HIGH-RATE GNSS TECHNIQUES FOR THE DETECTION OF LARGE SEISMIC DISPLACEMENTS

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1. INTRODUCTION

Seismic strong motion is the surface dispacements that occurs close to earthquake epicenters. The detection of the near-field deformation is important for the determination of the seismic source parameters and to provide information for engineers in order to improve earthquake resistance for buildings and other structures. Usually strong-motion observations in seismology are based on accelerometers. Displacements can be derived from double time-integrated accelerograms which are limited by glitches in the sensor occurring during the most intense period of the shaking. Strong-motion accelerations are often in the high-frequency domain (10 Hz and beyond). Displacements are, however, dominated by low-frequency signals that can be recorded at a few Hertz by GNSS observations and estimated with rather small uncertainty. Using 1-Hz GPS data to estimate the seismic displacement has been successfully demonstrated in several studies [1], [2]. They found that with a 1-Hz sampling the vertical component was too noisy for a significant reduction of variance when synthetic waveforms were fitted to and subtracted from the signal. Therefore, it is interesting to investigate the usage of high-rate sampled GNSS data.

2. EXPERIMENT

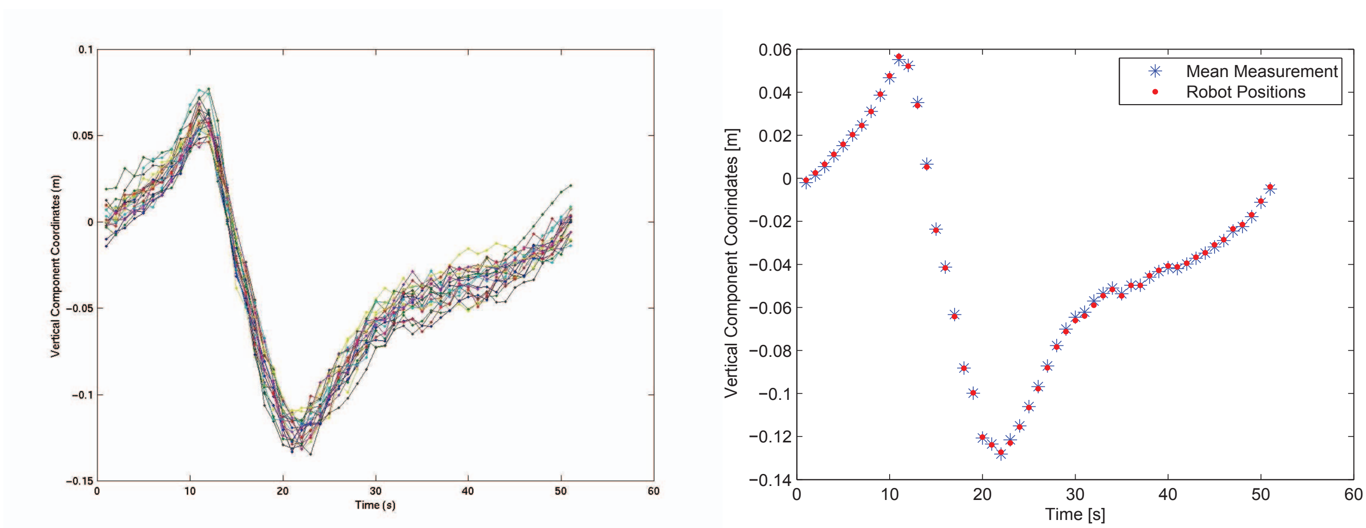
In this experiment all GPS data were acquired using 20 Hz (0.05 s) sampling. The recording from the 1985 Michoacán, earthquake in Mexico, has been chosen as reference data. A GPS antenna mounted on an industrial robot was used to simulate displacements occurring during this earthquake. Figure 1 shows the setup. A schedule has been implemented in the robot system to simulate the displacements of the earthquake that lasted for a time period of 51 s. The robot was moved with an upd-

Fig. 1. The installation of a GPS antenna mounted on an industrial robot simulating the displacement of the earthquake.

ate rate of 5 Hz (0.2 s), with 0.1 s motion to the next point and rest at the point for remaining 0.1 s. After the 51 s long period of motions, the robot will be static for another 309 s. Thereafter the cycle is repeated, meaning that it will repeat itself 240 times per day. Data from two sites in the International GNSS Service (IGS) station network have been used as reference. One is the ONSA station which is approximately 400 m away from the GPS antenna on the robot. The other station is the SPT0 which is about 60 km away. By this configuration a short baseline (robot – ONSA) and a long baseline (robot – SPT0) will be available for signal processing. The acquired data were processed using an in-house Matlab-based GNSS software package to estimate the four state variables, namely east, north, and vertical displacements of the antenna, plus the receiver time difference.

3. RESULTS

We present the first results of comparisons between estimated components obtained from GNSS data processing and the commanded robot positions for two processing geometries (short and long baselines). After corrections for the troposphere and ionosphere irregularities both methods give similar (within 0.5 mm) Root Mean Square (RMS) differences between the estimated coordinates and commanded robot positions. The RMS differences are approximately 3 mm in the east component, 4.5 mm in the north component, and 8.5 mm in the vertical component. One example of the estimated vertical components, from the long and short baselines processing, is shown in Figure 2. The results so far most likely suffer from mechanical instability in the mount of the robot. Thus, we expect the results to be even better than reported above and by adding additional sensors we hope to verify this idea. During the first half of 2009 the earthquake simulating industrial robot at Onsala will be equipped with additional position sensors and motion detectors such as a Laser Tracker and an Inertial Measurement Unit (IMU). Results from this second experiment will also be presented.



(a) (b)

Fig. 2. The estimated vertical component obtained from the GNSS data processing. (a) The results were derived from the long baseline processing for 20 simulated earthquakes and (b) the mean value of 240 simulated earthquake sequences obtained from the short baseline processing compared to the commanded robot positions.

4. REFERENCES

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