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# Minimization of Unnecessary Field of View Utilization and Redundant Data Transmission in Wireless Multimedia Sensor Networks

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***Abstract*— In this advanced era of science and technology, Wireless multimedia sensor networks (WMSNs) have many applications in almost all the spheres of life starting from medical to military applications. Out of various challenges encountered in WMSNs, redundant data transmission stands as one of the major challenge due to which unnecessary consumption of CPU power, bandwidth, battery power etc. occurs. Redundant data transmission takes place due to overlapping of field of views of camera sensors. Field of view represents the angle at which a camera can capture actual image of an object. Due to overlapping of FOVs among the camera sensors, scalars present at the common overlapping region communicate the same event information to same set of cameras. As a result, same information is communicated multiple times. This leads to transmission of redundant data. Therefore, several methods are adopted time and again to eliminate such redundant data transmission. When an event takes place in a monitored region, sensing of event not only takes place inside the event boundary as well as up to some extent of outside the event boundary. Therefore, some cameras present outside the event region also detect the event and are activated unnecessarily due to sensing of event outside event boundary. Such situation arises as some of the scalars present within field of view of these cameras sense the event as their sensing range cover the event region. The problem is that the depth of fields of such cameras do not cover the event region, but they are activated unnecessarily due to sensing of event by the scalars within their field of view. Therefore, Field of View Utilization (FOVU) increases unnecessarily due to activation of such cameras. Our objective is to minimize such Field of view utilization (FOVU) and redundant data transmission.***

***Keywords*— ECIM, ESIM, HPN, EDS, MD, FOV, DOF, FOVU**

## I. INTRODUCTION

Wireless Multimedia Sensor Networks (WMSNs) are extension of Wireless Sensor Networks (WSNs), where in addition to scalar sensors some camera sensors are present. Scalar sensors include motion sensors, temperature sensors, light sensor etc. Scalars are the sensors that can capture textual information. However, Camera sensors are the sensors, which are capable of taking image of object(s). Therefore, WMSNs have gained popularity in many fields such as surveillance, habitat monitoring, intrusion detection, industrial control, urban management, military applications, environmental testing, health care delivery, robotic exploration etc. In such applications camera sensors, operated by battery are used, which are deployed to capture multimedia data of occurring event of monitored region. The problem is that camera sensors quickly drain their battery power if they will be turned on always like the scalars. Therefore, cameras are generally kept in turned off condition. They are turned on whenever an event is detected by the scalar sensors present within their field of views [1]. Whenever, an event takes place in a monitored region, it is first of all detected by the scalar sensors. The concerned scalars communicate the information captured by them to their respective camera sensors. After hearing regarding the occurring event from the scalar sensors, the camera sensors decide which among them are to be actuated. So questions come to our mind that how many and which camera sensors are to be activated for covering the event region optimally. Therefore, a distributed Collaborative Camera Actuation scheme is used [1]. Again sensing of event not only takes place within the event region it also takes place up to certain extent outside the event region. The cameras present outside the event boundary region are activated unnecessarily due to sensing of event outside the event boundary region although their FOVs do not cover the exact event region. Such thing occurs as some of the scalars although being present within the FOV of camera sensor, sense the occurring event as their sensing range cover the event region.

Therefore, the cameras present outside the event boundary region are activated unnecessarily due to sensing of event. As a result of which unnecessary FOV utilization takes place. Therefore, our objective is to eliminate such unnecessary FOV utilization and activate required optimum number of camera sensors for adequate coverage of occurring event.

## II. ORGANIZATION OF PAPER

This paper is organized as follows. In the next section, We summarize the related work of paper. Section IV states the background study. Section V includes the problem description and proposed work. Section VI details the proposed algorithm. Section VII includes implementation and result analysis. Finally section VIII concludes the paper

 

## III. RELATED WORKS

Several research works are carried out in the field of WMSNs for the elimination of redundant data. We discuss the related works under the following categories.

### *A. Sensing Region Management Approach.*

The main idea of this Scheme is to divide the whole Sensing Field into number of Sensing regions. Each Sensing region is covered by set of scalar and camera sensors. The scalar sensors form cluster heads. Therefore, by hearing from the scalar cluster heads, each camera sensor can know regarding the occurring event [2].

