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SURVEY ARTICLE

A Comprehensive Survey of Various Localization Methods in Vehicular Ad Hoc Network

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Abstract – Internet of Things (IoT) has had an evolutionary impact in recent days. The various changes in lifestyle and other critical influences have a huge impact on the growth of IoT. IoT in localization-based applications has attained remarkable attention, especially in the localization/positioning of vehicle tracking, health sector, etc. Localization is vital for Vehicular Ad Hoc Networks (VANET) in wireless communication technologies. VANET is prominent for most accident prevention, vehicle tracking, and efficient transportation applications. Most of the existing systems contain GPS technology integrated with vehicles for localization-based applications. The evolution of IoT replaces GPS in the VANET localization application. Various localization solutions are evolved in the literature, but it fails to meet the localization precision according to the consumer needs. In this survey, we have done depth analysis of existing technologies and techniques in the field of localization along with IoT. The analysis includes various parameters like RSU usage, Cooperative Localization methods, VANET localization effects, etc. This study describes that the RSU structures did not improve localization accuracy; instead, it minimizes the required mobile anchor nodes in VANET. Different VANET operations and their results related to real-world scenarios are discussed in detail. Finally, as a result of this potential research, a refined methodology is introduced for future research.

Index Terms – Localization, VANET, IoT, GPS Technology, Cooperative Localization Methods.

1. INTRODUCTION

In vehicular networks, low-cost and accurate localization is the essential required factors. Nowadays, in-car navigation systems localization has become critical because of urbanization and transportation systems in metropolitan areas [1].

VANET (Vehicular Ad-Hoc Network) is used for vehicles to share and communicate the data [2] temporarily. VANET has recently been a very active study topic to address traffic concerns in jammed or overfilled cities. Moving vehicles and their approximate location gives you a better picture of traffic on the road and helps you avoid accidents [3]. It can also save a lot of money on gas by avoiding transportation service disruptions. Because of the proximity of vehicles in congested traffic, getting precise position information is essential for VANETs. The quality of the acquired position information determines to enhance the guided operations on electronic maps. However, because of vehicle motion and signal attenuation produced by ambient objects, it is challenging to locate automobiles in VANETs (fading and Doppler effects). This document includes comprehensive published works that address this area.

Nodes and vehicles must first identify their positions before using VANET for Localization. This can be accomplished using GPS signals or manually placed Road Side Units (RSU). In addition, as illustrated in Fig. 1, a vehicle in a VANET can establish its location by measuring the neighboring node's distance and substituting the distance information among the nearby nodes within the network. In Mobile Wireless Sensor Networks [4], relative localization is standard. Many research studies [4, 5] have focused on the VANET localization problems utilizing traditional techniques like a dead reckoning, GPS, map matching, and limited usage areas like Vehicle Collision and Autonomous Vehicles.

However, rigorous evaluations and comparisons of traditional methods and newly built IoT integrated solutions like RSUs are lacking. More research on the use of filters (Particle filter, Kalman, etc.) and their involvement in cooperative Localization for VANET localization is also required. The prior research focuses on data fusion and cooperative Localization, which is becoming increasingly needed in the coming days.

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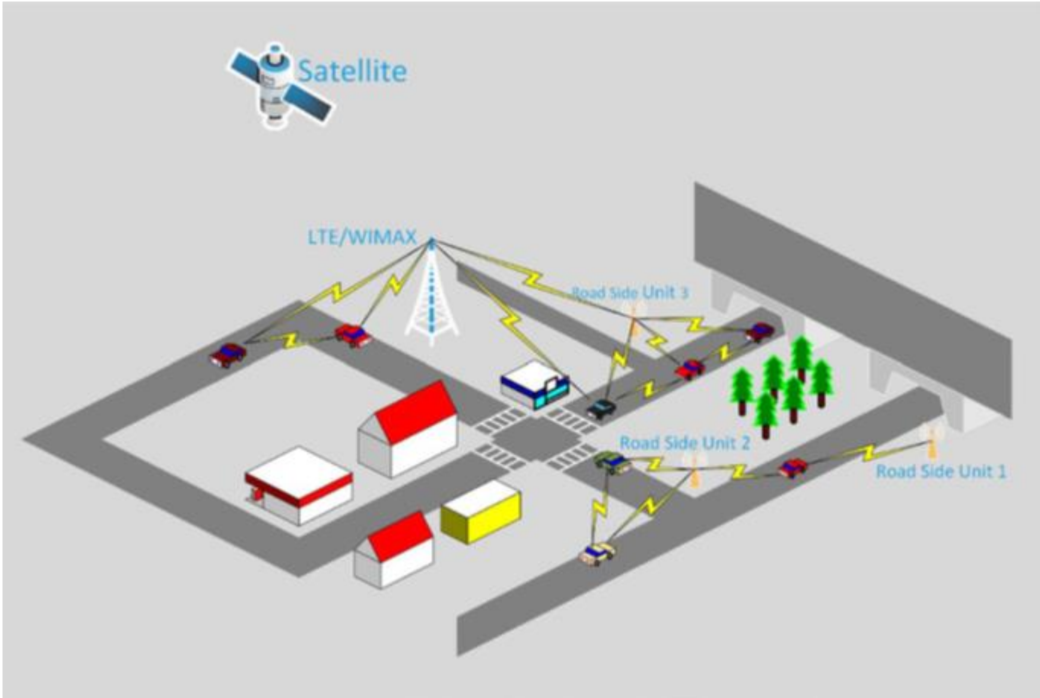

