Application of various neural network architectures for decoding BCH codes

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Motivation

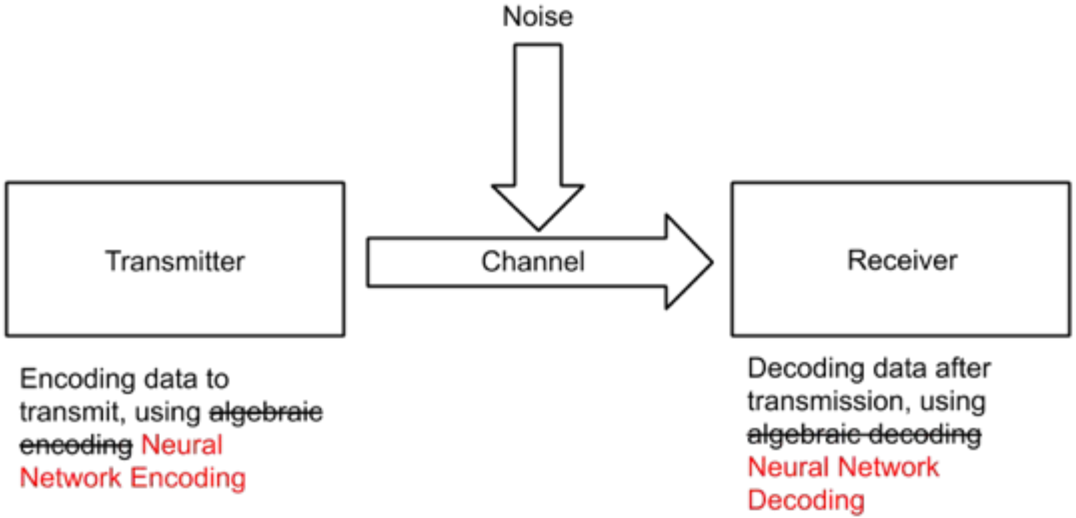
- Recent advances in deep learning;
- Deep learning is getting ubiquitous;
- Major neural decoders solutions are based on classical approaches;
- Deep learning might benefit in decoding algorithms (already proven fact for some of the algorithms)

Problem statement

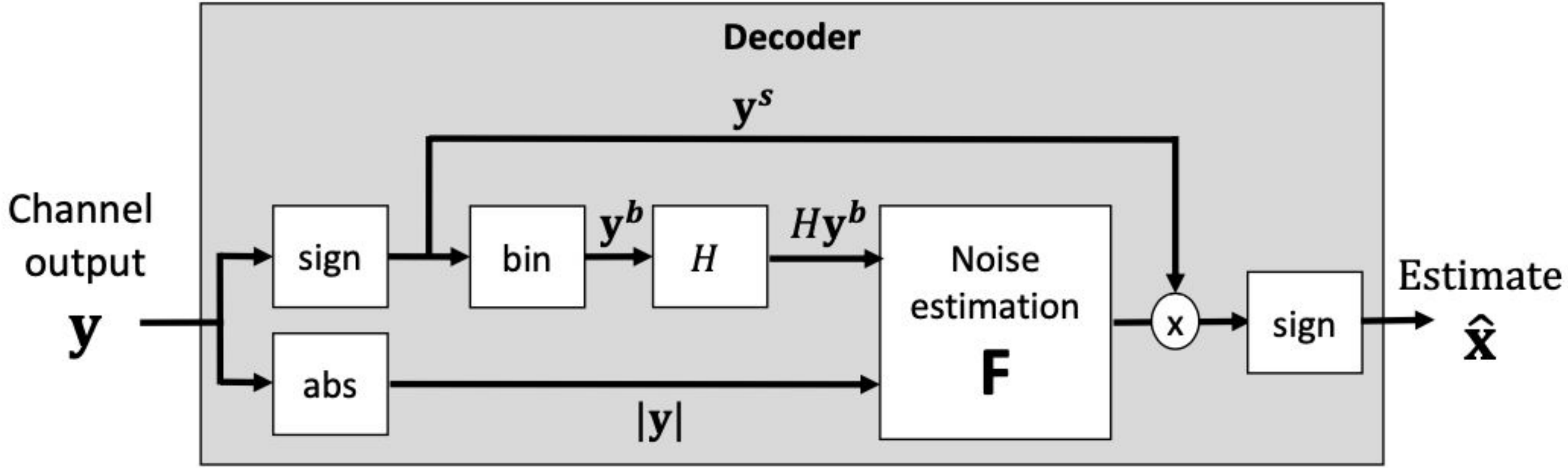
In this project we will compare the performance of different NN for decoding BCH codes with the following parameters

