Systematic Review on WSN Localization using Metaheuristic and Learning Methods Based on AI Techniques

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Abstract: The localization process in Wireless Sensor Networks (WSNs) is carried out for finding the exact position of the sensor node. WSN are applied in various number of applications like monitoring, humidity, hospitality and so on. Hundreds to thousands of nodes in the sensor sense the data to the base station. Thousands of nodes in the WSN makes the installing of Global processing System (GPS). It is more costly and the GPS not provide the exact location in the indoor environment. In spite of dense network, manual configuration is not possible in the indoor environment. This cause a raise in problem to identify the exact position without GPS or any manual configuration methods. This paper presents the methods to overcome the above issues in WSN localization, by path planning, metaheuristic and deep learning are the techniques having high scopes in the industries, mining etc. Many times sensing of data are restricted by accuracy, energy, power and efficiency in the nodes. This paper discuss the WSN localization process classifications and the methodologies in localization. Localization issues are minimized by various techniques like ToA, TDoA and RSSI. The types of localization, its applications are also discussed.

Keywords: Wireless Sensor Network (WSN), Artificial Intelligence, Optimization, Machine Learning, Deep Learning, Artificial Neural Networks.

1. INTRODUCTION

In the communication systems, wireless sensor device possess a broad range of applications in computations and network. Combination of single nodes in WSN are set up densely in the Region of Interest (ROI) [1-2]. WSNs are significant and are applicable in various fields like weather prediction, environmental monitoring, medicine, surveillance and so on, and the changes are occasionally observed and reported to the Base Station (BS) [2-4].Due to very limited source a small portion of data are collected from every nodes. The coordination of every nodes can calculate the given physical variables exactly. WSNs performs a task by the coordination of large amount of nodes in a dense layout form [5]. Fig. 1 represents the architecture of WSN.

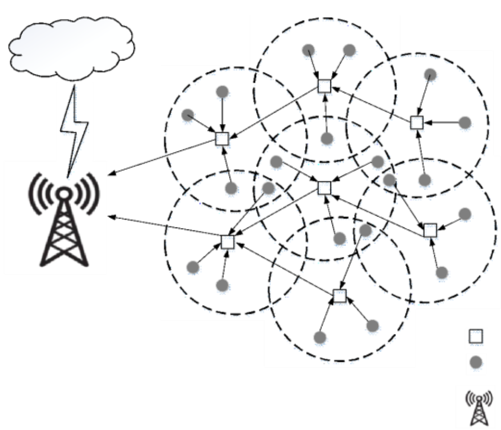

Fig. 1. Architecture of WSN

Now a days due to the evolution of modern technologies, the focus of WSN is based on the wireless distributed sensors remote processing and distributed data processing. WSN is widely used in computing paradigms like Internet of Things (IoT) and cloud computing [6]. In this process of execution of WSNs experience a numerous challenges like consumptions of energy in Sensor Nodes (SN), issues in data routing, coverage and node localization etc. Low cost and minimum size of SN plays a vital role in the number of applications like remote surveillance, fire detection in the forest, military and to monitor the volcano [7-9]. Sometimes the monitored areas does not have any existing infrastructures like power supply or telecommunication, that time finding the position by Global Positioning System (GPS) is the difficult task for sensors [8]. The main approach of the localization is finding the exact location of the node. By observing this issues and challenges, the most significant one is to localize the deployed nodes [9]. The accurate location of the unknown target nodes are find out by the SN's which are deployed randomly to monitor the environment by using the anchor nodes (precise locations of existing SN). To acquire the distance and position of target nodes, this technique used Time of Arrival (ToA), Triangulation, Angle of Arrival (AoA) and Radio Signal Strength (RSS). In general, the locations are precisely determined with the furnished GPS anchor nodes [10-11].

The localization nodes are classified as "GPS based localization or GPS free localization, anchor based localization or anchor free localization, centralized or distributed localization and range based localization or range free localization". GPS based localization is very expensive and also the accuracy is very high whereas GPS is not used in the GPS free technique. The node distance is calculated relatively on local networks [12-13]. The positions of few nodes are known in anchor based technique. Accuracy is highly depends on the amount of anchor nodes and the known nodes position localize the unknown nodes. In anchor free, regional map is used to calculate the node distance. When the node is aware about its position, data can transferred to the base station with appropriate time and minimum consumption of energy [14]. This paper presents the WSN localization using path planning, metaheuristic and learning methods based on AI techniques. Fig. 2 represents the AI techniques that are used in WSN localization.

