A Projective Approach to Quantum Error Correcting Codes

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Abstract

In quantum computing, the qubit is the quantum analogue of a classical bit. Protecting qubits against noise has posed a difficult problem, due to the fundamental fact that measuring the state of a qubit generally destroys the information. In the mid-90s, however, Caulderbank, Shor, and Steane began developing quantum error correcting codes that could detect and correct arbitrary errors without the need to ever know what errors occurred. In the late 1990s, Gotessman showed that certain quantum codes, called stabilizer codes, could be represented using parity check matrices of classical error correcting codes. It is well-known that the incidence matrix of the projective plane $PG(2, 2^s)$ can be used to construct very efficient classical error correcting codes known as low-density parity check codes. This presentation will discuss methods to adapt these incidence matrices to allow for the construction of quantum low-density parity check (QLDPC) codes. If time (and general interest) permits, we will break down $PG(2, 2^s)$ even further into points and lines relative to hyperovals, and analyze QLDPC codes constructed based on the incidence matrices of these subsets. We will conclude with several open problems that have come out of this research.

Keywords: quantum code, projective plane, incidence matrix.