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Review paper on Firefly algorithm with cyclic randomization in wireless sensor netowork

Amit Sarkar[1], Dr.T.Senthil Murugan [2]

[1] Research Follower Vel Tech Rangarajan Dr Sagunthala R&D Institute of Science and Technology Avadi Chennai-600 062 Chennai,India; email id:- amitsarkar_us@sginstitute.in

[2]Associate Professor Vel Tech Rangarajan Dr Sagunthala R&D Institute of Science and Technology, Avadi Chennai-600 062 Chennai,India; senthilmuruganme@gmail.com

ABSTRACT

The firefly algorithm is a stochastic meta-heuristic that incorporates randomness into a search process. Essentially, the randomness is useful when determining the next sensor node in the cluster head search space of Wireless Sensor Network and therefore has a crucial impact when exploring the sensor node during data transmission. This paper intends , to present extensive discussion on cyclic randomization used for the firefly algorithm. The cluster head is selected in such a way that it is spatially closer enough to the base station as well as the sensor nodes. So, the time delay can be substantially reduced. This, in turn, the transmission speed of the data packets can be increased. Firefly algorithm is developed for maximizing the energy efficiency of network and lifetime of nodes by selecting the cluster head optimally. In this paper Firefly with Cyclic Randomization (FCR) is proposed for selecting the best cluster head. The network performance is increased in this method when compared to the other conventional algorithms.

Key Words: Wireless Sensor Network, Cluster Head, Firefly with Cyclic Randomization (FCR)

1. INTRODUCTION

Wireless Sensor Networks (WSN) have been planned and elaborated for a wide variety of applications such as environmental or habitat tracking, smart battlefield, home automation and traffic management, etc. [1] [2] [3] [15] [28]. WSN basically comprises of sensor nodes, which are spatially distributed so that it can monitor the physical or environmental conditions. Each sensor node of a WSN receives a signal from a finite region. This signal is generally processed in the sensor node, and the sensed information is passed to the Base Station (BS). Basically, sensor nodes consume energy while transmitting, processing or receiving information. These sensor nodes work under the use of non-rechargeable battery [13], which last over several years or months [23] [24]. Therefore, the energy efficiency serves as the major objective of wireless sensor network and it is responsible for enhancing the life expectancy of the network. This objective can be met by an appropriate selection of cluster heads through which the communication link is established between the WSN and the sink.

In the clustered communication, the nodes of the network can be segregated into small groups called as a cluster [14] [13] through which the information transfer can be accomplished. Generally, each cluster has a cluster head that correlates the data grouping and aggregation process in a specific cluster. The data packets are generally transferred to the cluster head by any node of the respective cluster. In WSN, clustering provides assurance in basic performance attainment with a more number of sensor nodes. Clustering also improves the scalability of WSN, because the clustering process increases the need for central organization and stimulates local decisions [21] [22].

The existing clustering algorithm contains many drawbacks such as low life span of network, high energy consumption, lack of adaption with heterogeneous network [5], poor stability [6], death of nodes [7], delay in information transmission [4], complexity in handling large scale WSN [8], poor consideration to residual energy nodes [11], additional overhead and energy coverage [10] and unbalanced lifetime of nodes [9]. Many optimization algorithms such as Particle Swarm Optimization [17] [25], Ant Colony Optimization (ACO) [27], Genetic Algorithm [26], etc. have been exploited by the researchers to determine the cluster head. But still, the above mentioned meta-heuristic algorithms require additional improvement on energy stabilization and efficiency to increase the durability network [27].

This paper proposes a variant of firefly algorithm, called as FCR to select optimal cluster head so that energy efficient and delay less routing can be accomplished in WSN.

The remaining part of the paper is organized as follows. Section II reviews the literature and Section III states the problems in cluster head selection and the conventional Firefly algorithm along with cyclic redundancy for optimal cluster head selection. Section IV concludes the paper.

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2.LITERATURE REVIEW

2.1 Related Works

In 2010, Rajeev Kumar and Dilip Kumar [13] have proposed Artificial Bee Colony (ABC) along with fractional calculus, to increase the energy of the network and life of the nodes by selecting the cluster head. In that paper, multi-objective fractional ABC algorithm.. They have compared the proposed FABC-based method and proved that it maximizes the energy and the nodes' life span as related with the presently available protocols. In 2012, Buddha and Daya [17] proposed Particle Swarm Selection Optimization (PSO), to generate clusters having knowledge of energy by the process that makes a choice of the cluster heads in an optimal way. The main advantage of PSO is that the cost associated with detecting the head nodes' optimal position within a cluster reduces eventually.In 2014, Cheng et al. [20] had worked on QoS routing in the wireless sensor networks. They developed an efficient QoS-aware geographic opportunistic routing scheme for the quality of service provisioning in the wireless sensor networks. Regarding latency, the protocol organizes the prioritized sets, and the evaluation is carried out and compared to the existing multipath routing schemes whereas, in 2014, Duc et al. [34] have proposed Harmony Search Algorithm (HSA) for implementing the energy efficient cluster head selection in WSN. Through this mode, the inner distance between the sensor node and the cluster head was reduced.