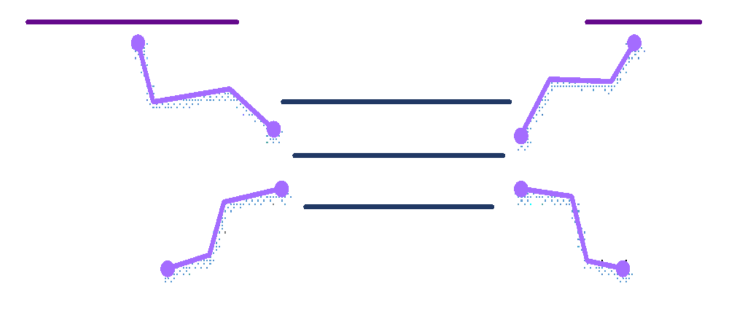

Fig. 2. AI techniques used in WSN localization

Section 2 discuss the research papers that are used in the present review work and Section 3 of this paper presents the localization approach of WSN. Section 4 describes the concept and characteristics of localization. Section 5 discuss the concept of path selection based WSN localization. Section 6 discuss about the literature review based on metaheuristic technique in WSN localization and section 7 discuss about literature review based on artificial intelligence in WSN localization. Section 8 discuss about the methodology and challenges in the literature review and section 9 completes the review by the future enhancement of WSN localization.

2. RESEARCH ANALYSIS

The review of 40 to 50 papers are study from respected journals like Springer, IEEE, Elseiver, etc. Also, these papers are from the recent works from 2019 to 2023 based on metaheuristic, DL, ML related to WSN localization and the techniques which are used for WSN localization. This review paper is differ from the recent reviews and this paper contains the methods of WSN localization for the future scopes. Fig. 3 represents the count of selected articles.

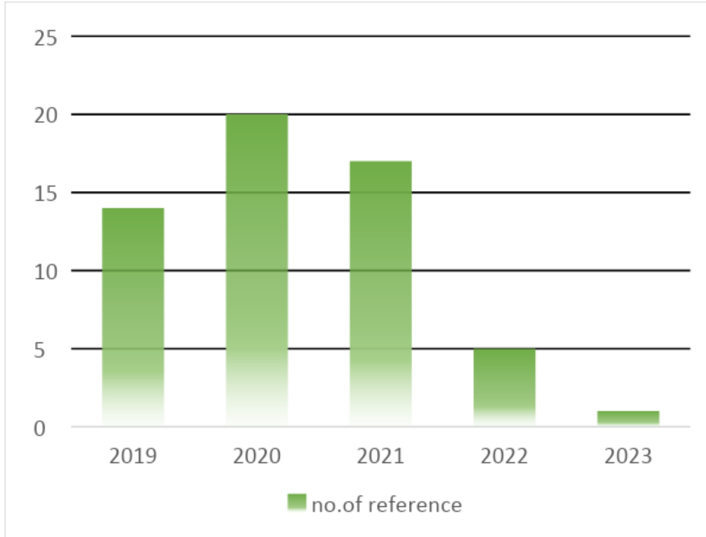

Fig. 3. Counts of article selection

3. LOCALIZATION APPROACH

The localization of SN are based on the data taken as the input. This means, the generated outputs are the location of the anchor nodes and the other input data from the target nodes are used to calculate the localization process. Thus the measuring formula used in localization is,

$$Y = h(X) + e$$

Where, X is the vector of sensor coordinate of whose distance to be estimated, Y is the vector in all measurements and e is the measurement of error. In this localization approach is classified as centralized technique and distributed technique.

3.1 Centralized Technique

In Centralized scheme, the sensor node allows all the information from the whole network and it is called BS. The node distance are monitored and calculate by the central BS. The data transmission process is responsible for band width, energy usage and latency. By compared with distributed algorithm, centralized technique is more accurate and it have the global view of entire network. This technique have the lack of capacity to access the data in correct manner. Due to the high complexity and lack of incomplete information, centralized technique is not suitable large-scale sensor network. It uses multi-Dimensional Scaling (MDS) to detect the different dimensions between the points. MDS method is used in computational chemistry and machine learning. This technique involves in calculating the shortest paths for the entire pairs of nodes. When the shortest distance is determined and the MDS matrix is constructed [15-17].

3.2 Distributed Technique

In the Distributed localization, the positions of the network is obtained by the sensor nodes by calculate and estimate themselves with the communication of each other nodes. In this distributed Bayesian-based filter localization is the algorithm that relies on this approach. By this technique, the sensor location is calculated by the noise measurement. This algorithm provides an output of the probability distribution of the available approximate position from the sensor data. This distributed probability reflects the predicted uncertainty location and it is called belief. When the localization process proceeds the generated belief from the algorithm are modified and reinforced. This algorithm provides better understanding the neighbouring sensors, and it is called propagation of belief. Distributed algorithms are more effective locally than globally and require a number of iterations to get the right solution. In centralized technique, it uses multi-hop method for sharing the information while in distributed technique uses single hop distributed algorithm. This technique is categorized by range based and range free based localization. In Range based localization requires the measured distance and angle based technique, while the range free localization not requires the distance or angle based technique and it utilize connectivity technique or pattern matching technique [18-20].

