# Localization Technique Model of Ships Ad Hoc Network (SANET) Using Geographic's Database and Clustering Analysis

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**Abstract—**The localization problem in ad hoc networks has drawn wide attention in recent years due to the rapid advances in mobile computing and improvements of wireless communication technologies. In this paper, we design the localization model for Ships Ad Hoc network (SANET) involves three stages (Data collection, Data clustering, and Localization model). Our proposal can estimate its own position by using the travelling distance and the previous position which is estimated after the achievement of the stability of the ships. Our experimental results will show the effectiveness of the proposal.

**Keywords—**localization, SANET, FCM, GIS, geomedia

## 1 Introduction

The mobility of the nodes makes the localization procedure more challenging, but it also delivers more data although many measurements may be collected while they are moving. As a result, this is critical to emphasize the localization algorithms would take into account the particular needs of the application.

Despite the fact that static network localization technologies might be applied to dynamic ad hoc networks by repeating them regularly after a configurable time interval, they generate significant communication and processing costs. Because of the widespread use of mobile and wireless technologies, mobile ad hoc networks are burgeoning technologies. An ad hoc network is a collection of mobile entities joined by wireless communication that forms a transitory network without the assistance of any management or fixed support. This class is characterized by a dynamic topology, restricted bandwidth, and energy power, and attempts to extend mobility principles to all composites of the environment. Due to the lack of a stable infrastructure, mobile devices are forced to act as routers, assisting in the finding and management of pathways for network hosts. These mobile hosts constitute an ad hoc global architecture that may be employed as communications infrastructure [1]. Due to various significant gains in mobile computing and advancements in wireless communication technology, the topic of localization in mobile ad hoc networks has received a lot of attention in past few years.

Indeed, mobile ad hoc networks have shown to be a great tool for a wide range of applications. Thereby, it's critical to facilitate mobility without jeopardizing the performance of wireless systems. Despite the fact that various research programs have effectively solved Several research have addressed the localization difficulty in mobile ad hoc networks, in contrast to the static network localization problem. Knowledge of node position is critical in these networks, and it is really essential for several network applications based on node location data, including military uses, traffic monitoring, objects tracking, etc. The physical location of the node's geographic coordinates are represented by the localization data. Subsequently, every node has to use noisy measurements to determine its exact location. A viable option for supplying node position data would be to equip each node with an inbuilt positioning system, incorporating GPS receivers. Nevertheless, this method has several flaws and is constrained by Limitations in terms of cost, size, and power constraints[2]. Moreover, GPS receivers do not operate under difficult settings, including adverse weather [3]. However, a small number of nodes with GPS receivers are aware of their geographic position. Beacons or anchors are the names given to these nodes. The anchors help to enhance the predicted placement of other nodes by defining any extra nodes that are referred to as the local coordinate system [2].

The following are the contributions we provide in this article:

1. In this paper, we look at a number of the most commonly used mobility modelling approaches. Then we have to go into mobility techniques that will assist the reader to comprehend the fundamentals of localisation in dynamic ad hoc networks like SANET.
2. We supply the most recent state-of-the-art of the most relevant geomedia dataset, maps information, as well as methodologies.
3. For SANET, we suggest a new localization model based on clustering algorithms.
4. Lastly, we address difficulties and potential future research areas.

The remainder of this article is arranged as follows: the next section provides a quick summary of a selection of the most relevant works. Section 3 describes the geographic system and geomedia database. In section 4 we discuss in detail our methodology, techniques, and localization model. Experimental results and discussions are illustrated in section 5. Finally, the conclusions and future works are stated in section 6.

## 2 Related works

### 2.1 Using geomedia techniques

There are various suggestions using geomedia fill in related work. C.Marcelo and et al proposed in [4] the Geographical eXtensible Business Reporting Language (GeoXBRL) specify an integration between geographic and business/financial data. For this, W3C technologies such as XML linking language (XLink), XML schema, Geographic Markup Language (GML) and XBRL have been used to make the data structure of this integration. The new business data scenario proposed to explain how to use the GeoX-BRL, which provides a link between GML and XBRL domains. By comparing and contrasting simultaneous localization and mapping–based devices with more traditional types of cartographic operations, we can see how they are routinely used in mobile devices and domestic appliances.

