AMC-Net: An Effective Network for Automatic Modulation Classification

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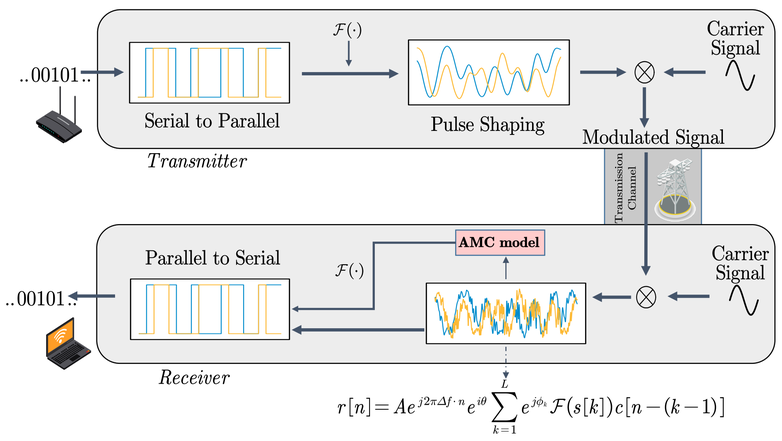
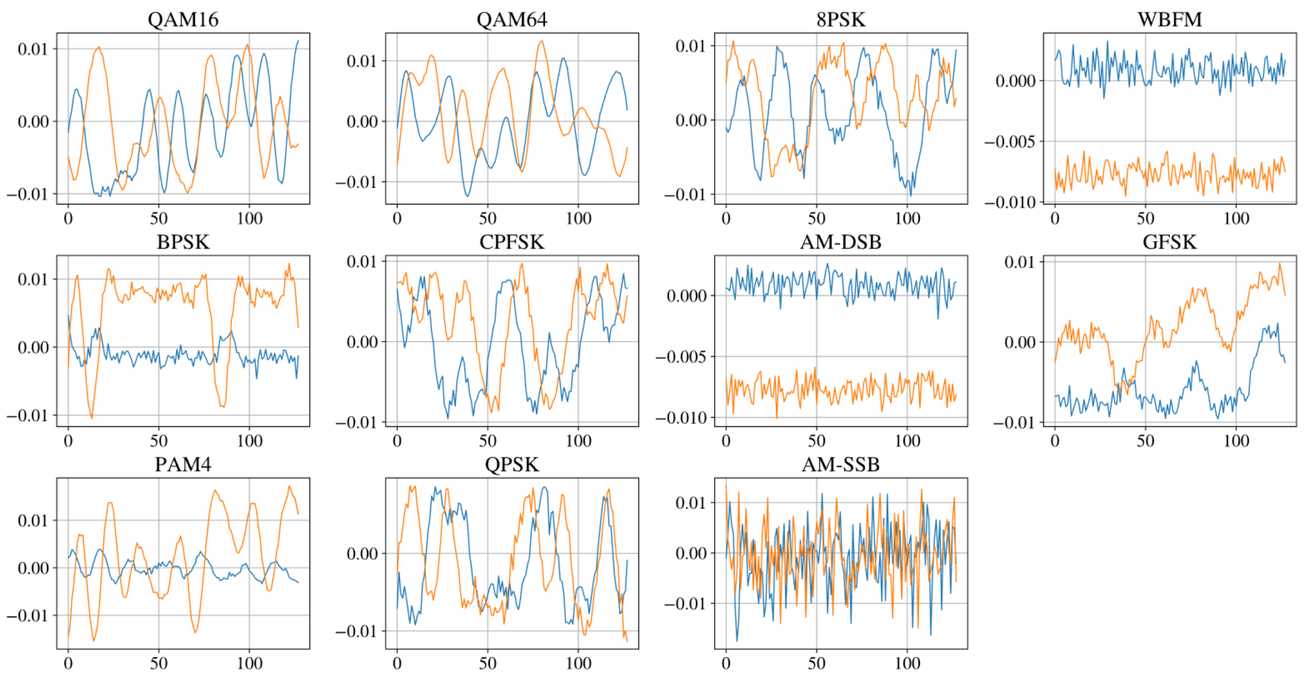
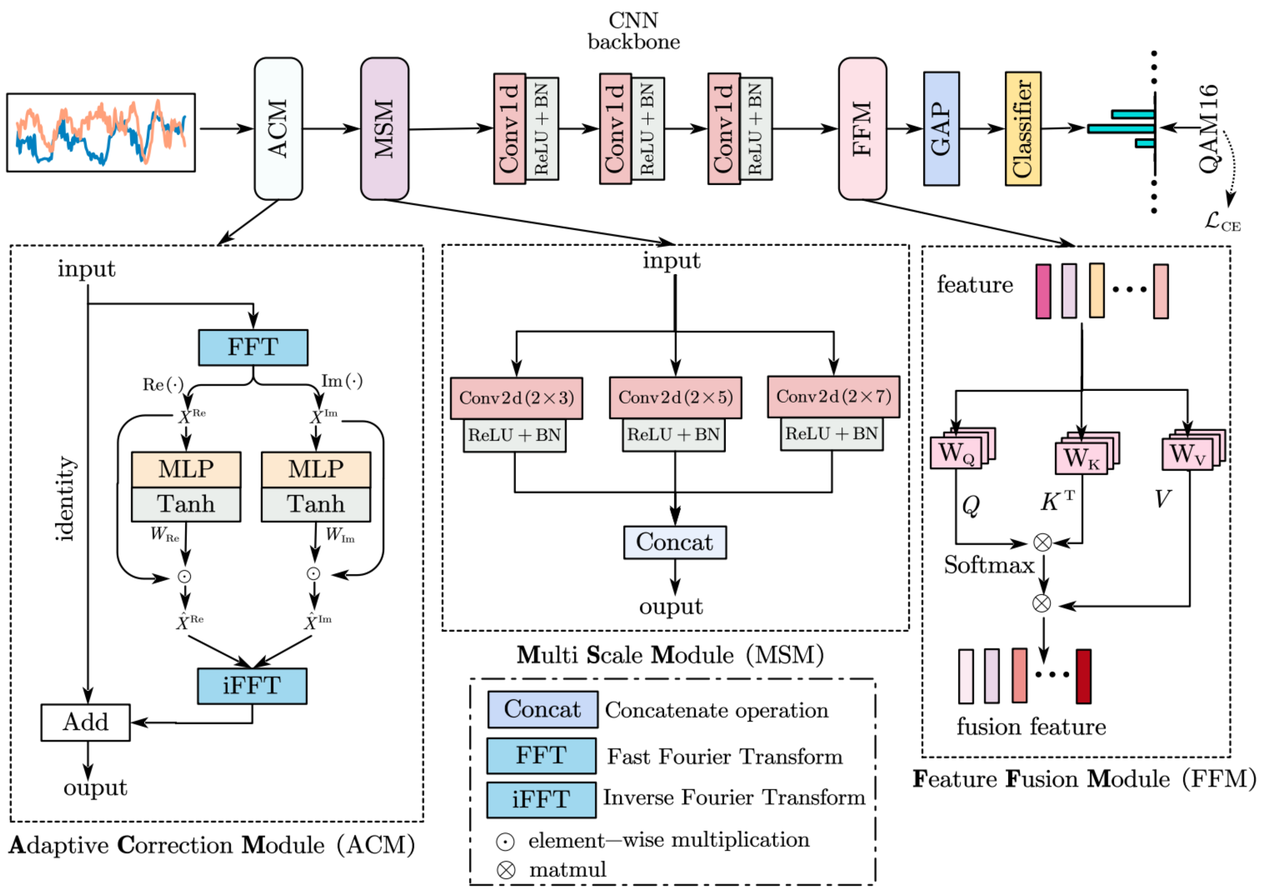
Background & Motivation

