International Journal on Recent and Innovation Trends in Computing and Communication
Volume: 2 Issue: 9
ISSN: 2321-8169
2819 – 2823

A Nobel Approach for Entropy Reduction of Wireless Sensor Networks (WSN)

Roma Agarwal[1], Rajesh Kumar[2]
[1]M.Tech. Student, ECE Deptt., AKGEC, *romaknpr@gmail.com*
[2]Prof., ECE Deptt., AKGEC, *itsrk2006@gmail.com*

Abstract – In contrast to RF, optical devices are smaller and consume less power; reflection, diffraction, and scattering from aerosols help distribute signal over large areas; and optical wireless provides freedom from interference and eavesdropping within an opaque enclosure. For a densely deployed Wireless Multimedia Sensor Network (WMSN), an entropy-based analytical framework is developed to measure the amount of visual information provided by multiple cameras in the network. The limitations of limited energy, processing power and bandwidth capabilities of sensors networks become critical in the case of event-based sensor networks where multiple collocated nodes are likely to notify the sink about the same event, at almost the same time. Data aggregation is considered to be an effective technique. Selective use of informative sensors reduces the number of sensors needed to obtain information about the target state and therefore prolongs the system lifetime. In this paper the use of entropy in spectrum sensing is also described. This sensing gives knowledge about the usage of spectrum by primary user and based on that a secondary user can utilize the unused spectrum without interfere the primary user.

Index terms – *Optical wireless communication, sensor networks, WMSN, camera selection, data aggregation, spectrum sensing, entropy.*

*****

I. INTRODUCTION

Optical communications has a number of features which are useful in the context of sensor networks, the foremost being the exclusivity from RF control signals in sensitive systems, such as aircraft control and monitoring. Due to short wavelengths, optical devices can be manufactured in small sizes, instead of requiring larger arrays that are prevalent in RF communications. However, there are challenges to be overcome when using infrared light for sensor communications. The optical signal has to be contained within the field-of-view (FOV) of the transmitter and receiver. Bandwidth reduces in non line of sight (NLOS) links, due to multipath propagation.

WMSNs are interconnected devices that allow retrieving video and audio streams, still images and scalar data from the environment. WMSNs are widely used in applications such as video surveillance, environmental monitoring, and industrial process control. Usually, WMSNs should be designed to deliver multimedia content with a certain level of quality-of-service (QoS). Compared with traditional wireless sensor networks that deal with scalar data, WMSNs have more design challenges. Also, image processing techniques are complicated and computation extensive, which will bring about extra computation costs for sensor nodes. Cameras are directional sensors with limited field of views, and the image observed by a camera is directly related to its field of view. The correlation characteristics of visual information in WMSNs includes –

- *Spatial correlation function* to describe the correlation characteristics for the images observed by cameras with overlapped field of views.
- *Entropy-based analytical framework* to evaluate the joint effect of multiple correlated camera nodes.
- *Correlation-based camera selection* algorithm based on the entropy-based framework.

Data aggregation is considered one of the most effective techniques to reduce energy consumption and combat congestion in sensor networks. To make aggregation more efficient, in case of event based applications, spatial correlation of data monitored by nodes in close proximity can be used. The limited on-board energy storage and the limited wireless channel capacity are the major constraints of wireless sensor networks. In order to save precious resources, a sensing task should not involve more sensors than necessary. Selective use of informative sensors reduces the number of sensors needed to obtain information about the target state and therefore prolongs the system lifetime. In the scenario of localization or tracking using wireless sensor networks, the belief state of the target location can be gradually improved by repeatedly selecting the most informative unused sensor until the required accuracy (or uncertainty) level of the target state is achieved.

Rapid growth of communication services and prosperous communication markets demands a high level of spectrum efficiency. If we were to scan portions of the radio spectrum including the revenue-rich urban areas, we would find that -

(1) Some frequency bands in the spectrum are largely unoccupied most of the time (white spaces);
(2) Some frequency bands are only partially occupied (grey spaces);
(3) The remaining frequency bands are heavily used (black spaces).

Cognitive Radio (CR) is a possible solution to the problem of spectrum shortage, because it uses dynamic spectrum access techniques. Primary users have higher priority or legacy rights on the usage of a specific spectrum band, while secondary users have lower priority and they need to exploit the spectrum in a way which does not interfere with primary users. CR systems have one important task which is called **spectrum sensing** (the detection of unoccupied bands, the so called **spectrum holes**, which can be used for data transmission).

