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Universal decoding: optimal detection for unknown channels

Abstract

In digital communication systems, optimal maximum-likelihood (ML) detection for a given channel relies on the knowledge of the channel statistics. In the absence of such knowledge, one would like to find detection schemes that can perform essentially as well as the optimal ones; specifically, that are capable of achieving the same error probability exponent [1, 2].

These are called *universal decoders* and are, in some sense, the dual counterpart to the universal source coding problem [3]. In communications, they can be particularly useful when the common estimation-communication paradigm is hard to implement. Versions of this problem have applications in other contexts, such as information storage in DNA molecules.

The objective of this project is to explore efficient ways to do universal decoding in a given channel (e.g., the discrete memoryless channel). For that, the student is expected to (1) familiarise themselves with the bibliography on the subject (both classical and recent papers), to make sure they can understand and formulate the problem; and (2) to implement and analyse solutions be means of numerical experiments, possibly envisioning new ones.

Mathematical tools

communication theory, information theory, probability and statistics

Programming/editing tools

MATLAB or Python (or similar), LaTeX

References

[1] J. Ziv, "Universal decoding for finite-state channels", *IEEE Trans. Inf. Theory*, vol. IT-31, no. 4, 1985.

[2] N. Merhav, "Reliability of universal decoding based on vector-quantized codewords", *IEEE Trans. Inf. Theory*, vol. 63, no. 5, 2017.

[3] T. M. Cover and J. A. Thomas, *Elements of Information Theory*, 2nd ed. Hoboken, NJ: Wiley, 2006.