### *B. Scalar Count Approach.*

When an event takes place in a monitored region the information is first of all captured by the scalar sensors and consequently the scalar sensors inform the camera sensors regarding the occurring event. Then the camera sensors decide who among them are to be actuated based on the scalar count of the cameras. Scalar Count (SC) represents the number of event detecting scalars present within the field of view of cameras and detecting the occurring event information [1].

### *C. Event Boundary Detection Approach*

Event boundary detection is a very popular area in WSN. The idea behind the scheme is as follows. First, each sensor exchanges its binary event measurement (0 or 1) with its. neighbouring sensors. Then each node independently determines whether or not it is a boundary node according to the predefined statistic model and the updated measurements distribution in its neighbourhood. Basically, the sensors look at the number of 1s and 0s collected [1].

### *D. Art Gallery Problem Approach*

. Once the FOVs of cameras are known the art gallery problem can be used to determine least number of nodes and locations in order to provide 100% coverage of a monitored region. But for art gallery problem a prior manual deployment of nodes should be done. However, in our case We are considering the random deployment of nodes. Therefore, this approach cant be used in our case [3].

### *E. Guaranteed Connectivity and Coverage Approach*

It proposes a node placement strategy for providing full coverage and connectivity among nodes in the network [4].

### *F. Data Similarity Measurement Technique*

In a monitored region nodes record the information and send their reading to a centralized base station. Nodes close to each other sense similar information. The information is geographically correlated before sending [6].

## IV. BACKGROUND STUDY

A distributed algorithm is used for redundant data elimination as discussed in paper [1]. When event takes place in monitored region, it is captured by scalar sensors. Then scalars communicate their respective cameras regarding the occurring event. Then the cameras collaboratively decide who among them are to be activated, thereby eliminating data. redundancy . Let us now discuss some of the related terms.

### *A. Field of View (FOV)*

Field of View(FOV) represents the angle at which camera sensor can capture the accurate image of an object [1]. Camera sensors are of two types. They are directional and omni-directional camera based on the field of view angle. If the camera capture image of object along a particular direction, then the camera is regarded as directional camera. If camera can capture image uniformly in all the directions, then it is called omni-directional camera.

### *B. Depth of Field (DOF)*

It represents the distance at which a Camera Sensor can take accurate image of an Object [1].

### *C. Sensing Region*

Entire Sensing Field is divided into number of Sensing Regions. Sensing Region consists of number of points. Any two points belong to the same Sensing Region if they are covered by the same set of Camera Sensors [2].

### *D. Target Region*

The target region refers to the sensing region in which the scalar sensors detect event information [2].

### *E. Event Grade*

Event Grade refers to the number of activated Camera Sensors required to capture the event [2].

### *G. Coverage ratio:*

It is defined as the portion of the area of an event which is covered by all actuated camera sensors with respect to its total area [1].

 

### *H. FOV Utilization (FOVU)*

It is defined as the ratio of the area of an event covered by all actuated camera sensors to the total area of FOVs of all actuated camera sensors [1].

### *I. Number of messages*

This indicates the total number of messages sent in the network [1].

### *J. Data Redundancy*

Data redundancy occurs due to overlapping of field of views of camera sensors. Due to overlapping of field of views of cameras, the scalars present at the overlapping region of field of views send the same event information to the cameras. As a result of which same data is transmitted multiple times. So data redundancy takes place [1].

## V. PROBLEM DESCRIPTION AND PROPOSED WORK

### *A. Problem Description*

Several works have been carried out in the field of WMSN to eliminate the redundant data. In paper [1] it is considered that whenever, an event takes place in a monitored region it is first of all detected by the scalar sensors. After detecting the event the scalars communicate the information to their respective cameras. The condition is that the scalar sensor should lie within the field of view of camera. Then the camera sensors exchange their reading with each other collaboratively and decide in a distributed manner that who among them are to be actuated. However, the problem is that when the event takes place sensing of event not only occurs within the event region but also up to some extent outside the event region. But the cameras that are present outside the event region are actuated unnecessarily as their DOF don't cover the event region. Still then they are informed regarding the event as sensing range of some of those scalars present within the FOV of cameras but closer to the event area sense the event and they communicate their reading to their respective cameras. As a result of which the camera sensors are unnecessarily activated.