On this distributed framework, the mediatory nodes are classified as heuristic and analytical [21]. The algorithms of range-free localization is divided into "(1) mobile sensor nodes and mobile anchor nodes, (2) mobile sensor nodes and static anchor nodes, (3) static sensor nodes and mobile anchor nodes, (4) static sensor nodes and static anchor nodes". In recent days WSN localization algorithm tends to have more issues so, it is generally studied. From the anchor nodes the rest nodes evaluate their positions and calculate their distance by multi-lateration technique. To reduce some security issue and various problems in WSN, various optimizations like Grey wolf optimization algorithm (GWO), Particle Swarm Optimization (PSO), Whale Optimization Algorithm (WOA), etc., are used in localization. Various algorithms and methods are projected to solve the problems in localization with different applications [22-23].

4. CONCEPTS AND CHARACTERISTICS OF LOCALIZATION

Generally localization process is performed by using neighbouring nodes. Either by using GPS device or manual configuration references, nodes made their location references and the techniques that are used in localization process are discussed [24]. Localization process is classified as proximity based localization, known location based localization, range and distance based localization and angle based localization. Range based localization requires a special hardware for finding the range, but distance based localization does not require a special hardware.

4.1 Proximity Based Localization

In Proximity based localization, WSN is split up into various clusters. Each and every cluster has a node (head), and each nodes provide a GPS. Nodes find the proximity or nearby localization by using Bluetooth or Infrared waves. This localization technique do not have the fading issues but it is not applicable when the threshold value is higher than the power threshold [25-26].

4.2 Known Location Based Localization

In the known localization based localization, the SN identify its locations by using GPS or manual configuration method. Location exactness is very high in GPS based technique and it is more effective when GPS receiver is put on every nodes. GPS receiver requires minimum of four satellites to find its location. The position of the SN is identified by the GPS satellites. Distance between the GPS satellite and the GPS receiver is carried out by the time taken for the signal to reach the device. When the distance is known, receiver use trilateration or triangulation technique for determining its location [27].

4.3 Range Based Localization

The range based localization is carried out by the basis of range. By using Received Signal Strength Indicator (RSSI) or ToA or Time Difference of arrival (TDoA) the sensor node distance is being calculated. Time synchronization is the very important factor for ToA and TDoA. Because, timing is used for calculating the range. In RSSI, the sender gets the strength of the signal along with its reference from the receiver. The distance is calculated on the basis signal strength by the sender [28-29].

4.4 Distance Based Localization

In Distance Based Localization, the location reference is being identified by using hop distance between the transmitter and the receiver node. This localization technique uses the propagations like DV-distance or Distance Vector hop (DV-Hop) propagation [30].

4.5 Angle Based Localization

Angle based localization is the technique to identify the distance by AoA or received signals angle. AoA is described as angle between the received signal of an incident wave and some reference direction (orientation). The most accepted suggestion is the antenna array is placed in every sensor node. The signal in the angular sector is identified by using the antenna array with reference direction [31].

5. PATH SELECTION BASED WSN LOCALIZATION

Kannadasan *et al*. [32] have introduced a method of M-curved technique node using Dolphin Swarm Algorithm for mobile anchor nodes to localize the sensor nodes. The deployed sensor nodes obtained the solutions in the localization of mobile anchor nodes. The method of M-curves for the path planning approach and DSA optimization algorithm was used for localization process to minimize the localization error. WSN localization is to target the node to calculate the unknown sensor node by the minimum objective function. From this technique this was acquired high accuracy, full coverage, and localization ratio.

Kaur *et al*. [33] have introduced a mesh based path planning model using single mobile node. This technique was developed to increase the accuracy in range-free localization technique using mobile anchor (Single) node and mesh based technique. By this algorithm, power consumption, localization error, coverage are evaluated and compared by the DV-hop algorithm.

Singh *et al*. [34] have introduced a localization approach in 3D WSN using AFPA Adaptive Flower Pollination Algorithm (AFPA) to locate the sensor nodes. In this technique, conventional FPA was used for WSN localization in SN with the good exploration and exploitation of AFPA. By this process, the single anchor node projects all the unknown target node by the hexagonal projection using AFPA. By deploying AN in the six direction to reduce the problem in LoS (Line of Sight). This algorithm technique was used in monitoring mine workers, animals tracking.