- (63, 45)
- BPSK modulation
- AWGN channel

The performance of the schemes measures in terms of frame error rate (FER) versus signal-to-noise ratio (SNR)



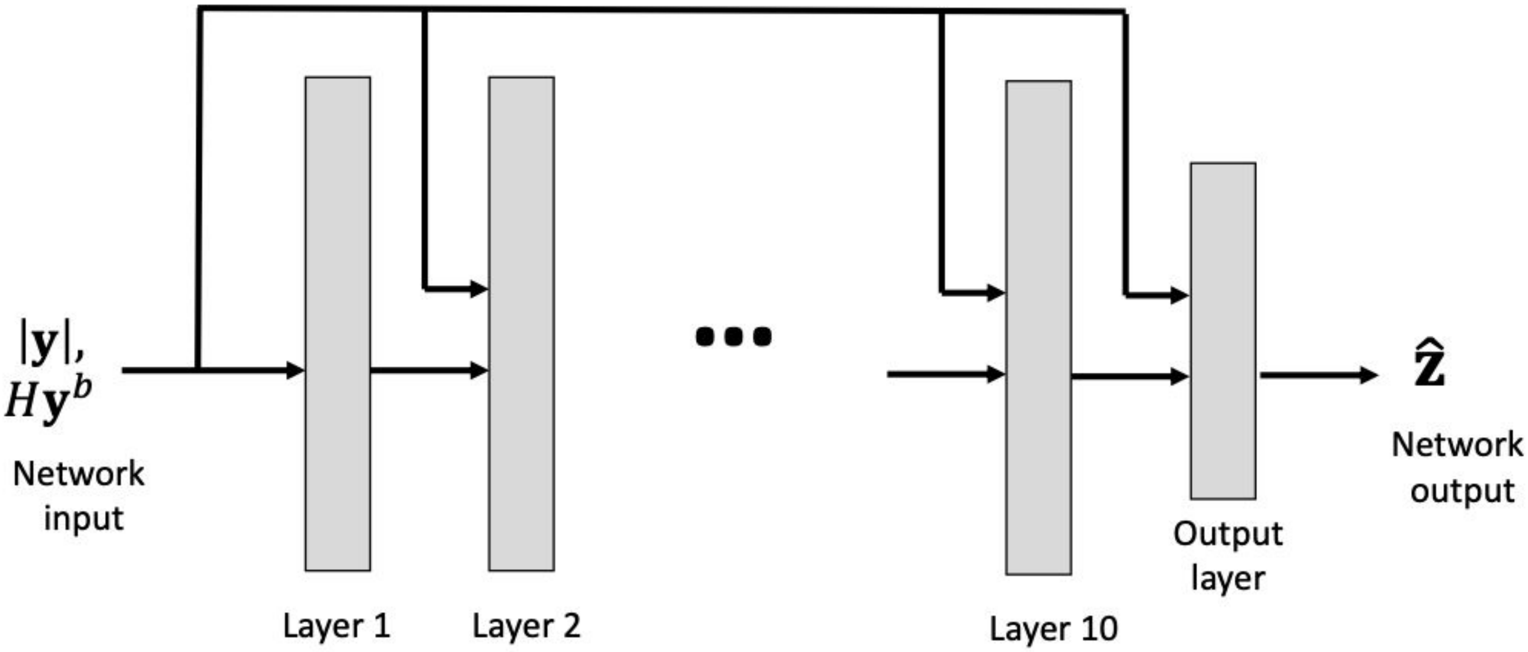