Automatic modulation classification (AMC) is a crucial stage in the spectrum management, signal monitoring, and control of wireless communication systems. The accurate classification of the modulation format plays a vital role in the subsequent decoding of the transmitted data. End-to-end deep learning methods have been recently applied to AMC, outperforming traditional feature engineering techniques. However, AMC still has limitations in low signal-to-noise ratio (SNR) environments. To address the drawback, we propose a novel AMC-Net that improves recognition by **denoising** the input signal in the **frequency domain** while performing multi-scale and effective feature extraction.





Proposed Approach



Adaptive **C**orrection **M**odule (ACM)

Multi **S**cale **M**odule (MSM)

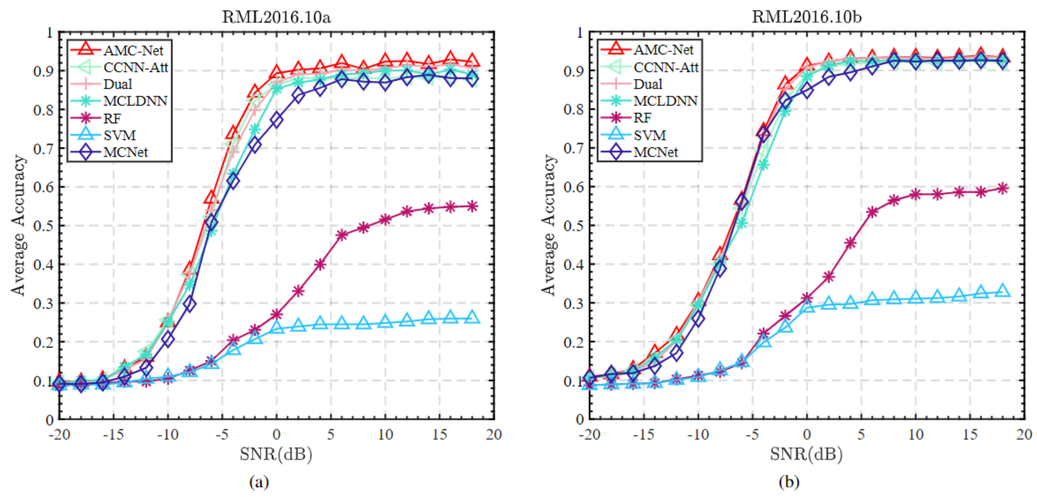
Feature **F**usion **M**odule (FFM)