Figure 1 VANET Architecture

The main aim of conducting this study is to fill a gap in the literature by compiling a collection of recent works on Localization in VANET, figure-1 shows vanet architecture which includes the works [6,7]. Another thing is implementing a novel categorization system for assessing and summering the data based on the data's functional status and content body.

1.1. Objective

In wireless communication systems, localization is considered one of the most vital topics. Vehicular Ad Hoc Networks (VANET) have a greater impact in various applications like efficient transportation, accident prevention, and vehicle tracking. In localization-based applications, GPS technology is fitted with vehicles for tracking.

To enhance the VANET localization, implementation of the Internet of Things (IoT) is evolved, which does not require GPS. In this work, several techniques proposed and their connection with VANET localization use cases are discussed. Further, this study is classified according to the methodologies respective to their merits and demerits. As a result of this survey, an efficient research overview is gained.

The contribution of this work is listed below;

- IoT technologies are the commonly used in various applications for getting access to automobiles. It is more simple and easy to obtain massive data at minimum cost.
- VANET localization applications are discussed in this study from the perspective of IoT technologies; it includes other aspects of the existing works
- Various parameters like communication technologies, RSU usage, and Cooperative Localization methods, along with VANET localization effects, are discussed in detail.
- This study provides a comprehensive overview of all VANET localization methods proposed in the literature.
- This study describes real-world tests in a city setting along with the simulations.

This paper is organized as follows: Section 1 describes the introduction and the research objective and contribution. Section 2 describes the various literature works on VANET localization in various domains. Section 3 describes various VANETs Localization Methodologies. The section describes the conclusion, and in section 5, future work is discussed.

2. RELATED WORKS

For technological development and various need, Localization-based services are more important. Localization or positioning is known as tracking an object based on certain information with various reference points. Localization is applicable for tracking moving and fixed objects like drones, mobile computing devices, vehicles, watches, smartphones, and beacons [1]. The location information is valid for various monitoring, tracking, navigation, etc. In most Internet of

Things (IoT) applications, localization information becomes a necessary element. In recent years, most of the advent of technologies has ensured location information as the primary data for IoT solutions. Generally, IoT is determined as the interconnection of networks or internet-connected items such as software, actuators, sensors, and other devices used to collect, receive, and communicate the data using a wireless network. A prediction describes in 2025, about 22 billion devices will be linked to IoT globally [2]. The combination of localization on IoT with Big data is a more significant concept but complex too. It is like ordinary people struggling to find a particular location inside the huge shopping malls, warehouses, hospitals, or complex industrial areas. The issues grab the attention of commercial staff and researchers globally, and still, it's retaining as a challenging task.

Few popularly known localization system examples are Global Navigation Satellite System (GLONASS), Global Navigation Satellite System (GNSS) signals [3], Beidou, Global Positioning System (GPS), and Galileo. GPS is a widely used satellite-based localization system for global coverage. But it is limited in indoor environments and urban areas because indoor setting GPS devices will lose substantial power. Multiple building materials induce GPS signal attenuation, or the GPS signals will lose deep indoors [4]. It shows in indoor environments, GPS is not applicable for localizing devices/items. The major reasons for these drawbacks are indoor environment complications, reflection within the building that relies on human activity, object position, etc., signal interference, and defective indoor communication channel [5-10]. ZigBee [11,12], Bluetooth, Radio Frequency Identification (RFID), To overcome this multiple solution using various technologies are evolved such as cellular networks (including LTE and 5G) [13], [14], Ultra-wideband (UWB), Frequency modulation (FM), inertial sensors and wearable devices [15] and Wi-Fi Additionally, few hybrid approaches had the merits of combining two or more technologies to improve indoor localization [15].

There are various types of mechanisms used in localization which are based on Time of Flight (TOF) measurements and Received Signal Strength Indicator (RSSI) signal measurements [16,17]. The RSSI measurements are utilized in two types: (1) Placement through assessing the distance between the known fixed stations and target device using RSSI. (2) Secondly, RSSI fingerprint-based location estimation. The distance measurement concept of TOF is implemented in various methods like AOA, TOA, and TDOA. But these localization or measurements systems contain some drawbacks, like suffering from an inaccurate way of processing the localization. In Dead-reckoning measurements, wearable devices or inertial sensors are used, giving pre-defined reference data and location information [18].