Decoding technique



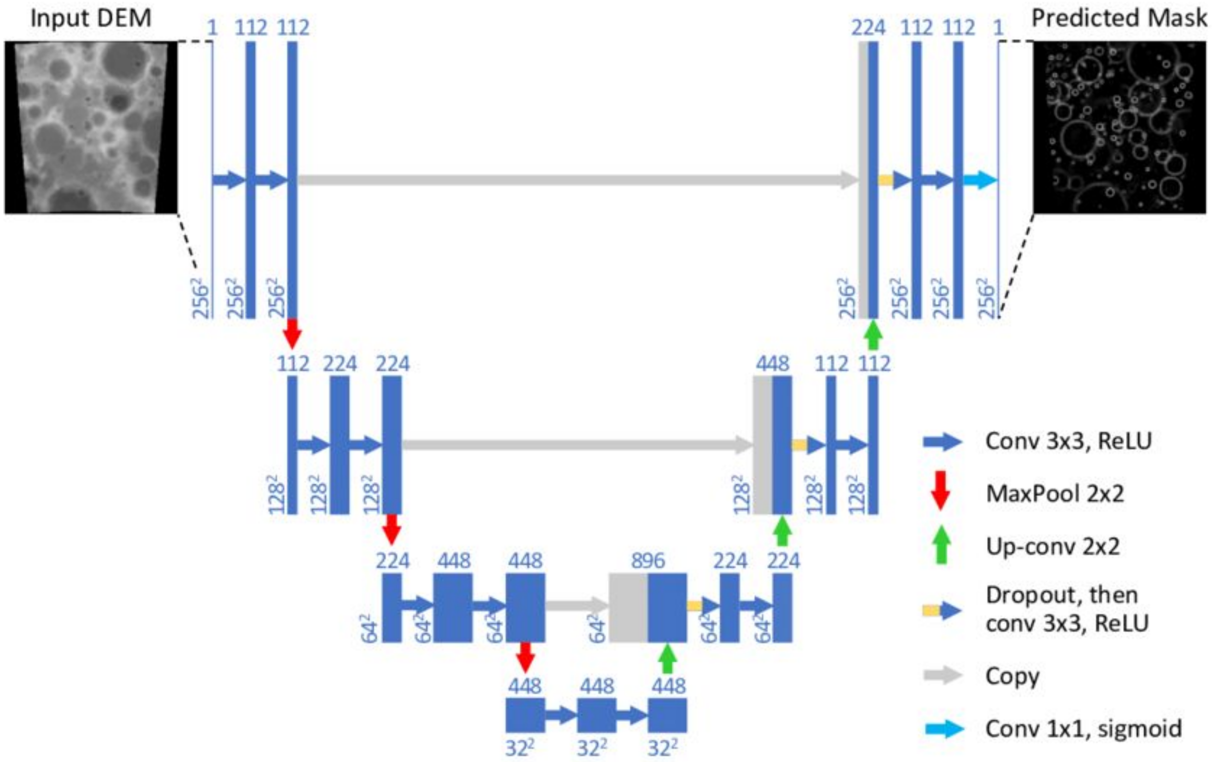
Neural network architectures

- Fully Connected Neural Network (Proposed in paper)
- 1D Convolutional Neural Network (1D U-Net)

