A Review on Wireless Sensor Network Localization Techniques: Deployment and Challenges

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Abstract.

Because of the ubiquitous real-time applications they make possible, Wireless Sensor Network (WSN) technologies are becoming more important and popular in many different industries, including manufacturing, smart city planning, transportation, healthcare, and the IoT. In this study, we survey recent efforts to solve the problems of WSN coverage, deployment, and localization by using latest available techniques along with AI and machine learning techniques. We provide an in-depth review of the most current research on the topic, focusing on the studies that have used different latest available techniques along with AI and machine learning techniques to achieve different WSN goals in the previous several decades. This would let the reader learn about the most recent uses of AI and machine learning techniques for addressing various WSN issues. Then, we compare and evaluate the many AI and machine learning approaches employed in WSNs on a broad scale to help the research community choose the best approach and weigh the costs and advantages of using different AI and machine learning approaches to problems like WSN Localization.

Keywords. artificial intelligence, machine learning, range based, range free, deployment, localization, wireless sensor networks.

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I. Introduction:

Because moving robots inside are becoming more important in transportation and a variety of location-based (LB) services, the topic of indoor localization has become a highly popular topic of debate in the scientific community in recent years [1–4]. This is due to the fact that the importance of moving robots inside has increased. An rising variety of location-based services, also known as LBS, are being developed to enhance people's quality of life as a consequence of substantial advancements in RF and MEMS technology. In order to provide location information, security, or entertainment, the location-based service often gathers geo-data in real time from a smartphone. The usage of LBS technology enables customers to "check in" at a range of different venues, including coffee shops, retail stores, restaurants, and a broad variety of other businesses. When it comes to any of these services, having previous information of the region in question is the single most important and necessary need that must be met. When it comes to navigation in the vast outdoors, many people choose to make use of traditional techniques in conjunction with GPS [5, 6]. On the other hand, it might be very difficult to achieve the appropriate degree of localization accuracy when employing them for usage in applications that need indoor localization. There are a great many reasons why GPS-based gadgets don't work as well indoors as they do outside. These reasons may be broken down into many categories. The biggest contributor to this problem is that GPS signals are not always accessible inside of structures. In addition, there are difficulties such as signal attenuation brought on by the layout, problems with channel fading, the amount of barriers, and their thickness, all of which change based on the interior environment. As a result, a solution that does not rely on GPS is often required in order to effectively address the difficulties associated with indoor localization. Numerous technologies, including Bluetooth, Wifi, RFID, etc., are often used for the purpose of localisation inside of buildings [7], [8]. The wireless sensor network (WSN), which is an emerging technology of the 21st century [9], [10], provides a broad range of applications that are based on localization and tracking in order to take use of its capacity for smart sensing and ubiquitous computing (L&T). A wireless sensor network, or WSN, is constructed from a large number of wireless sensor nodes. These nodes are very inexpensive and are dispersed throughout a physical space for the purpose of monitoring anything of interest. Every node in the network is not only able to communicate with the nodes that are directly next to it, but it also has the capability of gathering data and information, processing and storing it. The first major category that may be used to classify the applications of WSNs is monitoring, and the second primary category that can be utilised is tracking. Applications for monitoring include tracking power use, monitoring the position of inventory, monitoring the environment both inside and outside, keeping an eye on health, and monitoring the environment both inside and outdoors. The monitoring of the movements of birds, tiny animals, and insects is one example of an environmental application. Other applications include the detection of forest fires and floods, the mapping of the biocomplexity of the environment, and the research of pollution. Applications of tracking may include monitoring cars, objects, animals, and even people and their movements. Applications for tracking also include applications related to the environment. Localization and tracking of targets, often known as L&T [11–15], is one of the most significant applications for wireless sensor networks and is abbreviated as L&T. The most major benefit of using WSN as a solution to the L&T problem is the fact that it is a technology that requires little power and is also quite inexpensive.

