# Efficient Bio-inspired Method for Disaster Monitoring in Wireless Sensor Networks Using Improved PSO

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Abstract - *Now days the use of Wireless Sensor Networks (WSNs) is most widely used in different areas of day to day life such as military, security etc. However such networks are vulnerable to different kinds of network disasters such as flood disaster, gas leakage disaster, weather disaster etc. Once disaster occurs in WSNs, network damage is done and hence WSNs system fails to operate. To prevent such disaster the traditional methods such as video cameras, sound sensors etc. But these traditional methods of disaster management having limitations such as ineffective, time consuming and most of damage done before managing disasters. Hence this becomes interesting area of research for most of researchers to present efficient, effective and instant method for disaster management since from last decade. Many recent methods used bio inspired optimization methods for disaster management in WSN. The optimization methods such as Genetic Algorithm (GA), Ant Bee Colony Algorithm (ABC), and Particle Swarm Optimization (PSO) etc. used for efficient deployment of wireless sensor networks after disaster happens. However these methods still suffered from limitations over network performances. In this paper we are introducing the new improved PSO algorithm for efficient disaster management. This new IPSO method presented to overcome the limitations of PSO such as less efficiency for node deployment, less precision etc. The practical analysis of this proposed method is done using NS2, and performance is compared against existing PSO method. The performance metrics that we are considering in this paper for comparative analysis is average throughput, average energy consumption, and packet deliver ratio and delay.*

*Key Words: Bio-inspired, Disaster Management, PSO, Wireless Sensor Network, IPSO, PDR, Throughput, Energy.*

## 1. INTRODUCTION

This paper is dealing with disaster management in wireless sensor networks. Before going to main research area in this section we first introduce about WSN. Wireless sensor networks are being used in many different applications, initially for military networks as well as in other areas like environment, health, habitat monitoring and commercial purposes. With the recent break-through of "Micro Electro Mechanical Systems (MEMS)" technology whereby sensors are becoming smaller and more versatile, WSN promises many new application areas in the future. Wireless Sensor Networks (WSNs) are used in a wide variety of applications, such as environmental monitoring, target or event tracking, pervasive security, smart healthcare, as well as in disaster management and recovery to deliver critical information. Sensor nodes are deployed over a monitoring area, perform in-network processing (e.g., data aggregation and filtering) and forward the results to one or more collection points (i.e., sinks) via multiple hops. Communication between sensors may fail due to different factors, such as the distance between the nodes, temporal variations of the wireless channel and interference. Additionally, node failures can also occur due to hardware faults or sensor nodes running out of energy, thus disrupting the network. As a consequence, the deployment of WSNs must be robust and resilient to such failures.

Therefore to solve such problems, Bio-inspired approaches have been extensively used in WSNs. For instance, swarm intelligence has been exploited to organize and route data in WSNs. To this regard, Gene Regulatory Networks (GRNs), a graph-based representation of genes/proteins and their interactions, serve as a useful model for robust network design. In fact, similar to sensor nodes, genes perform three major functions: sensing, actuating and signaling. In the sensing phase, genes detect the levels of specific proteins in cells through signals mediated by other genes and environmental variables (e.g., temperature) to determine their own expression levels. Then, in the actuating phase, each gene produces enhancer or inhibitor proteins to regulate the expression level of other genes in the network. Lastly, in the signaling phase, genes interact with each other to co-regulate target protein levels in the cell. This distributed behavior of genes has evolved over many millennia into a robust biological network. Thus, in order to design a robust WSN, the topology of GRNs can be used as a template for deploying wireless sensor nodes. On the other hand, disasters, man-made or natural, can have significant consequences on both people and the environment. Major disasters include but are not limited to earthquakes, storms, floods, fires and terrorist attacks; such catastrophes can be of very large scale, potentially resulting in detrimental outcomes.

