Information Sciences

Error-Rate Bounds for Coded PPM on a Poisson Channel

It is now possible to calculate tight bounds at high SNR.

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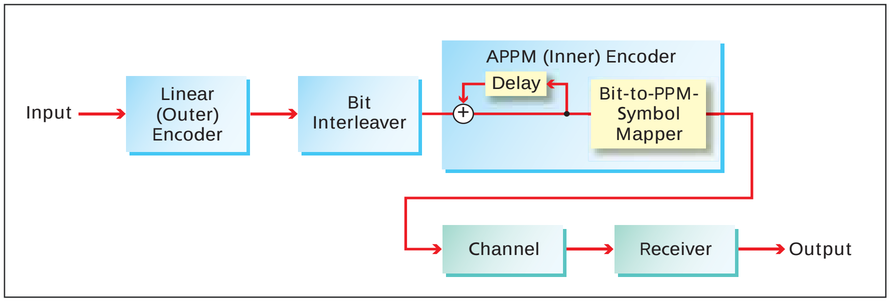
Equations for computing tight bounds on error rates for coded pulse-position modulation (PPM) on a Poisson channel at high signal-to-noise ratio have been derived. These equations and elements of the underlying theory are expected to be especially useful in designing codes for PPM optical communication systems.

The equations and the underlying theory apply, more specifically, to a case in which

- At the transmitter, a linear outer code is concatenated with an inner code that includes an accumulator and a bit-to-PPM-symbol mapping (see figure) [this concatenation is known in the art as "accumulate-PPM" (abbreviated "APPM")];
- The transmitted signal propagates on a memoryless binary-input Poisson channel; and
- At the receiver, near-maximum-likelihood (ML) decoding is effected through an iterative process.



Two Codes Are Concatenated in a PPM system of the type to which the present innovations apply.

Such a coding/modulation/decoding scheme is a variation on the concept of turbo codes, which have complex structures, such that an exact analytical expression for the performance of a particular code is intractable. However, techniques for accurately estimating the performances of turbo codes have been developed. The performance of a typical turbo code includes (1) a "waterfall" region consisting of a steep decrease of error rate with increasing signal-to-noise ratio (SNR) at low to moderate SNR, and (2) an "error floor" region with a less steep decrease of error rate with increasing SNR at moderate to high SNR.

The techniques used heretofore for estimating performance in the waterfall region have differed from those used for estimating performance in the error-floor region. For coded PPM, prior to the present derivations, equations for accurate prediction of the performance of coded PPM at high SNR did not exist, so that it was necessary to resort to time-consuming simulations in order to make such predictions. The present derivation makes it unnecessary to perform such time-consuming simulations.

Because a mathematically complete description of the derivation and equations would greatly exceed the space available for this article, it must suffice to summarize the three most novel aspects:

- For purposes of analysis, M-ary PPM was treated as equivalent to a binary code of rate $\log_2(M)/M$ (where M is an integer >1). This treatment was necessary for modeling of the iterative demodulation/decoding process.
- Closed-form expressions for input-output-weight-enumerator functions for PPM and APPM were derived for the first time.
- An improvement to the union bound for a Poisson channel was derived and shown to be extensible to low SNR.
- The union bound was shown to be applicable for PPM, a nonlinear code.

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Biomorphic Multi-Agent Architecture for Persistent Computing

Computing systems would reconfigure themselves to continue functioning despite failures of components.

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A multi-agent software/hardware architecture, inspired by the multicellular nature of living organisms, has been proposed as the basis of design of a robust, reliable, persistent computing system. Just as a multicellular organism can adapt to changing environmental conditions and can survive despite the failure of individual cells, a multi-agent computing system, as envisioned, could adapt to changing hardware, software, and environmental conditions. In particular, the computing system could continue to function (perhaps at a reduced but still reasonable level of performance) if one or more component(s) of the system were to fail.

One of the defining characteristics of a multicellular organism is unity of purpose. In biology, the purpose is survival of the organism. The purpose of the proposed multi-agent architecture is to provide a persistent computing environment in harsh conditions in which repair is difficult or impossible.