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UWB Localization in Wireless Overlay System:An Overview

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Abstract

Ultra-wideband (UWB) is the technology, which is meant for the transmission of data or information by the techniques, where it spreads the radio energy in a wide frequency band (3.1-10.6GHz) having low power spectral density. Localization is the technique which is commonly employed in wireless network to improve routing and enhance the security. It is the method of finding out the position of the object, people, and equipment etc. Indoor positioning system (IPS) has varieties of applications like indoor area navigation system for the blind people, location of objects inside building, locating the emergency escape out in the smoky area, locating the kids over a crowded area, locating the expensive and valuable equipment's etc. UWB localization techniques have many applications in different fields, such as Robotics, Body area network (BAN), Personal area network (PAN), Surveillance area (mining area, military area, navigation area, underground tunnel etc). This paper contains different location based techniques like Time of arrival (TOA), Time differential of arrival (TDOA), Received signal strength (RSS), Angle of arrival(AOA) method. The SWOT (Strength, Weakness, Opportunities, threats) analysis has described to analyse the UWB positioning technologies. In Wireless sensor Network (WSN), it provides robust performance in dense multipath environment and creates the best choice for indoor localization. The objective of this paper is to represent a survey on Localization of latest researchers in the field of UWB positioning System including both indoor and outdoor positioning area. It also contains the importance of localization in the field of Internet of Things (IOT), which is mainly based on connecting different smart devices that is embedded with sensor and can able to connect with Internet. The previous related works are summarized, reviewed and compared according to the year of publication. It also provides an overview of different positioning systems which are categorized into different wireless Technologies.

Keywords: Ultra Wide Band, Localization, Positioning, TOA, TDOA, RSS, AOA, SWOT, IOT, WSN

1. Introduction

Nowadays, the utilization of wireless communication increases rapidly,so the requirement of high data rate also increases,for this there is a need increased data rate capacity, which can satisfy the user's demands fruitfully.The data rate can be increased by increasing the signal bandwidth.UWB is a wireless technology for the transmission of the information in a frequency range of 3.1GHz to 10.6GHz.It consumes low power (approximately 0.5mw) and operates in a short distance area (approximately up to 200m). It has a very less power spectral density (PSD) that is -41.3dbm/MHz, which causes it for easy and safe deployment with already existing wireless communication with no interference. UWB broadcasts the digital pulses with a very precise in time on different obstacles, which will again reflect the signal with more limited carrier signal through a wide spectrum having number of frequency channels. In wireless ranging measurement, UWB provides very high accuracy (cm) along with low power consumption and immune to multipath fading. In UWB the information's are transmitted through wide spectrum having low PSD [1-2]. Comparing the conventional radio transmission and UWB we find the former transmits information with varying the levels of power, frequency and phase of the sinusoidal wave, the later transmits data through radio energy in a specific interval of time using a spectrum of 7.5GHz bandwidth. Pulses are very short: approximately less than 60cm for 500MHZ and less than 23cm for 1.3GHZ, hence there is no overlapping occurs between the reflected signals and the original signals or pulses without causing any multipath fading for narrowband signals. Localization is the technique which is commonly employed in wireless network to improve routing and enhance security. It also determines the position of people, object, equipment in an indoor area location system. The classification of Positioning is categorized in types based on the environment where the position is to be calculated: outdoor positioning system and Indoor positioning system [3-4]. The outdoor positioning system is conducted outside the building area and the indoor positioning is performed inside building area like hospitals, house, malls, university campus etc. Now it has become an important research topic, where the different research searches for the utilization of the existing technology for finding out the position determination in the indoor area localization system. The positioning technologies are application dependent that is they will fit according to their needs and the constraints. Taking one example the Global positioning system (GPS) is responsible for outdoor area but not suitable for indoor area since the satellite radio signal do not enter through the solid walls or obstacles. Now a day's most of the applications requirements are based on locating

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or tracking the physical belongings inside the indoor area like buildings accurately, hence indoor localization service has become an important prerequisite in the market. Indoor localization is the technology, which finds its applications in the commercial and in the public safety areas. An indoor positioning system (IPS) is the technique, which determines real time positioning of an object or a person in an indoor experimental environment [4]. UWB transmits the signal using pulses and has the potential for transmission with increased data rate, low power, low EIRP level along with short to medium range communication systems. The indoor positioning and navigation of moving objects are also known as localization in the communication network community. The global positioning system (GPS) and satellite systems work well in line of sight (LOS) area. But there is very low energy obtained from satellites, hence the satellite positioning system cannot be used in an indoor area for the operation of localization. UWB wireless communication has some characteristics which makes it a better one in indoor wireless positioning system. Indoor position estimation is used to find the location of user or required objects with in a closed area and in a large building, like locating the patients in the hospital, finding the people in a burning indoor area like building, finding workers in a large office block area. The indoor environment is more complex than outdoor environment since there are many multiple objects that cause the reflections of the signal and lead to multipath delay problem. Again, for the presence of different objects IPS pass through on non-line of sight (NLOS) propagation, where the signal cannot pass directly from transmitter to receiver, by this it produces delay in receiver, which is shown in Fig.1.

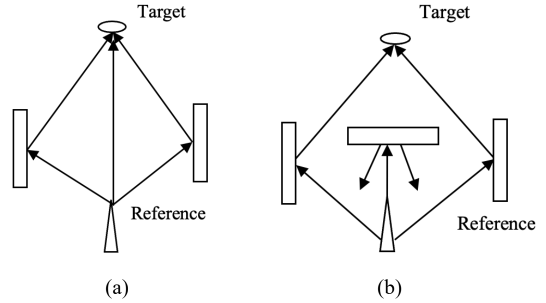

Fig. 1. (a) LOS, (b) NLOS

Again, due to the presence of object, which creates high attenuation along with signal scattering. IPS system suffers from signal stability, which fluctuates due to presence of different interference sources like mobile, Bluetooth, WiMax devices, cordless phone, fluorescent lights etc. In comparison with outdoor environment, the indoor environment shows the structural movements where the reference point may move from one place to another hence it requires higher precision with higher accuracy than that of the outdoor environment to interact with small area and in the existing obstacles.

The classification of different localization algorithm can be represented as: range independent and range dependent algorithms. The location metrics are used in case of range-based technique, like Time of arrival (TOA), Time differential of arrival (TDOA), Received signal strength (RSS), Angle of arrival (AOA) for estimation of distance between the nodes [5] as presented in Figure 2. UWB localization techniques have many applications in different fields. It requires very less power at transmitter; therefore, it is coexisting peacefully with other wireless systems. A trade off exists between Range dependent and Range independent algorithms since the accuracy is more found in case of range-based algorithms than that of the range free algorithms. Applications such as personal health monitoring, cardiac pace makers, capsule endoscopies etc are exciting in the area of research called Wireless body area network (WBAN). UWB utilizes a train of impulses instead of modulated sine wave for transmission of the data or information. These pulses retain a wide range of frequency band with a very steep rising edge, by this the receiver can measure the signal arrival very accurately. These pulses are very narrow with no more than two nano second. This behaviour clarifies it as the perfect range measurement technology. The main features of UWB technology are:

- The localization precision is very high that is approximately in decimetre level.
- It generates no interference with other existing radio systems.
- It is an immune to multipath signal propagation.
- It creates less noise.
- It uses a low power transceiver system.

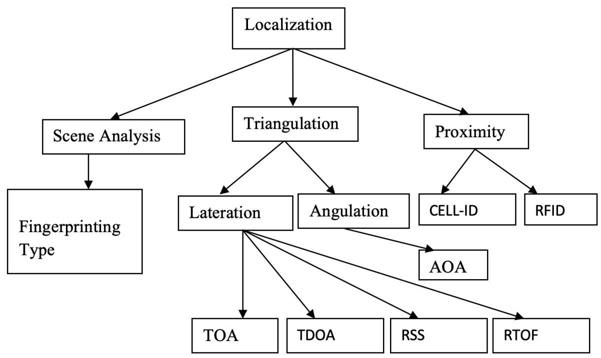

Fig. 2. Classification of Localization System

2. Literature Review

The determination of the physical location is the key basis for localization-based service (LBS). Now-a-days it plays an important role in our life. It includes its application in navigation, in mapping, in geometry based social networking and different types of entertainment etc. Basically, Localization is of two types: outdoor localization system and indoor localization system. GPS uses 24 satellites for total coverage with precision of 1m-5m range. Though the cost of GPS transceiver chip is low with easy to scale, but it operates well only in open area environment, because its signal gets blocked by the physical obstacle, thick forest. Hence it cannot operate properly in indoor area region. The Indoor Localization Service improves the life quality and boosts the business market. The mapping of indoor area and the navigation system provides the position of the user, which helps in finding the proper way according to their deservedness. It is also useful for those persons having visually impaired and robot navigating system. It also helps in fire and other emergency situation. It enables the rescuers to find their position along with determining the easy and shortest way to come out from that indoor area, where the varieties of obstacles block their vision. Now a day’s the application of localization become very important in different sectors, like health, industry, universities, offices, malls etc. It is also applicable in IOTs along with smart architectures like smart home, smart cities, smart buildings, smart grids etc. The advancement of internet of things (IOT) is very interesting for Location estimation with proximity type of detection. The concept of IOT mainly based on connecting different smart devices that is embedded with sensor and can able to connect with Internet. The main aim of IOT is to enhance the output result of different systems like Health care system, marketing, monitoring, parking, positioning, navigation, transportation, security, disaster control management, automation, smart architecture etc. This determines that IOT technology has the potential to improve and enhance the different services for wide scale adoption in near future. Mainly IOT is categorized into three parts that is sensing or collecting the data, secondly communicating the data and thirdly processing the data. For sensing it uses the sensors for sensing the different activities like temperature, heartbeat, speed of vehicle etc. In second phase the data collected from sensor are communicated to the server through wired or wireless technology and finally data processing is done like compression, feature extraction, aggregation etc. in server and send to the user [6-7].

The different categories of indoor localizations are based on GPS, Infra-Red, Radio Frequency, Ultrasound etc. In vision-based localization, the visual information is gathered and practiced in indoor navigation system. In unmanned aerial vehicle (UAV) system, the distance can be predicted from the ground or wall by capturing and analyzing the laser point position on it. But image-based localization consumes more power and computing resources. In a robot navigation system, it wonders over the floor for a long duration to narrow down its position, by which the camera use increases the cost and degrades the system. In wireless indoor area localization system, the wave gets into the wall, buildings and different obstacles. It uses the features of received signal to know the point and get the location of current position. The deployment of this system is easy with the presence of microwave doesn't disturb the activities of the human being in the indoor operating area system. The wireless chip is very much cheaper than cameras and the consumption of power and resources are much less than vision based indoor localization [8-9].

The localization system includes two parts that is the beacon station, which emits the signal and user device, that receives signal and vice versa. GPS can also be included in this category, and it uses the wireless signal for communicating in between the satellite and the GPS device. The 24 satellites have 24 number of beacon stations. The GPS calculates its location by the signals that is received from the satellites. But the indoor area is different from that of outdoor environment. The propagating wave get distorted by the reflection, diffraction and scattering. The strength of the signal gets distorted by multipath fading and shadow effect. In indoor area the wall, furniture, walking people affects the propagation wave produce the obstruction to the signal, that is received by user.