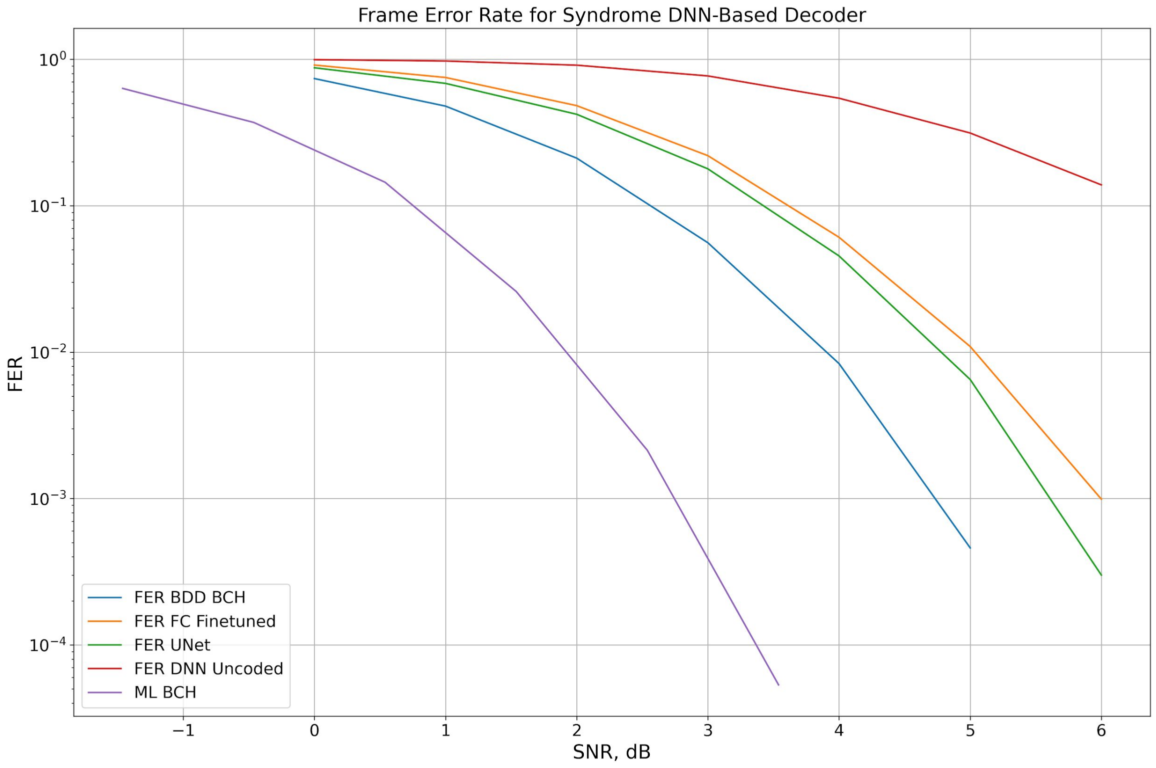
Neural network architectures



Neural network architectures

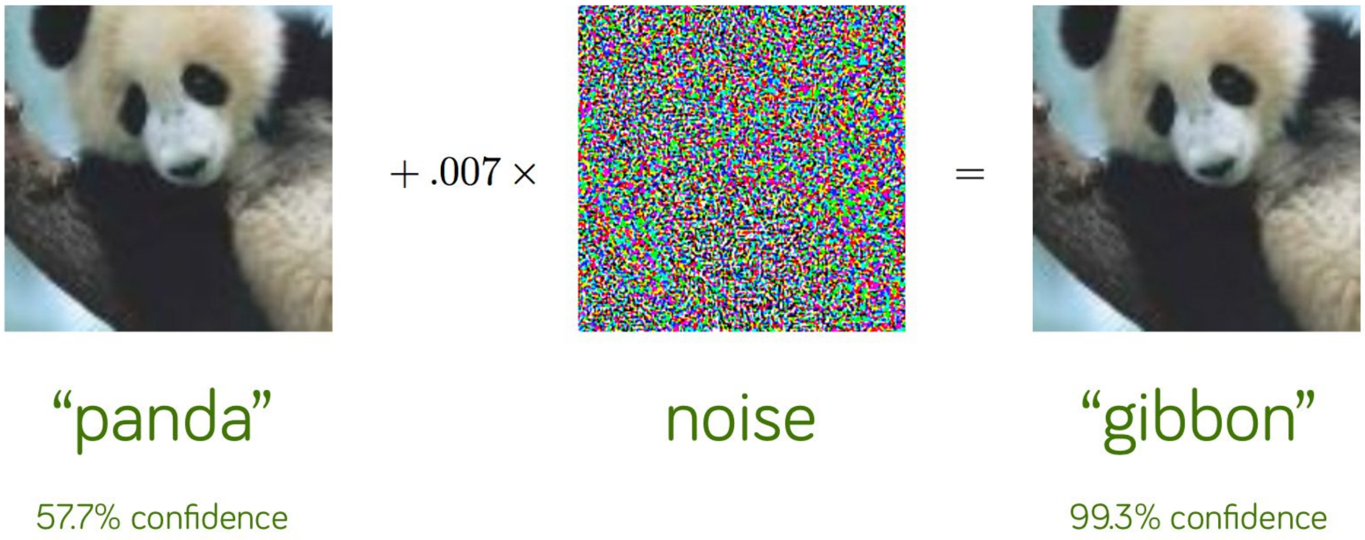


Results



Frame Error Rate for Syndrome DNN-Based Decoder
FER
SNR, dB
10^0
10^-1
10^-2
10^-3
10^-4
−1
0
1
2
3
4
5
6
FER BDD BCH
FER FC Finetuned
FER UNet
FER DNN Uncoded
ML BCH

