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Review Article

Moth-Flame Inspired Routing Protocol for Selection of Relay Node in Wireless Body Area Networks

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Abstract: Wireless Body Area Network (WBAN) represents a critical rising technology to resolve the problem on, in or around the patient body, but the implementation of WBAN technology is constrained by the energy consumption by them and by their shelf life. The solution may rely on employing an additional relay node that can reduce the traffic and save the energy consumption of the biosensor node. The present study addresses these issues of reduce the energy consumption by optimum design of network and routing protocol by employing heuristic-based optimization algorithms. Moth-Flame Optimization (MFO) is a search-based heuristics algorithm which updates the position of search agents. MFO has tremendous exploration capabilities and contributes significantly to global search, but it quickly becomes locked in local minima. The recently developed Inspired MFO (IMFO) has been validated by comparing the results of existing MFO for WBAN problem. It has been found that proposed IMFO algorithm outperforms other recently proposed meta-heuristics search algorithms for better relay nodes selection which is a key element for optimization of energy consumption.

Keywords: WBAN, MFO, IMFO, Routing, Energy-efficient, multi-hop.

INTRODUCTION

In the fast-changing, global scenario when life has gone jet set, health-related issues are mushrooming at an alarming rate. So, medical facilities have become of paramount importance today. The million-dollar question that arises is whether people at large can get required and desired access to health care centers as needed. The answer in general to this notation is that majority of people fail to make to the hospitals and such institutions on time, thereby leading to irreparable loses and even deaths. All this made the researchers make headway to find an effective and efficient solution to this concerning matter. This leads to the concept of Wireless Body Area Network (WBAN) [1].

Moreover, the mushrooming use of Wireless Networks and continuous minimizing of the electrical devices has led to the evolution of WBAN. WBAN is an assemblage of sensor nodes that are worn or implanted on body for monitoring the functionality of various body organs. It performs anywhere and anytime monitoring without putting check on the movement of patients. These tiny intelligent nodes sense different anatomical parameters and send this to the sink (intermediate node) which lies inside or outside the human body. The continuous power of data sensing over high-distance results in the energy utilization of these nodes. So, conserving the energy is the major requirement. In order to fulfill the same, the researchers need to develop the energy-aware routing protocols for the dependable monitoring of human body systems. These protocols will work in a way to put the nodes in a resting state when the human body is functioning normally and resume their working whenever some disorder is observed. Lately, Several MFO based energy efficient routing protocols for wireless sensor networks have been referred to in the literature such as [1] and TCEP [2]. Different meta-heuristics search algorithms have been studied like Grey Wolf Optimizer [3], Ant Lion Optimizer [4], Whale Optimization Algorithm [5], The Runner Root Algorithm [6], Binary Bat Algorithm [7], Mine Blast Algorithm [8], Adaptive Cuckoo Search Algorithm [9], Cognitive Behavior Optimization [10], Firework Algorithm [11], Particle search agent optimization algorithm [12], Self-Adaptive Bat Algorithm [13]. Presently WBAN problem had been solved using PSO [14], Genetic Ant Colony [15]. An energy-efficient method[15], rooted on GACA. Kaur *et al.*, [16] proposed GA for WBAN problem.

Novelty and Contributions of the Proposed Research

In the proposed research, MFO algorithm has been modified by an inspired algorithm renamed as IMFO to avoid entrapment in local minima and implement to select the relay node for minimization of energy consumption in the WBAN. This also improves the exploitation phase of the existing MFO algorithm, which in turn trapped it out of the search space.

Each of updated position of the search agent for objective functions is evaluated by IMFO and it also determines the best fitness value use for algorithm for optimizing multi-objective parameters to select the forwarder node that has been significant in providing referable outcomes instead of direct selection.

Moth-Flame Optimizer and Mathematical Formulation

Moth Flame Optimization (MFO) [17], a new meta-heuristic optimization method that has been proved by Seyedali Mirjalili, the inventor of the algorithm. The calculation accuracy and convergence speed of this algorithm need to be further improved as the MFO algorithm has been in the research stage from a long time. An enhanced version of MFO is proposed that is Inspired Moth Flame Optimization (IMFO).

The conjunction of the moth in the direction of the light is shown in Fig. 1 (a to c) as below:

Fig.1 (a to c) Conjunction of moth in the direction of a light

At the first step, the start location of search agents is assigned by Eq. (1).

$Pos_i^0 = LB + rand() * [UB - LB]$…………………………………………..…… (1)

Where Pos_i^0= initial position of i[th] search agent, UB = outer boundary of the search space, LB = lower bound and rand () is represented random-number (0,1).

