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Editorial

Advances in Signal Tracking for GNSS Receivers: Theory and Implementation

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Synchronization tracking loops are key components of the GNSS receiver architecture. Their function is to estimate the evolution of the satellite signals' code and carrier phases at the receiver's antenna, yielding the observations required for computing the users' position, velocity, and time. Hence, the tracking loop performance is intimately related to the receiver behavior in terms of precision, sensitivity, reliability, and robustness to interference and multipath.

While the traditional delay lock loop (DLL) and phase lock loop (PLL) architectures have been present in commercial GPS receivers since their inception, various new developments have introduced new challenges in the design of tracking loops for modern GNSS receivers, including the introduction of new GNSS and their associated signal structures, the application of GNSS technology in safety-of-life-related systems, and its use in the distributed synchronization of infrastructures such as the power grid (and thus the associated need for robustness against unintentional and intentional jamming).

The papers in this special issue constitute a representative set of the various possible approaches that the synchronization problem admits.

A. Jovanovic et al. present a tracking algorithm designed for Galileo E1 CBOC signals, analyzing its performance in terms of tracking accuracy, sensitivity, and robustness. The paper provides a full theoretical analysis of the proposed two-step tracking algorithm for Galileo E1 CBOC signals and confirms the results through simulations as well as using real Galileo satellite data.

The particularities of receivers operating in high-dynamics environments have been tackled by P. A. Roncagliolo et al. Their paper proposes a new loop structure named unambiguous frequency-aided phase-locked loop (UFA-PLL) that outperforms classical coupled-loop schemes while allowing simpler design and implementation. Their loop design includes the selection of the correlation time and loop bandwidth that minimize the pull-out probability, without relying on typical rules of thumb. Hence, high-quality phase measurements usually exploited in offline and quasistatic applications become practical for real-time and high-dynamics receivers. Experiments with fixed-point implementations of the proposed loops and actual radio signals are also shown.

M. Tahir et al. propose and demonstrate the use of a quasiopen loop architecture to estimate the time-varying carrier frequency of GNSS signals, showing that this new scheme provides an additional degree of freedom to the design. These results are especially convenient for the design of loop filters operating in electromagnetically harsh environments.

Antenna diversity is known to be a possible way to address the problem of estimating the propagation time delay of the line-of-sight signal in a GNSS receiver under severe multipath conditions. S. Rougerie et al. present a new, complexity-reduced implementation of the space-alternating generalized expectation maximization (SAGE) algorithm. This paper focuses on the trade-off between complexity and performance thanks to the Cramér-Rao bound derivation and shows how the proposed algorithm can be integrated with a classical GNSS tracking loop, constituting a very promising approach for multipath mitigation.

Finally, P. Closas et al. undertake the synchronization problem from a statistical standpoint, resorting to Bayesian estimation techniques and proposing algorithms that mitigate the bias introduced by multipath. The analysis includes trade-off among realistic propagation channel models and the use of a realistic simulation framework. The authors propose a filtering technique that implements Rao-Blackwellization of linear states and a particle filter for the nonlinear partition and compare it to traditional DLL/PLL-based schemes.

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