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EDITORIAL

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Navigator Notes

Editorial Highlights from the Editor-in-Chief

Welcome to the Fall 2020 issue of *NAVIGATION*, my second after fully taking over from Dr. Boris Pervan as editor-in-chief of the journal. I will do my best to fill his very big shoes. I would also like to mention that Brianna Snow has taken over as the assistant editor of the journal, succeeding Miriam Lewis who served the journal with such expertise for many years.

This is the first issue to present papers in our newly adopted APA (American Psychological Association) style. You will notice, for example, the explicit use of authors' names for the in-text references and the alphabetical ordering of the entries in reference lists. I hope you like the change.

This issue also introduces "Navigator Notes" where we will list *NAVIGATION* milestones and featured articles. It serves to provide a unique emphasis to the readership. The announcements highlighted will be especially useful to researchers, teachers, and broader audiences alike.

2019 SAMUEL M. BURKA AWARD WINNERS

This award, sponsored by The Institute of Navigation, recognizes outstanding achievement in the preparation of papers advancing the art and science of positioning, navigation, and timing. Given in memory of Dr. Samuel M. Burka, a dedicated public servant who devoted a long and distinguished career to the research and development of air navigation equipment and reviewing technical material for official publications.

Presented to the following authors for their paper "Gaussian-Pareto Overbounding of DGNSS Pseudoranges from CORS" published in the Spring 2019 issue of *NAVIGATION*:

Dr. Jordan D. Larson is an assistant professor in the Department of Aerospace Engineering and Mechanics at the University of Alabama where he works closely with the Remote Sensing Center and runs the Laboratory for Autonomy, GNC, and Estimation Research. His research interests include data processing, precision navigation and mapping, and guidance algorithm design for autonomous systems including multi-sensor/multi-agent systems. Dr. Larson received his BS, MS, and PhD in Aerospace Engineering and Mechanics from the University of Minnesota.

Dr. Demoz Gebre-Egziabher is a professor in the Department of Aerospace Engineering and Mechanics at the University of Minnesota, Twin Cities. His research deals with the design of multi-sensor navigation and attitude determination systems for aerospace vehicles. He was the past secretary of the Satellite Division of The Institute of Navigation and has also served as associate editor of navigation for the *IEEE Transactions on Aerospace and Electronic Systems*. He is current director of the NASA/Minnesota Space Grant Consortium. Dr. Gebre-Egziabher received his BS in Aerospace Engineering from the University of Arizona, an MS in Mechanical Engineering from the George Washington University, and a PhD in Aeronautics and Astronautics from Stanford University.

Dr. Jason Rife is an associate professor of Mechanical Engineering at Tufts University in Medford, Massachusetts. He directs the Automation Safety and Robotics Laboratory, which applies theory and experiment to characterize robots and autonomous vehicle systems for safety-of-life applications. He has worked at Pratt & Whitney as a development engineer in the Turbine Aerodynamics Group, and at the Stanford University GPS Laboratory as a research engineer supporting FAA and Navy projects. Dr. Rife received his BS in Mechanical and Aerospace Engineering from Cornell University and his MS and PhD degrees in Mechanical Engineering from Stanford University.

Abstract: This paper presents a novel approach for overbounding unknown distribution functions called the Gaussian-Pareto overbounding. This extends the current practice of using Gaussian distributions for overbounding,

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but combines it with methods from Extreme Value Theory for modeling tails. Hence, this approach uses a Gaussian distribution to overbound the core of the distribution and generalized Pareto distributions for the tails. Furthermore, this approach is applied to Differential Global Navigation Satellite System (DGNSS) pseudorange data collected from two Continuously Operating Reference Stations (CORS) and compared to Gaussianoverbounding. It is shown that Gaussian-Pareto Overbounding more closely matches the empirical distribution than the simpler Gaussian overbounding approach in the case where there is significant heavy-tailedness of DGNSS data. This approach also highlights the ability of the flexible Gaussian-Pareto model to become less conservative in the tail region as more data is collected. (https://www.ion.org/publications/abstract.cfm?articleID=102781)

Article Citation: Larson, JD, Gebre-Egziabher, D, Rife, JH. Gaussian-Pareto overbounding of DGNSS pseudoranges from CORS. *NAVIGATION*. 2019; 66: 139–150. https://doi.org/10.1002/navi.276

WEBINARS

ION Webinars highlight timely and engaging papers published in *NAVIGATION* on topics of interest to the PNT community in an interactive virtual presentation.

July 9, 2020 Webinar: Improving Environment Detection by Behavior Association for Context-Adaptive Navigation

By Dr. Han Gao (https://www.ion.org/publications/webinar-gao.cfm)

Navigation and positioning systems depend on both the operating environment and the behavior of the host vehicle or user. The environment determines the type and quality of radio signals available for positioning, and the behavior can contribute additional information to the navigation solution. In order to operate across different contexts, a context-adaptive navigation solution is required to detect the operating contexts and adopt different positioning techniques accordingly. This paper focuses on determining both environments and behaviors from smartphone sensors, serving for a context-adaptive navigation system. Behavioral contexts cover both human activities and vehicle motions. The performance of behavior recognition in this paper is improved by feature selection and a connectivity-dependent filter. Environmental contexts are detected from global navigation satellite system (GNSS) measurements. They are detected by using a probabilistic support vector machine, followed by a hidden Markov model for time-domain filtering. The paper further investigates how behaviors can assist within the processes of environment detection. Finally, the proposed context-determination algorithms are tested in a series of multi-context scenarios, showing that the proposed context association mechanism can effectively improve the accuracy of environment detection to more than 95% for pedestrian and more than 90% for vehicle. (https://www.ion.org/publications/abstract.cfm?articleID=102840)

