

Collision Mitigation by Dolphin Ant Lion Optimizer Pre-Packet Scheduling Approach

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Abstract

A wireless sensor network (WSN) consists of distributed autonomous sensors deployed over a large geographical area. Wireless Sensor Networks (WSNs) are composed of large-scale sensors that are specifically assigned to do particular tasks, with a significant portion of these tasks involving reporting and monitoring activities. Nevertheless, because to the potential expansion of the network to several sensor nodes, the likelihood of collision is significantly increased. This research presents an innovative approach for conducting collision detection and mitigation in wireless sensor networks (WSN). The first step involves conducting a simulation of Wireless Sensor Networks (WSN), followed by the utilization of the Fractional Artificial Bee Colony (FABC) algorithm for the selection of cluster heads. In this context, the network-based parameter is derived by considering factors such as the Received Signal Strength Index (RSSI), priority level, delivery rate, and energy consumption. The Deep Recurrent Neural Network (DRNN) has been modified to suit the task of collision detection. The training of the deep recurrent neural network (DRNN) is conducted via the Lion Crow Search optimizer (LCSO). Following the completion of collision detection, the subsequent step involves the implementation of a collision mitigation process utilizing a pre-scheduling technique known as Dolphin Ant Lion Optimizer (Dolphin ALO). In this context, the evaluation of fitness encompasses many factors related to collision mitigation, including energy consumption, Sleep Index (SI), delivery rate, priority level, E-waste management, and E-save measures. The approach presented in this study demonstrated superior performance in terms of energy consumption, throughput, Packet Delivery Ratio (PDR), and collision detection rate. Specifically, it achieved the least energy consumption of 0.185, the greatest throughput of 0.815, the highest PDR of 0.815, and the highest collision detection rate of 0.930.

Keywords: *Wireless sensor network, deep recurrent neural network, collision mitigation, Cluster head selection, energy consumption, Sleep Index (SI), delivery rate, priority level, E-waste management, and E-save*

1. Introduction

A wireless sensor network (WSN) refers to a collection of sensor nodes that are strategically distributed around a given region to monitor and record environmental variations. In this context, it is observed that each individual node possesses reduced energy, processing capabilities, and memory resources. Consequently, the transceiver is employed for the purpose of transmitting and receiving packets to and from adjacent nodes [11] [4]. Wireless Sensor Networks (WSNs) consist of a multitude of interconnected nodes that facilitate the transmission and communication of collected data with a central processing station. The constituents of Wireless Sensor Networks (WSN) encompass power, storage, communication, and computing. Therefore, these sensor components possess a reduced computational capacity. Nevertheless, the nodes within this network are responsible for both information gathering and multi-hop data transfer in order to analyze the data alongside the base node [5]. Wireless Sensor Networks (WSNs) has the unique characteristic of being able to operate autonomously without the need for human involvement. This is made possible by their inherent aptitude to self-configure. However, the presence of these limitation factors has a detrimental effect on the performance of Wireless Sensor Networks (WSNs). Therefore, it becomes imperative to optimize the lifespan of the nodes by developing methodologies and protocols that reduce energy consumption. The utilization of this technology is prevalent across several domains, including

micro-surgery [14] [4], healthcare [13] [4], environmental monitoring, and military [12] [4]. The issue of accessing and controlling the shared media among sensor nodes is a significant challenge in wireless network transmission. Therefore, the medium access layer (MAC) is implemented in wireless sensor networks (WSNs) to enhance network performance by taking into account parameters such as energy conservation, packet delivery ratio (PDR), and latency. Several solutions have been developed to address the challenges associated with accessing the transmission medium and resolving network difficulties in Wireless Sensor Networks (WSN) [29] [30] [4].

Wireless Sensor Networks (WSNs) are employed for various applications such as environmental monitoring, object tracking, and surveillance. These networks serve as an innovative technology that takes into account the distributed sensor nodes inside the network. The monitoring of the physical aspect of network environments is beneficial in mitigating many detrimental impacts [10] [2]. Nevertheless, the sensor node possesses the capability to detect the occurrence of an event and exhibits several attributes, including communication and possible processing capabilities. Nevertheless, the sensor nodes maintain a constant surveillance of the deployed region. A collection of sensor nodes is aggregated to form a sensor network. In contemporary times, the necessity for security measures has become increasingly imperative across many network systems. Furthermore, the deployment of sensor nodes is predominantly observed in unattended locations that need a high level of security [2]. Due to the large number of network nodes in a Wireless Sensor Network (WSN), the rate of data collision among the sensor nodes is significantly elevated. When many sensor nodes within a shared network region broadcast data concurrently using the same frequency channel, it is anticipated that collisions would occur at the data packets [15] [16] [7]. However, a collision refers to an assault that results in the breakdown of data transmission, necessitating the use of techniques for frequent re-transmission [2]. Nevertheless, the occurrence of packet collision has a detrimental effect on the overall performance of the system as it leads to an increase in channel bandwidth waste, power consumption, and data loss [17] [7]. These aforementioned concerns have the potential to result in the interference problem, such as the occurrence of data corruption caused by packet loss and the failure to convey data packets to the intended destination. Previous studies have made various attempts to detect and address collision avoidance [9] [7]. Nevertheless, the Wireless Sensor Network (WSN) exhibits heightened sensitivity towards several parameters, including energy efficiency, latency, and transmission. These factors have been identified as significant contributors to the degradation of WSN performance, as indicated by previous studies [18], [20], [3].

The distributed algorithm in wireless sensor networks (WSN) operates in accordance with centralized algorithms, but with less information on the specific region or surrounding nodes. This characteristic contributes to the network's improved performance. Efficient data transfer between sensor nodes necessitates the consideration of interference. However, the retransmission resulting from collisions and interference greatly reduces the lifespan of nodes. The user has provided two references: [19] and [3]. In order to mitigate the occurrence of collisions between adjacent nodes during data transmission, two distinct forms of interference are taken into account: primary interference and secondary interference. In the context of main interference, the node is able to receive data communication from many surrounding nodes simultaneously. Secondary interference arises when the transmission between a pair of nodes hinders communication with surrounding nodes [3]. Several link scheduling solutions now in use employ the time division multiple access (TDMA) protocol and graph coloring theory (references 21, 22, and 23) to ensure collision-free transmission between sensor nodes. Graph coloring theory is a commonly used approach to mitigate collisions among nodes. This is achieved by taking into account the independent node set and obtaining an efficient link scheduling [24] [3]. The network medium is accessed using the Energy-based collision avoidance MAC (ECA-MAC) technique, as described in reference [4]. In this context, the categorization of nodes into distinct classes, specifically referred to as first class, second class, and third class, is established based on three distinct levels of importance [4].