Contributions

- To mitigate the effects of noise and offset, we propose a novel ***Adaptive Correction Module (ACM).*** By learning a set of weights in the frequency domain to correct the spectrum, it can eliminate noise in the original signal.
- To learn multi-scale representations in modulated signals, we design a ***Multi-Scale Module (MSM).*** It can effectively capture features of signal, such as amplitude, phase and frequency, at different scales.
- For better learning of temporal correlation in signal sequences, we propose a ***Feature Fusion Module (FFM)*** based on self-attention mechanism. It can handle long-distance dependence and support parallel computation.

Results

- Comparisons with baselines



(a) (b)

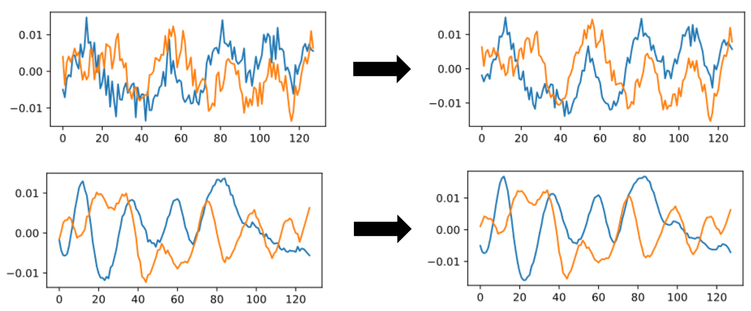
Model	RML2016.10a Dataset		
	OA	macro-F1	Kappa
SVM	18.55%	0.1923	0.1472
RF	29.73%	0.3023	0.2733
MCLDNN	61.23%	0.6344	0.5776
CCNN-Att	60.30%	0.6243	0.5609
Dual-Net	61.11%	0.6328	0.5731
MCNet	57.38%	0.5879	0.5360
AMC-Net	**62.51 %**	**0.6483**	**0.5885**
Model	RML2016.10b Dataset		
	OA	macro-F1	Kappa
SVM	21.83%	0.2214	0.1833
RF	32.46%	0.3318	0.2841
MCLDNN	62.78%	0.6338	0.5874
CCNN-Att	63.03%	0.6364	0.5901
Dual-Net	64.05%	0.6399	0.6017
MCNet	62.34%	0.6279	0.5832
AMC-Net	**64.63 %**	**0.6487**	**0.6081**

Model	Learned Parameters	Inference time(ms/batch)
SVM	-	0.018
RF	-	0.015
MCLDNN	0.41M	4.24
CCNN-Att	0.38M	1.93
Dual-Net	0.83M	9.12
MCNet	0.13M	1.78
AMC-Net	0.47M	1.52

- Ablation study

model	OA	macro-F1	Kappa
AMC-Net w/o MSM	0.6135	0.6336	0.5749
Δ	-1.16%	-1.47%	-1.36%
AMC-Net w/o ACM	0.6038	0.6277	0.5641
Δ	-2.13%	-2.06%	-2.44%
AMC-Net w/o FFM	0.6093	0.6304	0.5702
Δ	-1.58%	-1.79%	-1.83%
AMC-Net	**0.6251**	**0.6483**	**0.5885**

- ACM visualize



Datasets & Metric & Project

- Datasets: RadioML2016.10a and RadioML2016.10b
- Metrics: Overall Accuracy, Macro-F1, Kappa Coefficient
- Link: https://github.com/zjwXDU/AMC-Net

Key References

[MCLDNN] "A Spatiotemporal Multi-Channel Learning Framework for Automatic Modulation Recognition" in IEEE Wireless Communications Letters

[MCNet] “MCNet: An Efficient CNN Architecture for Robust Automatic Modulation Classification” in IEEE Communications Letters

[CCNN-Att] "A Radio Signal Recognition Approach Based on Complex-Valued CNN and Self-Attention Mechanism," in IEEE Transactions on Cognitive Communications and Networking

[Dual-Net] "Automatic Modulation Classification Using CNN-LSTM Based Dual-Stream Structure," in IEEE Transactions on Vehicular Technology.

Acknowledgement

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