

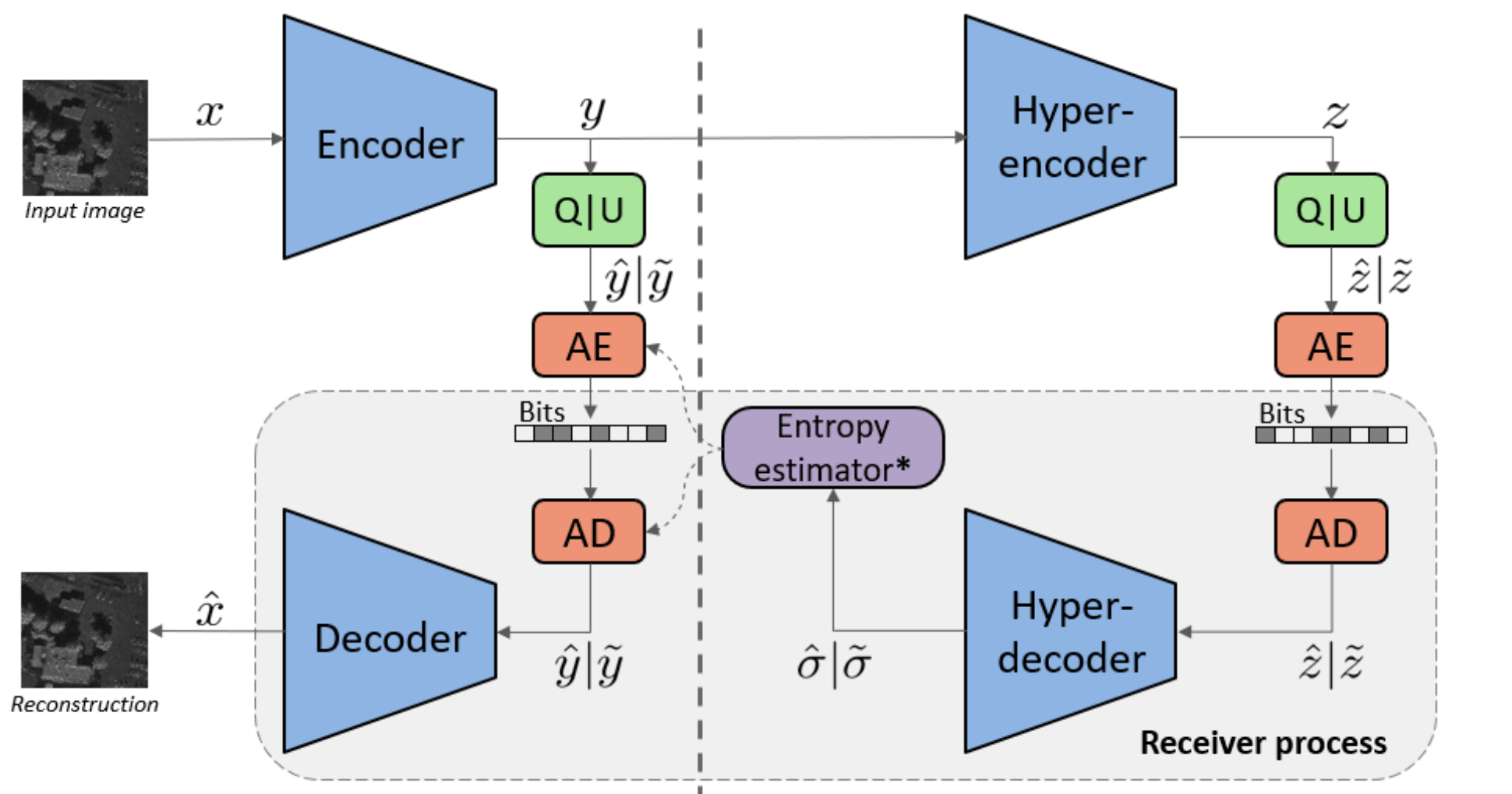
A Benchmark for SAR Learned Data Compression On-Board

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Autoencoder for Data Compression



Q/U: Quantization or added Uniform Noise AE / AD: Arithmetic Encoder and Decoder
Inspired by [1] and [2]

SAR Data Compression

Baseline

- Traditional on-board: **CCSDS 123.0-B-2**
- ML on-ground: VAE + GSM [1] and multi-Resblock + GMM [2]

Objectives

- Lowest **bits-per-pixel** rate + smallest reconstruction error
- Real-time + minimize resource consumption

