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Enhancement of Input to State Stability with Particle Swarm Optimization and Ant Colony Optimization in WSN

Shaina Kataria*, Gaurav Bathla* and Anshul Mittal*

ABSTRACT

Wireless sensor network consists of nodes and these nodes can be movable or stationary as according to the user application. In wireless field of research, sensor network is an attracting the researchers because they have distinct applications and there feasibility of incorporating themselves into network systems that are more sophisticated. A wireless network consisting of stationary nodes (static nodes) is known as Static Wireless Sensor Network and network with movable nodes (mobile nodes) is known as Mobile Wireless Sensor Network. In this paper the conception related to sensors and issues related with WSNs are delineated. In the wireless network, the crucial concern is Optimization. In this paper PSO and ACO is applied in combined to overcome issues occurring by using PSO technique alone. The RMSE and localization error are the two parameters used to validate the approach proposed.

Keywords: MWSN; PSO; ACO; RMSE; Localization Error; Stagnation point.

I. INTRODUCTION

Wireless is a vast field constituting of different types of networks. Wireless Sensor Network is an intriguing research field. Among all those, wireless Sensor Network is gaining attraction of the researchers. WSN consists of nodes and these are known as 'sensor nodes' and can be of two types static nodes or dynamic nodes. Static nodes are those nodes that cannot change their location i.e. they are stationary and network consists of theses nodes is called Static WSN whereas the dynamic nodes are the nodes that can change their location i.e. they movable nodes and network consists of these nodes is known as Mobile WSN. There are issues with designing a wireless sensor network because of which it has become a challenging task. For addressing the challenges, there is need of advancement in the field of Optimization, as optimization is very useful for designing a network. The main aim behind this research is to overcome different problems occurred when PSO algorithm is applied alone, and for examining and comparing the results obtained from PSO alone and proposed technique (PSO+ACO) in this paper. In section II literature survey is discussed that shows a wide range of techniques for all the problems in wireless sensor network. Fig1 shows the sensor nodes forming a wireless sensor network.

In the Mobile wireless sensor network, the nodes are moving, so there is complication in find the exact position of the node i.e. node localization. Localization process is applied for attaining the specific position of different sensor nodes. It is on crucial challenge faced by researchers these days. The algorithms available earlier for localizing nodes are only applicable to static networks with stationary sensor nodes. Those algorithms are imprudent to Dynamic networks with mobile sensor nodes. This is the reason of requirement of new localization algorithms. There is high loss of data and energy is dissipated when localization is performed by using the traditional algorithm. The main ambition of the wireless sensor network is to

* Department of CSE Chandigarh University, Gharuan, Punjab, India, *E-mails:shainakataria92@gmail.com*; *gauravbathla86 @gmail.com; anshulmittal @gmail.com*

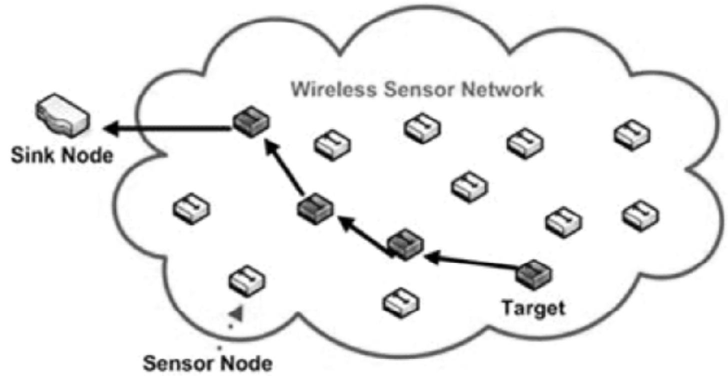

Figure 1.1: Wireless Sensor Network

acquire the geographically absolute position of the sensor nodes. There are various techniques available for performing localization.