For WBAN, assume that optimal energy values are moths and that node locations are moth positions in space. Matrix given below represents the set of moths:

$$Q = \begin{bmatrix} q_{1,1} & q_{1,2} & \cdots & q_{1,d} \\ q_{2,1} & q_{2,2} & \cdots & q_{2,d} \\ \vdots & \vdots & \vdots & \vdots \\ q_{n,1} & q_{n,1} & \cdots & q_{n,d} \end{bmatrix} \quad \text{……} (2)$$

Where d = no. of variables (population or dimension) and n = no. of moths (no. of sensor nodes)

Similarly, matrix of the set of flames is represented below:

$$R = \begin{bmatrix} R_{1,1} & R_{1,2} & \cdots & R_{1,d} \\ R_{2,1} & R_{2,2} & \cdots & R_{2,d} \\ \vdots & \vdots & \vdots & \vdots \\ R_{n,1} & \cdots & \cdots & R_{n,d} \end{bmatrix}_{n\times d} \quad \text{……} (3)$$

Where d = no. of variables and n = no. of moths

The MFO based on 3 tuple algorithm that estimates the global optimization problem given as:

$MFO = (Z, Y, T)$………………………………………………………………. (4)

Where three functions are Z, Y and T.
Z = random population of moths, its represent fitness-values is given by:
$Z{:}\,\Phi = \{Q, OQ\}$……………………………………………………………. (5)
Y = moths around the exploration space. It can be written as:
$Y{:}\,Q \rightarrow Q$……………………………………………………………….…. (6)
T= function (true and false) means true is fulfilled and false is not fulfilled the conditions. It can be represented as:
$T : Q \rightarrow \{True, False\}$………………………………………………………. (7)
The function Z is used for calculating energy value and generating an initial generation schedule.
The random location of nodes used in Z() can be implemented MFO algorithm with Z, Y and T restructured as:

Q= Z();
while T(Q) is equal to False
Q=Y(Q);
End

The maximal and minimal generating units can be given as:
$UB = [UB_1\ UB_2\ UB_3\ \ldots \ldots UB_{n-1}\ UB_n]$ ……... (8)
Where UB_i = maximal capacity of ith node

$L = [LB_1\ LB_2\ LB_3\ \ldots \ldots LB_{n-1}\ LB_n]$ …………………………………………. (9)
Where LB_i = minimal of i^{th} node
Position is updated with relation to a flame using eq^n (10), in order to model the transverse orientation.

$Q_i = S(Q_i, R_j)$ ………………..……………………………………….……… (10)
Where S = spiral function, R_j = j^{th} flame, Q_i= i^{th}-moth.

After the eq^n (10), the logarithmic coiled/spiral of MFO is:
$S(Q_i, S_j) = D_i . e^{bt} . \cos(2\pi t) + R_j$ ……….....................………….……… (11)
WhereD_i= Distance, b = logarithmic constant spiral, t =number between [-1,1]. D_i of eqn. is
$D_i = |R_j - Q_i|$ ………………………………………………….…….……… (12)

The continuous change in the position of moths, following model is used to solve this problem:
$F_{NUMBER} = round\left(N - iter * \frac{N-1}{iter_{max}}\right)$ ……………………….……….. (13)
"), centered on the page, beginning 2.54 cm (1") from the top of the page and ending with 2.54 cm (1") from the bottom. The right and left margins should be 1.9 cm (.75”). The text should be in two 8.45 cm (3.33") columns with a .83 cm (.33") gutter.
Flow chart and Pseudo code of MFO is shown in Fig.2.

Step:1 Update flame no using eqn. (13)
Step:2 OQ=Cost Function(Q)
if iteration==1
R=sort(Q);
OR=sort(OQ);
else
R=sort(Q_{t-1}, Q_t);
OR=sort(Q_{t-1}, Q_t)
end;
for i =1: n
for j=1: d
Update r and t
Step:2.1 calculate D using eqn. (12) w.r.t. corresponding moth
Step:2.2 Update Q(Z,j) using eqn. (10)and(11)w.r.t. corresponding moth
end
Step:3 end