Sun *et al*. [35] have introduced a technique of PP-MMAN (Path Planning for Multiple Mobile Anchor Nodes). To solve the problems in localizing the unknown nodes for estimating their position by introducing CAP (Compensation Algorithm for Positioning) near the boundary area. By this technique improves the efficiency and reduce the energy consumption.

Bala *et al*. [36] have developed the technique to allow two anchor nodes by using Z-curves. Two anchor nodes are used to localize and transmit the sensed data along both direction. The Z-curve trajectory is used for securing the every static node position in the every sensing field.

Sabale *et al*. [37] have developed a method to improve the anchor node path planning mechanism in WSN localization by introducing the D-connect technique. This method can overcome the collinear beacon problems and reduce the localization time. This also solve the coverage problem by giving beacon data for every sensor nodes and it leads to localize the every sensor by acquires minimum localization error. Table 1 represents the analysis of path selection based WSN localization

Table 1: Analysis of path selection based WSN localization

Ref no / Author	Technique	Objective	Advantage	Limitations	Performance
Kannadasan *et al*. [32]	M-curves using DSA optimization	Path planning for mobile anchor nodes	High accuracy, full coverage	Complex in architecture	It obtains the localization ratio – 0.88m.
Kaur *et al*. [33]	DV-hop for 2D space	Mesh based path planning model using single mobile node.	Power consumption, localization accuracy is high, high coverage.	Energy consumption is not reduced.	Coverage obtained is 90 to 100%
Singh *et al*. [34]	AFPA	To locate SN in 3D WSN using AFPA	Localization error is minimized.	Difficult to locate the TNs in 3D environment	Coverage time of AFPA-0.1234s.
Sun *et al*. [35]	PP-MMAN	Estimate the positions of boundary nodes by PP-MMAN using CPA	Improves location efficiency and reduce energy consumption.	Obstacles in the movement of mobile beacon nodes.	Efficiency increases up to 14.42%, Energy efficiency is reduced to 24.48%.
Bala *et al*. [36]	Z-curves trajectories	Positioning of every nodes by path planning	Reduce time consumption and minimize localization error	Needs improvement in the localization performance.	This technique enables almost zero fault.
Sabale *et al*. [37]	D-connect	Path planning to reduce time consumption.	Acquires minimum localization error	Needs improvement in energy and the power schemes.	Trajectory length decrease by 380m.

6. REVIEW BASED ON METAHEURISTICS TECHNIQUE FOR WSN LOCALIZATION

This section presents a review of metaheuristic in WSN localization. The importance of metaheuristic is to reduce the practical hard problems in NP. Metaheuristic algorithm is generally classified as Swarm Algorithm and Evolutionary Algorithm (EA). The Genetic Algorithm (GA) is the well-known representation of EA and it can able to solve NP hard problems.

Pan *et al*. [38] have introduced a node localization method in WSN based on hybrid optimization algorithm. The hybrid of WAO and Quasi-Affine Transformation Evolutionary (QUATRE) algorithm and it was a convolutionary algorithm based on quasi-affine transformation. WAO stimulate the hunting behaviour of hump back whale groups. This method has the combination of bubble net and encircling mode. Once the agent update their position with reference, WAO create spiral equation for simulating the location. QUARTE are used to solve the distributed bias in the Differential Evolution (DE) and WAO-QT algorithm used RSSI for improving the positioning accuracy. By the hybrid of these two algorithms was used to reduce slow convergence and local optimal stagnation and improves the efficiency.

Chowdhury *et al*. [39] have introduced the energy optimization and green mobile coverage in WSN. The authors identified constrained and efficient sensor movement as important for area coverage and energy consumption. These issues in sensor can reduced by mobile WSN. Further the random movement of sensors the energy gets deployed. So in need of coverage and efficiency FISRGSO (Fuzzy Inference System Based Reverse Glowworm Swarm Optimization) was used. Energy consumption is reduced by using FIS algorithm by maximum coverage. For minimizing the energy consumption in RGSO, EEMRGSO algorithm is used as a reverse in GSO. From this optimization, it reduces the energy efficiency and improves the area coverage.

Lu *et al*. [40] have proposed the method by using technical strategy for the improved ABC algorithm. ABC algorithm is good in exploration than exploitation. So, this technique was introduced by improved teaching strategy based on Teaching Learning Based Optimization (TLBO). So, this optimization includes the advantages of ABC with TLBO rapid covergence. Original onlooker bee phase was used to increase the ability of local search in ABC. This approach used certain amount of SN to maximize the coverage.