In this paper PSO and ACO techniques are used in WSN and the results obtained in form of RMSE and Localization error is then compared with the outcomes of individual PSO algorithm. For designing a WSN it is always considered that the cost related to designing should be minimum, Power consumption should be less and the designed network must be reliable. Designing has deal with various factors such as deployment of nodes, nodes connectivity, network coverage, and flexibility to faults. All these issues must be taken care of so as to design a practicable, feasible and energy efficient network. For composing a sensor network, large no. of sensor nodes are deployed. WSN algorithms used must attain the self-organizing abilities. The various areas of applications where wireless sensor network is used are in health, for security purpose, and in military field.

In future, our lives will be dependable on WSN that is sensor network will going to play imperative part in growth. There is requirement of networking techniques for recognizing these along with other applications in sensor network. For traditional wireless networks, many protocols and algorithms have been prospected still all those algorithms cannot be applicable for certain application as they are inappropriate for specific features required by the wireless sensor network. In [1] authors proposed an algorithm based on PSO (Particle Swarm Optimization) technique in addition to feedback cascade system to evaluate Input to state stability. In this paper, algorithm proposed is based on the PSO and ACO (Ant Colony Optimization). With PSO alone there occurs a stagnation point due to which the communication in a network is interrupted. This issue is taken care with the use of ACO along with PSO technique. For analysing the input to state stability, the particle swarm optimization algorithm is applied with a feedback cascade system.

1.1. PSO (Particle Swarm Optimization)

An algorithm ascribed by Eberhart, Shi and Kennedy named Particle Swarm Optimization. Particle Swarm Optimization is a computing method that optimizes a problem repetitively trying for improving a solution with commendations to a given measure of quality. This scheme is applicable for optimizing an issue frequently arduous to embellish a solution with approbation to a given quality measure. Particle swarm optimization algorithm was pursued to perform optimization and it was the algorithm first premeditated to imitate the social behaviour of an organism for example bird. PSO is an optimization algorithm that is partly erratic, noisy and in there occurs the stagnation point, that hinders the communication. PSO is used as a feedback cascade system and then apply the input-to-state stability analysis. By using feedback cascade system, it involves the effects of the personal-best value and global-best value directly in the model. Though, this algorithm was made easy to understand.

1.2. ACO (Ant Colony Optimization)

Ant Colony Optimization algorithm is a class of calculations where artificial ants are used. It was proposed firstly by Colorni, Dorigo and Maniezzo. The algorithm is basically based on the behavious of genuine ants search for food by selecting an optimum path between the colony and the food source. Algorithm of ACO involves three steps:

Step 1: The first ant randomly roams until unless it finds the food source, then after it returns to the colony, laying a pheromone trail.

Step 2: Other ants follow one of the paths at random, also laying pheromone trails. Since the ants on the shortest path lay pheromone trails faster, this path gets reinforced with more pheromone, making it more appealing to future ants.

Step 3: The ants become increasingly likely to follow the shortest path since it is constantly reinforced with a larger amount of pheromones. The pheromone trails of the longer paths evaporate.

Walk of Ant

- Initialize ants and nodes (states)
- Choose next edge probabilistically according to the attractiveness and visibility
- *Prob(choose available edge e)=* $\dfrac{\tau_e.\eta(e)}{\Sigma_{available\, edges\, e'}\ \tau(e').\eta(e')}$
- Each ant maintains a tabu list of infeasible transitions for that iteration
- Update attractiveness of an edge according to the number of ants that pass through
- Pheromone update

$$\tau(e) = \begin{cases} (1-\mu).\tau(e), & if\ edge\ is\ not\ traversed \\ (1-\rho).\tau(e) + new\ pheromone, & if\ edge\ is\ traversed \end{cases}$$

- Parameter $0 \le \rho \le 1$ is called evaporation rate
- Pheromones = long-term memory of an ant colony
  - ρ small low evaporation slow adaptation
  - ρ large high evaporation fast adaptation
- “new pheromone” usually contains the base attractiveness constant and a factor that you want to optimize.

1.3. Event Driven

The usage of event driven algorithm is to communicate the events between the source to destination (provider to consumer). The end user register all the advertised events. With the occurrence of the event the end user to notifies the event manager that the events consumes instantaneously. This way of communication is depend upon the conventionally contained by object oriented world. The design pattern also in the form of events which is depend upon the statement which is travelled from source to destination. The function of this driven is dependent upon the survival of essential platform extensions, which if not already present, would sustain extra cost and therefore would force the IT budget.