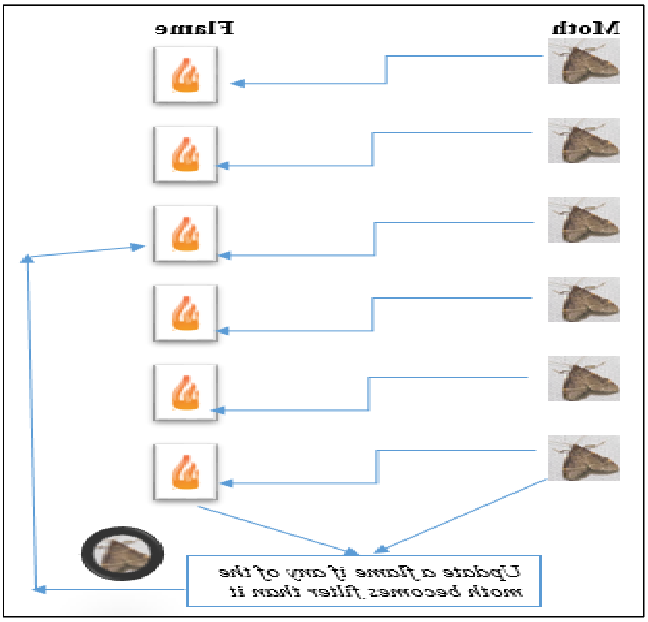

Fig. 2 PSEUDO code and Flow chart of MFO algorithm

Wireless Body Area Networks Design Problem

The main optimization problem of wireless body area networks has been taken into consideration, whose objective function is to reduce the energy utilization of the WBAN. The aim of minimizing energy-consumption, reply node used by the proposed protocol along with fitness function. The suggested approach determines the relay node based on the least value of the fitness function that has been chosen as the forwarder node to minimize energy use.

A. Network Model

At first, a number of total eight sensors used in WBAN. All eight nodes worked on bidirectional approach after sensing the data. The deployment of nodes on the patient's body with X and Y coordinators are shown in Table-1.

Table 1: Deployment of nodes on the patient body

Node	S1	S2	S3	S4	S5	S6	S7	S8	SINK
Location (X, Y)	(0.55, 1)	(0.26, 0.1)	(0.27, 0.3)	(0.47, 0.24)	(0.2, 0.4)	(0.3, 0.4)	(0.43, 0.12)	(0.36, 0.6)	(0.3, 1.2)

B. Energy Model

The overall Energy Consumption (EC) spent in transferring or forwarding the data, can be calculated using Eq. (14).

$$En_{trans} = En_{T\_elec} \times p + En_{amp} \times n \times p \times d^2 \quad (14)$$

Where En_{trans} = transmission EC, En_{rec} = reception EC, En_{T_elec} = energy needed for the electronic circuitry of the transmitter, En_{R_elec} = energy needed by a receiver, En_{amp} = amplifier EC, p =size of frame/packet and n is loss-coefficient.

Simulation Results and Analysis

A contrast of the simulation results of IMFO is made with MFO using MATLAB simulator for the scenario in which all nodes are static and data is forwarded with help of relay (forwarder node). Eight sensors (S_1, S_2, S_3... S_8) are deployed. A relay node is utilized in this case to fill the gap between distant nodes and the sink. The goal is to locate the best relay node for each node by evaluating data cost of transmission using the Cost Function.

Cost Function $CF_i = (D_i)/(R\ E_i)$ (15)

The key performance metrics for the proposed protocol is estimated. The definition of performance metrics is given in the next subsections. Simulation results of MFO, IMFO for WBAN problems shown in table 2.

