Optimized Occlusion-Free Viewpoint for Improving the Coverage in Wireless Multimedia Sensor Networks

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Abstract— Successful transmission of online multimedia streams in the wireless multimedia sensor networks (WMSNs) is big challenge due to limited bandwidth and power resources. The existing WSNs protocols are not completely appropriate for multimedia communication. The effectiveness of WMSNs varies upon on the correct location of its sensor nodes in the field. Thus, maximizing the multimedia coverage is most important in delivery of multimedia contents. In this paper, we study the location problem in order to maximize the multimedia coverage of the node. Our approach helps the multimedia sensor nodes to calculate their directional coverage. We apply optimized occlusion-free viewpoint (OOFV) that improves the multimedia coverage. Based on our simulation, we demonstrated that our research approach obtained substantial improvement in multimedia coverage.

Keywords—Wireless multimedia sensor networks (WMSNs), optimized occlusion-free viewpoint and multimedia coverage

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I. Introduction

WMSNs enable numerous applications in surveillance and system monitoring. WMSNs are capable of capturing audio-visual information by using low-cost cameras embedded with sensor nodes. The necessity of using multimedia sensors is to obtain ample information that is related to specific area of interest [1-3]. However, multimedia applications face online media transmission challenge [4]. To facilitate the on-demand multimedia services, we focus on multimedia sensor nodes to calculate their directional coverage. The limitations of the multimedia sensing capabilities relate to the location coverage. Once the best location coverage for multimedia sensors is determined, the results will help to improve the capability of WMSNs applications overall. Unfortunately WMSNs experience problems due to limitations such ass tall buildings, mountains, and trees. By Setting the location and orientation of multimedia sensors add the multimodality advantage. Several interesting works are available for image processing that obtain object geometry information such as input resource from the multiple database. In addition it is necessary to modify in the camera and lens in order to regulate the camera settings and poses. Hence, directional coverage of multimedia sensors could be done once they are deployed an area of interest. However, proper directional location for multimedia sensors requires accurate field information prior to deployment of sensors. It is also possible that multimedia sensors might change their pose over time. Another issue with WMSNs is the failure of sensor nodes due to battery outage. This problem can by solved by dynamic update of the locations through location information exchange. This paper introduces an approach for the directions and locations for sensor nodes used in WMSNs. Our research focuses on the improvement of the aggregated quality of sensed information and minimize the effects of obstruction in the environment. Our approach helps multimedia sensors detect the most useful location and direction of an entire area that should be developed by using low-resolution portraits from multiple sensors. Furthermore, our approach helps multimedia sensors set their configuration automatically and also improve the coverage. The proposed approach also reduces the negative effect of obstacles that can improve the Quality of Service (QoS). The remainder of the paper is organized as follows: Section II gives an overview of the existing approaches. Section III gives detailed information of our proposed optimized occlusion-free viewpoint approach. Section IV presents setup and experimental results. Finally entire paper is concluded in section V.

II. RELATED WORK

In this section, the important features of various approaches are discussed. Maximizing the coverage area has been addressed in the fields of wireless sensor networking, multimedia, ad-hoc network, and robotics. Substantial work is available for wireless sensor networks that address an omnidirectional coverage discussed in coverage problems [5, 6]. However, solutions in the proposed approaches cannot be used for bidirectional and occlusion-free viewpoint sensors such as low resolution enabled video cameras. Existing approaches measure environmental information using omnidirectional sensing. However, several applications require bi-directional support. Thus, existing developed coverage models are suitable for traditional wireless sensor networks (WSNs), but not suitable for WMSNs. An initial study regarding the coverage of multimedia sensors is addressed in [7]. In this work, authors proposed routing approaches with the field of view camera placed on the floor. The wide numbers of video sensors are used by oceanographers to monitor the shallows using image-processing approaches. Furthermore, triangular view sections are deployed for calculating the coverage of WMSNs in [8]. This contribution aims to determine the least detected distance to any multimedia sensor. The Voronoi diagram and Delaunay triangulation are introduced for measuring the worst and best case coverage in WMSNs in [9]. Additional sensors are added to increase the coverage in [10]. In the proposed work, a two stages process involves phase coverage holes the boundaries and obstacles that are eradicated by employing the sensors with the distance $\sqrt{2 * R}$ (R: sensing radius of sensors) from each other. In the second phase, the sensor's disposition becomes more sophisticated through the use of Delaunay triangulation and circumcircles. Virtual centripetal force-based coverage-enhancing protocol is introduced in [11] for WMSNs. In this work, the centripetal force model, the grid theory and the essential mass of the sensors and overlapping of the sensors are discussed. In this approach, the idle multimedia sensors are shut off to improve the network coverage. Furthermore, redeploying sensors using centripetal force found within circular motion enhances the network. In our approach, we applied the optimized occlusion-free viewpoint to improve the multimedia coverage that provides an accurate coverage of deployed multimedia sensor nodes.

