PURDUE INNOVATES | Office of Technology Commercialization

Signal Generation and Information Estimation with Recurrent Neural Networks (RNNs)

RNN-based coding scheme improves reliability and noise tolerance in feedback-enabled communication systems.

All modern communication relies on advanced computer coding to package, transfer, and decipher information, taking it securely from one point to another. In broad terms, all of these systems utilize both an encoder and a decoder. The encoder, which sits at one end of the communication stream, packages user input into a form readable by the computer system, then sends it to the decoder at the other end, which receives that information and translates it back to a form that human users can understand. This is the basic principle underlying all computerized communication systems, including text messaging, satellite communications, Wi-Fi, and more. Often, these systems are feedback-enabled, meaning that feedback from the receiver is used to try to improve system reliability. However, there has been a long-standing problem in this field designing codes for feedback-enabled communication due to the complexity of incorporating that feedback into the code. New developments in communication have begun to include non-linear, deep learning-based coding schemes to address the complexity of encoder/decoder designs in neural networks, which do improve reliability over traditional linear schemes but are vulnerable to problematic noise.

In response to these limitations, researchers at Purdue University have designed a novel coding scheme for feedback-enabled one-way communication channels that not only increases reliability but can also handle high-noise communication scenarios better than previous coding designs. Their innovation includes a novel encoder/decoder design that utilizes Recurrent Neural Networks (RNNs), a type of deep learning, to package (encode) and translate (decode) information sent over the channel. Built on non-linear coding and autoencoder-based architecture, their system is extremely robust to channel noise. The inclusion of a built-in power control layer also ensures that their coding scheme is capable of handling typical hardware and power constraints. Numerical experiments designed to

Technology ID

2023-KIM-70301

Category

Artificial Intelligence & Machine Learning/AI Model Optimization & Acceleration Tools

Aerospace & Defense/Hypersonics & Propulsion Systems

Authors

Christopher G. Brinton

Junghoon Kim

Taejoon Kim

David Love

Further information

Parag Vasekar

psvasekar@prf.org

View online

test the technology's performance have shown that this novel encoder/decoder design outperforms other state-of-the-art feedback codes by wide margins. Although designed with one-way channels in mind, these researchers have also established the ability of their technology to be expanded to two-way communication channels by the incorporation of an additional encoder/decoder set, all of which can be made to communicate with each other through the use of their learning-based RNN algorithm. This novel coding scheme promises to be of utmost relevance in our increasingly digital world, improving reliability, reducing the impact of noise, and ensuring peak performance across all kinds of communication.

Technology Validation:

This coding strategy has been tested through numerical experiments and simulations. These tests demonstrated that the new feedback coding system matches or outperforms traditional channel coding schemes in bit-error rates or block error rates. Results indicate the potential for this scheme to improve communication reliability in feedback-enabled communication systems.

Advantages:

-Improved reliability when feedback is enabled for point-to-point communication systems

-Outperforms traditional coding schemes in terms of bit-error rates and block-error rates

-Demonstrates power distribution similar to the current most optimized linear coding schemes

-Promotes block length gain within lower limits of processing bits (K)

-Autoencoder-based architecture is designed to learns codes based on consecutive blocks of bits instead of bit-by-bit processing, which makes it better at handling noise

-The proposed power control layer handles hardware and power constraints

-Recurrent Neural Networks and deep-learning enhance the quality and efficiency of encoding/decoding

Applications:

-Communication technology

-Computer programming

-Enhanced one- or two-way information exchange

TRL: 5

Intellectual Property:

Provisional-Gov. Funding, 2024-04-24, United States

Utility-Gov. Funding, 2025-04-23, United States

Keywords: Communication, Computer Engineering, Computer Technology, deep learning, feedback-enabled communication, Gaussian two-way channel, GTWC, Machine Learning, point-to-point communication, recurrent neural networks, two-way communication