The rationale for choosing collision detection in wireless sensor networks (WSNs) as the study topic and an overview of the primary obstacles encountered in related studies are provided in the following sections. The primary impetus for this research is the occurrence of data corruption during packet transmission. Consequently, the research encompasses a limited number of issues, which are outlined as follows. One of the primary issues identified in the study articles was to the network's lifespan, which was adversely affected by the extended energy

consumption during transmission. In reference [4], the longevity of the network presented a significant obstacle in wireless sensor networks (WSNs) due to the energy saving requirements of the transmitting and receiving units. Another problem that has been discussed in the literature is the differentiation of network nodes in order to prioritize those with low energy levels for accessing the communication channel. Furthermore, Djukic and Valaee (23) have documented a significant problem pertaining to the retrieval of comprehensive global information on network topology. In contrast, Zhao, H. et al. [17] documented the decline in network performance resulting from packet collision as the number of users in the sensor network rises.

In light of the aforementioned issues, this section will address some research inquiries pertaining to the collision avoidance method.

- In light of the aforementioned issues, this section will address some research inquiries pertaining to the collision avoidance method.
- The second research question is to the impact of the proposed detection model on network performance. Specifically, it seeks to determine whether the model enhances network performance and whether the assessment demonstrates performance improvement compared to previous methodologies.
- To what extent does the collision mitigation mechanism demonstrate efficacy through the utilization of the packet pre-scheduling approach?

2. Motivations

Several strategies have been developed for the purpose of collision detection and mitigation. However, these techniques have not been successful in achieving efficient processing within a shorter time frame, resulting in significant delays in Wireless Sensor Networks (WSNs). The aforementioned issues and obstacles are sometimes referred to as the driving force for the development of novel techniques.

2.1. Literature survey

The strategies derived from traditional collision detection and mitigation methods are enumerated. K et al. (1) proposed a novel MAC protocol that focuses on energy efficiency and collision avoidance in wireless sensor networks (WSNs) with the aim of mitigating traffic congestion. The enhancement in network performance was achieved by the implementation of traffic management mechanisms at non-relay nodes. The use of this protocol resulted in energy conservation and improved delivery ratio. The implementation resulted in a significant reduction in energy usage and a notable decrease in packet loss. Nevertheless, this protocol has subpar latency performance. Valarmathi (2) proposed a cross-layer design strategy to improve latency by mitigating data collisions at the data connection layer. The architecture was built with the intention of enhancing system security and flexibility, while also prioritizing energy efficiency. The use of this technology enhanced the integrity of data and improved the dependability and security inside the Wireless Sensor Network (WSN). The measures used were inadequate in safeguarding against security breaches. In order to mitigate security assaults, Kang et al. (3) proposed a distributed degree-based link scheduling (DDLs) method. This solution involves calculating the degree information to allot timeslots to the corresponding links. The system successfully implemented an optimized link scheduling mechanism, resulting in a notable reduction in transmission delay. Nevertheless, the system was unsuccessful in utilizing several time slots for the connection. In order to make use of several time slots, Iala, I et al. [4] developed a model for an energy-based collision avoidance medium access control (MAC) technique. This approach was designed to address the energy limitations in various applications. The Quality of Service (QoS) in Wireless Sensor Networks (WSNs) was enhanced in terms of latency, energy consumption, and Packet Delivery Ratio (PDR). Nevertheless, this technique has not been assessed across many application contexts. In their study, Kumar and Tiwari (5) devised a target tracking approach that enables the tracking of a target and the transmission of data to a base station across various application situations. The network coding paradigm was employed to perform encryption and decryption of the data packets. The network lifespan experienced an increase. The utilization of communication protocols and encoding methods in Wireless Sensor Networks (WSNs) proved to be unsuccessful. Cahyadi et al. (6) devised an approach based on Voronoi diagrams to address the challenges associated with coverage control, incorporating communication protocol and encoding. In this study, the power-based coverage control approach was employed to address the sensing restriction, namely the sensing tolerance and sensing radius. The method exhibited rapid convergence. Nevertheless, it was

unsuccessful in mitigating the disparity between the maximum and actual coverage for every search agent. In order to enhance the disparity between the maximum and actual coverage of the search agent, Sainuddin, N.B et al. [7] devised a strategy for data packet collision avoidance with the aim of preventing collisions. The implementation successfully mitigated packet collisions. The identification of the accident proved to be a challenging task for the operator. In order to detect collisions, Kamimura and Tomita (2018) devised a self-organizing network coordination framework (SoNCF) for the purpose of collecting information inside a wireless sensor network (WSN) (Kamimura & Tomita, 2018, p. 8). The intervention successfully mitigated traffic congestion; nevertheless, it overlooked the potential impact on transmission time compensation.

3. Challenges

The following list enumerates the challenges faced by traditional collision detection and mitigation techniques:

- a. The topic of network lifespan elevation in Wireless Sensor Networks (WSNs) is primarily concerned with the energy conservation of sensor nodes in both the transmitting and receiving units. The task of distinguishing network nodes in order to prioritize those with restricted energy levels for accessing the communication channel is a significant difficulty in Wireless Sensor Networks (WSN) [3].
- b. The utilization of an ECA-MAC technique is employed in order to prioritize nodes with lower energy levels. Nevertheless, the identification of collisions is a challenging task due to the intricate nature of the random back-off period during which a sensor node must wait before transmitting data [4].
- c. A data packet collision avoidance technique has been developed in order to minimize delays. The subterranean environment presents a significant problem for data transmission in wireless sensor networks (WSNs) due to the considerable attenuation and signal loss [7].
- d. The SoNCF (Self-Organizing Network Coding Framework) has been developed to enhance the efficiency of data transmission. In this context, the nodes typically operate on battery power and are designed to do routine functions. Revitalizing or replacing batteries in sensor nodes is a significant challenge due to the inherent complexity associated with the battery-powered nature of these nodes [8].
- e. The security of sensor nodes in wireless sensor networks (WSNs) is of paramount importance, as they must possess the capability to safeguard both themselves and the data they collect from external assaults. However, the limited hardware resources available in lower-end sensor nodes provide a significant obstacle to achieving robust security measures.

4. Collision mitigation

The process of mitigating a solution involves employing a pre-packet scheduling strategy, specifically utilizing the suggested Dolphin ALO method. The Dolphin ALO is derived by the integration of Dolphin Echolocation Algorithm (DE) [28] and Ant Lion optimization (ALO) [26]. The next section outlines the definition of the solution encoding, fitness function, and pre-packet scheduling using the proposed Dolphin ALO. This study proposes a collision mitigation system that employs the packet pre-scheduling technique. The framework takes into account many parameters like energy consumption, electronic waste generation, energy conservation, priority level, sleep index, and delivery rate. The pre-scheduling is performed with proposed Dolphin ALO, obtained by integrating DE and ALO.

