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# Vehicle-Mounted Positioning Monitoring System for Construction Machinery Based on Location Service

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Recent years have seen the rapid development of information technology, automation and data acquisition in industrial production. This has greatly facilitated the integration and innovation of information technology and design tools. An intelligent engineering vehicle is one where the construction shop has sensors that determine the working environment and physical condition of the vehicle. It also assesses workplaces and automatically checks construction equipment to complete projects based on the analyzed data. The accurate positioning of construction vehicles is an important basis for their intelligent operation. In this paper, location-based service technology is discussed and research is conducted on the on-board positioning of construction machinery. According to the functional requirements of the engineering vehicle work, the paper determines the requirements that the main controller should meet, and the associated pin performance indicators. After obtaining the driving direction calculation diagram, experiments show that the errors between the measured driving direction angle and the calculated driving direction angle of the four groups of experiments are 0.719°, 0.907°, 0.682° and 0.458°, respectively.

Keywords: location service, construction machinery, vehicle positioning, positioning monitoring

## 1. INTRODUCTION

With the rapid development of information and communication technology, the research on control theory is becoming comprehensive. The innovative construction vehicle design process continues to accelerate and contribute significantly to industrial productivity. Intelligently designed vehicles take industrial manufacturing to the next level, enabling the dynamic development of industrial manufacturing in the age of automation and data acquisition. The development of vehicles designed for intelligence and automation will increase the availability and safety of equipment. Intelligent equipment can effectively monitor the operational status of each function to ensure the efficient, continuous and safe work of construction vehicles.

Vehicle-locating devices are developing rapidly, and there are many car-locating devices on the market. However, due to different uses, the positioning requirements for different vehicles are also different. The rental of construction machinery such as cranes, trucks, etc. is a growing market segment. Due to the specific features and functions of each type of vehicle, many issues are considered in the design process, and the intelligentization of engineering vehicles is of great significance for improving industrial production efficiency.

This paper proposes an innovative location-based services technology for the protection of users' location privacy, which is a primary concern of location-based services. It explains three types of location privacy protection technologies. In

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the obtained anonymity protection technology, the communication volume and communication time change according to the level of the anonymity value. According to the factors to be considered in choosing the GPS positioning system, the working environment data of the receiver is obtained.

## 2. RELATED WORK

Several researchers have conducted studies on position monitoring. Peker and Acarman (2017) introduced a set of procedures for fused communications to improve the performance of stand-alone onboard receivers and ensure mutual localization with limited error. A particle filter algorithm is used to improve the mutual localization of vehicles. It incorporates information provided by the receiver, wireless measurements in the vehicle's environment, odometer and digital road map data, including accessibility and area probability. They studied the number of cooperating vehicles during mutual localization in terms of localization accuracy and network performance through real simulation studies [1]. Rui et al. (2017) proposed a fusion approach to localize urban vehicles by integrating visual odometry, low-cost GPS, and 2D digital roadmaps. Unlike traditional sensor fusion methods, they propose two types of potential functions to represent measurements and constraints. Their approach enables an intuitive understanding of the integration of data from various sensors without additional map matching by selecting different potential functions based on data attributes. Compared with pure visual odometry and map matching methods, experiments were carried out under real-world conditions to verify the satisfactory localization accuracy and robustness of their method [2]. GNSS real-time dynamic technology is widely used in vehicle navigation. However, in complex environments, satellite signals are easily attenuated or even unavailable. Hence, Liu et al. (2020) proposed an ensemble algorithm which is used for vehicle navigation in complex urban environments. They conducted real-time experiments in urban degradation and denial environments to verify the performance of the integrated system. In a complex environment, the positioning accuracy of the order of 0.1m can be achieved when the satellite is interrupted for 1 minute. This can meet the positioning needs of most scenarios [3]. Sung and Kim (2020) proposed an improved vehicle localization method. The method provides more reliable positioning results by fusing measurements from a GPS receiver and a Bayesian filter-based digital compass. Although SKF is simple and intuitive to implement, it can achieve competitive localization accuracy with less computational cost [4]. Szymański et al. (2018) collected data on public transport delay obtained from the city's integrated public transport positioning system. They determined the nature of the delay between the terminals based on the time direction and the offset delay of the delay series pair. They created a simple set of matrices that represent the probability of a particular change in delay on the boundary between two terminals at any one time, and analyzed the latency variation patterns in the configuration file of each analysis [5]. To tackle the problem of positioning differences caused by the error accumulation defect of the inertial navigation system, Zhang et al. (2017) proposed an improved federated integrated navigation method for autonomous underwater vehicles based on two-stage position matching technology. The simulation results show that the algorithm removes the limitation of the rigid transformation of the traditional iterative nearest contour point. It effectively solves the problem of matching failure caused by the large initial position error of long-term navigation [6]. Xu et al. (2017) addressed the problem that an improved Kalman filter or two-stage Kalman filter in MEMS inertial sensors cannot obtain sufficient positioning power when exposed to precise acoustic waves. Developed from other applications, various sound characteristics cover a wide volume range. They used an interactive polynomial algorithm to accurately compute the distortion analysis to fit the target filter. Therefore, if the inertial sensor failure is detected, the automatic positioning system may not work properly [7]. These methods provide some references for research. However, due to the short time and small sample size used for studyies, its findings have not been accepted by the research community.

## 3. DESIGN METHOD OF VEHICLE-MOUNTED POSITIONING MONITORING SYSTEM FOR CONSTRUCTION MACHINERY

### 3.1 Location Based Services

Location-based services can be defined as applications that depend on a specific location. LBS can be divided into two categories: user demand and trigger type. When the user receives his own location information, the server will request specific location information from the server according to that location. These types of services typically include the user's personal location and service location. A navigation system is an example of an LBS application. When the LBS is turned on and the mobile phone is restored to the specified state, the server starts the mobile phone and determines its location. For example, in emergency services, when a user makes an emergency call, the system turns on the phone and automatically sends the user's current location on the mobile network. Positioning is the basis of LBS, and only when the user's location is specified can the service be restored [8].