Adversarial attacks



Adversarial attacks

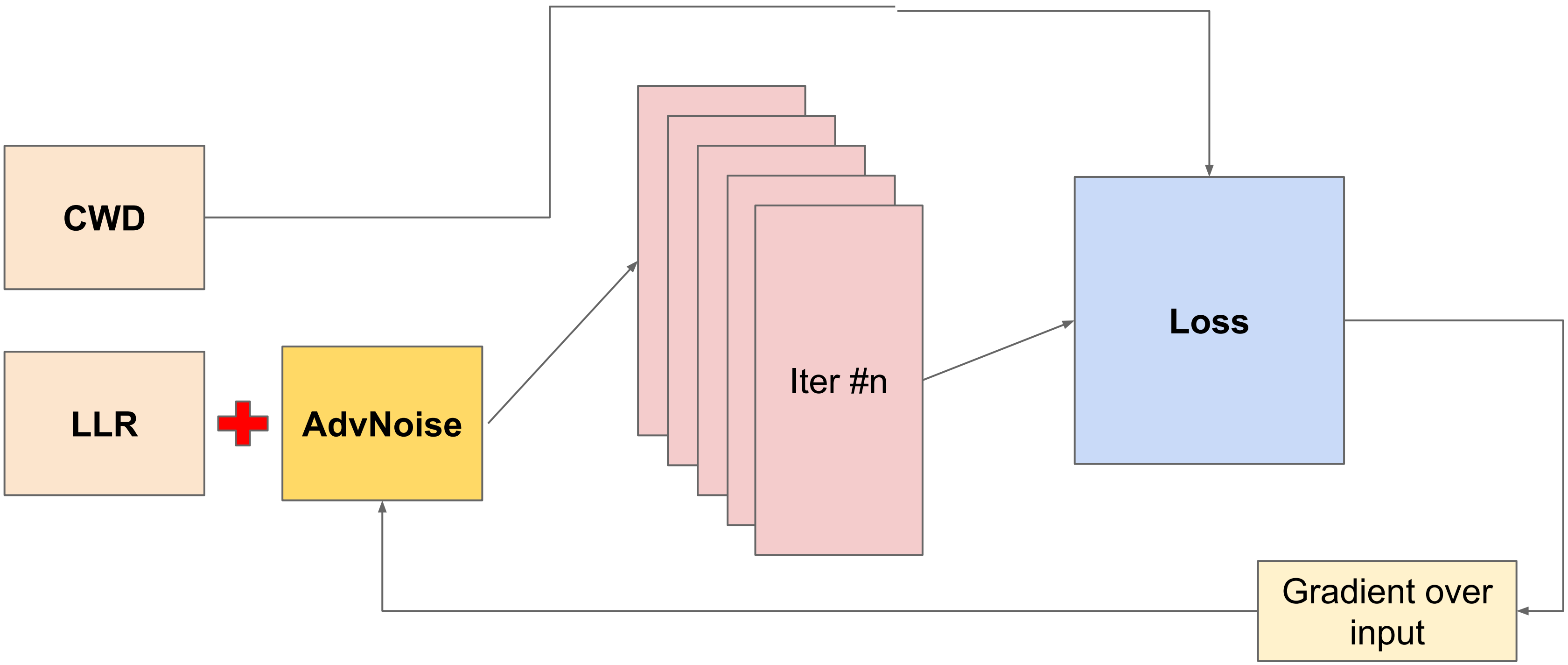
Suppose a classifier mapping $f : \mathbb{R}^m \to \{1...k\}$ is given.
The loss function is denoted by $L_f : \mathbb{R}^m \times \{1...k\} \to \mathbb{R}^+$ and is to be continuous.
Provided $x \in \mathbb{R}^m$ is an image and $l \in \{1...k\}$ is a label, the problem can be formulated as follows:

$$\min_{\substack{f(x) \neq f(x+r);\\ \|r\|_p \leq \xi}} \quad \|r\|_p$$

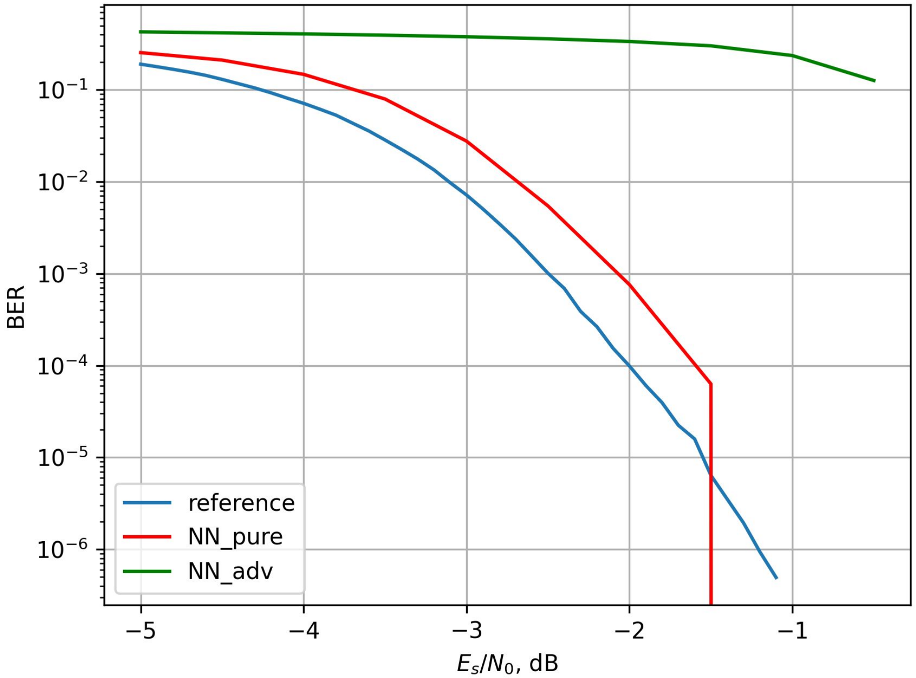
So, we need to solve the following optimization procedure:

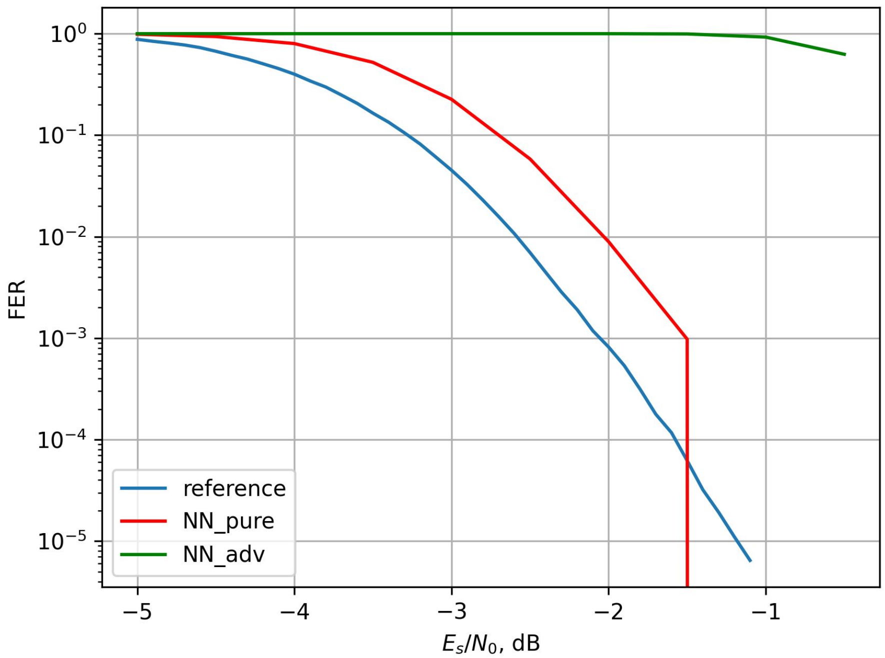
$$\upsilon \leftarrow \arg\min_r \|r\|_p \text{ s.t. } f(x+r) \neq f(x)$$