II. OPTICAL INDOOR WIRELESS CHANNEL MEASUREMENT

A. BACKGROUND

Until now, frequency response measurements for non-line-of-sight diffuse links are available upto a bandwidth of 1 GHz, which clearly indicates the huge bandwidth available in the optical regime. However, these works have been in the context of indoor wireless communications, and many of the stated solutions would not be compatible in a sensor network framework. To integrate optical links on miniaturized sensor devices, simple modulation and detection schemes, e.g., intensity-modulation/direct-detection (IM/DD), are preferred over more complex transmission methods. In principle, the main challenge for optical wireless to be used in a sensor network is power and bandwidth degradation due to shadowing, non-alignment, diffusion and multi-scattering.

B. MEASUREMENT SETUP

The measurement system is comprised of a network analyzer, which uses a continuous wave swept frequency approach to obtain the amplitude and phase characteristics of the channel at frequencies between 10 MHz and 1 GHz. *Fig. 1* shows a block diagram of the indoor optical channel measurement system [1].

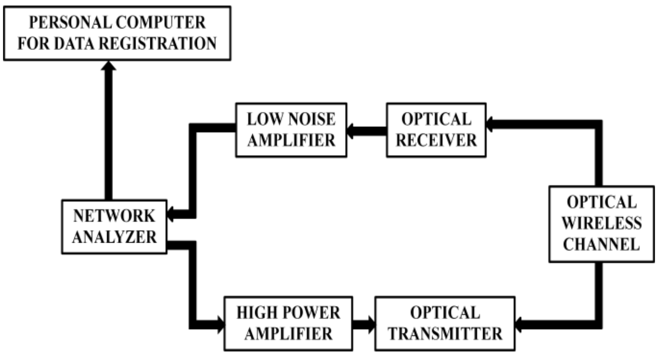

Fig. 1 Block diagram of indoor optical wireless channel

The sinusoidal signal from the network analyzer is amplified using a high-power amplifier before input to the laser transmitter. This ensures sufficient modulation depth of the transmit laser. An aspheric lens attached on the laser diode produces a focused spot on the ceiling. The laser temperature is stabilized at room temperature with a temperature controller, and a current controller. For the receiver, an avalanche photo-diode with an integrated adjustable-gain low-noise amplifier is chosen for its high-sensitivity, and high gain, as opposed to previous high-frequency measurements Due to the small APD sensitive area, it is very difficult to detect any signal at a distance without a lens assembly. The output of the receiver is fed to a low-noise amplifier, which is connected to the measurement port of the network analyzer using a shielded coaxial cable. A ratio measurement is done with respect to the reference transmitted signal to find out the amplitude and phase responses over the bandwidth of interest. To align them properly, the receiver is mounted on a rotary assembly with gimbals, which enables it to be rotated and pointed toward any direction, and as such can be moved to any other location inside the room for measurement. The laser is modulated in the specified frequency range by the network analyzer using a Bias-Tee network included in the laser mount. This setup is effectively an indoor directed non-line-of-sight configuration, where the transmitter sends modulated collimated light towards the ceiling, which acts as a secondary Lambertian (diffuse) source, and the reflected signal is captured at the receiver through a focusing lens, which is pointed towards the ceiling spot.

III. VISUAL INFORMATION IN WMSN

In a multimedia sensor network, multiple camera sensors are deployed to provide multiple views, multiple resolutions, and enhanced observations of the environment. A typical scenario of WMSN is: the application specifies which area it is interested in, and the cameras that can observe this area will transmit their observations to the sink [2].

A. SPATIAL CORRELATION

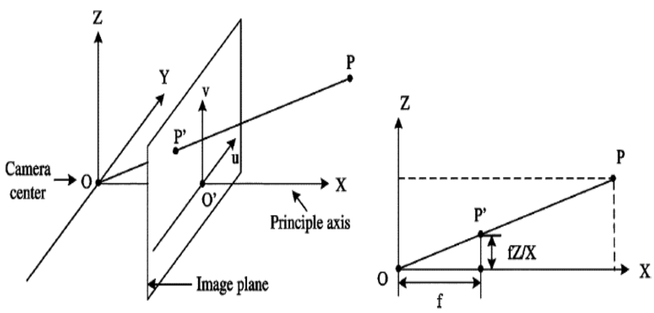

Fig. 2 Camera projection model

Firstly, we study the correlation characteristics of the images observed by different cameras. Different from scalar data sensors, the sensing of a camera is characterized by directional sensing and 3-D to 2-D projection. In computer vision, this sensing process is usually described by the pinhole camera model as shown in *Fig.2*.

B. ENTROPY-BASED ANALYTICAL FRAMEWORK

After we obtain the spatial correlation coefficient, we study the joint effect of multiple correlated cameras in WMSNs. In particular, we study how to measure the amount of visual information from multiple cameras in a WMSN. Intuitively, the visual information provided by multiple cameras should be related to the correlation characteristics of the observed images. If the images observed by these cameras are less correlated, they will provide more information to the sink.

