Characteristic Analysis of GNSS Real-Time Kinematic for Mobile Platforms

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Abstract: The Real-time Kinematic (RTK) GNSS positioning has predominantly been applied to short baseline applications. The characteristics of RTK were analyzed in this study, especially depending on the baseline lengths between two receivers to verify the spatial decorrelation of the measurements. Three different network-based RTKs were tested under operational mode in Korea.

Keywords: Network RTK, SSR, Correction

1. Introduction

With new technological revolution for last several years, the ICT (Information & Communication Technology) has been increasingly highlighted, namely IOT (Internet of Things) and the unmanned vehicle to name a few. Especially the Unmanned Aerial Vehicle (UAV) is being actively developed and studied for various purposes from many countries, which became one of the fast-growing fields. It was usually used for surveying and other civil applications, which requires the determination of accurate position for the best performance. We apply the real-time technology to mobile platforms such as unmanned transportation to conduct more precise and convenient positioning.

Global Navigation Satellite System (GNSS) Real-time Kinematic (RTK) surveying is required for the positioning of moving objects in situ (Kim and Bae, 2013). The accuracy of the RTK depends on the ambiguity resolution rate. While the single-baseline RTK (SRTK) generally works for the baselines not more than 10 km. The network-based RTK (NRTK) was conducted for three correction information, that is, Virtual Reference Station (VRS), Flächen-Korrektur-Parameter (FKP), and the State Space Representation (SSR) (Talbot et al., 2002). Among these three techniques, VRS and FKP are currently operational in Korea by the National Geographic Information Institute (NGII), provided by the Radio Technical Commission for Maritime Services (RTCM, 2001) format. The initialization time and the stability were inspected for both static and kinematic environments. The accuracy was analyzed by the reference coordinates obtained from the Mobile Mapping System (MMS) which integrate the GNSS and the Inertial Measurement Unit (IMU) information.

2. OSR vs. SSR

VRS and/or FKP are generally used for NRTK (Takac and Zelzer, 2008), which is basically Observation Space Representation (OSR) technique. Due to the limitation of concurrent number of users, there is a weakness in operational NRTK other than communication method and the amount of data. Therefore, we would like to investigate the possibility of applying for future national infrastructure. We analyzed the characteristics and the positioning

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performance of the correction information of SSR, which has been recently introduced by many countries and institutions.

Unlike the OSR method, the SSR uses the reference station network to separate the GNSS error components such as satellite clock, satellite orbit, signal bias and ionospheric/tropospheric delays. Based on the model, the correction information is estimated by the rover. While most OSR methods require two-way communication, the SSR method can broadcast one-way to all users with lower bandwidth, resulting in various possible ways such as satellite and digital radio (Figure 1). Therefore, it has an advantage of different level of correction information according to density of reference stations.

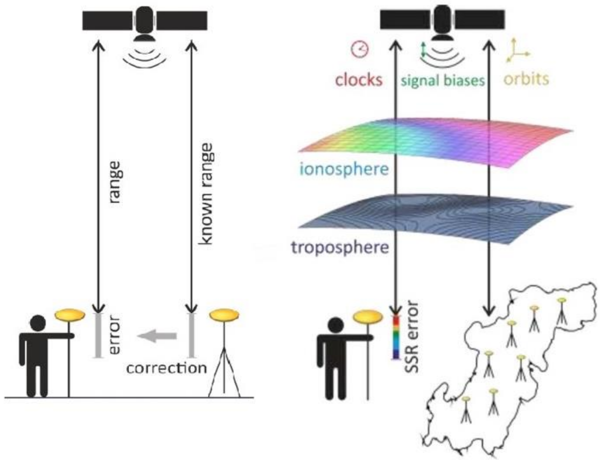

Figure 1. OSR vs. SSR (Wübbena et al., 2017)

However, since the SSR correction information has not been standardized yet, the receivers that support the SSR correction are not available on the market. Furthermore, it has a disadvantage of longer initialization time compared to those of OSR method.

3. Methodology

We constructed the procedure for acquiring coordinates of Mobile Mapping System (MMS), and the kinematic positioning was conducted for the region of Jeolla-do located on the southwest corner of Korea (Figure 2).

