**Report on Real-Time Kinematic (RTK) GNSS**

Introduction Real-Time Kinematic (RTK) Global Navigation Satellite Systems (GNSS) are used for high-precision positioning and navigation applications. RTK GNSS systems offer sub-centimeter-level accuracy, which is essential in various fields such as surveying, construction, and precision agriculture. This report provides an overview of RTK GNSS, highlights the differences between RTN GNSS and GNSS, and discusses the sources of error in RTK GNSS.

RTK GNSS RTK GNSS systems use a combination of a base station and a rover to provide real-time, high-precision positioning. The base station, which is usually stationary, receives signals from multiple GNSS satellites and transmits correction data to the rover. The rover, which is usually mobile, receives signals from the same GNSS satellites as the base station and applies the correction data to improve the accuracy of its position. RTK GNSS systems can provide sub-centimeter-level accuracy in real-time, making them ideal for high-precision applications.

RTK GPS (Real-Time Kinematic GPS) is a type of GPS that uses real-time corrections from a base station to improve the accuracy of the positioning data. In an RTK GPS setup, there are two GPS receivers involved: a base station and a rover. The base station is set up at a known location and receives signals from the same GPS satellites as the rover. The base station then sends correction data to the rover, which uses this data to improve the accuracy of its positioning data.

On the other hand, GPS (Global Positioning System) is a satellite-based navigation system that uses a network of satellites orbiting the earth to provide location and time information to GPS receivers on the ground. In a GPS setup, there is only one receiver involved - the GPS receiver. The GPS receiver receives signals from the GPS satellites and uses the information contained in these signals to determine its location and time.

The main difference in setup between RTK GPS and GPS is the addition of a base station in the RTK GPS setup. The base station is a second GPS receiver that is set up at a known location and used to provide real-time corrections to the rover. This allows for higher accuracy positioning data than can be achieved with GPS alone.

Additionally, in an RTK GPS setup, the base station and rover must be in communication with each other to exchange the correction data. This can be done using a radio link or a cellular network. In a GPS setup, the GPS receiver only needs to be able to receive signals from the GPS satellites, which can be done without the need for additional communication equipment.

RTN GNSS vs. GNSS Real-Time Network (RTN) GNSS and GNSS are both used for positioning and navigation applications. However, there are some key differences between the two systems. RTN GNSS uses a network of base stations that transmit correction data to rovers, while GNSS uses a single base station that transmits correction data to a rover. RTN GNSS offers greater coverage and can provide real-time, high-precision positioning in areas where a single base station is not sufficient. On the other hand, GNSS is more cost-effective and can be used for applications that require lower levels of accuracy.

Sources of Error in RTK GNSS RTK GNSS systems are subject to several sources of error that can affect the accuracy of the positioning data. These sources of error include:

1. Atmospheric Conditions: Changes in atmospheric conditions, such as ionospheric and tropospheric delays, can affect the accuracy of RTK GNSS positioning. These delays can cause errors in the calculation of the position of the rover.
2. Multi-Path Effects: Multi-path effects occur when the GNSS signal is reflected off of surfaces such as buildings, trees, or the ground, causing the signal to arrive at the receiver from multiple paths. These reflected signals can cause errors in the calculation of the position of the rover.
3. Signal Interference: Signal interference can occur when the GNSS signal is disrupted by other electronic devices or signals, causing errors in the calculation of the position of the rover.
4. Receiver Error: Errors can occur in the receiver hardware or software, causing inaccuracies in the calculation of the position of the rover.

To the problems raised in the question box, here are the respective answers to them pointwise:

a. The error or deviation in RTK GNSS navigation as compared to GNSS without RTK provides insight into the accuracy of the RTK GNSS system. RTK GNSS systems generally provide higher levels of accuracy than GNSS without RTK, as they use real-time correction data to improve the accuracy of the positioning data.

b. The distribution of noise in the signal can be analyzed using a scatterplot of the data. The scatterplot can show the relationship between the measured positions and the true positions. The distribution of noise in the signal can also be quantified using statistical measures such as the standard deviation of the errors.

c. The distribution of noise in RTK GNSS data is different from GNSS data collected in Lab 1 because the RTK GNSS system uses real-time correction data to improve the accuracy of the positioning data, while the GNSS data collected in Lab 1 did not use any correction data.

d. The moving data in the open and occluded cases may be different due to the quality of the GNSS fix. In the open case, the GNSS fix may be of higher quality as there are fewer obstructions that can interfere with the GNSS signals. In the occluded case, the GNSS fix may be of lower quality due to the presence of obstructions that can block or reflect the GNSS signals.

e. The stationary data in the open and occluded cases may also be different due to the quality of the GNSS fix. In the open case, the GNSS fix may be of higher quality as there are fewer obstructions that can interfere with the GNSS signals. In the occluded case, the GNSS fix may be of lower quality due to the presence of obstructions that can block or reflect the GNSS signals. Additionally, the stationary data may show more variation in the occluded case due to the longer period of time that the receiver is stationary, allowing for more time for signal interference and other sources of error to affect the positioning data.

Conclusion RTK GNSS systems provide sub-centimeter-level accuracy in real-time, making them ideal for high-precision applications such as surveying, construction, and precision agriculture. RTN GNSS and GNSS are two types of positioning and navigation systems that have key differences in their use and applications. Sources of error in RTK GNSS include atmospheric conditions, multi-path effects, signal interference, and receiver error. Understanding these sources of error is essential in using RTK GNSS systems for accurate positioning and navigation.

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