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Linear Insertion Deletion Codes in the High-Noise and High-Rate Regimes

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Abstract: This work continues the study of linear error correcting codes against adversarial insertion deletion errors (insdel errors). Previously, the work of Cheng, Guruswami, Haeupler, and Li \cite{CGHL21} showed the existence of asymptotically good linear insdel codes that can correct arbitrarily close to 1 fraction of errors over some constant size alphabet, or achieve rate arbitrarily close to $1/2$ even over the binary alphabet. As shown in \cite{CGHL21}, these bounds are also the best possible. However, known explicit constructions in \cite{CGHL21}, and subsequent improved constructions by Con, Shpilka, and Tamo \cite{9770830} all fall short of meeting these bounds. Over any constant size alphabet, they can only achieve rate $< 1/8$ or correct $< 1/4$ fraction of errors; over the binary alphabet, they can only achieve rate $< 1/1216$ or correct $< 1/54$ fraction of errors. Apparently, previous techniques face inherent barriers to achieve rate better than $1/4$ or correct more than $1/2$ fraction of errors.

In this work we give new constructions of such codes that meet these bounds, namely, asymptotically good linear insdel codes that can correct arbitrarily close to 1 fraction of errors over some constant size alphabet, and binary asymptotically good linear insdel codes that can achieve rate arbitrarily close to $1/2$.\ All our constructions are efficiently encodable and decodable. Our constructions are based on a novel approach of code concatenation, which embeds the index information implicitly into codewords. This significantly differs from previous techniques and may be of independent interest. Finally, we also prove the existence of linear concatenated insdel codes with parameters that match random linear codes, and propose a conjecture about linear insdel codes.

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