Simultaneous localization, as well as mapping, show a moment of radical situatedness free of the constraints of a fixed, external database, just as the mathematical production of the surrounding space occurs at the instant of its discovery with simultaneous localization and mapping. K.Kanderske and T.Thielmann suggest that this instant of situative, which is likewise embedded in the ensuing extremely the defining feature of a new form of geomedia that establishes both vertical and horizontal geography at the same time is mobile as well as fluid visuals [5].

In various aspects, such as monitoring, communications, warning dissemination, evacuation, rescuing, and relief help, portable mobile phones could play a significant part in resolving a crisis or disaster scenario. Furthermore, the use of smartphones with GPS capabilities can aid in the management of a crisis or a tragic circumstance. There are a slew of apps that can help users in an emergency on a certain service. However, none of them genuinely combines many capabilities into a single platform that can be used both online and offline. Through A. C. Shayhan and et al, the user will be able to obtain relevant information both online and offline using the suggested approach [6].

Spatial Data Infrastructures (SDI) the principles are founded on the concept of infrastructures, which is a platform on which products and services are given or constructed, with governments playing a key role in its creation, operation, and upkeep. The envisioning of a future condition in which the whole global society interacts in a sustainable geospatial environment, utilizing high-quality as well as dependable location-based data and sophisticated geo-analytics presented through dynamic geomedia at any time, in several ways, and on a wide range of devices. The geospatial eco-system consists of billions of 'actors' (citizens, businesses, government agencies, civil society organizations, etc, Internet of Things (IoT) devices, as well as more 'intelligent' devices) creating and consuming geographical data via ever-changing platforms, a constantly broad range of geo-analytical tools, and dynamic, continually growing networks. C. Serena and et al are submitting a paper to begin off a global exchange of ideas on the 'Beyond SDI' topic. The article takes the initial steps toward a 'future vision,' aiming to spark a rethinking and remaking of how geographic information is disseminated, analyzed and applied in today's and tomorrow's which is continually changing atmosphere[7].

In addition to the location technologies produced by mobile phone firms and carriers, we have witnessed the rapid growth of Bluetooth, whether in advertising or user file-sharing; as well as satellite navigation technology; geoweb applications (Google Earth and Google Maps); the use of location in mixed and alternative reality mobile gaming; the discovery of friends, intimates, and new contacts using mobile social software; the annotation, photographing, filming, recording, and marking of locations via mobile Internet applications; smartphone apps that make use of location technologies. These location technologies are now a vitally important part of the relations between place and mobile technologies[8]. NASA's Artemis program aims to cooperate with private and international partners to land humans on the Moon in 2024, followed by the establishment of a permanent "base camp" by the end of the decade. Exploration of the Moon by human and robotic missions, as well as colonization via the development of a permanent base, would need the establishment of several critical supporting infrastructures, including communication networks and positioning, navigation, and timing (PNT) systems[9]. Furthermore, successful resource allocation in the aftermath of an earthquake in an afflicted region is strongly dependent on identifying post-disaster key rescue sites. M.S. Hossain and et al suggested the Earthquake Emergency Micro Response System (EEMRS), It sends data on trapped people via a wearable device application. The second half of related research on the use of smartwatch and geographic information systems (GIS) to identify critical rescue zones after an earthquake is now accessible. As a result, an analytical model is designed to evaluate its performance in search and rescue (SAR) operations [10]. It is very important in natural disasters, especially earthquakes the networks must be still in working condition. For this purpose, the researchers have proposed a Geographic Information System to develop for the altitudinal calculation of live lines by using GEO apparatuses. The Geographic Information System creates a map of live-lines, which are fast in execution time, modifiable and user friendly to adopt during the disaster[11].

H. M. S. Sibghatullah provided a comprehensive algorithm for establishing an ad hoc monitoring system to follow candidates who leave the test hall during the examination for medical breaks or other reasons. Because most exams are taken indoors, present GPS and GPRS-based technologies are extremely challenging. The authors propose deploying an interior monitoring system based on the RSS of precisely positioned receivers communicating with active tags carried by the candidates. The suggested technique may be utilized to build up the monitoring system deployment in any environment with a strictly delineated path [12].