Measurements	**Accuracy**	**Sensitivity to Multipath**	**Additional hardware**	**Attenuation problem**	**Cost**	**Advantages**	**Disadvantages**
TOA [19]	High	Yes	Yes	Low	Average	✓ No need for a fingerprint database. ✓ Higher accuracy localizations.	✓ More time and synchronization cost for APs and target devices. ✓ Complex to implement in a low-bandwidth environment. ✓ Need Line of sight. ✓ Specification required on the access point's location.
TDOA[20],[21]	High	Yes	Yes	Low	Average	✓ No need for a fingerprint database. ✓ Higher accuracy localizations. ✓ Synchronization time is not required between the target devices and AP devices.	✓ For removing prior details is required. ✓ Complex to implement in a low-bandwidth environment. ✓ Need of accurate time during synchronization between the AP

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						✓ Synchronization time required only between the AP devices ✓ Localization accuracy is high	devices. ✓ Need Line of sight.
RTT [22] [23]	High	Yes	Yes	Low	Average	✓ The synchronization issue is addressed	✓ Location-Based Services (LBS) applications are suffered from problematic latencies. ✓ High network traffic load ✓ Signal Delay problem ✓ Measurement errors owing to non- receipt ✓ Predisposed by NLOS
AOA [24] [25]	Avera ge	Yes	Yes	Averag e	High	✓ Need minimum of two receivers ✓ Synchronization time is not required	✓ There is a need for extra antennas that have the measuring capacity of angles that maximize the AOA implementation costs. ✓ Influenced by NLOS signal transmissions, multipath, reflecting surfaces like reflecting objects, walls, etc.
RSSI [26] [27]	Avera ge	Yes	No	High	Low	✓ No need for Special mobile station hardware (MS) in addition to wireless network interface cards ✓ No need for synchronization time and angle measurements is required. ✓ Implementation is simple.	✓ Need of fingerprinting database for scene analytical methods. Radio map database required more effort and time. ✓ NLOS and noise-sensitive

Table 1 A Comparison Table of Various Literature Works

2.1. VANET Localization in Various Domains

Table 1 shows a comparison table of various literature works although localization is used in a wide range of applications, it can be divided into two groups for VANET: military and civilian. There are numerous uses for the former, including vehicle placement and tracking, search and rescue operations, target location guided control, and aircraft landing/launching in severe weather circumstances.

Civil applications include agriculture, cartography, forestry, tourism, and vehicle monitoring systems. Under any conditions, reliable location identification is crucial in each area mentioned above. Localization in VANETs is mostly for civilian usage, although progression needs to be quick and precise.

In VANET, Localization is a dynamic network which are generally utilized for civilian purposes, must be done rapidly and with great precision. The prior applications included vehicle speed, crash reports, additional location estimation, and accident prevention. Its main goals are position estimation, accident prevention inside tunnels, precise navigation, and autonomous parking. It is also available for cooperative driving and driver assistance. VANET-based localization key application areas are listed in the following sections.

2.2. Importance of VANET Localization in Accident Prevention Applications

IEEE 802.11 is a communication protocol used in accident prevention applications and vehicle sensors for crash

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Localization. The precise position can be established when speed and heading data are combined with localization data [5, 8]. Several systems, such as RSUs and Dead Reckoning (DR), are used to estimate position and avert accidents inside tunnels. When GPS signals are unavailable, communication protocols can perform effectively.

Another application is warning cars to stay away from red lights. If traffic signs are not obeyed, this application sends warning messages to the vehicle. Furthermore, a safe trailing distance application warns drivers when the space between vehicles is less than the required distance. Furthermore, the left turn helper collects information about intersections and assists vehicles in safely turning left. Besides these, other applications in this group include junction collision warning, pedestrian crossing, and blind-spot capture [9].

2.3. Importance of VANET Localization in Public Safety Applications

Emergency response teams might use Public Safety Applications to get to an accident scene as quickly as possible. An ambulance attempting to reach an accident site can contact all vehicles on the road and transmit a message to clear the lane for this purpose [10]. The emergency vehicle signal preemption system uses a vehicle-to-infrastructure (V2I) communication system to adjust traffic lights at intersections where ambulances approach, converting red lights to green and assisting the vehicle is going forward without becoming caught in traffic. In addition to lane change warnings, the visibility enhancer alerts drivers to inclement weather and makes driving easier in these conditions. In addition, the road condition alert app reports road conditions such as rain, snow, gravel, ice, and others. It also uses VANET to notify all vehicles approaching specific road zones. Finally, the SOS service and applications that provide post-crash warnings are included in this category.

