THEORETICAL AND PRACTICAL ASPECTS FOR FASTER (RE-)CONVERGENCE OF PRECISE POINT POSITIONING SOLUTIONS

Abstract

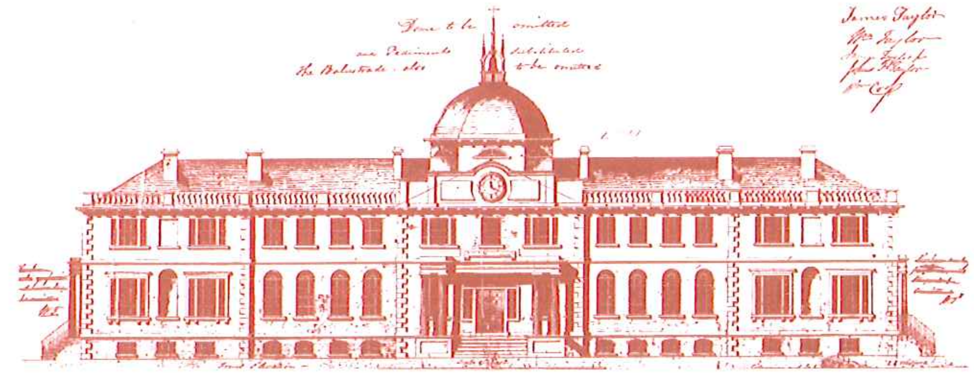
The precise point positioning (PPP) methodology allows for cm-level positioning accuracies using a single GNSS receiver, through careful modelling of all error sources affecting the signals. Adoption of PPP in several applications is however muted due to the time required for solutions to converge or re-converge to their expected accuracy, which regularly exceeds 30 minutes for a moving receiver. In an attempt at solving the convergence issues associated with PPP, three aspects were investigated.

First, signal tracking interruptions are typically associated with integer discontinuities in carrier-phase measurements, often referred to as cycle slips. A refined method for detecting and correcting cycle slips was thus developed, in which all error sources affecting the observations are either modelled or estimated. Application of this technique allows for instantaneous cycle-slip correction, meaning that continuous PPP solutions can be obtained even in the presence of short losses of lock on satellites.

Second, external information on the ionosphere allows for reduced convergence times, but consistency must be observed in the functional model. A new technique, termed integer levelling, was thus developed to generate ionospheric delay corrections compatible with PPP based on the decoupled-clock model. Depending on the inter-station distances in the network providing ionospheric corrections, instantaneous cm-level accuracies can be obtained in PPP.

Third, processing of GLONASS signals is more problematic than GPS due to frequency division multiple access, leading to inter-frequency carrier-phase and code biases. A novel approach for the estimation of such biases was then proposed and facilitates processing of mixed receiver types. It also allows for undifferenced GLONASS ambiguity resolution based on a heterogeneous network of stations, the first demonstration of such an approach, and therefore has the potential to further reduce PPP convergence times.

This research also emphasized potential benefits of integer-levelled observations for improved ionosphere monitoring. The main justifications for adopting this approach are: a reduction in the determination of slant total electron content errors, a simplification in the GLONASS processing strategy, its applicability in real time, and the generation of satellite biases required for the use of ionospheric constraints in PPP with ambiguity resolution.



Home of the School of Graduate Studies, Sir Howard Douglas Hall was designed by J.E. Woolford in 1825 and is the oldest university building in Canada still in use.

UNIVERSITY OF NEW BRUNSWICK

SCHOOL OF GRADUATE STUDIES

ORAL EXAMINATION

Simon Banville

IN PARTIAL FULFILMENT
OF THE REQUIREMENTS FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY

Ph.D. Candidate

Simon Banville

Graduate Academic Unit

Geodesy & Geomatics Engineering

~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

July 4, 2014

9:30 a.m.