C. CORRELATION-BASED CAMERA SELECTION

Since the delivery of visual information needs very high bandwidth, which may reduce the lifetime of the network, the communication load in WMSNs should be reduced as much as possible. Suppose a total number of N cameras can observe the area of interest, if network resources permit, we can let all these N cameras transmit their observed images to the sink, so that the users at the sink can obtain comprehensive information about the area. However, if the sink/application allows a certain level of distortion of the observations, it may not be necessary for all the cameras to report their observed information to the sink.

IV. DATA AGGREGATION IN WSN

Let us consider an event-based application scenario. In this case, nodes are required to monitor unexpected events and report the monitored information to the sink which disseminates queries through an interest-like approach. When different metrics are monitored throughout the network, only homogeneous data is aggregated. So if a node manages different types of data, we assume it can aggregate packets carrying the same data items [3].

A. ENTROPY ESTIMATION

In this section we focus on the information aggregation process which can be performed at an aggregator node, so as to reduce the amount of data traveling towards the sink, while preserving the integrity of the information. According to the goal being pursued, on the one hand the aggregation process should be lossless because no information has to be lost; on the other hand, the process should be such that useless data packets are not worth being forwarded.

V. ENTROPY BASED SENSOR SELECTION

During the development of wireless sensor networks for localization, we have observed that the localization uncertainty reduction attributable to a sensor is greatly affected by the difference of two quantities, namely, the entropy of the distribution of that sensor's view about the target location, and the entropy of that sensor's sensing model for the actual target location [4].

VI. SPECTRUM SENSING PROCESS

The spectrum sensing represents the fundamental ability to extract information about spectrum holes in the radio’s vicinity. The spectrum sensing is a complex process comprising signal detection, spectrum availability detection, spectrum opportunity detection and finally spectrum access as shown on *Fig. 3*.

Signal detection refers to assessing the existence or absence of a signal in certain spectrum band. It requires information acquisition, reasoning and decision making in order to reliably detect spectrum vacancies. Spectrum availability detection determines whether a spectrum is available for usage by secondary users. Finally, spectrum opportunity detection extends the spectrum availability detection encompassing secondary users and services requirements.

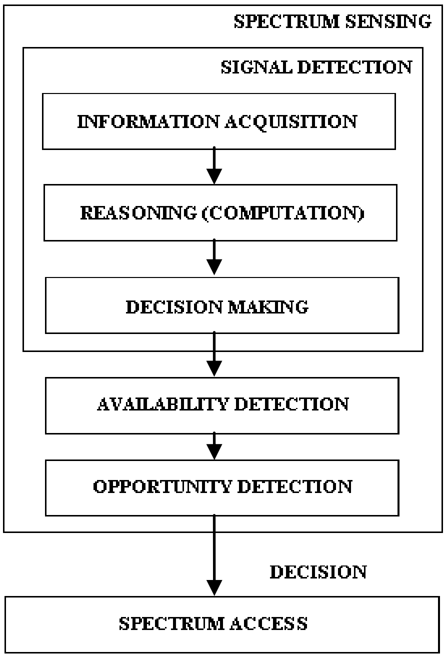

Fig. 3 Spectrum Sensing Process

VII. SPECTRUM SENSING METHODS

A number of different methods are proposed for identifying the presence of signal transmissions. In some approaches, characteristics of the identified transmission are detected for deciding the signal transmission as well as identifying the signal type. Some most common spectrum sensing techniques are explained.

1) *Energy detector based sensing*, detects the signal by comparing the output of the energy detector with a threshold which depends on the noise floor.
2) *Waveform based sensing*, is only applicable to the system with known signal patterns. Sensing can be performed by correlating the received signal with a known copy of itself.
3) *Cyclostationarity-based sensing*, detects by exploiting the cyclostationarity features (periodicity in the signal or statistics like mean and autocorrelation) of the received signals.
4) *Radio identification based sensing*, have a complete knowledge about the spectrum characteristics that can be obtained by identifying the transmission technologies used by primary users.
5) *Matched filtering*, is the optimum method for detection of primary users when the transmitted signal is known and SNR is low.
6) *Entropy based sensing*, detects the signal by calculating different entropy values (Approximate Entropy, Sample Entropy, Renyi Entropy, Bispectral Entropy, Shannon Entropy, etc.).

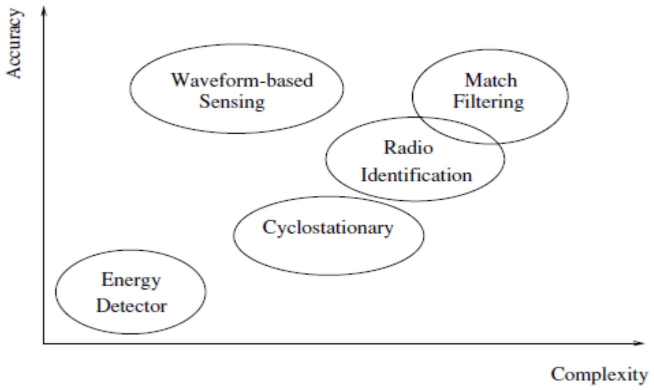

Fig. 4 Comparison of various sensing methods

VIII. ENTROPY BASED METHOD

Entropy based spectrum sensing schemes is used to detect the existence of a primary user. Different types of entropies have different characteristics which make them more or less suitable for specific applications [5].

