Revolutionizing WBAN communication for public health: Effective Optimization strategy-driven health assessment

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KEYWORDS

Customized Chicken Swarm Optimization (CCSO), Public Health, Communication, Cluster Head, Wireless Body Area network (WBAN).

ABSTRACT

This study explores the optimization procedures that are critical to enhancing WBAN communication efficacy in an environment of public health initiatives. In order to observe someone's physiological characteristics continuously and non-invasively, wireless body area networks (WBANs), are an essential piece of innovation for distant health observation. The WBAN individual nodes, yet, might relocate and lose reception from a distant base station over time. Thus, an effective inter-WBAN interaction approach is required to address this issue. In order to lower cost associated with networks and maximize cluster lifespan towards the network's effectiveness, this research develops a clustering-driven routing approach that uses cluster head serving as a gateway. For efficient cluster head selection, a novel customized chicken swarm optimization (CCSO) technique was introduced. Various parameter adjustments are made in multiple trials to verify the suggested approach effectiveness. The research conduct comprehensive comparison analysis of suggested and existing algorithms, several tests are conducted. The results show that the approach technique can increase the effectiveness of WBAN engagement and create clusters more quickly than the other methods in the framework of public health initiatives.

1. Introduction

WBAN (Wireless Body Area Networks) is transforming public and health in modern technology and health care. WBAN is made up of a network of sensors and devices that are supposed to constantly observe and transmit physiological details obtained from the human body to other systems [1]. It holds the key possibility to revolutionize the assessment, diagnosis, and management of numerous health conditions for public health reasons [3]. Continuous, non-intrusive health monitoring enhances patient outcomes and saves healthcare expenses; wearable biosensors (WBANs) provide viable solutions for problems [2]. The creation of WBAN was for the purpose of monitoring physiological processes like blood pressure and heart rate. After acquisition, the data was forwarded to healthcare practitioners via the internet or other communication networks through wireless connectivity among sensors and hub [13]. WBANs may be seamlessly incorporated into healthcare system to help with early health anomaly identification, prompt intervention and individualized treatment programs [4]. WBAN can track a diabetic patient's blood sugar levels constantly and notify the patient and doctor when patient's levels deviate from normal. By enabling quick changes to medicine or lifestyle, this real-time input helps to avoid bouts of severe hyperglycemia [5]. The inter-WBAN communication can be helpful in overcoming communication barriers. However, WBANs are made up of lightweight devices nodes, inter-WBAN communication cannot be realized without an effective consumption of energy routing method. The transfer of data for WBANs was handled by the CH (cluster head). The longevity of the cluster affects network efficiency [14]. WBANs can identify sick people quickly and stop the spread of infectious illnesses by continuously monitoring physiological changes and symptoms [6]. The WBAN capacity seems extremely helpful in communities and highly populated places where access to healthcare services. [9] Interference from many portable devices can cause data loss or delays in transmission of WBAN. To ensure the confidentiality and security of delicate medical information was difficult on WBAN. The study's aim is to develop a novel customized chicken swarm optimization (CCSO) approach for efficient cluster head selection.

Related works

Ahmad et al. [7] examined environmentally friendly communication among sensor nodes operating in the healthcare industry. WBAN (Wireless Body Area Network) systems were effectively applied in the field of medicine. The experimental outcomes demonstrated that the procedure permits effective package delivery. Pandey et al. [8] introduced an innovative medical system of WBAN, which shifts the paradigm in the medical sector. The sensors were utilized to effectively exploit the WBAN design on health state. WBAN was utilized as foundational network design for various sensor kinds to reduce various public health and not healthcare elements. The experimental outcomes show how WBAN is used for communication and security. Jose et al. [15] examined WBAN sensor networks that are intended to function independently and link various medical devices and sensors both within and outside the body. The creation of WBAN was for the purpose of monitoring physiological processes such as blood pressure, and heart rate. The findings showed various types of mental illnesses and how they affect a person's life. Manna and Misra [10] develop WBAN that uses CR (Cognitive Radio) for search licensed PU (Primary User) channels for opportunistic access that enables spectral-efficient, economical and dependable NRT (Non-Real Time) backhaul services distribution of WBAN information for widespread of public health surveillance. The outcome demonstrated the cost-efficiency of healthcare data sets under different CR pricing regimens. Ramaswamy and Gandhi [16] examined WBAN in healthcare sector, constituting various tasks like tracking patients remotely that possess an assortment of small portable sensors in the body with little processing power that communicate over small distances [11]. The findings indicate that protocol constitute low cost.