II. Literature Review:

Over the last several years, a number of different localization methods for WSNs and IoT have been suggested. When it comes to our line of business, the most important concern is giving attention to the many security-related components of the localization process. As a result, we give overviews of relevant research that have been categorized into the following four categories: techniques that are Artificial Intelligence (AI) based,range-free, range based and security-aware methods.

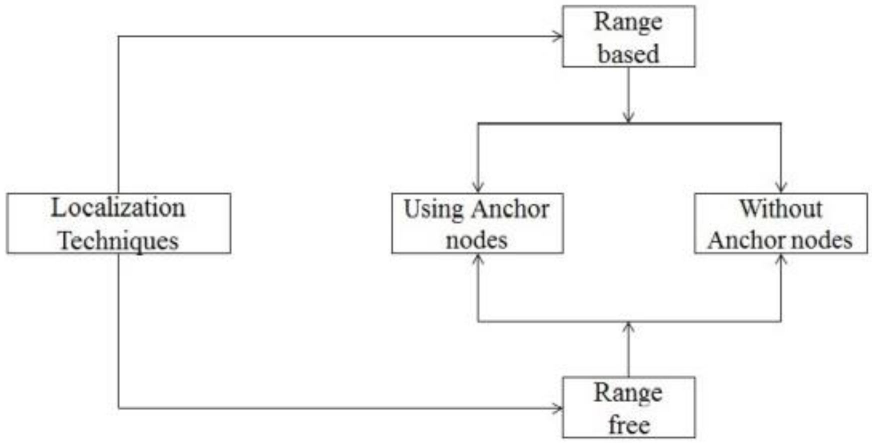

Figure1. Localization methods for WSNs

A. Range Based Localization

Numerous range-based localization techniques have been developed, as was covered in the first half of this article. An RSS-based localization method called Uncertain Data Mapping (LUDM) was developed for use with WSN by Luo et al. [12]. The results of the simulation reveal that the strategy that was provided performs better than alternative options when compared to the absolute mean localization error. On the other hand, the four anchor nodes are immovably affixed in their positions at the four corners of the testing area. In addition, the use of the RSS attenuation model, which is intended to increase generalisation in unknown localization contexts, may result in a significant reduction in the accuracy of the localization.

The localisation of a dispersed sensor network [16] that is linked wirelessly is of critical significance for a wide variety of applications. The range-based localization and tracking issue for extremely large dynamic, that is, moving sensor networks is the primary topic of discussion in this study. The explorability of undersea systems is something that we look at using enormous swarms of very small sensors that have limited and constrained capabilities. In this context, we offer a localization technique that is based on least squares, and it demonstrates better performance while also having a lower computational cost than existing approaches, such as those based, for example, on unscented Kalman-filtering or semidefinite programming. Both newly developed algorithms and those already in use are assessed by means of two distinct system models, each of which is taken from actual fluid dynamics. In addition, we explore the performance gain of the new technique in terms of estimate accuracy, quantify the computing cost of the new method, and compare our algorithm to existing approaches that are based on the least-squares approach.

In [17], a range-based distributed localization method is developed with the purpose of addressing the issue of the inaccuracy in localization as well as the rate of localization coverage that occurs in wireless sensor network nodes. The introduction of the confidence component, which makes the credibility as weights adding to the coordinate computation of the unknown nodes, is the key to the algorithm's ability to bring the localization error down to a more acceptable level. When compared to the traditional Euclidean localization technique, the results of the simulation demonstrate that this algorithm is capable of significantly enhancing the positioning accuracy and promoting the localization coverage rate.

The authors of this study [18], investigate the use of benchmarks as well as the possibility of combining two approaches in order to address the problem. In the first, a device known as an inertial measurement unit (IMU) is included into the equation to take into account the path that the vehicle is taking (IMU). The second assumes that lanes have been located, and that data about roads is prepared and ready to be accessed in advance. The method of data fusion is based on a modified version of the Extended Kalman Filter (EKF), which may either use lane boundaries in order to numerically optimise the density of posterior state estimates or filter out the unbounded noise process that is integrated at the gyroscope. It has been shown that, in comparison to conventional range-based approaches, the proposed solutions enhance the possibility of obtaining an accuracy of 0.5 metres from 60% to 85-90%, which is a significant improvement.

