Machine Learning Techniques for Ground-based and Space-borne GNSS Remote Sensing Applications: Lessons Learned and Progress Made

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Abstract

For more than a decade, the Satellite Navigation and Sensing (SeNSe) Laboratory at the University of Colorado Boulder has been deploying ground-based software-defined radios that capture disturbances experienced by GNSS signals worldwide. To date, more than 2PB of GNSS data has been collected. Machine learning (ML) is the only viable means to exploit and make sense of the information hidden in the data. A variety of ML algorithms have been developed in the SeNSe Lab to detect, classify, and forecast GNSS disturbances. In this presentation, we will highlight lessons learned and progresses made in developing ML techniques to work with the data. In particular, we will discuss feature engineering that enables random forest-based ML algorithm to effectively separate ionospheric scintillation from satellite oscillator anomalies, both of them share similar time domain features. We will also present an implementation of the long short-term memory convolutional neural network (convLSTM) architecture with custom loss functions. The convLSTM algorithm exploits space and time relationships of high latitude ionospheric disturbances propagation and demonstrates the potential for space weather effects forecasting.

In recent years, SeNSe Lab also engaged in developing spaceborne GNSS receiver technologies for Earth space environment and surface remote sensing. In particular, we have been working with GNSS reflectometry data collected by low Earth orbiting (LEO) satellites for remote sensing of Earth surface properties. In this presentation, we will discuss ML algorithms developed for ocean wind vector retrieval using NASA's CYGNSS satellite data as well as coherent signal detection algorithms for precision altimetry applications.