If the mobile sensor node receives location information from supplementary than three anchor nodes, it selects three largest RSSI values for its location evaluation. Because large RSSI corresponds to small distance between two nodes, large RSSI can achieve the best communiqué channel and highest accuracy.

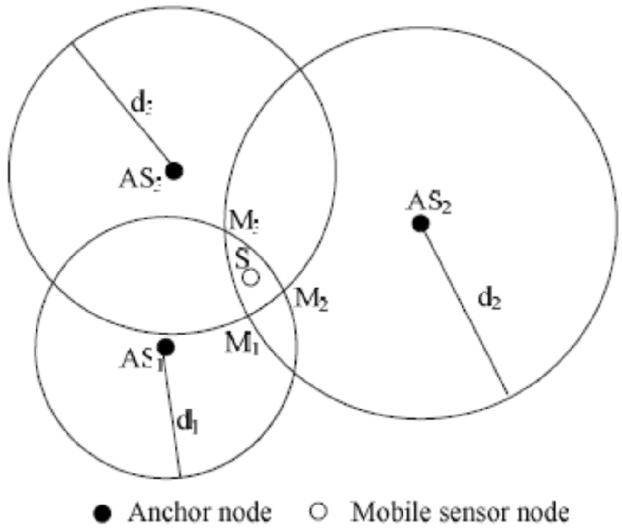

Figure 1.2 : Location determination

1.4. ISS (Input to State Stability)

The concept of input-to-state stability attempts to confine the view of “surrounded input surrounded state”. Under definite situations the dynamics of complex systems can be understood by first decaying the system into a set of individual input-to-state stable components. This approach can be taken with PSO. Parallel combination of input to-state stable components yields a combined structure that is also input-to-state stable. The position-update component which combines all the dimensions , in the case of PSO if each component is input-to-state stable.

1.5. Optimization

Optimization is an act, procedure, or method of making something as fully ideal, efficient, or valuable as possible; specifically the mathematical actions concerned in this. Optimization plays a very important role in wireless sensor network. Finding an another with the use of fewer resources, most cost effective or highest achievable performance under the given constraints, by maximizing required factors and minimizing undesired ones.

1.6. FCS (Feedback Cascade System)

In communication, feedback is a necessary part because it allows the transmitter (who sends the message) to judge how efficient it has been. It is important because it indicates successful transmission of the message and enables us to evaluate the effectiveness of the message.

Cascade control systems control the system to allow more impartiality to the commotions. Feedback cascade system gives response instantly if there is any problem in communication or if there is point of stagnation.

The paper is organized as follows: Section II constitutes the literature part which is related to this research. In III section methodology of the research is defined. The experimental results are discussed along with the parameters used in section IV and section V concludes the paper.

II. LITERATURE REVIEW

In this section literature related to wireless sensor network is delineated. The survey helps in further research and it goes farther the exploration for information. It comprises of the articulation and description of connection in between literature and our field of research.

Goodrich *et al.* [1] work on analysis of ISS (Input to State Stability) with PSO technique. The dynamics of PSO (particle swarm optimization) are reviewed in this paper by modeling it like a feedback cascade system and then apply ISS analysis. The asset of input to state stability is used for the analysis of particle swarm optimization before the stagnation point and at that stagnation point.

Su and Guo *et al.* [2] for localization an algorithm was prospected by making use of a movable anchor node. In the algorithm proposed, a movable anchor node travels in a sensor area and broadcasts beacon messages that has information related to its current location over and over again. A static sensor node receives and stores the initial location and final location of moving anchor node.

Swangmuang *et al.* [3] proposed a technique based on location fingerprinting which associates information related with location with the aspects of Received Signal Strength and such aspects are employed for inferring sensor node location.

Zhang *et al.* [4] delineate that there are many algorithms designed for localization for static WSN (static sensor nodes) but these algorithms are not applicable with mobile nodes that is in Mobile WSN. So this problem in Mobile WSN is overcome by using the event trigger localization algorithm described in [4]. This algorithm is construed with the help of RF fingerprint and RSSI techniques.

