A Survey of Coverage analysis in Wireless Multimedia Sensor Networks

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***ABSTRACT*: Due to random deployment of camera nodes in wireless multimedia sensor network (WMSN) to cover surveillance area [1], there will be increase in overlapped field of view (FOV) and redundant transmission [2] of images in the network. This leads to increase in bandwidth utilization and reduce the network lifetime. This article concentrates on survey of node deployment strategies in WMSN to provide better coverage with minimum overlapped FOV to increase network lifetime. This paper also focuses on reduction of number of cameras deployed in surveillance field. In this paper coverage issues are inspected by considering different factors such as node type, deployment strategies and angular coverage problems.**

***Keywords*: WMSN, FOV,QOS.**

I. INTRODUCTION

Wireless multimedia sensor network are the networks of wirelessly interconnected devices connected to retrieve and process video, audio, image and sensor data in real time. Wireless multimedia sensor networks are referred as distributed networked systems consisting of inexpensive CMOS camera and microphones. Main objective of WMSN is to reduce energy consumption and effectively deliver QoS. Power, data redundancy and bandwidth requirement are the limitations of WMSN because of high volume visual information captured by nodes. It is very crucially important to effectively utilize available resources in WMSN nodes.

Increase of multimedia applications such as video surveillance and environment monitoring in Wireless Multimedia Sensor Networks (WMSN), energy conservation and prolonging network lifetime become increasingly important. Therefore, energy conservation and maximization of system lifetime are commonly recognized as a key challenge in the design and implementation of WMSNs. In these networks, nodes sense the area with high degree of correlation [3] due to the overlapping Field of Views (FoVs) and causes wasting network energy. In wireless multimedia sensor networks (WMSNs), visual correlation exists among multiple nearby cameras, thus leading to considerable redundancy in the collected images.
Due to wider applications of the sensor networks, recent advancement in sensor technology leads to small sensor nodes, longer communication range, better sensing technology and fast processors. But in comparison to these advancements, lifetime of the battery is not improved. Energy saving can be done if only few sensor nodes can provide the same function as provided by all sensor nodes in the network. So, minimum number of nodes is activated to monitor the sensing field.

The increased energy consumption of a WMSN is also due to random deployment of camera nodes. There will be overlapped FOV between multiple cameras deployed in surveillance field lead to redundant data transmission between multiple camera nodes. These redundant camera nodes consume unnecessary power to capture information from surveillance area. To tackle this, the following section discussed different works that has been proposed to reduce number of camera nodes, to provide complete coverage and increase the network lifetime. The following section we discussed about work that has been done on coverage problems in WMSN.

II. Angular Coverage Techniques in WMSN

Binary Particle Swarm Optimization inspired probability (BPSO-IP) [4] to take care of camera position issue to give an exact visual scope with least number of cameras. The visual coverage depends on camera characteristics such as depth of view, field of view etc. For large scale dimension case this technique provides better result in-terms of success rate when compared to BPSO, Simulated Annealing (SA), Tabu Search (TS), and genetic techniques.

An angular coverage by determining optimal camera placement [5] in WMSN has been proposed. Angular coverage refers to capturing event spans 360. To find minimum cost camera placement Bi-level algorithm has been developed. In first level the master problem is used to identify camera placement points to achieve angular coverage from region of interest. Master problem may not provide complete angular coverage. In such cases, use sub problem to identify points that are not covered by master problem. Authors consider two cases (i) placement of homogeneous camera with fixed resolution and (ii) placement of heterogeneous camera with different resolutions. In this paper they have used ω-pc (identify angular coverage) to find coverage area. Optimal camera deployment technique has been used provide full ω-pc (100%). Experimental results shows BLA provide better results compared to Binary integer programming (BIP) and heuristics approaches interms of coverage value.

Technique to gather correlated images efficiently using differential coding based on scheduling framework [6] has been discussed. The framework has two components including MinMax degree hub location (MDHL) and maximum lifetime (MLS). To find optimal locations multimedia processing hubs to collects images from adjacent cameras, MDHL has been proposed. Correlated cameras perform differential coding on the fly to increase the network lifetime by using MLS. In this paper, it proves that MDHL is NP-complete and MLS is NP-hard. The designed algorithm can take only camera setting as inputs and they are independent of specific multimedia applications.

