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Data Fusion using Mobile Agent to Improve the Coverage of Wireless Sensor Networks

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Abstract
Fusion algorithm design to optimized energy consumption in wireless monitoring process. This study aims to obtain trade-off between power consumption and accuracy. This implementation constitutes a data fusion in itself. Some of applications can include large number of nodes, which poses challenges to network lifetime, data transmission, overall reliability and flexibility. ACO elite method is used for fusion. Data fusion technique is used to improve data accuracy, to predict future events and improve reliability of delivered information. The proposed algorithm uses data fusion as a technique to reduce energy consumption in large WSN. It also uses mobile agent to find appropriate root and to migrate between two nodes and examine remaining energy which avoid invalid node. Mobile agent collects data from the leader node in ACO and passes it to the base station which is placed on central grid of the large network. Position of base station is fixed in this algorithm. The significance of using such applications is sensing coverage i.e.; how well a sensing field is monitored within a network. In the proposed work, an effort is made to bridge this gap by exploring the limits of coverage based on stochastic data fusion models by fusing noisy data of multiple sensors. The proposed algorithm has less energy consumption and more transmission power.

Keywords: data fusion, mobility, fixed base station, large area coverage, wireless sensor networks.

Introduction
Wireless Sensor Networks (WSN) is the innovation that comprises of expansive number of small sensor nodes placed in a specially appointed way within the network. The sensors are spread widely over a large range. These sensor hubs can perform differently based on its power and capacities. In WSN, the sensor nodes are deployed in a sensor field. The deployment of the sensor nodes can be random, regular or mobile. Sensor nodes coordinate among themselves to produce high-quality information about the physical environment. Each sensor nodes' decision is based on mission, the information it currently has, and its knowledge of computing, communication, and energy resources. Each sensor nodes collect the data and route it to the base station. All the nodes may not be communicating at any particular time and each node can communicate only with a few nearby nodes. The network has a routing protocol to control the routing of data messages between nodes. The routing protocol also attempts to send messages to the base station in an energy-efficient manner.

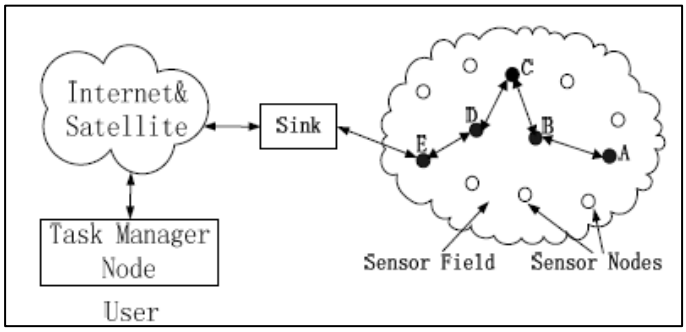


Fig.1: Wireless Sensor Network

The base station is a master node and is the main computer where data from the sensor network will be compiled and processed. The base station may communicate with the Remote Controller node via Internet or Satellite. Human operators controlling the sensor network send commands and receive responses through the base station. The wireless sensor nodes cluster together to form a network with each node that has the capability to process.

Data fusion is also known as data aggregation and is defined as the process of aggregating the data from multiple sensors to eliminate redundancy and provide fused information to the base station. Data fusion can process all the data sensed within the area to get more accurate information.

Mobile agent migrates between different nodes in the network applying the transfer rules, and it can filter data and process them at the node where it stays, so it does not need to transmit mass data to the system, just send and return only necessary data. Therefore, mobile agent can significantly reduce the data traffic on the network, and improve network bandwidth utilization. Also Mobile agent has many other characteristics, such as robustness, fault tolerance. Mobile agent routing problem is a kind of complex combinatorial optimization problem which solves the optimal path based on the sequence of visited nodes and energy efficiency in WSN. Ant colony optimization (ACO) is put forward to solve migration of mobile agent along with some improved mobile agent route algorithms based on ACO [1]. But the function of algorithm reaches optimum difficultly because its parameters are usually set by experiments that lead the optimization performance of algorithm that is closely related to the client experience. Furthermore, ACO Algorithm has some weakness, such as easy to bring premature convergence and take long computing time. This paper presents an improved ACO in order to strengthen convergence speed and avoid partial optimal solutions. In order to avoid invalid path, a mutation operator is imported [1].

