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Finding Source of Electromagnetic Interference Using Sine cosine optimization and GPS in Sensors Network

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Abstract

The applications of sensor networksare gettingpopular in the different areas reaching from daily usage to industrial usage. The performance evaluation of WSN deployed in industrial and high-voltage areas is receiving a great attention and becoming an interesting area of research. Typically, wireless sensor network contains wireless field devices (nodes) connected to a base station via a central gateway. The gate way centralizes information gathered and processed by the nodes. The nodes can communicate with each other and with the gateway via radio wave. The quality and usability of the data sent by WSN can be degraded due to the packet loss and delay. In the presence of high-voltage, the electromagnetic interference, EMI, can affect the performance of WSN. For the performance evaluation of WSN sensor failure rate, angular and network sensor data reliability and average value of the received signal strength indicator are used and measured. The results show that the electromagnetic frequencies and high voltage environments affect the wireless sensor network performance. All these performance evaluate done using Sine Cosine optimization algorithm.

Keywords: Sine Cosine algorithm, Sensor nodes, EMI etc.

I. Introduction

Most appliances emit electromagnetic noise, and because devices have different internal switching mechanisms, each produces a unique EMI signature. For identical devices, there is sufficient variability in production to make individual recognition possible. Gupta, et al. investigated transient and continuous electromagnetic phenomenon in the power line, and were not only able to reliably detect the powered devices, but also distinguish between different states [8]. We point interested readers to that work for a more in-depth examination of the sources of EMI. With a similar approach, Chen et al. were able to recognize hover and touching gestures in front of a LCD monitor [3]. The difference between their system and ours is that in order to observe signals in the power line the user needs to tap into the infrastructure. EMI sensor, on the other hand, provides a mobile and wireless solution. Artists and designers have explored EMI as a medium, mapping the invisible electromagnetic terrain to user experience. In [9], Vaucelle et al. introduce a bracelet that captures and visualizes EMI to the wearer for immediate feedback as well as review later on. Researchers have used the body as an antenna to capture EMI signals. Cohn et al. have developed a number of applications based on capturing EMI through the body, focusing on classification of indoor location, movements and gesture recognition [6], [5], [4]. In [5], the authors mention that they are able to recognize kitchen appliances with 100% accuracy. However, in these experiments, the authors make an assumption that the electromagnetic noise profile is static. In general, this is not the case; the EM background in a typical home or office changes when other devices go into standby mode, turn off, or are moved. In contrast, our system uses features that are not affected by changes in the background. By classifying the EMI signature of each target device independently, our approach is insensitive to day-today changes in the environment. Others have demonstrated active transmission of EM signals through the human body. [7] and [11] implemented interaction between user and devices using the body as both a physical and metaphorical carrier of information from one device to another.

II. Capturing EMI

The EMI is a differential signal between the local ground and a local signal plane, measured through the organization. The switching frequencies of interest in typical home appliances range from approximately 100Hz to as high as 500kHz [8], or even higher for other types of switching circuits. Ideally, this signal would be digitized at 1Msps or higher; in practice, a much lower sampling rate is sufficient to identify many devices. For signal components higher than our sampling frequency, we intentionally took advantage of the aliasing effect to shift those out-of-band frequencies to the lower spectrum, and found the technique effective for our machine learning system, despite the loss in fidelity [10]. When a user touches a device, it dominates the energy of the spectrum, but we can still observe signals from other nearby devices. The spectral energy of the device decreases nonlinearly with distance from the source; the drop-off depends on the geometry and composition of the emitting surface. For example, the signal amplitude increases with the size of the emitting surface. Similarly, if the source is touching a metal surface, the signal will be stronger.