Zhang *et al.* [5] an energy efficient algorithm for localization in WSNs is presented in this paper. In the wireless sensor network is using a movable anchor node. The algorithm proposed is based on the distance measurement. The localization of a sensor node is performed by estimating the distance by using TDOA (Time Difference of Arrival) method.

Zhang *et al.* [6] analyze that the directional antenna proposes distant advantages for wireless sensor networks, such as escalation in spatial reuse ratio and devaluation in energy consumption.

In Mobile Wireless Sensor Networks applications there is restriction of power of a node, and movable nodes don't require their localization frequently. They only require their localization when nodes are asked for reporting the collected data. Although many algorithms have been proposed till now but recently, those protocols and algorithms cannot be pertinent to Mobile WSN.

III. METHODOLOGY

This section constitute of methodology applied in the research. The main aim of the research is to apply the PSO algorithm and then after to overcome the issue of stagnation point which occurs because of PSO by using ACO algorithm. There will be no stagnation point. Fig 3.1 shows the flowchart of methodology.

Step 1: In this step the network system is created. Two types of nodes are used namely, anchor node and mobile sensor node.

- Anchor node is used for determining the location of mobile sensor node whereas mobile sensor node is used to transmit the data from the source to destination.

Step 2: In the next step the network parameters are initialized.

Step 3: After initializing parameters, the different possible paths from source to destination are created.

Step 4: The PSO algorithm is initialized and which help to find out the best possible path from source to destination.

Step 5: In this step, ACO algorithm is initialized

Step 6: In this step the efficient and shortest path is selected without stagnation.

Step 7: Compare the distance travelled and time taken from source to destination in alone PSO and in PSO+ACO.

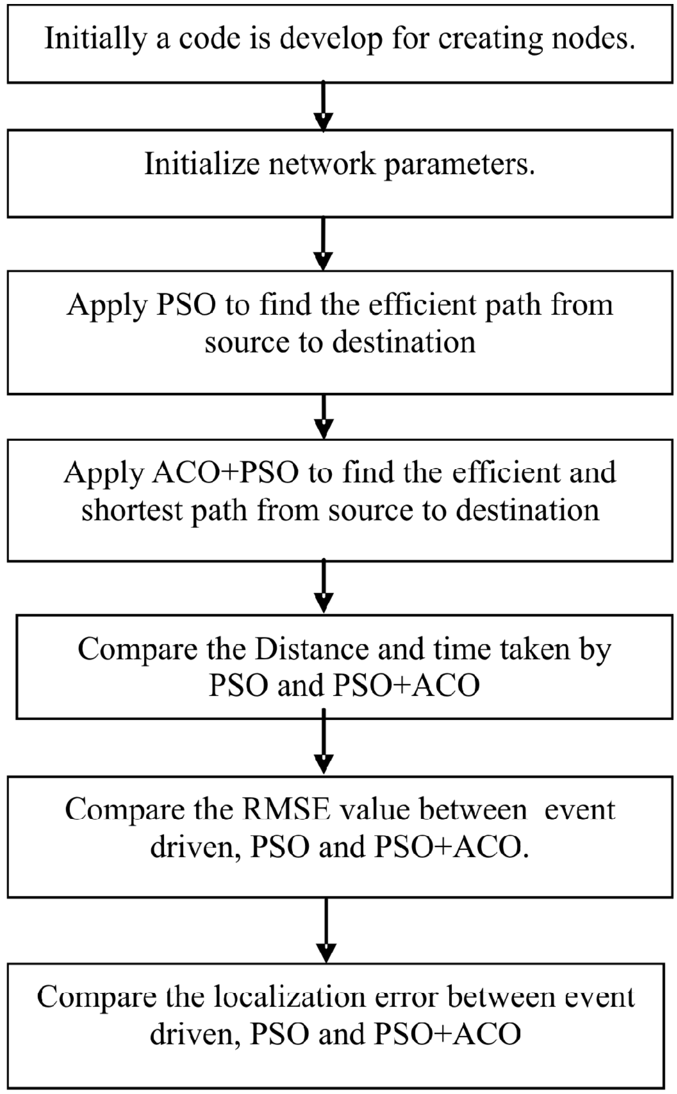

Figure 3.1: Flowchart of Methodology

STEP 8: Here, the RMSE value is compared with the help of PSO algorithm and the PSO and ACO algorithm. The value of root mean square error is decreases by Particle swarm optimization algorithm and there is no stagnation point with the help of Ant Colony Optimization algorithm.