Rama *et al*. [41] have developed WSN localization technique to track the mobile node by using Firefly Algorithm (FA) based Artificial Neural Network (ANN). ANN technique help to round off the difficult and it was consider and calculate the function between RSSI value and position. To improve the accuracy of ANN, FAA is used. In this model estimation is effectively by using RSSI value. This proposed model shows the perfect result parameters are localization accuracy attains with 95%, minimize the localization error, average energy consumption.

Singh *et al*. [42] have introduced the concept of location optimization using Naked-Mole-Rat algorithm (NMRA) in dynamic WSN. In the case of localization, the method of SN localization in 2D is developed using an anchor node (static single) with a virtual anchor (dynamic) to locate the target node through the projection model of hexagonal. In order to optimize the target node by using NMRA technique. The deployed only one anchor node determines the location of the moving target node in 2D scheme and the results are optimized by using NMRA metaheuristic algorithm. Then the errors are calculated by NMRA and validate by localization algorithms like PSO, FA and BBO. From this technique, localization errors is minimized up to 0.21 and the time of convergence is 0.1834s.

Sruthi *et al*. [43] have developed a method to reduce the path loss by Grey Wolf Ant Lion Recurrent (GWALR) localization in WSN and find the position of every unknown nodes and improve the Received Signal Strength (RSS) to reduce the localization error. The location of every node is tracked by the function of GWALR. The importance of this model was find the location of unknown nodes with the help RSS which has better data broadcasting ratio. AL was applied to GW to fix the threshold to localize each nodes. Thus, the frequency range greater than 1 means known nodes and less than 1 means unknown nodes. The unknown nodes are detected by the anchor nodes. By this technique maximize the throughput ratio, accuracy and minimize the error.

Nagireddy *et al*. [44] have developed a technique of velocity adaptation based on PSO to minimize the localization error in WSN. To mitigate the localization problem PSO is applied. According to the current velocity and the position, position of every particle changes. In order to minimize the localization problem, PSO and Social Group Optimization (SGO) are introduced along with the Velocity Adaptation algorithm. This results in improving the location accuracy rather than SGO and PSO.

Deepa *et al*. [45] have introduce a technique in the coverage problem based on Levy Flight with WAO (LWAO) to overcome the failure in network coverage guarantee. This increase the ability of exploration in WOA. In order to perform the convergence optimization, LWOA are developed and determine the nodes which are deploy in the certain coverage area. The stuck in LWOA by KNN was very efficient in coverage optimization. Nearly 33% of nodes were optimized in this process.

Sekhar *et al*. [46] have developed metaheuristic based Group Teaching Optimization Algorithm with Node Localization (GTOA-NL) for WSN. The task was to decrease the localization error and maximum accuracy with the help of anchor nodes. The unknown nodes are determined by the known nodes (anchor nodes). When the node begin to start collecting information from the neighbouring sensor nodes was followed the GTOA-NL and identifies the node position using anchor nodes. To perform this function in GTOA-NL by Euclidian distance that determines the location of then node distance. This technique is based on GTOA-NL for WSN indoor communication. By this process GTOA-NL gets node position by anchor nodes and this derives fitness function from Euclidian distance. This executes the process of minimization of error in localization and maximize the accuracy.

Singh *et al*. [47] author have developed an efficient localization approach by introducing a hybrid optimization of Dragonfly Algorithm (DA) with Firefly Algorithm (FA). This combination of exploration technique DA-FA was exploit for obtaining the ideal global solution. Static swarm and vibrant swarm represents the ability to explore and exploit DA's. FA has the problem in objective function and light intensity variation. In the single anchor node, its projection of size angles by using hybrid of DA-FA within the circle. DA-FA is effective in performing the localization error compared with competitive algorithm. DA-FA was used in localization and it helps to maintain energy in the node. Table 2 represents the analysis of existing metaheuristic techniques in WSN.

Table 2: Analysis of existing metaheuristic techniques in WSN localization

Ref no / Author	Technique	Objective	Advantage	Limitations	Performance
Pan *et al*. [38]	Hybrid of WAO and QUARTE	To solve the node localization process and optimize the accuracy.	Accuracy of node location in WSN is increased.	QUARTE algorithm cause many variants.	Location error and distance error are identified Distance error - 20.76
Chowdhury *et al*. [39]	FIS and RGSO	To increase the area coverage and minimize the consumption of energy	Unnecessary movement towards the grid-point is reduced.	Obstacles that cause deviation when calculating the lifetime	Minimization of consumed energy-45%
Lu *et al*. [40]	Improved ABC using Teaching strategy	Maximize the convergence with certain no. of SN	Solve complicate WSN coverage problem.	This is complex in prohibited coverage area.	Solve WSN coverage problem
Rama *et al*. [41]	Hybrid of FA and ANN	To decrease the error in localization	Track the mobile nodes accurately in WSN.	Requires various applications to get optimal location accuracy	Increase Localization accuracy-95%
Singh *et al*. [42]	NMRA	Location optimization by using 2D strategy	Locate a target node by using single anchor node.	Lateration process is not possible without the use of DV-HOP, DV-DISTANCE	Minimize localization error - 0.21