For range-based source localization [19], a popular method that finds the most likely location of mobile station is least squares estimate. In a non line of sight (NLOS) route between the mobile station and the base stations, these solutions cannot give the desired precision. Many techniques have been developed to detect and correct this flaw, but they all introduce more work for the programme to do in its runtime. In contrast, modern locating systems rely on a dense network of base stations, which necessitates a computationally efficient algorithm. To find and fix the NLOS mistake, we suggest a brand new technique here that makes use of the subspace approach. Extensive simulation tests demonstrate the superiority of our approach over state-of-the-art alternatives, particularly in large-scale scenarios.

In wireless sensor networks, localization [20] is essential. In recent years, several range-based localization methods for 2-D sensor networks and densely distributed 3-D sensor networks have been suggested. The sparsity of the network makes it hard to get an appropriate sequence of nodes to be sequentially localised, making range-based localization in sparse 3-D sensor networks a complex challenge. Although the patch-and-stitching localization technique has proven effective in resolving the sparseness issue in 2-dimensional networks, the best way to combine two patches in 3-dimensional networks when there are insufficient shared nodes remains uncertain. In this study, we derive the circumstances under which two subnetworks may be merged uniquely, therefore providing a solution to this difficult issue. The translation parameters are seen as unknowns in the proposed method, and a set of equations is developed to allow for their unique solution. Our technique is new in that it uses similar nodes and connecting edges to merge neighbouring subnetworks, greatly increasing the likelihood that the subnetworks may be combined. So that we may gauge how well the suggested method works, we do comprehensive simulation trials. The findings reveal that in sparse 3-D networks with an average node degree of 11 and an anchor ratio of 5%, the proposed approach was able to localise more than 90% of nodes, whereas the best known solution could only localise 52% of nodes.

In this work [21], the problem of determining the location of a target in an unsafe environment, in which no connections may have a direct line-of-sight, is investigated. It does this by making use of distance estimates that are derived from integrated received time of arrival and signal strength observations. Additionally, it makes use of the known architecture of available reference points to act as an irregular antenna array. This allows it to estimate the azimuth angle that exists between a reference point and a target. The measurement models may be linearized by using this imaginary azimuth angle data, which in turn enables the easy closed-form derivation of a new estimator. In this paper, we show that the performance of localization can be significantly improved by utilising a fixed network design in which the target's orientation with respect to a line formed by a pair of anchors can be accurately predicted. This design allows for a more accurate prediction of the target's position in space. The unique technique has been validated via the use of computer simulations, which verify our intuition that we may profit from the knowledge that is already available in a network.

In the work[22], offer a generic localization framework based on graph optimization that can operate with a wide range of measurement kinds and measurement times. To that end, we'll be focusing particularly on range-based localisation. To estimate the robot's trajectory, a optimized graph based approach is used to a position graph that contains range and trajectory smoothness constraints. The algorithm's convergence is also investigated, and the localization accuracy is studied in relation to the number of optimization iterations and the size of the optimization window. Extensive testing on quadcopter in a wide range of settings confirm the efficacy of the proposed algorithm and show a much greater localization accuracy than the current range-based localization approaches, particularly in the altitude direction.

Location leakage may harm wireless network anchoring [23]. This letter hides anchor positions in range-based localization using a secret sharing technique to safeguard anchor location privacy. Due to its division into several secret shares and concealment in the constant term of the secret polynomial, no network node, including the server, may reveal anchor location information during the localization process. Simulations evaluate how effectively the proposed system protects user privacy, provides exact location updates, and reduces operating costs.