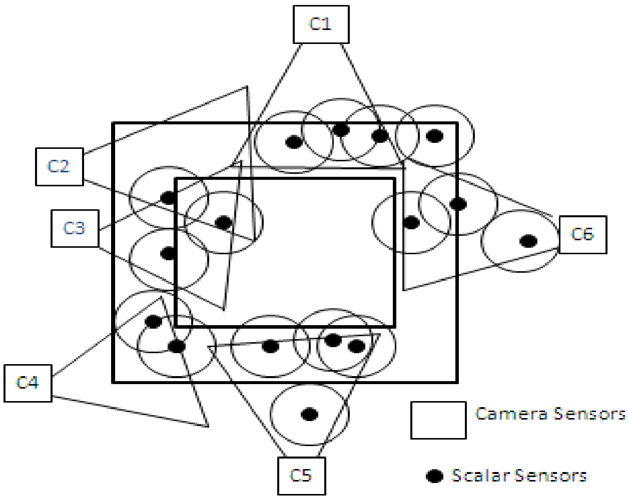


Fig. 1 Sensing of Event Outside Event Boundary

Consider Fig:1. Here six camera sensors are present namely C1, C2, C3, C4, C5, C6, represented by the tiny square. The triangular shape represents the field of views (FOVs) of cameras. The dark tiny circles represent the scalar sensors. The large circles present around dark scalars represent the sensing range of scalar sensors. That is the range within which the scalar sensor can sense the occurring event information. Out of the two large squares, the region within the inner one represents the actual event region as well as the sensing region of event and the outer one represents the total sensing region of the occurring event. Here when an event takes place it is first detected by scalar sensors. Then the scalars communicate their reading to their respective camera sensors. After being informed, the camera sensors exchange their reading among themselves to decide who among them are to be activated. Here in Fig:1, consider the case of C1, C4, C5, C6. These are the cameras whose DOF do not cover the actual event region. But they are informed by the scalars as the sensing range of some of the scalars present within their FOVs cover the sensing region of occurring event. As a result, these four cameras are unnecessarily activated which leads to unnecessary power consumption a well as CPU processing. Hence our objective is to keep these cameras in turned off condition. As only the required number of cameras will be actuated, eliminating the case of unnecessary actuation of the other cameras, this leads to minimization of unnecessary FOVU.

### *B. Proposed Work Description*

Let us consider an area of interest. Let this area be our monitored region. The approach used in paper [1] is treated as our initial approach. In our initial approach , whenever an event occurs in this monitored region it is at first detected by the scalar sensors. Then the scalar sensors broadcast DETECTION message [1]. This message contains the ids of scalars and the occurring event information. Being informed from scalars, the cameras exchange INFORM messages with each other that contain the SC values of each cameras. SC value of a camera sensor represents the number of scalar sensors that are present within the FOV of the camera and which are also detecting the occurring event [1]. The camera having the maximum SC value is activated first. Then the activated camera sends UPDATE message to each other so that other cameras can match the ids of scalars present in their SDE (Scalars Detecting Event) table to the ids of scalars contained in UPDATE message. A priority list is maintained by each camera that contains the ids of cameras to be activated.

In our proposed approach, a table namely MYDETECT (MD) is maintained. Initially the cameras broadcast Exchangeable Camera Information Message (ECIM) and scalars broadcast Exchangeable Scalar Information messages (ESIM) respectively. We considered a binary parameter having value either 0 or 1 is used. This binary parameter value is sent by the scalar sensors while broadcasting HAPPEN (HPN) message. When there is no event in the monitored region the parameter value is 0 for scalars. It is changed to 1 for the scalars who detect the event within the event region. The HPN message is sent by the scalars when event occurs. The HPN message contains value 1 if the scalar sensor is present within the event region. If the HPN message contains binary value 1, then the id of that scalar is included in MD table. Along with the binary parameter value, the HPN message contains the event information and id of the concerned scalar.

Next, the camera sensors match the ids of scalars maintained in their FOV tables with those maintained in MD table. In our new approach it is assumed that if any of the scalar id present within both the tables match, then that camera undergoes distributed camera actuation scheme. Otherwise, it is kept in turned off condition and does not take part in distributed camera actuation scheme. Here two situations arise.

The two cases can be described as follows.

