Energy Enhancement in Wireless Sensor Networks Based on SVD and DWT Algorithms

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ABSTRACT: The Energy Enhancement and increasing the network lifetime in Wireless Sensor Networks (WSN) are the most important issues for the protocol design. In these networks, sensors have small dimensions, limited energy and have ability to sense the environments and can be used for data processing and information transmission between each other by means of radio channels. The Bandwidth and energy consumption of the WSN are two important issues that need to be considered. Most of the energy consumption in WSN is used for transmitting and receiving the data between nodes and among nodes and sub stations. Since the lifetime of sensors and lifetime of networks depends upon the limited amount of energy in sensor nodes, an efficient method of transmitting data between nods will reduce the energy consumption and prolong the network lifetime.

To obtain a high efficiency WSN for increasing the network lifetime, data transmission of these networks need to be reduced by employing different methods of data aggregating and image compression, to reduce the energy consumption. We have presented an optimized image transmission technique for energy enhancement in WSN that utilizes the Discrete Wavelet Transform (DWT) and the Singular Value Decomposition (SVD). In our method the data aggregating and image compression are performed to reduce the rate of date transmission and to increase the network lifetime. Our algorithm used DWT to compress the images and then applied the SVD to eliminate the image redundancy in order to prevent the unnecessary data transmissions and prolongs the lifetime of sensor networks.

Key Words: WSN, DWT, SVD. Compression, Lifetime, Sensor, Redundancy, Energy, Image

1. INTRODUCTION:

Wireless Sensor Networks (WSN) constructed by large number of small nodes. These nodes are wirelessly linked and each node can work independently without human intervention. They are typically very small and have some limitations in memory processing power and power supply.

The most important task of nodes in a WSN environment is to detect events (sensing), performing local data processing and transmitting the sensed data to other nodes or other sub-stations (communication)[1]. Investigation on the field of wireless sensor network clearly show that most of energy consumption in nodes has been used for the transmitting and receiving data between nodes and sub-stations.[2].

Moreover, the amount of energy consumed during the data transportation is much higher than the energy consumed for the communication and the required transmission energy increase exponentially as the transmission distance increase linearly. Thus, it is wised to reduce the amount
traffic between nodes as well as to reduce the transmission distance in order to increase energy saving and prolong the network lifetime [3].

We have already mentioned that a wireless sensor networks have a large number of sensors that randomly have been scattered in a specific areas or environment. They are responsible to collect the ambient conditions related to the environment surrounding the sensors and then transform them into electrical signal that are suitable to be transmitted via radio transmitter to Base Station (BS) or Sink. BS points are responsible to make a connection between the main data processing center and the sensing area via sensor nodes. The connection between nodes and BS can be done directly which is not optimal in terms of energy consumption in network because the adjacent nodes usually transmit similar or even the same data to the BS. Thus, an optimal algorithm can be used to remove the redundancy during the data transmission from the sensor node to the BS. Furthermore, a robust and fast data compression algorithm can be applied on the sensor data to reduce the transmission volume and saving the energy consumption of the sensor nodes.

There are several different structures for the WSN but the one that is more common is called hierarchical clustering technique. In hierarchical structure those nodes that geographically are located at the same region can be put together and form one cluster. The set of all clusters at different regions can choose one cluster head during the self-organization and the data from the nodes are aggregated at each cluster head and then will be sent to the central BS for the processing [4].

In these networks, sensors have small dimensions but they are able to sense the environment, have the potential of collaboration among the sensors during the data gathering and data processing. They also have the ability of information transmission via radio transmitter central station directly or through a gateway. There are two important issues in these networks, bandwidth and energy consumption, which relying on different applications and depends upon the functionalities of the system and would be different designs.

Data aggregation and image compression is one of the best ways to use the limited resources of sensor nodes, such as low processing speed, low memory and power constrains. Collected data from neighboring nodes, are always repetitive, redundant, and are highly correlated. Furthermore, the amount of data generated in large scale wireless sensor networks, is too much for processing in central station. Therefore, it seems necessary to use data compression and data redundancy reduction techniques to produce high quality data in sensor nodes that reduce the number of transmitted packets, and thereby reduce the energy and bandwidth of consumption.