B. Range Free Localization

We provide a wireless geo-localization approach without range in [24]. This approach is radio range-resistant (IRRD). The technique does not depend on the widely held assumption that all anchor (location-aware) nodes have the same communication range. It uses two or more anchor nodes to determine the general position of unknown (location-aware) nodes without a ring. The True Intersection Points (TIPs) used to construct the anchor nodes' shortest communication overlap polygon (SCOP) are located in the first step. Estimate the node's position after compiling all TIPs into a SCOP. After creating a geometric and mathematical model, a new localization method is presented. This method does not require all anchor nodes to have the same radio range.

For a wide variety of uses, localization in wireless sensor networks [25] is a crucial problem. In order to improve localization accuracy without raising hardware or communication costs, this work introduces a new range-free technique based on DV-Hop. As a first step, this technique employs an average hop-size adjustment to minimise range mistakes. Second, the technique employs the weighted least square approach and an enhanced equation solving method to boost localization precision and mitigate the effects of distance measurement inaccuracies. The programme then incorporates the new information into the equation solving process to refine node positions. Simulation findings demonstrate that the suggested approach outperforms the standard DV-Hop algorithm and other comparable algorithms.

Wireless sensor (WSNs) networks have been more accessible in recent years [26], leading to the development of a plethora of novel, often "smart," new applications. As the number of use cases for WSNs grows, so does the attention given to localization within academic circles. In the academic literature, localization is often classified into two categories: range-based and range-free. While the former depend on distance measurements to determine node placements, the latter make use of the network's connection information. Since the DV-Hop technique may locate WSNs without the need of a physical range, it has been the subject of much research. In this research, we will take the original version of this reference approach and assess how well it performs when improved using an unique weighted hop-size expression. The outcomes of the simulations could get more accurate.

Nowadays, ultra-wide band plays a crucial role in short-range communication [27], particularly for indoor localisation. However, additional elements of the inside environment lead the localization to be less exact and the distance inaccuracy to grow. The paper introduces a novel metric with which to assess the effectiveness of UWB technology for indoor localisation. In order to calculate the inaccuracy of distance based on weighting algorithms, the suggested approaches make use of the received signal strength indicator (RSSI).

There are many uses for wireless sensor networks [28], and knowing where the sensors nodes are at all times is crucial. The localization methods may be broken down into two categories, centralised and decentralised, depending on how the computations are spread throughout the nodes that make up the sensors (distributed). There are two broad types of distributed localization methods: those that need little or minimal range information, and those that rely on it. Although suggested enhancements to DV-HOP have helped increase the algorithm's localization accuracy, DV-HOP is a range-free, straightforward localization method that falls short in this regard. Striking a balance between robustness and simplicity in addition to pinpoint precision in location is difficult. The most crucial aspect of any localization algorithm is its accuracy error, thus we've chosen to concentrate on that here. Our research is on range-free DV-HOP. We developed DV-HOP in MATLAB to properly examine the method. The focus of this article is to introduce readers to Range Free localization methods and to provide context for the potential proposal of further localization methods applicable to wireless sensor networks.

The resolution limit of localization error provides a measure of the maximum error-recognition capability that may be shown by range-free techniques. In this study [29], we demonstrate that the present resolution restrictions are inadequate. Finding the real upper limit of localization error at zero range is, thus, the major goal of this work. For this purpose, we describe two approaches, one suitable for usage in an ideal channel and the other in a shadow-fading channel. We first define and characterise the essential features of an ideal channel with a maximally movable distance, then introduce the concept of a critical point and its related proposition. Then, a method is given for determining the genuine upper limit on resolution over a perfect channel. Following the steps outlined in the stochastic channel model for shadow-fading channels, we first discretize the random variables at each time instant, then determine the instant resolution limit, and finally derive the expectation of the resolution limit. The results of these simulations corroborate the resolution limit we've calculated. It's clear from the outcomes that the resolution limits and bounds established by the existing methods are far lower than the genuine resolution limit.

Wireless sensor placement is one of the most difficult tasks. Wireless Sensor Networks (WSNs) have low placement accuracy [30] because most range-free localization algorithms ignore these anisotropic effects. A powerful Sun Flower Optimization Algorithm (SFO) is suggested for range-free anchor-free localization in WSN using Distance Vector-Hop (DV-Hop). Even without a beginning point or anchor point, an unique goal model may locate undiscovered network nodes. Localization accuracy increases significantly over older methods.