Entropy is widely used for measuring randomness, uncertainty and diversity of a signal. There are different types of entropies for the time series data. The modulation signal contains predictable structures which allow the receiver to access the transmitted information. Therefore, the entropy values of white Gaussian noise would be larger than the modulated signal.

1) *Approximate Entropy (ApEn)* – It is defined as the measurement of systems complexity. It is a quantitative regularity statistic which measures the predictability of time series fluctuations

$ApEn (m, r, N) = \Phi^{m}(r) - \Phi^{m+1}(r)$

If the time series is a predictable, the past and current value will enable us to predict the future value and the ApEn will decrease. ApEn can be used as feature for signal detection in spectrum sensing. It has been used in biomedical engineering to identify abnormalities in biomedical signals.

2) *Sample Entropy (SampEn)* - SampEn is the negative natural logarithm of the conditional probability that two sequences which are similar for *m* points remain similar at next point.

$SampEn (m, r, N) = \ln [\Phi^{m}(r) - \Phi^{m+1}(r)]$

SampEn is used as a measure of signal complexity.

3) *Renyi Entropy (RenyiEn)* – RenyiEn extends Shannon Entropy to a family of entropy measures, which can have is flexible in its applications. RenyiEn values reflect difference in modulation schemes and same as the Shannon entropy.

4) Bispectral Entropy (BispEn) - BispEn is a kind of spectral entropy which is derived from the so called *bispectrum*.

$BispEn = -\Sigma P_i \log P_i$

It is an effective method for vehicle detection based on acoustic signal. The Bispectral entropy detector can detect vehicles which are more than 1,000 m away, but a time domain detector can only do it when the vehicle is just 200 m away and frequency domain detector 500m away.

IX. RESULTS AND CONCLUSION

We studied an indoor optical communication channel operating at near-infrared frequency, and evaluated its frequency-domain and time-domain characteristics. The correlation characteristics of visual information in WMSNs can be exploited to design multimedia in-network processing schemes. By studying the sensing model and deployment of cameras in the network, we propose a novel spatial correlation function to describe the degree of correlation for the images observed by cameras with overlapped field of views. Data aggregation can improve energy efficiency in high density wireless sensor networks. In these networks, nodes send multiple correlated data to the sink, thus, causing the propagation of redundant information throughout the network. This leads to both waste of energy resources and bandwidth, and increase network congestion.

ISSN: 2321-8169
2819 – 2823

Aggregation, however, can be a costly process since the cost of aggregating information cannot be ignored. This point, however, has been neglected in the literature because the focus is typically on the performance in terms of reduction in the energy consumption as a consequence of the decrease in the number of data packets traveling through the sensor network. The change in different sensing methods results in performance improvement or degradation. Different methods work on different characteristics (sequence length, SNR, etc.) to give the tradeoff between theoretical performance evaluation and simulation or practical implementation.

X. REFERENCES

[1] Jarir Fadlullah & Mohsen Kavehrad, "Indoor High-Bandwidth Optical Wireless Links for Sensor Networks", Journal of Light wave Technology, Vol. 28 (21), 2010.

[2] Rui Dai & Ian F. Akyildiz, "A Spatial Correlation Model for Visual Information in Wireless Multimedia Sensor Networks", IEEE Transactions on Multimedia, Vol. 11 (6), 2009.

[3] Laura Galluccio, Sergio Palazzo, & Andrew T. Campbell, "Modeling and designing efficient data aggregation in wireless sensor networks under entropy and energy bounds", Wireless Inf. Networks, 2009.

[4] Hanbiao Wang, Kung Yao, Greg Pottie, & Deborah Estrin, "Entropy based Sensor Selection Heuristic for Target Localization", Berkeley, 2004.

[5] Wanjing Zhu, Jianguo Ma, & Oliver Faust, "A Comparative Study of Different Entropies for Spectrum Sensing Techniques", Wireless Pers Commun, vol. 69, 2012.

Roma Agarwal received her diploma in Electronics Engg. from Govt. Polytechnic, Kanpur with hons. and B.tech. degree from JSS Academy of Technical Education, Noida. Now she is persuing M.Tech from Ajay Kumar Garg Engg. College, Ghaziabad. Her area of interest is wireless sensors and wireless communication.