The Ant Lion optimization (ALO) algorithm is

- motivated from the hunting behavior of antlions.
- It assists to solve real problems and contains less parameter to adjust. Thus, it is flexible to solve diverse issues.
- it is gradient-free model, which is adaptable to address real problems and can balance exploration and exploitation in an effectual manner.

The Dolphin Echolocation Algorithm (DE) is

- inspired from the mimicking behavior of dolphins.
- it is flexible and poses the ability to adapt itself for solving any kind of problem with a reasonable convergence rate and causes an acceptable best solution with any number of loops.

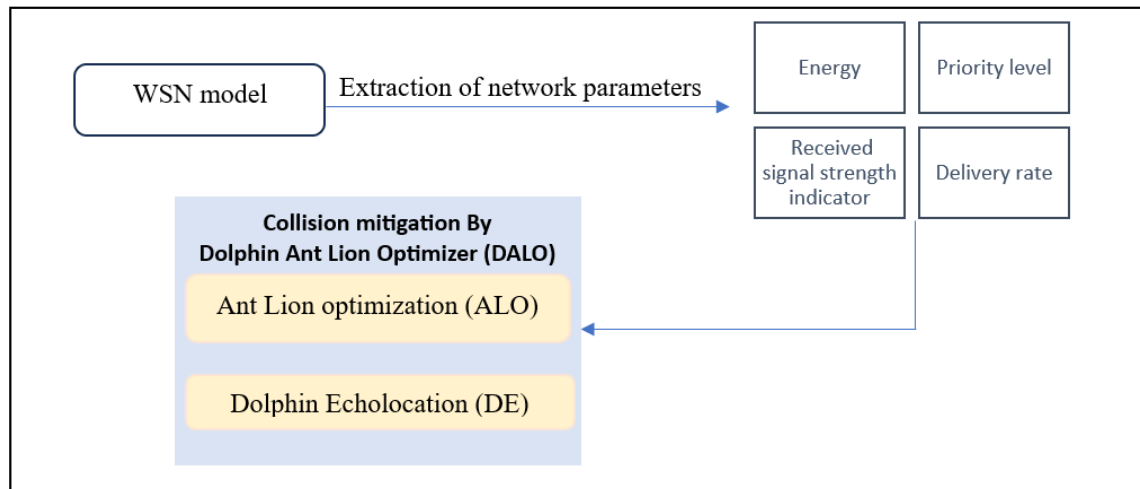


Figure 1: Proposed Dolphin ALO for Collision mitigation

4.1. Solution encoding

The solution vector is illustration of solution to be discovered with developed Dolphin ALO. It consists of number of collision detected nodes that are considered as the solution dimension. For instance, if the number of collisions detected nodes is 4, then the solution dimension is 1×4 . Figure 4 reveals solution representation using Dolphin ALO.

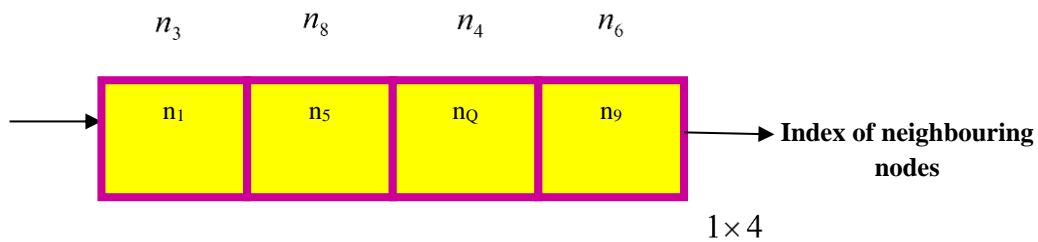


Figure 2. Solution encoding based on proposed Dolphin ALO algorithm.

Once we detect collision at j^{th} node, then we need to reschedule the routing path based on its neighboring nodes. If n_1, n_2 and n_5 are neighboring nodes of n_3 , then find the optimized single node based on its fitness parameters, like maximum energy saving, minimum energy waste, maximum sleep index, maximum data delivery rate, and maximum priority level for data transmission. Here, the j^{th} node having l number of neighboring node is modelled as,

$$n_l^j = 1, 2, \dots, l, \dots, l \quad (1)$$

where, l signifies total number of neighboring nodes.

4.2. Fitness function

The fitness is evaluated for discovering optimal solution using a set of solutions. The fitness computed for proposed Dolphin ALO uses five factors, namely energy saving, energy waste, sleep index, delivery rate, and priority level [1]. The fitness factor of developed Dolphin ALO is modelled as,

$$Fitness = \frac{1}{l} \sum_{i=1}^l [(1 - E_{save}^i) + E_{waste}^i + (1 - P^i) + (1 - D_r^i) + (1 - E^i) + (1 - SI^i)] \quad (2)$$

where, E_{save}^i indicate energy saving, E_{waste}^i indicate energy waste, SI^i is sleep index, D_r^i denote data delivery rate, and E^i and P^i represent priority level.

The energy saved [1] in i^{th} neighboring node is formulated as,

$$E_{save}^i = k\mu E_{Rx} N_p + k\mu(E_{Rx} + E_{Tx})N_l \quad (3)$$

where, E_{Rx} and E_{Tx} refers consumed energy from receiving and transmitting state, N_p refers number of CH nodes and N_l number of normal nodes, k refers number of data packets, and μ is constant. It is a maximization function.

The energy wasted [1] in i^{th} neighboring node is formulated as,

$$E_{waste}^i = \left(E_{Rx} + \frac{E_{Tx}}{i} \right) \mu(N+1)n \quad (4)$$

where, $N+1$ is total number of nodes, i refers subslots, and k refers number of data packets such as

$$k > \frac{\left(E_{Rx} + \frac{E_{Tx}}{i} \right) (N+1)n}{E_{Rx}(N_p + N_l) + E_{Tx}N_l}. \text{ It is a minimization function.}$$

The sleep index [1] in i^{th} neighboring node is formulated as,

$$SI^i = \begin{cases} 1 & \text{Active} \\ 0 & \text{Sleep (Dead)} \end{cases} \quad \begin{cases} \text{; If energy of node} \geq \text{Thres} \\ \text{; If energy of node} < \text{Thres} \end{cases} \quad (5)$$

The energy of i^{th} neighboring node is expressed as E^i , the priority of i^{th} neighboring node is expressed as P^i , and delivery rate of i^{th} neighboring node is given by D_r^i . It is a maximization function.

