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Research paper

Sustainable Wireless Sensor Networks: Leveraging Data Reduction to Enhance Performance and Longevity

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Abstract

Wireless sensor networks are vital technologies in environmental monitoring systems, but they face challenges related to energy consumption and data transmission efficiency, especially when dealing with huge amounts of constantly changing weather data. This research aims to improve the efficiency of wireless sensor networks and performance by proposing a hybrid approach to data reduction through redundancy detection and data compression using the LZW algorithm, which is a lossless compression algorithm used to reduce data size while maintaining data accuracy. The proposed model consists of two main stages: 1) Duplicate detection, in which duplicate or temporally close values are removed to reduce the size of the transmitted data, and 2) compressing non-duplicate data using the LZW algorithm to reduce energy consumption. The proposed model was tested on simulated weather data including temperature, humidity, visibility, pressure, wind speed, and wind bearing. The results showed that the pressure sensor achieved the highest throughput (0.02 kb/s) in the traditional method due to its large volume (9000bytes) of data, when applying the proposed method, the pressure sensor continued to achieve the high-est throughput after compression, while the vision sensor recorded the lowest energy consumption, as it decreased from (0.0042 J) in the traditional method to (0.0000084 J) using the proposed method. The results confirm the efficiency of the network and the extension of the network's life in environmental monitoring through the effectiveness of combining redundancy removal and data compression.

Keywords: *WSN; Throughput; Energy Consumption; Data Compression; LZW; Redundancy Elimination.*

1. Introduction

Wireless sensor networks have become widely used in a variety of applications, including healthcare, smart agriculture, environmental monitoring, and disaster management, due to their ability to monitor, process, and transmit data from the surrounding environment to a central station. This network consists of a group of nodes, each with a limited processing unit, simple storage capacity, and a limited power source. One of the ongoing challenges in sensor networks is energy consumption and network lifetime. Data transmission and processing are considered energy-consuming. Researchers are seeking to develop effective strategies and techniques to reduce energy consumption and extend the network lifetime without affecting the quality of service and data accuracy. Among these techniques is reducing the size of data, which is one of the most effective solutions in reducing energy consumption and increasing throughput. In this context, the use of the LZW algorithm is one of the most important lossless compression algorithms. It is characterized by its high efficiency in reducing the size of the data while preserving the original information, which directly leads to reducing energy consumption and improving network performance [1]. Terry Welch invented a data compression algorithm called (Lempel ZIV Welch) in 1984 based on the LZ78 algorithm. LZW is one of the most important lossless compression algorithms. The basic idea of the LZW compression algorithm is to use a dictionary to store repeated sequences of symbols and characters and then replace these sequences with shorthand symbols that represent the dictionary entry. Unlike the original LZ78 algorithm, LZW does not output the character itself. Rather, it uses symbols that refer to sequences stored in the dictionary, which saves data size. The algorithm starts by initially loading all basic symbols, letters, or numeric values, and gradually updates the dictionary through the encryption process and adding new sequences of previous repetitions. Thus, the LZW algorithm is effective in data with repetitive patterns, such as in weather data for the sensor network, where values are repeated closely. The LZW algorithm is lossless, but it maintains the accuracy of the original data from any loss of information, which is very important for environmental weather data, as it does not allow data loss during transmission and processing [2].

1.1. Objectives and contributions

1.1.1. Researcher objective

1) Increasing WSN's lifetime through increasing sensor node lifetime by decreasing energy consumption.
2) Decreasing energy consumption for data transmission by reducing the amount of transmitted data.

3) Increasing WSN Throughput by decreasing the time for data transmission through data size reduction.
4) Decreasing the amount of transmitted data by using a proposed approach.

1.1.2. Researcher contribution

1) Proposing a hybrid data compression technique based on combining redundancy reduction and the LZW algorithm.
2) Improving the LZW algorithm by applying it to pre-processed data using redundancy detection.
3) Practical development of simulations by testing the performance of the proposed method using climate data.
4) Comparative analysis between the proposed technique and the LZW compression method.
5) Using a pre-processing technique before applying the compression algorithm in a network environment, including a weather monitoring application.