With the development of positioning technology and the popularization of information technologies such as big data and cloud technology, the development of positioning-related services has become inevitable. Location-based services rely on precise long-range or wireless GPS positioning to obtain real-time location information from users using mobile tracking devices such as smartphones, tablets, PDAs, and automotive terminals, relying on third-party location providers to provide mobile users with multi-faceted location-based services with added value [9].

Location-based services have been used for some time in military and commercial applications in the United States. More recently, a large number of location-related services have emerged in Western Europe and East Asia, including

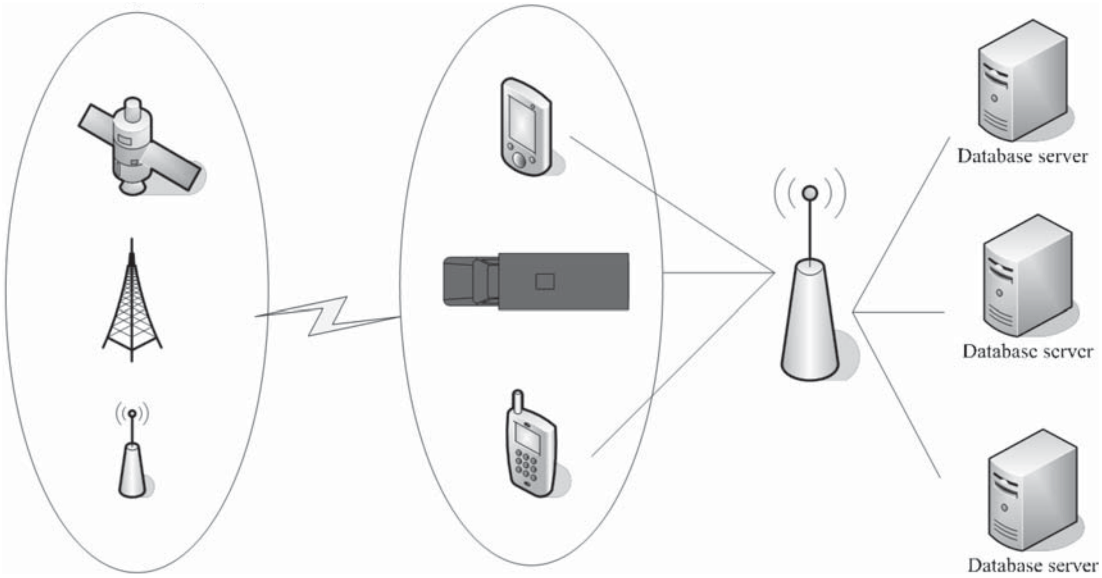


**Figure 1** Location-based service system structure and process.

social, dining, medical, education, and more. Today, location-based services in China are generally divided into four categories: entertainment and leisure services, life services, social networking and business. For example, they are used to access games and entertainment, and are applied to location maps to find real-time traffic conditions and directions. Location based applications view group purchases and request discounts at hotels, restaurants, and cinemas near shopping centers. At the same time, it also checks friends on Weibo, WeChat and other social media news, store computers, etc.[10].

The main process of location-based services consists of three stages.

(1) Mobile device users have mobile tracking devices (smartphones, mobile terminals, PDA devices).

(2) According to the personal location information and the requested content, apply for a service from the server based on location services. The application form can be expressed as $R = \{Mid, location, content\}$, Mid is the unique identifier of the user ID, the actual information of the user's geographic location, and the content is the representation of the application content of the user's location.

(3) After receiving the mobile user request, the location server refers to the location database and returns the corresponding location request result to the user.

As shown in Figure 1, the structure flow chart of location-based service is shown.

The location-based service architecture consists of four main parts: the positioning system, the mobile terminal, the communication network and the location service provider. (1) Positioning system: this is the most important part of the technology of a positioning service. Therefore, a stable and reliable positioning system is the basis of a positioning service system. When the location of the mobile user is received by the international positioning network and the international mobile network positioning system, it is forwarded as a storage device to the designated cellular and communication networks. (2) Mobile terminal: broadly, this refers to the mobile positioning service provided for mobile devices such as mobile phones, tablet computers, PDAs, and car navigation, with functions such as calculating and recording location, map search, and online communication. They are part of a location services system that communicates directly with customers. (3) Communication network: the communication network is a transmitter based on location services and storage devices. With the development of communication technology, including satellite communication, private wireless network, wireless local area network, Bluetooth communication, Ad hoc network, etc., users can choose the contact link to a location service. (4) Location service providers: these include third-party platforms and site databases. LSP is the core of location services. Some LSPs can provide users with different localized and personalized services. The LSP retrieves the location database by downloading the location information sent by the mobile device, and returns the query results of interest to the user. In the long run, location databases store large amounts of user location information in real-time. The misuse of this location information will directly endanger the privacy of site users [11].

When a user utilizes location-based services, all such services rely on the user's mobile data. Users are encouraged to use location-based services in high-frequency private locations (e.g., home, work, frequently visited hospitals, etc.). When the service searches for attractions such as nearby logistics centers, hotels, gas stations, train stations, or repeatedly requests directions, an intruder can analyze and understand the user's collected website data, and obtain basic information and other personal information about the user's lifestyle, identity, and religious beliefs. A malicious entity can place various malicious advertisements and misinformation on the user's mobile phone. This not only violates the user's privacy, but also affects his normal living environment [12].

