Integration of a Geodetic Grade GNSS Receiver and an Android Dual-Frequency Smartphone with Low-Cost IMU for Seismogeodetic Applications

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SUMMARY

Today, Global Navigation Satellite Systems (GNSS) are accepted as effective seismic sensors for crustal deformation monitoring and structural health monitoring (SHM) applications. High-rate seismogeodesy provides accurate and well-sampled semi-static and dynamic displacements through the kinematic data processing methods. Currently, strong and broadband displacements are analyzed using the integration of high-rate GNSS (HR GNSS) and accelerometer sensors. However geodetic grade GNSS receivers and high-quality inertial sensors are expensive tools for seismogeodesy, compared to consumer-grade motion sensors. Integrating low-cost sensors to obtain displacements and velocities has become a hotspot research area for seismogeodetic applications. Recently, smartphones are popular for low-cost studies due to their accessible positioning and motion sensors. Smartphones with low-cost accelerometer sensors have been widely used for classical seismologic applications. With the release of Mi8, the first smartphone with a dual-frequency GNSS chipset released by Xiaomi, interest in smartphone-based positioning has been increased and numerous studies have been conducted. In this study, we present the performance assessments on the integration of geodetic grade (Trimble NETR9) and Xiaomi Mi8 dual-frequency GNSS displacements with low-cost Xiaomi Mi8 inertial sensors for seismogeodetic applications. 1999 Duzce earthquake (Mw = 7.2) in Turkey and 1989 Loma-Prieta earthquake (Mw = 6.9) in United States of America were simulated on a single axis shake table. To integrate GNSS data with the accelerometer, the magnetometer sensor in Xiaomi Mi8 was adopted to align sensor frame accelerations with the local geodetic reference frame using Singular Value Decomposition (SVD). GNSS data collected from geodetic grade GNSS receivers and Xiaomi Mi8 smartphone were processed with Precise Point Positioning (PPP) method using an open-source data processing software RTKLib ver 2.4.3. Multi-rate Kalman Filter was used to optimally combine GNSS displacements with Xiaomi Mi8 accelerometer records to estimate displacements and velocities. Results showed that integration of geodetic grade GNSS with smartphone accelerometer sensor can

estimate displacements with mm-cm level accuracy. On the other hand, Xiaomi Mi8 GNSS / accelerometer integration produces dm-m level deviations and is not sufficient for monitoring cm level displacements. It can be concluded that although the low-cost accelerometer sensor in Xiaomi Mi8 is efficient for seismogeodetic applications, the accuracy of the dual-frequency GNSS chipset needs to be improved.