In recent years, the increased diffusion of geographic information systems (GIS) has widened the availability and usage of geospatial technologies, mostly for analyzing spatial data from various areas. A territory can be viewed at different scales of analysis, and some structures are as complicated as smaller towns, offering the potential to investigate the dynamics, patterns, and phenomena within a building using GIS. T. Hugo and colleagues present a comprehensive assessment of the relevant research focusing on the application of GIS in indoor areas. The findings show that investigation on the use of GIS in interior settings is still in its early stages, despite the fact that it can help GIS users, information producers, academics, and policymakers enhance their research consists of providing empirical proof to aid decision-making [13]. In [14], N. H. Minh and others describe a strategy for enhancing purpose interpolation from global positioning system data without using geographic information system data by selecting.

important features from 6 categories: activity time, user characteristics, predicted travel modes, actual travel modes, estimated home location, and estimated location of the most frequently visited non-home place. K. Krystyna and et al present the findings of a study on the environmental, economic, and social factors of spatial development in rural areas, closely linked with the concept of growth that is sustainable and the challenges faced by Europe in a globalized economy. The main study goal was to assess the relevance of GIS tools (data, tools, and multi-dimensional analysis) to the application of sustainable development priorities in rural regions. which enhances access to information and raises database managers' understanding of the importance of highly precise data for geographical analysis. GIS systems enable us to develop designs that represent both the existing condition and the changes that will take place in space in an organized and formal manner [15]. L. Barazzetti introduces a revolutionary prototype of an integrated Historic BIM-GIS that can deal with data from several sources, scales, and time periods. It mixes components from the cartographic scale with a finer level of detail in the direction of the structure. Despite the importance of digital recording and its outputs, it can be described as a 3D virtual environment with an accompanying (geo) database capable of encapsulating heterogeneous data not limited to products obtained from the geometric survey. The system also has a high level of interoperability, allowing BIM and GIS applications to interchange data without having to implement capabilities and tools that are already available in other software packages [16]. B. M. Monica and A. Valarmathi use GIS and VANET architecture to forecast routing strategies and control traffic congestion [17].

### 2.2 Using other techniques

To deal with the typical problems in centralized underwater networks, H. Yunfeng and et al. propose a range based multilateral accumulation method (RBMAM). The method is designed for large-scale, high-efficiency and high precision underwater networks. They compared the performance with the area localization scheme (ALS), which is widely used in wireless localization, and the least square method (LSM) [18]. W. Zhuo and others proposed the Energy Optimized Distributed Localization Method (EODL) as an efficient technique for the distributed sensor network localization based on the mobile beacon water. This technique employs an Autonomous Underwater Vehicle (AUV) as the mobile beacon. The moving path of the AUV in the three-dimensional water environment and the time interval of the broadcast transmitting are found by applying a qualitative analysis of the superiority of the rectangular path [19]. H. Huai and R. Z. Yahong proposed a novel node localization method in sparse underwater wireless sensor networks (UWSNs) where the locations of only a small number of anchor nodes are available. The proposed method estimates the Euclidean distances from anchor nodes to multi-hop sensor nodes with the help of angle of arrival (AoA) measurements in the local coordinate systems of the routing nodes. A new distance estimation method is proposed for sensor nodes with greater-than-two-hops to an anchor node by accurately estimating the rotation matrix between the routing nodes [20]. On the other hand, F. Mohammed and et al presented a new localization technique that combines the received signal strength indicator method which limits the communications between nodes to the range of an accessible radiated signal, with a new trend which is social network analysis that deals with relationships between nodes in any network with metrics and layouts. By using mixed metrics between degree and closeness, they maintained the suitable elected seeds that would be anchors for around nodes inside the network. Trilateration calculations will be applied between optimized elected nodes with higher centrality to localize the target nodes [21]. M.D. Nabil, and B. Otman proposed intervehicle-communication assisted localization, a localization technique that takes advantage of the emerging vehicle ad hoc networks environments. Communication among vehicles is utilized to compute a relative vehicle location, the integration of which with motion information and GPS location estimates leading to highly accurate vehicle localization [22].

## 3 Geographic system and geomedia database

A geographic information system (GIS) is a computer system for capturing, storing, checking, and displaying data related to positions on Earth’s surface. GIS can show many different kinds of data on one map. This enables people to more easily see, analyze, and understand patterns and relationships. GIS can use any information that includes location[23][24][25]. GIS has the following four capabilities in handling data that is a geographic reference, including input, data management (data storage and calling), data analysis and manipulation, and output. As an information system, GIS comprises spatial data, software, and analysis and modelling tools [14][26][27]. It produces visual or data outputs shared on a network or cloud, stored in a database, or displayed on mobile or computer devices. The most widely used data is the spatial data type[28]. The location can be expressed in many different ways, such as latitude and longitude, address, or ZIP code[23]. Cartographic data are already in map form and may include such information as the location[29].

