

EC-291 EXPLORATORY PROJECT - 2025

AUTOENCODERS FOR COMMUNICATION

GROUP MEMBERS

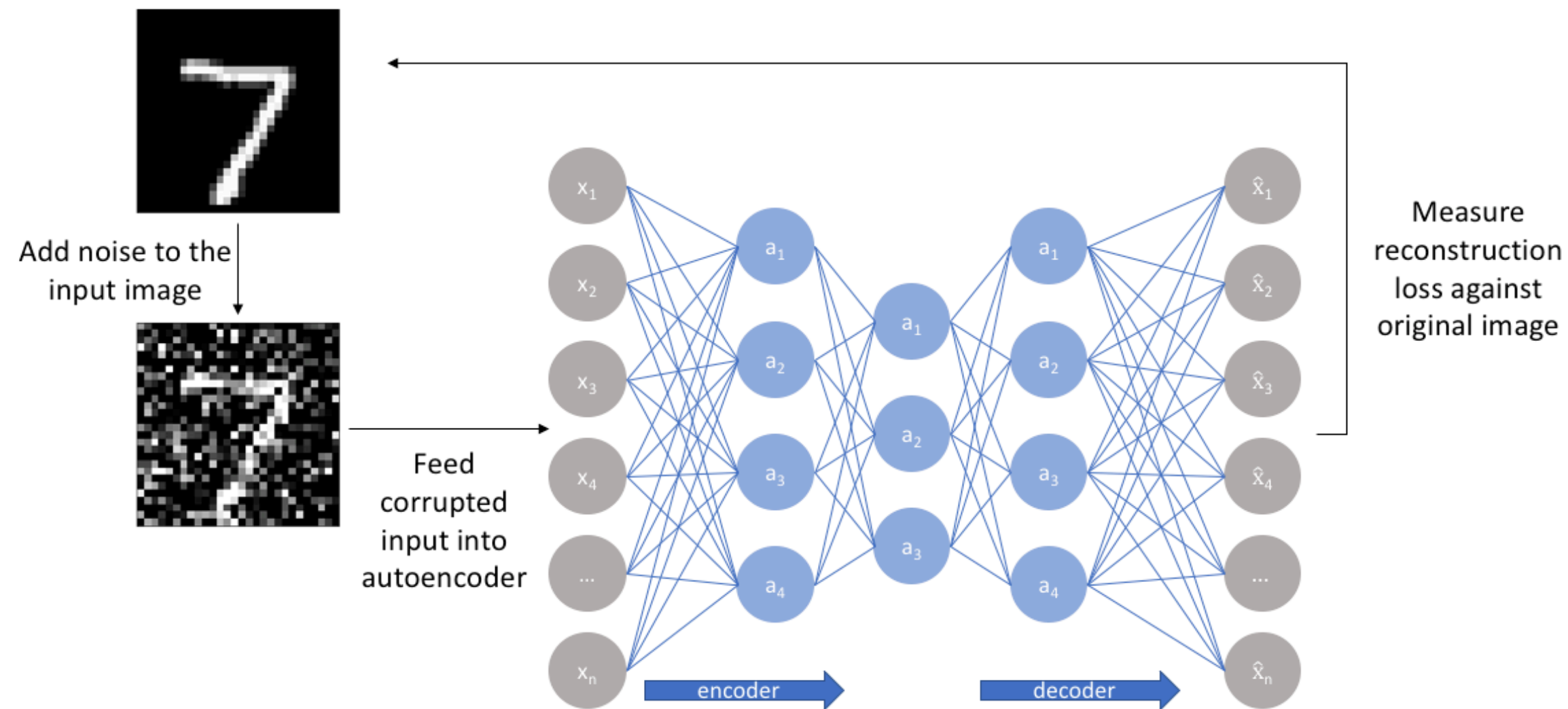
