to aid in easy operation and upholding.
- Devising the modus operandi for enforcing safe, private and reliable networks.

A wireless sensor network provides many significant functions like remote environment monitor and target tracker. It is being facilitated through accessibility (that has taken place just recently) of compact, economical, smart & wise sensors. This WSSN are outfitted by the wireless edges to allow them to converse to each other to shape up a networking arrangement. The structure of a wireless sensor network relies considerably upon the appliance, thereby it should also take into consideration, the factors like environment, the design of an application, its objective and price, the hardware components and the limitations of the systems [2, 4, 5, 6]The ease of use of the low-priced hardware in diverse assortment for the various applications like CMOS cameras and microphones has encouraged the growth of WMSNs, i.e., the networks of wireless interrelated systems that are competent all over the place in a dispersed surroundings for monitoring and surveillance, repossessing multimedia objects like video and audio streams, images and the scalar sensor data from the surroundings [3, 16]. In these types of networks like any other wireless sensor networks, the data composition removes the redundancy and gets better bandwidth consumption and sensor node power-efficiency [4]. An explanation to that for the network communications effectiveness, a paper was presented on safe multimedia sensor power-efficient data aggregation protocol called Energy-Efficient Secure Pattern-based Data Aggregation. As compared to the traditional data composition techniques, ESPADA prohibited the duplicate copy of video information transmission from nodes to the cluster-heads and performance assessment displayed that the ESPDA extraordinarily performs the traditional data composition ways up to 50% in the bandwidth effectiveness. Purushottam et. al. after conducting a detailed study on the design and functioning of SensEye-a multi-tier network of various assorted wireless nodes and cameras inferred that a surveillance application utilizing SensEye consists of three major tasks: First, the object detection, second recognition, and third tracking[5,14]. They then anticipated new machinery for low-power low-latency detection, low-latency wakeups, efficient recognition, and tracking**.** These techniques which were developed by them to show that a multi-tier sensor network can bring together the conventionally incompatible system for latency and energy-effectiveness. The experimental assessment of their model presented that, when contrasted to a single-tier prototype, the multi-tier SensEye be able to attain an order of scale diminution in the usage of energy while giving an analogous surveillance precision.

There is a huge scope of wireless communication in the video surveillance system. It is an emerging area of research for the weather monitoring system, (FireWxNet,2006) technologically advanced can help in the area if fire prevention like, communicate in the Bitterroot National Forest in Idaho to watch the forest fire due to the lightning in the thunderstorm[4], with the help of smart cameras (SCNS,2011) it can be used for the railway tracks monitoring for safety purpose [5], and for the surveillance in indoor environment of a multi-floor department building at the University or a tall tower apartments[6]. The major drawback of this system is to find the appropriate location to deploy the sensors and the system structure and arrangement for the video communications.One of the major concern of the video surveillance system using wireless sensors is power consumption. Author (Panoptes, 2003) [8] presented a method in which, a central node obtained the data from other client nodes and executed a video compilation to sense the suspected events. The energy saving approach implemented by the client node contained the data altering, buffering, and adaptive message abandonment. Author (MeshEye, 2007) uses the hybrid-resolution smart camera node to reduce energy consumption [9]. Two low-resolution cameras sensor node followed by the camera having the high resolution is deployed at the location to identify the object, in this method video of a target region is only transmitted [10]. The multiresolution strategy was also taken in the multi-view target surveillance system which was discovered at the Tsinghua University (Tsinghua, 2009). [10,15]



(a) (b)

(c)

Fig. 1: (a) Detection of the object in Barrier Coverage with the help of a single camera sensor node. (b) A moving object is unidentified with the barrier coverage using a single camera sensor node. (c) An object is detected while leaving the camera frame through barrier coverage by using a single camera sensor node. Note: Yellow marking represents the detection box.

III. PROPOSED FRAMEWORK

A video consists of multiple frames (usual twenty-five to thirty frames per second) where each frame consists of multiple pixels. If we transmit each video frame by frame in a surveillance-based wireless sensor network, then a lot of bits would require to be transmitted making the network energy inefficient. So instead of transmitting all the frames, we try to find out critical frames that are to be transmitted [11]. Critical frames are frames where the presence of objects is detected.

A. *Assumptions*

The assumptions made for the proposed approach are:

- Simple channel: Single channel for communication has been assumed.
- Deployed Network: To cover the entire region and give a comprehensive view, the sensor nodes have been deployed densely.
- Sensing Region: All nodes are having same sensing dimension and are unidirectional along with their sensing range.
- Static Node: Wireless Sensor nodes are considered to be without mobility. It is also supposed that the nodes know their orientation and position and it is fixed in advance.
- Homogeneous Network: All the sensor nodes have the same angle of view, sensing direction and focal length.

B. *Network Models*

1) Sensing Model: Unlike traditional sensor nodes that were generally having a circular sensing range, camera/video sensors have a directional range of senses. A pinhole camera is used for describing the sensing process in which a world coordinate point is projected onto 2D image plane in computer vision, Here, 3D to 2D projection of points has been used in order to describe camera projection. Multimedia sensors have a limited field of view and can only capture or target the areas in their field of view.

