KO codes

Ashok Vardhan Makkuva (UIUC)

Joint work with Xiyang Liu, Mohammad Vahid Jamali, Hessam Mahdavifar, Sewoong Oh, Pramod Viswanath
Outline

• Motivation

• Learning codes

• **KO codes**: novel neural codes
  - KO codes, *ICML 2021*
Age of Information
1948: Then there was light

The Bell System Technical Journal

Vol. XXVII

July, 1948

No. 3

A Mathematical Theory of Communication

By C. E. SHANNON

INTRODUCTION

THE recent development of various methods of modulation such as PCM and PPM which exchange bandwidth for signal-to-noise ratio has intensified the interest in a general theory of communication. A basis for such a theory is contained in the important papers of Nyquist\(^1\) and Hartley\(^2\) on this subject. In the present paper we will extend the theory to include a number of new factors, in particular the effect of noise in the channel, and the savings possible due to the statistical structure of the original message and due to the nature of the final destination of the information.
Codes: a mathematical lens

$m \rightarrow \text{Encoder} \rightarrow \text{Channel} \rightarrow \text{Decoder} \rightarrow \hat{m}$

Code = (Encoder, Decoder)
Technical challenges

- **Challenge**: space of (encoders, decoders) very large
  - Rate = $\frac{1}{2}$, $k = 100$: $2^{100}$ codewords in 200 dimensional space

- **Our approach**: efficient DL-algorithms to learn codes
Learning a new code

$m \in \{0,1\}^k$ \rightarrow \text{Encoder} \rightarrow \text{Channel} \rightarrow \text{Decoder} \rightarrow \hat{m}$

Cross entropy loss

"Learn"
KO (encoder, decoder)

Codeword → Channel → Noisy codeword

\[ g_1, \quad g_2 \quad \text{and} \quad f_1, f_2, f_3, f_4, \hat{m}_1, \hat{m}_2 \]
KO codes

RM

Polar

KO codes
KO codes: An overview

- Novel family of neural codes
- Outperform both RM and Polar in certain regimes
- Fascinating properties
KO codes beat RM

Code-dimension = 46, Block length = 512

Bit error rate (BER)

Signal-to-noise ratio (SNR) [dB]
KO codes beat RM

Code-dimension=37, Block length = 256

Bit error rate (BER) vs Signal-to-noise ratio (SNR) [dB]

- KO Code
- Reed-Muller Code

KO beats RM at lower BER for the given SNR range.
KO beats Polar

Code-dimension=7, Block length = 64

Bit error rate (BER) vs. Signal-to-noise ratio (SNR) [dB]

- Polar Code
- Polar Code with MAP
- KO Code
- KO Code with MAP
Gaussian like!

Code-dimension=46, Block length = 512

Normalized count

Pairwise distance between two codewords
Collaborators
La Fin

Thank you!