The radio frequencies have been assigned to varieties of applications and this spectrum is regulated by FCC. The frequency less than 300GHz has referred as radio spectrum. The frequency of wireless technology indoor localization affects the wall penetration, resistance to obstacles etc. Hence according to frequency use the wireless technology in the indoor environment can also be categorized into three types: The Long-distance technique, which includes the wireless technologies such as: FM, GSM/CDMA. The middle-distance technique, which includes the wireless techniques like: Wi-Fi, ZigBee. The short distance technique, which contains Bluetooth and UWB Wireless techniques as presented in Figure 3.

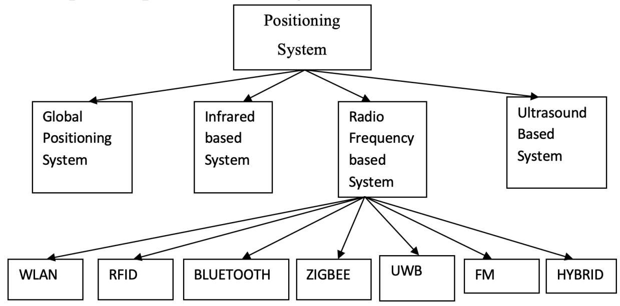

Fig. 3. Classification of Positioning System

- Long Distance Wireless Technology-FM, GSM/CDMA

FM (frequency modulation)-The spectrum allocation for this technology is 87.5 - 108.0MHz. It is comparatively less obstructed by weather and different obstacles than other technologies.FM receiver is very cheap and requires low power consumption, so it has better battery life. It does not require the extra beacon for FM in indoor localization, but it has large wavelength, for which the signal strength doesn't change dramatically in a short distance, so it operates better in large distance environment. It uses FDMA for sharing the spectrum and multiple channel signals for the reduction of variance [10]. GSM/CDMA-It is generally used in cellular communication. It has different frequencies in varieties of region like 850MHz, 900MHz, 1800MHz, 1900MHz bands. It has less propagation distance than FM in Indoor area. Since GSM/CDMA is highly patented, hence It is very difficult for doing any modifications and extensions.

- Middle Distance Wireless Technology-Wi-Fi, ZigBee

This technology uses two licensed exempted bands: 2.4GHz, 5GHz.The office building, super mall has already deployed with Wi-Fi hotspots. It works in Industrial areas, scientific area and medical area (ISM band) etc. Primarily it provides networking and connections to internet in varieties of devices with in the private area, public region and in the commercial environment. In the beginning Wi-Fi had the reception range about 100m, but now it has increased to 1km range. The different commercial support Wi-Fi, where the cost of the infrastructure and that of user device is very low. It can be easily adopted by building and users. It plays an important role for indoor localization. But however, the current Wi-Fi technology is meant for communication that means for increasing the data output along with maximizing the coverage network rather than localization purpose, so more efficient and improved algorithms are required for getting better location accuracy. The accuracy can also be affected due to the interference generated by ISM band, but now the Wi-Fi system gains the accuracy, which is increased to 23cm [11-12].

ZigBee-The specification of Zigbee is according to the IEEE 802.15.4 standard. It is meant for transmission with long distance communication among devices with mesh network topology. It provides lower data transfer with low cost as compared to Wi-Fi standard technology. This technology is suitable for sensors localization in the field of WSN, but this technique is not present in all devices, so Zigbee is not so favorable for localization in the field of Indoor area system [13].

- Short Distance Wireless Technology-Bluetooth vs UWB

Bluetooth-It uses 2.4GHz and 5GHz band. It is a personal area standard. It is used for short distance communication as cell phone, earphone. Power transmission for this technology is very low. The coverage area of Bluetooth is very low, so it is not suitable for large area of localization.

UWB-It uses the bandwidth normally greater than 500MHz.It uses sub-nanosecond radio pulse (time period<1nanosecond) for transmission the data in a large spectrum having range 3.1 to 10.6 GHZ. Its transmission is considered as the background noise for other wireless technology, for this it can be operated at any spectrum without any interference with existing technology. The power spectral density is low that is -41.4dBm/MHz (by FCC) hence it causes less power consumption. It is immune to multipath problem. This technology is primarily used for localization in indoor area, since it can penetrate through the materials; walls different obstacles and the small duration of UWB pulse make it possible to cope up with multipath effects and allow the determination of location estimation with better accuracy [14].

RFID-(Radio Frequency Identification)

This technology is mainly meant for transforming and storing information or data by the help of electromagnetic transmission in between the transmitter and the RF circuit. This technology includes the reader which can interact with the RFID tag. The tag emits data and the reader is able to read by using the RF and Protocols that are already defined previously and known to both the tag and Reader. The RF electromagnetic field is used by the reader for reading the information in tag; by this it is able to get the identification of the object. The RFID system includes Active RFID and Passive RFID.

- Active RFID- In this system, the tags are already equipped with the power supply for sending the contained data to the readers. This system covers more area, that is approximately 100m.This technique resembles as a real time localization system, which utilizes the ultra-high frequency for its operation. The accuracy is enhanced with increased number of tags and readers in indoor operating region.
- Passive RFID- The communication range is 1-2m. It can be able to operate without battery at high frequency. The tag of this system gain energy through nearby RFID Scanner for sending its coding information again back to scanner. This system operates as a checkpoint and consumes very low power and less cost in comparison with active RFID System. The limitation of this system is occurrence of collision due to tags and readers; hence this technique does not operate as real time basis in the field of localization. [15].

Summarizing all these technologies and the table is given in Table 1.

Table 1. Wireless technologies in Indoor area Localization system

Wireless technology	Range	Dedicated Infrastructure	Power Consumption	Disadvantage
FM	100km	No	Low	Cost is high, more complexity in TX, RX
GSM/CDMA	100m-10km	No	Unknown	Time synchronization required in CDMA, Limited data transfer
WiFi	35m(indoor)	No(For most places)	High	Not secured variance in signal is high
ZigBee	30-60m	Yes	Low	dedicated Infrastructure is required
Bluetooth	10m	Yes	Low	Limited range coverage
UWB	200m	Yes	Low	Covering area is very less
RFID	100m(Active RFID) 1m(passive RFID)	Yes	Low	Range coverage is limited

Infrared (IR)-It uses the spectrum of invisible light. This technique involves LOS communication up to 16Mbps.The Diffuse IR is stronger than that of the direct IR with longer range 9m-12m.proximity and angle of arrival method is frequently used in this IR technology.

Ultrasonic-It is defined as the mechanical wave due to the pressure oscillation and is transmitted by the medium. There is no interference occur in between this technique and that of the Electromagnetic wave. The relative distance can be estimated with TOA using ultrasound pulses travelling from emitter to receiver.

3. Mathematical technique for Indoor Localization

The mathematical technique can be categorized tin three types, such as: Proximity type, Triangulation type and Fingerprint type.

3.1 Proximity

This method is one of the simplest mathematical techniques of connectivity but it produces less accuracy. It is a simplest method of Localization. For the connection oriented wireless communication, the user position is approximated for accessing the point location. For this method the assumption is the user location should be within the range of known station, after this the user location is approximated to known station. This technology is used in GSM for localization operation. It This method gains the accuracy of 50-200m, which is equivalent to cell of GSM [16]. Due to the presence of high variance, this technique is not always preferred for of localization.

3.2 Triangulation-

It uses the geometric method for user location. It determines how to locate the user point through distance and angle information. Considering three reference points A, B, C having known position. In this technique if the distance is known in between the target and that of the reference point, after that location can be derived with intersecting three circles, again if angle of the target to the reference or angle of reference to the target is known, then the position is expressed with intersecting of three vectors, So the aim is to find either the distance or the angle between the object node and that of the reference point for getting the location of the target object.

3.2.1 Angle based Triangulation

Angle of arrival (AOA)-In this technique, it is involved in getting the received signal angle from reference point (known station) to the target point (user point). It is easily derived if the user point and the reference point or beacon station use the directional antenna technology. But due to the presence of multipath and reflections from different obstacles, the angle of station not always the angle of received signal. It uses the directional antenna or antenna arrays for finding the direction. It includes the geometric relationship for finding out the position of intersection of angle for each signal source bearings from known reference point. The limitation of this method is it uses the additional antenna, by which the cost of the system increases. This method is also get affected with multipath and non-line of site propagation of signal. So, this technique is not meant better for localization in indoor area system. for this it changes the arrival direction and degrades the output in positioning calculation. This algorithm shows high complexity due to presence of antenna geometry, which has the important role in position estimation. The accuracy reduces through increased range between the target and reference point [17]. This approach uses the antennae geometry at the reference side for finding the angle through which the transmitting signal falls on the reference point. This method provides better accuracy with reduced range in between the target object and that of the reference node. For the existence of multipath effect in indoor environment, the calculation of AOA for user estimation is very difficult [18].

3.2.2 Time based Triangulation

This method uses distance for the triangulation. The assumption of this method is, the time required between the target point and the reference point is used for deriving the range in between them. Here the speed of signal is the light speed in the medium of air. Here it consists of two methods: Time of arrival (TOA) method, Time difference of arrival (TDOA) method. In TOA method it calculates the time, that is used by the packet meant for transmission of data between target to the reference node and vice versa. The user point transmits a packet with timestamp on it. Here in this technique, it is assumed that both points are synchronized by their time. TDOA method is nearly equivalent to that of TOA method, but here the receivers are only synchronized properly in time. Here the beacons have varieties of hyperbolic curves for the location of assumed time. The intersecting point will give the location of the target point.

TOA/TOF (Time of Flight)

This technique determines the required time propagation of signal for estimating the range between the target point and the receiver point. This arrival time is multiplied with speed (light speed(c) = $3*10^8$m/s) and provides the range of the target location. In the below Fig.4, the three reference nodes for estimating the distance between the target and reference point. This technique needs synchronization in between the two points and also the time stamps are transmitted along with the signal. The bandwidth of the signal and the rate of sampling affect the determination of TOF. The lower is the sampling rate the lower is the resolution of TOF. With increased bandwidth in multipath environment greater is the resolution for TOA determination. It can be operated in both LOS and NLOS region of operation for obtaining the location.

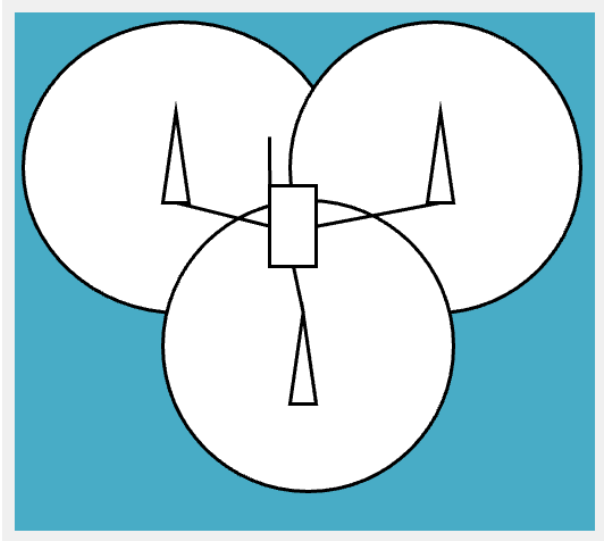

Fig. 4. Time of arrival positioning Method

This system is operated according to the synchronized signal time from unknown point to different known points. After the signals get received, the range between the target and reference point is measured through multiplication of time with that of signal speed. The radius of these circles shows the range between the operating points, which is estimated by one way propagation time in between them. The TOA based algorithm using UWB technology is very helpful for personal localization for worker inside the coal mines during the case of accident. It is also helpful for location of mobile robot in mobile robot tracking. There is possibility of two cases: Web camera and UWB based positioning and with localization accuracy, it is found that the localization error is about average of 8cm [19].

