DeepJSCC-f: Deep Joint Source-Channel Coding of Images with Feedback

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What is the relevance of this work?

*We present **deepJSCC-f**, a complete redesign of **wireless communications with feedback**, using machine-learning based **joint source-channel coding** (JSCC)*

- First practical JSCC scheme that fully exploits channel output feedback
- Performance superior than state-of-the-art
- Resilience to forward and feedback channel noise, showing graceful degradation
- Variable rate transmission, saving up to 50% bandwidth
- High performance, low latency, energy-constrained communication

Wireless Communications

How is information transmitted over a noisy channel?

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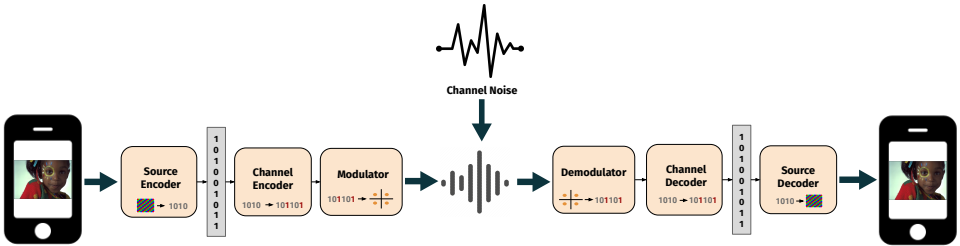
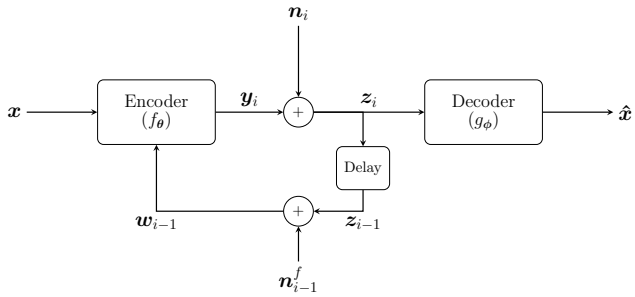


- **Shannon's Separation Theorem (1948)** motivates most designs
- Challenge: optimality holds only under unlimited delay and complexity; no solution to multi-user scenarios
- Lack of viable alternatives

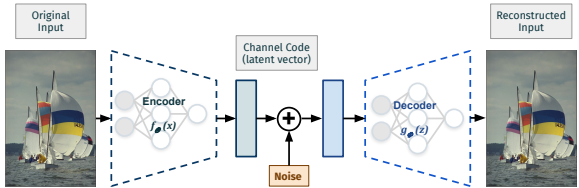
Communication with feedback



- Feedback can improve error exponents (Burnashev, 1976) and simplify the design (Schalkwijk, 1967)
- Again: Lack of practical schemes nor JSCC solutions

We can learn to do better!

Deep Joint Source-Channel Coding (DeepJSCC)

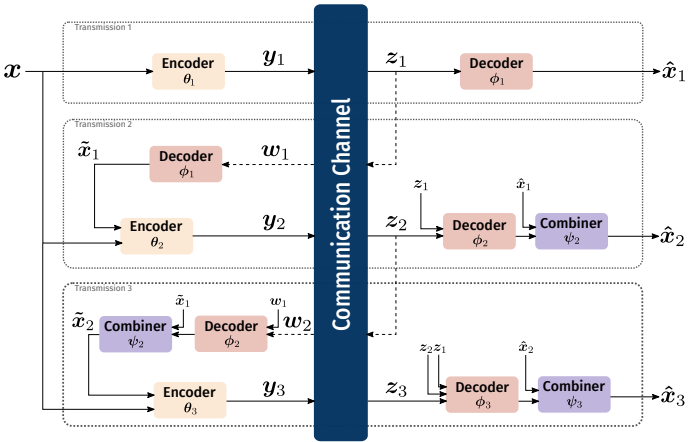


- Learn from data: unsupervised learning, without prior models, expert knowledge or labels
- Directly mapping to channel input symbols: no bits conversion, speeding up the process and exploiting channel coding compression
- Coherent mapping: similar content stay close to each other

E. Bourtsoulatze, D. Burth Kurka and D. Gunduz, **Deep joint source-channel coding for wireless image transmission**, in IEEE Trans. on Cognitive Comm. and Networking, Sep 2019.