III. OPTIMIZED OCCULSION-FREE VIEWPOINT FOR WMSNs

Our approach is designed for distributed WMSNs because the sensor nodes are deployed in a distributed fashion within a realistic environment. On the other hand, centralized location deployment is not suitable for WMSNs because these networks involve large number of multimedia nodes. Furthermore, updating the location is costly within a centralized approach when compared to a distributed approach. Our approach consists of two phases:

- Message Exchange Phase
- Distributed Location Detection Phase

A. Message Exchange Phase

In this phase, the sensor nodes exchange the messages between 1-hop neighbor nodes to gather the information. All sensors nodes broadcast the message. This process is called the neighbor handshake indication (NHI) process. The NHI consists of IDs and the current location of the sensor node.

Let us assume static sensor nodes that include identical viewpoint and list of overlapped neighbors are available in the same sensing location that returns the NHI. This aims to ensure that each sensor node should know their neighbor nodes and their location.

$$T_{nn} = \sum_{i=0}^{k} (N_{n1} + N_{n2} + N_{n3}, \ldots, N_{nn}) \quad (1)$$

In Equation (1), the total neighbor nodes $'T_{nn}'$ are accumulated to determine the exact number of all 1-hop neighbor nodes. Each neighbor node $'N_n'$ sends NHI message that can be described as:

$$N_n = \int_{i=1}^{1} (N_{id}) + L_c \quad (2)$$

In Equation (2), the neighbor handshake indication message is broadcasted by the neighbor node that consists of node ID $'N_{id}'$ and the current location $'L_c'$ of the sensor node.

$$N_n \rightarrow M_r = \int_{i=1}^{1} (N_{id}) + L_c \times \sum_{N_n \in N_o}^{T} (N_{o1} + N_{o2}, \ldots, N_{on}) \quad (3)$$

In equation (3), each neighbor node returns the message $'M_r'$ with node overlapping report $'N_o'$ including current location of each neighbor node.

B. Distributed Location Detection Phase

This phase helps determine the location of the sensor node. It involves the node boundary (area of the node that broadcasts the message), and node viewpoint within range $[0, 360^0]$. If the sensor node fails to determine the location of the neighbor node within the node boundary, then it initiates the neighbor distance process that checks the distance to node viewpoint neighbors. Finally, an obstacle-distance process is applied. If three processes are not successful then sensor node compares the optimized occlusion-free viewpoint to determine the largest viewpoint. Let us assume that sensor node $'S_n'$ is located in the field. There are three obstacle inside the viewpoint that are relatively close to $'S_n'$ that could be the reason for occlusion of the sensor node. The intersections of curves on the node boundary are displayed with points A and B for the first obstacle, C and D for second obstacle and C and E for third obstacle. Hence, the sensor node can identify that if there exists a $'\wedge_j^{\theta j}'$ where $\wedge_j^{\theta j} \cap \wedge_j^{<ATB} = 0$, $\wedge_j^{\theta j} \cap \wedge_j^{<DTC} = 0$, and $\wedge_j^{\theta j} \cap \wedge_j^{<CTE} = 0$, then $\wedge_j^{\theta j}$ is visible to the viewpoint that refers to curves AB (clock wise), CD and CE as occluded curve on the viewpoint of the sensor node. The node bound, not only determines the visible viewpoint, but also helps identify the non-overlapped viewpoint. Similarly, the sensor node also finds the overlapping area using node boundaries. The complete node boundary process is depicted in Figure 1.

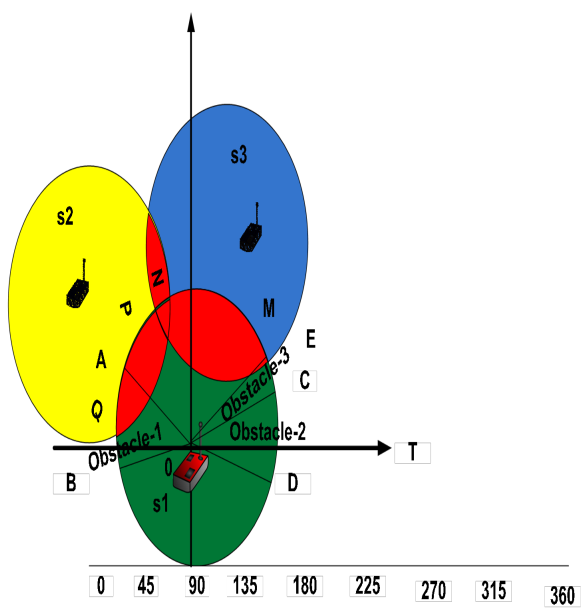

Figure 1: Showing complete boundary process

If the viewpoint is not covered by the neighbor nodes in any direction that is referred to as non-overlapping area, we check to see if the sensor node has an observable viewpoint field that might be overlapped.