Time Difference of Arrival (TDOA)

It determines the differences of arrival time of the signal, which is sent by the target and captured by different reference nodes or receiver nodes as shown in Fig. 5. The calculated TDOA, $T_{D(i,j)}$ from reference nodes i and j represented in Equation 1:

$$L_{D(i,j)}=C*T_{D(i,j)}, \tag{1}$$

where c represents the light speed.

Now the target at the hyperboloid can be shown in Equation 2:

$$L_{D(i,j)}=[(X_i-x)^2+(Y_i-y)^2+(Z_i-z)^2]^{0.5}-[(X_j-x)^2+(Y_j-y)^2+(Z_j-z)^2]^{0.5}, \tag{2}$$

Here, Xi, Yi, Zi represents the coordinate points at reference node I, x, y, z shows the coordinate point that of the target node. The below Fig. 4.2 shows three Reference nodes for getting the 2D position of the target. The accuracy of TDOA measurement is based on bandwidth of signal, the rate of sampling and LOS between the target point and the reference node [20].

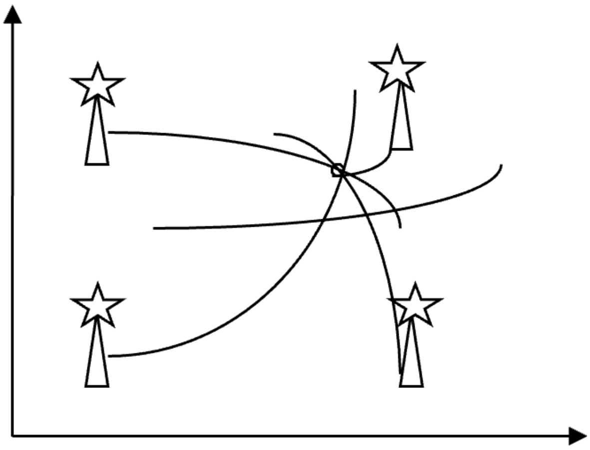

Fig. 5. TDOA based localization

3.2.3 RSS based Triangulation
The received signal property can also be used for getting the range between the beacon and that of user point. In triangulation the beacon station and the user point are needed as in Line of Sight condition, else accuracy of location of the target point is very low, but in real scenario there may be presence of walls, trees, mountains doors, buildings, walking peoples or different types of obstacles, which block the line of sight.The RSS measures the strength of the signal that is received in receiver node and is calculated decibel milliwatts (dBm) or in milliwatts (mW). It is the most simplest approach in Indoor area localization system[30-34]. The value of RSS is high with lowering the range between user and the reference node.

According to path loss model, the RSSI can be represented by Equation 3:

$$\text{RSSI} = -10\, n \log_{10}(d) + A, \quad (3)$$

Here n represents the path loss exponent (2 in case of free space and 4 in indoor environment), A is defined as the RSSI value at a reference distance calculated from that of target point. The RSS is classified in two categories: the Trilateration type and the fingerprinting type [21]. In the first one it uses the RSS measurement to find the distances with three reference nodes for estimation of current nodes. In the second one it requires the collection of datasets of RSS fingerprints, which is matched with the measured through online with the closest fingerprints in dataset for estimation of the locations. This technique is relatively chip to implement and obtained by low complexity algorithm. It does not require the expensive time synchronization and no clock bias. Table 2 and 3 provide the comparison of different positioning algorithm and comparative analysis on indoor positioning technology with different algorithms respectively. According to positioning in 2D space, the TDOA needs minimum three properly located base station, where as AOA needs two base stations for localization. Regarding accuracy, error generated while measurement of angle will create negative impact on accuracy of the system when target point is away from base reference point.

Table 2. Comparison of different Positioning Algorithm

Characteristics	AOA	TOA	TDOA	RSS
Estimation of the Position	Intersection point of lines.	Propagation Time required between target and reference node. The range is directly proportional to time.	The difference in time, that signals arrive at multiple reference points. The differences of time is mapped to intersected hyperbolas.	The strength of signal,that is received at target from reference points. The strength of signal inversely proportional to the range between them
2D Space	Minimum two reference points.	Minimum three reference points.	Minimum three reference points.	Minimum three reference points.
3D Space	Minimum three reference points.	Minimum four reference points.	Minimum four reference points.	Minimum four reference points.
Synchronization	Less necessity of synchronization.	All the transmitters and receivers need synchronization.	Only the receiver node require synchronization.	Not required.
LOS and NLOS	Requires clear LOS.multipath affects the phase and cause position error.	It is meant for both LOS and NLOS propagation.	It is meant for only NLOS propagation.	Requires clear LOS.It creates negative effect due to existence of obstacle and wall.
Remark	Small error in angle measurement creates negative impact in accuracy. It requires costly and large dimensional arrays.	Relative clock drift occures in sender and receiver nodes.	Less accuracy than that of TOA method with equal system geometry.	Requires short distance between nodes.

Table 3. Comparative analysis on indoor positioning technology with different algorithms.

Technology	Measured techniques	Advantages	Disadvantages
RFID	Proximity and RSS	Penetrates through the obstacles and not require LOS in between RF transmitter, receiver.	The positioning coverage is small, antenna affects RF signal, not secured, high power consumption as compared to IR devices.
UWB	TOA,TDOA	Positioning with more accuracy, effectively passes through obstacles, not interfere with existing RF signal.	Cost high, still undergoes interference by metallic materials, less operating range.
Infrared	Proximity,AOA	Suitable for sensitive communication, since it cannot penetrate through the walls.	Not penetrate through the wall, needs LOS in transceiver, poor performance in location, because the IR emission of light source

			interferes with signals.
Ultrasonic	TOA,TDOA	No need of LOS, No interference by electromagnetic waves.	Cannot enter through the solid wall, signals loss for obstructions, false output signals for reflections.
Zigbee	RSS	Its sensors requires very less energy and low cost.	Operates in unlicensed IS band and produce interference due to wide range of signal having same frequency.
WLAN	RSS	It exists in majority of building and uses the existing communications and may cover more than one building.	Recalculations of the predefined signal strength, which forms change in the environment like open or close doors, moving furniture.
Cellular based	RSS	Does not interfere with the device using the same frequency.	Reliability is low for variation in signal propagations.
Bluetooth	Proximity, RSS	No need of LOS, a lighter standard and highly ubiquitous, built in smart phones and personal digital assistance.	With more number of cells, forms better accuracy but it increases the cost. Needs expensive receiver cells, needs for a host computer for locating the Bluetooth radio, interference occurs.
Dead reckoning	Tracking	No need of additional hardware sensors.	Determines only the approximations of positions.
Image based technology	Pattern recognition	More cheap than other technologies.	Requires LOS and coverage is limited.
Pseudolites	RSS	It allows extending the coverage area to several kilometres with great flexibility and compatible with existing GPS receiver.	Distortion due to multipath, interference occurs, time synchronization is very weak.

4. Localization based on UWB system

This section represents the research on UWB based localization, NLOS identification and mitigation, localization in health care system which includes the vital sign detection, positioning for IOT applications, and localization in underground mines. The summery of different methods and technology including advantages and disadvantages are represented in Table 4.

Table 4. Summery of Review of UWB Indor/Outdoor localization

Author	Year/Ref	Technology/ Algorithm/Topic	Advantages/Outcome	Disadvantages
Juri Sidorenko Volker Schatz.et.al.	2019 [22]	(TOA) and (TDOA), (TWR) Protocol Two way Ranging Protocol, Multiple Error correction for UWB technology.	Correction of clock drifts error between the Reference point and Target.	The clock drift error is reduced to some extent but not fully left.
Long Cheng Yifan Li.et.al.	2020 [23]	WSN, (MJPDA) Modified Joint Probabilistic Data Association based on EKF,An indoor localization algorithm for WSN.	Prominent Localization Accuracy with Strong Robustness.	This technique is applied for a small range area and for single target tracking.
Imran Ashraf Soojung Hur.et.al.	2020 [24]	MPS: Magnetic Field based Positioning System, Deep Neural Network Smart Phone Based Indoor Localization	Reduces impact of device change for Localization Accuracy to increase the accuracy multiple neural networks is trained and should be used accordingly.	The measurements are done at fixed attitude, so if the device attitude changes then the accuracy decreases.
Hongchao Wang Xuexuan Wang	2020 [25]	Hybrid positioning mode LSTM with WKNN LSTM to predict the TDOA at future and use it to correct the actual UWB measurement, after modify TDOA transfer to WKNN,UWB based indoor localization.	High positioning Accuracy.	The technique only shows the pre analysis of LSTM and WKNN method but no depth idea is present there.
JanisTiemann Fabian Eckermann	2016 [26]	TDOA, (EKF)Extended KF, Wireless clock synchronization for improving multiuser scalability.	Accuracy is achieved by Robotic Movement along with optical reference system.	It includes complex set u and there is no improved filtering method is used.
Sehun Jeong Jun Bumpark	2016 [27]	Membership management Algorithm,(RTLS)Real time location system, positioning technique of multiple objects through UWB communication.	Increasing positioning accuracy, Low power consumption.	It requires many time for membership registration for more no of tags.
Klemen Bregar.et.al.	2018 [28]	LS,Weighted least square algorithm, (CNN)Convolution neural network, Reduction of LOS error in NLOS,Indoor localization on computationally restricted device.	Improves the location performance in centralized and distributed deployments	Finding out the propagation condition of LOS and NLOS is not improved.