Ref no / Author	Technique	Objective	Advantage	Limitations	Performance
Sruthi *et al*. [43]	Hybrid of GW and AL	To find the location of every unknown node	By the hybrid of GW with AL attain good accuracy.	Accuracy is less in complex data.	Maximum throughput ratio-7000bps, accuracy-98.8%,reduced error-1.4%
Nagireddy *et al*. [44]	Velocity adaptation based PSO	Localization error is minimized	Error percentage is decreased as the increase of anchor node percentage.	PSO is slow and complexity in convergence	Error minimize-0.0045
Deepa *et al*. [45]	Hybrid of WAO and Levy Flight (LWOA)	Optimization in WSN coverage	Optimal solution for the real time application.	It cause deviations in solving real time problems.	Nearly 33% of nodes were optimized
Sekhar *et al*. [46]	GTOA-NL	To minimize the error in localization and maximizing accuracy.	This technique is used to minimize the localization error.	GTOA-NL is suffer from efficiency in time synchronization.	Minimum localization error- 0.36,
Singh *et al*. [47]	Hybrid of DA and FA	Efficient localization approach for WSN	Convergence time is reduced and better accuracy.	For occurring efficiency, it needs large number of simulations.	Reduce energy and maintain convergence time.

7. REVIEW BASED ON ARTIFICIAL INTELLIGENCE FOR WSN LOCALIZATION

Lai *et al*. [48] have introduced a method of Force Direct (FD) and Transfer Learning (TL) for hole detection in WSN coverage. This topology was based on the capability of FD-algorithm and image captioning power of convolutional Neural Network (CNN) with TL. FD-TL is a pure topology based approach and it can perform both triangular and non-triangular for coverage the holes in WSN. The potential coverage holes are recognized from the generated layout by conventional ANN. FD-TL can generate the possible layout from the given input topology and this acts as an aid for recognition process. This methods achieves sensitivity of 90% and coverage 96%.

Chu *et al*. [49] have developed the process of classification methods that was used to detect the problems based on data learning and making decision by the combination of statistical learning and expert knowledge method to detect localization problem. Naive Bayes classification is applied to perform the task in data fault in CH’s to increase the reliability in WSN. This technique shows the effective way of forwarding correct data to WSN and the accuracy is 97% throughout the data learning process.

Sukhvir *et al*. [50] have introduce a taxonomy of Machine Learning Based Indoor Localization (MLBIL) to increase the localization accuracy. For investigating the computation time and local accuracy, algorithms like decision Tree (DT), SVM, RF and KNN are used. The exact location was identified and diving the area by classification and regression performs. This technique increases the localization performance.

Abhilash *et al*. [51] have developed machine learning by Average Localization Error (ALE) based on Support Vector Regression (SVR) method for decrease the time consumption. In this technique S-SVR, Z-SVR and R-SVR are used for the fast and accurate prediction of ALE. The modified Cuckoo Search (CS) simulations can extract the feature values. This method calculates the ALE by computation time and observed the time taken by the method is lower than the modified CS algorithm.

Akbari *et al*. [52] have introduced a method based on reinforcement learning and fuzzy logic for obtaining energy efficient and life time optimization in WSN. This technique is carried out by Optimum Network performance (OPNET). This technique uses three scenarios to approach the IoT routing problems. In the first approach fuzzy logic is capable in determining the path stability by the stability input variables. In the second scenario the coordination of reinforcement learning and fuzzy logic was to estimate the optimal path. In the third IEEE 802.15.4 protocol with low energy consumption, low data rate, and low construction cost.

Robinson *et al*. [53] have introduced to increase the amount of localization accuracy in WSN, have developed a method of 3-dimensional Manifold and Machine Learning (ML) based Localization algorithm. In order to obtain maximum efficiency, faulty nodes in the sensor nodes are identified by this technique. Root Mean Square Error (RMSE) was used to measure the error for quantization and increase better accuracy in WSN. This can reduce re-programming and useful data are extracted from the network. By this model, transmission error range decreased and increase the localization accuracy by identifying the unknown nodes.

Kumari *et al*. [54] have developed Machine Learning (ML) approach for Uncovering Excavators' Last Known Location Using Bluetooth and Underground WSN for finding the man and the machine can be found in case of accident in mining process. This method was introduced by the Machine Learning Architecture for Excavators' Location Detection (MLAELD), in which Bluetooth Low Energy (BLE). The live location is tracked and the data are collected from the multiple beacons at the certain point in a closed area. MLAELD finds the location of excavator by RSSI.