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C. Artificial intelligence (AI) techniques

Position estimation using filter approaches for safety-critical applications [32] is a large area of study. Several methods exist for estimating the condition of the Global Navigation Satellite System (GNSS), each with its own advantages and disadvantages depending on the specific use case. The KF, EKF, and PF have been devised and tested for state estimation. Algorithms for "map-matching" combine GNSS localization data with spatial road network data to pinpoint a moving vehicle's position along a known route. The purpose of map-matching methods is to make use of existing data in the form of transportation networks. Integrating digital map data into the standard KF framework is challenging, however, since this restriction produces extremely non-Gaussian posterior densities that are notoriously hard to adequately express with the tools at hand. The PF method allows for precise modelling of velocity and heading measurement errors due to its lack of constraints on non-linearity of models and noise distribution. The primary benefits of using the PF method for map matching are: One) The PF method is a straightforward technique to add road map data into the location estimate process. 2) The PF method can capture distributions with several modes. In this paper, we describe a set of PF-based location estimators that are tailored for use inside a smart GNSS-based localization system. As a part of a built satellite localization system using AI technologies, the PF-based map matching algorithms are given on a mathematical foundation and tested. Similarly, a "digital trap map" may be used to pinpoint a train's exact position inside the rails, allowing for seamless integration in the realm of railways. The localization systems that assist intelligent transport system navigation may have their performance enhanced by data fusion, a fundamental component of which can be a map-matching algorithm (ITS).

Identifying and categorising audio source signals over broad areas is suggested [33] using an intelligent system. The system consists of an AI system and a mic array that is poorly distributed. In order to pinpoint the origin of an acoustic wave and extract its characteristics, a sparse array is set up. The time difference in arrival is used as a metric for localisation (TDOA). At the outset, a subspace-based time delay estimation technique is used to estimate the TDOAs between a minimum of four sensors. The estimated TDOAs are then sent into a constrained least squares (CLS) method, which is used to pinpoint the exact location of the point of origin. After the source has been discovered, the MVDR beamformer and a postfilter are used to isolate the source signal. Using machine learning, the acquired audio signals are categorised further. The AI-based classifier relies heavily on a technique called ConvLSTM. The input layer of the ConvLSTM is the MFSC. The localization inaccuracy, the quality of the audio, and the F 1 scores are used to evaluate the effectiveness of the proposed system. The suggested TDOA-based localization and separation method is validated through simulation.

In [34], multi-objective algorithms with biological inspiration are proposed for maximising both network longevity and target coverage. The effectiveness of four multi-objective methods with biological inspiration is examined. We recommend the NSPSO, MOPSO and MOEA/D and NSGA-II frameworks as local search operators. In addition, there are two mutation operator frameworks. The suggested method satisfies the connection requirement and hence solves the issue. In order to investigate additional cover sets and the desired coverage probability, a self-adaptive heuristic operator was developed and the four approaches were supplemented. The findings prove that a strategy using multi-objective optimization algorithms and self-adaptive heuristic operators is the most effective and efficient.

Weakly-supervised temporal action localization (WS-TAL) is intriguing but challenging since training only uses video-level action category labels [35]. WS-TAL may categorise videos using automatically recovered video tags without temporal action boundary annotations in training data. In unedited recordings with several actions, such basic video-level supervision always causes confusion. Our innovative action proposal evaluator and CleanNet allow pseudo-supervision by utilising temporal contrast in snippet-level action categorization predictions. The new action proposal evaluator requires temporal contrast to boost the chance that high-scoring action proposals match real action occurrences. CleanNet's new action localization module aids complete training. Action localization is an afterthought in most WS-TAL implementations. Using THUMOS14 and ActivityNet datasets, CleanNet outperformed other state-of-the-art WS-TAL algorithms.