STEP 9: In concluding phase comparison of the localization error is performed between the PSO algorithm and the PSO with ACO algorithm.

The localization error obtained is improved with the proposed algorithm in comparison with earlier approaches.

IV. EXPERIMENTAL RESULTS

In this section the experiments performed and the results obtained are used to proof the effectiveness of the proposed approach. The steps followed to perform the PSO and ACO algorithms are shown along with the results obtained on the basis of RMSE and localization error. In initial phase a code is developed for initializing the nodes and the network parameters. After that different possible paths between source and destination are selected and then PSO algorithm and ACO algorithm is initialized. An optimum path is selected from all possible paths and with the use of ACO, there is no stagnation point. Two performance parameters, RMSE and localization error are used to validate the proposed approach.

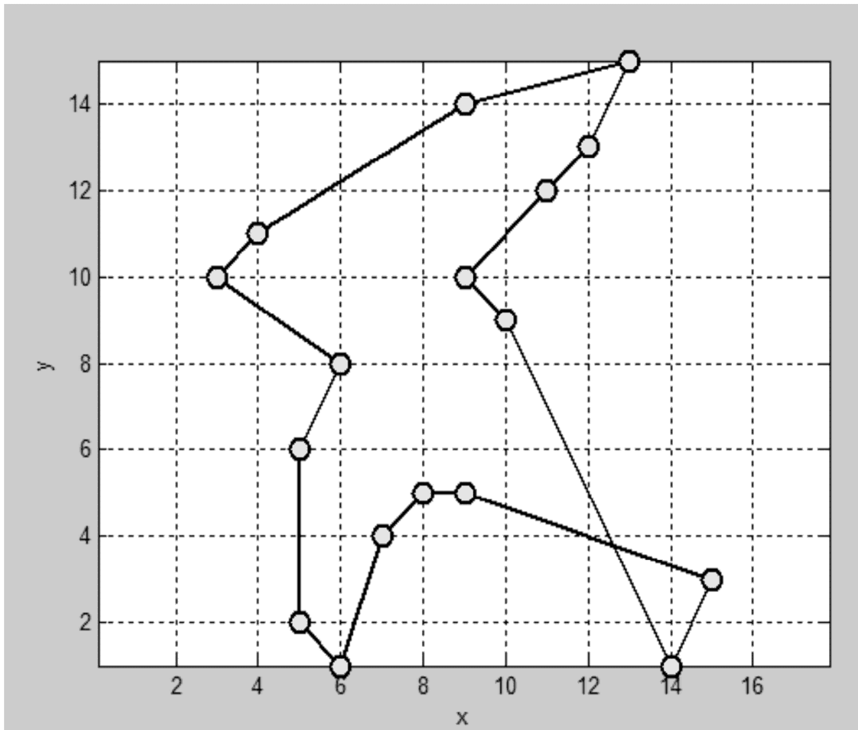

Figure 4.1: Creation of Nodes

Fig 4.1 shows the initial phase where nodes are created.. The paths connectivity between nodes is shown in fig 4.2. This figure also represents the stagnation point that occurs in PSO algorithm.

