Graduate Seminar

&

Student Technical Conference

Thursday, March 15, 2018

Department of Geodesy and Geomatics Engineering

University of New Brunswick

The Department would like to welcome you to the

Spring 2018 Graduate Seminar & Student Technical Conference

When:

Thursday, March 15, 2018 at 9:25 am

Where:

Head Hall – ADI Studio, Room C25

Department of Geodesy and Geomatics Engineering

Geodesy and Geomatics Engineering

Graduate Seminar and Student Technical Conference

Spring 2018

Chair: *Heather Nicholson (MScE; year 3)*

Thursday, March 15th 2018

9:25 **Welcome note**

9:30 **Investigating the Use of Vessel-based GNSS Water Height Determination for Validation of CVDCW HYVSEPS**

Weston Renoud (MScE; year 6)

9:45 **A RESTful API for what3words Extensions Encoding**

Wen Jiang (MScE; year 2)

10:00 **Effect of Glass Refraction on 3D Laser Scanning Measurement**

Enuenweyoi Daniel Okunima (PhD; year 3)

10:15 **Kinematic Precise Point Positioning with Map Constraints Performance Analysis**

Emerson Pereira Cavalheri (PhD; year 2)

10:30 **A Local Projection for Integrating Geodetic and Terrestrial Coordinate Systems**

Mike Bremner (MScE; year 3)

10:45 **Least-Squares Spectral Analysis of Zenith Total Delay Time Series**

Omeiza A. Mayaki (MScE; year 3)

11:00 **Break**

11:15 **Formulation and Validation of a Global Laterally Varying Topodensity Model**

Michael Sheng (PhD; year 4)

11:30 **Precise Point Positioning Convergence Time Evolution and External Initial Coordinate Integrity Analysis – Preliminary Results**

Marco Mendonça (PhD; year 4)

11:45 **Modelling Tropospheric Error for GNSS Reflectometry**

Thalia Nikolaidou (PhD; year 4)

12:00 **A DSM-Assisted Image Model for Improved Surface Reconstruction from Satellite Images**

Alexander Turner (MScE; year 2)

12:15 **Improving the Accuracy of Extracting Surface Water Quality Levels using Remote Sensing, Artificial Intelligence, and Water Quality Index**

Essam Sharaf El Din (PhD; year 4)

12:30 **RGBW DEMOSAICKING using a Collaborative Interpolation between Panchromatic and Colour Pixels**

Fatemeh Fathollahi (PhD; year 4)

12:45 **Geometric Constraints for Improved Automatic Image Matching of Satellite Images**

Alexander Turner (MScE; year 2)

1:00 **Closing Remarks**

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ABSTRACTS

You may contact the Authors for a copy of the full papers.

Department of Geodesy and Geomatics Engineering

Investigating the Use of Vessel-based GNSS Water Height Determination for Validation of CVDCW HYVSEPS

Weston Renoud

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Abstract

The Continuous Vertical Datum for Canadian Waters (CVDCW) project Hydrographic Vertical Separation Surfaces (HyVSEPs) released in 2016 promises access to chart datum with the use of GNSS positioning anywhere in Canadian waters. While accuracy targets of <10cm were believed to be achieved in the development of the HyVSEPs, the approach relied on biasing to published benchmarks and has yet to be validated.

The Ocean Mapping Group (OMG) has a history of mapping research in Canadian waters and an interest in exploring the use of HyVSEPs for the reduction of bathymetric data in future work. With previous work in global navigation satellite system (GNSS) based water height determination, OMG has existing data sets that may be viable for validation of the HyVSEPs.

This work investigates the use of existing OMG data holdings for use in validating HyVSEPs. Specifically the use of data acquired on the RV Nuliajuk platform mobilized and operated by OMG from 2012 to 2015 is explored. While equipped with multiple GNSS receivers, the previous research focused on tidal model based reduction of bathymetric heights leaving the recorded raw GNSS observations unexplored. This work looks at precise point positioning (PPP) processing of 5 days of GNSS data from 2013 and applying correctors for vessel dynamics to recover orthometric water heights with the vessel.