Attacks on user location are related to the distribution of user information on user sites, and include site sharing attacks

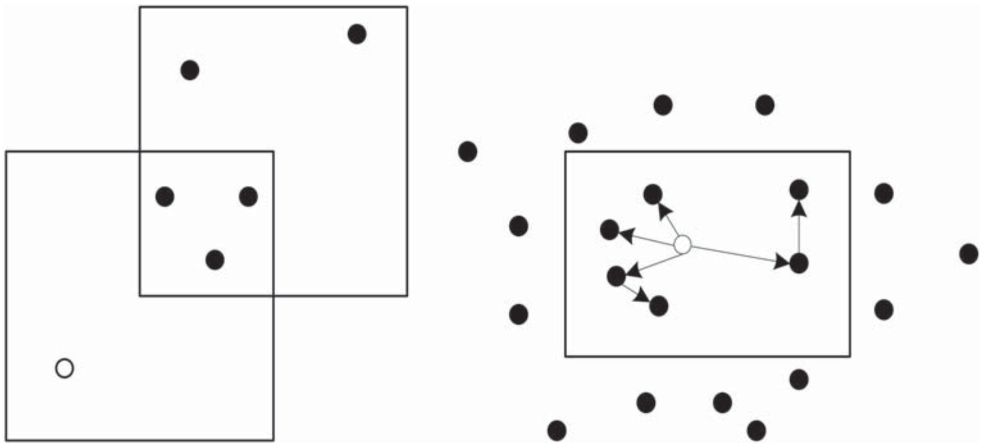

**Figure 2** Spatially-distributed attack model.

**Table 1** System structure advantages and disadvantages comparison table.

| | Taxonomy | Advantage | Disadvantage |
|---|---|---|---|
| Peer-to-peer system | Detached | Simple structure, easy to implement | Lack of globality, heavy client computing load, easy to breach |
| | Distributed | Flexible networking without third-party assistance | The user terminal that requires high computing power, the efficiency of the location privacy protection algorithm is low |
| Third-party anonymizer system | | Considering the overall situation, the privacy protection effect is better | Requires a trusted central anonymizer, which is prone to system bottlenecks |

and centralized attacks. The location information is related to how often users are located at or around a specific site. If a vulnerability is exploited to masquerade as a targeted user in a location-based service, an attacker could exploit the pattern of assigning users to an unknown location to search for them there. Figure 2 shows the spatial distribution attack model.

The central anonymizer plays an important role in the system. The central anonymizer trusted by the user and the location service-based server can share the computing overhead of the user's mobile device terminal. This is a good solution to the problem of heavy communication overhead on mobile devices. It also undertakes the implementation of the user location anonymization algorithm. It performs refinement calculation on the request result of the user to the server based on location services, and returns it to the user. This guarantees more precise and secure location-based services. In addition, the huge storage and anonymization workload of user location information will affect the efficiency of the anonymizer. This reduces the efficiency of the entire communication system to a certain extent. In order to better utilize the advantages of third-party anonymizers, it is also necessary to solve the system bottleneck problem of anonymizers. Since this system can usually provide better anonymity, it has become a widely-used and stable architecture in the field of location privacy protection [13]. As shown in Table 1, the advantages and disadvantages of the three system structures are compared.

The following will introduce the relevant formulas of the unknown privacy protection algorithm based on location services.

$$Q(c) = \sum_{u=1}^{\omega} q(mid_u, g_u) \tag{1}$$

$g$ - height of the quadtree after dividing the geographic space

$Q(c)$ - total area of anonymous domains

$\omega$ - number of anonymous domains

$$request = E(i, m_u, n_u, t_u, P_u), (1 \leq u \leq \omega) \tag{2}$$

$i$ - user

$(m_u, n_u)$ - user's real location information

$t_u$ - the moment when the user initiates the request

$P - u$ - privacy configuration information required by users at different times

$$f = \{i, t_u, m_u, n_u\} \tag{3}$$

$f$ - footprint data

$F$ - historical footprint database

$$I'(c) = I(c_1) \cap I(c_2) \cap I(c_3) \cdots \cap I(c_n) \tag{4}$$

An anonymous domain $c_u$ containing user $i$ is generated at time $t$, in which there are $i$ mobile users in total.

$$p(c) = p_k(c) = i \tag{5}$$

$p_c$- privacy value

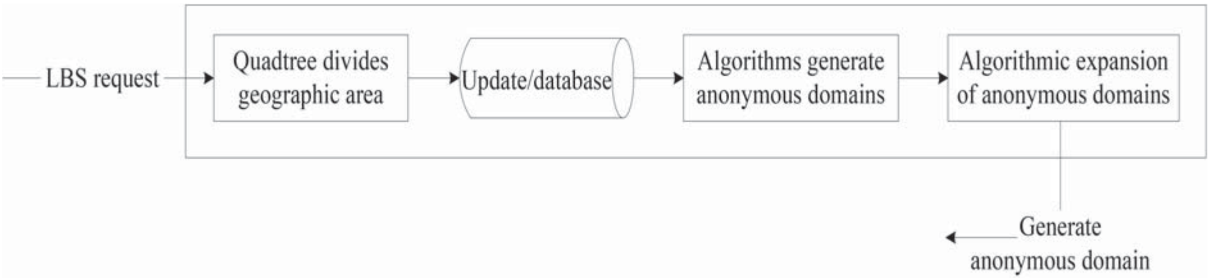


**Figure 3** CAPA algorithm flowchart.

$$B = \sum_{u=1}^{i} b_u \tag{6}$$

$$R(c) = \sum_{u=1}^{i} \frac{b_u}{B} \log \frac{b_u}{B} \tag{7}$$

$$p(c) = p_r(c) = 2^{R(c)} \tag{8}$$

$b_u$- the number of user's footprints in the user set
$R(c)$- Information entropy of anonymous domain
$B$- the number of footprints of all users in the user set

$$pu = \frac{\sum_{v=1}^{u=1} p(c_v) + p(c'_v) + \sum_{v=u+1}^{i} p(c_v)}{\sum_{v=1}^{u=1} q(c_v) + q(c'_v) + \sum_{v=u+1}^{i} q(c_v)} \tag{9}$$

