Comparison of Real-Time Kinematic GNSS Positioning Techniques Using Moving and Stationary Antennas

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The use of high-rate and real-time GNSS measurements for hazard monitoring and scientific studies is still in its infancy and there is great potential for its integration with other data types for improved accuracy, gravity, and seismic monitoring. Many commercial vendors and public agencies now offer real-time positioning services that provide sub-decimeter accuracy, with some approaching the decimeter level. An GNSS network operators typically base their service offering on real-time kinematic or static surveys and the availability of antennas, accuracy, solution latency, network-topology and bandwidth. Periodic evaluation of real-time positioning systems will need to be conducted to optimize software and network configurations for evaluating real-time systems, helping to identify system limitations, and making it possible to conduct comparisons of several candidate approaches. Preliminary results from using a GNSS antenna and a comparison of real-time kinematic positioning methods will be presented.

Goal: Develop a low-cost portable kinematic test system.

Trimble RTX

In 2012 Trimble introduced the CenterPoint RTX, a real-time positioning service, providing centimeter accurate position estimates in real-time for use in remote monitoring and geophysical applications. We have conducted preliminary experiments at two locations. Short-term (24h) kinematic testing was conducted on the roof of the UNAVCO facility. Long-term static stations are ongoing at the Plate Boundary Observatory (PBO) site P041. For all results shown in this poster only GPS satellites were tracked.

In addition to the real-time processing conducted at P041, UNAVCO is currently using Trimble’s Centerpoint RTX for their Network Geodetic Survey (NGS). In 2013 UNAVCO will deploy NGS receivers at the UNAVCO Real-time GPS Data Processing System and Community Reference Data Sets for more information regarding UNAVCO’s real-time processing.

Operation:

GNSS positioning is based on correlating the GPS code phase to estimate the distance to the satellite. This distance is then used to calculate the position of the antenna, assuming that the antenna is moving with the same velocity as the satellite. The accuracy of the position estimate depends on the quality of the satellites and the antenna. The position estimate is then refined by using a Kalman filter, which takes into account the position estimate, velocity estimate, and acceleration estimate of the antenna.

A close-up of the pneumatic cylinder, linear position sensor and relay. The cylinder is actuated by a servo-valve. The relay controls the servo-valve and is actuated by a USB connector. The linear position sensor outputs an analog voltage that is proportional to the distance traveled by the cylinder. The voltage is then converted to a digital signal using an Arduino microcontroller.

Preliminary Kinematic Test Results

Table 1. Preliminary results from testing Trimble RTX on a roof-mounted antenna in Boulder, CO. The positions are relative to the center of the building.

Long-term Stationary RTX Test

Long-term testing of Trimble’s RTX service is ongoing at UNAVCO and will be used to characterize the stability of the position time series produced by Trimble’s RTX. The data is recorded at the University of Colorado’s Plate Boundary Observatory site P041 in June 2013, and time series data to be released that show standard deviations of 223, 271 and 40 mm for north, east and up components, respectively. Position accuracy for these RTX stations using a server-based service was determined to be better than 20 mm.

Detailed statistics are shown in Table 1. The positions are relative to the center of the building. The positions are calculated by taking the root mean square of the differences between the positions estimated by Trimble’s RTX system and a reference position estimated by Trimble’s PIVOT software. The reference positions were calculated by taking the mean of the positions estimated by other Trimble’s RTX systems in the network.

Frame 1:

Trimble RTX

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Long-term Stationary Antenna Real-Time PPP Test Results

RTX was first enabled on the Netfllix receiver located at the Plate Boundary Observatory (PBO) site P041 in Boulder, CO on June 1st of 2013. UNAVCO began processing P041’s BRW streams using Trimble’s PIVOT software on a centralized server. Time series statistics from P041 are shown in Table 1. In addition to RTX, UNAVCO has been processing ~300 stations using the PBO real-time network since July of 2013. Averaged position estimate statistics for the entire PBO real-time network are shown in Table 2.

Can outliers be distinguished from true motion?

Proper identification and removal of outliers in real-time position estimates will be required for integration in hazard monitoring applications. The initial test of the RTX PPP solution caused large outliers in position. Re-initialization can occur during network outages, RF interference or any instance causing the receiver to lose lock. The receiver used has a unique position vector output by RTX that can be used more rapidly after re-initialization than the position solution does. This could make it difficult to use the uncertainties to remove real-time outliers from true motion. An alternative approach could use the number of fixed biases to weight the position estimates. However, RTX does not currently output this information.

The installation of accelerometers at real-time GNSS sites could be used to enhance real-time positioning for applications in hazard monitoring and geophysical sciences. Providing an independent measurement of a site’s motion could allow for easy and reliable identification of position estimate outliers.

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Table 2. RTX position estimate statistics for long-term stationary test site P041. Receiver-based RTX was enabled at P041 in June of 2013. 3004 and clock corrections were received via L-band satellite. Processing a BRLW stream with server-based RTX commenced in July of 2013.

Goal: Evaluate CenterPoint RTX Static and Kinematic Performance

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