Visual correlation between cameras is identified by using joint entropy function. If two cameras C_j and C_k can both observe an area of interest P_i, a spatial correlation coefficient $P_{j,k}$ for the observations P_i of at C_j and C_k is derived as

$$P_{j,k} = f(O_j, \vec{V_j}, O_k, \vec{V_k}, P_i) \quad \text{......Eqn (1)}$$

Which indicates that $P_{j,k}$ is a function of the two cameras' locations (O_j, O_k) and $(\vec{V_j}, \vec{V_k})$ sensing directions as well as the location of the area of interest.

Coverage enhancing algorithm is developed based on overlap sense ratio (OSR) [7] to optimize network coverage in WMSN. Coverage area is increased by adjusting sensing direction of the nodes. The rotation angle of the node is obtained according to the OSR and rotating direction is determined by centroid of overlapping region. The parameter of OSR, denoted by η, is introduced to quantify the overlapping region of current node. The OSR is the ratio of the overlapping area over sensing area

$$\eta = \frac{M_1}{M_2} \quad \text{.....Eqn(2)}$$

where $M_1 = \alpha R^2$ is the sensing area and M_2 is the overlapping area.

Coverage problem from the perspective of target localization for wireless camera sensor networks has been proposed [8]. Localization oriented coverage (L Coverage for short) using Baysian estimation theory has been proposed.

A centralized cum sub centralized scheme [9] handle multiple events that occurs simultaneously while reducing unnecessarily activated camera as to cover event region effectively. When event occur there may be chances of activating camera outside the event boundary unnecessarily. This technique avoids undesirable activation of camera to reduce power consumption as well as redundant data transmission is eliminated.

Distributed topological camera selection (DTCS) [10] is used to select minimum cameras to cover entire surveillance area when there is no location information. To select minimum cameras, Laplacian and topological properties of the network are used. DTCS runs in O (n^2) at each node and also required memory and amount of information transmission are reasonable.

Distributed barrier coverage algorithm [11] is designed for both cameras without rotation capabilities and with rotation capabilities. Basic distributed β-breadth belt barrier construction algorithm without rotation (D-TriB) which provide β –level of quality of measure and also proposed an enhanced distributed algorithm β-breadth belt barrier construction algorithm with rotation (D-TriBr) to enhance network lifetime effectively. The proposed work reduces number of camera sensor and also ensures that any barrier β-QOM in the network can be identified.

Designed a technique to improve effective field coverage of directional sensors [12] to propose a greedy algorithm and also use the characteristics of voronoi diagram. Using voronoi vertices identify the sensor direction and voronoi cells are formed by dividing the sensor field. Coverage contribution of convex polygonal cells of sensor and coverage overlap of directional select between neighbor sensors, the working direction is adjusted to improve overall sensing field coverage ratio. Efficiency of proposed algorithm is evaluated using different parameters like number of sensors, angle of view and sensing radius.

The energy efficient FOV (Field of View) characterization framework [13] has been designed. The characterization framework consist of (i) sensing range selection (ii) maximizing spatial coverage (iii) adaptive task classification (iv) minimizing the number of required nodes. This technique also proposes task classification and soft decision based on sensing range selection scheme for heterogeneous networks which results 49.8% energy savings compared to existing solutions. According to the study this technique can be utilized during network design and calibration phase to achieve an application aware solution in homogeneous and heterogeneous networks.

This work focused on finding optimal visual sensor network (VSN) [14] configurations given by (i) selection of camera to sufficiently monitor the area of interest (ii) setting of camera frame rate and resolution (iii) assignment of processing task to camera. This work used for optimizing the coverage and resource allocation in VSN with pan-tilt-zoom camera nodes.

This will give brief idea about equivalent sensing radius (ESR) [15] to evaluate critical requirement for asymptotic full view coverage in heterogeneous camera sensor network (CSN) in static and mobile camera sensor networks. Thecritical range has been covered in static and mobile nodes.