Madhavi *at al*. [55] have introduced Support Vector Machine (SVM) by Particle Filter (PF) with machine learning technique. PF was most considered and accepted by filtering algorithm and localization problems. The main benefit of this technique was avoiding arithmetic challenges throughout the process. Machine Learning classifier was employed and reduce the communication cost for sensor compression. This technique achieves target note localization, maximize the network coverage and minimize the energy efficiency.

Furat *et al*. [56] introduced wireless positioning network location prediction depends on machine learning technique. Behaviour in variation of RSSI signal unable to get tag in their range of reading. Therefore, this technique with enhanced algorithm improves WSN localization based on ML technique. By the enhanced algorithm basis of WSN has the ability to forecast the precise manner in the sensors position. Multi-Layer Perception (MLP) algorithm, provides a better estimation with an increased accuracy 94%.

Poornima *et al*. [57] have developed an Online Locally Weighted Projection Regression (OLWPR) for security in WSN. The irrelevant input data are handles by Principal Component Analysis (PCA) for the dimensionally reduction of LWPR. This technique was carried out in the network by three techniques. Set of features are extracted by PCA technique in data compression process. For this technique, PCA was used to extract set of features from high dimensional and it acquires much information without deviating the main objective, the prediction of data was carried out by memory-based locally weighted learning (LWL). This creates a local model and uses subset for data prediction. Table 3 represents the analysis of existing learning methods in WSN.

Table 3: Analysis of existing learning methods in WSN localization

Ref no / Author	Technique	Objective	Advantage	Limitations	Performance
Lai *et al*. [48]	FD and TL	Detect and Cover the hole in the coverage.	Detect holes from the input snapshot.	Dynamic data are generated in the continuous monitoring activity.	Sensitivity-90%, Coverage-96%
Chu *et al*. [49]	Naive Bayes	Identifying the correct data.	Noise is removed and obtain more accurate.	Optimal classification parameter is not possible.	Accuracy-97%
Sukhvir *et al*. [50]	MLBIL	Increase the accuracy in indoor localization in WSN	Improves the localization performance	Only applicable for the particular environment.	Increase the accuracy

Ref no / Author	Technique	Objective	Advantage	Limitations	Performance
Abhilash *et al*. [51]	ALE based SVR	Predict and minimize the average localization error	Minimize the time consumption.	When dealing with noisy data, the performance is low	Correlation Coefficient R=0.82
Akbari *et al*. [52]	Reinforcement logic and Fuzzy logic	High reliable rout in IoT by using fuzzy logic and reinforcement technique.	Network lifetime and minimize the power consumption	It lost more bits when the packet node cannot send data	Energy and Signal to noise data are consumed.
Robinson *et al*. [53]	Machine Learning	High accuracy and reduce energy consumption.	Reduces re-programming and extract useful data from network.	Complexity in the analysing process.	Location accuracy is achieved in the highest range
Kumari *et al*. [54]	MLAELD with BLE	By machine learning to track the live location of excavator by MLAELD with BLE.	In real time, this technique used to track and detect the person.	Error is high when compared to other methods	Location accuracy is high.
Madhavi *at al*. [55]	SVM by PF	To obtain the perfect coverage and energy efficiency	Good performance in target location and maintain energy consumption.	It has a problem in achieving optimal coverage.	minimize communications nodes nearly 49%
Furat *et al*. [56]	Machine Learning	WSN to improve the position prediction.	Accuracy in optimal forecast.	This needs larger number of anchor nodes to localize the target nodes	Prediction accuracy-93.91%
Poornima *et al*. [57]	OLWPR	Anomaly detection in WSN by using ML.	High deduction rate, false alarm rate.	This has optimal issues in the detecting the error rate	Deduction rate-86% , very low error rate-16%

8. ANALYSIS OF METHODOLOGY, CHALLENGES AND ITS SOLUTIONS

The challenges and features are discussed by the enhancement of feature works. In the recent days WSN experience various issues including area coverage, energy efficiency data transmission, data fusion, data transmission and deduction, security and query processing. Among all the optimization algorithms are not able to solve optimization problem. Fig. 4 represents the goals of WSN localization.