1.2. Problem statement

The problem of the research is that the data transmission in WSN decreases the lifetime of WSN by consuming the nodes' energy, and it leads to making the WSN out of service. Furthermore, it is impossible to change the battery of the sensor node in WSN because the sensor node might be in an inaccessible place, like a volcano, ocean, chemically polluted land, etc. Data Compression is used to decrease the size of transmitted data; however, the previously proposed Techniques are inefficient and are poor in terms of compression ratio.

2. Related work

Many researchers have proposed ways to reduce power consumption and increase throughput through various techniques, including reducing data size through data compression.

In[1] This study presents a traditional approach to data compression using a primitive algorithm without clarifying the mechanism for dealing with data duplication or the impact of energy consumption within WSN environments, which highlights the need to combine duplication detection in environmental data with compression techniques by presenting a hybrid approach that relies first on duplication detection within packets of weather data and then applying the LZW algorithm, which reduces the size of the transmitted data and thus reduces energy consumption. In[2] Many studies point to the importance of reducing energy consumption in wireless sensor networks by improving data transmission and compression. Therefore, researchers have proposed the MECCLADA method, which relies on clustering and merging to reduce the number of packets being transmitted, which contributes to reducing energy consumption. Despite the effectiveness of this approach, it focuses only on improving the network structure without addressing redundancy within the data, especially weather data which often contain a recurring time pattern. In[3] The improved network architecture was developed to combine clustering with high-precision data collection and focus on scaling, but did not address data size reduction or implement an efficient compression algorithm .Researchers have presented a combination method between k-means and the LZW compression technique to improve data efficiency in sensor networks. It aims to improve network expansion, reduce energy consumption, and accuracy in data collection through the selection of cluster heads, while the compression technique reduces transmission cost, improves network traffic, and contributes to reducing the number of packets from sensors to cluster heads. In[4] to improve network performance by optimizing energy and discovering the optimal path through the energy-efficient Ant-Cuckoo algorithm, improving throughput and network lifetime, this work combines the data compression algorithm "Adaptive Compression Scheme Fast and Efficient Lossless with Outlier Detection and Replacement(FELACS-ODR) with Cuckoo Search (CS)" to improve network performance. Therefore, a compression-based strategy is proposed to improve the network lifetime at the packet level using compression. This provides an improvement in energy consumption and does not rely on pre-processing to detect duplication, which reduces the efficiency of compression in cases of repetitive data such as weather data. In [5] Sensor networks face significant challenges in collecting data at high speed and reliability due to limited battery life. This paper presents a detailed review of methodologies and techniques that improve the energy efficiency of high-speed data collection in sensor networks. It highlights sensors for collecting data at high speeds and provides solutions to extend the network's lifespan. The study addresses a section of algorithms and protocols that provide energy to improve data collection in the sensor network according to its strategies in the optimization algorithm and cluster formation. A study reviewed the strategy of collecting rapid data to improve energy efficiency, but did not address the redundancy of data within transmitted packets, such as weather data, as in the study [3]. In[6], Packet routing is one of the most important challenges facing wireless sensor networks researchers due to the complexities of the limited battery capacity of nodes and computational capabilities. The difficulty lies in developing routing protocols in a changing environment. In this context, techniques have shown increasing interest in developing packet protocols, including the ant colony optimization (ACO) algorithm, through discovering the shortest path. Optimize routing using smart (ACO) models to optimize energy consumption at the protocol level, not the data level, so it does not address data inflation resulting from temporal or spatial redundancy. In [7] the focus of control topology in sensor networks is on increasing and extending the network lifetime. It results in routers sending data from the peripheral nodes to the distribution node, and the nodes surrounding the distribution point stop working due to the transfer of large amounts of data, which leads to energy consumption. Therefore, they proposed a mathematical model to represent energy consumption using topology in the sensor network. Although there are many previous studies on data compression in wireless sensor networks, some of them were limited to the LZW or Huffman algorithm without prior processing or finding duplicates, which leads to weak compression effectiveness and increased energy consumption. In this research, a new approach based on a hybrid method is presented that combines in the first stage, finding duplicates of the data, followed by LZW data compression, which leads to reducing the total size of the transmitted data, improving network efficiency, and pressure ratio. Among the advantages of this work is that it considers the challenges facing sensor networks, including battery limitations and small storage capacity. By using a set of metrics, namely pressure ratio, network age, and energy consumption, in addition to comparing them with traditional methods, the research provides a new contribution to linking two interconnected technologies, which contributes to enhancing network efficiency and providing smarter applications for monitoring the climate environment

