Application Research of 5G Communication Technology in Satellite Navigation and Positioning

Zhimin Bao

China Civil Aviation Hulunbuir Air Traffic Control Station, Hulunbuir, Inner Mongolia, China

Abstract: With the rapid development of 5G communication technology and the increasing perfection of global satellite navigation and positioning, the application of **5**G communication technology in satellite navigation and positioning is particularly important. Based on the overview of 5G communication technology and satellite navigation and positioning, this paper analyzes the important value of **5**G technology communication in satellite navigation and positioning, and then discusses the application of **5**G technology communication and satellite positioning, navigation and aiming to integrate 5G communication technology, further improve the performance of satellite navigation and positioning system, and expand its application scenarios. It will bring greater convenience and benefits to social development.

Keywords: 5G Communication Technology; Satellite Navigation and Positioning; Positioning Accuracy; Application Analysis

1. Introduction

The acceleration of global informatization has positioned 5G communication technology and satellite navigation positioning as pivotal forces propelling modern society's progress. 5G, with its high-speed, low-latency, and massive connectivity capabilities, revolutionizes data transmission and communication, while satellite navigation systems, exemplified by China's BeiDou, provide worldwide users with precise, all-weather positioning services. Integrating 5G into satellite navigation promises not only to refine positioning accuracy and speed but also to catalyze innovative opportunities across various industries.

2. Overview of 5G Communication Technology and Satellite Navigation Positioning

2.1 5G Communication Technology

Fifth-generation mobile communication technology (5G) represents the apex of current wireless communication standards. Characterized by high capacity, ultra-high data rates, and minimal latency, 5G is designed to deliver faster and more stable wireless services. It offers theoretical data speeds up to 10 Gbps, a quantum leap from 4G, and latency as low as 1 millisecond, crucial for real-time applications. Additionally, 5G supports the Internet of Things (IoT) with its capacity to connect a multitude of devices.

2.2 Satellite Navigation Positioning

Satellite navigation and positioning technology is a technology that uses navigation satellites to accurately navigate and position users on the ground, sea, air and space. It relies on a set of dedicated positioning satellite systems and their ground launching stations to determine the precise position of the site. Because of its high precision, real-time, global coverage and condition controllability, this technology has become one of the most cutting-edge positioning technologies. Globally, the most famous satellite navigation and positioning systems are GPS in the United States, Galileo in Europe, GLONASS in Russia and Beidou in China. Such systems transmit signals to user devices to achieve accurate positioning, navigation and timing services on a global scale. Satellite navigation and positioning technology has played an important role in military, aviation. transportation, ocean, surveying and mapping and many other fields, and with the progress of technology, its application field is still expanding.

3. Significance of 5G in Satellite Navigation Positioning

3.1 Help to Improve Positioning Accuracy and Response Speed

From the perspective of positioning accuracy,

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the high-speed data transmission capability of 5G technology enables satellite navigation and positioning to receive and update a large amount of information in real time, such as satellite orbit data, clock correction parameters, etc., which can effectively improve positioning accuracy. Using 5G networks, such data can be transmitted to user devices more quickly, thereby reducing positioning errors caused by data transmission delays, and the technology can also assist satellite navigation and positioning systems for signal processing and error correction, further improving positioning accuracy. In terms of response speed, the low latency characteristics brought about by 5G technology are of great significance for satellite navigation and positioning. The traditional satellite navigation and positioning system may affect the real-time location because of the delay of signal processing and data transmission. With 5G technology, such delays are greatly reduced. For example, in application scenarios that require rapid response, such as autonomous vehicles, 5G technology can ensure that vehicles receive accurate positioning information in almost real time to make timely driving decisions and improve driving safety. In addition, the wide application of 5G technology also promotes the integration of multi-source positioning data, in addition to traditional satellite signals, it can also combine ground base stations, wireless networks and other data sources to jointly improve positioning accuracy and response speed. The fusion processing of multi-source data can effectively enhance the robustness of the positioning system, and also make the positioning more accurate in complex environments (such as urban canyons, indoor, etc.).

3.2 Help to Expand the Scope of Service and Signal Coverage

The application of 5G communication satellite navigation technology in and positioning has greatly expanded the service boundaries of satellite navigation and positioning systems, enabling precision positioning services to benefit a wider range of regions and users. First, the high-density distribution of 5G base stations, especially in urban and densely populated areas, effectively makes up for the possible blind spots in satellite signals. In these areas, tall buildings and other obstructions can block or weaken satellite

signals, resulting in unstable or unusable location services. [2] The use of 5G communication technology can receive satellite signals and forward them to user devices in the coverage area, thus ensuring the continuity and accuracy of positioning. Second, the high speed low delay characteristics of and 5G communication technology enable satellite navigation data to be transmitted to the user more quickly, even in remote areas or areas that are traditionally difficult to cover such as the ocean, as long as there is 5G network coverage, users can also obtain real-time, high-precision positioning information. It is particularly important for activities such as maritime transport, pelagic fishing and exploration and development in remote areas. In addition, the 5G network can use the signal transmission between the base station and the mobile device to achieve indoor positioning, so as to improve the continuity and availability of positioning, and then provide technical support for commercial applications such as indoor navigation and intelligent warehousing.