4.3. Pre-packet scheduling using proposed Dolphin ALO

To address the issue of collision among regular nodes, a pre-scheduling method has been developed, which operates on a schedule-based medium access mechanism [1]. The assignment of data frames is determined by the fitness value, which represents a node that has a higher number of Packets (NoP) and hence more data frames than other nodes. Therefore, when a node generates a certain number of packets, the parent node will allocate a proportionally higher number of data frames. In the event that normal nodes do not have any packets to send, the data frames are occupied by the other node according to the NoP parameter. If many nodes possess the same NoP values, the normal nodes are granted equal opportunities for transmission. The observation is made that when a cluster node broadcasts a Sleep Information Packet (SIP) with a schedule field indicating zero units, it signifies that no normal nodes are utilizing the slots described by zero. Consequently, the cluster node switches the receiving slot to sleep mode. In this study, the process of pre-scheduling is conducted using the suggested Dolphin ALO algorithm, which is developed by combining the Dolphin Echolocation Algorithm (DE) and Ant Lion Optimizer (ALO) techniques. The ALO algorithm is derived on the foraging behavior exhibited by antlions. It provides assistance in resolving tangible issues and offers a reduced number of parameters for adjustment. Therefore, it exhibits adaptability in resolving a wide range of problems. Furthermore, the model under consideration is devoid of gradients, making it suitable for tackling practical issues while effectively managing the trade-off between exploration and exploitation. The Dolphin Echolocation Algorithm (DE) algorithm is derived on the observed behavior of dolphins, which involves imitating actions and strategies. The Dolphin Echolocation Algorithm (DE) algorithm has a high degree of flexibility and possesses the capability to adjust itself in order to solve a wide range of problems. It demonstrates a good convergence rate and is able to produce an acceptable best solution regardless of the number of iterations. The following section outlines the procedural procedures involved in the planned Dolphin ALO.

Step 1) Initialization

The first step is dolphin population initialization and is denoted as, G with total λ solution, where $1 \leq \mu \leq \lambda$

$$G = \{G_1, G_2, \dots, G_\mu, \dots, G_\lambda\} \quad (6)$$

where, λ refers total solution, and G_μ is μ^{th} solution.

Step 2) Evaluate PP of loop

The adjustment of the convergence factor is necessary during the entirety of the optimization process and must be allocated accordingly. Consequently, the alteration of the convergence factor is determined by a specific formula or equation.

$$PP(I_i) = PP + (1 - PP_1) \frac{I_i^p - 1}{(I_N)^p - 1} \quad (7)$$

where, PP express predefined probability, PP_1 is convergence factor of first iteration, I_i is number of current loops, and p is power which represents degree of convergence curve.

Step 3) Determination of fitness

The fitness is defined in section 4.2.

Step 4) Determination of dolphin position

In DE [28], each dolphin location contains a search space dimension and its position is expressed as,

$$S_{m+1}^k = S_m^k + F_{m+1}^k \quad (8)$$

$$S_{m+1}^k = S_m^k + F_m^k + \beta_1^k (B^k - S_m^k) + \beta_2^k (C - S_m^k) \quad (9)$$

$$S_{m+1}^k = S_m^k (1 - \beta_1^k - \beta_2^k) + F_m^k + \beta_1^k B^k + \beta_2^k C \quad (10)$$

According to ALO, the update of current position of ant lion is given as,

$$S_m^k = w^k + \frac{b_m^k - w^k}{b^k - j_m^k} (S_{m+1}^k - j_m^k) \quad (11)$$

Substitute equation (11) in equation (10),

$$S_{m+1}^k = \left[w^k + \frac{b_m^k - w^k}{b^k - j_m^k} (S_{m+1}^k - j_m^k) \right] (1 - \beta_1^k - \beta_2^k) + F_m^k + \beta_1^k B^k + \beta_2^k C \quad (12)$$

$$S_{m+1}^k = w^k (1 - \beta_1^k - \beta_2^k) + \frac{b_m^k - w^k}{b^k - j_m^k} (S_{m+1}^k - j_m^k) (1 - \beta_1^k - \beta_2^k) + F_m^k + \beta_1^k B^k + \beta_2^k C \quad (13)$$

$$S_{m+1}^k = w^k (1 - \beta_1^k - \beta_2^k) + \frac{b_m^k - w^k}{b^k - j_m^k} S_{m+1}^k (1 - \beta_1^k - \beta_2^k) - j_m^k \frac{b_m^k - w^k}{b^k - j_m^k} (1 - \beta_1^k - \beta_2^k) + F_m^k + \beta_1^k B^k + \beta_2^k C \quad (14)$$

$$S_{m+1}^k - S_{m+1}^k \frac{b_m^k - w^k}{b^k - j_m^k} (1 - \beta_1^k - \beta_2^k) = w^k (1 - \beta_1^k - \beta_2^k) - j_m^k \frac{b_m^k - w^k}{b^k - j_m^k} (1 - \beta_1^k - \beta_2^k) + F_m^k + \beta_1^k B^k + \beta_2^k C \quad (15)$$

$$S_{m+1}^k \left[1 - \frac{b_m^k - w^k}{b^k - j_m^k} (1 - \beta_1^k - \beta_2^k) \right] = w^k (1 - \beta_1^k - \beta_2^k) - j_m^k \frac{b_m^k - w^k}{b^k - j_m^k} (1 - \beta_1^k - \beta_2^k) + F_m^k + \beta_1^k B^k + \beta_2^k C$$

$$S_{m+1}^k = \frac{(1 - \beta_1^k - \beta_2^k) \left[w^k - j_m^k \left(\frac{b_m^k - w^k}{b^k - j_m^k} \right) \right] + F_m^k + \beta_1^k B^k + \beta_2^k C}{1 - \left(\frac{b_m^k - w^k}{b^k - j_m^k} \right) (1 - \beta_1^k - \beta_2^k)} \quad (16)$$

$$S_{m+1}^k = \frac{(1 - \beta_1^k - \beta_2^k) [w^k (b^k - j_m^k) - j_m^k (b_m^k - w^k)] + (b^k - j_m^k) F_m^k + (b^k - j_m^k) \beta_1^k B^k + (b^k - j_m^k) \beta_2^k C}{b^k - j_m^k} \quad (17)$$

(17)

The update of Dolphin ALO is expressed by,

$$S_{m+1}^k = \frac{(1 - \beta_1^k - \beta_2^k) [w^k b^k - j_m^k b_m^k] + F_m^k (b^k - j_m^k) + \beta_1^k B^k (b^k - j_m^k) + \beta_2^k C (b^k - j_m^k)}{(b^k - j_m^k) - (b_m^k - w^k) (1 - \beta_1^k - \beta_2^k)} \quad (18)$$

Step 5) Re-evaluate fitness: The fitness is re-calculated in which optimum solution is attained.

Step 6) Terminate: The optimum solutions are devised in repeated way until highest iterations is acquired. The pseudo code of developed Dolphin ALO is examined in table 1.

Table 1. Pseudo code of developed Dolphin ALO

Input: Population S
Output: S^*
Begin
Initialize dolphin population and other algorithmic parameters
Evaluate each dolphin position
Evaluate PP using equation (41)
Evaluate fitness using equation (36)
Update position of dolphin using equation (52)
Update other algorithmic parameters
Re-evaluate fitness of new position using equation (36)
Return S^*
End

The output of proposed Dolphin ALO is denoted as κ , which reveals mitigated result.

