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Modulation recognition network of multi-scale analysis with deep threshold noise elimination

Key words: Signal noise elimination; Deep adaptive threshold learning network; Multi-scale feature fusion; Modulation recognition

Corresponding author: Chunrui TANG
E-mail: chunruitang@126.com
ORCID: https://orcid.org/0009-0005-6995-283X

Motivation

- Adopt deep learning techniques to replace traditional modulated signal processing techniques.

- Improve the accuracy of modulated signal recognition in variable environments and reduce the impact of factors such as lack of prior knowledge on recognition results.

- Solve the problem of low recognition accuracy of the modulated signal at low signal-to-noise ratios.

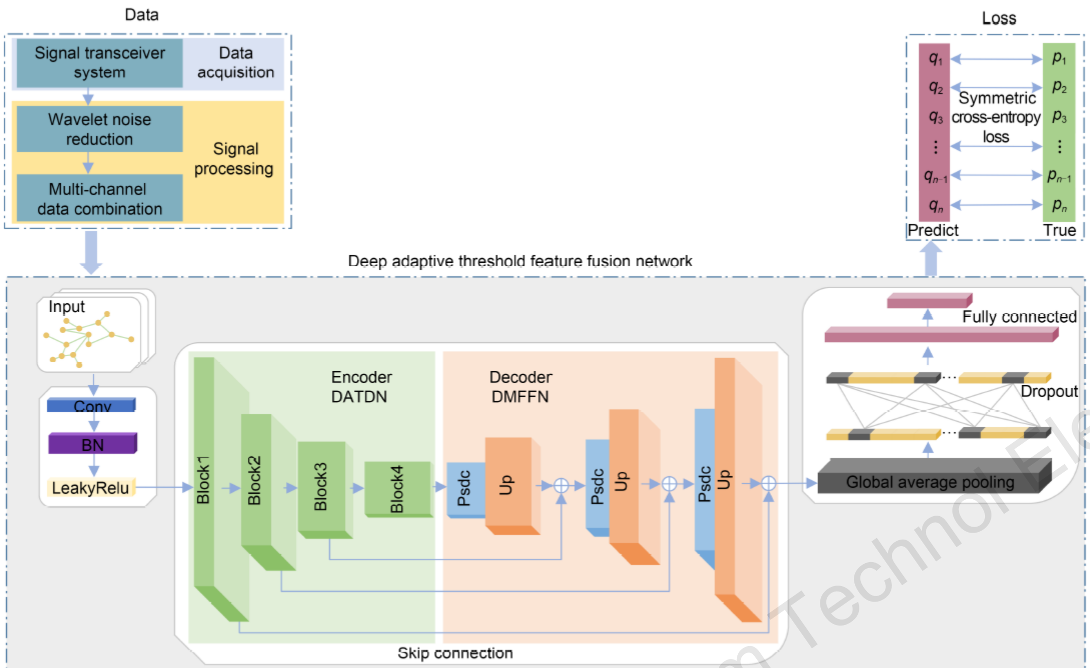
Main idea

- We design a novel modulation recognition network of multi-scale analysis with deep threshold noise elimination to recognize the actually collected modulated signals under a symmetric cross-entropy function of label smoothing.

- The network consists of a denoising encoder with deep adaptive threshold learning and a decoder with multi-scale feature fusion.

- The two modules are skip-connected to work together to improve the robustness of the overall network.