A. Stability Period: It is the period length of network operation till the beginning node expires.

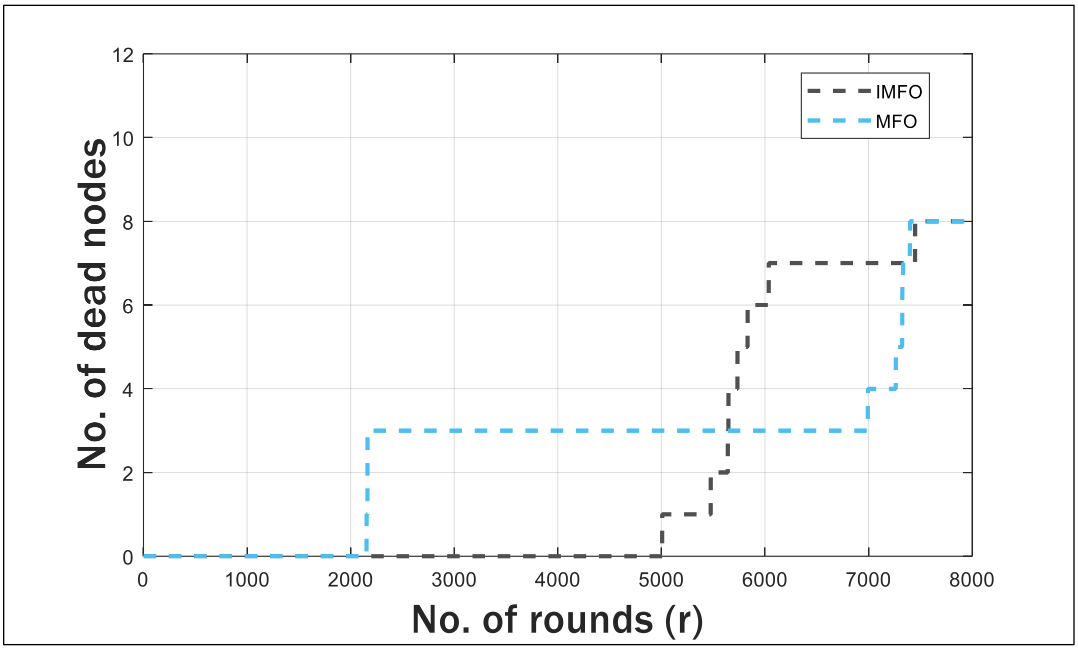

Fig 3: Stability period

From the fig 3, the first node dies of proposed scheme dies at around 5000 rounds, whereas the first node of MFO dies at around 2000 rounds. As a result, it is possible to conclude that the suggested system has a longer stability period than the MFO.

B. Throughput: The total successfully packets received at the side of final destination.

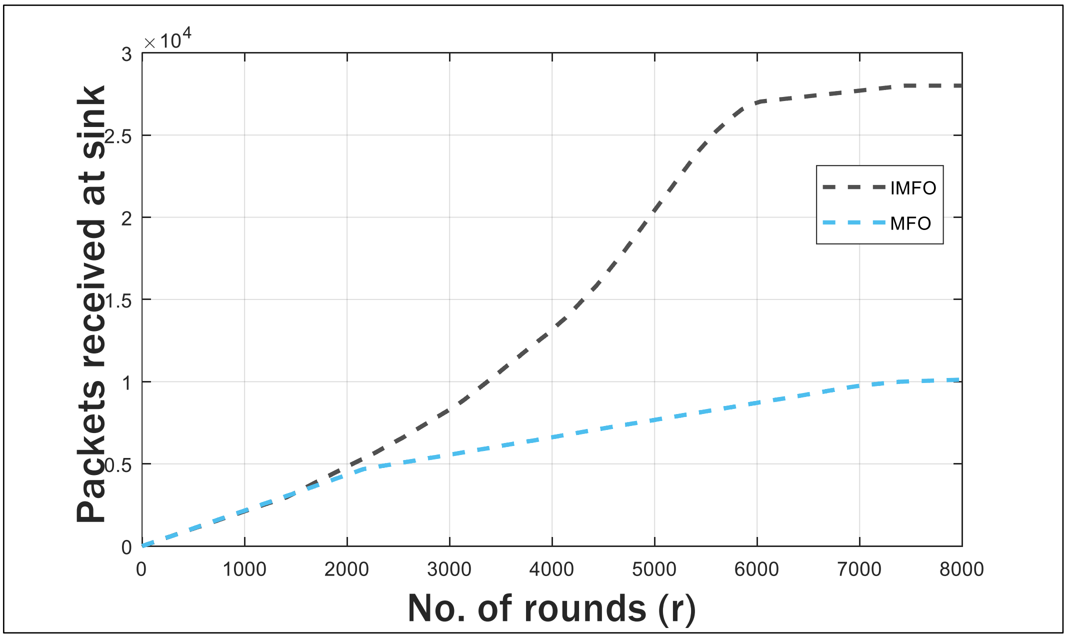

Fig 4: Throughtput

This is critical information since it pertains to human health and must be sent to its intended destination. The packets received by both schemes are shown in fig 4. After 8000 rounds, packets received by the MFO is about 1.0 x 10^4. And packet received by proposed scheme is nearly 2.8 x 10^4. This result of proposed scheme has been achieved due to availability of nodes.