III. SYSTEM MODEL

In this paper, we investigate a GPS-based node optimization algorithm for WSNs. It is assumed that distance measurements are already made hop-by-hop between neighboring sensor nodes. There are a number of technologies and techniques for performing the distance measurement. The simplest way is to measure the received signal strength and then apply a path loss model, such as the log path loss model [13]], to calculate the distance. The distance can also be determined based on the time-of-arrival measurements and the measurements of round-trip time-of-flight of a radio signal [14, 15]. When both a radio signal and an ultrasound signal are employed, an extremely accurate time-of-flight estimate and hence distance estimate can be obtained [16]. We make the following main assumptions on our model:

- All sensors are stationary. So the network topology is fixed.
- There are no landmarks in the network. That is to say, no sensor has absolute location information.
- All sensors are homogeneous, with the same technical characteristics, and especially the same transmission range.
- All sensors have enough energy to accomplish a node localization algorithm.
- All sensors use omnidirectional antennae.
- All the wireless links between sensors are bidirectional.
- There are no base stations to coordinate or supervise activities among sensors. Hence, the sensors must make all decisions without reference to a centralized controller.

In a stationary wireless sensor network, as sensors are battery-constraint devices, network topology may change in two cases: some sensors will die away or go to sleep periodically, and some sensors will be resupplied to maintain the work efficiency and quality of the whole network. In general, we run our proposed Sine cosine algorithm when all sensor nodes are deployed in some area. After that, the location information of all sensor nodes will remain during all lifetime of sensor networks even some sensor nodes die due to energy exhaustion or go to sleep periodically to save their energy. In the latter case, we can use other absolute localization approaches to determine the coordinates of new sensor nodes because the former sensor nodes which know their global coordinate now can be considered as encouragements. The simplest and the most widely used absolute localization approach is trilateration, which is suitable for our purposes because the number of new sensor nodes is trivial compared with hundreds and even thousands of former sensor nodes.

Similar to the other relative localization algorithms, the coordinate establishment phase of Sine-Cosine algorithm is split into two phases: the local coordinate establishment at master nodes and the convergence of the local coordinate systems to form a global coordinate system. The following sections describe the two phases in more detail.

Construction of Local Coordinate Systems

Scalability and the need to conserve energy and reduce communication overhead led to the idea of organizing the sensors hierarchically, which can be accomplished by gathering collections of sensors into clusters [17]. Clustering sensors, which are the core ideas of CSPA (Cluster based SPA) and its improved algorithms, are advantageous because they: (i) conserve limited energy resources and improve energy efficiency, (ii) aggregate information from individual sensors and abstract the characteristics of network topology, (iii) provide scalability and robustness for the network.

In the following discussion, we assume that a number of sensors are deployed randomly over a geographical region with a given average density. After deployment, each sensor starts to decrement a random waiting timer. If the timer of node i expires, then the sensor i broadcasts a message M1 with a multiplication factor $\alpha \geq 1$ proclaiming that it is beginning a master node, a focal point of a new cluster. All nodes in the communication range of node i who receive this message become a slave node. We refer to some nodes, which hear from other master nodes as the border nodes. At the same time, all nodes hearing the message M1 also transmit messages M2 to their neighbor nodes announcing their existence and the distance between them. However, events may occur and cause a sensor toextend or stop its timer. For example, if a neighbor declares itself to be a master node, the sensor lengthens the timer. On the other hand, whenever the timer is greater than threshold value, the sensor cancels its own timer. The complete procedure of the clustering phase is outlined in Algorithm 1. After clustering phase, there are three different kinds of sensor: master nodes, slave nodes and border nodes.

Algorithm 1

```
(1) Each sensor initializes a random waiting timer with a value $WTi^{(0)} \in (0, T_{max})$ and initial status Si = none (i = 1, 2, 3, …)
(2) Decrease all random waiting timer $WTi^{(k)}$
(3) Master node check:
if the random waiting timer expires, that is, $WTi^{(k)} = 0$
    (a) Si = master node
    (b) broadcast a message M1 with multiplication factor $\alpha$
    (c) delete the waiting timer
end
(4) Establish and update the neighbor identification:
if a sensor Sj receives a message M1 at time step k
    (a) if Sj = slave node
        Sj = border node
    else
        Sj = slave node
    end
    (b) transmit messages M2 to its neighbor nodes with the distance between node i and j
    (c) $WTj^{(k+1)} = \alpha \times WTj^{(k)}$
    (d) if $WTj^{(k+1)} > Tmax$
        delete the waiting timer
    end
end
(5) Termination conditions check:
if the waiting timers of all sensors are deleted
    algorithm is over
else
    k = k + 1 and go to step (2)
end
```