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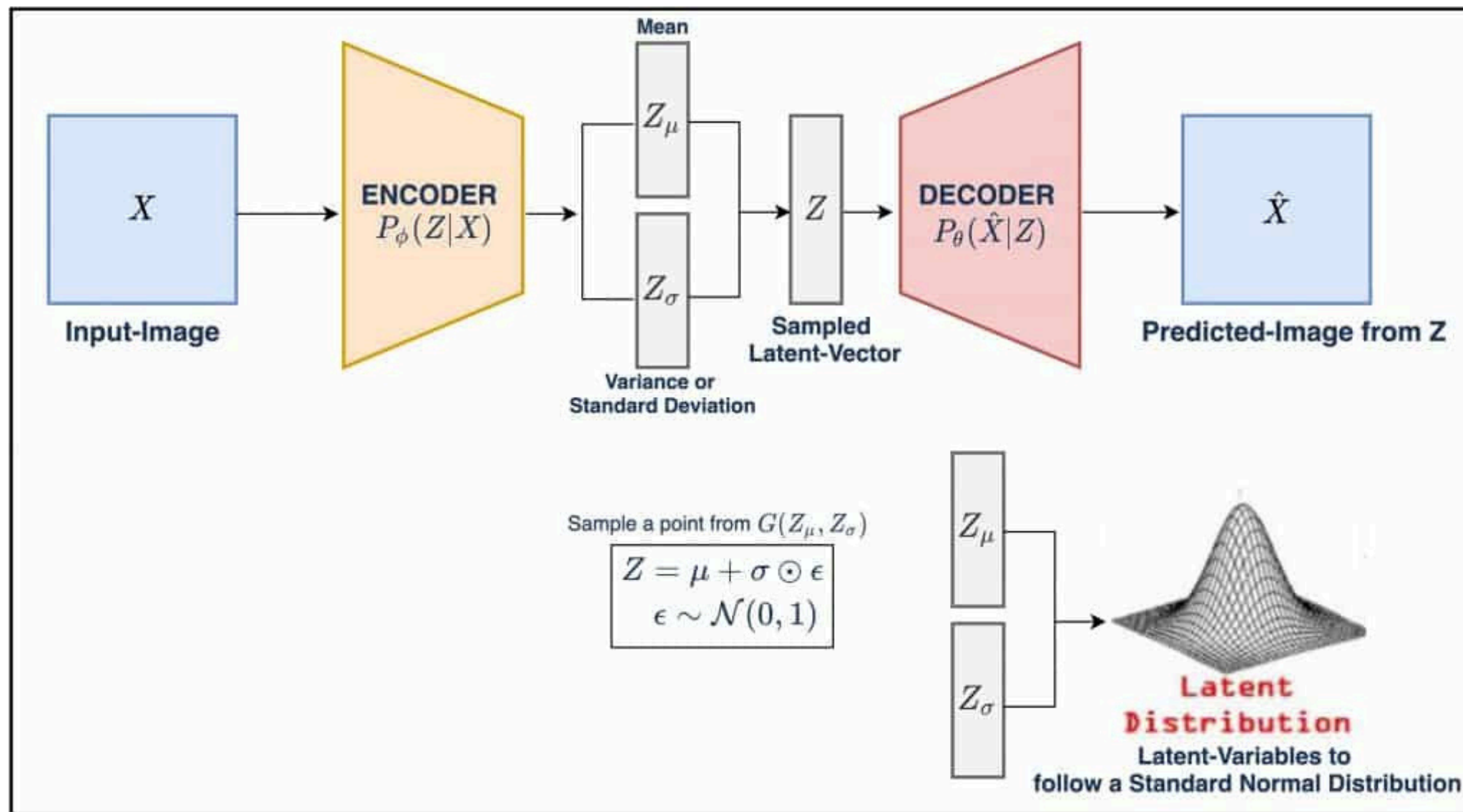
WHAT IS AN AUTOENCODER?