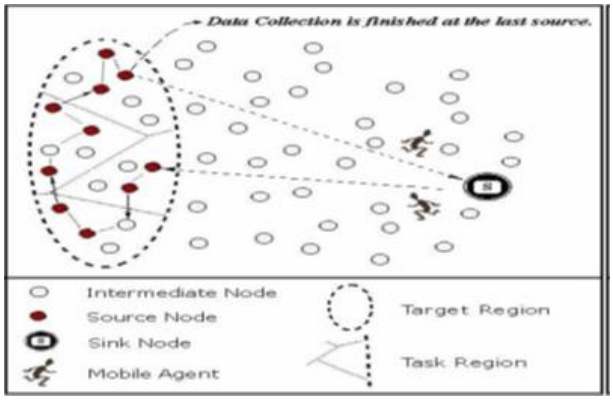


Fig. 2: Working of mobile agent [17]

Related Works

Muhammad Aslam et.al.(2016) The author proposed Two-Hop Centralized Energy Efficient Clustering (THCEEC) and Advanced heterogeneity-aware Centralized Energy Efficient Clustering (ACEEC) routing protocols which are derived from Centralized Energy Efficient Clustering (CEEC) routing protocol for three level heterogeneous WSNs to enhance stability period of nodes and network lifetime of WSN. Applying it, WSN became energy efficient and acheive stable elections.

Ben Liu et.al. (2016) this algorithm uses sink side least-square algorithm, which reduces the communication traffic between sink and the monitoring center, on the side of monitoring center, the incident identification accuracy improved in D-S evidence recognition framework, by using the triangular fuzzy membership function for obtaining basic probability assignment value. It Reduces communication traffic between sink and source and identification accuracy is improved in D-S evidence theory recognition framework.

S.G. Santhi et.al.(2015) proposed an algorithm DCHM used for secure and accurate data fusion as well as Accuracy of data fusion results is also improved. It performs well in improving security and accuracy of data fusion by update reputation and trust systems.

Mohammadreza Soltani et.al.(2014) In this research, kalman filters based on data fusion used to reduce the number of active sensor node in large network, in this Only those sensor considered which are inside of the gate validation region, Reduction of network resources, less network load, secure communication.

The application uses in study to track a moving object utilization which has a constant velocity model that includes noise. The centralized architecture for data fusion is considered. In this structure, each node sends its own observation as raw data to the data fusion center for processing. All nodes sense position at constant rate, and measurements are performed at the same time and arrive at the data fusion center at the same time, sensor network is constant over the time. It means that the nodes are stationary and environmental conditions do not change during the observation time.

Jin-gang-cao et.al. (2013) In this research allow ACOE algorithm to find better route. This algorithm reduces the impact of invalid nodes in WSN. Reduce transmission delay, network traffic; prolong the network lifetime and reliability of links**.**

Structure of Mobile Agent consists of four sections in this: (i) identification number, (ii) the executing code, (iii) data space and (iv) migration route.

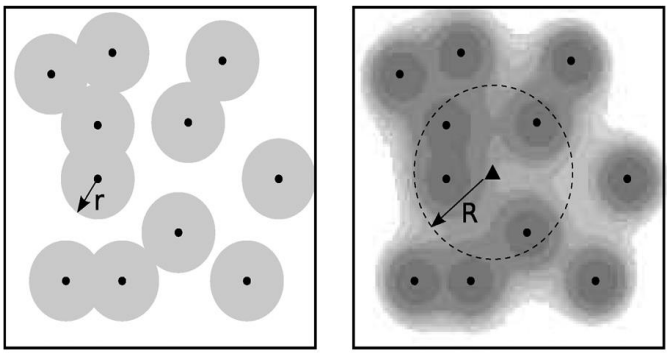
Data fusion theory for WSN, data fusion is to find a route between the sensor nodes and the sink node, and merge to reduce redundant data. Firstly, MA is initialized with the order and number of nodes it will be visited, and then it will be distributed to collect useful information by the sink node. Finally, it will come back to the sink node with data fusion results, it calculates as follows:

$$min \sum_{i,j \in V} w(i,j) * eij, i \neq j$$

where e is the connectivity status of wireless sensor nodes, (i,j) and its value is "0" or "1 ", where "1" denotes v(i) and v(j) are connection, and "0" expresses they are disconnection. This calculates minimum distance in network.