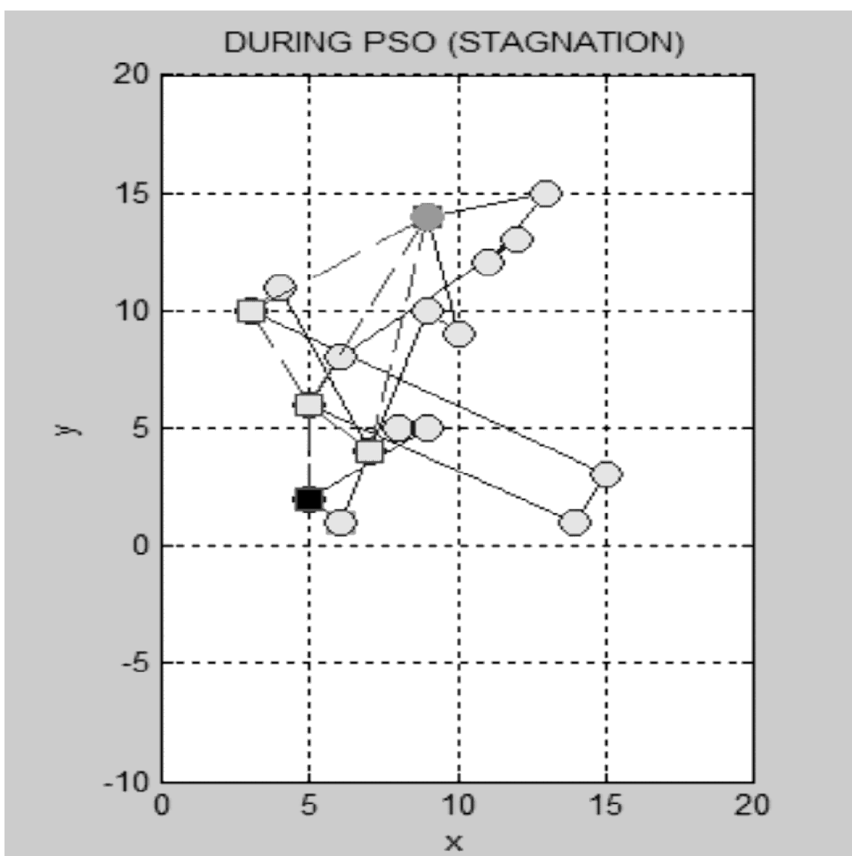

Figure 4.2: Path between nodes and Stagnation in PSO

Fig 4.2 shows that the, Stagnation point occurs in Particle Swarm Optimization algorithm due which alone PSO was not satisfying the needs of research. Then there come our approach in which along with PSO, ACO algorithm is used. This results in no stagnation.

In the above fig. shows that the stagnation occur when transmit the data from source to destination while using the PSO algorithm.