In this work [36], provide a novel approach to indoor localisation using Bluetooth Low Energy (BLE4) technology. The envisioned tracking system predicts people's whereabouts inside buildings by using a mobile beacon, a wearable gadget, and permanent anchors. By using a machine learning technique in conjunction with the received signal strength indication, we are able to achieve high precision without invading users' privacy or restricting their mobility.

Indoor localization, which is accurate and reliable, is essential for many robotics applications [37], including warehouse management and surveillance. UWB time difference of arrival (TDOA)-based localization is a lightweight, low-cost solution that can scale to many devices. Limited-resource multi-robot applications benefit from this strategy. However, because to substantial measurement bias and outliers, market-available UWB radios' localisation accuracy is generally poor. Our reliable UWB TDOA localization method uses I learning-based bias correction and (a) M-estimation-based robust filtering to handle outliers. Our system's main advantages are (a) its learnt biases may be applied to a broad variety of UWB anchor configurations and (b) its efficient implementation on hardware with limited CPU resources. Crazyflienano-quadcopters will show our approach. Some studies show that the suggested localization framework, which simply uses the onboard IMU and UWB, reduces localization errors by 42.08 percent compared to the baseline approach without bias correction. In our last study, we autonomously track a quadcopter using UWB TDOA localisation.

Smartphones have quickly become the go-to method for indoor localization and user location assessment [38]. Wi-Fi, RFID, and magnetic sensing are the key technologies being used by existing systems for crowd tracking. These devices rely on LAMF, which might compromise their performance due to magnetic clutters. Not every situation lends itself to these methods since they rely on either already completed mapping surveys or the existence of operational beacons. We place small-volume, high-moment magnets in precise geometric configurations to generate guided magnetic signature patterns for analysis. These characteristics define a magnetic environment that is both clear and present for the sensor carrier in motion. The dispersed magnets' one-of-a-kind patterns are trained into the localization algorithm, which then finds them in the continuously flowing data. Our help is dual in nature. To get started, instead of using control active magnetic transmitters, we employ power-free passive permanent magnets. Second, instead of relying on the magnetometer's fixed location, our localization method makes use of the smartphone's mobility. Previously, we focused on only one possible superstructure pattern. This paper presents an improved version of that technique for multisuperstructure localization, one that is capable of pinpointing the user over a wider region. The experimental findings show that artificial intelligence can improve localization accuracy to 95%, with an MLE of less than 1 metre (AI).

In [39] provide a thorough review of the literature spanning the years 2010–2021, focusing on the research that have used different artificial intelligence techniques to achieve diverse WSN goals. By doing so, the reader will get an appreciation for the current uses of AI techniques in relation to various WSN difficulties. Then, we compare and evaluate the various AI approaches employed in WSNs on a broad scale to help the research community zero in on the best strategies for addressing the Coverage, Deployment, and Localization problems that arise in this context. Last but not least, we end the study by outlining the remaining research questions and potential future lines of inquiry.

III. Comparisonof Various Localization Techniques

Sr. No.	Title	Localization Method used	Remark (Pros and Cons)
1	G. M. Hoang et. al,[18]	A localization approach that makes use of least squares support vector regression (LSSVR) parameter optimization and is based on RSSI is shown here.	The method has a localization error that is 11.70%, which is quite a significant percentage. In addition, the experimental area that was examined was relatively tiny (i.e. 10 metres on a side, 10 metres high, and 10 metres deep). In addition to that, the model that is presented in this study is reliant on the optimization of model parameters.
2	A.Abolfathi et. al, [19]	An RF-based system called RADAR is being proposed for the purpose of finding and monitoring people inside of buildings.	This model is assessed at a distance of 43.5 metres by 22.5 metres, and the results show that the localization accuracy achieved is in the range of 2 metres to 3 metres. Therefore, the precision of the localisation is rather great.
3	X. Liu et. al., [20]	In order to manage the time-sensitive applications, a modified version of the KOS-ELM algorithm with a forgetting mechanism, known as KOS-ELMF, was proposed.	This document is not designed for use in the tracking and localisation of targets; rather, it is meant to be used for online learning of stationary applications.
4	S. Tomic et. al, [21]	A localization approach, based on CNN, has been proposed. This framework moves the difficulty of online prediction to an offline preprocessing stage.	The simulation area that is being evaluated is just 20 metres by 20 metres, despite the fact that the suggested system is better to other systems that are already in existence. In addition, the report does not examine how changes in the RF ambient dynamicity can affect future research.
5	X. Fang et. al, [22]	The proposed technique of localisation uses a Hybrid Wireless fingerprint, also known as a HW-fingerprint, and is	The fact that the localization accuracy attained with the suggested model is more than 5 metres is one of the drawbacks

