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A live case study of SFMC GNSS dense network for continual monitoring of ground deformation

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The use of Global Navigation Satellite System (GNSS) technology for sub-centimetre landslide and ground deformation monitoring is nowadays an approved strategy, often adopted as complementary to satellite (i.e. InSAR), land and aerial based technologies.
Under specific technical constraints, the adoption of low-cost single frequency multi-constellation (SFMC) GNSS sensors for ground displacement monitoring is representing nowadays a valid alternative to the deployment of multi-frequency geodetic GNSS receivers. Several solutions are already available on the market and NSL are developing commercial high accuracy GNSS solutions and services affordable and accessible to users.
NSL's "STICK" is an affordable L1, multi-constellation, IMU-integrated GNSS sensor designed for precise movement detection of ground-based surface, structures and infrastructures.
STICK and the related monitoring service have been developed within the context of three ESA IAP demonstration projects aiming at the use of space assets to monitor land and structure stability.
Among many applications, the deployment of affordable GNSS solutions is of particular interest considering the ground related risk to transportation infrastructure. Considering only the United Kingdom, several thousands of sites are affected by ground instability and movements of earthworks that could potentially disrupt transport infrastructures.
An affordable continuous GNSS monitoring solution provides the infrastructure operators with a cost-effective preventative maintenance and alerting system.
In this paper we present the operational challenges, performances and results of a SFMC GNSS monitoring network deployed in the Scottish Highlands for providing alert, warning and long-term monitoring of a landslide affecting the transport infrastructures.
The network comprises of fifteen stand-alone STICKs transmitting data back to the NSL's server over GSM connection. The STICK firmware allows the remote configuration of the internal GNSS receiver and microcontroller. The power consumption is carefully optimized.
GNSS data is automatically processed server-side following the Real Time Kinematic technique. Displacement estimations are generated in quasi real-time providing regular alerts. Stored solutions are then automatically analysed, periodically providing long term refined solutions.
Typically, the actual displacement is smaller than or comparable to the precision of the measurements. This suggested the opportunity of adopting a Bayesian approach for assessing the significance of the calculated displacements.
The approach combines the current measurements with all a priori knowledge of the phenomenon under examination in order to produce a powerful and effective approach for the analysis of deformation.
Here we present the application of this model on our network, considering the following three cases: the first one by extrapolating prior information from a first period of observation, the second one by using the stochastic representation of the prior information based on structural and geotechnical hypotheses. Finally, showing the behaviour of the model after the introduction of a wrong prior information.
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