The methods described in this research are shown to have a 0.003 meter (1σ=0.110 $meters$) mean difference with observed tide gauge water heights which supports the use of RV Nuliajuk data holdings for validating of the HyVSEPs in the eastern Arctic.

A RESTful API for what3words Extensions Encoding

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Abstract

With the advent of location-based services, the demand for location data has dramatically increased. Geocoded locations have become necessary in many GIS analysis, cartography and decision-making workflows. A reliable geocoding system that can effectively return any location on earth with sufficient accuracy is desired. This study is motivated by a need for a geocoding system to support university campus applications. Address-based geocoding systems have been used for decades. However, they present limitations in address resources, address standardization and address database maintenance. These limitations have recently sparked an interest in developing alternative geocoding systems that apply alphanumeric codes as a reference to locations, such as Geohash, Google's Open Location Code, and what3words to name a few. Comparing to other geocoders, what3words (w3w) has many advantages. It uses a simple format of code consisting of three words, it is less error-prone, codes are easier to memorize, and multiple languages are supported. However, its fixed resolution (consisting of 3 meters by 3 meters square cells) and lack of consideration of the third dimension may limit its applicability. To better sup-port geographic applications with special requirements, the w3w geocoding system needs to be extended. This paper proposes extensions of w3w in two aspects: variable-resolution and third dimension support. And a HTTP-based RESTful API that implements QTEM extensions has been developed to validate the geocoder processing in the two-way transformation between the extended codes and coordinates and defining simple line and polygon features, as well as to provide web services for data interaction and information exchange between client programs. This research could support the need of a university campus' facility management, emergency evacuation and route navigation planning, student survey data management, and other location based services.

Effect of Glass Refraction on 3D Laser Scanning Measurement

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Abstract

3D laser scanning is a non-contact technology that allows rapid collection of three dimensional (3D) data of objects and surfaces. This technology provides solutions to several industries including transportation, cultural heritage, topographic surveying, volume estimations, reverse engineering, and as-built surveying of facilities and buildings.

Glass is an important material in the construction of different kind of buildings because it improves aesthetics of buildings and provides a means for natural light to get into buildings. Hence it is common to encounter glass during laser scanning documentation of buildings. In some instances, laser scanning practitioners find it more convenient to scan through glass during the data acquisition. In other instances, scanning though glass may be the only way to capture the object(s) of interest with a 3D laser scanner when there is limited room to setup the scanner. Therefore, it is important to determine the effect of glass refraction on the laser scan measurement.

Trimble TX5 3D laser scanner was used to scan three black and white checkerboard targets by positioning the equipment so that the laser pulse from the scanner passes through either one or two 5 mm thick glass sheets before getting to the checkerboard targets. Two sets of laser scans comprising four scans per set were obtained from two instrument heights to produce eight point cloud dataset. For each set, the checkerboard targets were scanned without a glass sheet, with a glass sheet in the front position (i.e. closer to the laser scanner), with a glass sheet in the rear position (i.e. closer to the targets), and with both glass sheets in place. The results obtained shows that the traveling of the laser pulse through glass increased the measured distance for both instrument heights. The increase ranged from 3 mm to 6 mm. The effect of refraction on the measurement was greater when the laser pulse passes through both glass sheets.

Kinematic Precise Point Positioning with Map Constraints Performance Analysis

Emerson Pereira Cavalheri

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Abstract

For high precision kinematic applications using the Precise Point Positioning (PPP) technique the use of the precise carrier-phase observable is imperative. However, obstructions in the line of sight in challenging environments, e.g. urban space, limits the carrier-phase use. Attempts of providing an a-priori information to the PPP filter has been developed. The main success was only in the reduction of the initial convergence time, however the reconvergences in the middle of the kinematic collection, to the best of our knowledge, has not been yet addressed. In this contribution, an alternative a-priori position coming from a ground truth trajectory is used on a kinematic PPP collection at every epoch. To connect where the rover is in this trajectory, a map-matching algorithm is necessary. At every epoch, using a single point position (SPP) and uncertainty coming from the less accurate pseudoranges, the map-matching localizes the receiver in the trajectory and determines a search space where the true position will likely to be. Finally a search of the best candidate is performed using the Kalman filter residuals. The results have shown that convergences and re-convergences could be eliminated, and when compared to the PPP-only solution, the pseudorange ionosphere-free residuals have shown an improvement of 17.5 cm and 24.3 cm in the residuals bias and standard deviation, as for the carrier-phase ionosphere-free residuals, both solutions were unbiased, and the standard deviation were 3 times better than the PPP only solution residuals.

