Geomatics Innovation @ UNB

Fall 2019 Graduate Seminar

Thursday, November 28 @ 12:30pm

Head Hall – Room E-11

Resilient Multipath Prediction and Detection Architecture for Low-cost Navigation in Challenging Urban Areas

Ivan Smolyakov

ABSTRACT

GNSS remains one of the key building blocks in mass-market positioning applications, many of which require a high level of accuracy, integrity and availability. Conventionally, the GNSS receiver and antenna are a part of a multisensor integrated solution with an inertial measurement unit (IMU) at the core of the navigation system. One of the multisensor fusion challenges is to continuously adjust the Kalman filter stochastic model to reflect the environment of operation. Apart from poor satellite geometry, the reception of multipath-contaminated signals is the main factor contributing to GNSS performance degradation in urban areas. Signal quality monitoring (SQM) techniques are implemented to first detect and then exclude, de-weight or correct the multipath-contaminated GNSS measurements to minimize the impact of multipath-induced errors on the multisensor data fusion filter performance. The implementation of such an approach for kinematic scenarios in deep urban canyons with mass-market hardware suffers from high rates of false-positive and false-negative multipath detection due to frequent cycle slips, discontinuous satellite tracking, and a complex multipath environment. The alternative approach for the IMU/GNSS integration filter stochastic model tuning is to extract the a priori statistics characterizing the probability of the multipath-contaminated signal reception from a GNSS multipath environment map. The map is generated with collectively recorded carrier-to-noise-density ratio (C/N0) readings streamed from the connected vehicles operating in a given urban area and assigned to a space-time cube. While improving positioning accuracy, the application of the concept is constrained by the GNSS multipath environment map availability only to the areas directly surveyed by the connected vehicles.

The novel contributions of this paper are as follows. To extend availability of the GNSS multipath environment map, a random forest machine-learning model for predicting the spatial pattern of the map is developed. The model is trained with a real-world GNSS multipath environment map covering the area of ten square kilometres including downtown Montreal. A LiDAR elevation profile, 2D building polygons, street polygons, street types and foliage polygons are used as feature data. An 89% map prediction accuracy is reached. Further, the Extended Kalman Filter (EKF) stochastic model adjustment architecture combining the SQM multipath detection and the GNSS multipath environment map-aided multipath prediction is developed. The architecture aims to address the limitations of each method and allows for continuous multipath monitoring increasing the resilience of the multisensor data fusion. The method is tested in several use cases with low-cost hardware: loosely-coupled and tightly-coupled IMU/GNSS integration. The evaluation of the proposed method shows 20% positioning accuracy improvement compared to standard Kalman filter performance. The results of this work are expected to facilitate future improved integration of GNSS in multisensor platforms operating in challenging urban areas.

Please join us for coffee and sweets in the GGE hallway after the presentation.