An Energy-Efficient Dynamic Area-Selective Compression Scheme in Wireless Multimedia Sensor Networks

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1. Introduction

In recent, with the development of hardware technologies and monitoring schemes, the applications for gathering multimedia data such as sound and image using multimedia sensors have been increased. As the multimedia data are very large over simple data in traditional sensor networks, the network lifetime of the sensor network is significantly reduced due to excessive energy consumption in particular nodes for transmitting the multimedia data [1]. In addition, the multimedia data increase the data transmission time and decline the data reception ratio. Consequently, the existing schemes based on the traditional sensor networks are not suitable for the environments to collect the multimedia data [1].

It is necessary to use compression schemes to alleviate such problems. However, most of the existing compression schemes for sensor data are based on signal compression such as wavelet and variable quantization and code compression [2]. These studies are not suitable for the environments based on wireless sensor networks. The compression schemes for wireless multimedia sensor networks are at an early stage. Considering this, a novel compression scheme based on the Chinese remainder theorem for the multimedia data has been proposed in [3]. The compression scheme based on the Chinese remainder theorem considered the characteristics and limitation of wireless multimedia sensor networks. However, the existing compression scheme still suffers from energy consumption in the wireless multimedia sensor network with the limited energy. In this paper, we propose an energy-efficient dynamic area-selective compression scheme in wireless multimedia sensor networks. The proposed scheme considers the distributed environment and monitoring characteristics of multimedia sensor networks. It detects and extracts the dynamic area of sensed image data. The proposed scheme also uses the virtual comparison block to compress the dynamic area based on the Chinese remainder theorem. By partially compressing and transmitting only the dynamic area, it minimizes the energy consumption and increases the lifetime of a whole network.

2. The proposed dynamic area-selective data compression scheme

In general, the wireless multimedia sensor networks require the installation costs and distribute the few multimedia sensor nodes and many general sensor nodes together. The first detection is done through a general sensor node. When an abnormal signal (event) is detected, the near multimedia sensor nodes perform the second detection for the detailed monitoring. . The position of a sensor node distributed to the network is fixed. As the multimedia sensor node is designed for the unidirectional shooting, it continuously shoots the image data of the space that the abnormal signal is detected by adjusting the shooting angle and transmits the sensed data to the base station. Figure 1 shows the characteristics of sensed images in the wireless multimedia sensor networks. As shown in the Figure 1, the wireless multimedia sensor node continuously shoots the image of space that the abnormal signal is detected so that a dynamic area and a static area with considerable size occur according to the time. Considering this characteristics, the transmission of the whole sensed data causes the unnecessary communication cost. It also reduces network lifetime. In order to solve such problems, the proposed scheme extracts and compresses the high efficient dynamic area.

(a) t_0 (a) t_1

Figure 1. Characteristic of sensed images in the wireless multimedia sensor networks

First of all, it is important to detect the dynamic area in the sensed data. As it needs a high arithmetic operation cost to compare all pixels in the detection stage of the dynamic area, it is not efficient. Therefore, the proposed scheme generates the virtual comparison block through the pixel clustering and the detection of the image change, and uses it as the transmission unit. As the virtual comparison block is utilized as a transmission unit, there should be no effect on the compression based on the Chinese remainder theorem [3]. The conditions of the virtual comparison block are as follows by the definition of compression scheme based on the Chinese remainder theorem.

[Condition 1] As the continuous decimal numbers to utilize the Chinese remainder theorem are at least more than two, it must be possible to express the comparison block data with two continuous decimal numbers.
[Condition 2] As the actual transmission data to the base station is the remainder, the remainder is below the maximum expression range of a specific variable type for the maximum efficiency.
[Condition 3] For the easy restoration of original data and block data, it is a structure of square which is applicable for the QCIF format.

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By the above conditions, the maximum block size for a possible utilization is 3 x 3pixels (the proof is omitted due to the space limit).

The virtual comparison block with a grid shape is generated to the sensed image. As in equation (1), the proposed scheme clusters the colors of all pixels inside the corresponding virtual comparison block and computes their average values. At this time, if the average values of the colors in the virtual comparison blocks of the initially sensed images and the currently sensed images are above the threshold value, they should be recognized as the dynamic areas.

$$|\text{firstImgBlock\#n.avrValue} - \text{curImgBlock\#n.avrValue}| > \alpha \quad (1)$$

Figure 2 shows the detection of the dynamic area and the extraction of the transmission area. Through the comparison of average values of colors in the virtual comparison block, the dynamic area that must be transmitted is recognized. The corresponding dynamic area is compressed based on the Chinese remainder theorem to transmit it to the base station. At this time, when the packets are transmitted in the virtual comparison block unit, unnecessary data transmission occurs due to header and trailer. To solve such a problem, the proposed scheme transmits the dynamic area in a single packet through the establishment and extraction of the maximum transmission area. Through this process, the proposed scheme minimizes the energy consumption by the partial compression and transmission of the dynamic area. As a result, it increases the lifetime of a whole network.

(a) t_0 (a) t_1

Figure 2. Detection of the dynamic area and extraction of the transmission area

3. Performance evaluation

We have developed a simulator based on JAVA to evaluate the data transmission scheme without the compression scheme [3], the data transmission scheme without the compression scheme [4] and our proposed scheme. Figure 3 shows the ratio of surviving nodes according to the execution time. The energy consumption in the sensor network is proportional to the size of transmission data. As a result, the lifetime of a whole network is shortened rapidly. In this performance evaluation, among all distributed sensor nodes, the valid lifetime of network has been set up to the time when more than 80% nodes survive. As mentioned above, the proposed scheme detects the dynamic area of original sensed data and compresses the corresponding areas to minimize the size of transmission data and the energy consumption, As a result, the proposed scheme can eventually extend the lifetime of the network. It was shown through performance evaluation that the proposed scheme increases the network lifetime by about maximum 14% compared to the existing compression scheme.

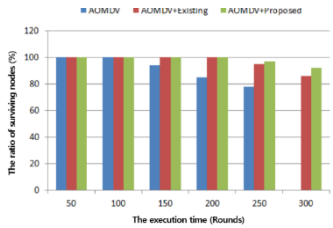

Figure 3. The ratio of surviving nodes according to the execution time

4. Conclusion

In this paper, we have proposed the energy-efficient dynamic area-selective compression scheme in wireless multimedia sensor networks. In order to increase the efficiency of the existing compression scheme under the multimedia sensor network environments, the proposed scheme performs the partly compression and transmission of sensed data based on the Chinese remainder theorem, the detection of the dynamic area, and the separation algorithm The proposed scheme minimizes the energy consumption in the data transmission of mass multimedia and eventually increases the lifetime of the whole network. It was shown through performance evaluation that the proposed scheme significantly reduced the amount of transmission data and increased the ratio of surviving nodes by 14% on average. In the future work, we plan to study the effective transmission scheme considering the characteristics of compression data.

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