On the Structure of NP-Hard 3-SAT Instances and an Analogous Question for Locally Testable Codes

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Abstract

The PCP theorem says that it is NP-hard to approximate the fraction of satisfiable clauses in a 3SAT instance. What is the structure of such 3SAT instances? Here by the "structure" of a 3SAT instance we refer to the constraint (hyper-)graph whose vertices are variables and whose hyper-edges are the clauses. There are many interesting questions about the structure of hard instances of constraint satisfaction problems like 3SAT. For example, is it true that the constraint graph of a hard 3SAT instance must always be an expander?

We study this question in an analogous setting of so-called locally testable codes (LTCs). LTCs are error correcting codes that come with a constraint (hyper-)graph. We prove a structural theorem on LTCs: every LTC can be decomposed into a constant number of "basic" codes whose constraint graph is an expander.

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