JCCM: Joint Conformer and CNN Model for Overlapping Radio Signals Recognition

**Junbin Liang, Xiaofan Li, Hao Tong, Guanghua Yang, Zheng Shi**
School of Intelligent Systems Science and Engineering, Jinan University, Zhuhai, China.

Background

Recognizing overlapping radio signals is essential for efficient spectrum management, interference mitigation, coexistence of wireless systems, signal identification, and regulatory compliance. Two key challenges are summarized in this scenario as following:

1) In low SNR, characteristics of the overlapping signals spectrum are strongly obscured by the noise, leading to compromising identification accuracy.

2) In the propagation of wireless signals transmission, each individual component of the overlapping signals experiences diverse propagation loss, which means the scaling among each component signal exists large differences. That will introduce the difficulty on the scaling preservation.

Joint conformer and CNN models (JCCM) is proposed for the overlapping radio signals recognition and separation with scaling preservation.
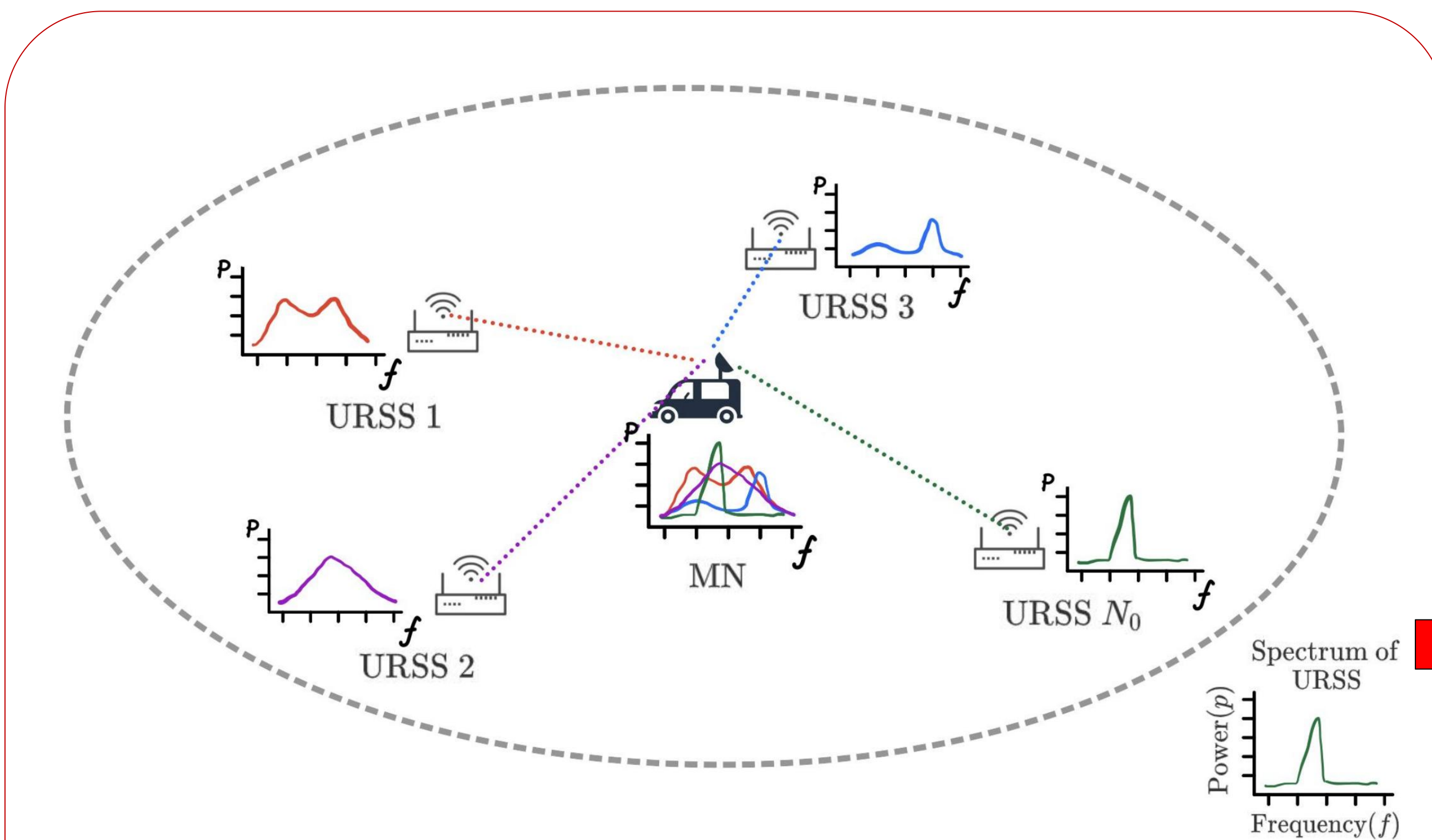
Figure 1 Overlapping Radio signals transmission model. we consider N unknown radio sources (URSs)are randomly distributed in the monitoring area (MA). one monitoring node (MN) located in the center of MA detects the radio signals, but does not have any prior information (e.g., category, location and transmitting power) about URSs. We assume that the received power of each URS is above the receiving sensitivity at MN.
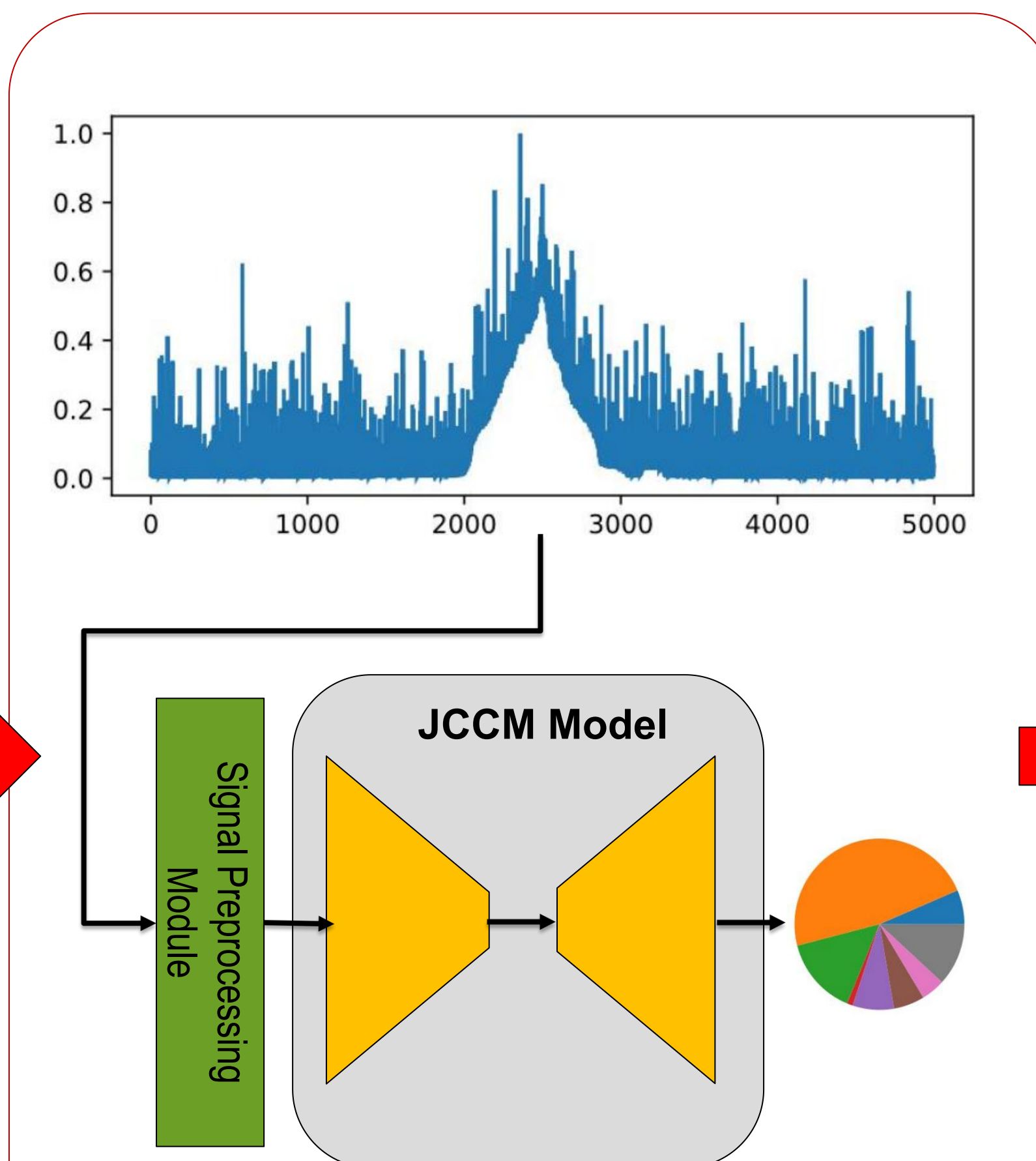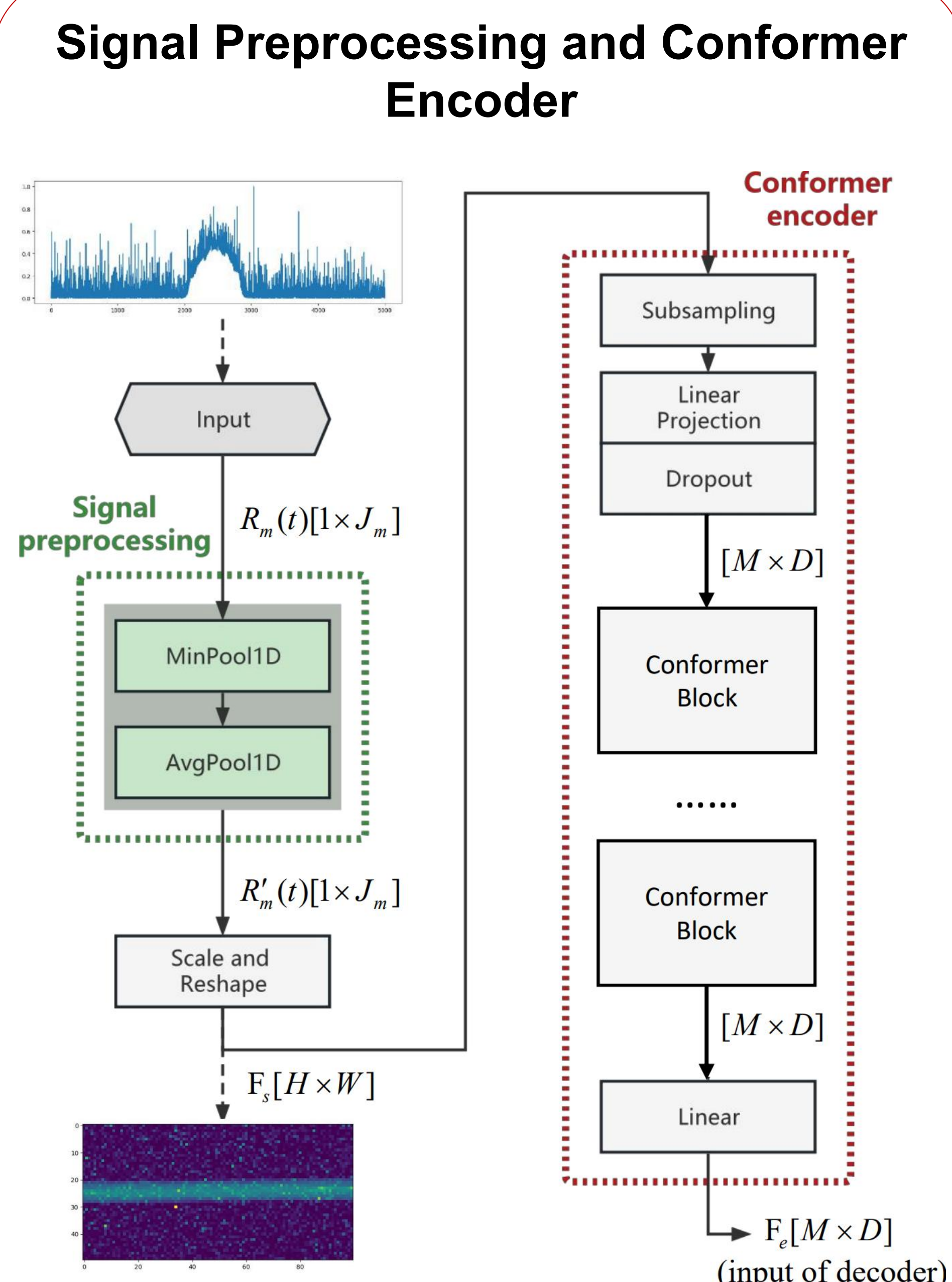