Chenglong Li.et.al	2019 [29]	Hybrid type AOA/RSS/TOF, (CRLB) Positioning Performance of Hybrid metrics.	Good positioning Performance and Robustness.	The hybrid technology did not consider about the system complexity and computational load.
Junhua Chen.et.al.	2019 [30]	TDOA, Architecture of Multilevel IOT Positioning System.	Reduced system construction cost, improved time compensation TDOA method, positioning accuracy high, and reduced power consumption.	It requires the clock synchronization among all anchor nodes.
Xiaolin Liang.et.al.	2018 [31]	(DSFT) Distance Short time Fourier Transform, (EEMD) Ensemble Empirical Mode decomposition based accumulation, Through wall human detection.	Removes harmonics effectively, excellent performance, removes clutter, better SNR	Range estimation is not so improved.
Elerson R.S.Santos Hector Azpurua	2020 [32]	RSS, Non linear Bayesian Filter,EKF,UKF Indoor and Outdoor Localization.	Improved location of Robot but it creates high variance in readings	Performance decreases for NLOS among the UWB devices, requires the configuration of anchor devices, produces high variances.
Changhui Jiang Jichun Shen	2020 [33]	Channel Classification, CNN, Deep Learning Method, LSTM-Long short term memory, classification of LOS/NLOS.	CNN is more effective for redundant information, LSTM increases the accuracy.	Difficult to find the threshold which varies with different areas. Computational load is high, No investigation of classification accuracy on position determination.
Faheem Zafari.et.al.	2017 [34]	Localization technologies (AOA/TOF/RTOF/RSS), Wifi, UWB, Survey of Indoor area Localization systems. and Techniques.	Importance of Localization after IOT and its improved connectivity to different sensors	Multipath effect and noise degrades the localization accuracy,costly,lack of standardization
Muhammad Usman.et.al.	2018 [35]	Proximity Estimation, Localization and proximity technologies for finding the proximity of different devices in LBS.	Better accuracy and performance by emerging the Technologies MIMO,LTE-M,NB-IOT	Technologies are not sufficient to find the better accuracy in LBS.
Philipp Mayor, Michele magno	2019 [36]	Embedded H/W & S/W Solutions, Doubled sided Two Way Ranging(DSTWR),Embedded UWB Indoor outdoor Localization.	High accuracy, Low latency, low cost.	High complexity system architecture.
Long Chen Yifan Li	2020 [37]	WSN LS, EKF for LOS, JPDA for NLOS, MJPDA Modified joint probabilistic data association algorithm based on EKF,Indoor localization for WSN.	Prominent Localization accuacy,strong Robustness	Virtual points are necessary to know LOS/NLOS,It can't give result for the multimarket localization and not able to handle the complicated situations.
Yanying Gu.et.al.	2009 [38]	Trangulation Positioning Technology, Firefly motion tracking, PAN, Living system component, Indoor positioning in WPAN.	Improved accuracy with reduced cost.	Application of single medium for position estimation provides less quality of positioning service than the combined positioning technology.
Jieum Hyun Takejum Oh	2019 [39]	TOA,RTT-Round Trip Time, (OWR)One way Ranging,(TWR)Two way Ranging,Raytracing Algorithm for position of unmanned areal vehicle in indoor disaster environment particle filter based UWB localization	Improved localization Performance.	It requires the configuration of UWB anchors, No of anchor requirement is high.
Sinan Gezici Zhi Tian	2005 [40]	TOA, CRLB, Localization through UWB radios.	Better accuracy, excellent multipath energy capture capacity.	No application of hybrid scheme technology which can give accurate localization.
Dongchen Ni Octavian AdrianPostolache	2019 [41]	3D TOA, Weighted Least square Linear estimation combination with kalman filter,UWB indoor positioning application.	Reduced interference error in transmission process, Improved positioning accuracy.	There is no visualization of tag trajectories.
Sathaporn Promwong Phonipaseuth Southisombat	2016 [42]	RSS and TOA, (VNA) Vector Network Analyzer, UWB wireless Localization Measurement, comparision between Trilateration and min-max localization technique.	Trilateration TOA provides good accuracy	The biconical antennas are required for both transmitter and receiver which increase the cost of the system.
Jasurbek Khodjaev Yongaan Park	2010 [43]	TOA, NLOS Identification and mitigation Technique.	For NLOS identification channel statistics based method is better and for mitigation statistics based method.	It produces long convergence for iterative solutions hence the computational complexity is high.
Emanuel Pusschita Raluca Simedroni	2020 [44]	TOF and RSS, (CDS) Control data system, Evaluation of UWB based indoor localization kit by CDS.	Good positioning Accuracy.	Only consideration of accuracy with respect to localization error variation.

MatteoRidofi Samuel Van Develde.et.al.	2018 [45]	TDOA, TWR, ALOHA & TDMA, Scalability of UWB Indoor positioning system.	High scalability solution.	For uncoordinated protocols the scalability of the system decreases. For TDOA Anchors synchronization is required, for TWR energy consumption is high and complex implementation.
Mohammadreza Yavari.et.al.	2015 [46]	TOA,TDOA, TWR protocol, Data fusion using EKF,(Statistical positioning algorithm)LS algorithm linearized by Taylor series, Real time range measurement	IMU with UWB increases positioning accuracy in NLOS but in LOS.	It does not show the positioning for moving target and also not show the estimation of position for multiple target nodes. Limitation of accuracy for 3D real time positioning.
Tingcong Ye Michael Walsh.et.al.	2011 [47]	TWR, UWB based WSN localization technology both Indoor and Outdoor environment.	UWB Transceiver is a dependable wireless communication mechanism for WSN.	System complexity is high.
Ruiqing Ye Stiphen Red fied	2010 [48]	TDOA/TOA, LE, Leading edge detection algorithm, elimination of timing error, High precision indoor UWB localization.	Elimination of timing error due to path overlap.	Reduced robustness for localization system.
Xinya Li Zhiqun Daniel Deng	2016 [49]	TOA, TDOA, (LS) Least Square,(ML)MaximumLikelyhood,source localization algorithm and application.	High accuracy, estimation of source position, when Transmitter is in LOS with Rx.	The nonlinear equations at the Tx produce less accuracy due to the Rx error with low level of output performance.
Marcus Utter.et.al.	2015 [50]	RSSI, (TWR)Two way Ranging, Indoor positioning using UWB technology,	Robust and improved accuracy.	The operation of localization is only for 2D IPS.
Paul Meissner Erik Leitinger	2013 [51]	TOA,(JBSF)Jump back search forward ranging algorithm, (MINT)Multipath assisted indoor navigation and tracking using EKF,Impact of NLOS on accuracy and robustness of system.	Gain in estimation performance.	The clutter is high in the produced output estimation.
Eiji Okamoto Manata Hariba	2015 [52]	TOA based LS, Particle swarm optimization,(NR)Newton Raphson, Low complexity indoor localization	Balanced output in complexity, high accuracy	When the height of receiver node and user node are very close then the output estimation decreases and the complexity increases.
Chil-Yung chen.et.al.	2010 [53]	RSS, Fuzzy Logic, An indoor positioning Technique.	Determines the localization when the measured distance is distorted.	Based on RSS, the output accuracy for distance measurement is very low.
Ran Liu Chau Yuen.et.al.	2017 [54]	RSS, Particle filter, combined IMU with UWB for relative positioning.	Finds multiple users relative positioning.	The accuracy of IMU is less and it does not applied in 3D environment.
Depeng Yang.et.al.	2011 [55]	TDOA, (CS) Compressive sensing,(FOMP)Fast Orthogonal Matching Pursuit, compressive sensing TDOA for UWB positioning system.	Produces high positioning accuracy than sequential sampling method.	It uses very low sampling rate Analog to Digital Converters.
Chen Chen Hong Ding	2012 [56]	TDOA, LS estimation, Numerical propagation approach through wall localization with UWB sensor network.	Increasing positioning accuracy	Accuracy is not high.
Stefania Monica.et.al.	2013 [57]	TDOA, (AGV) Automated Guided Vehicle, Optimized Anchor placement UWB based localization.	Finding the optimal distance between consecutive anchor node to reduce the RMSE of position estimation,Low RMSE	It is only applicable to AGV in straight line.
Junyang Shen.et.al.	2012 [58]	TOA, (TSE)Two step Estimation algoriyhm,(CRLB)Cramer Rao Lower Bound, Accurate Passive Location Estimation.	Synchronization between Transmitter and Receiver, Reduces the localization error.	The complexity of iterative method is high than TSE technique.
Yuan Xue.et.al.	2018 [59]	TDOA, LS method, Asynchronous TDOA, no time synchronization between TN and AN, A model on Indoor localization without synchronization.	It calculates the difference in time by using reference node and provides good accuracy, dicreases the packet transmission and improves the localization precision.	Use of reference node for asynchronization which may increase the system complexity.
Chaur-Heh Hsieh	2019 [60]	RSS and CSI, Deep learning, MLP, ID CNN, Indoor localization.	Excellent localization performance, Low network complexity, better location accuracy	It only considers the amplitude part of CSI signal but not the phase part of the signal.
Rejina Wei Choi Ling.et.al.	2018 [61]	TDOA, UWB-IR Positioning for IOT application	Architecture and implementation of IPS,good positioning accuracy	The processing is only for static target in the system.

Chien-Sheng Chen.et.al.	2017 [62]	TOA, Particle swarm Optimization, Localization of MS in NLOS.	Error mitigation in NLOS, Good efficiency.	It does not tell about the localization in IOT system.
Eva Arias-de-Reyna.et.al.	2012 [63]	TOA, Fingerprinting, ML, UWB localization algorithm gives exploiting knowledge of service area layout.	Trade off is there between performance and complexity of Algorithm,Posses Robust against modification in floor plan	The ML algorithm used here is complex.
Hongmei Zhao.et.al.	2015 [64]	TOA, (PLS)Particle Least Square,(PSO) Particle swarm optimization, An improved positioning algorithm.	More adaptable to complicated deployment environment, High positioning accuracy in complex environment.	The PSO creates premature convergence..
Silvano Cruciani.et.al.	2015 [65]	PSTD(Pseudo Spectral Time Domain)method, (FDTD)Finite difference time domain,UWB source localization in Biological tissue.	It allows smaller memory occupation and faster localization	There is no information about the effect of noise to the localization.
Dongchen Ni.et.al.	2019 [66]	3D TOA, KF, 3D Positioning algorithm, Replace the quadratic term with a new variable and use of weighted LS linear estimation,UWB indoor positioning application.	Reduced error due to interference in transmission, Improved positioning accuracy.	It does not give idea about the visualization of track of tag path.
Xinghangzhou.et.al.	2019 [67]	TDOA, Cross region TDOA positioning method, wireless synchronization based TDOA.	Time synchronization, produces high precision with improved positioning Accuracy and Robust system,Reduces the ranging error than TOA.	Though it reduces the ranging error than TOA but increases the complexity.
Mark Obuchowicz.et.al.	2019 [68]	UWB Technology, Locating objects moving in indoor space pilot study.	This accuracy is acceptable for the system for a blind person in unknown indoor space.	It produces low accuracy.
Yuan Xu Taoshen.et.al.	2019 [69]	INS and UWB based distance measurement, Adaptive Kalman filter, Tightly coupled INS/UWB integrated human location at missing data in indoor human localization.	Output performance of AKF is better than KF,PAKF can be able to obtain the output when UWB measurements unavailable.	The integrated system depends on prior information for prediction of localization.
Kimio Oguchi.et.al.	2014 [70]	RSSI, Human Position estimation in WSN.	This method is flexible in running existing devices and WSNs.2 Experiments are carried out,one in lab building with good output result,2nd in university library with use of wireless sensor devices.	Lower output performance.
Stefania Monica.et.al.	2018 [71]	Time domain (RCM) Ranging and communication module, (CI) Circumference Intersection algorithm, (TSML) Two stage maximum likelihood algorithm, LS method improving UWB based localization in IOT.	Improvement of linear statistical model of distance error, improved performance with given algorithm.	Dependent on geometry of localization.
Martina Barbi.et.al.	2018 [72]	RSS, Multilayer phantoms, Wireless capsule Endoscopy, Localization inside human body.	Good localization accuracy.	It only considers for 2D case.
Long cheng.et.al.	2019 [73]	TOF, (TF)Triple filter,NLOS localization based on Fuzzy-c-means,KF,UKF	NLOS mitigation with enhanced accuracy, Residual analysis for identifying LOS/NLOS,Improved accuracy and robustness	Though robustness is high but not correct accuracy.
Lionel Reyero, GillesDelisle	2008 [74]	Trilateration algorithm, WLAN,GPS Pervasive indoor/outdoor Positioning.	Best effort accuracy, Excellent coverage and accuracy in indoor and outdoor	Power consumption is high.
Chee-Hyun park, Joon-Hyuk chang	2020 [75]	Maximum Likelihood multistage WLS, Weighted least square algorithm, ML type,(UKF)Unscented KF, Robust localization under mixed LOS/NLOS condition.	Robust localization, better positioning accuracy, but large power consumption	It requires large energy consumption and not robust to the distributed positioning system.
A Lazaro D Girbau	2010 [76]	Non-invasive Technique, IR-UWB Radar, Vital sign monitoring.	Detection of breathing and HR detection by non contact method	It only measures the detection only in relaxed and after exercise mode of situations.
Charlotte E.Goldfine	2020 [77]	Trillateration technique, KF,IR-UWB-Radar, Respiration rate monitoring	In and out of Hospital environment with improved monitoring	Positioning in 2D requires more than one radars.