WBAN structure

WBAN reduces the need for frequent route searches by creating persistent clusters. The suggested approach obtains a WBAN-to-WBAN connection directly through the PS (personal server) rather than connecting WBAN to BS physically. The PS constitutes the charge of handling additional data transfer, and receives data from sensor nodes. PS from various WBANs group together in the suggested technique. Every cluster has a CH (cluster head) and nearby CMs (cluster members). Every cluster possesses CH that constitutes charge for managing the CM of vicinity. Additionally, multi-hop interaction among CH of various WBANs allows data to be routed to the closest access point.

Cluster Communication Architecture

Three hierarchical categories of communication may be identified in the proposed method: CH to BS, sensor node to PS and CM to CH. Nodes are placed randomly around the grid during network formation. The algorithms were utilized to experimentally verify the suggested technique.

Inter-WBAN Communication Strategies

Figure 1 shows the inter-WBAN clustering. Although cluster Y was close to BS that can connect with cluster X's WBANs and CH is outside of BS communication range. To interact the BS, cluster X need cluster Ys assistance. A straightforward cluster communication method was achieved by cluster X members having a direct link to CH of cluster X, which in turn may connect to CH of cluster Y.

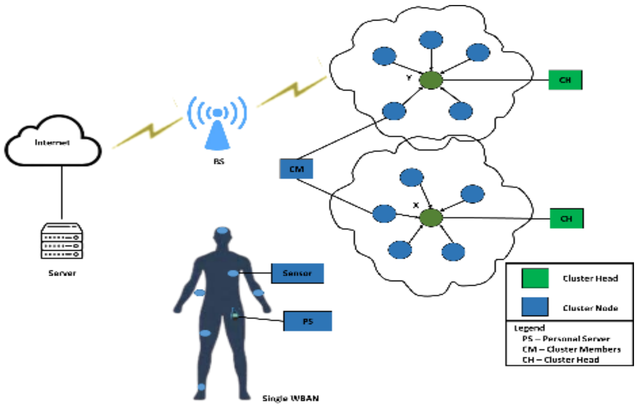

Figure 1 Architecture of Inter-WBAN clustering

2. Methodology

Proposed method- Customized Chicken Swarm Optimization (CCSO)

Lévy Flight-Inspired Search Strategy

To maximize wireless body area network (WBAN) connectivity, Customized Chicken Swarm Optimization (CCSO) blends the ideas of swarm intelligence with tailored settings. The method improves the efficiency and dependability of data transmission in WBANs, which was essential for enhancing public health surveillance and provision of healthcare. The Levy flight search method was typified by short-term deep search operations and sporadic longer distance treks because the whole flock searches food in an uncertain environment. It may enhance the effectiveness of the search and provide more disruption to encourage a more uniform distribution of the hens. The CCSO method incorporates the Levy flight search strategy on hen's location as a result of inspiration. They prevent iterations from reaching a local minimum and improve the algorithm's capacity for global search. The following equation describes the location of hen, improved:

$$w_j^i(s+1) = w_j^i(s) + T_1 * rand * \left(w_{q1}^i(s) - w_j^i(s)\right) + T_2 * rand * K_{evy}(\lambda) \otimes \left(w_{q2}^i(s) - w_j^i(s)\right) \quad (1)$$

The jump path of the K_{evy} distribution, represented by λ, and scale variable in the interval [2, 4], and it indicates a randomly selected step size. In this case, vector multiplying was shown by $\otimes$.