3.3 Help Promote Innovative Applications and Industry Integration

The application of 5G communication technology in satellite navigation and positioning has brought new development opportunities to all walks of life, and spawned many new applications and service models. Specifically, the combination of 5G and satellite navigation provides strong technical support for the realization of intelligent transportation systems (ITS). In the field of intelligent transportation, high-precision positioning and fast data transmission are particularly important. The high speed and low latency of 5G networks can ensure real-time information exchange between vehicles and between vehicles and high-precision infrastructure. while the positioning provided by satellite navigation guarantees precise control and path planning of vehicles. The application of this technology enables autonomous vehicles to drive more safely and efficiently, effectively reducing the risk of traffic accidents and improving the efficiency of road use. In addition, in smart cities, various sensors and devices need to transmit and share data in real time and accurately. Using 5G networks, such data can be quickly uploaded to the cloud for analysis and processing, and satellite navigation can ensure the spatial

positioning accuracy of the data, so that city managers can monitor the city situation in real time, make scientific decisions, and improve the efficiency and level of city management. In the field of agriculture, intelligent agricultural machinery equipment equipped with 5G communication and satellite navigation can monitor the growth of crops in real time, accurately put pesticides and fertilizers, and improve the yield and quality of crops. At the same time, in emergency rescue, the combination of 5G and satellite navigation enables rescue teams to quickly locate the affected area, transmit on-site conditions in real time, and improve rescue efficiency. In the field of environmental monitoring, it can more accurately monitor and predict natural disasters and protect people's lives and property safety. In logistics transportation, the use of real-time positioning and data transmission can optimize transportation routes and improve logistics efficiency.

4. Analysis of 5G Applications in Satellite Navigation Positioning

4.1 Revolutionizing Indoor and Outdoor High-Precision Positioning

Traditional satellite navigation and positioning systems, such as GPS and Beidou, provide positioning services worldwide, but in indoor or high-rise urban centers, due to signal occlusion and multi-path effects, positioning accuracy is often greatly reduced. Due to the occlusion of buildings and multi-path effects, satellite signals may become weak or unstable, resulting in positioning errors, and the introduction of 5G communication technology has brought revolutionary changes to satellite navigation positioning. First of all, in urban areas, the distribution density of 5G base stations is much than that of traditional higher mobile communication networks, and user devices can more easily receive signals from multiple base stations, using these signals, combined with large-scale MIMO (multi-input multi-output) antenna technology, 5G networks can enhance the penetration and coverage of signals, even in indoor or high-rise environments. The user device can also receive a stable, high-quality signal for more accurate positioning. Second, 5G networks use advanced signal processing technology to improve positioning accuracy. For example, using the triangulation of multiple base

stations, the system can accurately calculate the location of user devices. The method can measure the propagation time difference of signals received by the equipment from different base stations, and then determine the position of the equipment. Due to the high speed and low delay characteristics of 5G network, this positioning method can be carried out in real time to provide users with instant location information [3]. In addition, the traditional satellite navigation and positioning system often fails in the indoor environment, and the 5G network can effectively integrate the outdoor satellite navigation signal with the indoor wireless signal (such as WiFi, Bluetooth, etc.). By utilizing the propagation characteristics of these wireless signals, the system can achieve continuous, high-precision positioning services in indoor and outdoor environments. The seamless switching of location capabilities can enhance the user experience and open up new possibilities for business applications such as indoor navigation and smart shopping malls. Finally, the high speed and low latency characteristics of 5G communication technology also provide strong support for real-time data transmission. Because of the delay of signal transmission, the traditional satellite navigation and positioning system can not realize the real-time positioning. With 5G networks, positioning data can be transmitted to user devices or service centers in real time, ensuring that users can quickly obtain accurate location information, which is of vital significance in application scenarios requiring rapid response such as emergency rescue or automatic driving.