GIS can also include data in table or spreadsheet form. The two major types of GIS file formats are raster and vector. Raster formats are grids of cells or pixels. Raster formats are useful for storing GIS data that vary. Vector formats are polygons that use points (called nodes) and lines. GIS must make the information from all the various maps and sources align, so they fit together on the same scale. A scale is a relationship between the distance on a map and the actual distance on Earth[30].

GIS technology sometimes allows users to access further information about specific areas on a map. A person can point to a spot on a digital map to find other information stored in the GIS about that location. People working in many different fields use GIS technology. GIS technology can be used for scientific investigations, resource management, and development planning. There is no limit to the kind of information that can be analyzed using GIS technology[23][31][32][33]. Maps present data visually, allowing you to visualize the location and gain other information from your data. Hexagon Geospatial's (a division of Intergraph Corporation) GeoMedia Professional is a geographic information system (GIS) management solution for map generation and the analysis of geographic information with smart tools that capture and edit spatial data[34]. GeoMedia is used for creating geographic data; managing geospatial databases; joining business data, location intelligence and geographic data together; creating hard and soft-copy maps; conducting analysis in 'real-time'; a base platform for multiple applications, geographic data validation, publishing geospatial information and analyzing mapped information[35].

GeoMedia is a powerful, flexible GIS management platform that lets you aggregate data from a variety of sources and analyzes them in unison to extract clear, actionable information. It provides simultaneous access to geospatial data in almost any form and displays it in a single unified map view for efficient processing, analysis, presentation, and sharing. GeoMedia's functionality makes it ideal for extracting information from an array of dynamically changing data to support informed, smarter decision-making[36]. GeoMedia assists transportation agencies with managing and analyzing their networks, generating reports, and determining appropriate actions to ensure safety on their roadways. GeoMedia gives defence analysts immediate data integration and visualization to detect targets and points of interest in order to makefast, informed, mission-critical decisions[37].

# 4 Methodology

Our system, design of localization model for Ships Ad Hoc network (SANET) involves three stages:

- Stage 1--Data collection: data is obtained from GeoMedia platform by using Military Ship Shock Boxes Atlantic / Gulf of Mexico Data Set as described in the next subsection. Typically, the dataset is created to obtain enough and rich system information.
- Stage 2-- Data clustering: could be viewed as such "coarse" modelling based on information (or data structure) derived from data mines. The dynamic behaviour of the system should be sufficiently excited to the data-clustering problem so that the data from the system are sufficiently abundant to feed the data into the clustering system. Realizing the data clustering feature using FCM, to derive the main spatial distribution aspect of spatiotemporal dynamic systems. FCM would be used for data analysis to identify the intrinsic spatial distribution nature of the Spatio-temporal dynamic systems as described in subsection 4.2.
- Stage 3-- Localization model: to determine the estimated location of the ships after the achievement of the stability of the ships, a new mathematical model is built for this purpose as described in subsection 4.3.

## 4.1 Military Area dataset within geomedia application

In this work, we use the Military Ship Shock Boxes: Atlantic / Gulf of Mexico Data Set from ORIGINATORS: Department of Commerce (DOC); National Oceanic and Atmospheric Administration (NOAA); National Ocean Service (NOS); Office for Coastal Management (OCM), NOAA's Ocean Service; Office for Coastal Management (OCM). Download URL: ftp://ftp.coast.noaa.gov/pub/MSP/MilitaryAreas.zip. The type of file is Arc Geodatabase. A location, where ship trials can be conducted by Naval Sea System Command on new classes of Navy ships. The MarineCadastre.gov team worked with the Navy to provide this data, which is a subset of the Navy's Common Operating Picture, for ocean planning purposes. In accordance with the Energy Policy Act, to assist coastal and ocean planning and other activities, Coastal Zone Management Act; Magnuson-Stevens Fishery Conservation and Management Act; National Environmental Policy Act; Rivers and Harbors Act; and the Submerged Lands Act.

This Data Set is represented as a map. Using the GeoMedia application to open this map, extract the essential information from it, and store it as a CSV file need many steps. Initially, creating a project contains Geo-workspace (for maps) and Data-warehouse (for a database) together to generate the Geodatabase. Then open the Military Area file and import the data from the warehouse connection to the project warehouse, insert the world map connection to define the geodatabase map location. After that capture the ships data grid according to the Mexico Gulf map by the registration process. The next step is creating the feature class to draw the paths (or tracks) for ships according to the data grid, and adding the vertexes layer that represented the movement of the ships on the path. Finally extract the x,y coordinate from these vertexes and store them as a CSV database file. These steps are arranged as the following Figure 1.