Hongming Shen.et.al.	2018 [78]	Autocorrelation, FFT, IR-UWB Radar, Respiration and HR monitoring.	Low complexity algorithm, Provides high accuracy	The extra background noise affects the data; the sample size used here is very small.
Bernhard Grobwindndhager	2019 [79]	TDOA, TOA, Snaploc-an ultrafast UWB ILS for unlimited no of tags.	Clock synchronization between anchors not required, low cost.	There is a limitation of 3D measurement of positioning.
Jeong woo chol.et.al.	2017 [80]	Clustering and detecting process, IR-UWB Radar, Multi human detection algorithm.	Realization of people counting and positioning system for multi human by IR-UWB Radar sensor	Repeated clustering is done for detection.
Zhendong Yin.et.al.	2019 [81]	TOA, (WDMA) Waveform division multiple access for multiuser position, UWB positioning for indoor multiuser application.	High precision indoor positioning, good performance in reliability and efficiency, high positioning accuracy.	It performs the system level operation but not on field test observation.
Zakaria Kasmi.et.al.	2019 [82]	TOA,RSSI, (GNM)Gauss Newton method,(LVMS)Levenberg marquardt method, position optimization for decentralized location on resource limited device like microcontroller/Rasberry pi.	Reduced multipath error, accurate and smooth localization, adaptive selection of optimization algorithm locally on MS.	It only considers the localization and error mitigation in resource constrained devices.
Kegen Yu.et.al.	2019 [83]	TDMA, (ECTSRLS) Equality constrained Tailor series Robust Least Square, NLOS mitigation, Localization in Harsh indoor environment, determination of specific NLOS Channel.	Less environment dependent, prior knowledge independent.	Performance evaluation purely depends on channel identification which creates complexity to the system.
Qinglin Tian.et.al.	2019 [84]	TOF, Particle filter, body shadow effect for pedestrian tracking.	Decreases the mean positioning error, Robust and accurate tracking performance.	It considers only human body obstruction not other obstacles like wall for error model generation.
Qinglin Tian.et.al.	2019 [85]	Trilateration Technology, Particle filter sensor fusion, low cost INS and UWB integrated system for pedestrian using one anchor.	Robust and accurate tracking performance, reduced average positioning error compare to INS only, not require prior knowledge.	It considers only single anchor which is estimated only once in the initial state, so coverage is less.
Melanielipka.et.al.	2019 [86]	Phase based Localization, EKF, High precision indoor localization.	Precise, simple, low cost, wireless localization, lower computational effort.	It requires distributed coherent receiver channel.
Qin Shi.et.al.	2019 [87]	TOF, (ESKF)Tightly coupled error state KF, Anchor self localization.	Accuracy high for UWB anchors tracking of moving tag, easy for using the UWB anchor self localization.	Moving tag is compulsory for the automatic self anchor localization.
Yuan Xu.et.al.	2019 [88]	P_0^{UWB} by distance measured between RNs and BN,P_0^{INS} by IMU, Predictive UFIR filter, loosely fused UWB with INS system with missing data.	High robustness than KF, Produces acceptable accuracy in missing data condition, accurate observation of human state.	It only considers for short term UWB coverage.
Timothy Otim.et.al.	2019 [89]	Gaussian variable is used for modelling the range in LOS, QLOS, NLOS, Effect of (RHA) Relative Heading Angle between pedestrian tag, anchor, and impact of wearable sensor on UWB ranging.	Sensor on forehead is the best range estimation	It does not consider the error model for pedestrian tracking and also not consider the impact of wearable sensors on large environment area.
Pengfei Wang.et.al.	2019 [90]	(FDTD)Finite difference time domain, Un Supervised M/C learning algorithmic-UWB Radar, on contact monitoring of vital signs,(Convolution sparse coding).	Effective for detecting HR and improve the accuracy of HR.	It requires noise assisted method for insufficient samples in HR detection.
Abbas Albaidhani.et.al.	2019 [91]	Fuzzy Logic, NLOS identification in Harsh indoor environment.	High acceptable NLOS identification(99%)and ranging accuracy(<20cm)	It only operates on a very limited area of NLOS for localization.
Paul N.Beuchat.et.al.	2019 [92]	TWR and TDOA, Non linear LS, Optimization approach based on two way TOA for localization of IOT devices.	Decimetre accuracy	It requires three UWB anchors which should be installed.
Long Cheng.et.al.	2020 [93]	(MJPDA)Modified Joint Probabilistic data association for WSN, For LOS EKF, for NLOS MJPDA, An indoor localization algorithm for WSN.	Mitigates large NLOS error, high localization accuracy, strong robustness	It is applies in 2D scenario and single target tracking but no multitarget tracking is done.
Daquan Feng.et.al.	2020 [94]	TOF, (SDTWR) Symmetric double sided two way ranging protocol, EKF, UKF, integration of IMU and UWB for high accuracy and indoor navigation.	Improved robustness accuracy, improved accuracy than LS algorithm depends on UWB measurement, better efficiency, produce real time	It only considers the Gaussian noise distribution not generalized noise distribution.

			computational output.	
Richa Bharadwaj.et.al.	2017 [95]	TOA, Compact and cost effective, body worn antenna IR UWB Localization and tracking of human body and limb movement.	Simple and cost effective high accuracy(1-3cm) suitable for human motion tracking, average localization accuracy(.05-2.5cm) simple and robust localization	It does not consider the application specific area that includes the real-life health care applications.
Jerzy Kolakowski.et.al.	2015 [96]	TDOA, Global navigation Satellite system (GNSS), EIGER project, Indoor/Outdoor Positioning system.	Better positioning accuracy	Output performance is not so accurate.
Liangliang Lou.et.al	2020 [97]	TOF, IOT driven vehicle determination method based on multi source data fusion technology, (SPMS)smart parking management system, UWB channel with magnetic signal CIR	(WVDs)Wireless Vehicle detection, reduces average power consumption, high accuracy in data source for SPMS.	It did not represent the robustness of the vehicle detection. And also incapable of anti-interference representation in UWB based vehicle detection.
Lingyun Ren.et.al.	2015 [98]	Phase based algorithm,(LM)Logarithmic method, Non contact multiple heart beats detection and localization UWB Impulse Doppler Radar.	Suppression of respiration harmonics, avoidance of intermediation between RR and HR signal, multiple heart beat detection, identification, location.	Produces low accuracy. Doppler produces drift error in long term operation.
Faheem Khan Sung Ho Cho	2017 [99]	Autocorrelation technology for detecting (RBM) Random body movement, KF for noise removal, IR-UWB Radar for Vital sign monitoring.	RR is the highest peak of signal waveform, measuring HR from back side is better than front side.	It does not consider the monitoring of vital sign of infants.
Yongqiang Han.et.al.	2020 [100]	Trangulation method, Cooperative localization based on IMU and UWB,(AACOPF) Adaptive ant colony particle filter algorithm.	Solving the problem of localization in harsh and complex environment is better than EKF and PF.	The integrated system generates a complex infrastructure for positioning system.
Faheem Khan.et.al.	2020 [101]	FFT for transform from TD to FD,MTI to cancel the harmonics, notch filter to remove the multiples of breathing frequency, Signal processing technology,IR-UWB Radar, Remote health monitoring.	Vital sign measurement of stationary and non-stationary human.	It did not consider the heart rate monitoring for obese person.
Imane Horiya Brahmi	2018 [102]	2 step algorithm Fuzzy logic approach, LS estimation, Fuzzy logic improving tracking accuracy in indoor localization application.	NLOS error mitigation, significant gain in localization accuracy.	There is no information for getting idea to know the physical activity of the target.
Thang van nguyen.et.al.	2015 [103]	TOA, Relevance vector machine, machine learning,(TSI)Two step iterative algorithm, Machine learning for wide band localization.	Robust and efficient algorithm, enhanced accuracy.	It did not show the result for navigation system.
Can uysal.et.al.	2020 [104]	Hyperbolic tangent function convert measure error to parametric error, RR is nonlinear, Noncontact respiration rate estimation, (ModJUKF).	Device free real time RR monitoring, highest accuracy as per the windowing based method in time varying RR.	Computational complexity is high.
Yuanqing Qin.et.al.	2015 [105]	TOF, Particle Swarm Optimization, A distributed UWB localization in Underground mines.	Reduced cost with less time delay.	No information about the NLOS condition and the time delay is high.
Jie He.et.al.	2014 [106]	TOA, (CCKF) Channel classification KF, enhanced performance in multipath and NLOS environment.	It smooths the distance and reduces the error due to channel condition in indoor environment.	In case of misidentification condition, the proposed algorithm produces error.
Stefania Monica.et.al.	2014 [107]	TOF, (PSO)Particle swarm optimization,Accurate Indoor localization with UWB WSNs.	Improved range capacity,solving multipath component.	The geometrical approach presented here produces low accuracy.
Hongmei Zhao Yanan Wu	2015 [108]	TOA, (PLS)Partial Least square,(PSO)Particle swarm optimization,An Improved Positioning algorithm for UWB indoor localization.	MSE upto very low upto cm,high positioning accuracy.	Though accuracy increases,but it increases the processing complexity.
Eiji Okamoto.et.al.	2015 [109]	TOA, (PSO)Particle swarm optimization,(NR)Newton Raphon,Low complexity indoor UWB localization.	Less complexity, accurate estimation.	Complexity in the calculation arises in upper height close to the anchor node.
Junyang Shen.et.al.	2012 [110]	TOA, (TSE) Two step estimation algorithm,(CRLB)Cramer Rao Lower Bound, Accurate Passive location Estimation.	Synchronization is there in transceiver system, Reduced localization error.	The complexity of iterative method is high than TSE.
Mohd Shamian,Bin Zanial	2014 [111]	TOA, RSSI, (VRTS) Virtual Reference Tags, Improved UWB WSN for human intruder localization.	Produces better accuracy.	Complexity high.

