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Computer Science : Data Structures and Information Theory

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List Decoding of Error-Correcting Codes

Winning Thesis of the 2002 ACM Doctoral Dissertation Competition

How can one exchange information effectively when the medium of communication introduces errors? This question has been investigated extensively starting with the seminal works of Shannon (1948) and Hamming (1950), and has led to the rich theory of "error-correcting codes". This theory has traditionally gone hand in hand with the algorithmic theory of "decoding" that tackles the problem of recovering from the errors efficiently. This thesis presents some spectacular new results in the area of decoding algorithms for error-correcting codes. Specifically, it shows how the notion of "list-decoding" can be applied to recover from far more errors, for a wide variety of error-correcting codes, than achievable before. A brief bit of background: error-correcting codes are combinatorial structures that show how to represent (or "encode") information so that it is resilient to a moderate number of errors. Specifically, an error-correcting code takes a short binary string, called the message, and shows how to transform it into a longer binary string, called the codeword, so that if a small number of bits of the codeword are flipped, the resulting string does not look like any other codeword. The maximum number of errors that the code is guaranteed to detect, denoted d , is a central parameter in its design. A basic property of such a code is that if the number of errors that occur is known to be smaller than $d/2$, the message is determined uniquely. This poses a computational problem, called the decoding problem: compute the message from a corrupted codeword, when the number of errors is less than $d/2$.

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