A Local Projection for Integrating Geodetic and Terrestrial Coordinate Systems

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Abstract

Within the larger research project, a need was found for a system capable of transforming between global geodetic coordinates and local coordinates defined by terrestrial measurements. To fulfil this need, a system is proposed that uses an extension of the Double Stereographic Map Projection for transformations and a parametric least squares estimation to calculate the parameters for the map projection.

Research was performed on existing solutions; however, literature was found to be sparse. Research was also performed on map projections, with particular interest on the Double Stereographic Projection.

The transformation equations of the Double Stereographic Projection are extended to include a rotation parameter, and a least squares estimation for the calculation of projection parameters is devised. The original Double Stereographic Projection and the extended model are both implemented, as is the projection parameter estimation.

Tests performed comparing the results of the two map projection implementations are found to be successful. A test comparing the results of the projection parameter estimation against local grid transformation with known parameters is also successful. Future tests are also proposed, although some aspects are expected to be indeterminable.

Least-Squares Spectral Analysis of Zenith Total Delay Time Series

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Abstract

As a product of ground-based Global Navigational Satellite Systems (GNSS) observations, the derived Zenith Total Delay (ZTD) plays an important role in meteorological studies. Several institutions undertaking atmospheric research utilize networks of GNSS continuously operating reference stations (CORS) as additional source of ZTD information which they assimilate operationally into regional and global Numerical Weather Prediction Models (NWP/NMW) for accurate weather forecasting and now-casting. In West Africa, there are no operational GNSS networks in which its ZTD data are assimilated into NWP models, or used for GNSS meteorology generally. In Nigeria however, the suitability of the Nigerian GNSS reference Network (NIGNET) for meteorological applications is being investigated. Analysis of a collection of ZTD time series can provide insight about the seasonal variability of the weather in the different climatic regions of the country. This report presents a study of the temporal variation of the periodic constituents of ZTD time series computed from NIGNET data sets in the precise point positioning (PPP) and from NWM, using Least Squares Spectral Analysis (LSSA). Results show strong periodic constituents that relate to known seasonal weather phenomena in Nigeria, below and at the 1-year time span, and constituents with periods longer than a year. This analysis enables the characterization of the nature of the troposphere over Nigeria in both the local and regional sense. It also further affirms the prospective relevance of ground-based GNSS as a tool for future exploration of Nigerian weather and climate.

Formulation and Validation of a Global Laterally Varying Topodensity Model

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Abstract

The distribution of masses within topography is extremely important for evaluation of a rigorous geoid model. Present day models of topographical density are either determined via gravity field inversions or are at too coarse a resolution to be useful on a regional level. The ideal solution would be to formulate a 3-dimensional (3D) density model but such a dataset does not currently exist and would likely be extremely complicated and expensive to develop. As a substitute, a 2-dimensional (2D) model (UNB_TopoDens) is presented in this paper through the application of a lithological map. The methodology that was applied in the formulation of the UNB_TopoDens model is discussed and then this model is validated against present-day global and regional models in both its spatial and spectral forms. Apart from some water and ice covered regions, the UNB_TopoDens model validates very well with all regional and global models with the differences all falling within the 95% confidence region associated with the UNB_Topodens model. UNB_TopoDens is the first laterally varying topographical density model with associated error estimates that spans the globe at a 30” x 30” resolution and is there-fore extremely useful across various disciplines.