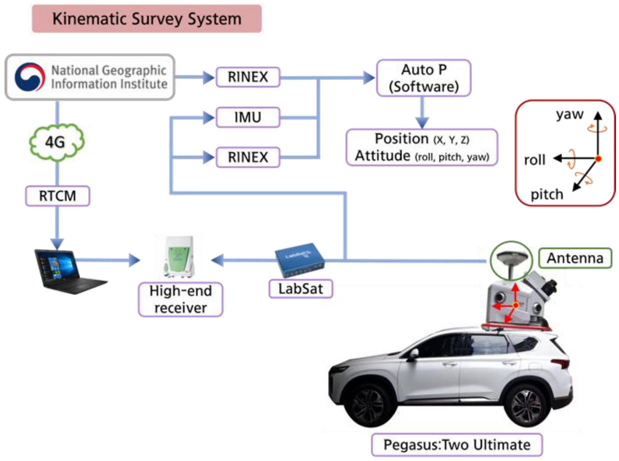

Figure 2. The architecture of kinematic positioning based on MMS used in this study

Radio Frequency (RF) signal was recorded in LabSat equipment, and the VRS, FKP, and SSR correction signals were separately saved in a laptop. If the stored RF signal and the correction information are put in the receiver with an appropriate format, the coordinates of the moving path can be obtained according to the correction information. Also, the (assumed) true coordinates of MMS was acquired from the AutoP software which processes the GNSS and IMU information together, which was used as the reference coordinate for comparison.

However, there is no receiver to understand the SSR correction information directly, we need to convert the SSR into OSR. Geo++ provided the software called SSR2OBS to facilitate the transformation of the messages. The procedure of receiving SSR correction information is depicted in Figure 3.

In this way, we simultaneously received three correction signals at user location. We analyzed the relative difference between coordinates of MMS and the rover position estimated with different correction information.

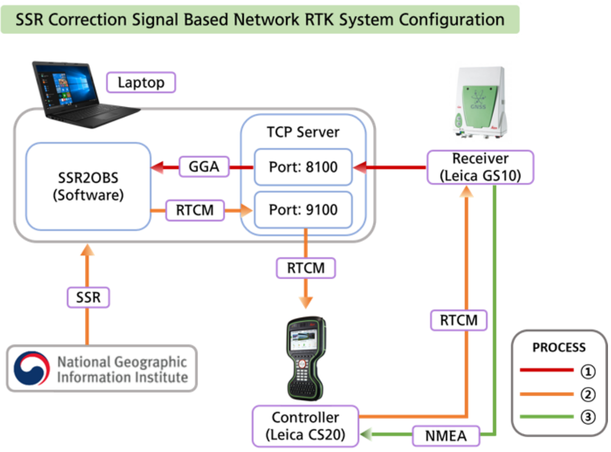

Figure 3. The procedure of SSR correction

4. Results

The kinematic positioning was conducted in the network of Jeolla which is consisted of four stations (YONK, NAMW, JAHG, and SONC). The red line represents the route of the MMS vehicle within the network (Figure 4).

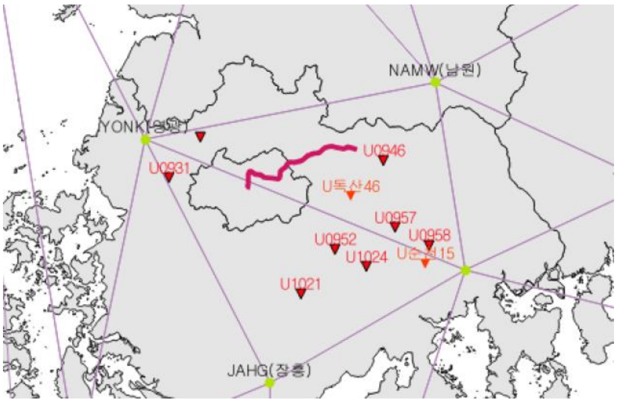

Fig.4 The route of kinematic positioning in a network

The VRS, FKP, and SSR correction information was received at the same time using RTKLIB software (Takasu, 2018). Each solution was plotted in Figures 5-7 compared to the MMS results as mentioned above. All plots are represented by the horizontal components in one subplot, and the Up component is given as a separate figure.