AdvAttack. NN-based BP algo

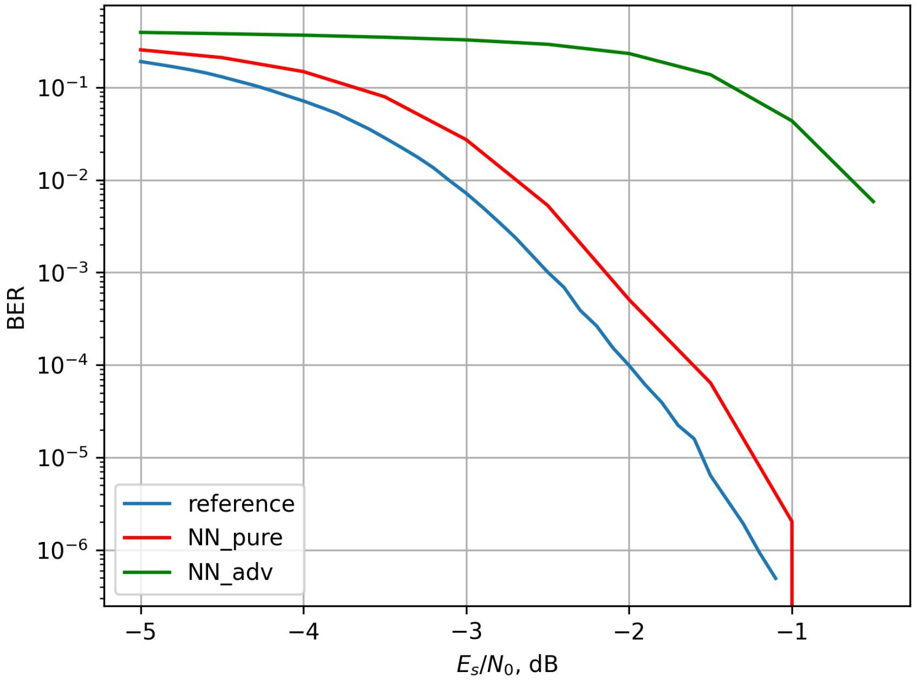


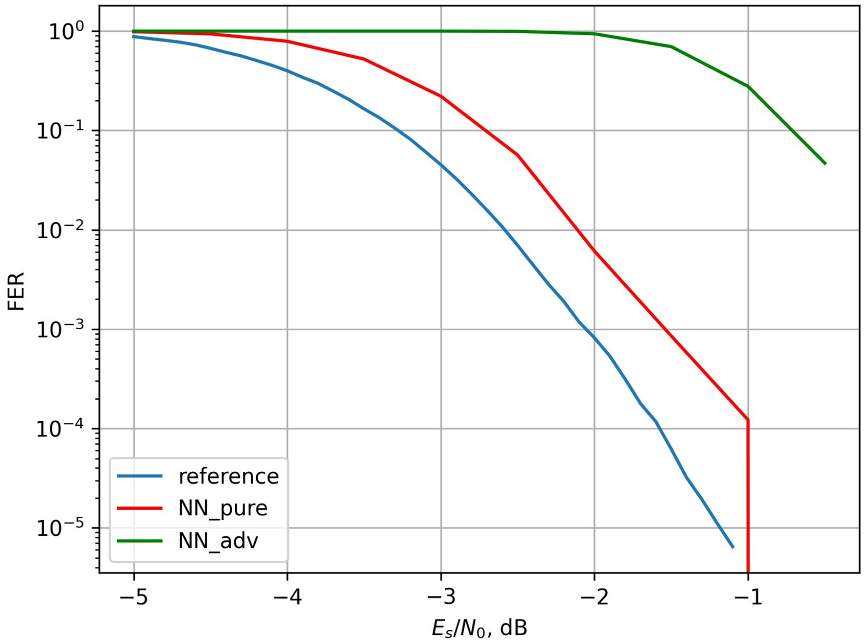
AdvAttack. NN-based BP algo



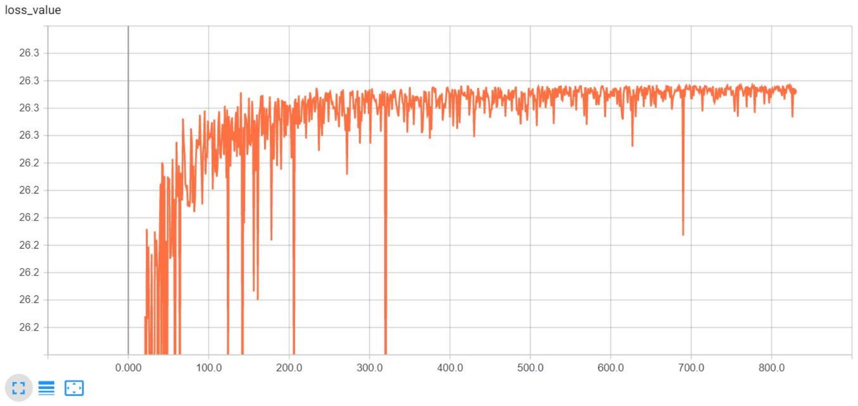


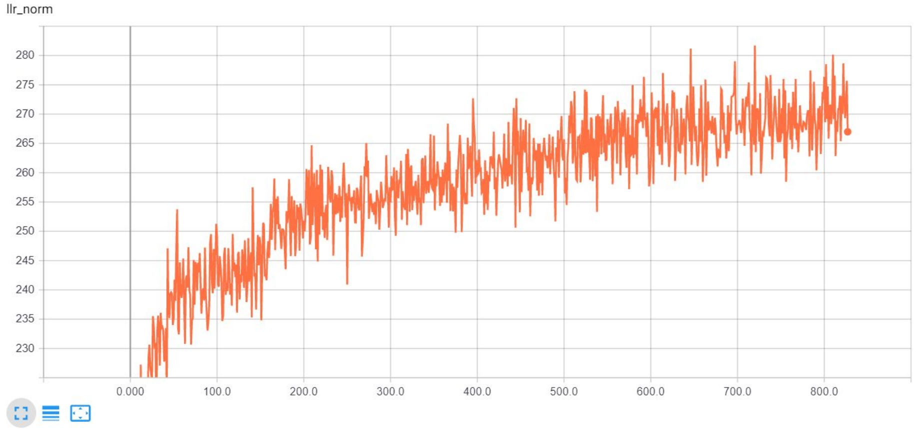
AdvAttack. NN-based BP algo



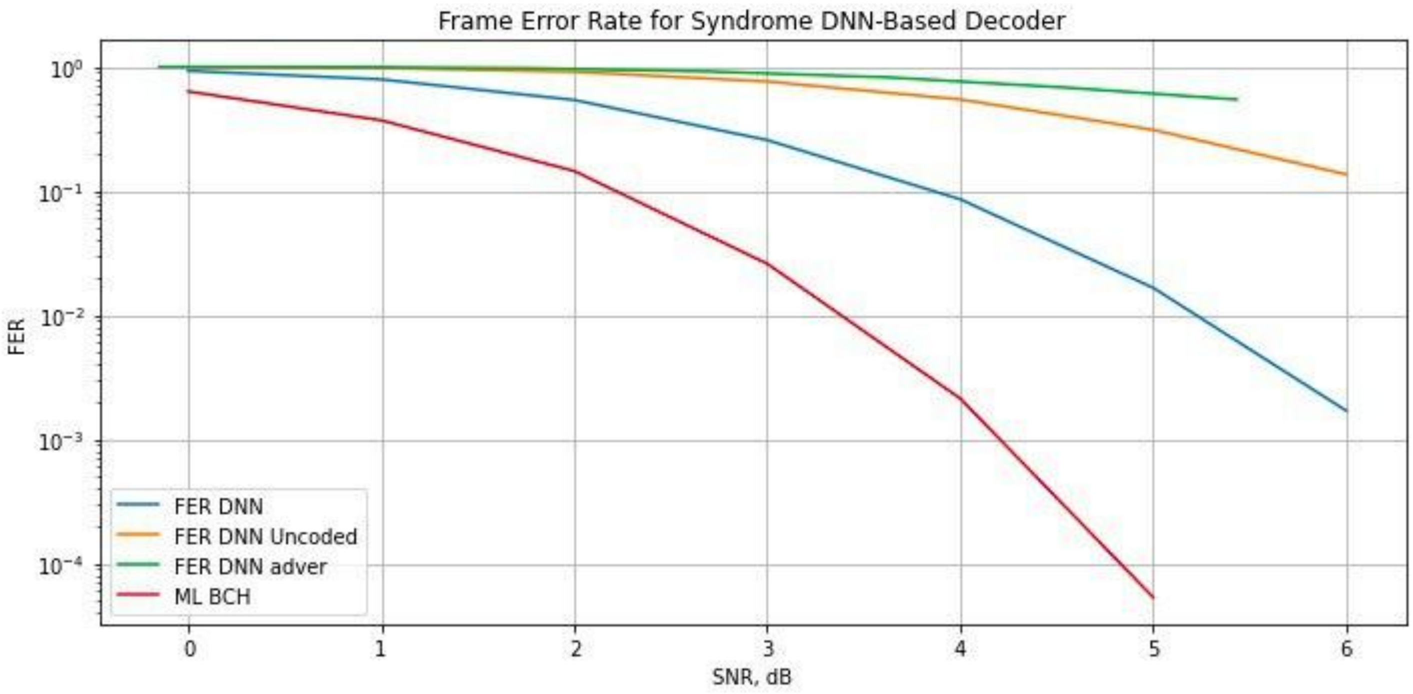


AdvAttack. NN-based BP algo





AdvAttack. Syndrome decoding



Contribution

Balitskiy Gleb - AdvAttack, Presentation
Kaziakhmedov Edgar - AdvAttack, Presentation
Dzis Andrei - FC NN, Presentation
Korobkina Anastasiia - CNN (U-Net), Presentation
Shcherbakova Valeriia - FC NN, CNN, Presentation

Q&A