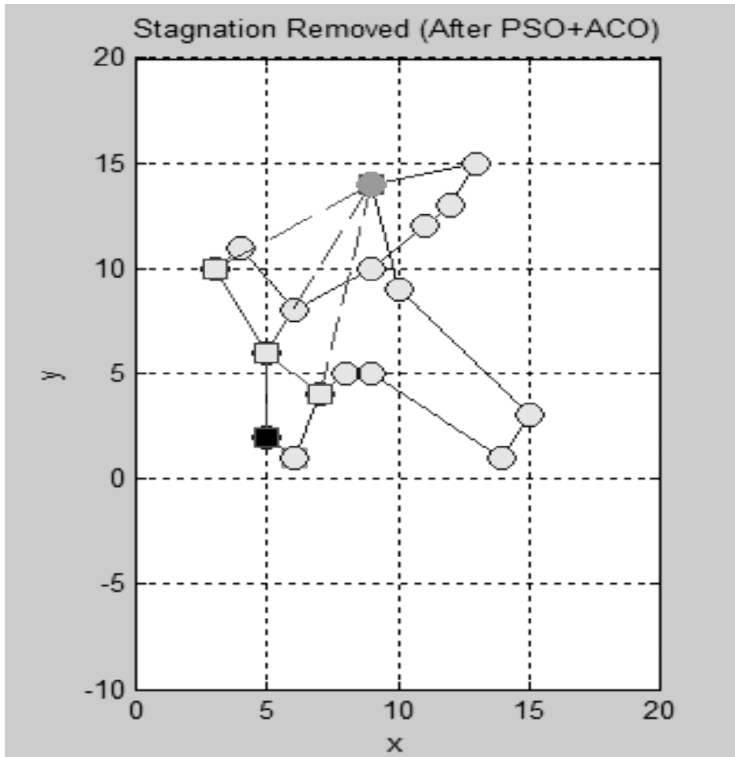

Figure 4.3: Path between source to destination using ACO+PSO

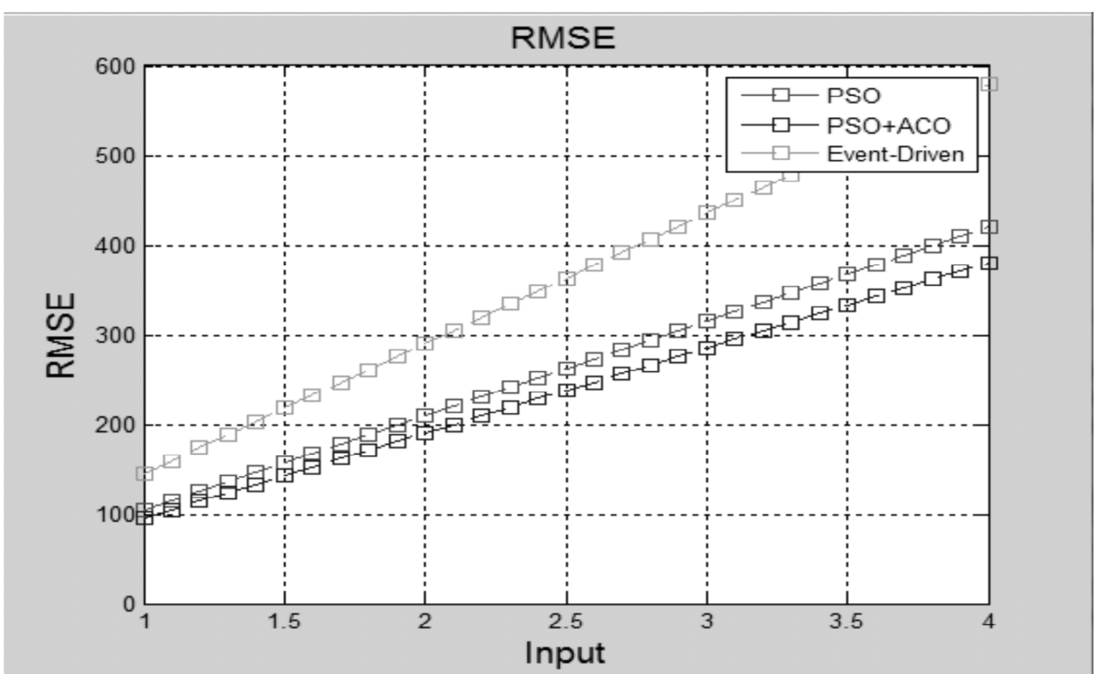

Figure 4.4: Graphical comparison of RMSE of previous and proposed work

Above figure represent that no Stagnation take place using PSO+ACO. Stagnation is removed using with this proposed work. Using this hybrid of algorithms helps to locate the shortest and efficient path without any stagnation.

RMSE is a performance parameter used to proof that the proposed approach is more efficient than alone PSO and previous approaches, shown in given figure.

Above figure shows the graphical comparison of Root Mean Square Error between the proposed and previous approach. The results obtained that the proposed work (ACO+PSO) is more effective as compare to previous work (alone PSO, event driven).

$$RMSE = sqrt\left(\frac{1}{M*N}\sum_{x=0}^{M-1}\sum_{y=0}^{N-1}[f(x,y)\ -F(x,y)]\right)$$

where MxN is the size of size of data, f(x,y) is the transmitted data and F(x,y) is the received data.

RMSE obtained with proposed approach is shown with blue colour and red colour represents alone PSO and green colour shows the previous approach.