3. Theoretical background

3.1. WSNs concept

A wireless sensor network is a group of devices known as nodes. These nodes are small and low in power. These nodes are designed with a large capacity for storage and wireless transmission. They are distributed across areas to monitor phenomena such as temperatures and earthquakes. They contain a wireless system to receive data and send it to the base station. BS) Sensor network nodes have limited power. Usually, sensor nodes consume the main battery power when transmitting data to the base station. Due to the limited battery capacity, it is difficult for customers to determine the area of the sensor nodes during applications. They can use their battery to discover the area [9]

3.2. Challenges of wireless sensor networks

Since sensor networks play a major role in our ability to expand our ability to monitor and interact with the physical world remotely.
Energy: One of the most important challenges in designing sensor networks is energy efficiency, so they must be distributed across three functional areas: communications, data processing, and sensing. [12] Limited bandwidth: In sensor networks, much less energy is consumed in data processing compared to data transmission, and wireless communication is limited to a rate of between 10 and 100 kilobits per second. The limited bandwidth directly affects the exchange of messages between sensor devices, so synchronization cannot be achieved without message interaction [12] Contract cost: Since sensor networks consist of a large group of nodes, the cost of each node is very important to the financial indicator of the network, and the cost of each sensor node must be kept low for global standards to be acceptable. Depending on the application of the sensor network, many sensors might be dispersed randomly over an environment, such as weather monitoring [8]. Deployment: Deploying nodes in a sensor network is a major problem. A node deployment plan can reduce the problems. [8] Design limitations: One of the most important challenges in sensor networks is design. In all software and hardware design models, with limited constraints, the main goal in sensor network design should be to have nodes that are less expensive, smaller in size, and more efficient. [8]

3.3. Reasons for energy waste in sensor networks

Energy consumption rates in sensor networks vary among sensor nodes depending on their operational status (receiving, transmitting, listening, or hibernating). The most prominent reasons for energy waste are:

- Collisions: When multiple nodes send data at the same time, it leads to packet loss.
- Idle listening: consumes power when monitoring the channel in the absence of actual traffic.
- Overhearing: the node receiving data that is not intended for it.
- Over-transmission when sending data to nodes that are not ready to receive.
- Package overload: excessive use of packages without benefit.

This leads to energy consumption and reduces the life of the network [9]

3.4. Data compression

Data compression is one of the most important technologies used to reduce the size of transmitted data, which helps reduce energy consumption, improve network efficiency, and improve performance. Compression technology is divided into two types:
Loss compression) LOSSY): Losing part of the data, achieving higher compression rates.
Lossless compression restores the original data without any loss
Lossless compression is the preferred choice for weather data for sensor nodes, increasing the effectiveness of compression technology with data redundancy, and is common in environmental sensor networks [10] [11]

3.5. LZW algorithm

One of the most prominent lossless compression algorithms is the LZW (Lempel-Ziv-Welch) algorithm, which relies on the principle of a dynamic dictionary containing basic symbols (ASCII) that is built during compression without the need for prior knowledge of the symbol frequency. The dictionary automatically discovers new patterns. One of its advantages is its high efficiency when dealing with duplicate data, such as temperature readings in wireless sensor networks. Accurately restore original data during decompression using a dictionary building mechanism, which can reduce data size, reduce power consumption, and improve network performance [11].
To build the dictionary during the compression process, we start with the first empty string at the beginning, and then we read the first letter L to form the string SL. If it is present in the dictionary, meaning there is a repeated pattern, we continue to build the longest string S=SL. If we do not add SL to the dictionary, we output the corresponding code and start assigning a new string S=L, as shown below in the algorithm.