Figure 2 JCCM with Signal Preprocessing module designed for separation and scaling preservation on the overlapping radio signals.
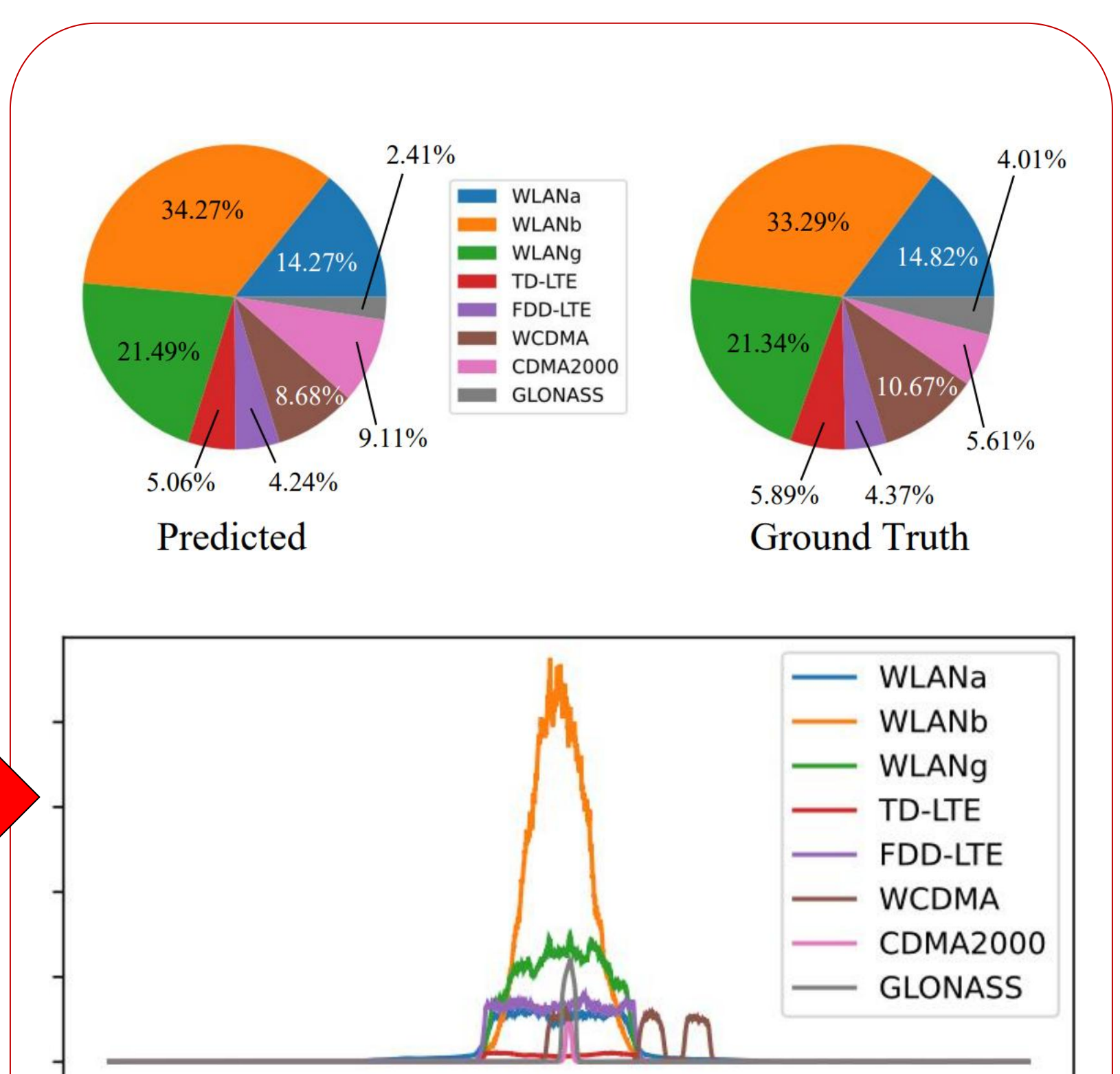