Rui tan et.al. (2012): the research defines fundamental limits of coverage based on data fusion models that process

noisy measurement of sensor that measured by probabilistic disc model. Result of research allows analysis of existing disc space model and provides key into designing and analyze of WSN adopted data fusion algorithm. It define mobile agent within the coverage area of the network and for better signal coverage and to count total consumption by sensor.



(a) (b)

Fig. 3: (a) Disc space model, (b) probabilistic disc space [12]

to study the coverage of large-scale WSNs.

Yuzhi Wu et.al. (2012) In this work Minimum Spanning tree is used to combine sensor node energy level to layout the routing. Consider data fusion energy and transmission and adapt to adjust mobile and data fusion. Decrease energy consumption, increase network efficiency, it find minimum possible total cost. There is also a need increase the area for large coverage link.

WSN is composed of Processing Element (PE) sensor nodes and communication network. PE is a node that has more power, memory and communication ability. It depends on its network scale to decide mobile agent's best route. Mobile agent begins with PE, goes along with the route that designed firstly, to collect and fuse the useful data, and then returns to the PE.

Huang Lu et.al. (2009) Proposed novel power efficient routing algorithm for hierarchal cluster compared with simple directed diffusion and non-clustering routing algorithm, proposed routing algorithm prolongs the system lifetime for large scale multi-hop transmission WSNs. Results show that, or large scale WSNs, our proposed algorithm performs better than the existing routing algorithms in terms of network lifetime. Future plan includes the improvements for better comparison results, such as changing the position of the BS, and changing the probability of becoming CHs from all sensor nodes.

Performance Analyzer

Table 1: Performance analyser

Topic	Network delay	Cost	Network survivability	Data transmission	Network coverage	Consumption of network resources	Reliability of links	Secure communication
[1]	×	Minimum	Medium	Minimum	×	More	×	×
[2]	√	Minimum	Medium	√	Small	Minimum	√	√
[3]	√	High	√	Minimum	Large	Less	√	×
[4]	More	High	√	Maximum	Large	Less	√	√
[5]	√	High	√	√	Small	Sometimes less	√	√
[6]	√	Medium	Easily	Slow	Small	Less sometimes	√	√
[7]	×	Less	√	×	Small	Maximum	×	×
[8]	√	Less	√	Easily	Medium	Less	×	×
[9]	×	Less	Better	Better	Better	Less	√	√

Proposed Work

Grid based elite ACOMA routing algorithm

It uses centralized algorithm, designed with the goal that the mobile agent quickly delivers the information during its iterations and adapt the changes in network in order to maximize the survival time of each node in grid.

In the proposed work following assumptions have been taken as shown in the table

Table 2: Parameters

Sr. no	Parameters	Value
1	Sensor field	100*100
2	Initial energy(E_0)	0.1J
3	Distance(d_0)	70m
4	Advanced nodes(α)	3
5	Heterogeneity(m)	0.1
6	Energy uses in each network (L)	4000
7	Energy for path loss parameters(ε_{mp}, ε_{fs})	(0.0013pj/bit/m,10pj/bit/$m^{2)}$
8	Data aggregation(E_{DA})	5Nj/bit/signal

Set-up phase

In set up phase network is divided in small grids –: There are total 100 nodes in the sensor field. Each grid contain 10% of total nodes and central grid contain 20% of total network nodes and a base station at center. Nodes are static in nature and continuously sensed data. Each grid contains unique id. Each sensor node send data to the base station directly or indirectly base on energy consumptions.