Algorithm 1 LZW: LZW Compression

```
S=NIL;
While (read a character L)
{
If SL exists in the dictionary
S=SL;
Else
Add SL to the dictionary;
Output the code for S;
S=L;
}
```

In the decompression process, we read the first L symbol and define it as the string S. We print it, and then we start iterating over the remaining L symbols. We retrieve the corresponding Entry string in the dictionary, print Entry, and add a new string S Entry [0] to the dictionary, which represents the extension. We update S=Entry and complete the construction. As shown below for the decompression algorithm.

Algorithm2 LZW: LZW Decompression
Read a character L;
Output L;
S=L;
While (read a character L)
/* L could be a character or a code. */
{
Entry =dictionary entry for L;
Output entry;
Add S+ entry [0] to the dictionary;
S= entry;
}

3.6. Redundancy in a sensor network

Duplicate detection before the data compression stage plays an effective role in the sensor network, where sensor data, including environmental monitoring, appears, as neighbouring nodes record close or identical readings within a short period. When all this repeated data is sent, it leads to energy consumption and an increase in the load on the network. Here, the importance of duplicate detection has a fundamental role before the compression stage, and includes, for example, differential coding, and it can be applied at the node level [12]

3.7. Integration in sensor network between duplicate detection and LZW algorithm

To address the problem of energy consumption and increasing data volume in the sensor network by integrating duplicate detection and the LZW algorithm, it starts by detecting duplicate data and its dimensions, which reduces the size. After that, the data compression stage and the integration lead to:

- Reduce energy consumption by reducing the number of bits transmitted.
- Increase network lifetime by reducing the load on nodes.
- Improve reliability and reduce collisions.

This achieves positive results for networks with limited battery [13] [14]

4. Proposed work

To improve network performance, we reduce network data through high data compression using the proposed method by reducing the number of repeated input readings of sensors. We store the number of input readings in the first step, and in the second step, we apply the LZW algorithm after processing the data. In the proposed method, as shown in Figure 1, weather data readings are read every minute through the counter that starts for each new reading and is set to one. It shows the number of times the input data is repeated, as the next input readings are compared with the previous input readings. If the next input readings are equal to the previous input, the counter is increased. Otherwise, the current input data and the counter value are output. The new input is considered the current input, and the counter is also set to one when the time expires, which is one hour, and the process output is the current input and the counter. This scheme continues, as in Figure 1, until the end of the weather sensors' contract life. The idea of this diagram of the proposed method shows the calculation of weather data entered through sensor networks for every hour, and this weather data is (temperature-humidity, visibility, pressure, wind bearing, wind speed).

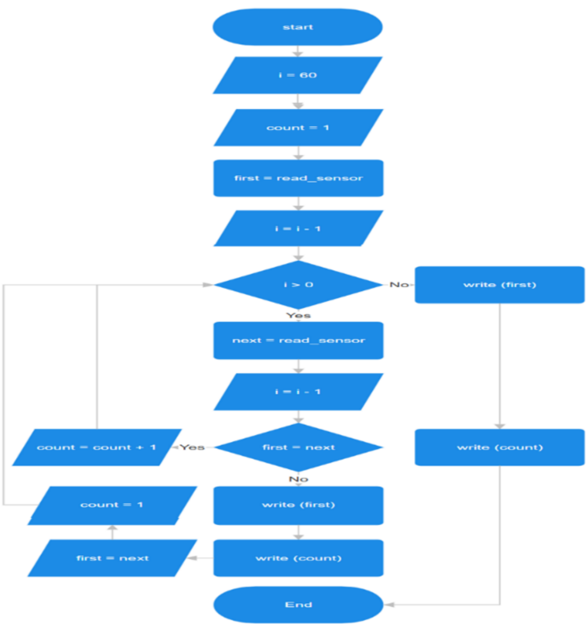

Fig. 1: Proposed Work.