		based on CNN.	of using this approach.
6	Y. Zhu and J. Hu, [23]	A localization approach using ad hoc networks that is based on a support vector machine that has been proposed.	The strategy that has been provided operates on the presumption that all of the nodes are connected to one another and that the locations of the anchor nodes in the network are already established. On the other hand, it's conceivable that this won't be achievable in real life.
7	S. A. Demilew et. al, [24]	A localization strategy based on the SVM that was proposed.	To begin, LSVM pinpoints the exact location of the network based only on connection statistics (that is, hop counts only). Because of this, the suggested method is more expensive than a localization system that is based on RSSI.
8	L. Yan and Y. Zhang, [25]	A statistical support vector machine (SVM)-based localization model that makes use of RSSI and other statistical features of the channel state information has been proposed (CSI).	The localization precision that can be achieved using the suggested model is more than 2 metres for the majority of the target sites.
9	M. Guadaneet. al, [26]	A semi-supervised online support vector regression model has been proposed (OSS-SVR).	Despite the fact that the suggested system can properly track a moving target, the simulation area that is being evaluated for validation of the proposed method is just 4 metres by 3 metres. On the other hand, real-life interior spaces are often far more expansive than this.
10	J. Thongkam, P. Supnakoon et. al, [27]	RSSI and WLAN were the foundations of the proposed positioning system.	The suggested method has a mean distance test error of 1.79 metres. However, since we relied on WSN to pinpoint the location of the target, we are unable to compare our suggested model to any others.
11	R. Mehannaoui and K. N. Mouss[28]	For the purpose of monitoring mobile targets in wireless sensor networks (WSN), integrated algorithm called RSSI+KF and RSSI+UKF based on trilateration and KF have been proposed.	The suggested techniques are computationally demanding compared to existing range-free localization solutions since they often calculate transmitter-receiver distances. This is true

			even if the suggested techniques have localization errors < 1 metre.
12	L. Guiet. al, [29]	The GRNN-based target localization system that is being proposed makes use of PSOC BLE nodes as well as a smartphone.	The suggested system has a localization accuracy of around 1 metre, although it has only been tested in an area that is 10 metres wide and 15 metres long.
13	V. C. S. R. Rayavarapu and A. Mahapatro, [30]	For the purpose of target localization, GRNN+KF and GRNN+UKF are two range-free algorithms that have been proposed.	Although the suggested techniques provide accurate localization down to a scale of 1 metre, the level of computational complexity is rather high.
14	Y. Zhu and J. Hu, [31]	A localization approach based on trilateration, centroid, and GRNN is proposed. Trilateration, Centroid, and Generalized Regression Neural Network is TCGRNN.	Despite the fact that the suggested model was evaluated over an area of 100 metres by 100 metres, the localization accuracy attained was around 8 metres, which is a very high value. In addition, in order for the system to provide accurate position estimates of a mobile target, it requires simultaneous estimates of trilateration, centroid, and GRNN.

