High-rate bridge displacement monitoring with low-rate Virtual Reference Station data

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SUMMARY

We present a new Global Navigation Satellite Systems (GNSS) positioning approach that utilizes low-rate Virtual Reference Station (VRS) data to achieve high-rate displacement monitoring. The method integrates tightly the VRS technology with asynchronous Real-Time Kinematic (RTK) method to overcome the limitation of VRS in high-rate structural health monitoring (SHM) applications. When this approach is used, no local reference station is required so that the efforts and cost of setting up reference stations can be avoided. Experiments with datasets from a controlled shaking platform and a long-span bridge in Hong Kong with both temperature and typhoon excitations have indicated that the proposed approach worked effectively. The results demonstrated that when a baseline exceeded about 3 km, the vertical errors of RTK GNSS positioning could be up to about 15.9 mm (standard deviations), insufficient for most SHM applications. In this case, the proposed method enhanced the accuracy by about 60% to 6.0 mm when using VRS data openly available in Hong Kong. The accuracy achieved was equivalent to that of RTK positioning using a 1.2 km baseline. The shaking platform trial demonstrated that the monitoring station could be up-sampled to 100 Hz without a noticeable loss in accuracy. The proposed method could capture precisely the peak frequencies and amplitudes of vibrations, with errors as low as 0.001 Hz and 0.1 mm. This method broadens the applicability of GNSS positioning in SHM applications.