5. Methodology of the research

In this study, we used a computer simulation to evaluate the performance of weather data in a wireless sensor network. No real sensors were used, and the simulation was carried out using a Java programming environment to generate and process weather data. A network of six sensor nodes (temperature, humidity, visibility, wind speed, pressure, and wind bearing) was implemented. Each sensor collects 1,000 input values for processing. After generating the data, the number of iterations is first determined to reduce the data size. Then, the well-known LZW compression algorithm is used to reduce the amount of data transmitted and reduce energy consumption.

Table 1: Virtual Network Specifications Used in Simulation (Default)

Item	Default value
Number of sensor nodes	6 sensor node
Type of data	(Temperature, humidity, visibility, wind speed, pressure, and wind bearing
Transmitter frequency	60 minute
Data model	Duplicate data to simulate reality
Communication protocol	A simple simulation does not simulate the actual network layer.
Compression type	LZW compression
Programming language	Java programming language
Evaluation outputs	Data size before and after compression, performance network (throughput, energy consumption)
E(elec)	Elecronic energy(50 $*10^{-9}$) J/bit
E(amp)	Amplifier power(0.1 $*10^{-9}$) J/bit /m

5.1. Simulation environment

The proposed model was implemented using the Java language due to its programmability and support for flexible simulation. The simulation was implemented on a computer with an Intel Core i5 processor, 8 GB of memory, and Windows 10 operating system. The number of nodes is randomly distributed over a 100-by-100-meter area, and the network structure is flat with a direct connection to the base station. Weather data is generated every 60 seconds.

- Duplicate detection is applied before data compression.
- The LZW compression algorithm is designed to handle digital data.
- The power model is based on the first-order radio model.
- The measured metrics (power consumption, compression rate, and number of throughput packets) in this setting allow for the overall evaluation of the network.

5.2. Network performance

The measured metrics for wireless sensor nodes include throughput (T) and Energy Consumption: Sending data from weather sensors or processing it, as well as receiving data to central nodes, all these processes consume energy. The following law explains energy consumption and plays an important role in the sensor network. The goal is to reduce energy consumption.

$$\text{Throughput}=\frac{\text{the amount of data transmitted}}{time} \quad (1)$$

The concept of throughput refers to the number of bytes or bits that are transmitted during a unit of time.
To construct the equation, let's assume that
D: the amount of data sent per unit of time (in bytes or bits).
T: the data transmission time in seconds .

$$Throughput = \frac{D}{T}, thoughput = \frac{total\ bit\ received}{time}$$

Throughput is defined as the amount of data received and sent during a period of time and the total time used in seconds.[11]

$$\text{Energy consumption=E(elec)*K +E(amp) *K* d}^{\text{n}} \quad (2)$$

E(elec): Electronic energy(50 $*10^{-9}$) J/bit

K: Number of bit

E(amp): Amplifier power(0.1 $*10^{-9}$) J/bit /m

d: The distance between nodes
n=2 for short distances
n=4 for long distances with multipath interference
Also, to calculate it as a percentage

$$energy\ \text{consumption} = \frac{size\ \text{after compress-size before compress}}{size\ \text{before compress}}\times 100\%$$

The energy consumed includes two parts
1) The electronic energy used to operate the transmitter/receiver, which includes processes such as modulation and encryption.
E (elec)*K
2) The amplifier power depends on the distance d and the propagation environment.