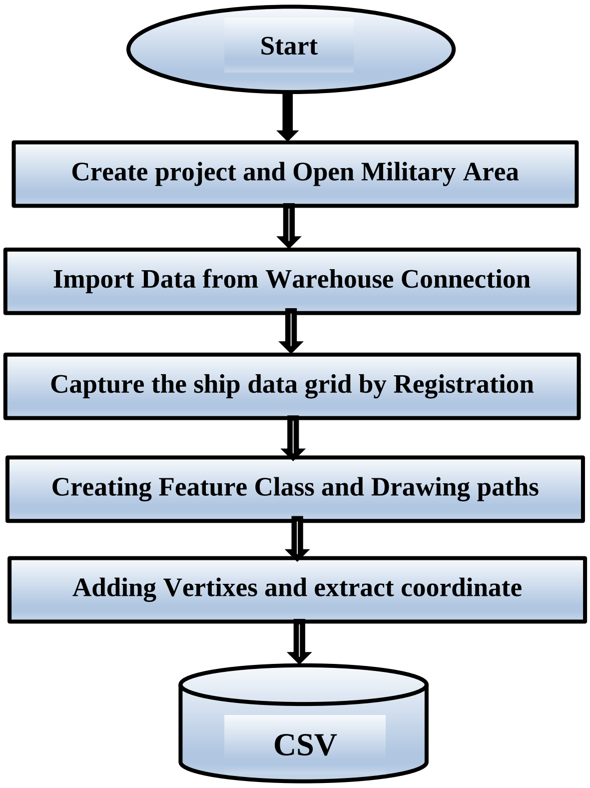


**Fig. 1.** A geomedia data set design steps

As a data set file, the GeoMedia Application's CSV file is regarded as one of the most essential outputs of the SANET Geodatabase. The clustering processing system receives a valuable data set as input, such as coordinate information.

### 4.2 Clustering by FCM

The Input dataset Z = {z1,z2, . . ., zN}, with Zj = (zj1, . . ., zjp) where zj will be the jth pattern ($1 \leq j \leq N$), zji be the ith feature of the jth pattern- ($1 \leq i \leq p$.), the patterns number N.

FCM would be carried out directly on Z. We obtain the fuzzy-partition matrix after three FCM stages U = [µkj]c×N as well as the matrix of cluster centre V = [v1, . . . , vc ], Next, locate the data collection. This would also keep in mind U and V the outcomes of clustering can be influenced by initialization. Under the requisite constraints U and V, the algorithm may be expressed as a series of iterations. A suitable upper constraint for the number of clusters should be chosen Cmax. In addition, the fuzziness factor m > 1 and the termination criterion must be specified.

Following the initialization phase, the algorithm iteratively updates the partition matrix and prototype until a predetermined termination threshold is met. The process will terminate if there are no important modifications to the division matrix, modifications to the prototypes, or cost function enhancements.

The algorithmic process of the FCM clustering technique used to generate the findings given in the experimental setup is as follows[38]:

1. Setup of the input variables, like the database matrix. The dataset matrix, for example, is initialized. [no. of patterns × no. of features], no. of clusters, fuzzy constant, initial partition matrix numbers are zeros', as well as the initial values of the centres' matrix from the algorithm's initial implementation
2. Whilst neither of the main improvements in the partition and centres matrix affect 3 and 4.
3. Implement the following equation to find an updated partition matrix:

$$u_{ij} = \left[\sum_{k=1}^{c}\left(\frac{\|x_j - v_i\|}{\|x_j - v_k\|}\right)^{2/(m-1)}\right]^{-1} \quad , \forall \text{i, j.} \tag{1}$$

4. Apply the following equation to find the revised centres matrix:

$$v_i = \frac{\sum_{j=1}^{n}(u_{ij})^m x_j}{\sum_{j=1}^{n}(u_{ij})^m} \quad , \forall \text{i.} \tag{2}$$

5. Until the criteria of the equation:

$$obj = \sum_{i=1}^{c} \sum_{j=1}^{n} u_{ij}^m \|x_j - v_i\|^2 \tag{3}$$

is satisfied.