2.4. Importance of VANET Localization in Vehicle Maintenance and Diagnostics Applications

The goal of these systems is to send notifications to drivers about vehicle issues and potential breakdowns in a 400-meter coverage zone. Information can be sent from other cars using VANET's many apps [11]. Aside from safety, several applications, such as cooperative cruise control, make it easier for drivers to operate their automobiles. Its goal is to make sure that a group of cars travels in the fleet autonomously at speed determined by the driver before departure, without the need for the driver's interaction. Vehicle-to-vehicle (V2V) communication is employed in the application, and intra-vehicular communication is used to make partly automatic changes to the velocity-dependent on the road direction and conditions .Generally, the localization process is required or makes the VANET activities of vehicle maintenance and inspections, sign extension, public safety, accident prevention. The combined use of several localization approaches enhances efficiency.

In VANET, V2V communication during localization is critical in making it more accessible. It is vital to use localization in many VANET apps in this regard. Naturally, this requirement differs from one application to the next. For example, high-accuracy localization information is required in cooperative adaptive cruise control and vehicle following applications. The cars that are moving together must share their respective locations. A smart application or process needs to have ultrahigh localization accuracies like autonomous parking or car collision warning. Because of the excellent accuracy of the localization, the target may avoid a crash or damage before it occurs using this type of application.

3. VANETS LOCALIZATION METHODOLOGIES

3.1. GPS and DGPS

The Global Positioning System (GPS) is a satellite network that determines a person's location on the Earth's surface. Its operation is based on computing the discrepancies between the devices and the satellites to determine the position. The United States Department of Defense owns the GPS satellite network and delivers location data constantly estimated to the Earth. Each satellite takes roughly 12 hours to complete one orbit around the Earth [12]. A network of 24 satellites (21 actives, 3 spares) was developed from 1978 to the 1990s. The number has risen steadily over time, especially in recent years. Satellites deliver low-power radio signals to the Earth's surface from orbits that move at the height of roughly 20.000 km. They are positioned so that at least four satellites can see every location on the planet. The GPS receiver the satellite signals and location are estimated to complete the positioning operation. A mechanism known as Time of Arrival (ToA) is used in the computing process, and as a result, the GPS receiver determines its altitude, latitude, and longitude.

On the other hand, the temporal equalization problem arises due to the satellites' mobility during signal transmission. It's solved by using an atomic clock found in every GPS satellite. Any time lag between the satellites or between the satellite and the receiver can be avoided with this clock [13]. The United States launched the first GPS satellite for military objectives, and it was utilized for the same purpose for an extended period. Russia also began developing its satellite system, GLONASS, which suffered from coverage zone limitations until the mid-2000s [14]. Countries like India, China, and the European Union contain their own positioning systems like NAVIC, BeiDou, and Galileo. Additionally, Japan has Quasi-Zenith Satellite System to enhance GPS accuracy and reliability; it launched its four satellite constellations.

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Differential GPS (DGPS) is a more advanced GPS that relies on reference ground stations rather than GPS satellites. The difference between satellite and actual pseudo ranges is determined using this method. Those stations also broadcast the indicated disparity to other stations, which is interpreted as a corrective signal. Localization error is reduced from the meter to centimeter level in this manner. The requirement to set up fixed reference nodes for providing differential information is a downside of this technology [14, 15].

Advantages of GPS	Disadvantages of GPS
Maximum accuracy positioning (Up to 50 km in the area has an error rate of 6–10 m, 100–500 km in area 7–10 m, 1000 km in area 10–9 m) [16]	United States controls the whole GPS satellites. It uses those GPS satellites that need to get permission and varies in decisions because of sky changes in position. It results in multiple signals leads to delay in the decision and poor positioning accuracy [16]
Minimum complexity on the transaction	GPS receiver sensitivity may be drained by multipath and noise problems. High building in the urban areas blocks the signals. Reduce in satellites seeing an area results in inaccuracy in positioning. Additionally, satellite signals reflected on building surfaces will lack positioning accuracy and multipath effects. The implementation of modern technologies like Inertial Navigation System (INS), GPS, Dead Reckoning (DR), and GPS is proposed to overcome these issues.

Table 2 Advantage and Disadvantage of GPS

3.2. Cellular Localization

Cellular localization is based on calculating the position of an object utilizing a mobile cellular infrastructure in an urban setting table 2 shows advantages and disadvantage of GPS. Network data may differ depending on the Doppler effect and linked object's location. For the successful function of mobile cellular systems, communication infrastructure with various cellular base stations is required over the restricted area. To avoid interference and maintain QoS, each cell needs to provide various frequency ranges than their neighbors. Joining these cells will give broad radio coverage around the geographic locations. Various portable transceivers like mobiles, laptop computers, tablets, pagers, mobile broadband modems for network access and communication over the base stations. In the cellular networks, base stations are employed for device position estimations, and it helps transmit single to multiple connections. Additionally, compared to transmitters or satellites, mobile devices use minimum energy.

3.3. Image/Video Processing

In work [16], another capturing of the image and/or video data for positioning is described. The geometric parameters like vehicle's orientation, camera tilt angle, the width of the strip, the distance between the lane and the car are estimated precisely using this method. However, this strategy can generate a large quantity of data and cause network congestion. Furthermore, the image and video processing should be quick enough. Positioning accuracy may be degraded as a result of processing time delays.

