Compressed Sensing with Modulo Preprocessing

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***Abstract*—Compressed sensing has transformed signal sampling by utilizing signal sparsity to reduce sample requirements below the Nyquist rate. However, it faces challenges with ADC saturation when signals are either too strong or too weak. To address saturation errors, a recent approach uses modulo ADCs to preprocess samples via modulo arithmetic. In this talk, we explore the integration of modulo ADCs with compressed sensing to handle the limited dynamic range, leading to a framework known as modulo compressed sensing.**

We begin by presenting theoretical results on the minimum number of measurements required for the unique recovery of sparse vectors in modulo compressed sensing. We then present an algorithm based on ℓ_1-norm convex relaxation, with guarantees for sparse signal recovery from modulo measurements, and a mixed-integer linear program for the convex relaxation algorithm. However, the ℓ_1-norm-based sparsity approximation leads to computationally intensive mixed-integer linear optimization. The presence of noisy measurements complicates this further, requiring NP-hard mixed-integer quadratic programming. To address these challenges, we propose an alternative iterative hard-thresholding approach that simplifies the problem and handles noisy measurements effectively. Finally, we present a novel framework for modulo compressed sensing with one-bit side information, demonstrating that side information improves recovery by compensating for information loss during modulo preprocessing. We also provide theoretical guarantees for successful sparse signal recovery using iterative hard thresholding when the number of measurements is sufficiently large.

***Index Terms*—Modulo compressed sensing, sparsity, convex relaxation, iterative hard thresholding**