### 4.3 Localization model

We proposed the positioning method which can estimate the absolute position by the combination of the distance between nodes and centres and the memberships of these nodes with the centres. By our proposed method, the absolute position can be estimated with the assistance of the new distance measurements.

The proposed method is assumed to be used in position estimation on SANET. We have nine mobile nodes at different times (the time t and t + τ ). The position coordinate of the nodes at the time t is (x0, y0). And the position coordinate of the nodes at the time t + τ is (x, y). We want to estimate the position (x, y). We define that the position of the i-th centres is (xi, yi).

By using the FCM algorithm to define the initial values of the centres which can be described randomly then update these values according to implementation of the algorithm.

Also, the variables di(i =0, 1, 2) are the distances between the nodes and the centres. On the other hand, the variable d is the distance between the time t position and the time t + τ position. Here, we assume that the position was correctly calculated by the adequate centres at the time t. For the purpose of simple explanation, we assume that the number of the centres are three at the time t. The distances between the nodes and the centres denoted as di between the i-th centres as well as the nodes could be expressed using average distance measure as follows equation.

$$d_i = \left(\frac{1}{n}\sum_{j=1}^{n}\left(x_{ij}-y_j\right)^2\right)^{\frac{1}{2}} \ \forall\, i \tag{4}$$

The distance between both the nodes and the centres may be subject to error. As a result, the distance Li could be represented by (5).

$$L_i = d_i + nm_i \tag{5}$$

The parameter, in this case, represents the error nm which is calculated through the FCM algorithm as the values of nonmembership of the nodes with clusters. This equation may be applied to all of the centres. Because there are three centres at time t, the following three equations may be derived.

$$\begin{aligned} L_2 &= d_2 + nm_2 \\ L_1 &= d_1 + nm_1 \\ L_0 &= d_0 + nm_0 \end{aligned} \tag{6}$$

It is feasible to determine the position of the nodes (x, y) by solving (6). The distance Li for three centres can be represented by :

$$\begin{aligned} L_0 &= \left(\frac{1}{n}(x_0-x)^2+(y_0-y)^2\right)^{\frac{1}{2}} + nm_0 \\ L_1 &= \left(\frac{1}{n}(x_1-x)^2+(y_1-y)^2\right)^{\frac{1}{2}} + nm_1 \\ L_2 &= \left(\frac{1}{n}(x_2-x)^2+(y_2-y)^2\right)^{\frac{1}{2}} + nm_2 \end{aligned} \tag{7}$$

Where n is the number of movements of each node (x,y).

Due to the nonlinearity of simultaneous equation (7), The answer can be reached by doing a sequential approximation to the linearization to around the starting value. The sequential approximations approach are used here followed by applying many iterations to reach the best-estimated position. Because it is feasible to approach the right solution by compensating the same amount as the error for $x_0$, $y_0$, and $nm_0$, the compensation amount is calculated using the partial derivative about x and y.

$$\frac{\partial L_i}{\partial x} = \frac{-(x_i - x)}{n * L_i}$$
$$\frac{\partial L_i}{\partial y} = \frac{-(y_i - y)}{n * L_i} \tag{8}$$

From (7) and (8), to update x, y the compensation amount Δx, Δy can be represented as follows:

$$\begin{aligned} L_0 &= \left(\frac{1}{n}(x_0 - x)^2 + (y_0 - y)^2\right)^{\frac{1}{2}} + nm_0 \\ L_1 &= \left(\frac{1}{n}(x_1 - x)^2 + (y_1 - y)^2\right)^{\frac{1}{2}} + nm_1 \\ L_2 &= \left(\frac{1}{n}(x_2 - x)^2 + (y_2 - y)^2\right)^{\frac{1}{2}} + nm_2 \end{aligned} \tag{7a}$$

$$\begin{aligned} \Delta L_0 &= \frac{\partial L_0}{\partial x}\Delta x + \frac{\partial L_0}{\partial y}\Delta y + nm_0 \\ \Delta L_1 &= \frac{\partial L_1}{\partial x}\Delta x + \frac{\partial L_1}{\partial y}\Delta y + nm_1 \\ \Delta L_2 &= \frac{\partial L_2}{\partial x}\Delta x + \frac{\partial L_2}{\partial y}\Delta y + nm_2 \end{aligned} \tag{8a}$$