E (amp) *K* d^n
By combining the two parts, we get
Energy consumption=E (elec)*K +E (amp) *K* d^n
This equation is the basis for designing the energy-efficient network protocol [15]

6. Results and Discussion

6.1. Network performance (throughput)

Throughput is one of the most prominent indicators of the wireless sensor network environment. When reading the weather sensor inputs over 60 minutes, and the number of values read is 1000 values, the data transfer rate is determined during a unit of time across the network. When comparing throughput to the original data and after applying the LZW algorithm, a clear decrease is observed. This is not due to poor network performance, but rather due to the reduction in the size of the data resulting from compression. Reducing the amount of data transmitted across the network reduces the overall network load, reduces energy consumption, and increases the network lifetime. Compression contributes to reducing transmission time within the network, which leads to enhancing overall stability. The re
duced data transfer rate resulting from compression technology does not negatively affect network performance, but rather increases the efficiency of performance improvement and reduces the burden on the network infrastructure. As shown in Table 1 and Figure 1, the values for the data transfer rate range from the highest value for the pressure sensor (0.02kbps) and the lowest value for the vision sensor (0.00889kbps). After applying the proposed method, all values are very low compared to the original values, where the highest value for the pressure sensor is (0.0002889kbps) and the lowest value for the wind bearing is (0.00002 kbps)

Table 1: Throughput Values (in Kbps) for Various Weather Parameters Using the Original Uncompressed Method Versus the Proposed Hybrid Method

Sensors	throughput for original(kbps)	throughput for the proposal method
temperature	0.0156	0.000024
humidity	0.0133	0.0000222
visibility	0.00889	0.00001778
pressure	0.02	0.00002889
windSpeed	0.0133	0.0000222
windBearing	0.01111	0.00002

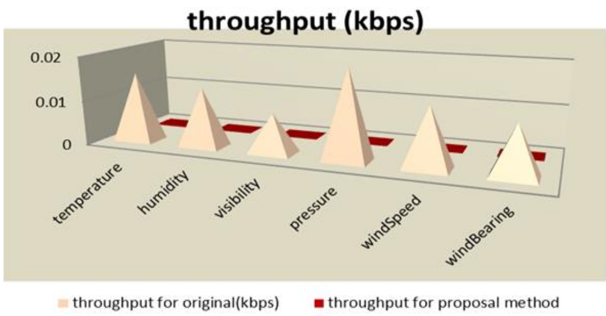

Fig. 1: Graphical Comparison of Throughput between the Original and Proposal Approach across Different Weather Parameters.

The graph visually shows the difference between the traditional method and the proposed method. The proposed method effectively reduced the throughput of all sensors. This visual gap shows the difference in reducing the data volume, which shows the positive effect of the proposed method in reducing energy consumption, improving network performance, and increasing the virtual network lifetime.

Table 2: Comparison of LZW Throughput (Kbps) Between the Original and Proposed Method for Different Weather Sensors

Sensors	throughput LZW original	throughput LZW proposal
temperature	0.0000978	0.0000422
humidity	0.0000911	0.00004
visibility	0.0000733	0.0000356
pressure	0.0001178	0.0000467
Wind Speed	0.0000911	0.00004
Wind Bearing	0.0000844	0.0000378

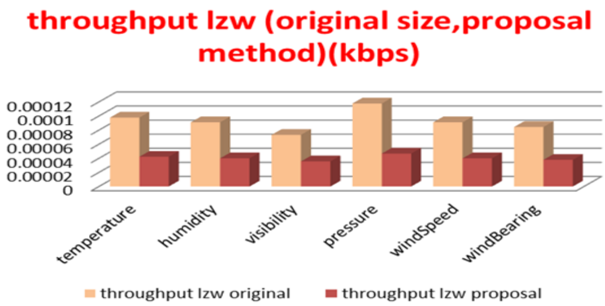

Fig. 2: Throughput Comparison (kbps) between the Original Compression and the Proposed Method for Various Sensor Types.