extend or stop its timer. For example, if a neighbor declares itself to be a master node, the sensor lengthens the timer. On the other hand, whenever the timer is greater than threshold value, the sensor cancels its own timer. The complete procedure of the clustering phase is outlined in Algorithm 1. After clustering phase, there are three different kinds of sensor: master nodes, slave nodes and border nodes.
factor α is related to the distance between two nodes i and j, that is $\alpha = f(dij)$, and the more dij is, the less α is. In this case, each master node has a greater chance of being deployed in the range of another master node. This procedure seems to coincide with that described in [12].

It is worth noting that more neighbor nodes can easily play the role of slave nodes during the early periods in Algorithm 1, while during the late ones, on the contrary, it is hard for neighbor nodes to become slave nodes. In order to avoid oscillation and keep the number of slave nodes and master nodes stable, one of the most viable solutions is the use of time factor in α to provide a little $\alpha(t)$ during the early stages and a large $\alpha(t)$ during the later stages.

The above implies that in the clustering phase, the multiplication factor α plays an important role in adjusting the number of master nodes and slave nodes and the degree of connectivity among master nodes and reducing communication overhead.

IV. Proposed method

Firstly, we can construct one three pyramid body, its vertex is P, 1, 2 and 3, according to vector algebra theory, the volume of three pyramid body is calculated by the following formula: of which cos α_1, cos β_1 , cos γ_1 is the cosine of P direction.

$$V = \frac{1}{6}\begin{vmatrix} x - x_1 & y - y_1 & z - z_1 \\ x - x_2 & y - y_2 & z - z_2 \\ x - x_3 & y - y_3 & z - z_3 \end{vmatrix} = \frac{1}{6} S1S2S3 \begin{vmatrix} \cos\alpha_1 & \cos\beta_1 & \cos\gamma_1 \\ \cos\alpha_2 & \cos\beta_2 & \cos\gamma_2 \\ \cos\alpha_3 & \cos\beta_3 & \cos\gamma_3 \end{vmatrix} = \frac{1}{6} S1S2S3\vec{A} \qquad (1)$$

Then the value of A of determinant can be indicated as follows:

$$A = \sqrt{\sin^2\varphi_{12} + \sin^2\varphi_{13} + \sin^2\varphi_{23} + 2\cos\varphi_{12}\cos\varphi_{13}\cos\varphi_{23} - 2} \qquad (2)$$

$\Phi12$, $\Phi13$ and $\Phi23$ are respectively the intersection angles of vector P1 and P2, P1 and P3, P2 and P3. Their sine and cosine value can be got by the known side length of $\Delta 1P2$, $\Delta 1P3$ and $\Delta 2P3$, using sine principle and sine, cosine reduction formula. We define the following vector as follows:

$$\begin{aligned} &(x_2 - x_1, y_2 - y_1, z_2 - z_1) = (X_2, Y_2 . H_2), \\ &(x_3 - x_1, y_3 - y_1, z_3 - z_1) = (X_3, Y_3 . H_3), \\ &(x - x_1, y - y_1, z - z_1) = (X, Y, \ H) \end{aligned} \qquad (3)$$

According to the above calculation formula of internal volume and mixed volume, we can list the following equations:

$$\begin{cases} \begin{vmatrix} Y_2 & H_2 \\ Y_3 & H_3 \end{vmatrix} X + \begin{vmatrix} H_2 & X_2 \\ H_3 & X_3 \end{vmatrix} Y + \begin{vmatrix} Y_2 & X_2 \\ Y_3 & X_3 \end{vmatrix} H = K_1 \\ X_2 X + Y_2 Y + H_2 H = K_2 \\ X_3 X + Y_3 Y + H_3 H = K_3 \end{cases} \qquad (4)$$

By calculation, then we get the coordinates of point to be determined as follows:

$$x = X + x_1, y = Y + y_1, z = Z + z_1 \qquad (5)$$

That is to say, we use the space position of mobile beacon node of three non-collinear received by one node to make code according to the clockwise sequence on the level, then take the corresponding coordinates and space data into the above calculation formula.