5. Results And Discussion

The effectiveness of Dolphin ALO+DRNN is analyzed using energy, PDR, collision detection rate and throughput by altering rounds with 150, and 200 nodes.

5.1. Experimental setup

The Dolphin ALO+DRNN are executed on Windows 10 OS with 8GB RAM and Intel i3 processor and are implemented in python.

5.2. Simulation parameters

The simulation parameters and the values of each parameter are revealed in table 2.

Table 2. Simulation attributes

Simulation parameter	Values
Initial energy	1
Number of nodes	150200
Width of simulation area	100 m
Height of simulation area	100 m

5.3. Evaluation measures

The developed method is analyzed using certain metrics that are described below.

a) Throughput: It refers count of data packets obtained by target at specific time, and is given by,

$$\text{Throughput} = \frac{Z}{r} \quad (19)$$

where, Z is count of nodes obtained at simulation time r .

b) PDR: The proportion of received data packets by sent data packets, and is used to evaluate efficiency of routing.

$$\text{PDR} = \frac{R_d}{S_d} \quad (20)$$

where, R_d is received data packets and S_d is sent data packets.

c) Energy: It indicates energy remained in nodes at highest iteration.

d) Collision detection rate: The rate at which the collision is detected. The collision happens whenever several nodes try to send a packet amongst network at same time.

5.4. Algorithm analysis

The analysis of each algorithm is devised by altering rounds using 150 and 200 nodes considering energy consumption, PDR, throughput and CDR. The strategies considered for assessment involves DDLS [3], ECA-MAC [4], seven bytes addressing string [7], SoNCF [8], and proposed Dolphin ALO + DRNN.

5.4.1. Analysis using 150 nodes

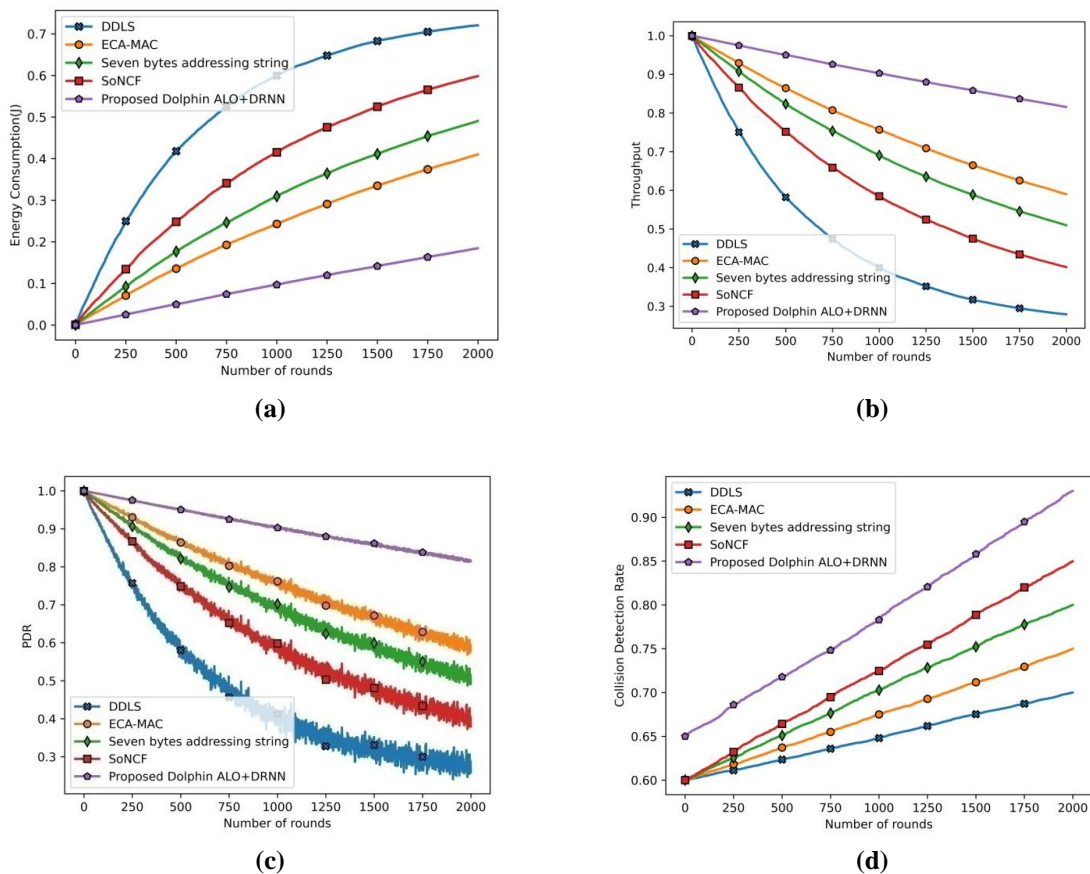


Figure 3. Assessment using 150 nodes with a) Energy consumption b) Throughput c) PDR d) CDR

Figure 3 presents the evaluation of several strategies with a total of 150 nodes. The figure labeled as 3a) presents the analysis pertaining to energy use. Among the considered algorithms, Dolphin ALO + DRNN exhibits the lowest energy consumption during a span of 500 rounds. In comparison, DDLS, ECA-MAC, seven bytes addressing string, SoNCF spend 0.418J, 0.135J, 0.176J, 0.248J, and 0.050J of energy, respectively. In the case of 2000 rounds, the Dolphin ALO + DRNN algorithm exhibits the lowest energy consumption, whereas the DDLS,