Paul Meissner.et.al.	2013 [112]	Ranging algorithm, (ML) Maximum Likelihood, (JBSF)Jump Back Search Forward, (MINT)Multipath Assisted Indoor Navigation and Tracking, Accurate and robust Indoor localization using UWB signals.	Produces better accuracy and Robustness.	Clutter is produced in path delay estimation.
Anqi Yin.et.al.	2022 [113]	Machine Learning(ML), ML aided precise Indoor Localization	Reduces number of measurements in Localization system	Noise is generated, which reduces the accuracy.
Chenyu Wang.et.al	2022 [114]	Fingerprint technique with Deep Learning (DL), Indoor Positioning based on UWB and DL	Increases the Localization accuracy.	It requires more amounts of data for better performance in Localization.
Zohreh.H. Meybodi.et.al.	2022 [115]	JUNO-jump start Reinforcement Learning, JUNO based UWB Localization	It reduces the error and enhances the learning process.	Difficult for Anchor selection in Non uniform distribution of UWB beacons.
Alwin Poulose.et.al.	2021 [116]	Deep (DLSTM) Long Short-Term Memory Network, Feature based LSTM Network in UWB Localization	It uses the feature-based localization and gives better performance with reduced error in Localization.	It requires more time of operation in the field of Localization

In [22], authors have represented the error correction method that is applied for UWB localization Technique. It includes both TOA and TDOA method for operation. It also considered the correction for clock drift for error correction. The TWR protocol is given here for correction purpose in UWB localization technique. In [23], authors proposed the (MJPDA) Modified joint probabilistic data association algorithm for avoidance of the occurrence of NLOS error in UWB positioning system. In this method after pre-processing the virtual points the measurement is categorized into two parts LOS and NLOS. EKF is used in case of LOS condition and MJPDA is used for NLOS condition for processing the operation. It is found that the MJPDA is much better than the EKF technology. In [24], authors have derived the way by which the positioning accuracy become same with chance of different smart phone. for this the information derived from magnetic data of mobile is inserted into Neural network for training, which helps in avoiding the effect of heterogeneity and increases the accuracy. In [25], authors considered the TDOA based LSTM-WKNN hybrid technology for avoiding the clock drift error of UWB in during localization. The LSTM is used for the prediction of TDOA future information for correction to UWB error and WKNN is used for localization in the same time period. In [26], authors provided the method for multi user TDOA positioning system, which is based on wireless clock synchronization. It includes the robotics, optical reference. The ATLAS system includes different modular part for operation. It uses the EKF for estimation of position.

In [27], authors represented the membership management along with positioning of multiple objects by the application of UWB communication. The algorithm used here includes two phases, in the first phase master provides signal to all tags for confirming the communication and in second master provides again another signal for confirmation and starting of positioning. The localization accuracy increases with minimized time period. It also reduces the power consumption. In [28], the authors represented the raw CIR for the reduction of error due to NLOS in indoor environment. The technique is on classification of NLOS and reduction of ranging error by the application of convolution neural network and Tensor flow computational framework. It also uses the LS and Weighted LS positioning algorithm. The localization through hybrid technology is derived by (CRLB) Cramer rao lower bound technique for localization. It provides the robustness by hybrid method instead of taking a single method [29]. In [30], the authors represented the multilevel IOT localization system. It decreases the constructional cost along with enhances the accuracy through the application of improved TDOA technology. It increases the positioning accuracy with reduction of power consumption of the localization tag. In [31], the authors represented the technique for getting the vital sign. This is done by knowing the skewness of the received UWB. The distance between the human and radar can be calculated by (DSFT)District short time failure transforms on skewness. It also uses ensemble empirical mode decomposition (EEMD)for getting respiration frequency and also removes the harmonics. In [32], the authors represented the localization problem in the field of Robotics is solved through non-linear Bayesian filters and WSN devices, which considers both indoor and outdoor area. It uses two metrics, UWB for good accuracy and RSS for localization in WSN. It fuses the odometry of robot and distance generated by UWB and RSS. The signal classification is done based on deep learning method, where CIR data is given to the CNN-LSTM, which extracts the features and the output is given to the LSTM for LOS/NLOS determination [33].

In [34], the authors represented the application of localization and the total summery of different Indoor localization techniques and technologies. It also determines the enhanced connectivity with different sensors. In [35], the authors determined the proximity estimation in LBS, which includes the technologies of localization in present, past and future. It also elaborates the LP techniques and technologies for finding the proximity of various devices in Location based services. The design and implementation of low latency and accurate DSTWR algorithm is described, that can be operated with low budget tags and also represents the H/W and S/W solutions for achieving the indoor/outdoor positioning accuracy [36]. A modified joint probabilistic data association (MJPDA)localization algorithm is applied to get the pre-processing points from measured value. Here EKF is utilized for LOS and for NLOS case modified JPDA is used and it is observed that MJPDA is much better than MPDA. This algorithm helps to reduce the large amount of NLOS error [37]. The descriptive analysis of different indoor positioning system is done in [38]. It includes the overview of different localization. It also covers the different IPSs based on the medium to determine the localization. A brief idea about the requirement of personal network localization is given along with location aware computing system architecture. In [39], the authors represented the compensation for ranging in UWB measurement with prediction of NLOS multipath by ray tracing algorithm is explained with improved localization output. It also provides unmanned area vehicle (UAV) positioning method in disaster area done by UWB radio signal. The particle filter based UWB localization is with updating of weight by compensated UWB measurement. In [40], the authors proposed different positioning technique and positioning system for UWB system is derived along with CRLB is applied for estimation of TOA in multipath environment. It verifies that time-based localization offers better accuracy than others. In [41], the authors discussed the 3D positioning method by 3D TOA technique.

The theme is replacing quadratic term in positioning by a new variable with application of weighted least square linear estimation in combination with KF for reduction of interference error in transmission process. In [42], the authors given the comparisons between the trilateration min-max localization by application of RSS and TOA is mentioned. It also uses the vector network analyser (VNA) and also it is proved that trilateration technique TOA provides the better accuracy. In [43], the authors proposed the technique for identification of NLOS and its avoidance are briefly described into different types. Their comparisons are also shown table. The identification method includes range estimation based, channel statistics based, position based, similarly the avoidance of NLOS can be represented on the basis of direct path and statistics. The evolution of UWB based Indoor positioning kit which is based on VN360 integrated with VW1000IC including UWB Reference point anchor nodes and a Tag [44]. Generally, this is mostly applicable in aerospace industry, Civil engineering entity, military. The kit is designed through control data system(CDS)for better localization of operator with respect to industrial equipment. In [45], the authors proposed the scalability of the system, that means the UWB system can be applied to hundreds of tags that are all active in the system. It uses different formulas to find the effect of various UWB scheme, hence it is verified that by TDOA-TDMA with short packets UWB can handle thousands of users per second. In [46], the authors has shown how the implementation of real time positioning using UWB and also determined the accuracy of DWUWB in area of LOS and NLOS. It uses the KF for improved accuracy in LOS and NLOS with inertial measurement unit (IMU). Derivation of range parameters in wireless including TOA,TDOA is described clearly. Extended KF used for fusion of data from IMU and UWB.IMU helps in improving accuracy in NLOS but not LOS condition. In [47], authors have found the reliability of impulse based transceiver for range estimation in the field of indoor and outdoor by the application of TWR method. A CRLB technique also described which shows that the signal of UWB is very precise in the range of cm level of accuracy. In [48], the authors achieved the 3D positioning estimation with cm level accuracy in a dense multipath area. It also shows how the pulse is distorted due to angle through UWB antennas. (LE)Leading Edge method is applied to nullify the error created by TOA due to overlapping path in dense harsh area. In [49], the authors represented the brief summary of characteristics of different localization, accuracies of different positioning algorithm and also improvement is done at both TX and RX for better accuracy of localization. It derived TOA and TDOA algorithm for locating the source in LOS area. The application of source positioning includes various fields like Radar and Sonar. In wireless sensor networks GPS, locating the underwater animals like fisheries, tracking of marine animal, It also considered different factors that affect the localization like LOS, NLOS, Sensor position, multipath, speed variation etc.

In [50], the authors represented the indoor positioning system by the application of (RSSI)Received signal strength Indicator in UWB localization. Here it also proved how clearly the UWB is accurate for positioning the object. The experiments are done within the range of 1 to 15m with output cm level accuracy. Two-way ranging (TWR)method is taken into consideration for localization in indoor system. In [51], the authors evaluated the performance by application of (MINT)Multipath assisted indoor navigation technology can avoid the effect of multipath along with superior improved accuracy, there is no loss of robustness for NLOS condition. The EKF tracking system is done depending on channel condition. MINT technology shows the better robustness against the NLOS condition. It uses two algorithms that is Maximum likelihood (ML) and Jump back Search Forward (JBSF) for estimation of channel and ranging. In [52], the authors proposed the low complexity location estimation by the application of hybrid technology that means combination of (PSO)Particle swarm optimization and (NR) Newton Raphson. The first one is meant for searching wide area space along with least square based localization by combining PSO and NR for getting lower complexity. In [53] the authors represented the positioning based on Fuzzy logic where the distance between object and station is measured using RSS and Fuzzy is applied to find the coordinate of the object. Generally, this method is applied to find the coordinate of the object when there is distortion occurs in measurement of distance. It is also found that the output of fuzzy logic-based operation is better than the performance of triangulation method. In [54], the authors proposed the combined effect of IMU and UWB for accurate positioning among different users is described. Here it also determines the position or location of group of users. An IMU technique can able to find the changed position in a short time but its limitation is it produces drift error if applied for long period of time. In comparison with laser based or vision-based localization UWB does not require LOS and produces good accuracy for distance estimation using trilateration technique. It also avoids the accumulative error for finding the relative location estimation. It shows how the ambiguity in motion measurement technique that means IMU is combined with UWB which provides information about distance to find the relative location of mobile users. In [55], the authors represented the (CS) Compressed sensing technology to find the high-resolution output with improved performance in UWB technology. A (FOMP) Fast Orthogonal Machine Pursuit algorithm is embedded with TDOA to find the better output with high accuracy. It provides mm level accuracy but have the capacity to find sub-mm level accuracy. Generally, the biases are generated in NLOS area due to presence of different obstacles; hence it produces error in position estimation through the wall localization. by which there is reduction in accuracies due to hyperbolas. By application of numerical simulations, the reduced accuracy can be improved to some extended to produce the better accuracy [56].

In [57], the authors proposed the analytical technique to prescribe the placement of optimized anchor nodes for better UWB localization. In (AGV) Automatic Guided Vehicle it allows to find the optimized distance among the consecutive

ANs to decrease the RMSE of position. In [58], the authors represented the situation of localization of passive target when one TX with multiple RXs. (TSE)Two step estimation algorithm is proposed for determination of positioning TSE along with RLB is used when the Gaussian error is low. In [59], the authors represented the reduction of packet transmission that is generally present in conventional TDOA method where there is time synchronization is must between TN and RNs. Here it uses the Asyn-TDOA that means no time synchronization is required. It only determines the time difference in one way. Though synchronization provides the precision but it increases the high burden of communication network and uses high bandwidth. In [60],the authors applied deep learning method for localization by application of the quality metrics of transmission channel with involvement of RSS and CSI with absence of device in indoor area localization. This is based on MLP and 1D CNN. Here routers used as TX and the (NIC) Network Interface card is used as RX. for getting the data. The four DNN that are involved in person location are MLP, RSS, MLP-CSI, CNN-RSS and CNN-CSI. With the CSI method the output performance is much better in comparisons with RSS. In [61], the authors represented the implementation and architecture of UWB for indoor localization system. Here it uses the differential TDOA method for positioning system. The operation is considered only for static object in indoor system. In [62], the authors proposed TOA to find the location of MS accurately in presence of 3 BS. In presence of NLOS the intersection of 3 TOA circle shows the position of target by application of particle swarm optimization. For use of nonlinearity between the intersection and MS position an object function is used. This is achieved accurately. By increasing the iterations, the object function decreases which helps in finding the optimal position of MS by PSO. It also helps in mitigating the NLOS effect. In [63], the authors represented the combined method that is maximum likelihood with range error model and fingerprinting technology for avoiding the problem which occurs due to absence of DP between the target and RNs. The ML algorithm applied here is though complicated but advanced and modified output produces in localization. In [64], the authors represented the high precision localization by using 2 algorithm that is (PLS) Particle least square and (PSO)Particle swarm optimization. It provides stable output with high robustness It determines the measured distance and physical distance. This method involves two steps, first one is training and second one is positioning. In [65], the authors invented the PSTD method for localization in Health care system. It is also proposed the localization algorithm defined the FDTD technique based on the requirement of memory and time requirement of operation that is less memory with speed calculation for PSTD method as compared to FDTD.

