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Trade-offs Between Weak–Noise Estimation Performance and Outage Exponents in Nonlinear Modulation

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Abstract

We focus on the problem of modulating a parameter onto a power–limited signal transmitted over a discrete–time Gaussian channel and estimating this parameter at the receiver. Considering the well–known threshold effect in non–linear modulation systems, our approach is the following: instead of deriving upper and lower bounds on the total estimation error, which weigh both weak–noise errors and anomalous errors beyond the threshold, we separate the two kinds of errors. In particular, we derive upper and lower bounds on the best achievable trade-off between the exponential decay rate of the weak–noise expected error cost and the exponential decay rate of the probability of the anomalous error event, also referred to as the *outage event*. This outage event is left to be defined as part of the communication system design problem. Our achievability scheme, which is based on lattice codes, meets the lower bound at the high signal–to–noise (SNR) limit and for a certain range of trade–offs between the weak–noise error cost and the outage exponent.

Index Terms: modulation, parameter estimation, joint source–channel coding, Shannon-Kotelnikov mappings, lattice codes, error exponents.

I. Introduction

Consider the problem of conveying a real–valued parameter u by means of n uses of the additive white Gaussian noise (AWGN) channel,

$$y_i = x_i + z_i, \qquad i = 1, 2, \ldots, n, \tag{1}$$

where x_i is the i–th component of a channel input vector, $\boldsymbol{x} = (x_1, x_2, \ldots, x_n) = f_n(u)$, that depends on the parameter u, and that is subjected to a power constraint, $\|\boldsymbol{x}\|^2 \leq nP$, $\{z_i\}$ are