$p[u]$ - the level of privacy achieved per unit of anonymous area
$i$ - the number of anonymous domains

$$J(M) = -\sum_{m \in M} p(m) \log(p(m)) \tag{10}$$

$J(M)$ - privacy metrics based on information entropy
Similarity can be defined by distance functions in data analysis.

$$s(u, v) = \sqrt{(m_{u1} + m_{v_i})^2 + \ldots (m_{uj} + m_{vj})^2} \tag{11}$$

$u$, $v$- item to be calculated distance
$m_{uj}$, $m_{vj}$- the attribute value corresponding to the item

$$s(LcP, LcQ) = 2\text{arcsin}\left(\sqrt{\sin\left(\frac{p}{2}\right)^2 + \cos(rLaP)\cos(rLaQ)}\right)R \tag{12}$$

$R$ - average radius of the area
$p$- dimensional difference between users
$q$- longitude difference between users

$$\sin R(p, q) = \frac{\sum_{c \in I_{pq}} (R_{p,c} - R_p)(R_{q,c} - R_q)}{\sqrt{\sum_{c \in I_{pq}} (R_{p,c} - R_p)^2} \sqrt{\sum_{c \in I_{pq}} (R_{q,c} - R_q)^2}} \tag{13}$$

$R_{p,c}$- relationship between users

$$o(i, j) = \overline{r}_i + \frac{\sum_{n \in N} sim(i, n)(r_i, j - r_n)}{\sum_{n \in N} sim(i, n)} \tag{14}$$

$o(i, j)$- predicted value of user's interest in non-friends
$R_i$ - user's average interest in his friends
$sim(i, n)$ - similarity between users

$$U(\alpha) = \{i | o(\alpha, i) <= T\} \tag{15}$$

$U(\alpha)$- recommendation set based on collaborative filtering

$$LBE = \frac{\sum_{u=1}^{B} |p_u - q_u|}{B} \tag{16}$$

$p_u$ - user's actual rating of the item
$q_u$ - user's predicted rating for the item
$B$ - total number of predicted scores

$$D = \frac{1}{\beta 1 * \beta 2} \sum_{1}^{\alpha} 2^{k_u - 1} \tag{17}$$

$\beta 1$, $\beta 2$ - total number of regions of interest for each track
$\alpha$ - the number of similar subsequences of the two trajectories
$k$ - the length of each subsequence

$$Sim_{m+n} = \sum_{1}^{\beta} D_v \tag{18}$$

$\beta$ - the number of pairwise trajectories of similar subsequences
The basic flowchart of the algorithm is shown in Figure 3.

### 3.2 Vehicle Positioning Monitoring

The VPS can use GPS estimation, advanced map matching capabilities, and map templates based on hard drives or memory cards. The interface can be a flat screen displaying text and maps, or a color touch screen with speech recognition and speech synthesis, and can also include translation prompts and path planning [14]. As shown in Figure 4, it is the function module of the vehicle positioning system.

The locating unit combines different sensor outputs and uses automatically-received radio signals to search for vehicles on roads and at intersections. Standard positioning techniques for radio signals use GPS receivers. However, the typical positioning technology calculates position, because no sensor can provide accurate vehicle position information. Therefore, the outputs of multiple sensors must be integrated

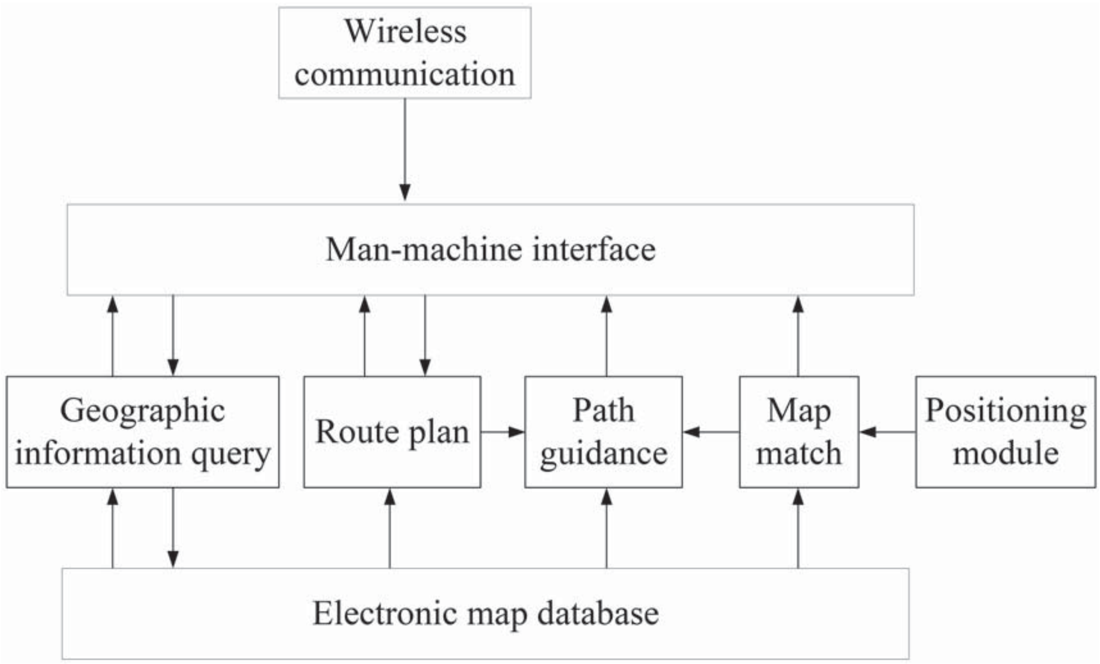


**Figure 4** Basic module for vehicle positioning.

**Table 2** Function comparison of in-vehicle positioning system.

| Features | MapO | MapX |
|---|---|---|
| Add raster image | Have | Have |
| Common operations on maps | Zoom in, zoom out, roam, etc. | Zoom in, zoom out, roam, etc. |
| Thematic map | Weaker | Have |
| User drawing layer | None | User drawing layer |
| Map symbolization | Weaker | Strong |

for each road sensor to provide accurate location information in real time [15].