**Case 1:**

If for any camera C following equation satisfies, then the camera is kept in turned off condition by sending a sleep message represented by Status = FALSE.

$$FOV \bigcap MD = \phi$$

**Case 2:**

If for any camera C following equation satisfies, then camera C undergoes distributed camera actuation scheme represented by Status=TRUE.

$$FOV \bigcap MD \neq \phi$$

. The camera sensors those decide to take part in distributed camera actuation scheme exchange the INFORM message thereby exchanging their scalar count values. Then the cameras are actuated based on the decreasing order of scalar count values like paper [1] by exchange of UPDATE message. As a result only the cameras whose DOF cover the exact event region are actuated. So unnecessary camera actuation is avoided. As only required number of cameras are actuated in this scheme, so unnecessary FOV utilization is eliminated.

In paper [1] a threshold value $\alpha$ has been taken to decide whether to actuate the camera or not. But in our proposed approach our objective is to eliminate redundant data and to avoid unnecessary camera actuation but in such a manner that no event information is missed. So no threshold value is taken in our proposed approach. As We are concentrating on 100% coverage of occurring event. In proposed approach, it is considered that even if at least one scalar is present within FOV of camera then concerned camera has to be actuated provided that scalar is not covered by any other camera sensor. As We are considering the case that each event point has to be covered.

## VI. MODIFIED PROPOSED ALGORITHM

1. Initialize the tables EDS, PCS and MD to zero.
2. Initialize table FOV to number of scalars within the field of view of concerned camera.
3. Camera sensors broadcast ECIM message and scalars broadcast ESIM . ECIM message contains the ids and locations of cameras. ESIM contains the ids and locations of scalars. As a result the cameras and scalars can know the position of each other.
4. At any instant of time scalars maintain binary value 0 or 1. Initially when no event is there, binary parameter value is zero(0) for all scalars. The binary parameter value of scalars covering event region is changed to 1, when the event takes place.
5. After occurrence of event the scalars broadcast their binary parameter value in HPN message. While receiving HPN message , if HPN message contains value 1 for a particular scalar, then id of that scalar is added to MD table.
6. If HPN received from scalar S and $S \in FOV$ , then add S to EDS table.

Two cases arise here.

**Case 1:** If for any camera C following equation satisfies, then the camera is kept in turned off condition by sending a sleep message represented by Status= FALSE.

$$FOV \bigcap MD = \phi$$

**Case 2:** If for camera C following equation satisfies, then camera C undergoes distributed camera actuation scheme represented by Status=TRUE.

$$FOV \bigcap MD \neq \phi$$

7. If $SC \neq 0$ then broadcast INFORM message
8. Consider threshold $\alpha$ = 0.
9. If INFORM message is received from j, and and scalar count value of jth camera is greater than or equal to i th camera, then add j to PCS table, If jth camera has maximum SC value.
10. If number of cameras within PCS > 0 and UPDATE message received from j then add the neighbouring scalars of j to neighbours of i.
11. Broadcast UPDATE message.
12. Cameras collaboratively decide who are to be actuated by exchanging the ids contained in UPDATE message with the ids contained in EDS table. Actuation of camera takes place based on decreasing value of scalar count (SC).

## VII. IMPLEMENTATION AND RESULT ANALYSIS

The implementation was done in C++ in UBUNTU platform. We have considered a 500 *500 topology. The location of the event has been chosen randomly. We varied the number of scalars, number of cameras, event radius and depth of field and observed their effect on number of cameras actuated and FOV utilization.

### *A. Assumptions Taken*

In this paper it is assumed that the scalars and cameras are randomly deployed. They are assumed to have fixed positions. The sensing range of scalars, depth of field, event boundary are assumed to be circular for easier implementation. Again it is assumed that the cameras and scalars broadcast ECIMs (Exchangeable Camera Information messages) and ESIMs (Exchangeable Scalar Information messages) respectively. These messages contain their ids and location information. Here message exchange occurs through broadcasting. Again a heuristic approach is used that is, it is assumed that no event information will be lost. That is 100% coverage of occurring event is to be achieved with minimization of overlapping of Field of Views. Here the implementation is done by considering100% coverage of event and thereby minimizing the FOV utilization. In the initial approach [1], We used concept of distributed camera actuation while considering omni-directional cameras for implementation, with full coverage of event region. But in our new proposed approach, full coverage of event region is achieved but elimination of unnecessary camera actuation is done. Such unnecessary camera activation occurs as the cameras present outside the event boundary are activated as the sensing of event occurs outside the event boundary up to certain extent. Such thing occurs as some of the scalar sensors present within FOV detect the event as their sensing range covered the event sensing region. Therefore, our objective in new approach is to eliminate such unnecessary activation of camera sensors. As these cameras which were activated unnecessarily are to be kept in turned off condition, therefore, unnecessary FOV utilization is eliminated in our proposed approach. In our implementation, We have considered that no portion of occurring event should be missed.