Recently many methods presented for efficient and effective management of disasters in WSNs, however there is still scope of improvement. The PSO method was previously used for disaster management, however as this method is suffered from limitations such as less efficiency in node deployment after disaster, less precision rate etc. it allows to present new improved PSO method which overcome the limitation of existing PSO method for disaster management in WSNS. In next section II we are presenting the literature survey over the different bio inspired disaster management methods are presented for WSNs. In section III, the proposed approach and its system block diagram is depicted. In section IV we are presenting the practical analysis and comparative results with discussions. Finally conclusion and future work is predicted in section V.

### 1.1 Aims and Objectives

The main aim of this paper is to present efficient, improved particle swarm optimization method for disaster management in wireless sensor networks. Along with this below are basic objectives of this research:

- To present study over different disaster management methods.
- To present study over existing PSO method in WSN.
- To present proposed IPSO with its algorithm details.
- To present practical analysis and comparative study for proposed work.

## 2. LITERATURE REVIEW

In this section we are discussing the different existing methods presented for disaster management in WSNs and later summarized in table with their advantages and disadvantages.

In [1], authors Majid Bahrepour, Nirvana Meratnia, Mannes Poel, Zahra Taghikhaki, Paul J.M. Havinga, presenting method for reducing residential fire disaster. They used Artificial intelligence methods for detecting the residential fire with more accuracy. The neural network is used in which output of previously detected event is referred for next input event. This feed forward mechanism helps to detect the event with fast and accurate manner.

In [2], authors presented another new approach for detecting the disasters in WSNs efficiently by minimizing the total number of errors using distributed Bayesian method. The goal of this method was to remove faults from the data transmission as well as event detection in WSNs. Decentralized event detection approach improves system efficiency with this method.

In [3], author Georg Wittenburg, presented collaborative method for detection of events in WSNs. In this method there is no centralized system used, means data collection was not done centrally at sink node, rather each node is having independent alarm system which can detect events and process further data for disaster detection.

In [4], authors Mihai Marin-Perianu and Paul Havinga, presented method for management of residential fire disaster. In this paper the next improved technique of artificial neural network technique is used called FFNN (feed forward neural network). FFNN is used for detecting the residential fire disaster more accurately. FFNN method delivers better performance in terms of processing speed and accuracy.

In [5], author Somsri Jarupadung, method for fire detection is presented in which detection is done by using different combinations of sensor nodes and remote sensing mote. The main process is to differentiate sources of fire from noise sources in order to remove unwanted chaos in WSNs.

In [6], authors M. Bahrepour, N. Meratnia, and P. J. M. Havinga, presented distributed fuzzy logic method for detecting the disaster events in wireless sensor networks efficiently. A crisp input along with membership function is provided as input and event is detected successfully as output.

In [7], authors introduced the watchdog processor for concurrent system level fault detection methods. A watchdog processor is easy, simple and small in size which identifies errors by behavior monitoring of system. This method claimed that more number of errors can be detected using control flow monitoring as well as behavior of memory access.

In [8], authors presented the method in which taxonomy for classification of faults in sensor networks as well as on-line model-based testing method introduced first time. This method is assuming the readings impact of particular sensor over the multi-sensors fusion consistency. But this method is centralized and hence sensor node data must be collected and then sent to base station node in order to detect online fault.

In [9], authors introduced energy efficient fault tolerant detection method with optimal event detection in wireless sensor networks. As the energy is important resource of wireless sensor network, hence there must be energy efficient disaster detection technique for WSNs. The Bayesian detection scheme in [9] selects the minimum neighbors for a given detection error bound such that the communication volume is minimized during the fault correction. Author of this paper did not explicitly attempt to detect faulty sensors; rather methods they proposed for improving the event detection accuracy in fault sensor nodes environment.

In [10], author presented algorithm for faulty sensor detection with its practical analysis. This method is purely localized and needs less computational overhead; it can be easily scaled to large sensor networks. If half of the sensor neighbors are faulty and the number of neighbors is even, the algorithm cannot detect the faults as expected.

In [11], authors presented a survey of localization systems for ubiquitous computing is presented.

In [12], authors introduced overview of localization systems for WSNs is presented.