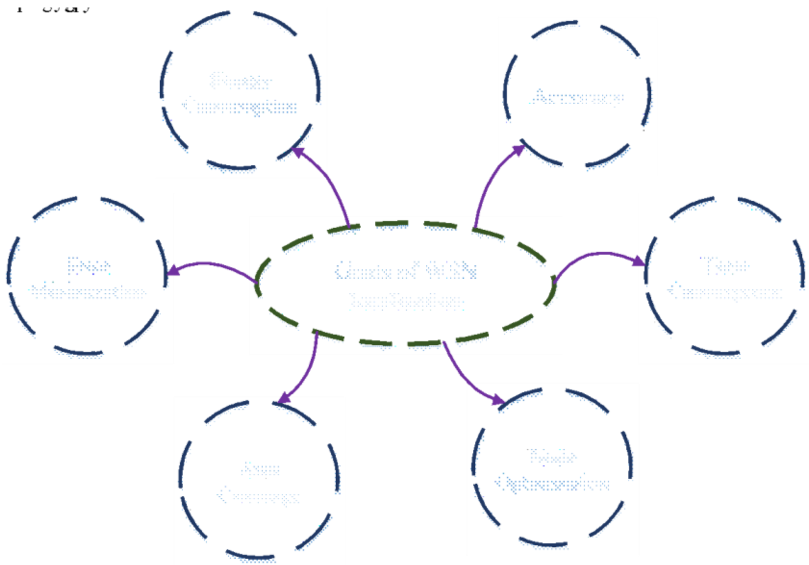

Fig. 4. Goals of WSN localization

8.1 Localization Accuracy

- The process of metaheuristic and AI based techniques still suffer to localize the accurate location of the unknown nodes.
- Still there exist a gap to develop an efficient localization technique for achieving high localization accuracy.
- Presence of irreplaceable nodes cause increase in the energy consumption. Sometimes it cause deviations in the unlocalized nodes.

8.2 Energy Consumption and Time Convergence

- Overall energy in the whole network is calculated by the total amount of energy consumed during the transmission of packets by each node.
- Reasonable consumption of energy can optimize the lifetime of WSNs.
- Many researches highlights the efficiency in the energy consumption, but still WSN localization of nodes are suffer due to energy efficiency issue. Recently, deep learning techniques like Reinforcement learning and Fuzzy logic has obtained high reliable routing with efficient energy consumption.
- Modified metaheuristic algorithm is also implemented for better accuracy and energy efficiency reduction in WSN localization.

8.3 Minimization of Error in Localization

- Accurate estimation is the key factor of WSN to provide correct conclusion for the end user.
- For obtaining accurate position in the localization process was obtained by the time of arrival technique.
- Path planning techniques of Z-curves and D-connect are used to minimize the localization error but it cause deviations in the coverage.
- These errors are minimized by NMRA and hybrid of GW, AL, etc., are some techniques used in optimization algorithm.
- The average localization error is predicted for WSN localization by using machine learning techniques. The process of estimating the coordinates of unknown nodes is still a challenging task.
- Anomaly detection in WSN by using ML, the errors in localization is minimized by obtaining the threshold value.

8.4 Area Coverage

- Most of the complex issues in WSN localization is area coverage. Also, the sensor to cover the physical area is important for localization.
- Number of hybrid techniques are used in path planning to obtain the maximum area coverage. But in some scenarios it is challenging task to detect the

8.5 Optimization of Nodes

- Optimization of node is defined as speeding up response time of the node.
- By increasing the number of anchor nodes takes larger time to optimize the node.
- It maximize the search performance and solving various real time problems but in rural environment the nodes are not optimized.

9. CONCLUSION

The localization in WSN have the various issues in localizing the unknown sensor nodes. Therefore efficient architecture needs to develop a better localization of unknown nodes in WSN. Recently some techniques like path selection, metaheuristic and AI based techniques are developed to achieve such objectives. However such techniques are suffered from few challenges like accuracy, time convergence, energy efficiency, error, etc. For improving localization accuracy, path planning trajectory plays an important role in it. The overcome of these issues are explained briefly in the paper by path planning based localization of WSN. To provide the exact location of the indoor environment, the researches research about to overcome the issues in localization process. For obtaining the better accuracy and efficiency metaheuristic is extensively used. Because, it is robust and maintain the performance in good quality by the rapid changes in the environment. In the recent days, AI based systems facilitate the optimization of service in WSN localization. This is also offering the WSN to have reality and it allows the system to monitor the activities and decision making process. From the review of this architecture is concluded that most of the existing techniques highly focus on improving the localization challenges in WSN using metaheuristic based path planning and AI techniques. Further the process of swarm intelligence is used in most of the research communities. The growth of deep learning and different strategies are embedded in WSN is enhanced in future work. The development of WSN needs the hybrid optimization to overcome the limitations in the optimization techniques. This needs learning platforms for providing the better solutions. The review of this paper provides the challenges and the issues in the proposing methods of localization process. In the future work of WSN can achieve efficient performance such as increasing localization accuracy, maximizing the area coverage, reduce the obstacles, optimization of nodes and minimize the energy and time consumption

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