Precise Point Positioning Convergence Time Evolution and External Initial Coordinate Integrity Analysis – Preliminary Results

Marco Mendonça

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Abstract

Seamless positioning is a recurring challenge among the scientific community. Modern technologies allow developers to work with multiple signals in parallel and solve systems of equations that a decade ago would not be handled in real-time. In this context, the idea of integrating satellite positioning techniques, such as Precise Point Positioning (PPP), with other techniques is facing an upsurge. Some of the techniques that are considered candidates to be integrated with satellite positioning are becoming more and more convenient when PPP faces its limitations. In urban-canyons, for example, kinematic PPP may not provide information reliable enough for most of applications. From autonomous vehicles, requiring positions better than 50 cm, to pedestrian navigation, at the decameter level, GNSS errors may cost time, money and even cause accidents. On the other hand, where GNSS may face most of its limitations, other positioning sources may thrive. Under such circumstances, the signal-of-opportunity, hereafter SOOP, presents itself as a potential source of information to fill the limitations of PPP platforms. By utilizing signals that are not specifically design for positioning, yet provide spatially variable information, one may integrate information originated from these systems with the PPP algorithm in order to increase its availability and reliability. In this study, a simulation of how the PPP convergence time may improve in the presence of external information being used as initial coordinates is performed. SOOP sources will provide coordinates in several different quality levels, hence, a simulation of 500 different combinations of offset and standard deviations is applied to the initial coordinates of a kinematic PPP processing and the results analyzed. This study concludes that the combination of offsets and standard deviations of the input coordinates provides essential information to the PPP algorithm, being able to significantly reduce the convergence time in a kinematic processing.

Modelling Tropospheric Error for GNSS Reflectometry

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Abstract

In the recent years Global Navigation Satellite Systems (GNSS) signals have been exploited for coastal sea lea level altimetry. The existing infrastructure along their low maintenance cost renders to signals of opportunity for GNSS multipath reflectometry (MR). Latter studies have shown that the error induced by the lower atmosphere causes a significant height/depth variance that if not accounted properly can lead to underestimation of the tidal amplitudes. Two empirical models that emerged to account for that, are based on the concepts of either angular or linear estimation of the delay and are functions of the elevation angle of the satellite and the sea level height/depth. The first model represents the geometric effect of the tropospheric error while the second attempts to give an estimation of the speed retardation of the signal. Although these models are able to express the tropospheric error to some extent, their rather simple formulation lacks a wholistic modelling of the total error, leading to biased results up to meter level. We have implemented a ray-tracing procedure to calculate the total error in a complete – three point boundary value-schema: broadcasting satellite, reflecting surface, and receiving antenna. Moreover, we have analyzed the models to gain insight about the dependence of delay on surrogate variables, such as bending angle and mean refractivity, as well as independent variables, such as satellite elevation angle, station altitude, and reflector height/depth. We present the results of the analysis and access their accuracy against the ray-tracing simulations for a station located in an exceptional high altitude by the shore. The use of the empirical models shows systematic errors that can reach centimeter to decimeter level errors in tropospheric modelling which in turn can lead to meter level error in the sea level height/depth estimation.

A DSM-Assisted Image Model for Improved Surface Reconstruction from Satellite Images

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Abstract

Satellite imagery is of great appeal to engineers and environmental scientists alike for its low repeat time and relatively low cost. However, satellite imagery is less straight forward for photogrammetry than aerial frame cameras being that they are linear array cameras. This means that instead of having a single principle point they have a different principle point for each line of pixels, so one could say that the images have a principle line. The exterior orientation parameters describing this line are, more often than not, not provided by the vendors but rather a series of rational polynomial co-efficients (RPCs) that can be applied to a rational function model to convert between image and object space. As with any measurement or calculated value, these RPCs contain errors which can lead to false matching and false geometry. Several publications have outlined that these errors can be reduced by applying an affine correction to the RPCs but do not provide an automated method for doing so. This proposal outlines a methodology for an automated RPC correction in such a way that false matching detection and surface reconstruction are completed as bi-products of the operations.