Article Citation: Gao, H, Groves, PD. Improving environment detection by behavior association for context-adaptive navigation. *NAVIGATION*. 2020; 67: 43–60. https://doi.org/10.1002/navi.349

May 28, 2020 Webinar: Impact of Sample Correlation on SISRE Overbound for ARAIM

By Dr. Santiago Perea (https://www.ion.org/publications/webinar-perea.cfm)

This paper analyzes the effect of error correlation on the SISRE bounding for GPS and Galileo satellites. For a given period of data collection, it computes the effective number of independent samples contained in a dataset applying an estimation variance analysis. Results show that the time between effective independent samples is highly dependent on the constellation and onboard clock type. On one hand, GPS satellites equipped with Rubidium clocks exhibit significantly longer error correlation than those with onboard Cesium clocks. On the other hand, Galileo satellites show substantially shorter correlation time among samples with less variability on a monthly basis. This paper also introduces a methodology to compute SISRE bounding accounting for the limited number of independent samples. Using a Bayesian approach, it computes the so-called uncertainty factor by which the Gaussian distribution needs to be inflated in order to account for the observation data independence. (https://www.ion.org/publications/abstract.cfm?articleID=102849)

Article Citation: Perea, S, Meurer, M, Pervan, B. Impact of sample correlation on SISRE overbound for ARAIM. *NAVIGATION*. 2020; 67: 197–212. https://doi.org/10.1002/navi.346

April 16, 2020 Webinar: Flight Results of GPS-Based Attitude Determination for the Canadian CASSIOPE Satellite

By Dr. André Hauschild (https://www.ion.org/publications/webinar-hauschild.cfm)

The paper presents attitude determination results of the "GPS Attitude, Positioning and Profiling Experiment"

(GAP) on board the CASSIOPE satellite using real flight data. The GAP payload consists of five minimally modified commercial-off-the-shelf NovAtel OEM4-G2L receivers that provide dual-frequency GPS measurements and allow for attitude and orbit determination of the satellite as well as electron density profiling. To the authors' knowledge, the CASSIOPE mission is the first space mission that provides dual-frequency observations for attitude determination. The data has been analyzed with a GPS attitude determination algorithm originally developed for the analysis of data from the "Flying Laptop" mission. The GPS-based solution for selected attitude maneuvers is compared to a reference orientation provided by the satellite's star sensors. Furthermore, an analysis of the typical time-to-first-fix (TTFF) for the attitude solution is provided. The advantage of dual-frequency ambiguity fixing compared to single-frequency is assessed. (https://www.ion.org/publications/abstract.cfm?articleID=102842)

Article Citation: Hauschild, A, Montenbruck, O, Langley, RB. Flight results of GPS-based attitude determination for the Canadian CASSIOPE satellite. *NAVIGATION*. 2020; 67: 83–93. https://doi.org/10.1002/navi.348

March 5, 2020 Webinar: Gaussian-Pareto Overbounding of DGNSS Pseudoranges from CORS

By Dr. Jordan D. Larson (https://www.ion.org/publications/webinar-larson.cfm)

This paper presents a novel approach for overbounding unknown distribution functions called the Gaussian-Pareto overbounding. This extends the current practice of using Gaussian distributions for overbounding, but combines it with methods from Extreme Value Theory for modeling tails. Hence, this approach uses a Gaussian distribution to overbound the core of the distribution and generalized Pareto distributions for the tails. Furthermore, this approach is applied to Differential Global Navigation Satellite System (DGNSS) pseudorange data collected from two Continuously Operating Reference Stations (CORS) and compared to Gaussian overbounding. It is shown that Gaussian-Pareto Overbounding more closely matches the empirical distribution than the simpler Gaussian overbounding approach in the case where there is significant heavy-tailedness of DGNSS data. This approach also highlights the ability of the flexible Gaussian-Pareto model to become less conservative in the tail region as more data is collected. (https://www.ion.org/publications/abstract.cfm?articleID=102781)

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December 5, 2019 Webinar: LTE Receiver Design and Multipath Analysis for Navigation in Urban Environments

By Kimia Shamaei and Zak Kassas (https://www.ion.org/publications/webinar-shamaei-kassas.cfm)

Mitigating multipath of cellular long-term evolution (LTE) signals for robust positioning in urban environments is considered. A computationally efficient receiver, which uses a phase-locked loop (PLL)–aided delay-locked loop (DLL) to track the received LTE signals, is presented. The PLL-aided DLL uses orthogonal frequency division-multiplexing (OFDM)–based discriminator functions to estimate and track the time-of-arrival. The code phase and carrier phase performances in an additive white Gaussian noise (AWGN) channel are evaluated numerically. The effects of multipath on the code phase and carrier phase are analyzed, demonstrating robust multipath mitigation for high transmission LTE bandwidths. The average of the DLL discriminator functions over multiple LTE symbols is presented to reduce the pseudorange error. The proposed receiver is evaluated on a ground vehicle in an urban environment. Experimental results show a root mean square error (RMSE) of 3.17 m, a standard deviation of 1.06 m, and a maximum error of 6.58 m between the proposed LTE receiver and the GPS navigation solution over a 1.44 km trajectory. The accuracy of the obtained pseudoranges with the proposed receiver is compared against two algorithms: estimation of signal parameters by rotational invariance techniques (ESPRIT) and EKAT (ESPRIT and Kalman filter). (https://www.ion.org/publications/abstract.cfm?articleID=102780)

Article Citation: Shamaei, K, Kassas, ZM. LTE receiver design and multipath analysis for navigation in urban environments. *NAVIGATION*. 2018; 65: 655–675. https://doi.org/10.1002/navi.272

Dr. Richard B. Langley