Table 2 and Figure 2 show a quantitative comparison between the throughput rate resulting from using the traditional LZW algorithm and its hybrid method through different types of weather data. The throughput is measured in kilobits per second. Table 2 shows that the proposed method led to a significant decrease in the throughput rate for temperature data from (0.000978kbps) to (0.000422kbps), while the atmospheric pressure data decreased from (0.0001178kbps) to (0.0000467kbps). Figure 2 shows a visual comparison between the two methods. It clearly shows that the columns for the proposed method are lower in all cases, which indicates the ability to reduce the size of the transmitted data and thus improve the efficiency of the network and reduce energy consumption.

6.1.1. Energy consumption

One of the most important challenges in designing and operating a sensor network is the high energy consumption due to the limited energy of sensor nodes. One of the main goals of a sensor network is to extend the overall life of the network and improve energy efficiency, especially in harsh weather environments. Therefore, the energy consumption law was used to calculate the energy required to process and send data to weather sensors. Therefore, we compared the traditional method and the proposed method that depends on reducing the redundancy of the data and then applying the LZW algorithm. The common model was adopted to calculate the energy consumption in the sensor nodes, and it is expressed by the following relationship

Energy consumption=E (elec)*K +E (amp) *K* d^n

By using this equation, reducing the number of bits resulting from data compression leads to a direct reduction in the value of k, which in turn leads to a reduction in energy consumption. The table 3shows a comparison between the original data size and the data size of the proposed method, which shows a clear reduction in the data size, as the temperature data size was reduced from (7000KB) to (11KB), and when it decreased after compression using LZW from (44KB) to (19KB) This improvement applies to all types of data) humidity, visibility, pressure, wind bearing, wind speed).

Table 3: Comparison of Original and Compressed Data Size Using LZW Algorithm and Proposed Method for Weather Sensors

Sensor	Original Size (K)	Proposal Size (K)	LZW Original (K)	LZW Proposal (K)
Temperature	7000	11	44	19
Humidity	6000	10	41	18
Visibility	4000	8	33	16
Pressure	9000	13	53	21
Wind Speed	6000	10	41	18
Wind Bearing	5000	9	38	17

Sensor	Energy Original (J)	Energy Proposal (J)
Temperature	0.00735	0.00001155
Humidity	0.0063	0.0000105
Visibility	0.0042	0.0000084
Pressure	0.00945	0.00001365
Wind Speed	0.0063	0.0000105
Wind Bearing	0.00525	0.00000945

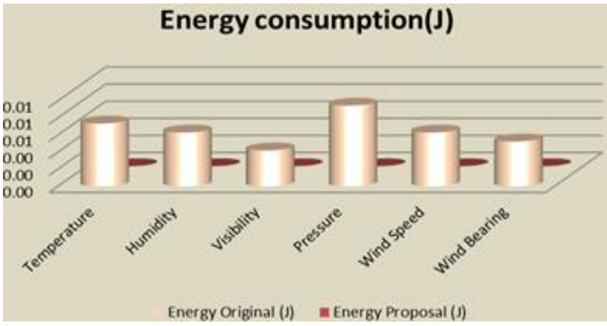

Fig. 3: Comparison of Power Consumption between the Original and Proposed Method States for Different Weather Sensors.

The figure shows a graphic representation that shows the large difference between energy consumption in the two cases, as the proposed method shows small increases compared to the original method, which indicates the effectiveness of the proposed method in reducing energy consumption, which is important for battery-limited sensor network environments.