3.4. Road Side Unit‑(RSU)

In VANET, RSUs are the permanent infrastructure communication nodes present around the roadsides. RSU is used independently in cooperative and non-cooperative methods of localization. The RSU structure is essential in VANET for a variety of reasons. First, they convey critical information to the network's vehicles. Secondly, to the end-users, messages are delivered successfully. The ability to connect automobiles to the Internet is their absolute advantage. RSUs make communication much more accessible because VANET is a fully mobile network with changeable topology and latency. The RSU structures maximize the VANET coverage and network performance. The number of RSUs in the VANET may also affect the network vehicles' communicative performance.

In VANET, RSU installation is very complicated and maximizes operation costs. As a result, a compromise between the RSU coverage area and installation cost should be struck. The concept of a restricted number of RSUs for usage in sparsely populated areas has gained traction [17]. Apart from that, RSUs can convey position data to VANET vehicles and information about the route, weather, and traffic status.

RSUs involve high-frequency DSRC communication such as 5.9 GHz to obtain quick reaction with collision avoidance and minimal latency. The GPS signals are broken readily or jammed, and the RSU can aid intra-vehicular communication for more accurate localization on heavily congested highways. The need for accurate and trustworthy position data from cars is a significant security issue for localization techniques. Fake location data has a substantial impact on the performance and security of location-based apps. RSUs are currently in use in various cities and areas around the world.

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3.5. Cooperative Localization (CL)

Cooperative Localization (CL) combines several localization approaches with fusion to get more accurate localization. The nodes in the cooperative localization work together to determine their location using relative distances. The accuracy of the localization system is improved by the extra information obtained from cooperative measurements among the node pairs [18]—several information sources for locating moving automobiles in VANET. To begin, an odometer or vehicular sensor measure can be used to determine the velocity and position of the moving vehicle. Other vehicles' positions can also be obtained and utilized. Finally, the RSU unit, base station, and position data will detect mobile vehicles (BS).

In Cooperative Localization, the Kalman Filter, Particle Filter, and Spawn Algorithm are effective strategies. The Filters Section explains Kalman and Particle Filters. The Spawn algorithm (SPA) contains Factor graphs and the sum-product techniques. Each node or vehicle obtains location information from the previous localization in the Spawn process. Based on the obtained information, the positions are adjusted and estimated. These new estimations are shared and describe the VANET node's probability density function among the neighbors. Various approaches describe the CL accuracy, including VANET landmark density, including their compatibility and individual accomplishments. They have something to do with vehicle or location hardware. Filtering and algorithms are two examples of methods in the aspect of software and mathematics.

A separate process was used in the classification of VANET localizations. Many publications on cooperative and non-cooperative localization have been published in recent years. In addition, the need for cooperative localization has necessitated the separation of GPS-based and non-GPS-based investigations. In this regard, purely classifying approaches by their names may not be sufficient to address the problems. Instead, systems are split into categories based on their traits or characteristics.

Similarly, studies using GPS-based approaches are categorized using the filter. The methods and associated studies are summarized after this division. In NON-GPS-based cooperative methods, built-in technologies or accuracy-increasing procedures are highlighted to enhance VANET accuracy.

3.6. GPS Based Cooperative Localization

When GPS is combined with other technologies, the accuracy values are more efficient and successful. It is now more helpful than existing works of VANET localization in the event of a GPS failure. It means that the GPS location discovered the previous outage and the most recent outage status after localization.

The Bayes filter mechanism is used in both the Kalman and Particle filter procedures. It includes various filters and discusses those filter usage in VANET localizations.

3.7. Kalman Filter (KF)

The Previous Path Detection (IVCAL+PPD) method [19] helps inter-vehicular communication between the localization by combining GPS, direction, speed, and the previous position is evaluated using a hybrid manner. In this research, initially, GPS data are combined with the data on speed and direction. The signal contains multipath, and the three efficient VANET neighborhood anchors need to improve our accuracy, found, and placement. In the Previous Path Detection (PPD) algorithm, the preceding location estimates are collected and averaged within a specific time frame, such as the previous one minute. Past data has been used in conjunction with the current estimate. The technique has not been put to the test in the actual world, but it has been compared against the approaches of IVCAL, IVCAL+PPD, GPS, and KF inaccurate simulations. With IVCAL+PPD, an efficient outcome is obtained with a 0.05 m accuracy error.

Non-cooperative factors such as traffic signals, dormant autos, or people increased VANET localization are explained in [20]. Implicit cooperative Localization is the name given to this phenomenon. The features listed above are also combined with V2V communication lines. This study also uses the Gaussian Message Passing technique, which combines GPS measurements with a Kalman filter. Various VHF (Vehicle to Feature) approaches are tried in this work, and the measurements are practically noisy. As a result, more accurate localization can be achieved by using those VHF techniques to build consensus. The Localization results which are obtained frequently are more accurate. For example, the 200 features were used in Urban Canyon, the localization root mean square error was roughly 0.2 m. However, only about 4 m of RMSE was obtained in the urban canyon for only 5 features. These characteristics were used in an urban canyon but not in a rural one.