ECA-MAC, seven bytes addressing string, SoNCF algorithms spend 0.721J, 0.410J, 0.491J, 0.598J, and 0.185J of energy, respectively. The analysis pertaining to throughput is visually represented in Figure 3b. In a series of 500 rounds, the suggested Dolphin ALO + DRNN algorithm achieved the greatest throughput of 0.950. In comparison, the throughput values obtained by the DDLS, ECA-MAC, seven bytes addressing string, and SoNCF algorithms were 0.582, 0.865, 0.824, and 0.752, respectively. In the case of 2000 rounds, the suggested Dolphin ALO + DRNN achieves the maximum throughput of 0.815. Comparatively, the throughput values for DDLS, ECA-MAC, seven bytes addressing string, and SoNCF are 0.279, 0.590, 0.509, and 0.402, respectively. The performance enhancements of DDLS, ECA-MAC, seven-byte addressing string, and SoNCF, in relation to the planned Dolphin ALO + DRNN, are measured in terms of throughput and yield improvements of 65.766%, 27.607%, 37.546%, and 50.674%, respectively. The study utilizing the PDR is depicted in Figure 3c. In a series of 500 cycles, the suggested Dolphin ALO + DRNN algorithm achieved the maximum Packet Delivery Ratio (PDR) of 0.949. The corresponding throughput values, as assessed by DDLS, ECA-MAC, seven bytes addressing string, and SoNCF, were found to be 0.565, 0.859, 0.818, and 0.740, respectively. In the case of 2000 rounds, the suggested Dolphin ALO + DRNN algorithm achieves the greatest Packet Delivery Ratio (PDR) of 0.815. On the other hand, the PDR values obtained by the DDLS, ECA-MAC, seven bytes addressing string, and SoNCF algorithms are 0.259, 0.579, 0.491, and 0.380, respectively. The performance enhancements seen for DDLS, ECA-MAC, seven bytes addressing string, and SoNCF in comparison to the suggested Dolphin ALO + DRNN utilizing PDR are 68.220%, 28.957%, 39.754%, and 53.374%, respectively. The collision detection rate analysis is depicted in Figure 3d. In a study including 500 rounds, the suggested Dolphin ALO + DRNN algorithm achieved the greatest collision detection rate of 0.718. In comparison, the collision detection rates obtained by the DDLS, ECA-MAC, seven bytes addressing string, and SoNCF algorithms were 0.623, 0.637, 0.651, and 0.664, respectively. In the case of 2000 rounds, the suggested Dolphin ALO + DRNN DDLS, ECA-MAC algorithm achieves the maximum collision detection rate of 0.930. Additionally, the collision detection rates for the seven bytes addressing string and SoNCF are 0.700, 0.750, 0.800, and 0.850, respectively. The performance enhancements of DDLS, ECA-MAC, seven-byte addressing string, and SoNCF, in relation to the planned Dolphin ALO + DRNN, may be measured by their respective collision detection rates, which are 24.731%, 19.354%, 13.978%, and 8.602%.

5.4.2. Analysis using 200 nodes

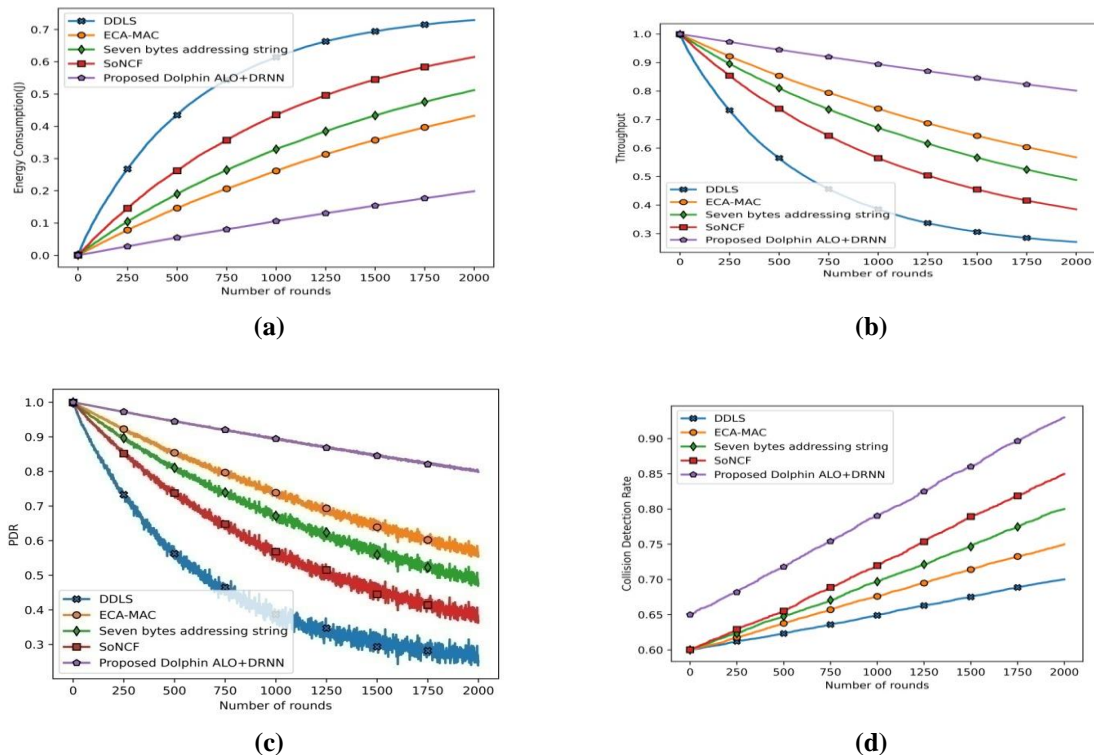


Figure 4. Assessment using 200 nodes considering a) Energy consumption b) Throughput c) PDR d) CDR

Figure 4 presents the evaluation of several strategies with a total of 150 nodes. The figure labeled as 4a) presents the assessment pertaining to energy use. In a series of 500 rounds, the energy consumption of the DDLS protocol amounts to 0.434J, while the ECA-MAC protocol consumes 0.146J. The energy consumption of the seven-byte addressing string is 0.190J, followed by the SoNCF protocol with a consumption of 0.262J. Lastly, the suggested Dolphin ALO + DRNN protocol exhibits an energy consumption of 0.055J. In the case of 2000 iterations, the energy consumption of DDLS amounts to 0.729J, ECA-MAC consumes 0.432J, the energy required for a seven-byte addressing string is 0.512J, SoNCF utilizes 0.615J, and the suggested Dolphin ALO + DRNN method consumes 0.199J. The analysis pertaining to throughput is depicted in Figure 4b. The throughput values obtained from the different protocols over a span of 500 rounds are as follows: DDLS (0.566), ECA-MAC (0.854), seven bytes addressing string (0.810), SoNCF (0.738), and suggested Dolphin ALO + DRNN (0.945). In the case of 2000 iterations, the DDLS yields a throughput of 0.271. The ECA-MAC scheme achieves a throughput of 0.568. The seven-byte addressing string scheme achieves a throughput of 0.488. The SoNCF achieves a throughput of 0.385. Lastly, the suggested Dolphin ALO scheme combined with the Deep Recurrent Neural Network (DRNN) achieves a throughput of 0.801. The performance enhancements of DDLS, ECA-MAC, seven bytes addressing string, and SoNCF in relation to the planned Dolphin ALO + DRNN, as measured by throughput, are 66.167%, 29.088%, 39.076%, and 51.935% respectively. The study utilizing the Photo-Diode Response (PDR) is depicted in Figure 4c. In a series of 500 iterations, the PDR (Packet Delivery Ratio) values obtained for various protocols are as follows: DDLS yielded a PDR of 0.576, ECA-MAC achieved a PDR of 0.857, the seven bytes addressing string protocol achieved a PDR of 0.816, SoNCF resulted in a PDR of 0.747, and the suggested Dolphin ALO + DRNN protocol achieved the highest PDR of 0.945. In the case of 2000 iterations, the PDR values obtained from the different algorithms are as follows: DDLS yields a PDR of 0.251, ECA-MAC achieves a PDR of 0.556, the seven bytes addressing string algorithm results in a PDR of 0.475, SoNCF attains a PDR of 0.368, and the suggested Dolphin ALO + DRNN algorithm achieves the highest PDR of 0.798. The performance enhancements of DDLS, ECA-MAC, seven-byte addressing string, and SoNCF, in relation to the planned Dolphin ALO + DRNN employing PDR, are measured at 68.546%, 30.325%, 40.476%, and 53.884% respectively. The collision detection rate assessment is depicted in Figure 4d. The collision detection rates obtained from several algorithms over 500 rounds are as follows: DDLS achieved a rate of 0.623, ECA-MAC achieved 0.638, seven bytes addressing string achieved 0.647, SoNCF achieved 0.655, and the suggested Dolphin ALO + DRNN algorithm achieved the highest rate of 0.718. In the case of 2000 iterations, the collision detection rates produced by various protocols are as follows: DDLS yields a rate of 0.700, ECA-MAC achieves 0.750, the seven bytes addressing string attains 0.800, SoNCF reaches 0.850, and the suggested Dolphin ALO + DRNN protocol achieves the highest rate of 0.930. The performance enhancements of DDLS, ECA-MAC, seven bytes addressing string, and SoNCF, in relation to the planned Dolphin ALO + DRNN, may be quantified by their respective collision detection rates, which are 24.731%, 19.354%, 13.978%, and 8.602%.