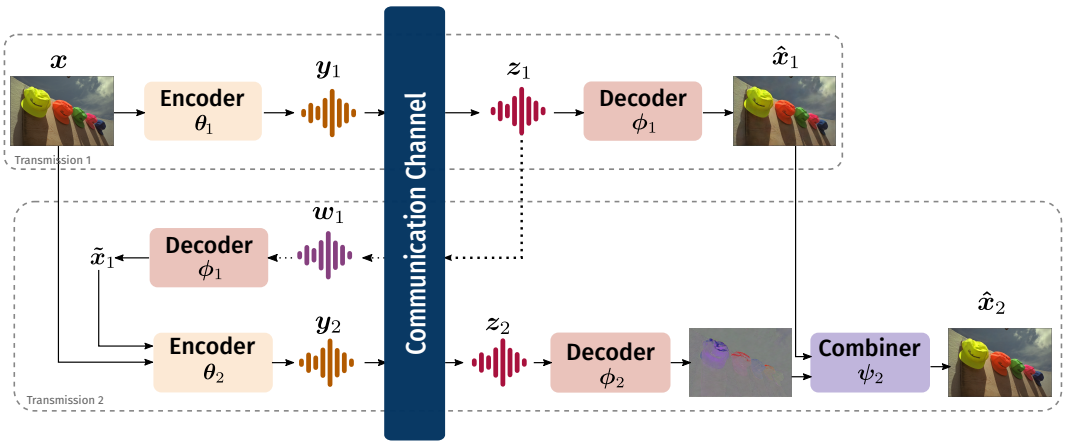
DeepJSCC-f: exploiting feedback

Key idea: **Layered Autoencoders**



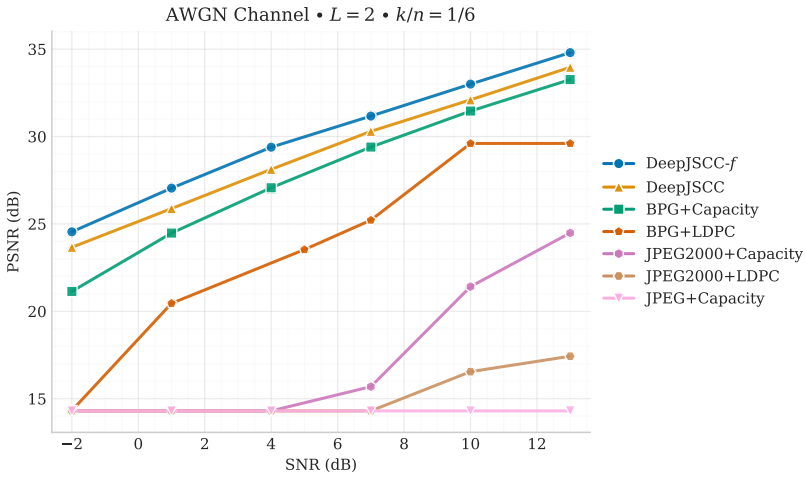
- Layers trained sequentially
- Each layer delivers a full reconstruction of the image (successive refinement)
- Both original input and feedback information available at the encoder

DeepJSCC-f: exploiting feedback

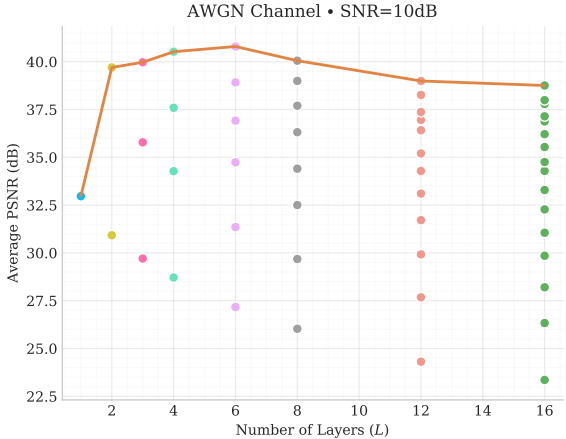


DeepJSCC-f: Results Comparison

What do we compare our scheme with?