IV. Research challenges:

In further studies, researchers may attempt to analyse the success of the activities that have already been completed with relation to deployment and localization concerns, such as obstacles and node mobility. Improved rooster behaviour, such as dynamically adjusting the number of hens and chicks in each group, or arranged behaviour in rooster characteristics to update their velocity in a structured way, could be implemented as an extension of existing works while using meta-heuristic optimization algorithms like CSO, which would allow for greater precision in localising unknown nodes. Other examples of improved rooster behaviour include: dynamically adjusting the number of hens and chicks in each For even better results, further research can be conducted into the possibility of combining one meta-heuristic algorithm. Thus, a hybrid algorithm would emerge, with efficient convergence and diversity movement taking precedence over pinpointing the maximum number of undiscovered node positions. After the most recent version of the algorithm has been built, it may be evaluated in more realistic environments, such as underwater WSNs, once this is complete. In addition, the localization error may be lowered further by assessing the performance of both centralised and distributed systems using a range of measurements. This can be done in order to compare the results. To further cut down on the location estimation inaccuracy, hybrid types of meta-heuristic algorithms, such as the Genetic Algorithm combined with the Firefly Optimization Algorithm, might be utilised. The metric in localization that has to be addressed in order to fulfil the various application requirements for the highest possible accuracy in localization is a problem for the research that will be done in the future. Therefore, in the future, instead of experimenting with various ANN designs, we may just use an optimization approach such as Backtracking Search Algorithm, PSO, etc.,. Artificial neural networks (or ANNs) are used in a specific branch of machine learning called deep learning. One potentially fruitful direction for future research is to investigate the use of existing methods in three-dimensional and real-world environments. It's possible that at the end of it all, we'll have a more accurate representation of the solution space, or we'll have found a way to apply the success of approaches like Search Economics to a wider variety of optimization problems. It is possible that more study will be conducted to evaluate how well present algorithms function in settings that have a number of different anisotropies, such as those that contain holes, unequal node densities, sparse networks, and irregular radio transmissions.

A exciting future development would be to conduct real-world testing to evaluate the effectiveness of the algorithm on a bigger data set and with additional metaheuristics. It is necessary to take into consideration scalability in terms of network density and diversity, network dimensions, signal propagation, and diversified data traffic, in addition to the effect of any additional protocol overhead that may be added as a result of doing so. All of these concerns and others are now being investigated by a number of ongoing research initiatives. It's possible that in the future, research may focus on developing more precise techniques for localising wireless sensors in their natural environments. Through the use of fuzzy control systems, noise may be decreased, and superior placement can be accomplished. The optimum placement of anchor nodes may lead to their installation in locations that are less likely to be obstructed by physical features. This might be the case if the best placement is achieved. As a consequence of this, next research may involve the development of a technique for determining the best locations for the anchor nodes in the network. Concerns about its safety in a variety of network setups might also be investigated further. In addition, it could be interesting to make an effort to generalise the results so that they can be used to a real-world WSN application.

V. Conclusion:

As such, we have offered a survey of some of the difficulties that arise with WSNs. Short descriptions and categorizations of several localization approaches in WSNs are provided. Over the course of the past several decades, academics and researchers have utilized a variety of localization approaches to try to figure out how to solve the problems of coverage, deployment, and localization in wireless sensor networks (WSNs). The difficulties that WSNs face and the ways in which latest techniques might help solve them have been examined and summed up. Coverage, deployment, and localization are summed up as examples of where research techniques may be used.

As we've seen, meta-heuristic algorithms based on population data are widely employed because of how well they perform. Both symbolic thinking and future planning are computationally costly, yet its members don't bother with either. They also have low memory needs since they don't have to maintain a lot of historical data. It has the potential to be resilient, able to keep performing at a high standard even while conditions around it change and diversify. The number of range based, range free and AI based technologies and solutions that help improve WSN service optimization is growing rapidly in the present day. Benefiting the IoT, and enabling systems to learn, monitor activities, and lend a hand in decision-making, is the coupling of developed techniques with WSNs, which is already a reality. We found that the majority of academic efforts are directed at the routing and clustering problem. In addition, owing to the nature of the issue or the features of the approaches, the research community has found that AI and machine learning based approaches for solving the localization problem in wireless-sensor network is emerged as a one of the effective technique in future.

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