In [13], authors introduced overview of the measurement techniques in sensor network localization and the one-hop localization algorithms based on the measurements is presented.

In [14], author presented efficient localization system that extends GPS capabilities to non-GPS nodes in an ad hoc network is proposed, in which beacons flood their location information to all nodes in the network.

Below table 1 is showing some of the recent research methods for disaster management in WSN with their advantage and disadvantage.

Table -1: Review of different methods

| Method | Advantages | Disadvantages |
|---|---|---|
| Distributed Bayesian Algorithms For Fault Tolerent Event Region Detection In Wireless Sensor Network | Fault tolerant | More delay for fault tolerant. |
| A System For Distributed Event Detection In Wireless Sensor Network | Distributed system resulted into more accuracy | Transmission of data is very slow. |
| Use Of AI Techniques For Residential Fire Detection In Wireless Sensor Network | Fake alarms reduced using FFNN | Possibility of delay and bottleneck |
| Automatic Fire Detection: A Survey From Wireless Sensor Network Perspective | Manual work is not required | Not reliable, fake alarms possibility more. |
| Fuzzy event detection in WSN | Simple and easy to execute | Not trusted method |

## 3. PROPOSED METHOD

In this paper main motive is to present improved, efficient and faster bio inspired method for disaster management system. Proposed method is based on existing PSO method. The disaster which we consider for this research work is flood and water level monitoring. In below section 3.1 we are introducing the flood and water disaster in WSN.

### 3.1 Flood and Water Level Monitoring System using WSN

Every year thousands of lives and billions of worth properties in India lost due to floods. Recently due to floods major lives loss with cattle and costly properties reported in different areas of India. Every year during the rainy season most of Indian rivers such as Yamuna, Ganga etc. cross their boundaries and hence resulted into numerous losses. Even if this kind of losses may not be fully prevented but it can be reduced at certain level if we use some protective measures before happening of such flood disasters. This kind of disaster management can be possible with use of electronic communication method over the wireless sensor networks. Such type of system development is consisting of different phases. All of these phases are important equally. The first phase is data collection in which physical deployment of sensor nodes in the riverbanks and implementation of an efficient localization method based on the environment and situation is done. This system can handle the flow path of river, history of water flows, and based on its future prediction of the flow of river resulted into deployment of wireless sensor nodes. For the robust deployment of sensor nodes for flood disaster management different optimized deployment solutions was introduced by different researchers such as PSO, GA, ABC etc. Figure 1 below is showing the data collection and aggregation process in WSNs.

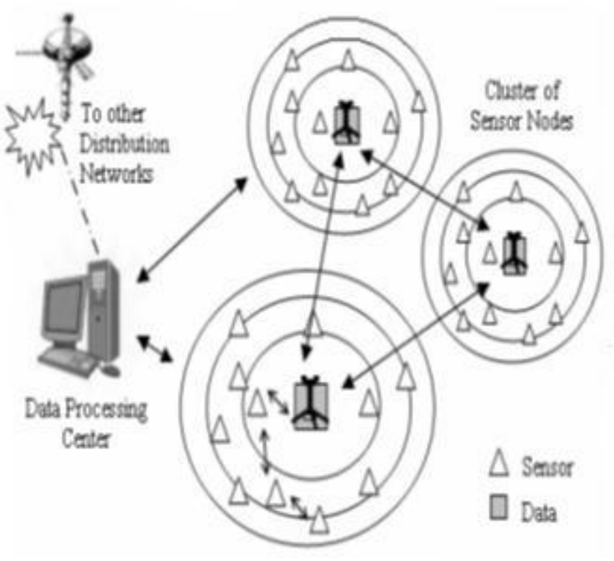


Figure 1: Process of data collection and aggregation in WSNs.

## 3.2 PSO and IPSO

Hence further various automated systems presented by researchers to efficiently monitor the disaster conditions in sensor networks. However most of methods are suffered from different limitations like, less packet delivery ratio, high end to end delay, more energy consumption etc.

Particle swarm optimization (PSO) is feasible for the localization problem because of its quick convergence and moderate demand for computing resources in wireless sensor networks.

