Total Electron Content Monitoring Complemented with Crowdsourced GNSS Observations

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The New Geodetic Prediction Center at ETH Zurich

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Geodetic measurements allow the determination of a wide variety of parameters describing the Earth system, including its shape, gravity field, and orientation in space. The importance of such parameters to science and society is manifested through geodetic contributions to the examination of geodynamic phenomena, climate change monitoring and navigation both on the Earth's surface and in space. In a recent effort led by the Global Geodetic Observing System (GGOS), a set of Essential Geodetic Variables (EGVs) has been defined, which are key quantities characterizing geodetic properties of the Earth. Certain requirements have been assigned to EGVs, including accuracy, spatio-temporal resolution, and latency.

For many real-time applications, the latency of geodetic products has become increasingly critical. Forecasts of certain EGVs at various time horizons are needed to accommodate the user's needs for many applications. In addition, spatial prediction of geodetic quantities on standardized grids on global and regional scales are of great benefit to certain scientific disciplines. The Space Geodesy group at ETH Zurich has thus established a new Geodetic Prediction Center (GPC), which aims to produce spatio-temporal predictions of various EGVs by employing state-of-the-art methods and providing them freely to the scientific community and other interested parties.

In the field of time series forecasting and spatial prediction, machine learning (ML) has become increasingly powerful in recent years due to its high accuracy, efficiency in coping with large amounts of heterogeneous data sets, and capability of capturing complex relationships between various data sources. For instance, ML allows to include auxiliary data in geodetic predictions, also in the cases when no mathematical or physical relation is known. The application of ML has demonstrated promising results in terms of geodetic time series prediction and is thus the tool of choice for many of the parameters provided by the GPC. ML methods applied in this framework include tree-based methods such as random forest as well as variants of convolutional and recurrent neural networks. Such a ML-based approach allows to assimilate geodetic measurements, environmental models, and auxiliary data sets with the aim to provide predictions of utmost accuracy.

Currently, ETH Zurich is invested in the prediction of Earth orientation parameters, Earth angular momentum functions, station coordinates, tropospheric zenith wet delays, ionospheric total electron content, and satellite orbits. In this contribution, an overview of these efforts in the framework of the Geodetic Prediction Center will be provided, highlighting the most recent scientific results.