In [66], the authors proposed the 3D positioning TOA algorithm. It uses the new variable in place of quadratic term and also uses the weighted least square for location estimation through the application of KF. It avoids the caused due to interference in transmission path. It derives the two-way ranging method along with modified 3D TOA algorithm. This method enhances the accuracy. In [67] authors used the cross region TDOA technology for avoiding the wired time synchronization of TDOA method. This method is mainly applicable to wireless system. It creates high precision with time synchronization with advancement of localization accuracy. It also improves the robustness of the system. It realizes multiregional coordination with expansion of range of localization and gains the higher efficiency. In [68] the authors proposed the tracking of moving object in indoor area. It approximates maximum error up to 35cm, which can able to protect the blind person from unfamiliar situations. In [69], the authors used the combined technology of tightly coupled UWB with INS for enhancing the accuracy of data fusion filter. Here the fusion filter makes the difference of INS output and that of the UWB output distances. Here a predictive adaptive KF is taken into consideration. In case of missing information from UWB measured value. It predicts the UWB measured information. It is also proved that PAKF produces better performance in compared with AKF followed by KF. PAKF is mainly applicable in absence of UWB measured information. For high accuracy of data Fusion filter AKF is taken into consideration. In [70] the authors determined the human location along with signal processing is done with application of RSSI technology. It conducts two experiments that is one in university lab and laboratory building. Estimation in building is simple one but localization in library is more complex than previous one due to presence of WSN to obtain the data about environment. In [71] the authors found the enhancement of accuracy through linear statistical based distance error. Least square method is used for estimating the range error among the UWB nodes. It is found that the localization error reduces by 66%. Different localization algorithm is formularized here like circumference intersection (CI), Two stage maximum likelihood algorithm (TSML). These two techniques are used to find the correct distance before inserting to positioning algorithm.

In [72], the authors given the localization of 2D through RSS method by the application of double layer experimental phantom. It shows the accuracy label up to 0.5 to 1cm.based on RSS is obtained. In [73], the authors represented the triple filter that is KF, UKF based on Fuzzy-c-means (FCM)for avoiding the effect of NLOS in WSN. Based on FCM NLOS categorized as SNLOS and HNLOS.KF and UKF used for filtration of NLOS and ML is applied for position determination of target node. KF and UKF by application of residual analysis, voting and FCM is given for reduce the error and improving accuracy for positioning in NLOS and LOS. The residual analysis shows the presence or absence of NLOS. In case of LOS, the KF is used for the operation. In [74], the authors proposed the pervasive method of indoor outdoor positioning system is achieved by the combined technique of WLAN and GPS, which produces good coverage with better accuracy of localization. A comparison views also taken here by taking different wireless technique for localization. It is also found that instead of taking one technique if we take combined hybrid of two methods then the output is more advanced with better performance. In [75], the authors given a robust algorithm including the maximum likelihood type, multistage type basing on weight least square along with for mixed type for avoiding the NLOS effect. An extrapolated single propagation UKF is introduced here. MSE analysis is also done here. In [76], the authors represented biomedical application of determining the breathing and heart rate by IR-UWB Radar is shown here. It also uses the filter to nullify the harmonics. Moving target indicator (MTI) is used as a harmonic canceller, which avoids the harmonics of breath rate along with nullify the intermediation product. It conducts the experiment for a person after exercise, in a relaxed condition, behind the wall etc. In [77], the author represented the non-contact method of measuring the respiration rate by application of IR-UWB Radar. It involves the localization method having UWB signal modelling, avoidance of clutter in waveform, thresholding value time synchronization, trilateration technique, kalman filtering etc. In [78], the authors proposed the autocorrelation which provides good solution to IR-UWB sensing. VMD algorithm is used to find the frequency of heart beat. In [79], the authors enhanced the scalability of tag density. A snap lock concept is defined by where there is positioning is obtained for self-localization. Tag gets the response from all anchors. Now tag by TDOA method among the anchors to find the location. It is also found that due to simultaneous responses, there is no need of synchronization among anchors. In [80], the authors represented the multi-human location is done by clustering and detecting method. The output performance depends on threshold value; hence threshold analyzation is done and the adjustment in threshold is done based on various factors. It uses multihuman detection algorithm for counting people and for positioning of multihuman based on IR-UWB Sensors. In [81], the authors considered WDUWB (waveform division UWB) multiple access UWB system for multiuser positioning system in dense environment.

Transfer leaving Concept is used to avoid ranging error due to NLOS. For this it uses shared hidden layer auto encoder (SHLA) it also shows the advanced and improved accuracy in dense multipath environment. In [82], the authors considered the algorithm for both optimized and unoptimized location of recourse limited MSs. The measured positions are got optimized through Gauss-Newton (GN), Levenberg-marquardt (LVMs) technique. It also develops the adaptive algorithm for better utility of resources like memory, better time computation, energy resource contained devices. In [83], the authors determined the special NLOS channel which is independent of prior knowledge and very few dependent on environment. Equality Constrained Taylor Series Robust Least Square (ECTSRLS) method is taken into consideration for robustness of measurement. Fuzzy Compressive Evaluation (FCE) technique is applied for mitigation of range error. UWB TDOA is taken into consideration for positioning in both static and mobile experiment in a harsh indoor area. In [84], the authors represented the error model generated by pedestrian shadow. It considers RHA in target and Rxs is taken into consideration for both indoor and outdoor area. It also considers particle based 2D for pedestrian localization. In [85], the authors considered the integrated technique of combined INS and UWB system for localization with low cost and single UWB unknown Anchor node. It provides robust and accurate output performance. It first considers PDR then it fuses the UWB measured data with particle filter fusion technique. In [86], the authors represented the 3D position localization through phase evaluation is presented. Generally, the KF provides low computational effort in comparison with SAR approach. The limitation is it requires a distributed coherence Rx. but again the system having distant dependent phase at Rx can also be applied in this method of localization. In [87], the authors represented the UWB Anchor self-localization with the help of measured range data from UWB and readings from IMU. The position can be automatically generated by moving UWB tag. This technique is enhanced through (SLAM) Simultaneous Localization and Mapping. The data fusion from UWB and IMU is done by tightly coupled error state KF(ESKF).

In [88],the authors considered rated system for avoiding the missing data problem in Indoor navigation system. For missing data, the prediction is done through application of unbiased FIR (UFIR) fusion filter. Experimentally it is found that the robustness for UFIR filter is better than KF. In [89], the authors proposed how the position of different wearable sensors provides effects estimation on range error. It considers different seven wearable sensors position and concludes that the sensor at forehead provides better output than other wearable sensors. It provides very less mean error about 20cm in multipath situation. In [90], the authors considered the unsupervised machine learning algorithm. that means convolution sparse coding technique for modelling the heart beat signal derived in time domain. The output of this method is enhanced by applying the noise assisted method and finally it concludes that the low amplitude heart beat signal can be derived from high amplitude respiration signal with high accuracy. In [91], the authors considered that the critical condition due to presence of NLOS in harsh environment can be avoided in UWB localization by application of Fuzzy logic. It helps in NLOS identification and mitigation. It considers the soft NLOS and Hard NLOS. For mitigation in harsh indoor environment, it includes 3 steps for operation hat is Fuzzification, Fuzzy reference process, Defuzzification. In [92], the authors represented the localization of IOT device by two-way TOA with application of non-linear LS optimization in IOT device and that of the UWB deployment in environment. It also provides the practical observations for advancing the positioning accuracy for the feedback control in particularly IOT applications. It shows the decimetre level accuracy. In [93], the authors proposed a modified joint probabilistic data association technique for avoiding the effect of NLOS in indoor localization. Here it categorizes the pre-processing virtual points into two types. that is LOS and NLOS. For LOS EKF is applicable for operating the localization and for NLOS MJPDA is used for processing and mitigating the NLOS error. It is also found that MJPDA have enhanced and improved performance in comparison with EKF. In [94], the authors represented the integrated INS and UWB technology with application of EKF and UKF for enhancing the robustness and accuracy of Indoor area positioning and navigation system. The output of IMU is meant for state equation of KF and output of UWB is meant for the observation equation of KF. In [95], the authors proposed the human body positioning with track of movement of limb. In 3D with the help of IR-UWB compact body worn antenna. This is applicable for tracking of human movement, patient monitoring. It also considered the different wireless channel parameters like path loss model, different multipath component, received signal etc. KF is utilized for improving accuracy when the body sensor network is present in body or around that area(PAN).In [96],the authors represented UWB positioning and architecture of the system. It describes the GNSS based indoor/outdoor localization system. The EIGER project represents the design of GNSS/UWB based system for indoor/outdoor localization. In [97], the authors described the idea about SPMS (Smart Parking Management System) for advancement of Wireless vehicle detectors (WVDS). IOT based vehicle detection is taken into consideration. It combines the data from UWB and magnetic signal. The energy consumption is high for UWB in comparison with magnetic sensor. so it is activated only when magnetic sensor is not in use. In [98], the authors represented the UWB Doppler radar for multiple heart rate detection along with localization. It uses the phase based logarithmic method for detection. Filter is used to nullify the harmonics and intermediation due to high amplitude of respiration rate. In [99], the authors proposed the non-invasive method for monitoring of vital sign that is RR and HR by application of IR-UWB radar It uses KF for avoiding the harmonics generated by RR. An algorithm is also introduced for extracting the HR from RR. An autocorrelation is applied to monitor the body motion that occurs randomly. The experiment conducted from front side (chest) along with back side. In [100], the authors represented the integrated INS/UWB for cooperative localization which needs very less auxiliary nodes that is one.

An algorithm that is Adaptive ant colony optimization particle filter (AACOPF) is taken into consideration. It does not require any prior knowledge for processing. It is verified that ACOPF is superior than EKF and PF. In [101], the authors proposed the remotely health monitoring system by non-invasive technique for monitoring the health system. It shows the detection of vital sign of different conditions like stationary and non-stationary, inside the vehicle, through wall etc. It also shows how the different signal processing technique is applied for measuring the vital signs. It also elaborates different signals and image processing algorithm. In [102], the authors represented the error avoidance technique in NLOS area for improving the accuracy of positioning. First signal parameters of the area is taken into consideration after this fuzzy is applied with two step adaptive algorithm to find the data that is used for locating the target. LSE algorithm is applied for finding the location of target. In [103], the authors proposed the Relevant Vector Machine (RVM) for identifying and mitigating the obstacles in NLOS. Two steps iterative algorithm is used for converging the iterations. A distributed cooperative algorithm is used for simplification and reduction of overheads during communications. In [104], the authors monitored the device free non-contact measurement of breathing rate. It considered the (JUKF)joint unscented Kalman filter for this purpose. It uses hyperbolic tangent function for converting the measurement error into parameter error due to non-linearity of RR. It also verifies that the modified JUKF provides the advanced output with reduced complexity as compared to JUKF technique. In [105], the authors presented the localization in underground mine area. They considered TOF for positioning for reduction of communication cost, time consumption of positioning a distributed positioning technique PSO is given for target. It requires no extra hardware and provides enhanced accuracy with low cost. In [106], the authors proposed the algorithm that nullifies the ranging error caused due to multipath effect and NLOS. An algorithm is the combined effect of channel classification and KF. This algorithm also enhances the output performance of TOA method.