### *B. Performance Evaluation*

A comparative study of initial and proposed approach is done. In the initial approach cameras lying in the entire sensing range of event undergoes activation. But in our proposed scheme the cameras covering the exact concerned event region are activated while keeping the camera sensors outside the event region and inside the sensing range in turned off condition.

The red line represents initial approach and green line represents proposed approach i.e. the line having triangular points within it, represent the initial approach and that having squared points within, represent the proposed approach.

#### *1) Effect of varying number of scalars (noss) on number of cameras actuated (noca):*

We varied the number of scalars keeping number of cameras, DOF, sensing range of scalars, event radius and sensing range of event as constant and observed its effect on number of cameras activated. In both the cases varying the number of scalar sensors increases the number of cameras activated as shown in Fig. 2. Such thing occurs as with increase of number of scalar sensors the number of event detecting scalar sensors also increases. Hence scalar count of the camera sensors also goes on increasing. In our approach We have considered that if at least one scalar is present within the field of view of camera and if that one is not covered by any other camera sensors then the concerned camera has to be actuated. As number of scalars goes on increasing more cameras contain at least one scalar sensor. Therefore number of cameras activated increases gradually.

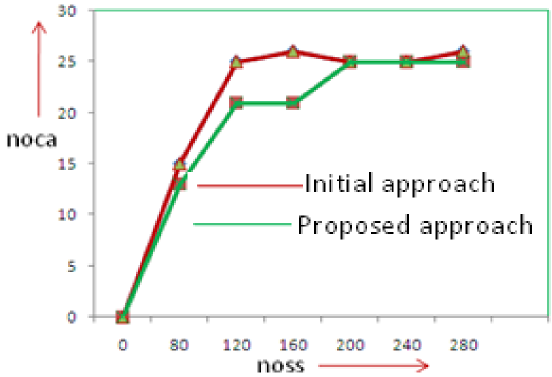


Fig. 2 Effect of varying number of scalars (noss) on number of cameras activated (noca)

Then the value remains almost constant. Such situation arises as the optimum number of activated cameras required to cover an event region is almost constant.

***2) Effect of varying number of cameras (nocs) on number of cameras actuate (noca)d***

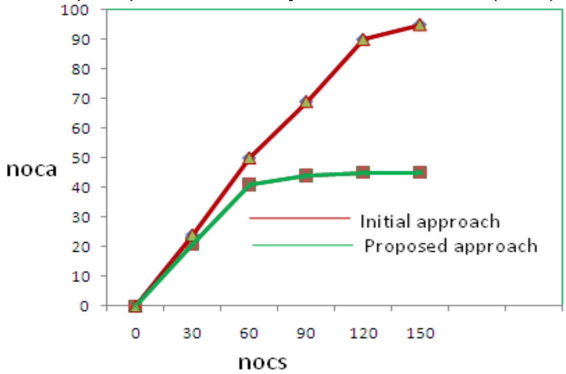


Fig.3 Effect of varying number of cameras (nocs) on number of cameras actuated (noca)

We varied the number of cameras keeping other parameters as constant and observed its effect on number of cameras activated as shown in Fig. 3. We observed that with increase of number of cameras the number of cameras actuated increases. As with increase of number of cameras, more cameras are going to cover at least one scalar. Again We are concentrating on hundred percent coverage and considered threshold $\alpha$ value as 0. So number of cameras actuated increases. As in case of initial approach the cameras present outside event region are also activated due to sensing of event outside up to certain extent of area, so number of cameras activated in initial approach is more than that of proposed one.