V. Performance Result

The sensor provides an accurate GPS location of the structure where an electrical component is emitting a RF Failure Signature. This is the first step in the technical process. The second step in the process is to go to the located structure and use ultrasonic sensing to isolate the exact component which is arcing.

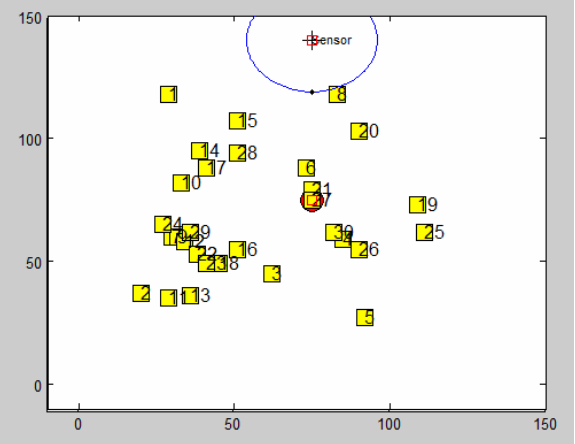


Figure 1: Sensor network for Source of Electromagnetic Interference

Above figure shows the Number of node with Random position, it adjusts the parameter of mobility range and it also control speed.

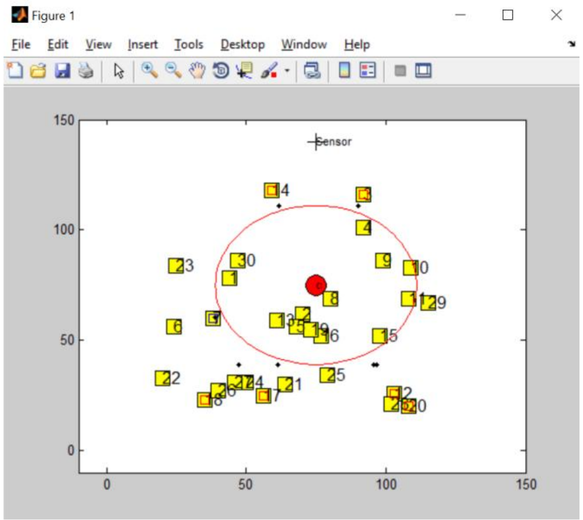


Figure 2: Random Sensor node

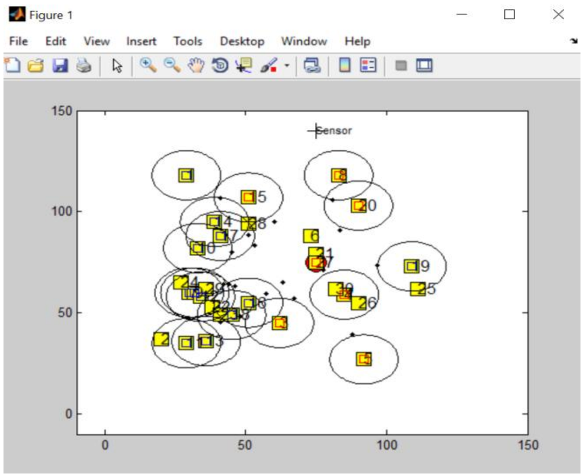
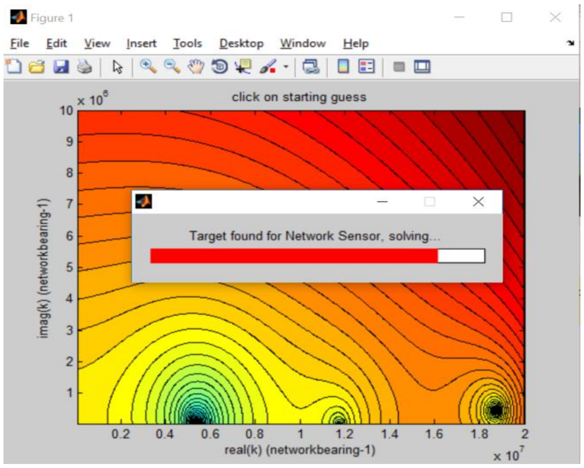