Data aggregation is the act of combining data from different sources by using functions such as suppression or eliminating duplication, min, max, or averaging. It reduces the amount of network traffic which helps to reduce energy consumption on sensor nodes. The purpose of using data compression techniques, which is a sub-branch of data aggregation methods, is to reduce transmitted and received data volume, and hence reducing the consumed power for communication [4].

In this paper, we proposed an energy enhancement method in WSN based on the DWT and SVD to apply the data compression and data redundancy reduction techniques, respectively. Our proposed method will reduce the transmitted and received data volume and hence increase the speed of operations, reduce the overall energy consumption and bandwidth and thereby increasing the lifetime of wireless sensor networks.
2. RELATED WORKS

In 2005, Q. Liang and L. Wang, suggested a method based on combination of both SVD and QR Decompositions, SVD - QR, to reduce the redundancy in wireless sensor networks [5]. In 2009, J. Liang and Q. Liang, presented a method that can be used to construct sensors into cooperative Multiple-Input, Multiple-Output, MIMO systems over the certain distance range rather than the Single-Input, Single-Output, SISO systems. They claimed that the MIMO systems will provide a better performance than the SISO systems with regarding to the energy consumption [6]. In 2011, Mirzaee et al. proposed a practical adaptive version of the SVD-QR algorithm, which was proposed by J. Liang and Q. Liang [6]. They called their proposed algorithm ‘Adaptive SVD-QR-T FCM’, in which the fuzzy c-means (FCM) adaptively adjusts the number of clusters it uses, as compared with the SVD-QR-T in which only two clusters are employed[7].

In Wireless Sensors Network, various image compression algorithms are used. However, the majority of the compression algorithms are not applicable on sensor nodes because the restriction that exist in terms of memory and processor speed. Discrete Wavelet Transform for image compression algorithm is used in most of papers, but it required a large memory to perform and it cannot be used for sensor network unless it combined with other algorithms. Furthermore, researchers [8-10] have presented a few efficient algorithms as well as applied the adaptive data compression techniques that can significantly minimize the required energy for wireless sensor network based on Discrete Wavelet Transform.

3. PROPOSED ALGORITHM

Data aggregating can be performed on unprocessed data or performed locally on the group of clusters. But as we mentioned, energy consumption for communication is more than energy consumption for computation. Thus, the aggregation of local data in the cluster head can significantly reduce energy consumption across the system. These actions reduce the redundancy and compress the data to create the useful data with least volume for transmission from the cluster head (CH) to the base station (BS).

The process of generating the useful data with least volume during the transmission time will become more important when the required data are image type. The node sensors in WSN network that are located inside one cluster usually transmit similar images with the high rate of redundancy. Our proposed method has considered this issue and designed to reduce the image redundancy as well as to compress the sensed images before the transmission. To achieve our objective and obtain an efficient algorithm we have performed the data aggregation locally in CH as well as applied the SVD in Cluster Heads for data aggregating. By applying SVD on each cluster we can reduce the number of the sensed images by removing the repetitive images as well as similar images. We also have applied the DWT on all sensed images to reduce the size of images by removing the high frequency components that carry less information and are not vital for the quality of the images. Thus those images that are passed through our algorithms have the vital information and best characteristic of the images inside the cluster group with the least image volume and suitable for the transmission from CH to BS.

4. SIMULATION

To simulate our proposed algorithm and to demonstrate its performance we have used the MATLAB software. In this simulation, 100 nodes in an area of 100*100 square meters are randomly distributed. The central node location is at the point (50, 50). In this scenario, each node of the networks can be selected and play the role of the
cluster head. We assumed that all images are the same because they are captured from the same camera, as taken by sensor nodes of the same type. To demonstrate the superiority of our method and to show its high performance as opposed to the existing algorithms, 100 different sets of images in m different cluster heads were transmitted over the networks using the existing algorithm as well as using our proposed algorithm. The simulated result in Figure 1 clearly shown the superiority of our method over the existing one because the number of transmitted images in each round is less the number images transmitted via the existing techniques.