AUTOENCODER ARCHITECTURE

- **IT IS A DEEP-NEURAL NETWORK THAT LEARNS TO COMPRESS DATA INTO A SMALL REPRESENTATION.**
- **AND THEN RECONSTRUCTS IT, CAPTURING IMPORTANT FEATURES USING A DECODER**

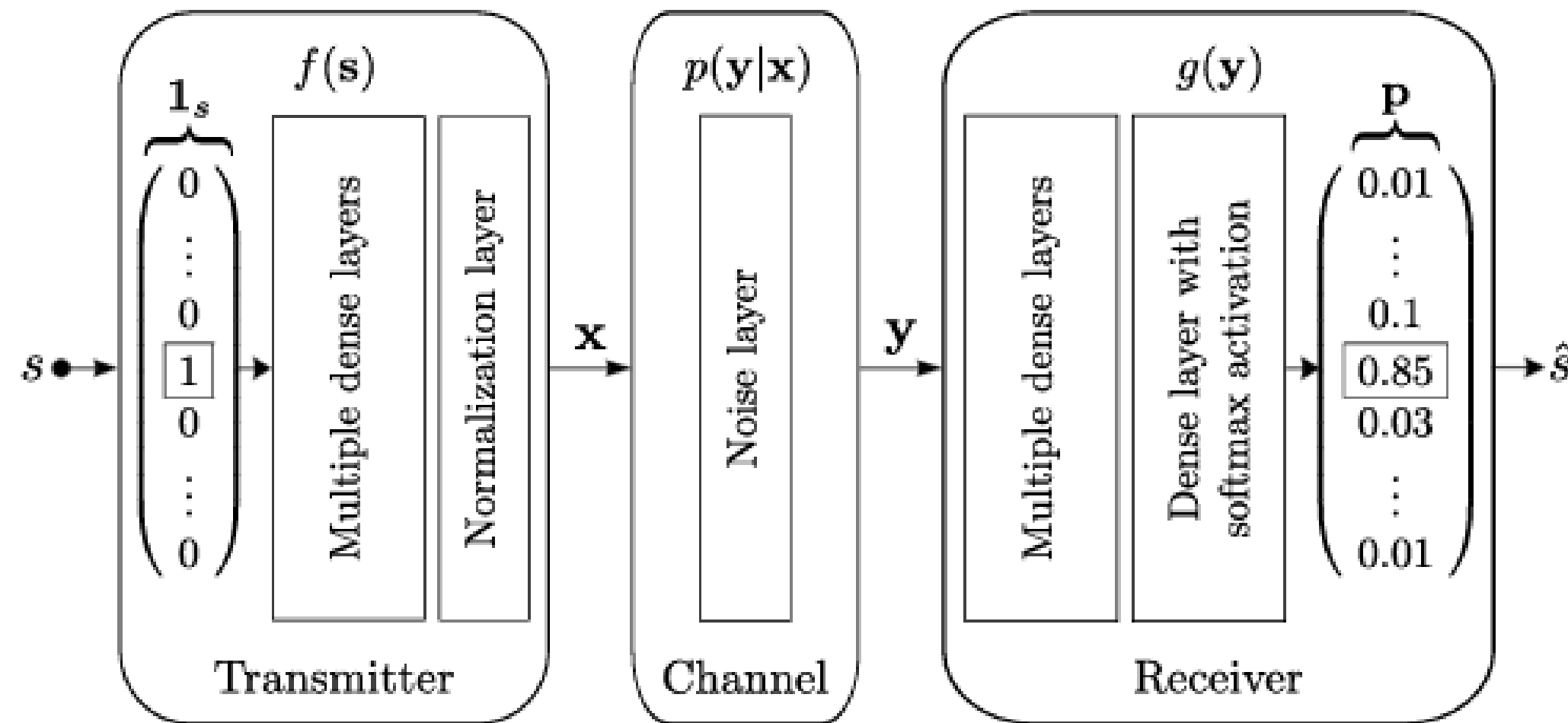
VARIATIONAL AUTOENCODER AND ITS ADVANTAGES



VARIATIONAL AUTOENCODER ARCHITECTURE

- A VAE ADDS RANDOMNESS BY LEARNING A DISTRIBUTION FOR THE LATENT SPACE.
- GENERATES REALISTIC DATA VARIATIONS QUICKLY AND EFFICIENTLY.