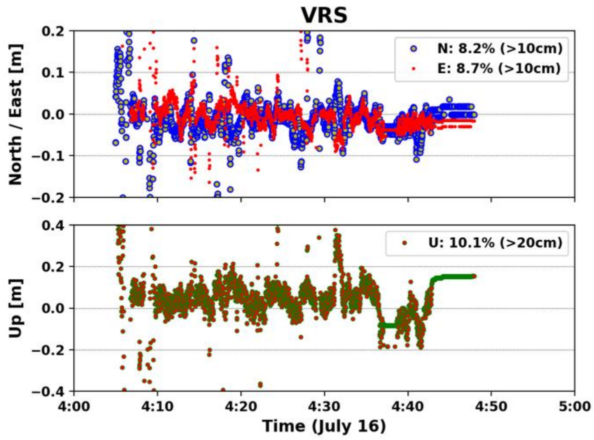

Figure 5. Comparison of MMS and VRS

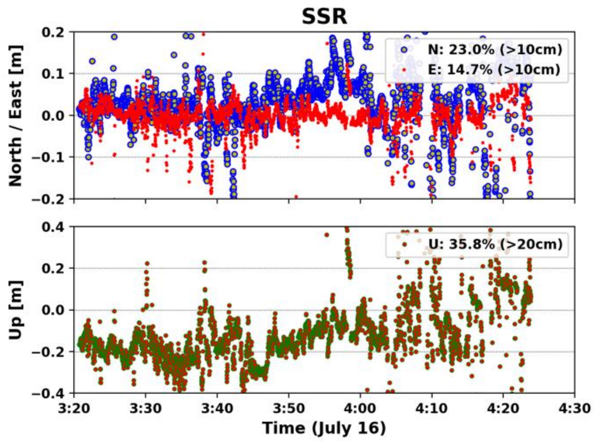

Figure 6. Comparison of MMS and SSR

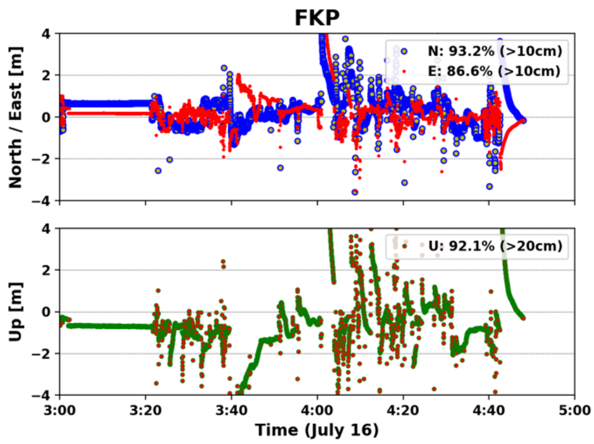

Figure 7. Comparison of MMS and FKP

Among three correction signals, the VRS shows better performance than the other two methods. There was no noticeable bias in the horizontal and vertical directions of VRS solution which provides the large errors of 8-9 cm in horizontal component (see Figure 5). However, the SSR shows worse positioning results with a relatively large bias in vertical component (Figure 6). The percentage of large error ranges 15-23% while the vertical component gradually increasing in its error. On the other hand, the FKP correction is generated from the same server as SSR but the GLONASS satellites were not fixed in the final solution. Thus, the positioning error is larger by an order of magnitude than the other two methods (Figure 7).

5. Conclusion

We conducted an experiment of new correction signals for real-time positioning technology of various moving objects. The MMS vehicle was used to calculate the correct position of the moving platforming the area of Jeolla-do. The results were compared with those from the NRTK by receiving correction signals of VRS, FKP and the new SSR method simultaneously. According to the results, the VRS had the highest accuracy, while the SSR provides the reasonably accurate position of the moving object. FKP is considered worse solution due to lack of fixed GLONASS satellites. Although the SSR correction is not accurate enough compared to the conventional VRS, it has unique advantage for real-time positioning of the moving object, as well as no limitation of the number of users. The characteristics of SSR should be addressed here, and the higher accuracy can be expected if an appropriate calibration procedure is applied.

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