Low-Density Parity-Check Codes on Partial Geometries

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Abstract: Many known algebraic constructions of low-density parity-check (LDPC) codes can be placed in a general framework using the notion of partial geometries. Based on this notion, the structure of such LDPC codes can be analyzed using a geometric approach that illuminates important properties of their parity-check matrices. In this approach, trapping sets are represented by sub-geometries of the geometry used to construct the code. Based on the incidence relations between lines and points in this geometry, the structure of trapping sets is investigated. On the other hand, it is shown that removing a sub-geometry corresponding to a trapping set gives a punctured matrix which can be used as a parity-check matrix of an LDPC code. This relates trapping sets, represented by sub-geometries, and punctured matrices, represented by the residual geometries. The null spaces of these punctured matrices are LDPC codes which inherit many of the good structural properties of the original code. Hence, new LDPC codes, with various lengths and rates, can be obtained by puncturing an LDPC code constructed based on a partial geometry. Furthermore, these punctured matrices and codes can be used in a two-phase decoding scheme to correct combinations of random errors and erasures.