Improving the Accuracy of Extracting Surface Water Quality Levels using Remote Sensing, Artificial Intelligence, and Water Quality Index

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Abstract

Extracting accurate surface water quality levels (SWQLs) always presents a great challenge to researchers. Existing methods of assessing surface water quality can only provide individual concentrations of water sampling stations without providing the accurate SWQLs. Therefore, the results of existing methods are usually difficult to be understood by decision-makers. On the other hand, the water quality index (WQI) can simplify surface water quality assessment process to be accessible to decision-makers. However, in most cases, the WQI reflects inaccurate SWQLs due to the lack of representative water samples. It is very challenging to provide representative water samples because this process is costly, labour intensive, and time consuming. To solve this problem, a cost-effective method, which combines Landsat-8 imagery and artificial intelligence to develop models to derive representative water samples by correlating concentrations of ground truth water samples to satellite spectral information, is introduced. Our method was validated and the correlation between concentrations of ground truth water samples and predicted concentrations from the developed models reached a high level of coefficient of determination (R2) > 0.80, which is trustworthy. Afterwards, the predicted concentrations over each pixel of the study area were used as an input to the WQI developed by the Canadian Council of Ministers of the Environment to extract accurate SWQLs, for drinking purposes, in the Saint John River, as the testing water body. The results indicated that the SWQL was observed as 67 (Fair) and 59 (Marginal) for the lower and middle basins of the river, respectively. These findings demonstrate the potential of using our approach in surface water quality management.

RGBW DEMOSAICKING using a Collaborative Interpolation between Panchromatic and Colour Pixels

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Abstract

A newer generation of the standard colour filter arrays (CFA) contains panchromatic pixels along with red (R), green (G), and blue (B) pixels. This CFA, known as RGBW, improves the SNR compared to the standard CFAs since the sensitivity of the panchromatic sensor is higher than the RGB sensors. However, the results of the demosaicking algorithms proposed so far still are not satisfying and suffer from the severe artificial colours especially in areas of high-frequency information.

In this paper, we propose a new procedure to improve RGBW demosaicking performance. This algorithm involves a collaborative interpolation between panchromatic and colour pixels, instead of a separate independent interpolation as performed in most demosaicking algorithms. Through collaborative interpolation we incorporate the available colour pixels in the panchromatic interpolation and vice versa, we incorporate the available panchromatic pixels in interpolating each colour channel. Finally, the interpolated panchromatic and colour images are fused together through UNB-pansharp technique. In this paper, we focus on Kodak Truesense pattern since a built sensor with such pattern is available within BOBCAT (IGV-B2320) camera.

To evaluate the proposed method, we used the Kodak benchmark dataset and we followed the same evaluation routine in literature to compare our results with other RGBW demosaicking methods. Furthermore, we test our method using some real-world images taken by the Kodak Truesense sensor. The quantitate evaluations in both test scenarios show that our proposed algorithm outperforms other demosaicking methods as well as the camera's result, especially in terms of sensitivity and produces less artificial colours.

Geometric Constraints for Improved Automatic Image Matching of Satellite Images

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Abstract

The prospect of using satellite imagery for engineering and environmental applications is an exciting enterprise in the modern world of digital imagery and high end computer processing capabilities. If the imagery is to be useful for automatic surface reconstruction or change detection then it is necessary to have the capability to accurately match the points from one image to the other. To limit the search area for matching points between two images Schenk (1999) outlines two methods, vertical line locus and epipolar geometry. Since a scene with no surveyed ground control points can only have a relative bias compensation based on approximate heights there is an error in the model that is associated with the error in the approximate heights. This error is in the direction of the images epipolar lines and so it will have no effect on the results derived from epipolar geometry. The unique problems with satellite images, as opposed to terrestrial and aerial frame cameras, is that the images are related to object space by means of a rational function model which contain errors and that epipolar lines are parabolic in shape rather than the straight epipolar lines found in frame cameras. Evidence is given to proven the non-straight nature of the epipolarity of linear array cameras and the approximate known height variance that is needed for the best approximation. This paper presents methodology on how a low resolution Digital Surface Model (DSM) can be used to constrain epipolar segments to reduce the potential of falsely matched points.

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