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KO Codes: Non-linear encoding and decoding for reliable wireless communication

Modern telecommunications rely on code formats to encode, transmit, and decode information. KO codes represent an entirely new family of codes, non-linear codes generated from training a neural network on the structure of linear codes. These codes show improvement in bit error rate over the linear codes that they are trained on, while retaining the same encoding and decoding efficiency.

Technology ID
BDP 8468

Category
Hardware/Other
Software/Communications
Selection of Available Technologies

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What is the Problem?

Encoding and decoding information underpins the entire telecommunications system that powers the digital age, from Wi-Fi to cellular networks. The impact of code methodologies such as Reed-Muller (RM) and Polar codes has had enormous impact through implementation in global communications standards. Codes are separated into two families: algebraic codes are deterministic, while graph codes harness statistical physics to emulate pseudorandom code. In searching for new coding methodologies designed for specific applications, the search space quickly becomes overwhelmingly vast.

What is the Solution?

KO codes introduce an entirely new family of codes that are neither algebraic codes nor graph codes. By using the linear structure of existing Reed-Muller or Polar codes as a skeleton, a neural network can train parameters for a non-linear code (minimizing the error rate) that improve upon the code used as a skeleton while maintaining the encoding and decoding complexity. This design principle can serve as a new paradigm for the creation of new non-linear codes that improve upon their linear counterparts.

What is the Competitive Advantage?

By generalizing the recursive operations that make up modern-day code formats, KO codes are the first family of non-linear codes to fall outside of the two families of existing codes. When analyzing the pairwise distance of codewords generated from KO codes, it is close to the distribution of random Gaussian codes, a type of code known to be reliable but difficult to decode. KO codes emulate their properties while maintaining the efficiency of encoding and decoding of the linear code they were trained on. Current linear codes such as RM codes maximize the pairwise distance between code words, which ensures reliability as the number of bits to be transmitted increases. However, for smaller amounts of information as would be used in Internet of Things applications, KO codes can provide better average-case reliability and show lower bit error rates. By training a model on a given application, this method can produce an optimal code balancing reliability and efficiency.

Patent Information:

WO2023283262A1

References

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