4.2 5G-Satellite Navigation Fusion in Intelligent Transportation Systems

In the intelligent transportation system, the integration of 5G communication technology and satellite navigation can enhance the intelligence level of the system, and also improve driving safety, traffic efficiency and urban management. Specifically, the high speed low latency characteristics of 5G and communication technology provide real-time data transmission guarantees for intelligent transportation systems. Combined with the high-precision positioning of the satellite navigation and positioning system, vehicles can obtain key data such as road information, traffic conditions and destination location in real time. For example, in the case of Chongqing Mobile, they implemented an indoor positioning and navigation system based on 5G network and Beidou system, solved the positioning problem in closed Spaces such as tunnels, and also monitored traffic flow in real time and conducted diversion guidance, greatly improving traffic efficiency. At the same time, the integration of 5G and satellite navigation makes intelligent driving technology develop rapidly, and its accurate positioning and real-time data transmission enable intelligent driving systems to make more accurate judgments and decisions. In autonomous driving tests, such as the remote driving experiment of Great Wall Motor in Xiongan New Area, the accuracy and real-time performance of remote control vehicles under the 5G network have been demonstrated, laying a solid foundation for the wide application of autonomous driving technology in the future. In addition, 5G communication technology also supports the efficient operation of intelligent traffic management systems, such as urban bus intelligence, taxi scheduling, intelligent street lights, and parking lot management. With the help of 5G network, the system can obtain and analyze the information of vehicles, passengers and road conditions in real time, so as to achieve more accurate scheduling and management, improve the convenience and comfort of public transportation, and relieve the pressure of urban traffic. The application of 5G communication technology in satellite navigation and positioning can provide real-time transmission and monitoring of high-definition video streams in this field, as well as accurate tracking of vehicle locations, so that city managers can quickly respond to traffic violations and emergencies, and ensure the safety and smooth of urban traffic. In the intelligent transportation system, combined with the high-precision positioning of satellite navigation, intelligent traffic lights can be flexibly adjusted according to real-time traffic flow, optimize road traffic conditions, and thus improve traffic efficiency and safety. Finally, the various sensors and devices connected by the 5G network can monitor the running status of the city in real time, such as transportation, energy, environment and other aspects, which can significantly improve the efficiency and level of urban management and provide citizens with a more convenient and comfortable living environment.

4.3 Advancements in UAV Navigation and

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Control Enabled by 5G

With the rapid development of UAV technology, it has shown a wide range of application prospects in many fields such as aerial photography, agriculture and logistics. However, the navigation and control technology of UAV has been the bottleneck of its further development. In recent years, the rise of 5G communication technology has brought new opportunities for breakthroughs in UAV navigation and control technology. Traditional UAV communication methods are often limited by data transmission rate, unable to transmit high-definition video, images and other large amounts of data in real time. The theoretical transmission speed of 5G network can reach 10Gb per second, which enables the UAV to transmit high-definition picture quality and accurate positioning data in real time, greatly improving the operational efficiency and accuracy of the UAV. At the same time, the UAV needs to respond quickly to operational commands during flight to ensure flight safety. The low-latency characteristics of 5G networks can reduce the transmission time of operational instructions to the millisecond level, ensuring that drones can respond quickly. At the same time, in traditional UAV operations, the collaborative work among multiple UAVs is often limited by communication capabilities and data processing capabilities [4]. The use of 5G communication technology can support the connection of massive devices, so that multiple drones can share data in real time and work cooperatively, improving the efficiency of drone groups. In addition, in terms of UAV navigation, the combination of 5G and satellite navigation and positioning system can provide more accurate positioning services. With the high-speed data transmission of the 5G network, the UAV can receive the positioning information of the satellite navigation and positioning system in real time to achieve accurate navigation. At the same time, the stability of the 5G network also ensures that the UAV will not lose positioning information due to signal interruption during flight. At the same time, with the help of 5G network, the UAV can receive and analyze the instructions of the ground control system in real time, and autonomously adjust the flight trajectory, altitude and speed and other parameters to achieve more intelligent flight control, so as to improve the autonomy of the UAV and further improve its operational

efficiency and safety.

4.4 Joint Application in Emergency Rescue

In the field of emergency rescue, the combination of 5G communication technology and satellite navigation can not only improve rescue efficiency, but also provide rescue workers with more accurate and real-time information support, which in turn saves more lives. First of all, the high-speed data transmission capability of 5G communication technology provides a smooth channel for information communication between the rescue site and the command center. Using 5G network, rescue workers can upload videos, images and data on the scene in real time, so that the command center can quickly understand the situation on the scene, make more accurate decisions and deploy resources. At the same time, the command center can also use the 5G network to send real-time instructions and strategies to rescue workers to ensure efficient and orderly rescue operations. Secondly, with the help of satellite navigation, rescue workers can quickly determine the exact location of the affected area, as well as the distribution and condition of the affected personnel, so that rescue workers can reach the scene more quickly, ensuring that they can accurately find the affected personnel in the complex environment and implement effective rescue. In addition, in the disaster scene, often accompanied by a large number of casualties, and on-site medical resources are often limited. Using 5G networks, medical experts can make remote diagnosis and treatment recommendations for injured people, while satellite navigation can ensure that these recommendations can be timely and accurately communicated to rescue workers on the scene to improve rescue efficiency and improve the survival rate of disaster victims. In practical applications, the joint application of 5G and satellite navigation has achieved remarkable results. For example, after natural disasters such as earthquakes and floods, rescue workers can use 5G networks and satellite navigation and positioning systems to quickly determine the location of the affected areas and personnel, and then quickly deploy rescue resources, and the 5G network real-time transmission of on-site images and data, the command center can more accurately assess the disaster situation and formulate rescue strategies. Finally, in a

complex rescue environment, rescue workers are often faced with a variety of unknown risks, using the precise positioning of the satellite navigation positioning system and the real-time communication of the 5G network, the command center can always understand the location and status of rescue workers, to ensure their safety.

5. Conclusion

In summary, the integration of 5G with satellite navigation positioning is proving transformative across sectors, from enhancing precision and responsiveness to enabling innovative applications that foster societal convenience and safety. As technology progresses and new integrations are explored, the future promises even more groundbreaking uses, propelling advancement technological and industrial evolution.

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