However existing PSO have below limitations:

- Flip ambiguity problem
- Less efficiency for nodes deployment
- Less precision

Therefore in our proposed work:

- We are presenting improved distributed two-phase PSO algorithm to solve the flip ambiguity problem, and improve the efficiency and precision.
- In this work, the initial search space is defined by bounding box method and a refinement phase is put forward to correct the error due to flip ambiguity.
- Moreover, the unknown nodes which only have two references or three near-collinear references are tried to be localized in our research.
- Simulation results indicate that the proposed distributed localization algorithm is superior to the previous algorithms.

This improved PSO algorithm is called as IPSO. Below section we will see the algorithm of IPSO and block diagram.

## 3.3 System Architecture and IPSO Algorithm

IPOS Algorithm

In this paper we presented distributed flood disaster management algorithm depending on PSO which can extend this approach for large scale WSNs. The main contribution of this paper is Improved PSO with below two goals: (1) it reduces the initial search space by bounding box method to speed up the convergence. (2) It proposes a distributed two-phase PSO algorithm to solve the flip ambiguity problem and localize more target nodes. The basic PSO algorithm and our proposed PSO algorithm is differentiated in algorithm by considering below points listed.

**Step 1: Initial Search Space Defined by Bounding Box Method:**

The existing PSO method employs a set of feasible solutions within the search space, called a swarm of particles with random initial locations. Rather than this in IPOS, we reduced the initial search space by using a bounding box method.

**Step 2: Anticipation of Nearly Collinear References.**

Step 3: A Refinement Phase to Correct the Error due to Flip Ambiguity.

Step 4: Localize the target node that only have two references or three near-collinear references.

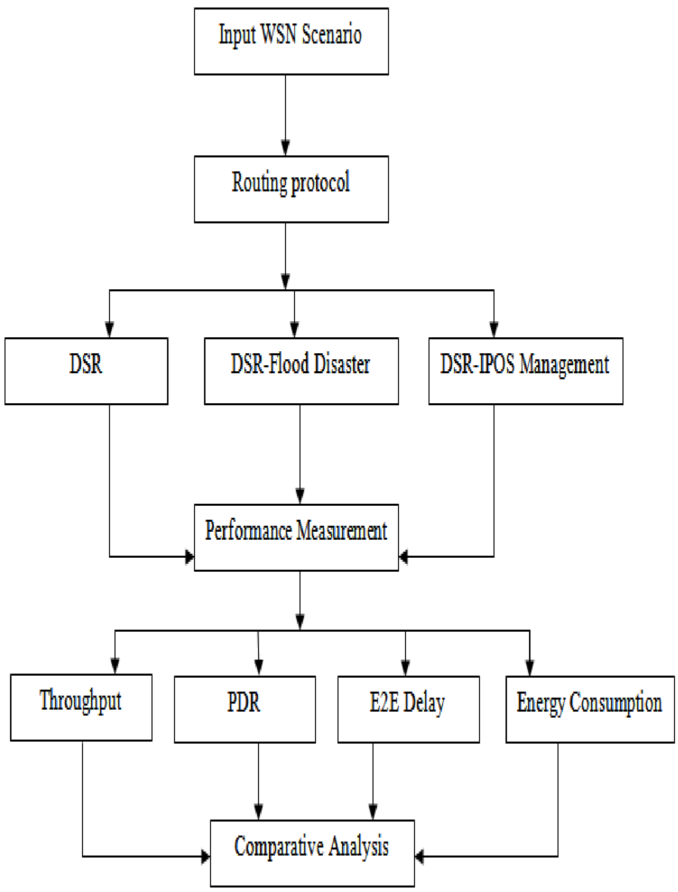


Figure 2: System Architecture for practical analysis

By considering above four steps in basic PSO new algorithm IPSO is used for flood disaster management.

 

## 4. PRACTICAL ANALYSIS

1. Simulation Platform: For the simulation of this work we have to need the following setups requirement for the same
1) Cygwin: for the windows XP
2) Ns-allinone-2.29.