In [21], GPS and vehicular sensors are used in wireless communication for delivering warnings to drivers using the movements of nearby vehicles. A fiber optic gyro, steering angle coder, and wheel velocity sensors are vehicle sensors. The Kalman filter was used to merge the data from these sensors and the steering angle coder. In this study, a dynamic cycle model is used. Data collected at low and high speeds throughout a 60-kilometer trip was analyzed, including lane changes, junctions, stops-turns, etc. These assertions are supported by the fact that the filter performs dead reckoning, disseminates speed, and activates the collision warning. The researchers compared real-time positioning structures created and placed on the vehicles. Vehicle sensors like DGPS data, steering angle, yaw rate gyro, wheel velocity all given an extended Kalman filter. Because the average number of

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satellites in the current study is less than 5, GPS location errors of higher than 2 to 3 m are poorly estimated. Similar research tries to reduce the multipath problem in VANET cars based on their localization precision. The Inter-Vehicle Communication Assisted Localization (IVCAL) method uses the VANET car communications to get additional data from neighboring vehicles. According to the simulation results, the positioning error is decreased by up to 53% compared to standard procedures [22].

In [23], KF structure-based study proposed the Constrained Weighting Scheme of Inter-Vehicle Communication Assisted Localization (CWS-IVCAL) method, which uses intra-vehicular communication to improve vehicular localization accuracy. In the localization approach, CWS-IVCAL complies with vehicles procedures using IVCAL, considering the uncertainty of dead reckoning. The proposed method was tested in a simulation and compared to a well-organized IVCAL scheme. CWS-IVCAL tests the accuracy of GPS in an urban setting and the flexibility of intra-vehicular distance estimates. An advanced assurance measurement is obtained from the application and finalizes that the constraint weighting method enhances localization. It is very effective in the aspect of localization accuracy and soundness.

In VANET systems, following vehicular position data is discontinuous, the frequency of location information updates should be reduced to reduce the load of data and communication administration. According to the following study [24], the Kalman filter difference model uses the equation to update the location. The Kalman filter is developed for updating vehicle position based on the obtained data in the future section. The vehicle location update data is presented using a decision technique for repeating packages to avoid package losses. Furthermore, the model generates location updating information based on a predetermined position and decides the distance between two neighboring cars' package repeating mode. The simulation shows that using a package repeating position updating approach may significantly reduce the cars' Messages Generation Density (MGD) and boost the Packet Delivery Ratio (PDR) to maintain bandwidth, reduce database difficulties, and improve network communication dependability.

Rohani et al. [25] proposed a decentralized Bayesian approach for merging the GPS localization with other car GPS data and estimating vehicular distance. This study aims to enhance GPS localization while removing data dependency, which is prevalent in probabilistic approaches [26–28]. It has also been established that, unlike previous methods, the suggested approaches have no difficulty with over convergence. The Kalman filter was applied to the new localization estimates generated by that method, compared to GPS measurement positions. As a result, it was discovered that this considerably reduces location uncertainty and localization mistake.

Ghaleb et al.'s [29] research aims to design a highly accurate system that can operate in dynamic and unstable environments. For this, an innovation-based Adaptive Estimation Kalman Filter (IAEKF) structure supports localization data with vehicular kinematic information and is refreshed partially as per the VANET localization. The satisfaction charts are built using the findings for performing the localization and the various noise levels encountered, with the EIAE-KF approach achieving the highest degree of satisfaction.

Sunil and Rekha [30] proposed vehicle localization using Kalman filters. They enable better findings without filling the memory obtained utilizing the Kalman channel. The penultimate situation is not remembered, significantly benefiting built-in systems that combine GPS and video images. [31] emphasizes the importance of observing a correlation between successive localization measurements. After that, the measurements are combined to simulate the localization error. The Yule-Walker equations describe the relationship between past and future vehicle positions. In addition, the p-order Gause-Markov approach is used to estimate future vehicle locations using past positions. This approach compares two datasets containing two cars' movement traces.

In work [32], the IVCAL localization technique is proposed to detect multipath circumstances and minimize vehicular Localization effects. The uncertainty of the location indicates the position interchange, which uses the position data for achieving maximum accuracy. Further urban or canyon and open landscapes contexts were used to test the increased localization performance.

3.8. UKF

Unscented Kalman Filtering (UKF) is proposed in [33] as a new method for vehicle localization. Multi-dimensional data is used to describe the movement and location of a vehicle's kinematic parameters (movement, position, acceleration, velocities). A comparison work is carried out with GPSIDR and EKF-based solutions in terms of reliability and accuracy. The 10 m resolution of GPS for vehicle localization is insufficient for VANET security applications. The proposed technique incorporates vehicle data, movement models, and UKF to improve localization precision. UKF was used as a second-step filter in Cruz et al. [33]'s investigation.