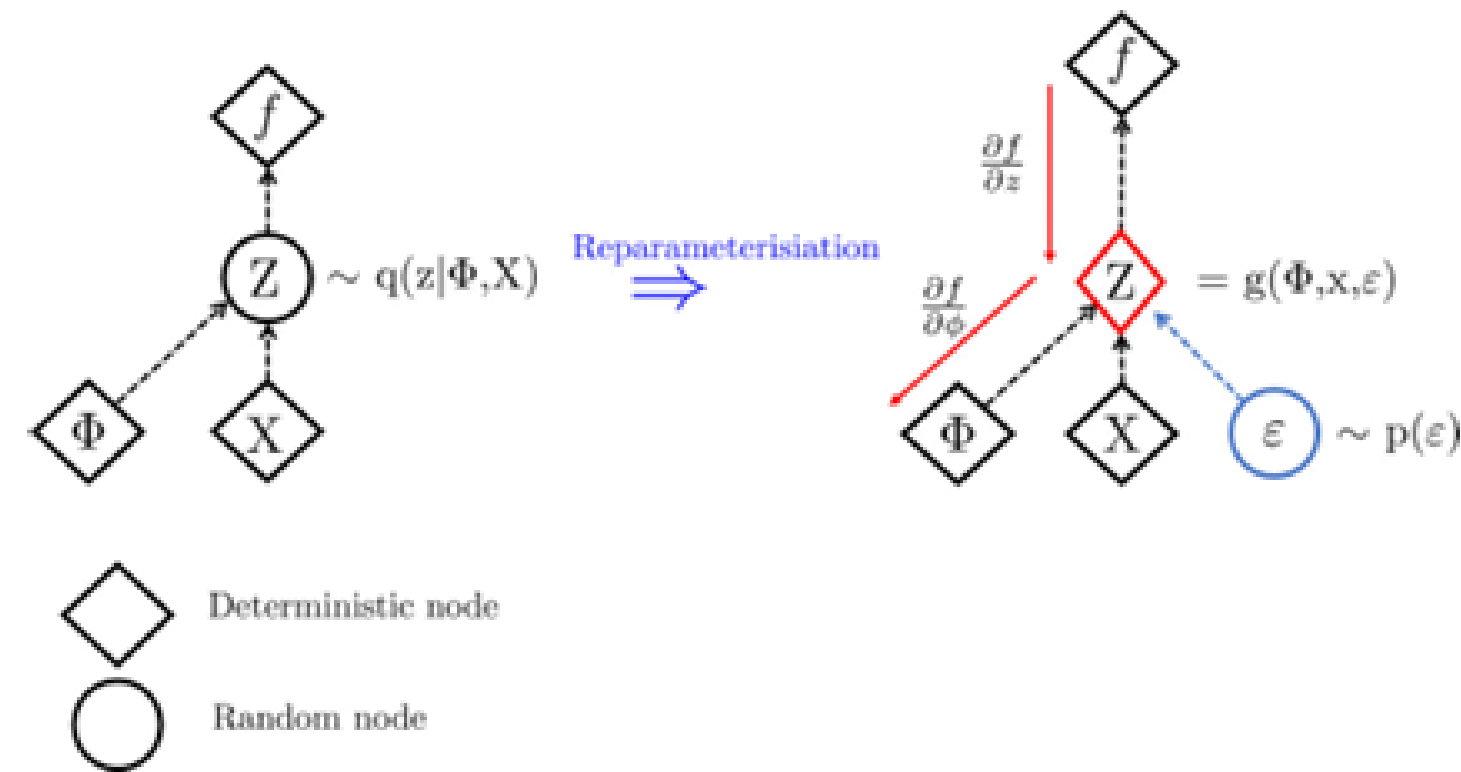
AUTOENCODER IN COMMUNICATION



AUTOENCODER IN A COMMUNICATION SYSTEM

- **TRANSMITTER (ENCODER): CONVERTS INPUT INTO A COMPACT SIGNAL.**
- **RECEIVER (DECODER): RECOVERS INPUT FROM THE COMPACT SIGNAL.**