In the existing methods no data aggregation is applied and all images in the clusters are transmitted from the cluster head to the base station. But, in our algorithm the SVD is applied and the redundancy is removed by calculating the norm of all feature vectors of the images in the same cluster group. The feature vector of each images is consist of the singular vectors of the image. Once the norm of two images is the same, or very close to each other as compared with a threshold, one of the images can be removed to decrease the redundancy. By using SVD we have eliminated the similar images and reduced the number images to be transmitted from VH to BS. Once the redundant images are removed we will apply the multilevel DWT2 with db2 filter to compress the images, Figure 2, and to reduce the volume of transmitted data from CH to BS.

5. ANALYSIS OF ENERGY CONSUMPTION

The results of the our proposed energy enhanced method based on the combined SVD and DWT for transmitting the images over the WSN clearly shown that the size of data volume significantly has decreased and caused that overall energy consumption to be reduced. Thus, the reduction in data transmission will provide the reduction of energy consumption and thereby increase the lifetime of wireless sensor networks. We have compared our proposed algorithm with the existing ones from two points of views:

First aspect is the total number of images that will be transmitted from the CH to BS using each method. Second aspect is the size of data volume which will be transmitted from CH to BS using each method. The results of simulation shown in Figure 1, indicated that the number of transmitted images from CHs to BS is reduced about 55% when our method is applied instead of the using the existing ones. Furthermore, when the SVD is applied, the feature vectors of the images in each cluster head are calculated to obtain the norm of the feature vector that can be used to eliminate the redundancy in images, number repeated or closely matched images. The correct image selection that causes the data reduction during the transmission from CH to BS, is depends upon the efficient feature vector generation based on the SVD and the vital image characteristic such as mean and variance.

Figure 1 : Comparison of Number of Transmitted Images in Each Round

To investigate the efficiency of our algorithm, we have applied it one 100 rounds of simulation but we only shown the picture of the round 20. The number of clusters in the simulation is 7 and we only have displayed the number of images in round 20 and cluster 2. In this round of simulation,
The cluster head 2 has only 9 nodes and consist of 9 images. Transferred images to this cluster head are according to the following images that show in Figure 3. If our proposed algorithm not applied, all of these 9 images must be transferred from CH to BS. But, when our proposed algorithm is applied, based on SVD and DWT, only 4 images that are shows in figure 4, are transferred to BS. Our method takes the advantages of the SVD properties that all singular values of any image would be the same at different angle of rotation. When the SVD technique is applied similar images will be recognized and will be eliminated to reduce the energy consumption and to increase the network lifetime.

Figure 3: All Images Received in One Cluster Head

(Round=20, Cluster =2)

Figure 2: First Level DWT2 applied on one image

Figure 4: Transmitted Images from CH to BS

(Round=20, Cluster=2)
6. CONCLUSIONS

In this paper, we have proposed a new data aggregation method for the wireless sensor networks based on the combined SVD and DWT to reduce the redundancy of the images in each cluster as well as to compress the size of the independent images in each cluster group, respectively. First, the captured image are grouped into different clusters and SVD is applied on each cluster to reduce the redundancy and then the multilevel DWT is applied to reduce the size of each image before the transmission process. The simulation result shown that our proposed method effectively reduced the number of images in each cluster as well as compressed all images before transmission. Thus the overall data reduction before the transmission is applied on the network and the volume of data is reduced and caused to reduce the overall energy consumption of the networks. More research need to be done to have a better clustering algorithm as well as to introduce a better data redundancy and compression algorithms to decrease the data volume and increase the number of transmitted images from CHs to BS in order to obtain an energy efficient Wireless Sensor Networks.

REFERENCES:


