ISSN: 1813-4890

Research on GNSS High Precision Positioning and Intelligent Connected Vehicle Technology

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Abstract

In recent years, China's automobile products have gradually developed towards intelligence and networking, and automobile users have gained new experience and fully recognized the intelligent networked automobile technology. Starting from the development of intelligent connected vehicle technology, this paper expounds on the high-precision positioning technology of GNSS in detail. Based on the introduction of its key technical content, Baidu Apollo 2.0 is taken as an example to introduce the application of high-precision positioning on intelligent connected vehicles. The main problems faced by Intelligent Connected Vehicle(ICV) at the present stage are emphasized, and the future development trend of the technology is analyzed.

Keywords

GNSS, high-precision positioning, intelligent connected vehicle.

1. Introduction

At present, with the rapid development of the automobile industry, the automobile industry is experiencing a technological revolution and industry reform characterized by electrification, intelligence, and networking. The intelligent connected automobile is the combination of intelligent vehicles and the Internet of Vehicles, which has gradually been highly valued by the public and society. It is the future development trend of automobile technology.

For ICV, the importance of positioning is self-evident. It can help the vehicle understand its precise position relative to the external environment, so as to make correct decisions. At the same time, it can assist the perception system to obtain more accurate detection and tracking results. Global Navigation Satellite System (GNSS) has the characteristics of global, all-weather, continuous and high-precision, which are incomparable to other navigation systems. It has been widely used in land, ocean, aerospace and other fields. Using GNSS to provide accurate positioning services, integrate global navigation satellite system information and the Internet of Things, realize the exchange and sharing of information between vehicles and people, vehicles, roads, backstage, etc., and achieve safe, comfortable and efficient driving, which can reduce the cost of ground equipment, simplify orbit determination equipment, improve orbit determination accuracy, increase reliability, and ultimately achieve driverless intelligent vehicles [1].

The development of ICVs will become the commanding height of global technological change and scientific and technological innovation. ICVs will also bring fundamental changes to China's local transportation industry and automobile industry. Although such changes are gradual and full of challenges, they are also a major opportunity for China to achieve efficient integration in the field of ICVs and help overtaking at corners [2].

ISSN: 1813-4890

2. GNSS high-precision positioning technology

Global Navigation Satellite System (GNSS) is a radio positioning technology based on satellite infrastructure with global coverage. Its positioning results can be calculated only after obtaining ephemeris information table, time information and ranging information. The main difference between GNSS and celestial positioning system is that the observation objects of GNSS are artificial satellites, and the measurement method is radio measurement technology. Generally, the GNSS system consists of three functional parts: space segment, ground control segment, and user segment. The distance is measured using the basic triangulation principle of satellite, as shown in the Figure 1.

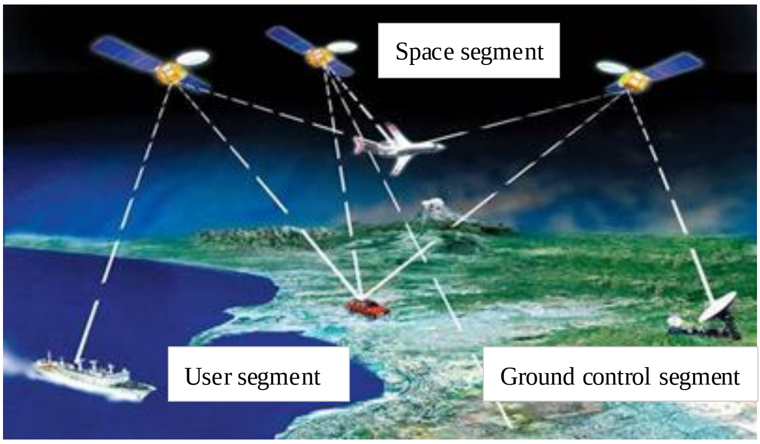

Figure1 Schematic Diagram of GNNS System Operation

Compared with non automated vehicles, ICV requires a navigation and positioning system with high accuracy (lane level positioning) and high frequency, which requires both global planning and local and vehicle real-time high-precision positions as important input information for ICV decision-making control. The basic requirements of ICV for the positioning system are as follows: 1) High precision: centimeter level. 2) High availability: ICV testing has shifted from closed scenarios to more open scenarios, which requires our positioning system to handle more complex situations. 3) High reliability: the output of positioning is the input of perception, planning and control. If the positioning system deviates, it will lead to serious consequences. 4) Autonomous integrity detection: since the reliability of the system can only be very close to 100%, but it is difficult to achieve the true 100%, this requires that the system can timely warn users to take measures to avoid accidents when it cannot provide accurate output. Therefore, the positioning system is required to ensure low false alarm rate and missing alarm rate.

According to different scenarios and positioning performance requirements, vehicle positioning schemes are diverse. Common positioning technologies include Global Navigation Satellite System (GNSS) technology, Inertial Navigation System (INS) technology, Dead Reckoning (DR) technology, landmark positioning technology, high-precision map matching positioning technology, radio (such as cellular network, LAN, etc.) positioning technology, visual positioning technology Simultaneous Localization and Mapping (SLAM) technology. Because any single positioning technology has insurmountable weaknesses, ICV usually needs combined positioning technology to achieve accurate positioning. Combined positioning technology combines two or more different types of positioning sensor information to achieve complementary advantages and obtain higher positioning performance. In the practical application of ICV, multi-sensor fusion positioning system is generally used, which not only complements advantages, but also improves stability and positioning accuracy. High precision positioning system mainly includes terminal layer, network layer, platform layer and application layer, as shown in the Figure 2.

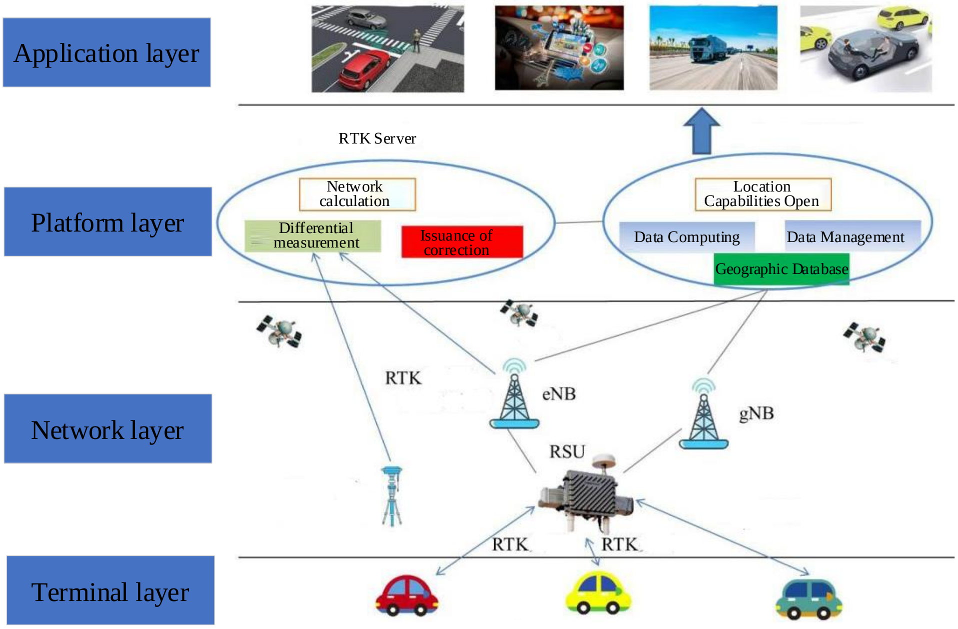

Figure 2 The framework of high precision positioning system

Among them, the terminal layer implements multi-source data fusion (satellite, sensor and cellular network data) algorithm to ensure the positioning requirements of different application scenarios and services; The network layer includes the base station and the road side unit (RSU) to achieve reliable data transmission for the positioning terminal; In order to meet the high-precision positioning requirements of vehicles in different environments, multi-source data fusion positioning scheme is required at the terminal, including GNSS positioning data based on differential data, inertial navigation system data, sensor data, high-precision map data and cellular network data.

3. Intelligent Connected Vehicle Technology

The intelligent network connected vehicle refers to a new generation of vehicles equipped with various advanced on-board sensors, controllers, actuators, and integrating modern communication and network technologies to meet the requirements of information exchange, data sharing, complex driving environment perception, intelligent decision-making, and collaborative control between vehicles and X (vehicles, roads, people, clouds, etc.), which can achieve intelligent, economic, safe, and comfortable driving, and ultimately achieve driverless driving.

The Internet of Vehicles (IOV) is a network system that uses new information and communication technologies to realize the connection between the car and X (car, road, people, cloud, etc.), improve the intelligence and automation of vehicles, create a new traffic service mode, improve the traffic efficiency, improve the driving experience, and provide users with safer and more convenient comprehensive services. The characteristics of the Internet of Vehicles are networking, automobile intelligence and new service formats. The Internet of Vehicles takes the "two ends and one cloud" as the main carrier, and the road infrastructure as a necessary supplement. It interconnects intelligently connected vehicles, Internet of Vehicles service cloud platforms, mobile intelligent terminals and other objects, including five communication scenarios, namely, vehicle to road communication, vehicle to vehicle communication, vehicle to person communication, and vehicle to cloud communication.

Intelligent vehicle refers to a new type of vehicle that is equipped with advanced electronic control system, adopts AI, information communication, big data, cloud computing and other new technologies, has semi-automatic or fully automatic driving functions, and changes from simple transportation tools to intelligent mobile carriers. At present, intelligent vehicles are developing in three directions: network connected intelligence (CV), autonomous intelligence (AV) and intelligent network connected vehicle (ICV).

ICV has realized the cross-border integration of automobile, information, communication, "new infrastructure" and other industries, and is the combination of Internet of Vehicles and intelligent vehicles.

The intelligently connected vehicle is a new product under the scientific and technological revolution, and a scientific and technological embodiment of the integration of interconnection and automation. The intelligent connected vehicle (ICV) is equipped with information-based actuators, controllers and sensor devices, which are fully integrated with network technology and communication technology to realize the intelligent information sharing and exchange between the vehicle and the cloud, road and people. It has the functions of collaborative control, intelligent decision-making and environmental awareness. It is a combination of intelligent vehicles and the Internet of Vehicles, using millimeter wave radar, monocular (binocular) camera, master controller and other devices, It is the future development trend of the automobile industry to integrate the global navigation satellite system information and the Internet of Things, realize the exchange and sharing of information between vehicles and people, vehicles, roads, backstage and other information, achieve safe, comfortable and efficient driving, and finally achieve driverless intelligent vehicles[3].

At present, ICV is still in the primary stage, mainly for auxiliary driving. The main technologies of the Assisted Driving System (ADAS) are: first, sensor technology, as the "eye" of the system, has the function of transmitting demands and ensuring safety, and its technical composition is relatively complex; Second, integration technology, which can integrate the steering system, braking and power electronically. Under the technical conditions of high safety and high configuration, the integration capability of the system can improve the vehicle safety performance; Third, human-computer interaction technology is an important embodiment of artificial intelligence. Good human-computer interaction can improve driving safety, convenience and comfort[4].

In the practical application of ICV, multi-sensor fusion positioning is generally adopted, which not only complements advantages, but also improves stability and positioning accuracy. L4 driverless vehicle operators often use multi beam laser radar and high-precision GPS/IMU in their common positioning solutions. Although these high-precision sensors can provide rich information, the cost is very high, and they cannot meet the requirements of vehicle specifications. Heduo Technology has developed a mass production oriented multi-sensor fusion positioning technology, which uses low-cost sensors of the whole vehicle scale, such as GNSS, cameras, low-cost vehicle scale IMU, wheel speedometer, etc., to meet the demand of mass production. Next, take Baidu Apollo 2.0 as an example to introduce the application of high-precision positioning on ICV.

The framework of Apollo 2.0 multi-sensor fusion positioning module is shown in the Figure 3: the left side lists the hardware and data that the positioning module depends on, including IMU, vehicle end antenna, base station, laser radar, and positioning map; The middle is GNSS positioning and laser point cloud positioning module, GNSS positioning outputs position and speed information, and point cloud positioning outputs position and heading angle information; On the right is the fusion framework, which includes two parts: inertial navigation solution and Kalman filtering; The results of fusion positioning will be used in the prediction of GNSS positioning and point cloud positioning in turn; The output of fusion positioning is a 6-DOF position and attitude, as well as a covariance matrix[5].

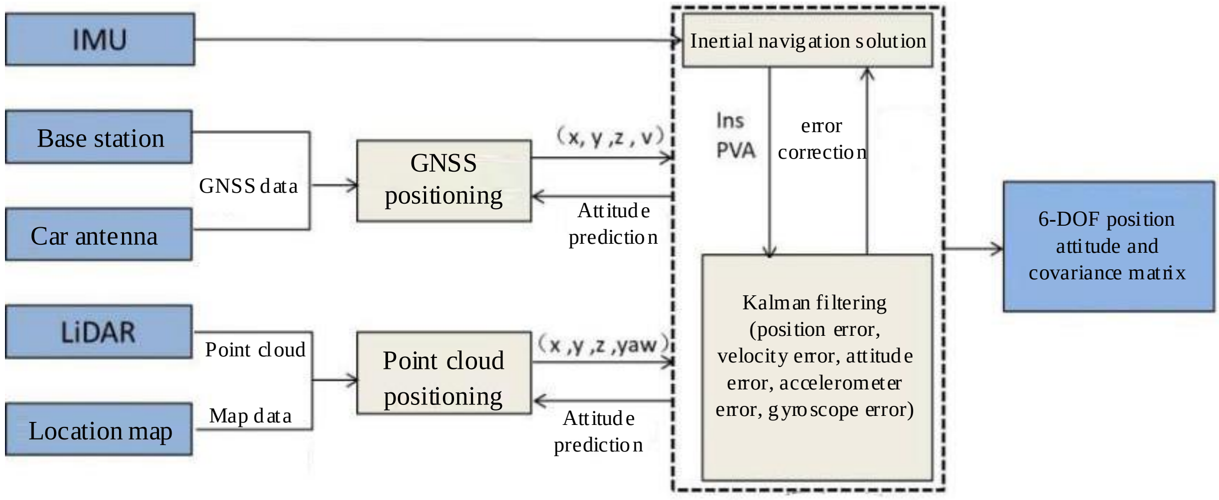

Figure 3 The framework of Apollo 2.0 multi-sensor fusion positioning module

Big data, as the basis and premise for the development of intelligently connected vehicles, will enable driving to truly achieve automatic driving, and have good social benefits. The application of big data technology can provide a large amount of data support for the driving environment and drivers, and help drivers to process information and make driving decisions. To complete the above work, a large number of demonstrations and verifications should be carried out, supported by standardization and standardization construction.

4. Key Technologies of Intelligent Connected Vehicles

The key technologies of ICV technology mainly include： (1) Information networking technology，(2) Automatic control technology，(3) Environment awareness technology，(4) Smart Cloud and Big Data Technology.

(1) Information networking technology

The information networking technology is mainly to add hardware that can realize wireless networking function in the traditional vehicle machine system, and match the software function of the vehicle machine. In terms of hardware, 5G network terminal, central processing unit, communication unit and GPS positioning module are required. In terms of software, network functions are integrated with vehicle functions to enable the vehicle to have network positioning, network control, network data acquisition and other functions, so as to further enrich the software functions of the vehicle.

(2) Automatic control technology

In order to improve the controllability of ICV, the electronic control devices in modern vehicles should be further increased and the functions of the electronic control system should be enriched. The automatic control functions required by the intelligent network connected vehicle include automatic drive, automatic steering, automatic braking, speed adjustment, gear adjustment, driving mode adjustment, suspension adjustment, seat adjustment in the vehicle, steering wheel adjustment, etc., and programmable technology and algorithm technology are used to make the automatic control function of the vehicle more reasonable.