C. Residual Energy: Residual energy parameters are considered to analyze the energy utilization of the network

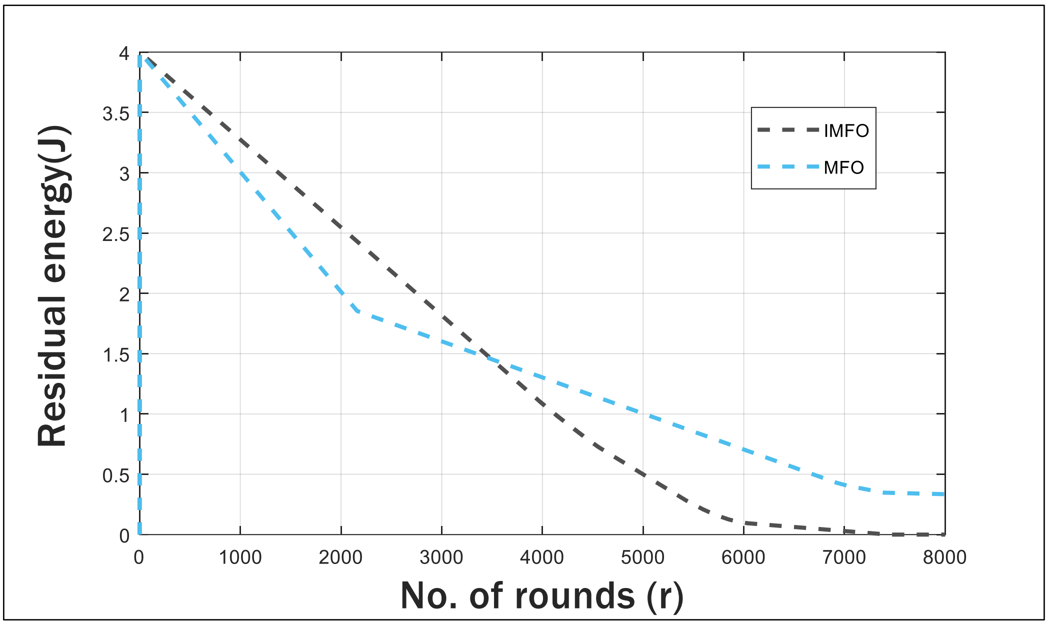

Fig 5: Residual energy

The energy utilization by both the schemes are shown in the fig 5. The energy consumption by the proposed scheme is achieved by the forwarder cost selection at the every round.

D. Path-Loss (dB): The variance between the forwarded power of the sender node and received power at receiver node is known to be the path loss.

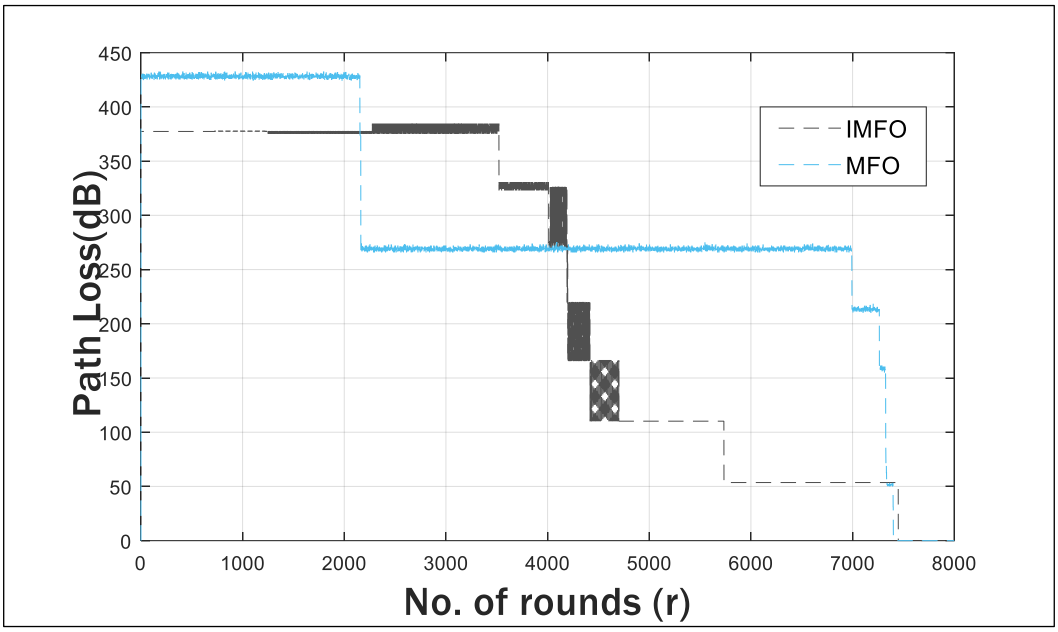

Fig 6: Pathg-loss

The path-loss by the MFO is just after 2000 rounds but in the proposed scheme are 3500 rounds. This is because nodes in MFO die faster than in the proposed design.

CONCLUSION

In this study, the exploitation phase of the previous MFO was effectively upgraded by integrating the exploitation phase of the inspired technique. The newly developed Inspired MFO (IMFO) has been tested for WBAN model for selection of relay nodes for minimizing the total energy consumption. To prove the efficiency of proposed IMFO for WBAN problematic, it has been found that network lifetime, stability period in terms of reduced energy consumption and longevity of nodes using IMFO are much better than other recently proposed MFO. Hence, the proposed algorithm is recommended for applications in future communication networks for better relay node selection strategies.

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