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Live GNSS Signal Processing using a Dual-Polarized Antenna Array for Multipath Mitigation

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Multipath results from reflections of Global navigation satellite signals (GNSS) signals arriving at a receiver that are delayed with respect to the desired line-of-sight (LOS) signals. The delayed signals distort the received LOS signals, thereby causing pseudorange and carrier phase measurement errors. Traditional multipath mitigation techniques include antenna gain pattern shaping (primarily to reduce ground multipath) and correlator gating techniques (such as narrow correlator and double-delta correlator [1]).

Antenna arrays use multiple antenna elements to collect information in the spatial domain. The received GNSS signals from each antenna element can be phase shifted, amplitude adjusted and summed together to form a beam and/or null in a given direction. Because reflected signals are often incident from different directions-of-arrival (DOA) from the LOS signals, spatial-domain processing is an effective way to mitigate multipath [2] [3]. The two main beam and null steering approaches include: 1) deterministic methods – where beams/nulls are steered to known DOAs; 2) adaptive approaches – where they are steered using feedback to maximize or minimize a given performance parameter, such as carrier-to-noise density ratio (C/N0).

Another multipath mitigation approach recently gaining attention employs polarization-based discrimination. By convention, GNSS signals are transmitted with right hand circular polarization (RHCP). When these signals are reflected at high incidence angles, their polarization changes to become primarily left hand circular (LHCP). Using a dual-polarized antenna, the multipath signal can be estimated through receiver signal processing. This can then be separated from the LOS signal to arrive at reduced multipath range measurements [4] [5] [6] [7]. We refer to this as polarization domain based multipath mitigation.

The authors of [8] and [9] have shown, through the use of simulations, that it could be more effective to combine both spatial and polarization domain processing for mitigating multipath. In both papers, a LHCP array was to estimate the DOA of the multipath signal. Their methods differ in that [8] uses the RHCP array to steer a null in the multipath direction whereas [9] uses both RHCP and LHCP arrays to perform a combined polarization and spatial beamforming method.

Deterministic spatial-domain mitigation approaches require a calibrated antenna array. This is because physical arrays exhibit individual element phase center offsets and variations as well as mutual coupling between elements. Furthermore, the multi-channel and multi-frequency RF front-ends used to digitize the signals from the elements also imprint additional delay (phase) and gain biases. Our previous work focused on calibrating a dual-polarized antenna array and associated multi-channel RF front-end [10]. This paper shows initial results from a multi-element dual-polarized antenna array in a live-sky GNSS multipath environment. The techniques and results presented in this paper benefit all applications that require enhanced multipath mitigation performance, such as for use in high precision GNSS signal monitoring stations.

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Describe what is new and/or innovative about your presentation.

This presentation shows live-sky results from a dual-polarized antenna array with multipath signals present. These results demonstrate the validity of the methodologies presented in [8] and [9], using a dual-polarized antenna array for multipath mitigation.