Figure 3: Sensor node deployment



Target found for Network Sensor, solving...

Figure 4: generating imaginary k plot for first wavelength

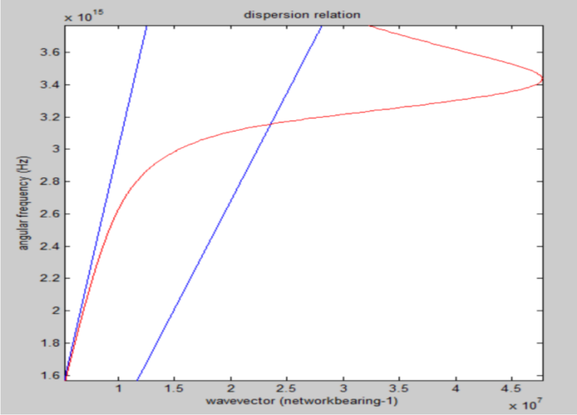


Figure 5: Angular frequency for dispersion relation

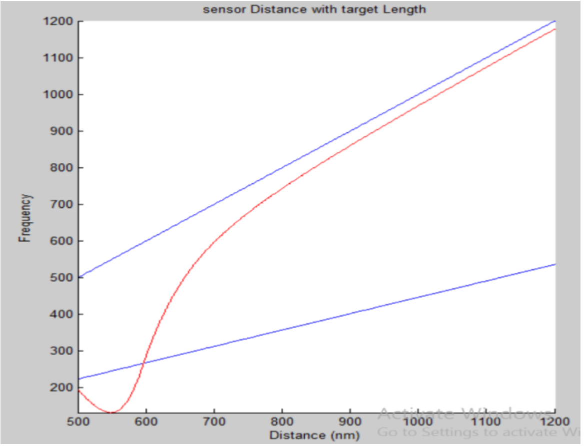


Figure 6: Sensor distance with target length

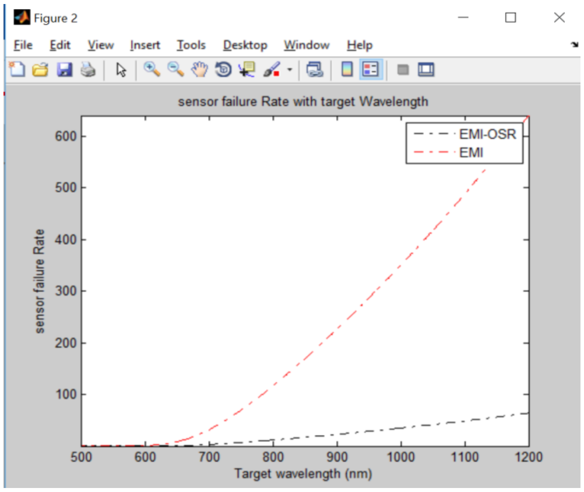


Figure 7: Sensor failure rate with target wavelength

In above figure we show the sensor failure rate is more than the proposed method

VI. Conclusion

In this paper, a GPS based real-time systemis proposed, further a bi-level model for Sine-Cosineoptimizing was proposed for system integrates Electromagnetic Interferencetraffic information dissemination and real-time application functions. It focuses on improving sensor failure by providing users comprehensive information about their individual target length which precise cost for traveling on congestion network. We hope that our preliminary research will throw some new idea on the future of GPS information service.

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