$$M_\lambda = M_0 + \sum_{u=0}^{\lambda-1} D_u \cos\theta_u \quad (19)$$

$$N_\lambda = N_0 + \sum_{u=0}^{\lambda-1} D_u \cos\theta_u \quad (20)$$

$M_0$, $N_0$ - the two-dimensional coordinates of the vehicle's location at the initial moment

$D_u$- vehicle travel distance

$\theta_u$- direction of the vehicle

The vehicle's tracking and traceability software consists of four parts:

(1) It receives and processes GPS data. It uses GPS receiver serial communication to collect latitude, longitude, speed, time and location and other navigational information needed to locate vehicles and navigation systems. The most important tasks include starting the serial port, receiving GPS data, and intercepting.

(2) Compatibility between GPS signals and electronic maps. It realizes the compatibility of GPS signal and electronic map by means of some algorithms.

(3) The user interface design of the system software should be concise, clear and easy to use in order to improve the usability.

(4) The realization of other functions is a complete system, and the software should also have other main functions, including map browsing, map information query, path planning, etc. [16].

Table 2 enables a comparison to be made of the functions of the two vehicle positioning systems.

## 4. DESIGN EXPERIMENT AND RESULTS OF VEHICLE-MOUNTED POSITIONING MONITORING SYSTEM FOR CONSTRUCTION MACHINERY

Construction machinery is any machinery used for engineering construction, and is a general term that covers a variety of machinery. It is widely used in various fields such as construction, hydropower, road construction, industrial and mining, and national defense construction. Construction machinery is an important part of the equipment industry and the foundation of industrial development. The degree

Table 3 Pin Specifications.

| Features | Parameter |
|---|---|
| Clock frequency | 75MHz |
| Interrupt mode | Interrupt nesting |
| Voltage range | 2V-4V |
| Low power mode | Sleep, suspend, standby three modes |
| Operating temperature | −40°C–+90°C |
| Timer | Four timers |

Table 4 The working environment of the receiver.

| Condition | Parameter |
|---|---|
| Operating temperature | −40°C–+80°C |
| Storage temperature | −50°C–+85°C |
| Working humidity | 15%–85% |
| Supply voltage | 10–35(V)direct current, recommended 12V |
| Shock | 6.5g RMS |
| Mechanical shock | 800D ± 40g |

of development of construction machinery plays a decisive role in the development of the national economy [17].

Accurate positioning of construction vehicles is the basis for the automatic operation of construction vehicles. The construction vehicle sends its position information to the controller through the GPS positioning system, and the main controller locates the vehicle according to the position information. According to the functional requirements of the engineering vehicle work, the main controller should meet the following requirements. It has multiple I/O pins; fast operation; and fast interrupt handling. It has a programming interface and has strong anti-interference ability. Table 3 lists the pin performance index.

In order to monitor a construction vehicle, it is necessary to ascertain its position. GPS performance is measured by its positioning accuracy and received signal strength. Engineering vehicles are usually on complex project sites, and therefore require high-precision positioning systems to achieve automatic and precise operation. Therefore, the factors to be considered when choosing a GPS positioning system are: positioning accuracy, communication protocol, control interface and cost [18]. The working environment of the receiver is shown in Table 4.

The GPS positioning system includes a set of base stations and a set of mobile stations. The installation of the base station requires the selection of the highest coverage area, with no obstructions in the immediate environment, and no large reflectors that could cause radio wave interference. To determine the known situation of the coordinates of the base station, the mobile station is installed on the experimental vehicle, and the positioning parameters are given to the master controller in real time. The GPS system consists of three parts, which are divided into the space part, that is, the GPS orbit satellites, and the ground control refers to the ground monitoring station and the user equipment GPS receiver. The ground control function of the GPS is used to observe the parameters of the satellite's orbit and forward the precise orbit data of the satellite to the user equipment. The task of the main control station of the ground control part is to provide the time reference of GPS, to monitor whether the working status of the satellite is abnormal and to correct the parameters of the ground monitoring station of the ground part. The job of the injection station is to send navigation information to the satellite when the satellite passes over the injection station, and at the same time, the accuracy of the data needs to be checked [19]. The basic structure of the receiver is shown in Figure 5.

After the GPS base station is installed, the mobile station positioning antenna is placed in a fixed position to collect latitude and longitude data, and the GPS positioning accuracy is tested. It selects multiple sets of test points to repeat the above operation, and takes one set of longitude and latitude data from the measurement and calculation data as shown in Figure 6.

Analysis indicates that there may be three reasons for the error: the error of the GPS system, the point error of artificial positioning, and an error in the calculation formula. In order to further reduce the positioning error, a GPS system with better performance can be selected. It uses special and professional tools to repeat the measurement to reduce measurement errors caused by human factors. It increases the number of data bits in the formula calculation and reduces the calculation error [20].

When the construction machinery vehicle is being driven, the GPS system mobile station positioning antenna and vehicle-mounted positioning first determine the current driving direction of the construction machinery vehicle in real time. Then the target driving angle of the construction machinery vehicle is calculated according to the longitude and latitude data of the fixed location of the vehicle and the longitude and latitude data of the target point. Through multiple experimental tests, the results shown in Figure 7 are obtained.

