FEW-SHOT MODULATION CLASSIFICATION VIA SEMI-SUPERVISED METRIC LEARNING AND CONV-TRANSFORMER

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Abstract

Automatic Modulation Classification (AMC) is a key enabler for adaptive and intelligent wireless receivers, yet practical deployments often face a shortage of labeled in-phase and quadrature (I/Q) data for new environments, devices, or waveforms. This work presents a few-shot AMC framework that combines semi-supervised metric learning with a lightweight Conv-Transformer encoder to achieve robust recognition with minimal labeled samples. The proposed model extracts local time–frequency patterns using efficient convolutional blocks and captures long-range temporal dependencies through a compact Transformer module, producing discriminative embeddings suitable for prototype-based classification. To leverage abundant unlabeled signals, we introduce a semi-supervised objective that integrates supervised prototypical loss on episodic few-shot tasks with consistency regularization under realistic I/Q augmentations and confidence-based pseudo-labeling. Experiments on synthetic I/Q datasets with channel impairments demonstrate improved accuracy and stability in low-label regimes compared to purely supervised baselines, while maintaining low computational cost suitable for edge receivers. The approach provides an effective and scalable pathway for AMC under limited annotation budgets, and can be extended to real-world datasets and more complex channel conditions.