Dynamic Inertia Weight Adjustment Strategies

The only source of knowledge for the chicks in the basic CSO algorithm was constituted by their mother. The chicks that follow a mother will likewise enter the local minimum whenever the mother reaches it. The nonlinear techniques of reducing inertia weight are used in the proposed CCSO algorithm to update the location of chicks, assisting them in learning from both their mother and themselves. The numerical tests will confirm that the CCSO method may be prevented from entering a local minimum that is feasible through linking the nonlinear processes reducing inertia factor in Chick's location. The following update represents the nonlinear reducing inertia factor ω:

$$\omega = \omega_{min}\left(\frac{\omega_{max}}{\omega_{min}}\right)^{\left(1+\frac{ct}{N}\right)} \quad (2)$$

The following is the location update formula for chicks that takes nonlinear reducing inertia factor.

$$w_j^i(s+1) = \omega * w_j^i(s) + FL * \left(w_n^i(s) - w_j^i(s)\right) \quad (3)$$

Here ω_{min} represent reduced inertia factor. Figure 2 depicts the flowchart of CCSO algorithm.

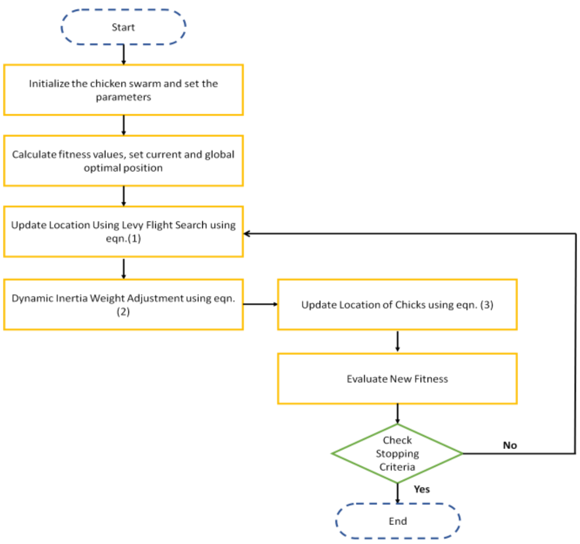

Figure 2 CCSO flowchart

3. Results and discussion

For simulation, many scenarios with varying transmission distance, node density and grid size were developed. In particular instance, the transmission range was maintained for every node. The grid size was adjusted between the subsequent values throughout the experiments of 1 km × 1 km. The node number was modified from 50 to 200.

The optimal solution was identified for every transmission range. A shorter transmission range leads to more clusters since each node has fewer neighbors because there was less coverage area for the nodes at distance. Hence, the cluster number rises and there are fewer CM as the transmission range was shortened. Fewer nodes in the proximity of a node with a limited transmission range have a smaller coverage area, which leads to a higher number of clusters. Tables 1 and 2 illustrate the parameters for simulation.

Table1 Parameters for simulation

Parameter	**Values**
Grid size	1 km × 1 km
W2	0.7
W1	0.3
Mobility model type	Freely mobility model
Node number	50,100,150,200
Transmission range (m)	2 m,4 m,6 m,8 m,10 m
Dimension	2
Upper bound (ub)	200
Lower bound (lb)	-10
Maximum iteration number	150
Population size	150

Table 2 Parameters for simulation

Parameter	**Values**
Operating system	Windows 10 (64-bit)
RAM	8 GB
CPU frequency	2.4 GHz
CPU	Intel i7-5500u
Simulation software	Matlab 2018a

We also present an efficacy comparison between our proposed strategy and other current approaches (Comprehensive Learning Particle Swarm Optimization (CLPSO) and Dragonfly algorithm (DA)) [12].