5.5. Comparative discussion

Table 3 discusses assessment with 150 and 200 nodes. Using 150 nodes, the smallest energy consumption of 0.185J is generated by developed Dolphin ALO + DRNN whereas energy consumption of DDLS, ECA-MAC, seven bytes addressing string, SoNCF are 0.721J, 0.410J, 0.491J, and 0.598J. The smallest energy is measured by proposed Dolphin ALO + DRNN, which assist to transmit data with less energy by selecting optimum path. The highest throughput of 0.815 is generated by developed Dolphin ALO + DRNN while the throughput evaluated by DDLS, ECA-MAC, seven bytes addressing string, SoNCF are 0.279, 0.590, 0.509, and 0.402. The DRNN helps to produce highest throughput as it assists to send data from sender to receiver in specific time. The highest PDR of 0.815 is measured by proposed Dolphin ALO + DRNN while the PDR evaluated by DDLS, ECA-MAC, seven bytes addressing string, SoNCF are 0.259, 0.579, 0.491, and 0.380. The highest PDR is produced by proposed Dolphin ALO by choosing optimum routes. The highest collision detection rate of 0.930 is measured by developed Dolphin ALO + DRNN whereas collision detection rate generated by DDLS, ECA-MAC, seven bytes addressing string, SoNCF are 0.700, 0.750, 0.800, and 0.850. The highest collision detection rate is generated by proposed model, which helps to detect the count of collision in less time. Using 200 nodes, the highest energy consumption of 0.199J, highest throughput of 0.801, highest PDR of 0.798 and highest collision detection rate of 0.930 is measured by proposed Dolphin ALO + DRNN.

Table 3. Comparative analysis

Nodes	Metrics	DDLs	ECA-MAC	Seven bytes addressing string	SoNCF	Proposed Dolphin ALO+DRNN
150 nodes	Energy consumption	0.721	0.410	0.491	0.598	0.185
	Throughput	0.279	0.590	0.509	0.402	0.815
	PDR	0.259	0.579	0.491	0.380	0.815
	Collision detection rate	0.700	0.750	0.800	0.850	0.930
200 nodes	Energy consumption	0.729	0.432	0.512	0.615	0.199
	Throughput	0.271	0.568	0.488	0.385	0.801
	PDR	0.251	0.556	0.475	0.368	0.798
	Collision detection rate	0.700	0.750	0.800	0.850	0.930

6. Conclusion

In this study, a novel optimization-based model is proposed for the purpose of conducting collision detection and mitigation in Wireless Sensor Networks (WSNs). Initially, the simulation of Wireless Sensor Networks (WSN) is conducted to initiate the transfer of data. The process of selecting a cluster head is performed using the Fractional Artificial Bee Colony (FABC) algorithm. After the process of cluster head selection has been completed, the routing procedure is carried out among the nodes. Additionally, the network-based parameter is extracted, which encompasses factors such as Received Signal Strength Indicator (RSSI), priority level, delivery rate, and energy consumption. The network-based parameter is regarded as the input for the Deep Recurrent Neural Network (DRNN). The Deep Recurrent Neural Network (DRNN) is utilized for the purpose of collision detection. Here, the DRNN training is done with LCSO. The suggested Lion Crow Search optimizer (LCSO) algorithm is derived by the integration of the Crow Search Algorithm (CSA) with the Ant Lion Optimizer (ALO). Following the process of collision detection, the subsequent mitigation of collisions is achieved by the implementation of a novel pre-scheduling method known as Dolphin ALO. The Dolphin Ant Lion Optimizer (ALO) algorithm is derived by the integration of Ant Lion optimization (ALO) algorithm and Dolphin Echolocation Algorithm (DE). The fitness metric has been recently established to address collision mitigation, encompassing factors such as energy consumption, system integrity, delivery rate, priority level, electronic waste, and energy conservation. The approach suggested in this study shown enhanced performance in terms of energy consumption, throughput, Packet Delivery Ratio (PDR), and collision detection rate. The energy consumption was measured to be 0.185, which was the lowest among all the evaluated methods. The throughput and PDR achieved the maximum values of 0.815, indicating efficient data transmission and successful packet delivery. Additionally, the method exhibited the greatest collision detection rate of 0.930, indicating its effectiveness in identifying and managing collisions. In the future, it is possible to utilize other advanced optimization models to assess the viability of the proposed algorithm.

References

- [1] Oh, K., Gim, G., Lim, W. and Kim, B.M., "An Energy-Efficient and Collision-Avoidance MAC Protocol with Pre-scheduling for Wireless Sensor Networks", *Wireless Personal Communications*, vol. 102, no. 1, pp. 61-78, 2018.
- [2] Valarmathi, A., "Secure architecture to circumvent collision using RSSI measurement in WSN: a cross layer design approach", *Multimedia Tools and Applications*, pp. 1-16.
- [3] Kang, B., Myoung, S. and Choo, H., "Distributed degree-based link scheduling for collision avoidance in wireless sensor networks", *IEEE Access*, vol. 4, pp. 7452-7468, 2016.
- [4] Iala, I., Ouadou, M., Aboutajdine, D. and Zytoune, O., "Energy based collision avoidance at the mac layer for wireless sensor network", *IEEE International Conference on Advanced Technologies for Signal and Image Processing (ATSIP)*, pp. 1-5, May 2017.