ADI Studio (HC-25)
Head Hall

~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

Examining Board:

Dr. Richard Langley (Geodesy & Geomatics Eng.)	Supervisor
Dr. Donghyun Kim (Geodesy & Geomatics Eng.)	
Dr. Marcelo Santos (Geodesy & Geomatics Eng.)	
Dr. P.T. Jayachandran (Physics)	Chairperson

External Examiner:
Dr. Marc Cocard
Département des sciences géomatiques
Université Laval

The Oral Examination will be chaired by:
Dr. Ed Biden, Dean of Graduate Studies

BIOGRAPHY

Universities attended:

2008-2014	Doctor of philosophy candidate, University of New Brunswick
2005-2007	Master of science, Laval University
2001-2005	Bachelor of science, Laval University

Publications:

Banville, S., P. Collins, W. Zhang, and R. B. Langley (2014). "Global and regional ionospheric corrections for faster PPP convergence," *NAVIGATION: Journal of The Institute of Navigation*, accepted for publication.

Banville, S., P. Collins, and F. Lahaye (2013). "Concepts for undifferenced GLONASS ambiguity resolution," *Proceedings of the 26th International Technical Meeting of the Satellite Division of The Institute of Navigation (ION GNSS+ 2013)*, Nashville, Tenn., 16-20 September 2013, pp. 1186-1197.

Banville, S., P. Collins, and F. Lahaye (2013). "GLONASS ambiguity resolution of mixed receiver types without external calibration," *GPS Solutions*, Vol. 17, No. 3, pp. 275-282. doi: 10.1007/s10291-013-0319-7.

Banville, S., and R. B. Langley (2013). "Mitigating the impact of ionospheric cycle slips in GNSS observations," *Journal of Geodesy*, Vol. 87, No. 2, pp. 179-193. doi:10.1007/s00190-012-0604-1.

Banville, S., W. Zhang, and R. B. Langley (2013). "Monitoring the ionosphere with integer-levelled GPS measurements," *GPS World*, Vol. 24, No. 3, March 2013, pp. 43-49.

Zhang, W., R. B. Langley, A. Komjathy, and **S. Banville** (2013). "Eliminating potential errors caused by the thin shell assumption: an extended 3D UNB ionospheric modeling technique," *Proceedings of the 26th International Technical Meeting of the Satellite Division of The Institute of Navigation (ION GNSS+ 2013)*, Nashville, Tenn., 16-20 September 2013, pp. 2447-2462.

Banville, S., and R. B. Langley (2012) "Cycle-slip correction for single-frequency PPP," Proceedings of the 25th International Technical Meeting of the Satellite Division of The Institute of Navigation (ION GNSS 2012), Nashville, Tenn., 17-21 September, pp. 3753-3761.

Langley, R. B., **S. Banville**, and P. Steigenberger (2012). "First results: precise positioning with Galileo prototype satellites," *GPS World*, Vol. 23, No. 9, pp. 45-49.

Banville, S., W. Zhang, R. Ghoddousi-Fard, and R. B. Langley (2012). "Ionospheric monitoring using 'integer-levelled' observations," *Proceedings of the 25th International Technical Meeting of the Satellite Division of The Institute of Navigation (ION GNSS 2012)*, Nashville, Tenn., 17-21 September, pp. 2692-2701.

Banville, S., and R. B. Langley (2011). "Defining the basis of an integer-levelling procedure for estimating slant total electron content," *Proceedings of the 24th International Technical Meeting of the Satellite Division of The Institute of Navigation (ION GNSS 2011)*, Portland, Ore., 19-23 September, pp. 2542-2551.

Banville, S., and R. B. Langley (2010). "Instantaneous cycle-slip correction for real-time PPP applications," *NAVIGATION: Journal of The Institute of Navigation*, Vol. 57, No. 4, Winter 2010-2011, pp. 325-334.

Banville, S., R. B. Langley, S. Saito, and T. Yoshihara (2010). "Handling cycle slips in GPS data during ionospheric plasma bubble events." *Radio Science*, Vol. 45, RS6007. doi: doi:10.1029/2010RS004415.

Banville, S., and H. Tang (2010). "Antenna rotation and its effects on kinematic precise point positioning." *Proceedings of the 23rd International Technical Meeting of the Satellite Division of The Institute of Navigation (ION GNSS 2010)*, Portland, Ore., 21-24 September, pp. pp. 2545-2552.

Several other publications