Table 4: Comparison of Data Compression for the Original Data Size with the Size of the Proposed Method Using the LZW Algorithm for all Sensors

LZW Original (J)	LZW Proposal (J)	Proposal Compression (%)	LZW Compression (%)
0.0000462	0.00001995	99.84285714	99.72857143
0.00004305	0.0000189	99.83333333	99.7
0.00003465	0.0000168	99.8	99.6
0.00005565	0.00002205	99.85555556	99.76666667
0.00004305	0.0000189	99.83333333	99.7
0.0000399	0.00001785	99.82	99.66

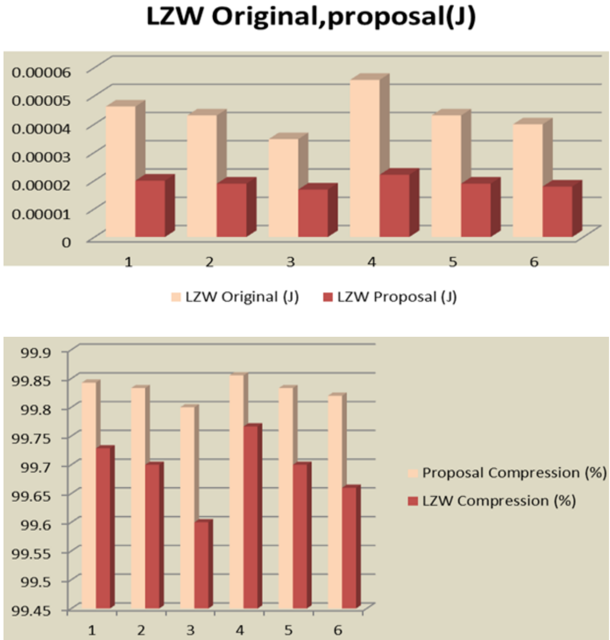

Fig. 4: Comparison of Compression Using the Proposed Method for Energy Consumption with LZW Compression.

Table 4 shows a comparison between the performance of the LZW algorithm for the data size of the original method and the proposed method. The proposed method achieves a slightly higher compression ratio compared to the original method, which indicates that the proposed method has led to a greater improvement in reducing the data size. In Figure 4, the clear difference between the columns indicates that the proposed method shows better performance compared to LZW compression, making it a better choice for network efficiency and data size reduction.

7. Discussion

The simulation results show that the proposed hybrid data compression technique contributes significantly to reducing energy consumption and improving throughput in wireless sensor networks. For example, the energy consumption of the vision sensor decreased from (0.0042 J) to (0.0000084 J), which means the effectiveness of combining duplicate detection with the LZW compression algorithm. Since energy efficiency is an important factor, combining duplicate detection before compression achieves effectiveness and improves the performance of the network. In terms of reducing the network load and reducing the data volume, which makes data compression vital to reduce energy consumption and increase the network lifetime, this technology can be used in air quality monitoring networks. There are limitations to this study, including evaluating performance using simulated data instead of real readings, so it does not cover the complex changes in the actual environment. It is suggested that real data be used in the future, such as (NOAA) data or air quality data available in the (UCI) machine learning repository. Duplicate detection may lead to resource consumption or impact response time. Therefore, it is proposed to integrate AI technologies such as small neural network models in the future to improve performance and reduce energy consumption.

8. Conclusion

In this paper, an effective hybrid method was proposed for data compression for wireless sensor networks. It consists of two basic stages: the first is detecting duplication in the data, and the second is applying the LZW algorithm. The results showed that the proposed method represents superior performance compared to the traditional method that uses the LZW algorithm without prior processing. This approach contributed to reducing the data size, which leads to reducing energy consumption in the nodes and improving the efficiency of the packages. The proposed method demonstrated the ability to maintain the accuracy and reliability of the data, which is of great importance in climate applications. The proposed method is shown to achieve significant improvement in energy consumption and throughput for simulation results using climate data.
Limitations and Future Work: A significant limitation of this study is the use of simulated weather data to evaluate the performance of the proposed hybrid approach. Although the simulated data provides a controlled environment for testing the effectiveness of the methodology, it does not fully reflect the complexity, noise, and irregular patterns present in real-world environmental data. In future work, we plan to use a real-world weather dataset collected from operational environmental sensor networks to evaluate compression efficiency, energy savings, and accuracy in finding redundancies in more complex real-world environments.

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