In 2015 Albert et al. [16] proposed a method that algorithmically added the network with redundancy at places, where it can be leveraged to a maxim extent by routing algorithms during the operation. They proposed the method to assist fast prototyping as well as to utilize WSN in constructing automation system. The synthesis problem was considered as a problem optimization. Di Tang et al. [18] have dealt a novel scheme, known as Cost-Aware Secure Routing (CASER) scheme, which is highly proficient and secure in solving the major problems such as, balanced energy control and probabilistic-random walking. They proposed an effective non-uniform energy deployment scheme for augmenting the network lifetime.

Zhao et al. [19] developed General Self-Organized Tree-Based Energy-Balance Routing Protocol (GSTEB) that created a tree process, enabling routing. Here, during every single round, the base station allot a root node and then transmits this choice to the complete number of sensor nodes. It has totally minimized the energy consumption, and also it balances the WSN load to achieve the objective of energy balance routing. In fact, it is difficult to distribute the load evenly on all nodes in such a case. In 2015, Rejina and Vasanthanayaki [33] have adopted the clustering process in WSN using the optimization methods such as Particle Swarm Optimization (PSO) and Gravitational Search Algorithm (GSA). With these algorithms, an appropriate cluster head was chosen to support the cluster head, so that the overhead of the cluster head was highly reduced.

In 2015, Madhusudhanan and Chitra [35] have promoted the cluster head selection technology in WSN using synchronous firefly algorithm. To the next of the implementation, its performance was compared with the LEACH and energy-efficient hierarchical clustering. Accordingly, the proposed method was effective with less number of packet loss and increased energy efficiency.

In 2015, Hamrioui and Lorenz [67] have developed the energy efficient switching among the role of nodes in WSN whereas in 2016; Lv et al. [65] have adopted a three- stage election mechanism of cluster heads through low energy uneven clustering (LEUC) topology control algorithm. Further, in the same year, Dong et al. [66] have proposed the cluster- based routing protocols for energy harvesting WSN using distance-and-energy-aware routing with energy reservation (DEARER). These methods have operated under balanced energy consumption for optimized selection of cluster head to maintain an increased network lifetime.

In 2017, Xiang dong et al. [21] have suggested the multi- mode clustering model for WSN. They have focused on the main issue in WSN such as the presence of a huge number of nodes, few resources, and various applications. Furthermore, the collapsed clusters were arranged using local maintenance algorithm. In 2017, Palvinder and Satvir [22] have proposed the energy efficient clustering protocol for WSN using Improved Artificial Bee Colony (iABC). This method has made possible the selection of cluster head based on improved search equation and efficient fitness function. Further, the performance of the current cluster head selection was compared with other protocols. Thus the experimental result has revealed that the proposed method has distributed numerous data packets with less delay as well as less energy.

In addition, the knowledge regarding the energy efficiency based on the intelligent methods [29] [30] are shown in Fig. 1, which is based on the analysis of the routing protocols using bio-inspired algorithms. Here, ACO is used to

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exploit the protocols such as SDG [36], EBAB [37], ACO-C [38], ACALEACH [39], MACS [40], Ant Chain [41], PZSWiD [42], ACMRA [43], ACMT [44], ACLR [45], JARA [47], ACOLBR [48], EEABR [49], AR &IAR [50], MO-IAR [51], Ant-Aggregation [52], ASAR [53], BABR [54], ACO-EAMRA [55], EAQR [56], IACR [57], E-D ANTS [58], ACO-QoSR [60], QDV [61], FF [62], FP [62], AntSensNet [63], Iaco [64] which attains weak (orange color), moderate (pink color), strong (green color) and very strong (blue color) performance respectively as indicated in the fig. 1. Furthermore, the protocol called JARA [47] is performed by the optimization based on colonies of biological organisms which attains the strong performance and Beesensor [59] is performed by artificial bee systems which attains very strong performance.