In [107], the authors represented the WSN for indoor localization. They discussed different positioning scheme like geometric approach, mathematical approach as optimization problem. Hence the application of PSO can avoid the problem of geometric method. The (CPS)Cyber physical system plays an important role in UWB localization by application of WSN. To reduce the problem of low efficiency in PSO an algorithm is developed that is combined effect of (PLS)Partial Least Square, (PSO)Particle swarm Optimization[108].The MSE of the above method is in order of cm level of localization. It provides the improved performance with enhanced robustness and better stability. In [109], the authors represented the hybrid technology of PSO and Newton Raphson for indoor localization with less complexity. It reduces the calculation with efficient performance proposed the sequential search approach by taking the output of PSO to the input of NR technique. It nullifies the condition of complexity when height of the reference node and that of the target node is very closed. In [110], the authors proposed the situation of localization of passive target when one TX with multiple RXs. Two step estimation (TSE) algorithm is proposed for determination of positioning TSE along with RLB is used when the Gaussian error is low. In [111], the authors represented the range estimation through determination of angle and distance for positioning the target and also represented the localization or positioning algorithm for location estimation. In [112], the authors proposed the (MINT) Multipath Indoor Navigation and tracking to avoid the error due to NLOS during localization. Comparison is done between connectional UWB ranging and tracking with implementing MINT. In [113], the authors described the Machine Learning Technique for positioning in Indoor area system by using the mathematical formula, which reduces number of measurements in the experiment of Localization. In [114], the authors represented UWB based Indoor Localization using fingerprint technique and Deep Learning method, which improves the accuracy in the field of Localization. In [115], the authors proposed JUNO based UWB Anchor selection, which enhances the learning process and takes very less time for getting the location in positioning system. In [116], the authors described the feature based DLSTM network for UWB Localization, which provides an improved model of performance and also it reduces the Localization error in comparison to the conventional method of Localization, which uses only the raw distance data for training and testing the model in the field of Localization. The Table 5 emphasises on the most current research and implementation in emerging trends of UWB localization.

Table 5. Current research and emerging trends in UWB localization with technical implementation

Author	Year/Ref	Technology/ Algorithm/Topic	Advantages/Outcome	Disadvantages
Yanjun Cao.et.al.	2020 [117]	Inertial Measurement Unit (IMU) Sensor for orientation estimation, Extended Kalman Filter (EKF) to determine the pose of a robot.	High tracking accuracy with less accumulated error.	Error reduction is by 60%. Single anchor node creates many limitations in tracking.
Yu. Xianjia.et.al.	2021 [118]	Collaborative localization approach from multiple transceivers in UWB system.	It generates the novel approaches in ranging, networking and localization in IIOT.	It does not meet the wider adoption in field of IOT.
Muhammad Shalihan.et.al.	2022 [119]	UWB System with Neural network (NN) model and the localization is through Weighted Least square (WLS) estimation method.	It creates improved localization accuracy.	It uses more number of anchor nodes for mitigation of NLOS in field of localization.
Paola Torrico Moron.et.al.	2022 [120]	Implementation of smart contracts for management of dynamic UWB localization in multi Robot systems using ToF or TDoA	It determines the UWB based localization on Hyper ledger fiber block chain.	Limitation is for use of fabric smart contracts to collaborative decision making problem.

		method.		
Fuhu Che.et.al.	2022 [121]	Performance of Unsupervised learning algorithm based on Gaussian distribution (GD) to discriminate between LOS/NLOS in IPS.	It enhances the classification of UWB IPS.	Small dataset with less signal feature generates low accuracy in IPS.
Jaron Fontaine.et.al.	2023 [122]	UWB localization is done using active channel impulse response (CIR) based fingerprinting having 7 anchor nodes.	Improved accuracy.	It requires smoothing filters and proper selection of anchor nodes.
Hongchao Yang.et.al.	2023 [123]	UWB sensor-based localization using Support vector machine (SVM) learning.	Improved ranging and location accuracy by mitigating the error due to LOS and NLOS.	Multi scene positioning accuracy is less.
Laura Flueratoru.et.al.	2022 [124]	Platform independent UWB localization system.	Varieties of solutions are found towards the platform independent localization, which enhances the system accuracy.	There is no error mitigation technique is available for localization in IPS.
Yijie Chen.et.al.	2024 [125]	Implementation of RefLoc on commercial hardware to make benefit to UWB system in NLOS condition.	Localization accuracy is high.	RefLoc relies on LOS link and maily verifies the NLOS scene of human body occlusion.
Fuhu Che	2020 [126]	Machine learning (Naïve Bayes) in localization for Industrial Internet of things (IIOT).	Improved accuracy of localization in both LOS and NLOS condition.	NLOS is influenced by ranging error and affects the accuracy badly in localization system.
Mengyao Dong.et.al	2023 [127]	NLOS mitigation method for localization in multiple walls and application of GWO algorithm for positioning of UWB tag.	It develops UWB through wall ranging error model.	The robustness and signal coverage is less.
Sangmo Sung.et.al	2023 [128]	UWB (TWR) Indoor positioning using Deep learning and proposed the kalman gain for NLOS probability calculation applied to UWB localization.	Improved localization accuracy in dynamic personnel device environments.	Limitation is found in localization for changed positioning environment.
Nour Smaoui.et.al.	2021 [129]	Anchor oriented approach is combined inter-anchor and intra-anchor concurrency for phase based localization and allows time based localization.	Design of UWB concurrent localization that estimate both TDOA and AOA simultaneously	System implementation cost is high.
Cung Lian Sang.et.al	2020 [130]	Machine learning techniques for identifying the LOS, NLOS, MP in UWB Indoor localization system.	Increased overall accuracy.	There is no hardware implementation.
Y. Zhao and M. Wang	2022 [131]	LOS/NLOS classification method based on deep learning and utilizing the Generative Adversarial network (GAN) to generate the data in NLOS condition.	Developed personnel localization in Coal mines with high classification accuracy.	Robustness for different environment is low.
Yan Li.et.al.	2023 [132]	Evaluation of NLOS and linearization errors and implementation of Robust theory based particle filter (RPF) based into UWB positioning.	It evaluates the linearization error and NLOS error, which are eliminated by nonlinerized filter.	UWB positioning accuracy in vertical component is less.
Amina Benouakta.et.al.	2024 [133]	Advancements in Industrial RTLs along with emphasizing the antennas for enhanced accuracy range.	Represents the localization techniques in complex environments.	It requires both reader and tag antenna for circular polarization, which increases the cost of the system.
Johannes Friedrich.et.al.	2021 [134]	UWB TDOA Localization in large scale NLOS environment using cascaded wireless clock synchronization.	It reduces the erroneous range measurements generated due to indirect signal path and gives real time positioning in IPS.	Less ranging accuracy and scalability.
Leyla Nasrati.et.al.	2022 [135]	It uses mobile UWB sensors, modified Saleh Valenzuela model, MLP, SVM, CNN for localization.	Improved performance of Indoor Localization using Machine learning and MAE is less.	Efficiency and Validity of the system has not recognized.
Zefu Gao.et.al.	2023 [136]	LOS/NLOS classification based on SVM, NLOS recognition and elimination using CNN, accurate coordinate solution based on Chan Taylor method.	Error correction updated, accuracy of coordinate of target point is improved.	Practical deployment of the algorithm (C-T-CNN-SVM) has not been detected.
Xiaoguo Zhang.et.al	2021 [137]	Integrated method of Firefly and Particle filter algorithm have been used for optimization in IPS.	Real indoor experiment has been carried out with greater positioning accuracy.	Due to NLOS condition the accuracy decreases.
Jinwang Li.et.al.	2022 [138]	Identification and reduction of NLOS effect in Indoor localization system and Kalman filter is used for optimal estimation.	NLOS error decreases with increased localization accuracy in IPS.	Robustness for the system is low.
Qiankun Kong	2023 [139]	CNN method based on Dung Beetle Optimizer (DBO) is used for UWB Localization.	It generates more optimal solution with quick convergence time period.	The model is not meant for varieties of scenarios and generates less identification accuracy.
Sreenivasulu Pala.et.al	2020 [140]	Modified leading edge detection algorithm for estimating the TOA of received UWB signal in IPS..	Enhanced positioning accuracy and improved performance at low SNR.	Limited deployment of base station.
Zhengyu Yu.et.al	2022 [141]	Curve fitted Kalman filter (CFKF) is used to reduce the multi sensor interference in localization.	Reduction of error, noise, interference with increased localization accuracy.	Enhanced implementation of the sensor has not been developed.
Luca Barbieri.et.al.	2021 [142]	UWB Real time Location system in Factory environment. It uses Bayesian filtering	Reduced positioning error due to dense multipath effect.	Limitation in development of NLOS ststistics mitigation

		method with particle-based implementation.		system.
Hua Guo.et.al	2024 [143]	Density clustering with noise combined with particle swarm optimization (DCNPSO) is used to minimize the effect of environmental factor in IPS.	Improved accuracy with reduced noise.	Low efficiency with more number of iterations, which increases the run time.
Shijia Wang.et.al	2020 [144]	Genetic Algorithm (GA) is used for Optimization node in UWB Localization.	The optimization improves the localization and reduces the mean error of target position estimation.	Ranging error is affected by NLOS in region of Localization.
Sander Coene.et.al	2024 [145]	Location aware ranging correction (LARC) is used to modify the range estimation in UWB localization.	Improved performance with decreases over fitting. High robustness.	No implementation of ranging and localization algorithm on proposed model.
Pengfei ji.et.al	2024 [146]	Combined UWB/IMU Localization with improved Cubature Kalman filter (CKF).	High localization accuracy in both LOS and NLOS conditions.	Less robustness.

5. Conclusion and Future Scope

This paper represents a survey on Indoor/outdoor localization with various technology in the range of UWB Radio frequency. Positioning is one of the most important goals for realizing the services that offers safety and security with high efficiency with in a small area system like home. UWB uses sub-nano second radio pulse for transmission of the data with in a large spectrum of bandwidth. The main feature of UWB based localization is its immune to multipath problem. Wireless localization technique plays a crucial role in people’s daily lives like living assistants, navigation, detection of emergency, surveillance with different location-based services. The different Range based algorithms have taken for UWB localization in various areas of network (WBAN, WPAN, Surveillance network). UWB localization system can be used for identify and to locate the valuable assets in hospital region, industrial area, and government offices etc. Another important application is in sensor network due to its low power consumption. Taking human location into consideration in a home or small area with a simple structure. Today, RF methods are generally used in location system, because they require less amount of hardware in comparison to other approaches and produces less error. As the demand for IOT is increasing day by day, hence an IOT based localization is to be done which will cover both Indoor and outdoor positioning system with greater efficiency and high robustness.

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