3.9. Particle Filtering

Using the RSU structures inside tunnels, an alternate method for vehicle location has been presented in [34]. The primary distinction is location determination requirements without access to a GPS satellite. A combination of Particle Filtering data and Inertial Measurement Units (IMU/WSS) data was used to determine the vehicle's location concerning other cars. ITS-G5 RSS and ToF-based ranges were used to test various

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localization infrastructures in a tunnel. Errors in localization range from 0.1 to 2.0 m, depending on the filter-fusion situation.

In work [35], particle filter and weight update theory are used to enhance accuracy while also considering vehicle motion and mutual positioning. TOA was used to find the range. Particle filters were used in the simulation findings for both the TOA and the GPS. GPS and GPS outage results are broken down into two categories: GPS and GPS outage. 3 to 9 nodes are employed in the GPS results, and 3.83 m positioning errors are obtained with particle filters for each of these results. Position errors were measured at 13, 04, 9, 68, 9, 21, and 7, 41 m when GPS was unavailable, while accurate findings were obtained when GPS was operational. Sumo was used to simulate Istanbul.

The work [36, 37] discusses localization systems performance, but outdoor localization remains a challenge. Integration of data from a vision system that computes the vehicle's position and direction on the road with GPS absolute location was proposed in this work [38]. The best standard deviation was 48 cm along the road axis and 8 cm along the axis normal when the system was deployed on an empirical car on real roads and in real-time. An urban route of 4 kilometers, including a twisty one and single-lane and double-lane roads, yielded this set of findings. The results show the need for integrating information from many sensors for

The results show that integrating information from many sensors without the GOS data for the vehicle is unpredictable and inaccessible. This strategy is also used in another investigation. [39].

3.10. Bayesian Filtering

In the study [40], Bayesian Filtering intends to improve CMM, get accurate GPS data between the vehicles, and based on the obtained information, a precise map is designed. The initial phase is the transmission of GPS data from one car to another via VANET and CMM. Using this information, other vehicles enhance their ability to find their way around by creating more accurate maps. When new cars join VANET, a dynamic base station, DGPS can fix their GPS Pseudo range inaccuracies without centralizing the process. Those GPS satellite-to-vehicle distance errors are called pseudo-range errors. Unlike earlier studies, this one does not require distance information between the connected car and other vehicles, and the CMM and DGPS reduce pseudo-range errors and mapping uncertainties. The position error for GPS was 14.06 m, 5.02 m for SVMM, and 2.74 m for CMM with ten vehicles in the best comparison scenario. Without intra-vehicular measurement, a reduced method was used; however, it's not apparent if it improves localization accuracy. Every car is required by law to have a GPS module, which is both costly and inconvenient.

3.11. Non-Cooperative Localization

Geoff: This approach provides the following information: direction, timestamp, and velocity. They've logged all the previous data and the GPS position information that was recently discovered. There are three primary localization situations examined in this study [39].

1. Short GPS outage: The interruption is so brief that the location obtained using traditional GPS appears to be in sync with the present location.

2. Long GPS outage for Road bend position: Compared to the traditional GPS, outage time is high and differs from the current position.

3. Long GPS outage for Straight road: Compared to the traditional GPS Outage, the outage time is longer, which considers the current position as both multiple and angular. This method is applicable for passing through perpendicular areas.

In the following outage, both a static and a dynamic relocation is performed. The study distinguishes between direction-based and geometric localization, one of its findings. This method was compared against the GOT and IVCAL techniques. Outage times were considered when applying localization (60 to 300 s). At speeds ranging from 20 to 80 km/h, GeoLV provided the most accurate results, followed by GOT and IVCAL. By employing the same set of parameters, localization delays were detected, and the same ranking was achieved. Despite this, GeoLV had a much better year. Accuracy and delay simulations were carried out in parallel.

3.12. IEEE 802.11 and IEEE 802. 11 b/g

Many vehicles have GPS. However, this does not mean they can be reliably located like in VANETs. However, a problem that is often overlooked is the location of the nearby automobiles. A neighbor vehicle's locational information may fast repeat its prior data in VANETs since the nodes can move at high speeds. Instead of raising the frequency of periodic exchange messages carrying a node's position, the article has a solution [41]. According to the simulations, an estimating model with modest complexity can significantly improve the accuracy of neighborhood localization. The periodic messages with vehicle locations include valuable information to estimate the nodes' nearer future positions (in a few seconds). One vehicle can locate another inside the coverage area using this method as necessary. Error rates for equal-frequency messages were lowered by more than half.