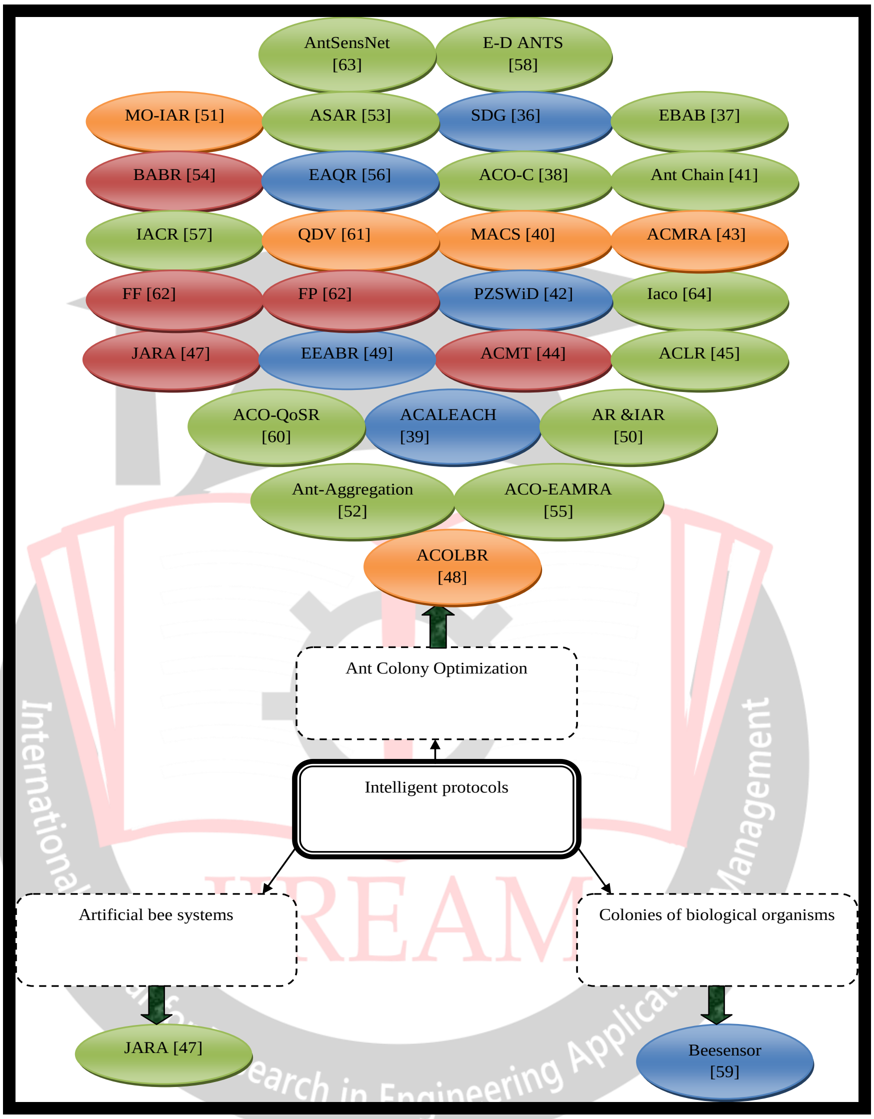

Fig. 1. Classification of intelligent protocols based on energy efficiency

In general, routing protocol of WSN is expected to minimize the total number of transmissions involved in route discovery and data delivery and to perform the distribution of data packets across multiple paths, so that all the nodes can preserve their batteries at a comparable rate. Based on in fig. 1 [29], they assigned weak, moderate, strong and very strong energy utilization efficiency to respective routing protocols depending on the total packets successfully delivered at the destination with respect to the energy consumed during the experiments.

Variants associated with the firefly algorithm

Author [Citation]	Modified Firefly algorithm
Lifang and Songwei [71]	Chaotic map is used to the initialization of firefly population
Gupta and Padhy [72]	Modification in the position formula
Prakash et al. [73]	Initialization of candidate solutions is done using opposition based learning
Abdollah et al. [74]	Addition of two mutation and three cross over operations
Mohammad and Urmita [75]	Usage of dynamic process control parameters

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3. PROBLEMS IN CLUSTER HEAD SELECTION

Diverse researchers have focussed on the problem regarding the transmission of data from one node to other, to implement an optimal WSN model. Finding the shortest path may upgrade the communication in data transmission. Energy consumption by each node is also another critical issue in WSN. Hence the major difficulty lies in transferring the data, which own the path with least length and reduced energy. Many researchers have developed diverse routing protocols for cluster head selection to transfer the data packets to the sensor nodes and the base station. The selection of appropriate cluster head, by the position and energy, is a major challenge in WSN.This problem may be solved by the FCR technique.

3.1. Conventional Firefly Algorithm

Firefly algorithm [31] [32] belongs to the category of meta-heuristic algorithms. This flashing light represented the inspiration for developing the FA algorithm by Yang [77] [76] in 2008 .The flashing activity concerned with light has been utilized to frame the algorithm. Finding the particle's position that yields optimum evaluation in a given fitness function is the main aim of the firefly algorithm. There are three main rules which the firefly algorithm follows:

(a) All the fireflies are considered as unisex. i.e.) Attraction among the fireflies is achieved, irrespective of their changing sexes.