2. Network Scenarios: There number scenario and traffic files needs to generate in order to evaluate the performance of the routing protocols under the different network conditions. Below table 2 showing network scenario and other parameters used for practical analysis.

Table 2: Network Scenarios and Parameters

| | |
|---|---|
| Number of Sensor Nodes | 50/100/150/200/250 |
| | |
| Traffic Patterns | CBR |
| | |
| Network Size | 1000 X 1000 |
| | |
| Mobility Speed | 2 m/s |
| | |
| Simulation Time | 100 s |
| | |
| Transmission Packet Rate Time | 10 m/s |
| | |
| Pause Time | 1.0s |
| | |
| Routing Protocol | DSR-Normal/DSR-Disaster/DSR-IPSO |
| | |
| MAC Protocol | 802.11 |
| | |
| Transmission Protocol | UDP |
| | |
| Number of Flows | 10 |
| | |

3. Performance Metrics
- PDR vs. Varying Number of Sensor Nodes
- Normalized Routing Load vs. Varying Number of Sensor Nodes
- Average Energy Consumption vs. Varying Number of Sensor Nodes
- Average Throughput vs. Varying Number of Sensor Nodes.

4. Results Analysis

Below are graphs for performance metrics defined in above section.

Energy Consumption: The metric is measured as the percent of energy consumed by a node with respect to its initial energy.

Percent_Energy_Consumed = (InitialEnergy – FinalEnergy) / InitialEnergy *100

Average_Energy_Consumed =Sum_of_Percent_Energy_Consumed_by_All_Nodes/ Number_of_Nodes.

A. Average Energy Consumption

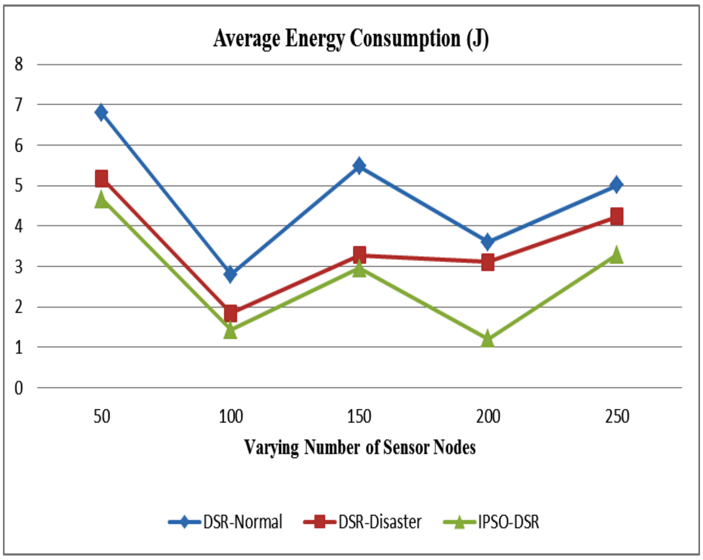


Figure 3: Average energy consumption analysis

B. Average Throughput

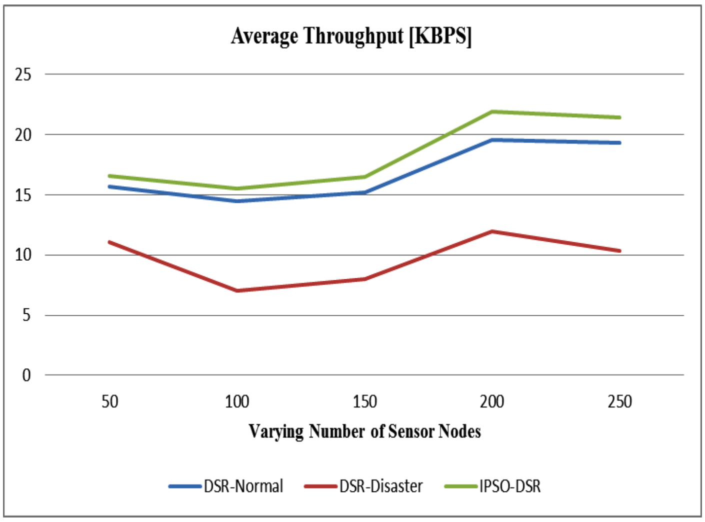


Figure 4: Average Throughput analysis

Throughput: This metrics calculates the total number of packets delivered per second, means the total number of messages which are delivered per second.