Metrics

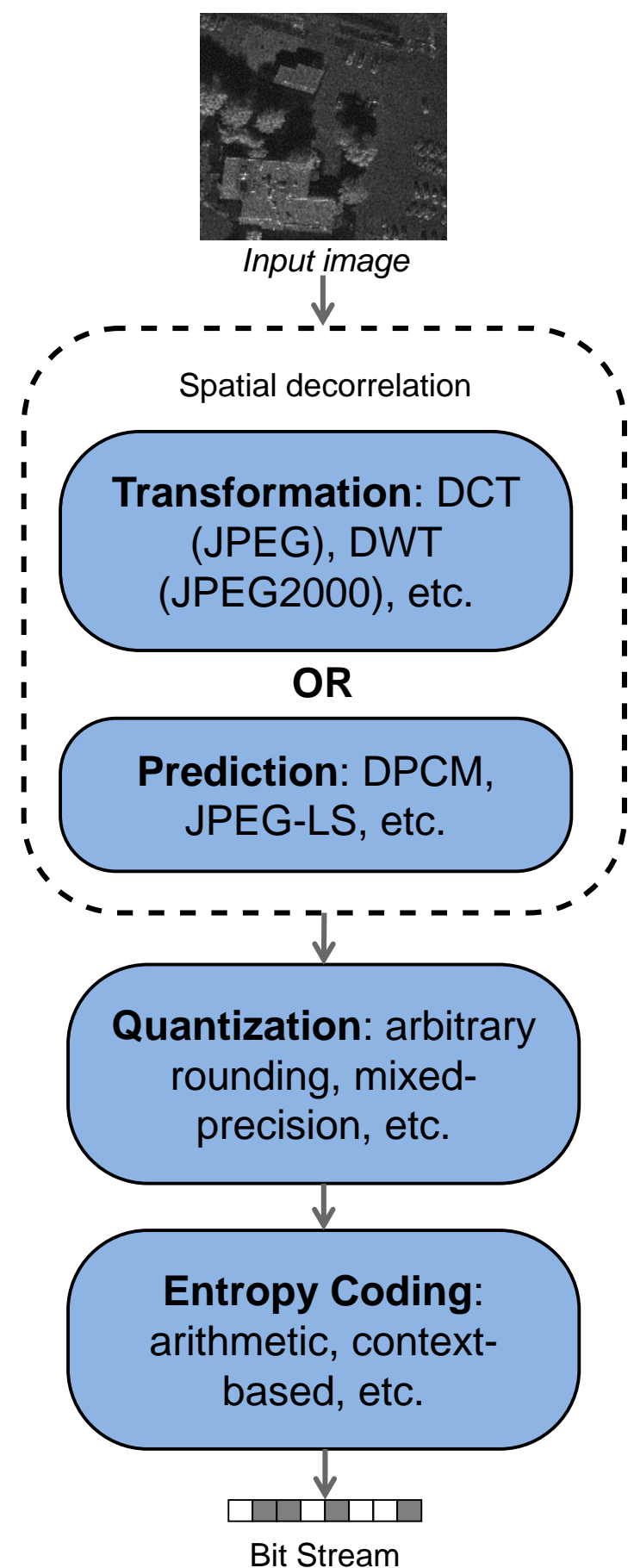
- MSE / PSNR / MS-SSIM

Data

- SARSIM / Sandia National Laboratory / ICEYE

Experiment investigation

- **Network footprint** Vs. reconstruction performance
- SAR data type format impact on performance



Processing

Network input - SAR data formats

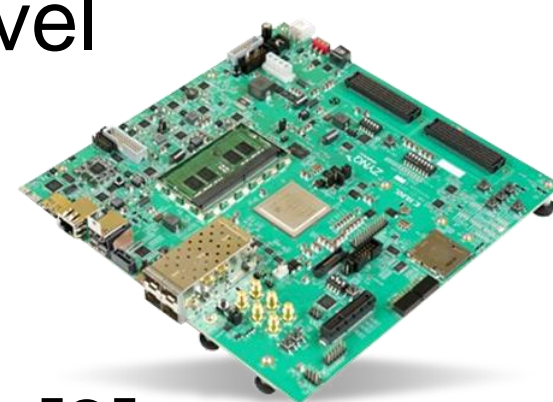
- Complex Neural Network
 $\Rightarrow [z = x + jy] \in \mathbb{C}^{W \times H}$
- Real + Imaginary
 $\Rightarrow [x, y] \in \mathbb{R}^{2 \times W \times H}$
- Magnitude + Phase
 $\Rightarrow [\sqrt{x^2 + y^2}, \text{atan}(\frac{y}{x})] \in \mathbb{R}^{2 \times W \times H}$
- Amplitude image
 $\Rightarrow [\sqrt{x^2 + y^2}] \in \mathbb{R}^{W \times H}$

A lightweight model

- **Automatic Mixed-Precision** training
- Post-training pruning + Fine-tuning

FPGA: Zynq™ UltraScale+™ MPSoC

- **DPU** with highly optimized tensor-level instruction set
- **VITIS AI** support: Quantization, Compilation, and Deployment
- Used in the EO-ALERT 2020 project [3]



Discussion

- Lossy (ML) Vs. **near-lossless** (traditional)?
- General SAR Data compression algorithm or scene / band specific?
- Quantization / Entropy Coding / Network Pruning + Fine-tuning, SAR-specific?

Sources

- [1] Q. Xu *et al.*, "Synthetic Aperture Radar Image Compression Based on a Variational Autoencoder," *IEEE Geoscience and Remote Sensing Letters*, vol. 19, pp. 1–5, 2022, doi: [10.1109/LGRS.2021.3097154](https://doi.org/10.1109/LGRS.2021.3097154).
- [2] C. Fu, B. Du, and L. Zhang, "SAR Image Compression Based on Multi-Resblock and Global Context," *IEEE Geoscience and Remote Sensing Letters*, vol. 20, pp. 1–5, 2023, doi: [10.1109/LGRS.2023.3243250](https://doi.org/10.1109/LGRS.2023.3243250).
- [3] M. Caon *et al.*, "Very Low Latency Architecture for Earth Observation Satellite Onboard Data Handling, Compression, and Encryption," in *2021 IEEE International Geoscience and Remote Sensing Symposium IGARSS*, Jul. 2021, pp. 7791–7794. doi: [10.1109/IGARSS47720.2021.9554085](https://doi.org/10.1109/IGARSS47720.2021.9554085).