VARIATIONAL AUTOENCODER IN COMMUNICATION

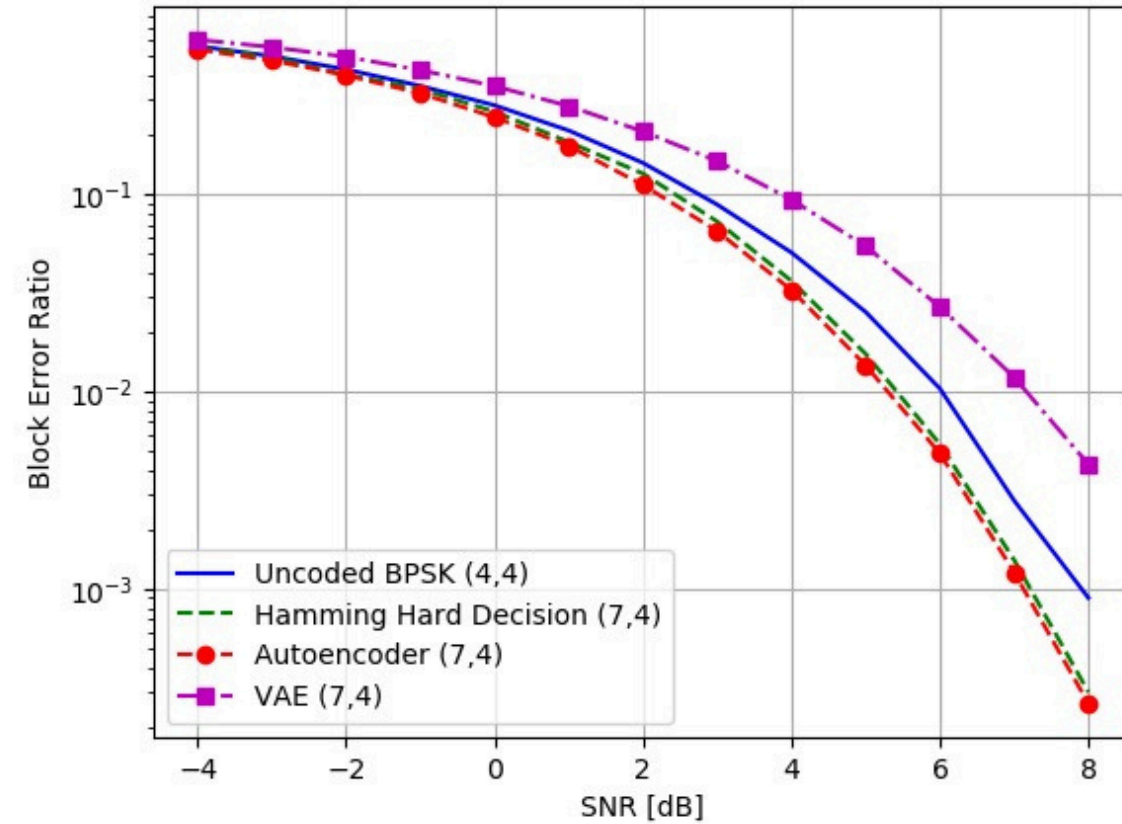


REPARAMETERISATION TRICK FOR BACKPROPAGATING THE LOSSES

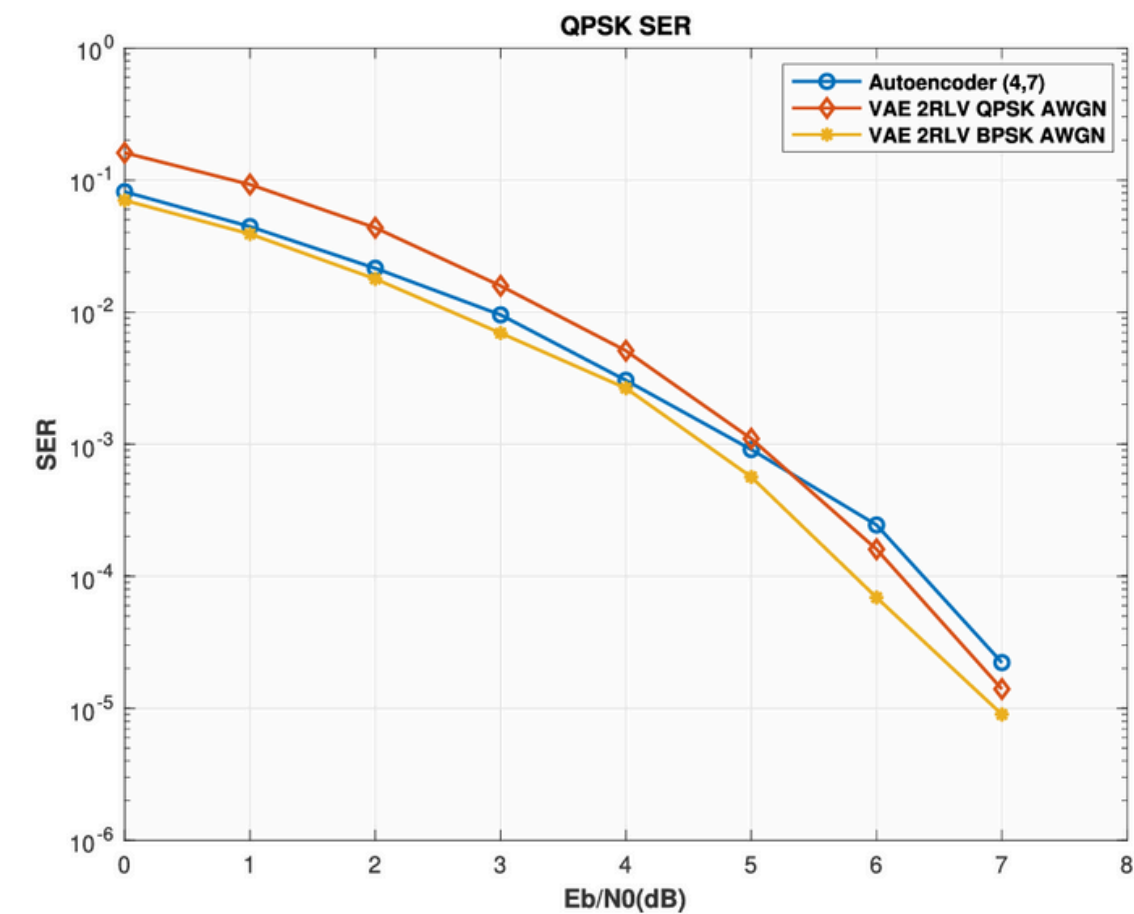
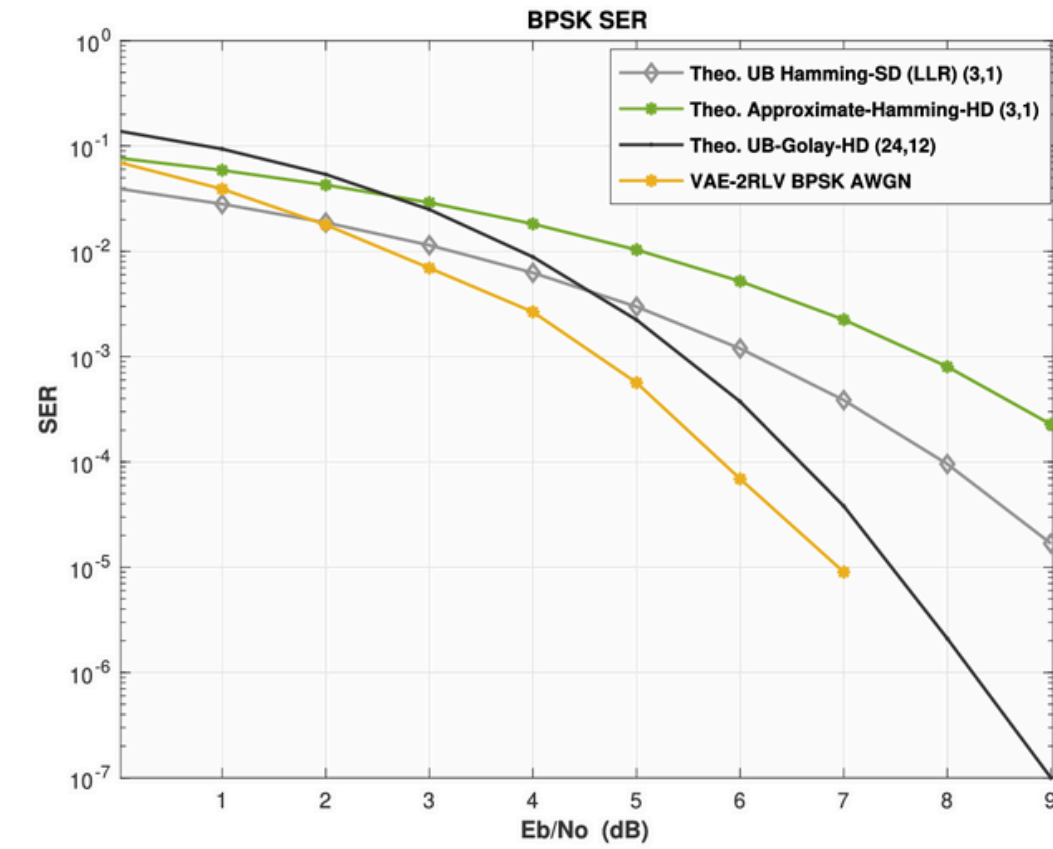
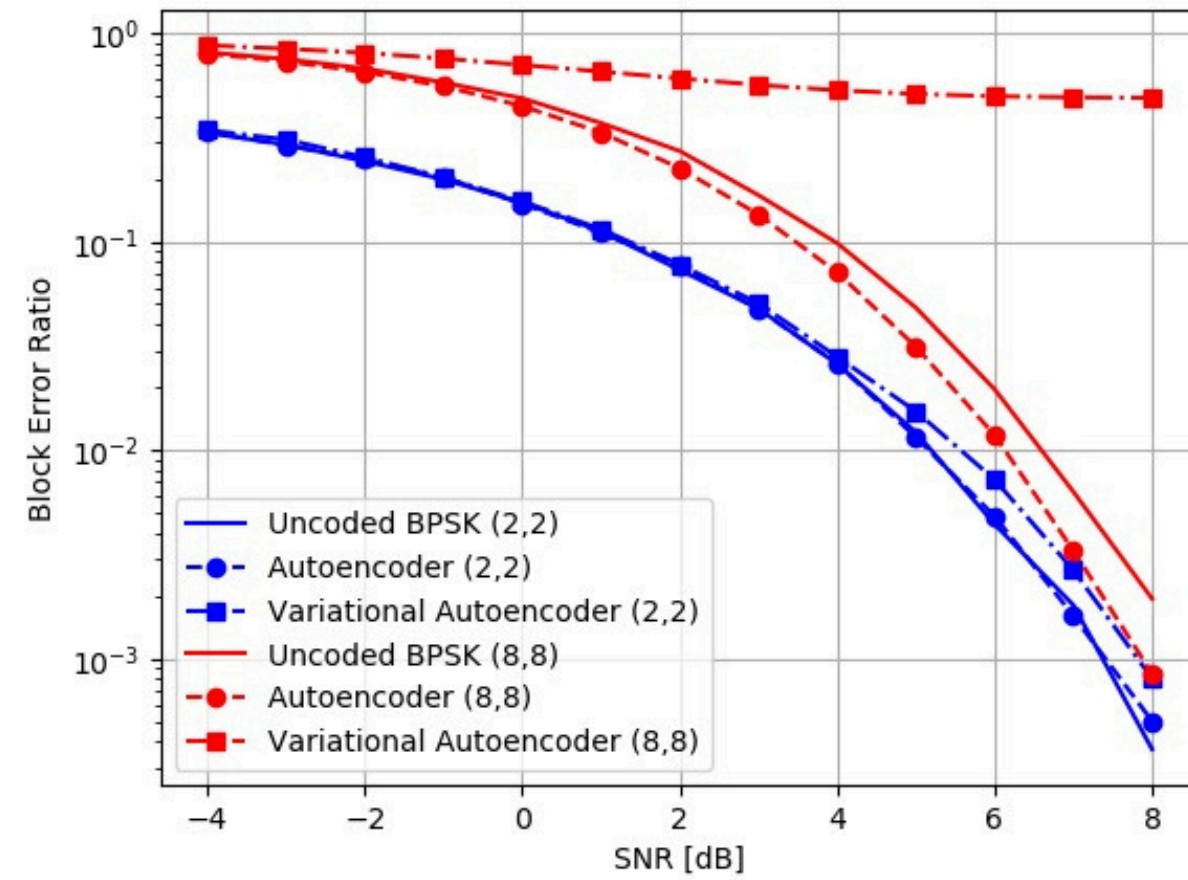
Feature	VAE	Standard AE
Latent Space	Probabilistic	Fixed points
Loss	Reconstruction + KL	Reconstruction only
Generation	Creates new samples	Reproduces training data

RESULTS OBTAINED

BLER vs SNR for VAE, Autoencoder and several baseline communication schemes



BLER vs SNR for Autoencoder, Variational Autoencoder and BPSK



CONCLUSIONS

- **FUTURE VAE LEARNING:
REAL-TIME CHANNEL ADAPTATION & MULTI-USER EXTENSIONS**
- **E2E AE FOR COMM:
JOINTLY LEARNS MODULATION + CODING, HITTING NEAR-OPTIMAL SER ON AWGN CHANNELS**
- **VAE ADVANTAGES:
PROBABILISTIC LATENT CODE → UNCERTAINTY QUANTIFICATION, ADAPTIVE RATE CONTROL**
- **FUTURE: ISAC AUTOENCODER:
DESIGN UNIFIED WAVEFORMS FOR SIMULTANEOUS SENSING & COMMUNICATION**
- **REAL-WORLD USES:
ULTRA-LOW-LATENCY IOT LINKS, DYNAMIC SPECTRUM SHARING IN 5G/6G, ON-DEVICE COMPRESSION**