(a) (b)

Fig. 2: (a) & (b) are representing the Blanket Coverage & Barrier Coverage respectively

2) Energy Model: The first order energy model is being used in the proposed approach as mentioned in Wu and Abouzeid (2005).

$$e_t(H) = E_{elec} * y + E_{amp} * y * R\alpha \quad (1)$$

$$e_r(H) = E_{elec} * y \quad (2)$$

Here the WMSNs, $e_t(H)$ denotes the power consumed in transmitting and $e_r(H)$ denotes the energy consumed in receiving y bits of data over distance H. In that order, E_{elec} represents the energy consumed while communicating where receiving and transmitting one bit of data by electronic circuit and E_{amp} is the power consumed by the transmission amplifier, while α indicates the transmission loss exponent.

C. *Detailed Description*

This work is the extension of our previous work [2], there are 'n' numbers of camera for the surveillance purpose, and they transmit the frames, in the previous technique [2, 3] author Juginder et. al.

consists of a single camera, in the multiple camera scenario all the camera starts sending the frames when the object is detected, or the camera node which detects the object will transmit the frame. In the proposed model nearest 'nt' camera nodes start sending the frames.

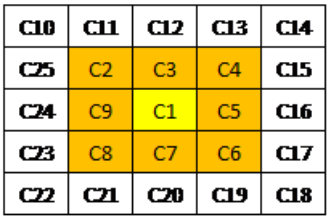


Fig. 3: Representing the possible Camera position deployed in the network.

IV. SIMULATION RESULT

A. *Energy Efficiency*

The main operations that consume the energy of a sensor node are communication among nodes, computation, and transmission of data.

$$E_{total} = E_{comm} + E_{comp} + E_{trans} \quad (3)$$

Where, E_{trans} is the energy consumed in the transmission of data bits, E_{comp} is the energy required for computation and E_{comm} is the energy consumed in sensor communication. In order to validate our proposed model, we have taken some scenario for remote area monitoring.

Table I: Simulation Parameter the border of size 20 x 20

Parameters	Values
Initial Energy	1J
Image Size	876*584
Path loss exponent(d)	2
E_{elec}	50nJ/bit
E_{amp}	10pJ/bit/m^2

Table II - Energy Destitution

Time (Sec)	Object Present	Single Camera		n Camera (n=25)		Proposed	Energy Saved
		Blanket Coverage (nJ/bit)	Barrier Coverage (nJ/bit)	Blanket Coverage (nJ/bit)	Barrier Coverage (nJ/bit)		
1	No	44507808	0	1.113E+09	0	0	0
5	No	222539040	0	5.563E+09	0	0	0
10	No	445078080	0	1.113E+10	0	0	0
15	No	667617120	0	1.669E+10	0	0	0
20	Yes	890156160	222539040	2.225E+10	5.563E+09	2.003E+09	3.561E+09
25	Yes	1.113E+09	445078080	2.782E+10	1.113E+10	4.006E+09	7.121E+09
30	Yes	1.335E+09	667617120	3.338E+10	1.669E+10	6.009E+09	1.068E+10
35	Yes	1.558E+09	890156160	3.894E+10	2.225E+10	8.011E+09	1.424E+10
40	Yes	1.78E+09	1.113E+09	4.451E+10	2.782E+10	1.001E+10	1.78E+10
45	Yes	2.003E+09	1.335E+09	5.007E+10	3.338E+10	1.202E+10	2.136E+10
50	Yes	2.225E+09	1.558E+09	5.563E+10	3.894E+10	1.402E+10	2.492E+10
40	Yes	1.78E+09	1.78E+09	4.451E+10	4.451E+10	1.602E+10	2.848E+10
45	Yes	2.003E+09	2.003E+09	5.007E+10	5.007E+10	1.803E+10	3.205E+10
50	Yes	2.225E+09	2.225E+09	5.563E+10	5.563E+10	2.003E+10	3.561E+10

B. *Scenario*

Traditionally all the multimedia camera sensor nodes are transmitting the data. However, in the proposed approach the camera sensor which detects the object will transmit the data and at the same time, it informs the neighbouring camera nodes to be active. The neighbouring nods after receiving the signal starts transmitting the data, rest all the nodes remain inactive till they receive the signal. In Fig. 3 when camera C1 detects the object, the neighbouring 9 camera (C2 to C9) starts transmitting the data.

V. CONCLUSION

This research study provides an analysis of the Sensor Network (Wireless Surveillance) applications as they utilize the video for the transmission of the data and hence requires more energy for transmission as compared to the normal energy requirement. Therefore, it is very clear that the utilization of energy for the transmission and processing of data using WSSN is quite high.

Thus, this study is helpful in providing a different and unique methodology that is energy proficient (requires lesser energy) and also is very helpful in retaining the obstruction reportage in case of single as well as multiple camera nodes by prolonging the network up to its lifetime.In order to design the multimedia in-network dispensation procedures, graphical information can be utilized to reduce the chunk of transferred data more despite transmitting the raw data that also helps in energy saving in WSSN's additionally.The proposed approach does not need any prior training and is not as complex as the traditional approach. Future we can apply compression technique to reduce the frame size for the transmission. The activity recognition system can also be used in order to raise the alarm on the basis of the activity or action recognition system.

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