A heuristic algorithm (FOVIC) has been designed to tackle the sensor coverage problem in wireless multimedia sensor networks (WMSN) [16]. Deploy sensor node one at a time to cover largest number of uncovered nodes and then remove the nodes which are deployed earlier stage. Experimental results shows that the proposed work successfully overcome coverage constraints (sensing range and Field of view) by using FOVIC. According to this work it requires less number of sensor nodes to cover given area.

A barrier coverage approach to address the issue related to K-barrier coverage problems [17] in WSN. Also find maximum number of distinct defense curves with each of which consist of few camera sensors as possible but still guarantees K-barrier coverage. To address these issues two barrier construction policies are used (i) Basic approach (ii) Branch approach. Experimental results shows that proposed mechanism constructs more defense curve then K-barrier approach and also reduce the number of camera sensor.

Electrostatic field based coverage enhancing algorithm (EFCEA) [18] has been proposed. It consists of two parts. Firstly, built a virtual field and grid in the scene sector and define grid's number covered by every neighbors charge and calculate the correlation degree of every neighbor for all sensors. Secondly, redundant sensor shut off if their grid are wholly covered and waked up according to correlation degree to die-out sensor. Coverage of networks can be enhanced although large numbers of redundant are shut off by their centroid point revolving round the sensor under the repel force based on electrostatic field.

Random deployment of camera sensor leads to waste of sensing resources. To tune this issue author proposed a novel approach [19]. First attempt is to explore the deployment strategy to achieve full view barrier coverage with rotatable camera sensors. Then select camera sensors from an existing deployment and determine their orientations to obtain full view barrier coverage by saving number of camera sensor used.

A camera network complex (CN-complex) [20] that accurately capture topological information about visual coverage of network hs been proposed. This provides a coordinate free calibration of the sensor network and demands no localization of cameras or objects in the environment. Decomposing the field of views of the camera nodes locally and then determining overlap between pairs by transmitting sparse occlusion events across the networks.

View coverage model is proposed to measure the coverage quality. The orientation of camera sensors is achieved by self-proposing distributed multi-round view coverage enhancing (VCE) algorithm [21]. In this sensors are continuously rotated to reduce overlapping view coverage with neighbors. View coverage ratio has been improved significantly by using refinement procedures.

To improve total area coverage, clustering based scheme has been proposed which re-orient the field of view (FOV) [22]. The network is divided in to various clusters depending on the nodes communication radius. Then each node is checked against every other node to find whether nodes intersect or not. At last , the reorientation of overlapping nodes takes place in order to reduce the overlapped area so that effective coverage can be improved.

Two stage optimization problems have been discussed [23]. At the first stage number of admitted sensor node is maximized and second stage network lifetime is maximized. This two stage optimization can be converted to one stage optimization. This is suitable for network having limited resource.

Comparison of Angular Coverage Technique:

Scheme	Advantages
Morsly, Yacine, et al.[4]	Better solution for coverage problems in large scale dimension.
Yildiz, Enes, et al.[5]	Provide full coverage by reducing the number of cameras required by 30%.
Chen, Jian [7]	Increase the network lifetime by switch off redundant nodes.
Sushree Bibhuprada B.et.al [9]	Turn off unnecessarily activated cameras to reduce power consumption.
Varposhti.et.al. [10]	Select minimum cameras to cover entire surveillance area when there is no location information.
Cheng.et.al.[11]	Reduce the number of camera sensor to in a given surveillance field.
Sung.et.al. [12]	Provide better sensing field coverage ratio.
Amjad.et.al.[13]	Maximizing spatial coverage and minimizing the number of required nodes.
Dieber.et.al. [14]	Select minimum number of camera to sufficiently monitor the area of interest
Hong-Hsu Yen.et.al.[16]	Requires less number of sensor nodes to cover given area.

Conclusion:

Coverage and connectivity are two of the most basic issues in WMSNs, which greatly affect QoS of WMSNs. Many algorithms, strategies and mechanisms have been proposed by specialists around the globe to take care of these issues. Initial, a brief prologue to the fundamental learning of coverage issues are explained in this paper. Second, we take energy efficient factors into consideration, and depict the coverage and connectivity issues from three aspects: coverage deployment strategy, sleep scheduling mechanism and adjustable coverage radius.

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