Method



Signal recognition system framework

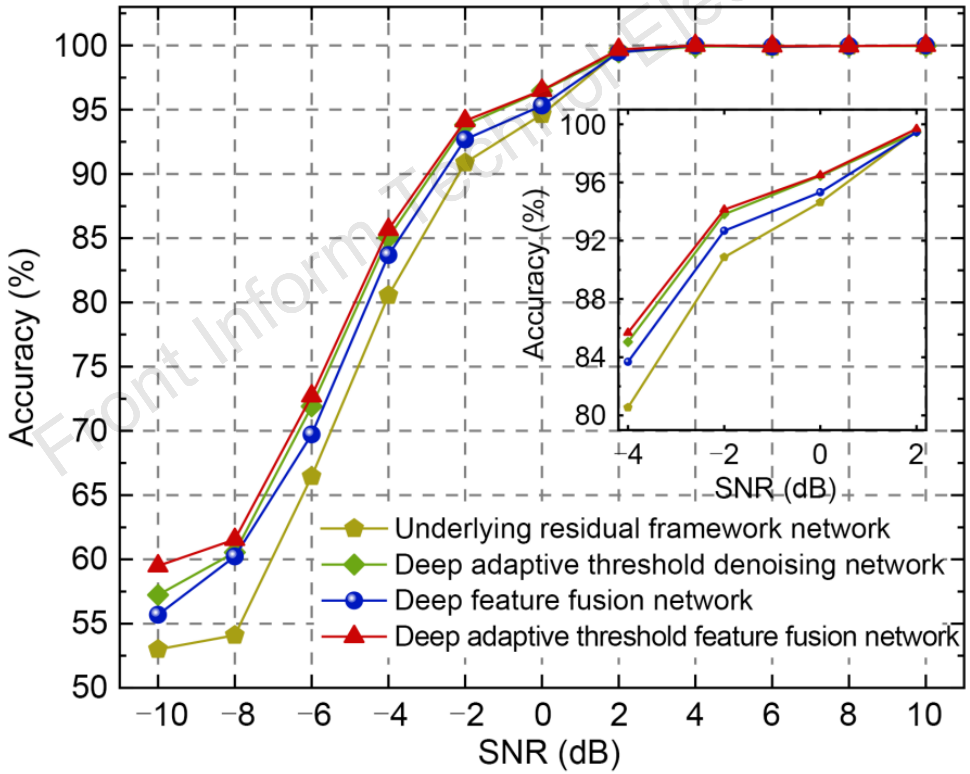
- DATDN: deep adaptive threshold denoising network
- DMFFN: deep multi-scale feature fusion network
- Psdc: parallel structure of dilated convolution
- Up: upsampling

- The signal transceiver system collects the modulation signal to obtain in-phase and quadrature components.
- We use wavelet noise reduction on the components and combine them into multi-channel data.
- The pre-processed data are read into the deep adaptive threshold feature fusion network to obtain a prediction.
- The symmetric cross-entropy loss function between predicted category and actual category is calculated to obtain the loss value.

Major results

1. Results of the role of each network

For experimentation, we chose the underlying residual framework network, the deep adaptive threshold denoising network, the deep feature fusion network, and the deep adaptive threshold feature fusion network.



Major results (Cont'd)

2. Model complexity of deep adaptive threshold denoising network based on multi-scale analysis

Table 2 compares the number of parameters and recognition accuracy of the network using the underlying convolutional architecture of $1\times n+n\times 1$ in the encoding stage, the network using the output equivalent features of $n\times n$ without expansion coefficients in the decoding stage, and our convolutional combination network, at low SNR.

Table 2 Numbers of parameters and recognition results of different convolutional architectures

Network	Number of parameters	Accuracy (%)				
		−10 dB	−8 dB	−6 dB	−4 dB	−2 dB
$1\times n+n\times 1$ encoding net	16909963	58.32	60.68	72.18	84.27	93.91
$n\times n$ decoding net	47652195	58.95	61.50	71.45	84.73	93.68
Convolutional combination net	18750859	59.50	61.55	72.73	85.68	94.14

Conclusions

- Propose a deep adaptive threshold noise elimination network based on multi-scale analysis, called the DATFF network.
- Use universal software radio peripheral (USRP) to build a software radio platform to transceive the actual signal and produce signal datasets.
- Design a coding network for deep adaptive threshold noise elimination to select the optimal threshold value in the denoising pre-processing stage.
- Design a deep multi-scale feature fusion decoding network and connect the coded and decoded features in the skip connection.

Xiang LI received her BE degree in the College of Information and Communication Engineering from Harbin Engineering University, Harbin, Heilongjiang, China, in 2021. She is currently pursuing a doctoral degree at Harbin Engineering University. Her current research interests include modulation recognition of communication signals.

Yibing LI received the BE, ME, and PhD degrees from Harbin Engineering University, Harbin, Heilongjiang, China, in 1989, 1997, and 2003, respectively.
He is currently a professor with the College of Information and Communication Engineering, Harbin Engineering University.