In this case, the simultaneous equation (8a) can be expressed using the matrix form to make handling easier. The vectors are defined $\Delta^{\rightarrow} x = [\Delta x, \Delta y, nm]^T$ as well as $\Delta^{\rightarrow}$L = [$\Delta L_1$, $\Delta L_2$, $\Delta L_0$]$^T$ -T represent transpose of the vector-.The formula (8a) may be written as follows:

$$G\Delta^{\rightarrow} x = \Delta^{\rightarrow} L \tag{9}$$

In this context, the matrix *G* is commonly referred to as the design matrix. The matrix *G* is represented as follows:

$$G = \begin{bmatrix} \frac{\partial L_0}{\partial x} & \frac{\partial L_0}{\partial y} & nm_0 \\ \frac{\partial L_1}{\partial x} & \frac{\partial L_1}{\partial y} & nm_1 \\ \frac{\partial L_2}{\partial x} & \frac{\partial L_2}{\partial y} & nm_2 \end{bmatrix}$$
$$= \begin{bmatrix} \frac{-(x_0 - x)}{n * L_0} & \frac{-(y_0 - y)}{n * L_0} & nm_0 \\ \frac{-(x_1 - x)}{n * L_1} & \frac{-(y_1 - y)}{n * L_1} & nm_1 \\ \frac{-(x_2 - x)}{n * L_2} & \frac{-(y_2 - y)}{n * L_2} & nm_2 \end{bmatrix} \tag{10}$$

The compensation amount $\Delta x, \Delta y, nm$ (8a) can be obtained by multiplying the inverse matrix of $G$ from the left by (9). As a result, by calculating the equation, the compensation amount Δx,Δy, nm may be calculated (11).

$$\Delta^{\rightarrow} x = G^{-1}\, \Delta^{\rightarrow}\mathrm{L} \tag{11}$$

By following the above procedure, our proposed method can calculate the position of the nodes (x, y). In our experience, the solution can converge by repeating several times with the initial values are x, y, nm.

To evaluate the results of the proposed method we use Mean Square Error (MSE) and Standard Deviation(SD).

## 5 Experimental results and discussion

The tests were carried out to assess the capability and efficacy of the suggested approach. The suggested approach performs location estimates while updating the travelling distance between centres and nodes with the information of the previous position. The presumed environment is the Gulf of Mexico. In the experiment, we are using ships as the moving nodes (SANET). The data set was extracted as the output of Using GeoMedia Application as CSV file.FCM has indeed been developed as a tool for applying and testing data set behaviour. Each iteration includes an update to the cluster centres and membership matrix.

The initial cluster centres are chosen at random to provide for a variety of outcomes rather than being locked into one. In the situation of divergence, the number of iterations hits the maximum allowable amount, and the algorithm is ended. The purpose of this stage is to get Popular metrics of clustering algorithms like cluster centre stability, changes of cluster centre, cluster stability average, node stability, changes of node, average node stability. The interconnectedness and consequences of nodes should also be investigated and displayed. In test circumstances, several node motions should indeed be provided. The following are the initial settings for testing the outcomes of centres and node behaviours: Number of centers= 3, m= 2, number of patterns (for dynamic nodes) = 581 -for 9 nodes-, number of features= 2 - x, y coordinate location data - for every pattern. Three iterations were carried out in order to get the best outcomes and the highest levels of both cluster centers and nodes stability, in their true positions. (100 %, 100 %) and in state of estimation position (97.96 %, 92.26 % - for X, Y centres -, 95.67 %) respectively at the last one as shown in the following Tables (1-4):

**Table 1.** Stability ratio of centres for true position

| **No. Of Center** | **The latest two iterations (2,3) Stability ratio** | |
|---|---|---|
| | ***X*** | ***Y*** |
| 1 | %100 | %100 |
| 2 | %100 | %100 |
| 3 | %100 | %100 |
| The average ratio of centres stability | %100 | %100 |

**Table 2.** Nodes' stability ratio for true position

| No. of Node | The latest two iterations (2,3) Stability ratio |
|---|---|
| 1 | 100% |
| 2 | 100% |
| 3 | 100% |
| 4 | 100% |
| 5 | 100% |
| 6 | 100% |
| 7 | 100% |
| 8 | 100% |
| 9 | 100% |
| The average ratio of node stability | 100% |