(b) The attractiveness of the Firefly is directly equivalent to its brightness, and also it decreases as the distance increases.

(c) The objective purpose is the brightness of the firefly.

The pseudo code to execute the firefly algorithm is prepared to depend on these rules. Some of the required functions of the firefly algorithm are discussed as follows.

Initialize the population $x = (x_1 ....x_d)T$
Perform the generation of initial firefly population, $x_i (i = 1,2.....n)$
Utilizing the objective function $F_n(x_i)$, search out the light intensity I at x_i
While (t<Max Generation)
  for every i
    for every j
      If $(I_j > I_i)$, then
        Make the firefly i to travel in the direction of j in d-dimension;
      End if
      Assess the new solutions to update the light intensity
    End For
  End For
Set the absorption coefficient ν of light
End While

3.2. OPTIMAL CLUSTER HEAD SELECTION USING FCR

The proposed FCR algorithm is different from the normal firefly optimization. The normal firefly approach just replaces the firefly in the following updates. But the proposed FCR method replaces the Firefly by following the conditions as given in pseudo code in a particular cycle. The pseudo code of the proposed Firefly is given below.

1. **Initialize** the population $x = (x_1 ....x_d)T$
2. **Perform** the generation of initial firefly population, $x_i (i = 1,2....n)$
3. **Find** out the light intensity I at x_i by $F_n(x_i)$ and obtain the best pool I_{best}
4. **Set** the absorption coefficient ν of light
5. **While** (t<Max Generation)
6. **For** every i
7. **For** every j

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8. **Update** fitness function and find light intensity
9. **For** $n_f = 1 : N_{flies}$
10. **If** $\max(I^{+}_{n_f}) > I^{best}$, then
    Replace with updated Firefly and go to step (13)
    Else
11. **Randomly** change function and generate new intensity
    End if
    End for
12. **Assess** the new solutions using to update the light intensity
    End For
    End For
13. Make a ranking of the fireflies to locate the present best
    End While

The major steps for the implementation of proposed FCR method are given below.

(1) Initialize S particles to hold randomly selected eligible cluster head.

(2) Compute the cost function for the initialized particles. This computation follows some basic steps such as

(i) For each node N_i, $i = 1,2....N$,

(a) Compute the distance $d(N, N_{c,k})$ between the node and all the cluster heads $N_{c,k}$ and

(b) Set node N_c to cluster head $N_{c,k}$ where the distance should be minimum such that, $d(N_i, N_{c,k}) = \min\{(N_i, N_{c,k})\}$, $k = 1,2,3...n$.

(ii) Enumerate the cost function. Further, the cost function of the initial population is calculated, and the maximum value is taken as the best pool (I_{best}).

(2) Update the population and compute the cost function and intensity for entire fireflies.

(3) If the updated intensity is greater than the best pool I_{best}, then replace the initial Firefly with updated Firefly and go to step (7).

(4) If the updated intensity is lesser than the best pool I_{best}, then randomly change the function of the best solution and then compute the intensity.

(5) To the next, it is necessary to repeat the steps (4) and (5) for N_{flies} cycles

(6) Then the new solutions are accessed and repeat the steps as steps (1-6) to find the respective light intensity of the solutions.

(7) Finally, it needs to make a ranking to spot out the light best.

(8) Repeat the above steps until the maximum count of iterations is reached.

4. CONCLUSION

Strengths: The proposed method provides betterment at the cornerstone of the routing process in the wireless sensor network. The adopted algorithm is superior over the state-of-the-art cluster head selection algorithms.

Weaknesses: Yet, the FCR algorithm may demand high computational cost, which requires substantial minimization. The computational cost, which is mentioned here, is the time required for determining the cluster head. It is to be noted that the computational complexity, which is mentioned here is entirely different from the time complexity in route discovery, link establishment and data transfers. Erstwhile complexity denotes the complexity of computing process included in the proposed method, while the latter indicates the comfort of data transfer after adopting the process. Without the proposed method, the second complexity increases to a large extent.

This paper discusses the optimized implementation of cluster head selection in WSN using FCR method which was the extension of conventional firefly algorithm. In fact, the main problem of WSN is associated with the data transmission with maximum preservation of energy and less delay. These problems have focussed on the current discussion, where its chief contribution was to promote an effective cluster head selection method by considering the

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distance, energy, and delay of sensor nodes within the network.In this metaheurestic approach the network model can also be altered to introduce security constraints and other practical constraints, and so the problem model may be developed with greater practical challenges.

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