The distance to which sensor nodes or communication devices can successfully transmit data or signals are termed as transmission range. The network's coverage and connection capabilities are established by it, which impacts the nodes' ability to interact directly or via intermediary relays. Figures 3 (a) and 3 (b) represent the transmission range of comparison between suggested and traditional methods. Compared to current techniques like DA and CLPSO, the proposed CCSO attains low transmission range. Our proposed method provided superior results for efficient cluster head selection. Figure 3 (a) illustrates the cluster heads vs. transmission range of 50 nodes. Figure 3 (b) illustrates the cluster heads vs. transmission range of 100 nodes.

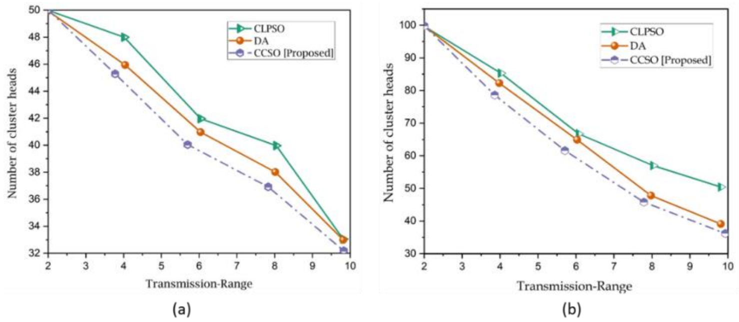

Figure 3 Cluster Heads vs. Transmission range (a) 50 nodes and (b) 100 nodes

Figures 4 (a) and 4 (b) represent the transmission range of comparison between suggested and traditional methods. Compared to current techniques like DA and CLPSO, the proposed CCSO attains low transmission range. Our proposed method provided superior results for efficient cluster head selection. Figure 4 (a) illustrates the cluster heads vs. transmission range of 150 nodes. Figure 4 (b) illustrates the cluster heads vs. transmission range of 200 nodes.

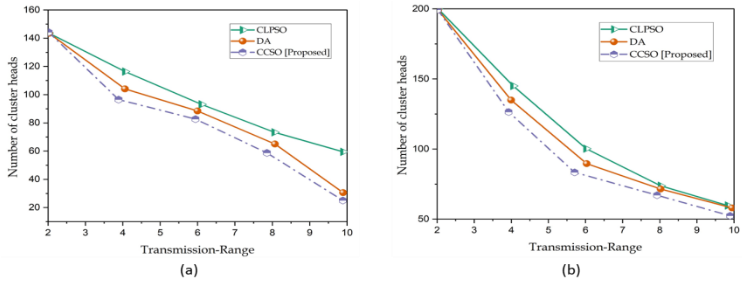

Figure 4 Cluster Heads vs. Transmission range (a) 150 nodes and (b) 200 nodes

4. Conclusion and future scope

In this work, we proposed a revolutionary strategy called customized chicken swarm optimization (CCSO) approach for efficient cluster head selection. Through the continuous transmission of information system and monitoring, WBAN safeguards the patient's life. Clustering was a crucial technique in WBAN load allocation, offers a workable solution for senior node energy optimization. In order to lower the cost associated with networks and maximize cluster lifespan towards the network's effectiveness, this research develops a clustering-driven routing approach that uses cluster head serving as a gateway. Various parameter adjustments are made in multiple experiments trials to verify the suggested approach's effectiveness. In order to conduct a comprehensive comparison analysis of suggested and existing algorithms, several tests are conducted. The results show that the approached technique can increase the effectiveness of WBAN engagement and create clusters more quickly than the other methods in the framework of public health initiatives. Interference from many portable devices can cause data loss or delays in transmission of WBAN. To ensure the confidentiality and security of delicate medical information, it was difficult on WBAN. Future research is moving towards the development of security and privacy by creating strong security mechanisms specifically for WBAN. The WBAN application in public health and community health contexts provides significant benefits.

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