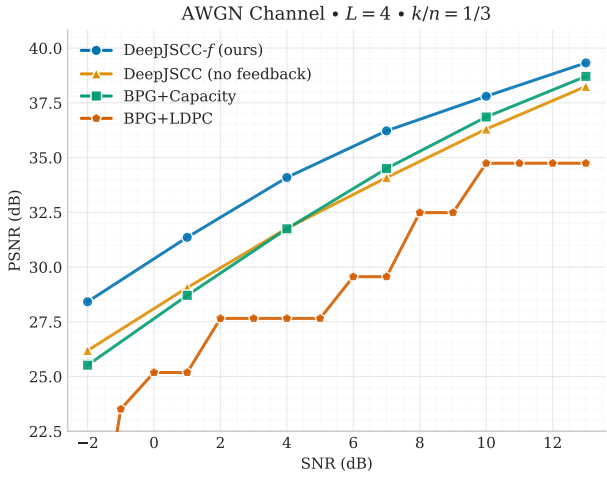


DeepJSCC-f: number of layers



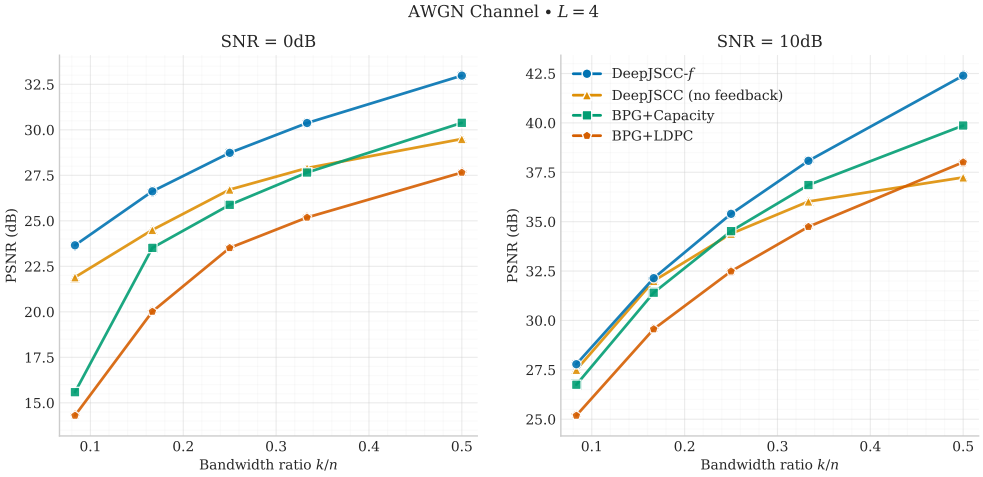
- Trade-off: feedback iterations vs blocklength size
- Good balance with $L = 4$

DeepJSCC-f: superior performance



Significantly superior than other schemes for a wide range of channel SNRs...

DeepJSCC-f: superior performance



. . . and bandwidth

DeepJSCC-f: visual comparison

Original Image

JPEG+LDPC

PSNR: 18.97dB
MS-SSIM: 0.668

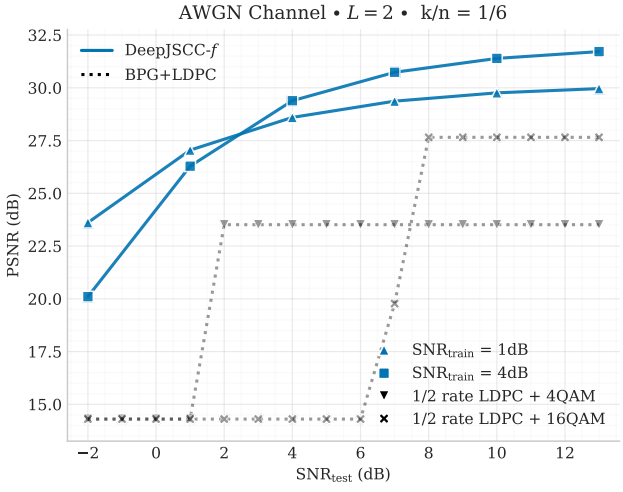
BPG+LDPC

PSNR: 22.98dB
MS-SSIM: 0.851

DeepJSCC-f

PSNR: 25.99dB
MS-SSIM: 0.948

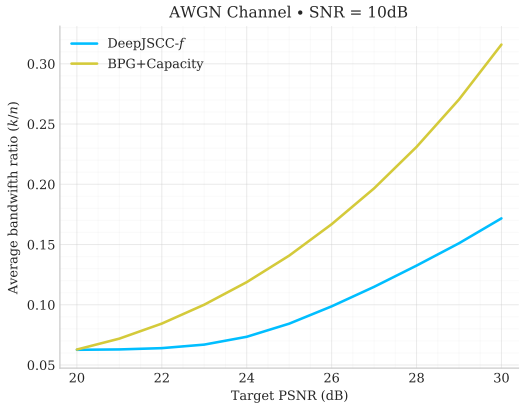
DeepJSCC-f: changes in channel SNR



Graceful degradation, instead of cliff effect!

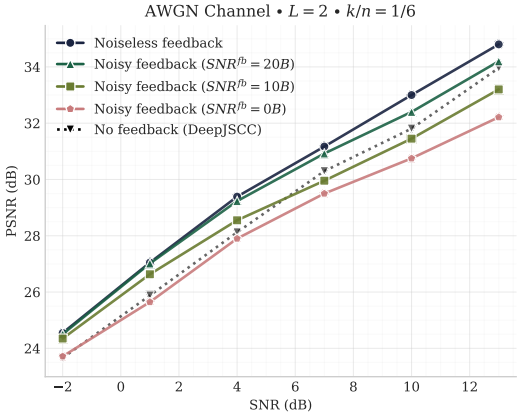
DeepJSCC-f: variable rate

Transmit until target PSNR is reached



Almost 50% of reduction in the bandwidth consumed!

DeepJSCC-f: noisy feedback



- Robust to feedback noise!

Final Remarks

- DeepJSCC-f, first practical JSCC scheme exploiting channel output feedback
- Performance superior to state-of-the-art image transmission models
- Flexibility and robustness to diverse noise conditions, both in forward and in feedback channels

- Check our demo on ICASSP2020 - video transmission with deep JSCC
- Extended journal version available in `https://arxiv.org/abs/1911.11174`, to appear in Journal on Selected Areas in Information Theory (JSAIT)