**Compact Null-steering Antenna System for GPS**

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It is no secret that GPS signals are highly susceptible to radio frequency interference, both from neighbors along the wireless spectrum and from more malicious sources, like jammers (I. J. Gupta, I. Weiss, and A. Morrison, *Proc. IEEE*, 104, 1195-1206, 2016). Many proposed solutions involve some combination of adaptive algorithms with a phased array design. Variations of sub-wavelength arrays are making more appearances in the literature, but most useful designs remain costly due to the number of feeds required. Single-antenna null-steering systems are large and generally not compatible with popular algorithms (S. Yong and J. T. Bernhard, *IEEE Trans. Antennas Propag.*, 61, 1063-1070, 2013). Software processing approaches range from MUSIC-based methods to truly blind techniques, like power inversion, to optimization based on some criterion, such as $C/N_0$. One problem is that these algorithms need multiple antenna inputs for good performance, driving up the array size and number of feeds noted here. Gupta et al. consider arrays of eight elements to be small with current methods. Another key problem is the required pattern for each individual antenna, which dictates larger element spacing to control coupling effects. Additionally, most algorithms eat up significant computational resources and memory bandwidth.

Viable solutions when space, cost, and computation burden are constrained need to optimize the hardware within the context of the software. Since similar system limitations plague the world of audio processing, solutions from that realm can be leveraged. In this work, such an algorithm is modified for GPS applications (F. Luo, J. Yun, C. Pavlovic, and A. Nehorai, *IEEE Trans. Signal Process.*, 50, 1583-1590, 2002). In addition to needing only two inputs, the original approach's ability to control a pattern null by updating a single-tap filter can be efficiently implemented using LMS, which avoids matrix inversions. Luo's requirement that the desired signal's direction of arrival (DOA) be fixed and in-line with the array can be lifted by the modifications made here. Furthermore, the two inputs required are a copy of the satellite's signal with the interference and a copy of only the interference, which allows for miniaturization down to a single antenna if it can provide both. To compliment the algorithm, a hemispherical spiral is designed that has two modes of operation: one results in a typical broad RHCP pattern, and the second results in a deep null that can be scanned continuously, though codependently, in the $xy$- and $xz$-planes of the upper hemisphere. The latter mode provides the noise-only input when the null is pointed at the satellite signal's DOA. The entire system volume is on par with today's smallest reconfigurable GPS arrays. In the first mode, simulations show comparable or better gain and axial ratio across L1, L2, and L5 bands when compared to a similarly-sized, non-reconfigurable COTS GPS antenna. The hemi-spiral's efficient use of the available volume yields especially impressive performance at the lower frequencies. With knowledge of a single satellite's expected DOA, which is generally available to GPS applications, this compact, cheap, and computationally light system can automatically protect users from a source of interference.