C. Packet Delivery Ratio (PDR)

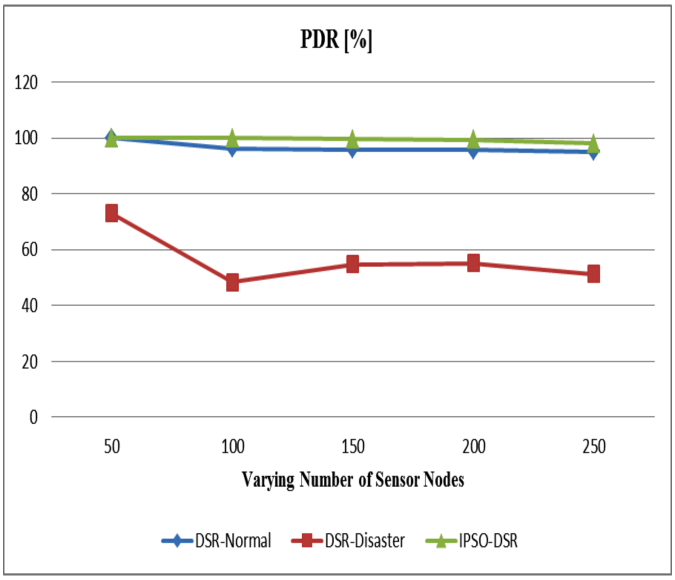


Figure 5: PDR analysis

D. Normalized Routing Load

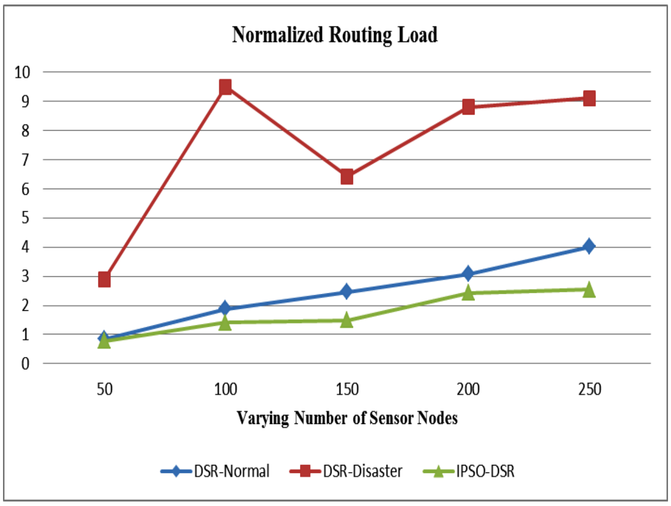


Figure 6: Normalized Routing Load Analysis

From above figures 3 to 6 showing comparative graphs analysis for normal WSN, disaster affected WSN and IPSO based disaster management based WSN. IPSO method is able to efficiently manage flood type disaster on varying number of WSNs.

## 5. CONCLUSION AND FUTURE WORK

Disaster is now day's frequent task happening in India as well as all over world. Therefore there should be effective technique or method that can manage such disaster which able to minimize the impact of such disasters. There are many methods already presented for disaster management on top of WSNs using bio inspired techniques. Recently bio inspired techniques were combined with optimization methods such as GA, PSO, ABC etc. for efficient localization and deployment of sensor nodes in WSNs. This paper proposed new IPSO method for effective, efficient and faster method of flood disaster management in WSNs. IPSO is based on existing PSO method. The practical analysis is done using NS2. Results shows that proposed work achieves better performance as compared to existing cases. For future work we suggest to test and deploy this work under real time environment for flood disaster management.

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## BIOGRAPHIES

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