If the latitude and longitude coordinates of point $\alpha$ and point $\beta$ are known on the earth, then point $\alpha$ and point $\lambda$ on the same latitude have the same longitude. If the latitudes of the points on the same longitude are the same, then the latitudes of point $\beta$ and point $\lambda$ are the same. Therefore, the latitude and longitude coordinates of $\lambda$ are obtained. Point $\alpha\beta\lambda$ forms

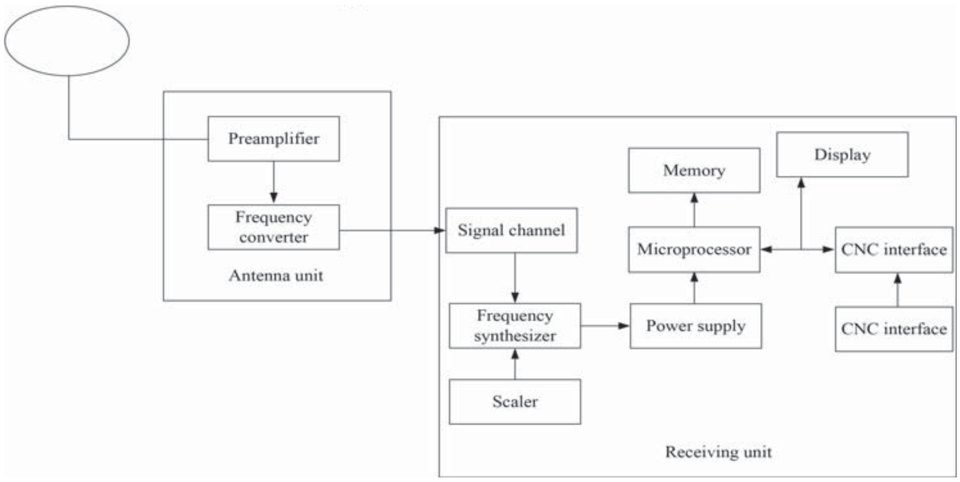


**Figure 5** The basic structure of the receiver.

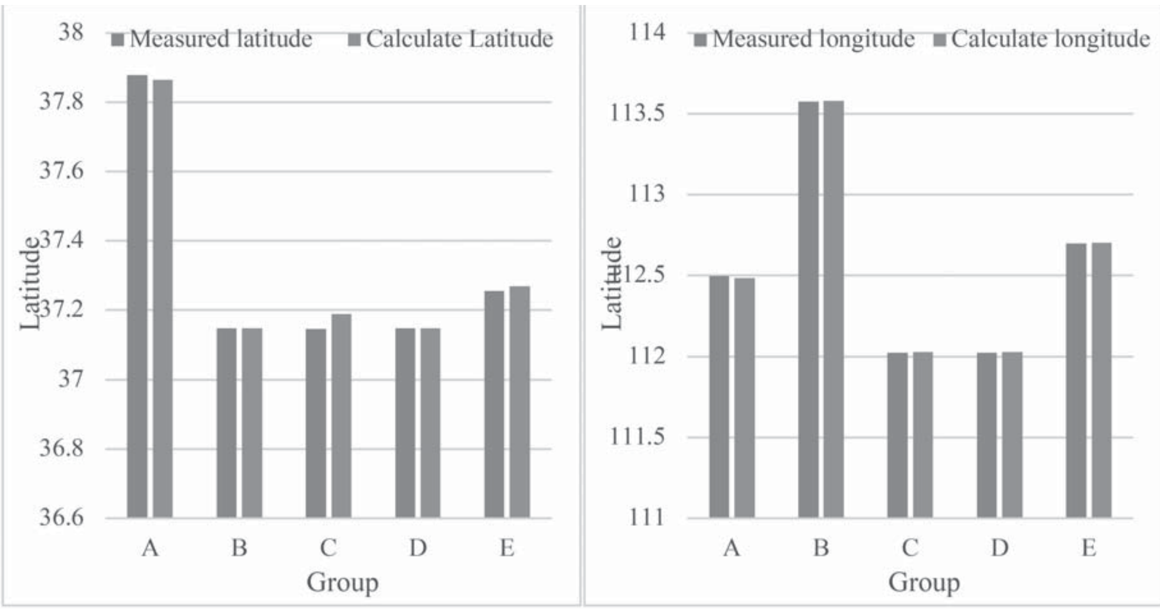


**Figure 6** Calculated and measured latitude and longitude data.

a right triangle, from which the driving direction angle of $\alpha\beta$ can be obtained based on the longitude and latitude of point $\alpha$ and point $\beta$ [21]. Figure 8 shows a schematic diagram of the calculation of the driving direction.

The driving direction test data comparison is shown in Figure 9 below.

The reasons for the error may be: artificial positioning error; formula calculation error; and/or weather conditions. Driving direction is measured with high-precision measurement tools to reduce measurement errors caused by human factors. It increases the number of data digits in formula calculation and reduces calculation error. In better weather conditions, the test results are likely to be accurate.

In the centralized system architecture, the LBS service request workflow is as follows: (1) the mobile client sends its location, anonymous request and information request to the anonymous central server; (2) after receiving the information requested by the user, the anonymous service center will review the data released by the user's request and published on the media, and send the information to the LBS server; (3) based on the LBS server request for information sent by the central service, the final query result is fed back to the central anonymous server; (4) after receiving the information, the central anonymous server filters the feedback information and sends the result of the user's request information to the mobile client [22].

The centralized system architecture can provide convenient location service information and reduce the traffic on the mobile side. However, the disadvantage of this type of structure is that the central anonymous server cannot be guaranteed to be absolutely credible. Once a third-party server is attacked by a malicious entity, the user's personal information and anonymity algorithm will be leaked. In addition, when the user's request frequency is too high, it is likely to cause a processing bottleneck in the central anonymous server. When receiving a large number of user requests for location information, the server's processing speed slows down, which may cause information delay and other problems [23].