***3) Effect of varying DOF on number of cameras actuated (noca)***

We varied the DOF keeping other parameters constant and observed its effect on number of cameras activated as shown in Fig. 4. We observed that with increase of DOF, the scalar count (SC) value of cameras also increases. Hence the number of cameras activated also goes on increasing. Such thing occurs as with increase of DOFs the cameras cover more and more scalars. Therefore, more cameras are activated. We observed from the graph that number of activated cameras in proposed approach is found to be less than that of initial approach. This situation arises as the cameras that are not covering the exact event region are kept in turned off condition in proposed approach. As less number of cameras are actuated in proposed one, so amount of overlapping also decreases, so proposed approach is found to be better than that of initial one.

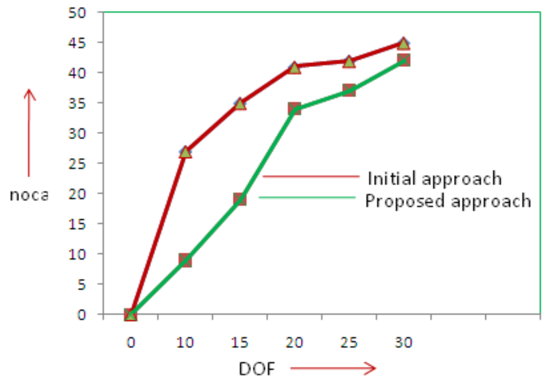


Fig. 4 Effect of varying DOF on number of cameras activated (noca)

***4) Effect of varying Event radius (evtrad) on number of cameras actuated***

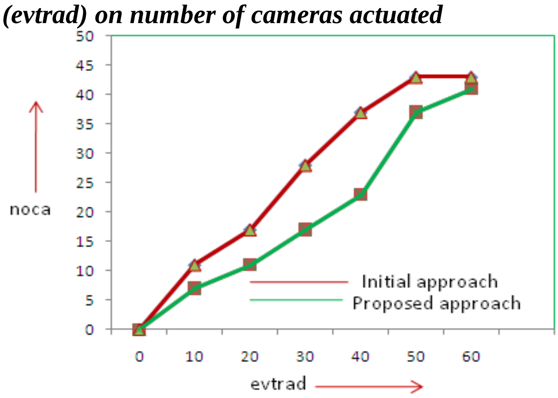


Fig. 5 Effect of varying event radius (evtrad) on number of cameras activated

 

We varied the event rdius keeping other parameters constant. We observed that with increase of event radius in both the cases the number of cameras actuated increases. As with increase of event radius, more number of scalars are going to detect the event and more number of cameras will be informed regarding the occurring event and are activated. In our proposed approach. We found that number of cameras activated is less than that of initial approach.

### *5) Effect of varying number of scalar (noss) on FOVU*

We varied the number of scalars keeping other parameters constant and observed its effect on field of view utilization as shown in Fig. 6. In case of initial approach we observed that with increase of number of scalars the field of view utilization increases and then it remains almost constant. Such thing occurs as due to increase in number of scalars, scalar count of cameras increases and hence number of cameras activated also increases. As a result, the area covered by the cameras goes on increasing. Hence field of view utilization increases. Then with excess increase of number of scalars amount of overlapping region of number of cameras increases.

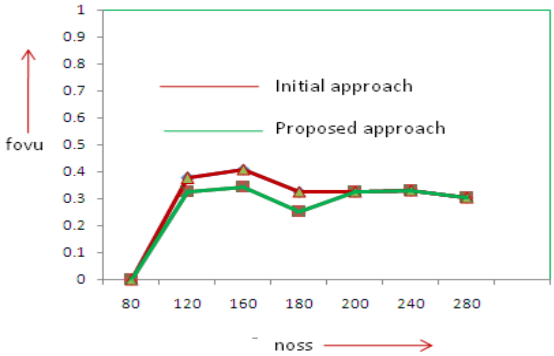


Fig. 6 Effect of varying number of scalars (noss) on Field of view utilization (FOVU)

As a result less amount of area is covered by activated cameras as they are closely placed. Hence after noss value exceeds 180 the number of camera actuated remains almost constant. Similarly in case of proposed approach FOVU increases as with increase of number of scalars, number of cameras activated increases initially. Then it remains almost constant. Since less number of cameras are activated in our proposed approach providing 100% coverage of occurring event, thereby keeping the cameras which are not required to be activated outside event area in turned off condition, so unnecessary FOV utilization is minimized.