IV. SIMULATION SETUP AND EXPERIMENTAL RESULTS

To validate the performance of our proposed optimized occlusion-free viewpoint, we conducted the simulation. Here, sensor nodes are randomly distributed in the field in the form of a two-dimensional terrain. All the sensor nodes are fully configured using the angle $\theta = 70^0$ and the 45 meter sensing range is set for each sensor node. The distance between the transmitter and the receiver node is set at 70 meter. Initially, 90 multimedia sensor nodes are deployed with automatic location capabilities. Then we set 2-18 obstacles for each sensor node that highly affect the viewpoint of the multiple sensor nodes. The rest of the simulation parameters are described in Table 1.

Table 1: Simulation parameters and its corresponding values

PARAMTERS	VALUE
Size of network	500 × 500 square meters
Number of multimedia sensor nodes	90
Queue-Capacity	40 Packets
Mobility Model	Random way mobility model
Maximum number of retransmissions allowed	03
Initial energy of node	10 joules
Size of Packets	512 bytes
Data Rate	430 kilobytes/second
Sensing Range of node	45 meters
Simulation time	10 minutes
Average Simulation Run	12
Base station location	(0,500)
Transmitter Power	12.2 mW
Receiver Power	13.4 mW
Buffer threshold	1024 Bytes
Distance between transmitter and receiver node	70 meters
Number of obstacles	2-18 obstacles

Based on our simulation, we obtained improvement results in multimedia coverage.

A. Multimedia Coverage gain

To confirm the effectiveness of our proposed optimized occlusion-free viewpoint, we have created several obstacles in order to determine the coverage gain. Furthermore, we compared the performance of OOVF with the Self-orienting wireless multimedia sensor networks (SOWMSN). Figure 2 a & b show 45 and 90 nodes respectively that include 2-18 obstacles. We observed in Figure 2 a & b that when the number of obstacles increase, the coverage gain decreases. However, coverage gain of our proposed OOVF is higher than SOWMSN with 45 and 90 sensor nodes. Our results demonstrated that the approach OOVF substantially improved the coverage of multimedia sensor nodes.

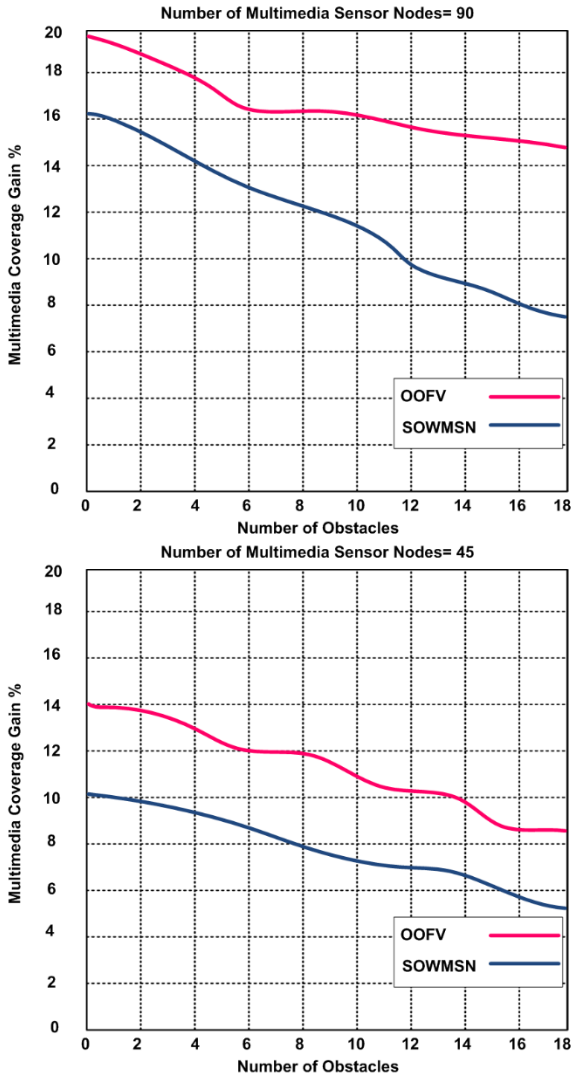

Figure 2: a & b showing multimedia coverage gain at different number of the obstacles

V. CONCLUSION

In this paper, an optimized occlusion-free viewpoint is introduced for improving multimedia coverage. Our proposed approach consists of a message exchange phase and a distributed location detection phase. Both phases help to determine overlapped and non-lapped area of sensor nodes. Furthermore, our approach finds the exact location of each sensor node that helps improve the coverage of multimedia sensors. The simulation results demonstrate that OOFV gains more coverage than SOWMSN. The coverage can also be improved even for sparse networks by using directional coverage for random obstacles in the wireless sensor network field.

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