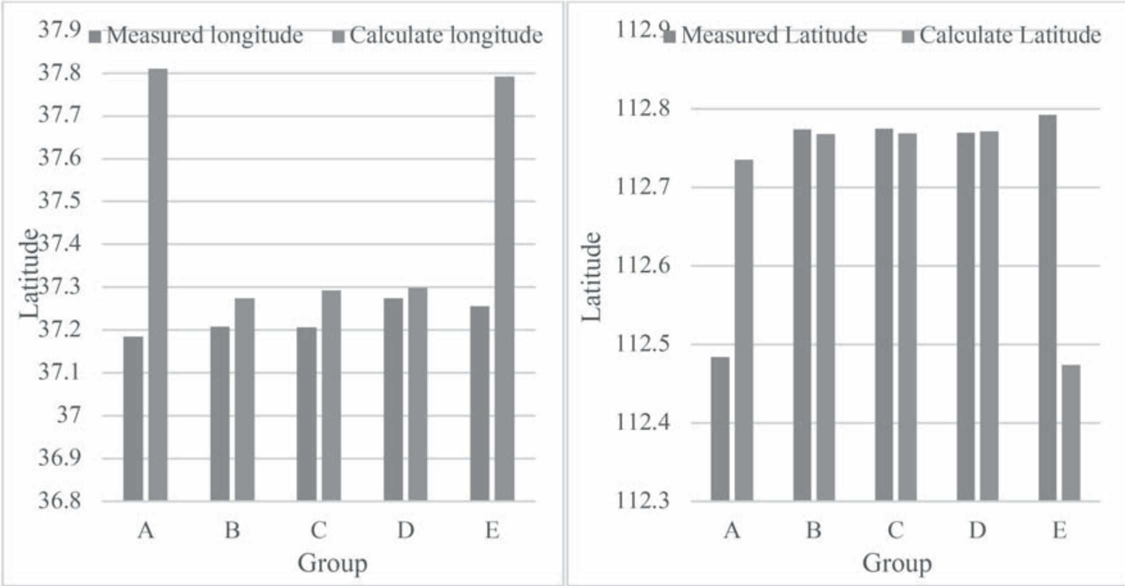


**Figure 7** Longitude and latitude data calculated and measured while vehicle is being driven.

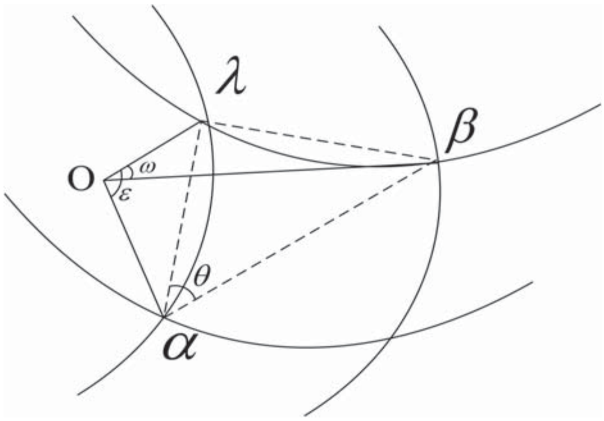


**Figure 8** Schematic diagram of driving direction calculation.

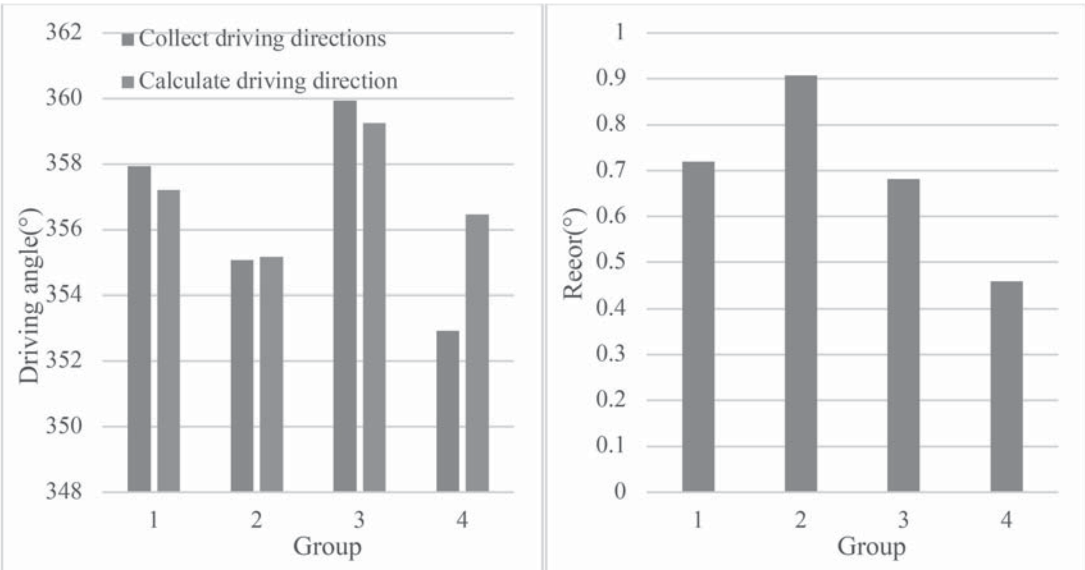


**Figure 9** Comparison of driving direction test data.

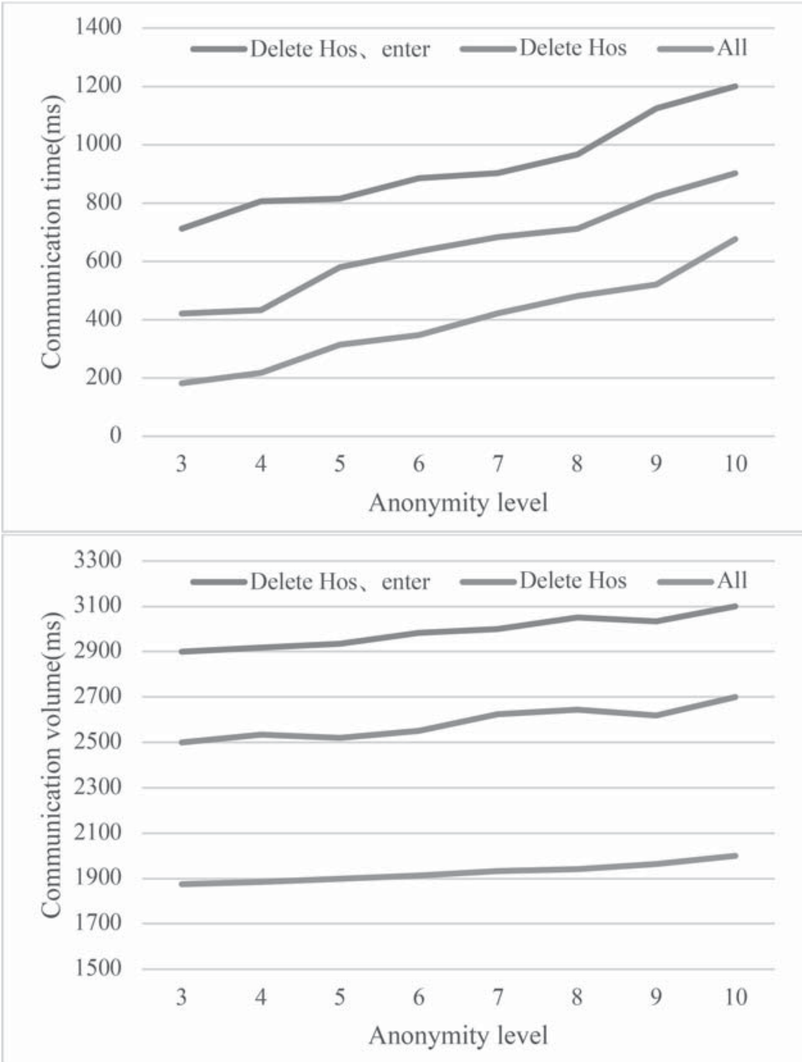


**Figure 10** Comparison of communication volume and communication time.

The protection of users' location privacy has become a top priority for LBS services. Location privacy protection technologies can be roughly divided into three categories. They are: location privacy protection based on policy law, location privacy protection based on generalization and obfuscation law, and location privacy protection based on encryption law. In Figure 10, the calculated entropy value is compared with the anonymity effect.

It compares the contact time used to the number of contacts when determining the size of the anonymous value. The more categories it needs to hide from users, the more traffic it needs. The shortest time and traffic occur when there are no more points of interest that need to be hidden. Users can measure the impact of anonymity and rights and interests in their own context [24].

## 5. DISCUSSION

LBS service providers can provide users with rich service information, and many Internet companies can be used as LBS servers at this stage. It returns service results according to the needs of customers, although it also raises the issue of the security of user information. Almost all LBS servers operate for profit, and it is possible for them to profit illegally from misusing users' information; hence, the LBS server itself could be a malicious attacker. It can calculate the user's personal privacy based on the specific location information and query information submitted by the user. Therefore, the LBS server presents the greatest security risk to location privacy protection [25].

Metrics are an important means of evaluating the privacy protection performance of LBS systems. Studies on privacy protection research have proposed various methods, although it is difficult to determine whether these methods are very effective in protecting the user's anonymity. At this time, the effectiveness can be evaluated by applying performance indicators to measure the level of privacy protection. The degree of privacy protection is one of the most important evaluation indicators of location privacy protection. It can measure the probability of mobile users being attacked when requesting services. Generally speaking, the higher the degree of privacy protection, the stronger the user's security. At present, the most commonly-used anonymity technology provides that the greater the anonymity value, the better the anonymity effect. But at the same time, users need to consider the overhead of the system, and this overhead increases with the increase of the anonymous value. Users can balance the anonymity effect and overhead according to their own needs, and choose the most suitable anonymity value scheme. Quality of service is an evaluation index measuring the accuracy of mobile users' acquisition of services, and is generally measured in terms of effectiveness and accuracy. However, service quality and anonymity are also a pair of contradictory indicators. The purpose of the researchers is to improve the service quality of users as much as possible while ensuring the privacy and security of users. Therefore, service quality is also an important evaluation index in location privacy protection [26].