### *6) Effect of varying number of cameras (nocs) on FOVU*

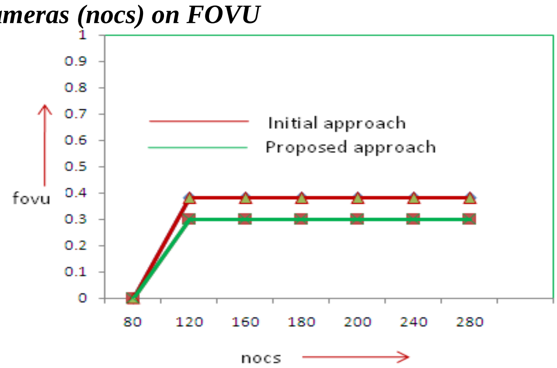


Fig. 7 Effect of varying number of cameras (nocs) on Field of view utilization (FOVU)

We varied the number of cameras and observed its effect on field of view utilization as shown in Fig. 7. In both the cases the FOVU was found to be constant. As optimum number of cameras required to cover a particular event region is always constant. Hence the area covered by the actuated cameras are found to be constant..

### *7) Effect of varying depth of field (DOF) on Field of view utilization (FOVU)*

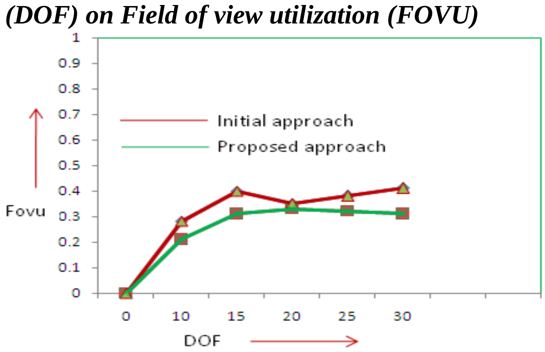


Fig.8 Effect of varying Depth of field (DOF) on Field of view utilization ( FOVU)

 

We varied the depth of field and saw its effect on FOVU as shown in Fig.8. We saw that with increase in value of depth of field FOVU increases and remains almost costant in both the approaches. But at DOF value 20 a sudden fall of DOF in initial approach occurs. This happens as We are considering random deployment of nodes and event occurrence. As in our proposed approach, the cameras present inside sensing region but outside exact event region are kept in turned off condition, so unnecessary FOVU occurring due to such cameras is avoided.

### *8) Effect of varying Event Radius (evtrad) on Field of view utilization (FOVU)*

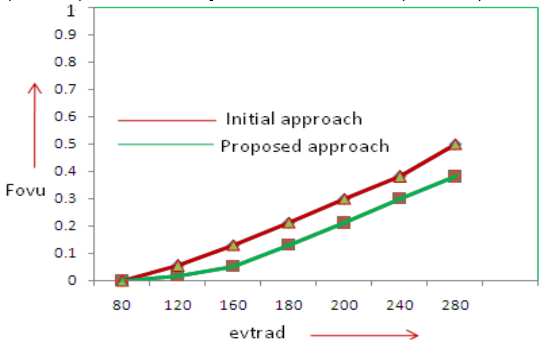


Fig. 9 Effect of varying event radius (evtrad) on Field of view utilization ( FOVU)

We varied the event radius (evtrad) and observed its effect on field of view utilization (FOVU) as shown in Fig.9. With increase of event radius more number of scalars come under the event region, Hence more number of cameras are communicated and they collaborate among themselves and decide who among them are to be activated. Since number of cameras actuated in proposed approach is less, therefore unnecessary FOV utilization that occurred in case of initial approach is minimized in our proposed approach.

## VIII. CONCLUSIONS

On considering the sensing of event up to certain extent of outside the event region and varying the different parameters like number of scalars, number of cameras, depth of field and event radius, We observed that number of cameras actuated in proposed approach is found to be less than that of the initial approach. As number of cameras actuated in proposed approach is less than that of initial approach, so the amount of overlapping of field of views is minimized in proposed approach. As a result, amount of redundant data transmission is minimized in proposed approach. The cameras that were activated unnecessarily in initial approach are kept in turned off condition. Therefore, the unnecessary FOVU occurred due to those cameras is minimized in our proposed approach.

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