- 10% of sensor nodes are deployed uniformly in each grid as

$$N1 = 10 * \frac{N}{100}$$

- and 20% of Sensor Nodes are deployed in central grid, (5th grid) as

$$N5 = 20 * \frac{N}{100}$$

4.2 ACO Elite method-: ACO Elite method of data fusion path finding is used in each grid separately to find the minimum path distance to transmit data to base station. It will create a chain in each grid to connect all the nodes,

collect data from nodes, and send it to base station. A leader node is required in each grid that collects data from all nodes present in the grid and sends further. Leader node will be chosen using ACO method and leader node will be changed in each iterations**.**

Place the m ants on the n nodes and chain is formed as (equation 1)

$$p_{ij}^{k}(t)=\begin{cases}\dfrac{[\tau_{ij}(t)]^{\alpha}[\eta_{ij}]^{\beta}}{\sum_{k\in allowed_k}[\tau_{ik}(t)]^{\alpha}[\eta_{ik}]^{\beta}} & \text{if } j\in \text{allowed}_k\\ 0, & \text{otherwise}\end{cases}$$

Compute the length L_k of every ant Update the shortest tour found. Move kth ant to town (j,p) For every edge (i,j), compute

$$\tau_{ij}(t+n)=\rho\tau_{ij}(t)+\Delta\tau_{ij}$$

Here i is source k is sensor node and j is destination node in a chain.

$p^{k}(t)$, is probability to form chain.

$\tau(t)^{\alpha}$, is Pheromone in this.

$\eta(t)^{\beta}$, is total nodes

For k: =1 to m do

$$\Delta\tau_{i,j}^{k}=\begin{cases}\dfrac{Q}{L_k} & if(i,j)\in \text{tour described by tabu}_k\\ 0 & \text{otherwise}\end{cases}$$

In this process, a node in a grid will look for a node with minimum distance to send data to the leader node within the grid and further the next node will apply the same method. Therefore, data will be aggregated on the leader node through chaining between multiple nodes. It will take less energy as compare to send data directly.

Mobile agent:-Mobile agent will move around the central grid in a disc drive pattern to receive data from leader node of each grid and send it to the base station. It collects information from each grid by visiting its leader node and deletes it after sending the data to Base Station and move on to next grid and so on.

Communication phase: Communication between leader nodes and base station is performed in this phase by using mobile agent. Communication between nodes depends on energy that each sensor contains. For data communication, mobile agent will find the point on the path where Leader Node and Base Station are at minimum distance. Ecluidian function is used to calculate distance between nodes and energy dissipation is applied on nodes for data communication leaving dead nodes.

Energy dissipation:-Energy will be dissipated from chain in each grid to base station. It moves from chain to mobile agent then to radius of central grid and at the end to the base station is as follow in equation-III

Energy dissipated= Energy dissipated + (ETX * L + Efs * L * distance^2)

Or

Energy dissipated = Energy dissipated + (ETX ∗ L + Efs ∗ L ∗ distance^4) …III

Here, ETX is transmission energy, Efs is aggregate energy.

Check dead node in each grid:-Each node has its initial energy. in grid each node send its energy to base station.the node lost its transmission energy(ETX),the node who receive it lost it receiving energy(ERX) as well as transmission energy.fuse the data and send it to further and so on.

So, if energy is less than given threshold then the node is considered as dead node and the previous node send data by bypass the dead node to the another node in the chain and chain reformation is applied.