The Vehicle Tracking Systems (VETRAC) is a valuable tool for tracking any moving vehicle. As well as its use and application, GPS modules are used by most automobiles [42]. VETRAC takes advantage of IEEE 802.11 b/g standard WiFi

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when it comes to wireless connectivity. An internet connection or special software can be used to view vehicle information on digital maps. In the project, a WiFi-enabled Intelligent Vehicle Navigation System (IVNS) was developed to help drivers navigate in low-traffic areas. This technique can also be used to help travelers find their way around a new city. To design an operating system that could be used in vehicles, Microsoft partnered with several different automotive manufacturers, and the authors chose Microsoft Windows as their platform. For large campuses like universities, airports, and train stations, VETRAC is a navigation system. Because GPS is inactive when following a vehicle on campus or in a tunnel, WiFi was used instead. Different cars, including TATA Sumo cars and motorbikes, were used to test the project on a WiFi-enabled campus.

3.13. ZigBee

Due to the wireless location model's "distance-loss" constraint, an approximate triangular centroid location algorithm model was suggested in the study. This strategy was compatible when tested in terms of distance errors and location accuracy [43]. In low-speed driving conditions, the collected data yielded a location accuracy of 2m and 3m. The triangle centroid method is used to identify the location of an unknown mobile node in VANET. That a low-speed car can meet operational safety standards was demonstrated in this study.

3.14. RSU in Non-Cooperative Localization

In the case of non-cooperative localization, the RSU method a mobile target or moving vehicle that is non-cooperative with VANET vehicles can be located using OBUs and RSUs within the coverage area of this document. [44]. There are, however, a variety of speed limitations and traffic jams on the road network that makes it challenging to track vehicles, in places where the target is likely to be, OBUs and RSUs exchange monitoring messages. Classifying the target's behaviors is done using OBU observations. They are used to predict the target's upcoming movements. Using Bayesian estimations, Dirichlet-Multinomial models were used to learn the behaviors of moving vehicles on a variable metropolitan road network. It was determined that the proposed strategy was successful after conducting an empirical study utilizing a real-world city map. To reduce the amount of OBUs and RSUs involved in the tracking process and the resulting volume of tracking messages, another paper looks to confine search coverage [45-50]. Camera-equipped OBUs are mobile sensors that can be moved around. The OBUs and RSUs exchange tracking messages. Observations from OBUs are utilized for action modeling and path estimation to make predictions for the future. Using non-parametric Bayesian calculation techniques with Gaussian before the conditional logit system parameters, a new model with improved estimation accuracy has been proposed recently. In addition, an actual city map is used to conduct an empirical analysis as part of this method's evaluation. Datasets were used to determine how each simulation was weighted, and the Bayesian technique was used to compare these results to the previously proposed D-M model [50-54].

3.15. DR, ANN, and KF

The study uses Artificial Neural Networks (ANN) to learn driver behaviors on the road and estimate lane changes. Like the other research, the Kalman filter is applied, which can recursively come up with the statistically best estimate. Linear optimum estimation in Non-Gaussian noise is also possible. It was found that the best results were achieved using KF and DR, while the ANN technique provided an undesirable effect with error rates of greater than 10 m. Researchers should use the ANN approach and recreate the city of Cologne in real-time on the NS-2 simulator as part of their research.

4. CONCLUSIONS

The current VANET localization algorithms were examined in this study. The various VANET localization techniques such as GPS-based Cooperative, Non-GPS based Cooperative, and Non-Cooperative are essentially split into three classes. Under Filter and Non-Filter scenarios, GPS-based approaches are also categorized. As can be seen, the tables and methods employed in the research have their unique qualities and cannot yield a faultless outcome. These methods successfully obtain submeter localization errors due to their precision and higher landmark density when applying filters. Furthermore, the study found that RSU structures did not improve localization accuracy; instead, they reduced the total mobile anchor nodes required in VANETs. VANET operations are executed in realistic settlements and speeds similar to obtain the results according to real-world scenarios. The obtained results have both good and bad outcomes to achieve accuracy.

5. FUTURE WORK

Several research works are available on localization for better understanding. However, in today's world, issues like privacy, security, mobility, dependable applications, particularly in the context of mobile vehicles and intra-vehicular ad hoc networks, have emerged as pressing concerns. When all VANET vehicles interact, they become vulnerable to systems and cyber-attacks, which makes intra-vehicular communication inherently risky. It may be essential for medium and large-scale networks to study protocol congestion structures and, if necessary, implement new protocols. Ad-hoc networks with many mobile vehicles necessitate a more significant data transfer speed. Bandwidth or data classification techniques could be required. As a result, the safety and privacy of this data are also an issue. The capacity to accurately estimate the location is one of the most critical issues in the localization process. A general study can be undertaken to improve localization accuracy by employing a suitable approach in the appropriate zone (e.g., tunnel, inner-city, dense traffic, etc.). These techniques can be linked to the locations in which they will be applied. Besides these issues, consideration should be given to the broadcast/multicast/unicast and Quality of Service (QoS) criteria. These need to be reworked to meet the requirements. As a result of all the transmitters on vehicles and the objects placed on the roadside to aid in localization, power consumption became the most severe issue.

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