**Table 3.** Stability ratio of centres for estimation position

| No. Of Center | The latest two iterations (2,3) Stability ratio | |
|---|---|---|
| | ***X*** | ***Y*** |
| 1 | 96.82% | 87.71% |
| 2 | 98.24% | 94.14% |
| 3 | 98.83% | 94.95% |
| The average ratio of centres stability | 97.96% | 92.26% |

**Table 4.** Nodes' stability ratio for estimation position

| No. Of Node | The latest two iterations (2,3) stability ratio |
|---|---|
| 1 | 96.58% |
| 2 | 96.20% |
| 3 | 96.43% |
| 4 | 96.20% |
| 5 | 96.76% |
| 6 | 95.83% |
| 7 | 96.09% |
| 8 | 93.62% |
| 9 | 93.34% |
| Average ratio of nodes stability | 95.67% |

The distance L had measured while movements of the nodes. The suggested method's location estimate is carried out employing by using distances measurement ( that mentioned in equation 4) between the three centres and nodes with the information about the previous position. This information is the error rates of the non-membership of the nodes with centres. Position estimate is carried out utilizing the data collected from the experiment by applying the mathematical model represented in the previous section (equations 5 to 11). As we can see, the proposed approach may continue to estimate the position even when the nodes are moved. Taking these findings into account, the suggested technique can estimate the node's position by utilizing the prior position as well as the three centres. The characteristics in this research were assessed by comparing the position estimation results received from all centres. Nevertheless, the measurement error of all centres' estimate findings may be included. To conduct a more in-depth investigation, it is required to analyze the qualities by comparing the genuine location with the estimated position using MSE and SD as shown in the following:

**Table 5.** The evaluation musurements

| Node no. | Mean Square Error (MSE) | | Standard Deviation (SD) | |
|---|---|---|---|---|
| | ***X*** | ***Y*** | ***X*** | ***Y*** |
| 1 | 0.00016991 | 0.00020705 | 0.00055505 | 0.00051389 |
| 2 | 0.0003869 | 0.00037098 | 0.00246435 | 0.00181177 |
| 3 | 0.01702495 | 0.00824654 | 0.13442792 | 0.06293118 |
| 4 | 0.00109292 | 0.00015332 | 0.00500783 | 0.00042827 |
| 5 | 0.00784641 | 0.02497475 | 0.03582881 | 0.120039 |
| 6 | 0.00834898 | 0.03660847 | 0.03728487 | 0.2591127 |
| 7 | 0.03856397 | 1.28811615 | 0.29888385 | 9.77298929 |
| 8 | 0.00078911 | 0.00116656 | 0.00410274 | 0.00444254 |
| 9 | 0.00459093 | 0.00704063 | 0.03183144 | 0.04699158 |

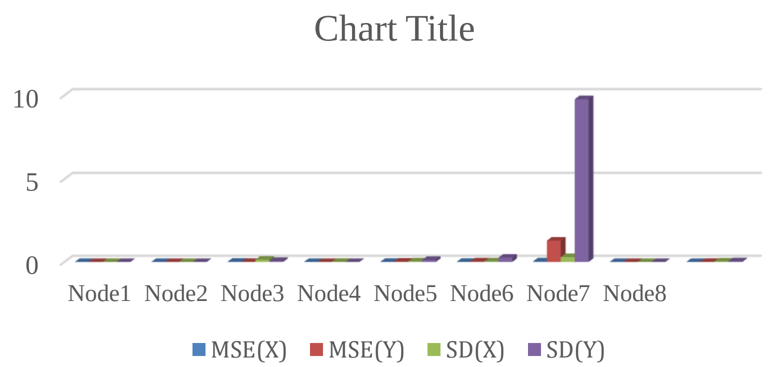


**Fig. 2.** The evaluation musurements

In the suggested strategy, we simply utilize the average distance rather than the mean character difference from a centre. As a consequence, there is no significant variation in calculating time.

## 6 Conclusions and future works

In this paper, we proposed a new model for localization based on clustering schemes for SANET using geomedia application to get a dataset. our proposal was to make a position estimation for SANET that based on the previous position. For using the previous position, we needed the travelling distance from the centres and the previous one by using the average distance measure to minimize the calculation time. In order to evaluate the proposed method, the positioning experiment was done using ships as the moving nodes (SANET). Through the experimental results, the possibility of the position estimation and the characteristic of the position estimation was shown when the proposed method is used. Also, the position estimation error was too little and we have a very good result as shown in the experimental part. As future work, we hope that our proposal can be calculated in real-time.

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