The application modes of LBS include leisure and entertainment mode, social interaction mode, life travel mode, etc. (1) In regard to the leisure and entertainment mode, in the current game market, many games have additional functions such as sign-in and positioning. Game developers encourage users to check in, and reward them with relevant virtual goods. There are also some games that can display actual shopping malls according to the positioning information of game users who can use game coins to purchase props and buildings. (2) The representative social interaction modes are the social software WeChat, the "Shake" function in Momo, etc. Unfamiliar users can make friends at the same time and place, and display the real-time location and distance of nearby users. Its geographic location-based community services, known as neighborhood committees, can provide community life services based on the user's displayed location. (3) Life travel is the most widely-used mode of LBS service. Users can find nearby shopping malls, movie theaters, and other buildings. It can plan the best route for the user to reach the destination point. In travel, it can recommend nearby attractions, snack kiosks, etc. to enhance people's daily travel experiences.

## 6. CONCLUSION

In recent years, with the rapid development of the national economy and the improvement of people's living standards, there has been a dramatic increase in the number of motor vehicles on the road. This has made it increasingly difficult to manage urban traffic and urban vehicles management, and problems such as vehicle theft are becoming more and more serious. With the rapid development of the mobile Internet, increasingly, social services are also adopting mobile terminals. As a result, a large number of mobile social applications with location-based service features have emerged. In this paper, the GPS positioning system is described to some extent, and the anonymous value technology is used to conduct research on the protection of privacy based on location services. In this paper, a preliminary forecasting study is carried out. Given the limited data available and the dearth of academic research, inevitably, this research has several limitations. The analysis of the current situation is not comprehensive as it examines only the changes of relevant indicators, and lacks of effective analysis and judgment. In terms of theoretical research, there is only a superficial discussion of the theory. It achieves communication between the vehicle controller and the remote PC, and writes the host computer program to realize the remote control and parameter display of the vehicle, which is convenient for the remote monitoring of the working state of the equipment.

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