(3) Environment awareness technology

Environment awareness is the ability of the car to independently obtain the surrounding information of the driving position. The environment awareness technology equipped with ICV includes visual recognition technology and radar detection technology. Visual recognition is the arrangement of 360 ° coverage camera modules on the car body to achieve comprehensive and real-time access to the surrounding environment (including the bottom) information of the car body. The application of visual technology enables ICV to achieve lane maintenance, road condition detection Panoramic navigation and other functions; Radar technology is mainly used in front of, behind and at the side of the vehicle. The main types of radar technology include laser radar, millimeter wave radar and ultrasonic radar. Radar technology can effectively realize active braking, adaptive cruise and other functions; The combination of visual identification of Wanfang data identification technology, radar detection technology, network technology and satellite positioning technology can also use positioning and big data information to achieve automatic overtaking, automatic driving, travel optimization and many other functions.

(4) Smart Cloud and Big Data Technology

Smart cloud and big data technology are important technologies after the Internet of Vehicles. The architecture of smart cloud platform enables cars to have a comprehensive network interaction function, making smart cars a networked driving tool. The combination of smart cloud and big data technology can realize network data interaction, data retrieval and storage, data analysis, data mining and other functions, further improving the comprehensive controllability of cars. With cloud technology and big data, The high-precision navigation, auxiliary positioning, intelligent route decision-making and driving scheme optimization of vehicles will be significantly improved.

The intelligent connected vehicle is an important direction for the future development of automobile technology, especially in the case of rapid increase in car ownership, the intelligent connected vehicle with the characteristics of intelligence, networking, controllability and data will effectively improve the current traffic and travel situation in China.

5. Future development trend analysis

The intelligent connected vehicle is an important direction for the future development of automobile technology, especially in the case of rapid increase in car ownership, the intelligent connected vehicle with the characteristics of intelligence, networking, controllability and data will effectively improve the current traffic and travel situation in China.

(1) Application of unmanned driving technology

At this stage, many automobile research institutions and automobile manufacturers are vigorously developing driverless technology, and driverless driving will also become one of the main driving modes for people to travel by car in the future. With the gradual maturity of driverless technology, the driverless auxiliary equipment equipped on the vehicle, combined with network positioning and satellite positioning data, will realize the rapid acquisition and judgment of numerous information during the driving process, and timely implementation of driving related decisions. Compared with manual driving, driverless technology has higher reliability in theory.

(2) Deep utilization of network data

On the basis of Internet of Vehicles technology, future smart cars should further improve the application of network and big data. On the one hand, big data technology can be used to guide traffic, so that vehicle control, traffic signals, traffic congestion and other data can form a good matching relationship. Cars can effectively avoid road congestion when driving. The time of signal lights can be adjusted in real time according to the congestion data provided by vehicles, making the intelligent connected vehicle and the transportation system integrated into an organic whole to effectively relieve the traffic pressure; On the other hand, satellite positioning combined with network big data technology can accurately locate the position of each car. The distance, speed and other relationships between cars can be intelligently adjusted under the supervision and guidance of big data network, effectively reducing the incidence of vehicle collisions, scratches and other traffic accidents.

(3) Further improvement of safety performance

In order to improve the driving safety of intelligent network connected vehicle, the vehicle safety should be improved from both hardware and software aspects. On the one hand, advanced synthetic materials are used to replace traditional body metal materials, which not only ensures the economy of driving process, but also improves the safety of vehicle collision and accident process; On the other hand, compared with manual driving, ICV uses visual recognition, radar detection technology combined with network positioning, data support, satellite positioning and other technologies to avoid driving fatigue, poor vision, carelessness, speeding violations and other problems during manual driving, and the probability of traffic accidents is significantly reduced.

6. Conclusion

Under the background of rapid development of intelligent technology, ICV has broad development space and is an extension of human technology. With the maturing of the Assisted Driving System (ADAS), its manufacturing cost will also be significantly reduced. Automatic driving will be the future development trend of the automobile industry. To achieve the full popularization of automatic driving, we need to overcome technical, policy and economic barriers, Promote the coordinated development of travel services and social benefits.

With the gradual establishment of China's intelligent automobile system, intelligent networked vehicles have entered people's daily life. To further enhance the market influence of new automobile products, automobile research institutions and production enterprises should continue to strengthen the overall quality of new automobile products in many aspects, such as intelligence, networking, reliability, safety, and humanization, so that China's intelligent automobile products gradually catch up with the international level, Create an advantageous brand of autonomous intelligent connected vehicle

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