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- [5] Kumar, S. and Tiwari, U.K., "Energy Efficient Target Tracking with Collision Avoidance in WSNs", *Wireless Personal Communications*, vol. 103, no. 3, pp. 2515-2528, 2018.
 - [6] Cahyadi, A., Darmawan, E., Dewanto, W. and Ardiyanto, I., "Application of Artificial Potential Field for Coverage Control with Collision Avoidance Under Sensing Constraints", *Journal of Control, Automation and Electrical Systems*, vol. 31, no. 2, pp. 304-318, 2020.
 - [7] Sainuddin, N.B., Abdal-Kadhim, A.M. and Leong, K.S., "Development of Wireless Sensor Node Addressing and Data Packet Collision Avoidance Scheme", *International Journal of Recent Technology and Engineering (IJRTE)*, vol. 8, no. 2S6, July 2019.
 - [8] Kamimura, A. and Tomita, K., "A self-organizing network coordination framework enabling collision-free and congestion-less wireless sensor networks", *Journal of Network and Computer Applications*, vol. 93, pp.228-244, 2017.
 - [9] Sahoo, P.K. and Sheu, J.P., "Design and analysis of collision free MAC for wireless sensor networks with or without data retransmission", *Journal of Network and Computer Applications*, vol. 80, pp.10-21, 2017.
 - [10] Yick, J., Mukherjee, B. and Ghosal, D., "Wireless sensor network survey", *Computer networks*, vol. 52, no. 12, pp. 2292-2330, 2008.
 - [11] Pantazis, N.A., Nikolidakis, S.A. and Vergados, D.D., "Energy-efficient routing protocols in wireless sensor networks: A survey", *IEEE Communications surveys & tutorials*, vol. 15, no. 2, pp. 551-591, 2012.
 - [12] Đurišić, M.P., Tafa, Z., Dimić, G. and Milutinović, V., "A survey of military applications of wireless sensor networks", *IEEE Mediterranean conference on embedded computing (MECO)*, pp. 196-199, June 2012.
 - [13] Ko, J., Lu, C., Srivastava, M.B., Stankovic, J.A., Terzis, A. and Welsh, M., "Wireless sensor networks for healthcare", *Proceedings of the IEEE*, vol. 98, no. 11, pp. 1947-1960, 2010.
 - [14] Puccinelli, D. and Haenggi, M., "Wireless sensor networks: applications and challenges of ubiquitous sensing", *IEEE Circuits and systems magazine*, vol. 5, no. 3, pp.19-31, 2005.
 - [15] Abid, B., Seba, H. and M'bengue, S., "Collision Free Communication for Energy Saving in Wireless Sensor Networks", *Wireless Sensor Networks-Technology and Applications*, 2012.
 - [16] Dandare, P. and Chole, V., "Detection of Collision Attacks and Comparison of Efficiency in Wireless Sensor Network", *International Journal of Engineering and Computer Science*, vol. 5, no. 5, pp.16400-16406, 2016.
 - [17] Zhao, H., Wei, J., Sarkar, N.I. and Huang, S., "E-MAC: An evolutionary solution for collision avoidance in wireless ad hoc networks", *Journal of Network and Computer Applications*, vol. 65, pp.1-11, 2016.
 - [18] Ye, W., Heidemann, J. and Estrin, D., "An energy-efficient MAC protocol for wireless sensor networks", *IEEE Proceedings. Twenty-First Annual Joint Conference of Computer and Communications Societies*, vol. 3, pp. 1567-1576, June 2002.
 - [19] Akyildiz, I.F., Su, W., Sankarasubramaniam, Y. and Cayirci, E., "Wireless sensor networks: a survey", *Computer networks*, vol. 38, no. 4, pp.393-422, 2002.
 - [20] Jung, S.G., Kang, B., Yeoum, S. and Choo, H., "Trail-using ant behavior based energy-efficient routing protocol in wireless sensor networks", *International Journal of Distributed Sensor Networks*, vol. 12, no. 4, p.7350427, 2016.
 - [21] Ergen, S.C. and Varaiya, P., "TDMA scheduling algorithms for wireless sensor networks", *Wireless networks*, vol. 16, no. 4, pp.985-997, 2010.
 - [22] Gandham, S., Dawande, M. and Prakash, R., "Link scheduling in wireless sensor networks: Distributed edge-coloring revisited", *Journal of Parallel and Distributed Computing*, vol. 68, no. 8, pp.1122-1134, 2008.
 - [23] Djukic, P. and Valaee, S., "Delay aware link scheduling for multi-hop TDMA wireless networks", *IEEE/ACM Transactions on networking*, vol. 17, no. 3, pp. 870-883, 2008.
 - [24] Kar, K., Luo, X. and Sarkar, S., "Delay guarantees for throughput-optimal wireless link scheduling", In *IEEE INFOCOM*, pp. 2331-2339, April 2009.
 - [25] Kumar, R., Kumar, D. and Kumar, D., "Exponential Ant Colony Optimization and Fractional Artificial Bee Colony to Multi-Path Data Transmission in Wireless Sensor Networks", *IET Communications*, 2016.
 - [26] Mirjalili, S., "The ant lion optimizer", *Advances in engineering software*, vol. 83, pp.80-98, 2015.
 - [27] Askarzadeh, A., "A novel metaheuristic method for solving constrained engineering optimization problems: crow search algorithm", *Computers & Structures*, vol. 169, pp.1-12, 2016.
 - [28] Kaveh, A. and Farhoudi, N., "A new optimization method: Dolphin echolocation", *Advances in Engineering Software*, vol. 59, pp.53-70, 2013.
 - [29] Nguyen, K., Nguyen, T., Chaing, C.K. and Motani, M., "A prioritized MAC protocol for multihop, event-driven wireless sensor networks", *IEEE First International Conference on Communications and Electronics*, pp. 47-52, October 2006.
 - [30] Jamieson, K., Balakrishnan, H. and Tay, Y.C., "Sift: A MAC protocol for event-driven wireless sensor networks", In *European workshop on wireless sensor networks*, Springer, Berlin, Heidelberg, pp. 260-275, February 2006.

- [31] Chen, Z., He, M., Liang, W. and Chen, K, "Trust-aware and low energy consumption security topology protocol of wireless sensor network," Journal of Sensors, 2015.
- [32] Yadav, A.K. and Tripathi, S., "QMRPRNS: Design of QoS multicast routing protocol using reliable node selection scheme for MANETs," Peer-to-Peer Networking and Applications, vol.10, no.4, pp.897-909, 2017.
- [33] Inoue, M., Inoue, S. and Nishida, T, "Deep recurrent neural network for mobile human activity recognition with high throughput," Artificial Life and Robotics, vol.23, no.2, pp.173-185, 2018.