Results

Alive Nodes Comparison for Existing and proposed

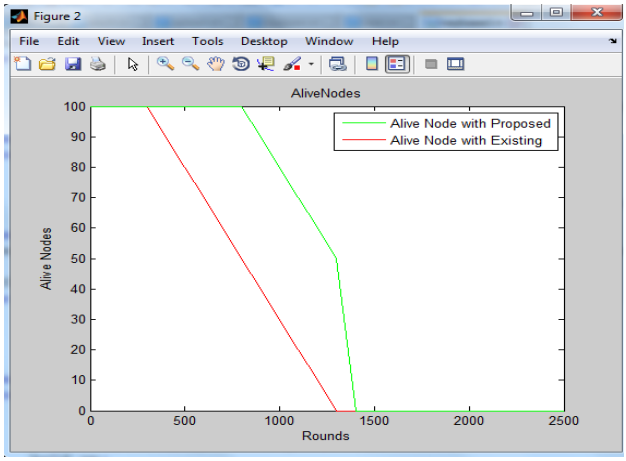


Figure 4: Alive Nodes in Proposed and Existing Technique

While communication large number of nodes energy will get depleted. An efficient and optimized technique can protect the nodes from depletion. In Proposed technique (figure 4) Number of alive nodes will remain more till 2000 iteration. After that alive node count starts decreasing. But compare to it in base technique (figure 4) the alive nodes count starts decreasing after 400 rounds.

Dead Nodes Comparison for Existing and proposed

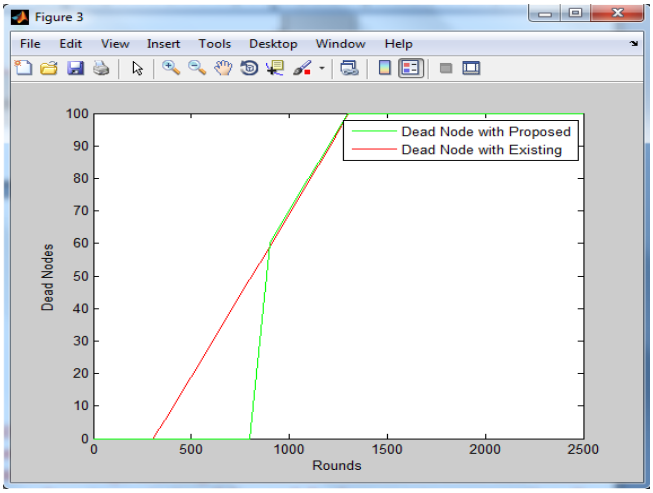


Figure 5: Dead Nodes in Proposed and Existing Technique

In case of dead node count the graph shows the reverse

trend. In proposed technique (figure. 5) the dead node count will starts increasing after the 2000 rounds. But in base technique (figure 5) the dead node count starts increasing after 400 round. That means energy depletion is more in case of base technique

Energy Comparison for Existing and proposed

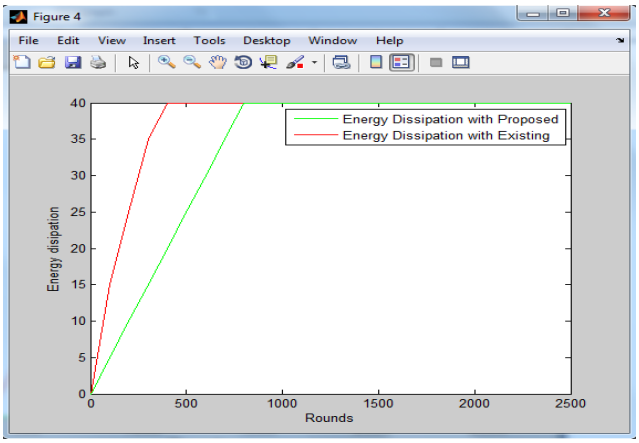


Fig.6: Energy Disipation comparison for existing and proposed

In this graph the energy depletion in case of proposed technique (figure 6) is slow. After the round 2000 this becomes stable at a point. But in base technique (Figure 6) the energy depletion is very fast compared to proposed technique

Conclusion and Future Scope

WSN is wireless sensor network where large number of wireless nodes stationed randomly at specific position. Their objective to collect the data from the environment for specific parameter and send that collected data to the sink node. Various performance parameters like dead nodes, Alive Node and Energy Disipation has shown improvement for the proposed technique compared to the base technique. Alive node count has shown the improvement of 10.52%, Dead Node count has shown the improvement of 13.33% and the energy dissipation has shown the improvement of 17.82%. In future more refinement in cluster building and leader node selection can be done. Because some energy get wasted in selection of leader node.

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