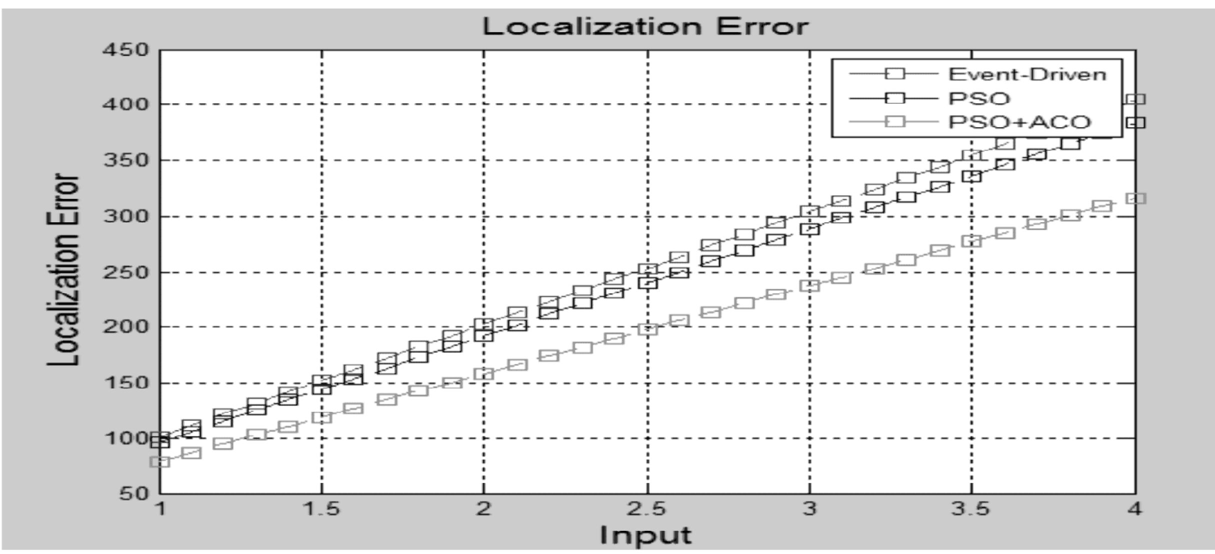

Figure 4.5: Graphical comparison of localization error with previous work and proposed work

Above figure represent the graphical comparison of localization error between the proposed and previous approach. The results obtained that the proposed work (ACO+PSO) is more effective as compare to previous work (alone PSO, event driven). In this fig. green color represents the localization error obtaine with the proposed approach.

$$E_{\text{receive}} = \text{l}*\ E_{\text{elec}}$$

$$E_{trans} = \begin{cases} l*(E_{elec} + E_{fs} * d^2),\ if\ \ d \le \sqrt{\dfrac{E_{fs}}{E_{mp}}} \\ l*(E_{elec} + E_{mp} * d^4),\ if\ \ d > \sqrt{\dfrac{E_{fs}}{E_{mp}}} \end{cases}$$

Where, l is the length of message i.e., size of data and d is the distance travelled by the data. $E_{\text{fs and}}E_{\text{mp are}}$ network system parameters.

Table 1
Experiments Result

Fig. No	*Criterion*	*Event Driven*	*With PSO*	*PSO+ACO*
4.4	RMSE	145.1189	105.1189	95.1189
4.5	Loc. Error	91.8622	87.9484	70.9484
4.2, 4.3	Distance Travelled	_	79.4718	56.2384
4.2, 4.3	Time taken	_	6.7600	4.7837

In the table 1, fig. 4.4 shows that the value of root mean square error obtained with proposed approach is 95 approx which is less in comparison to that obtained with alone PSO and in event driven work.

Fig. 4.5 shows the value of localization error obtained from proposed approach is 71 approx which is comparatively less than the earlier approaches.

In this table Fig. 4.2, 4.3 shows that Comparison of distance travelled for data from source to destination for proposed and previous work. And also comparison of time taken in data travelling from source to destination for proposed and previous work.

With the help of proposed techniques search out the shortest and efficient path from source to destination

The results attained validate the proposed technique that it is more efficient then previous approaches.

V. CONCLUSION

Wireless sensor network is the promising field that attract the researchers these days. In this paper a new approach is proposed which is based on PSO and ACO algorithms for optimization and for removing stagnation point along with determining the exact node position. The estimated values obtained of Root Mean Square Error and average localization error shows that the results attained from PSO and ACO algorithm are better than earlier algorithms (PSO alone). In future different algorithms can be used for improving the results and for minimizing the system complexity as well as execution time

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