Figure 3 Overlapping radio signals, predicted and ground truth proportion of signals separation, JCCM can nearly keep the scaling of each signal.

Methods and Results

Signal Preprocessing and Conformer Encoder

Figure 4 Aiming at filtering the additive white Gaussian noisemixed with the signals, Signal Preprocessing Module was designed with a stack of pooling layers, consisting of a MinPool1D layer and an AvgPool1D layer. The conformer encoder module, which combines CNNs and transformers that was originally used for automatic speech recognition.
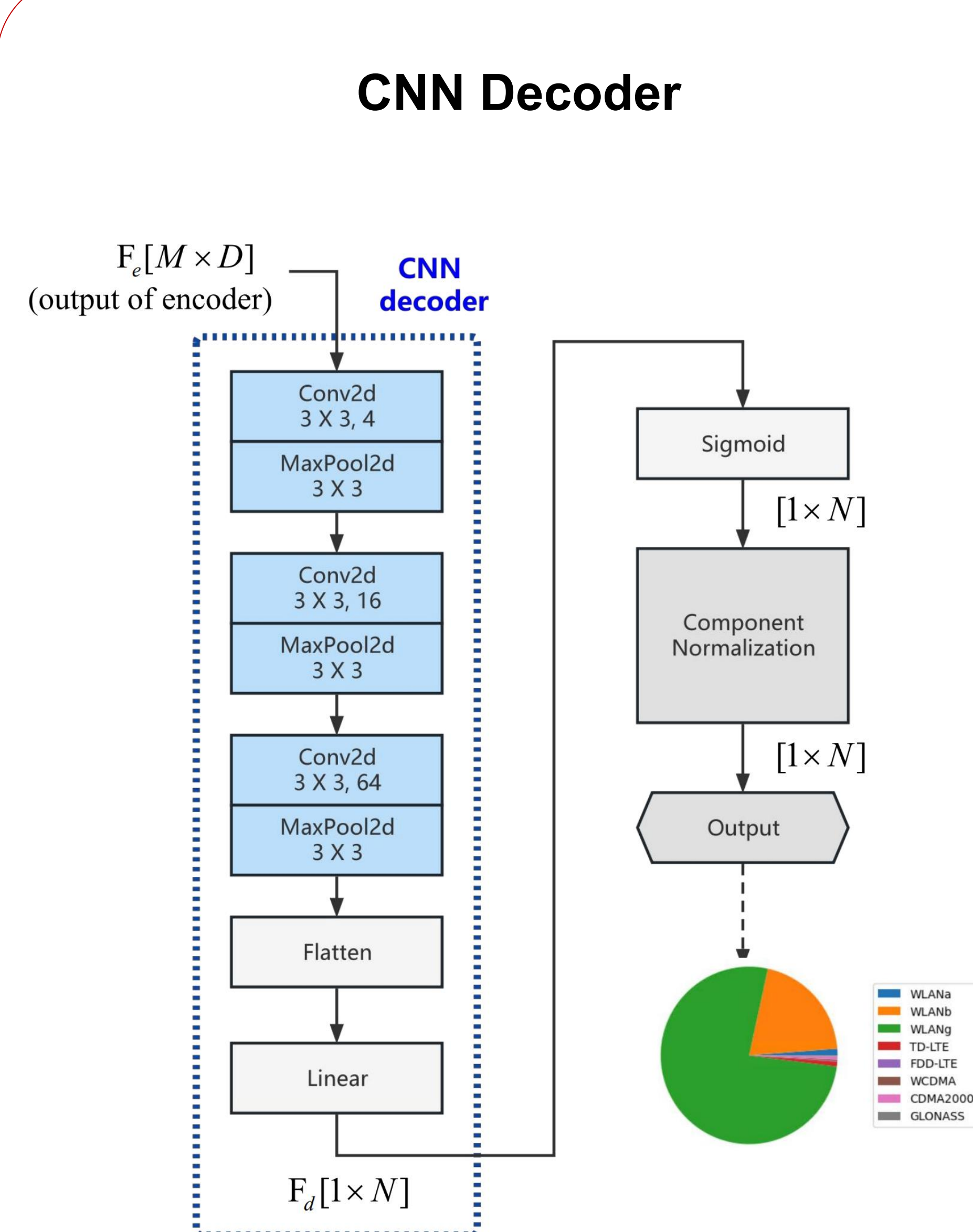
CNN Decoder

Figure 5 CNN decoder is designed to process the output feature map aiming to improve the separation accuracy and robustness of the model. To obtain the predicted component as output, the individual feature values go through Component Normalization module.

Overlapping Radio Signals Separation
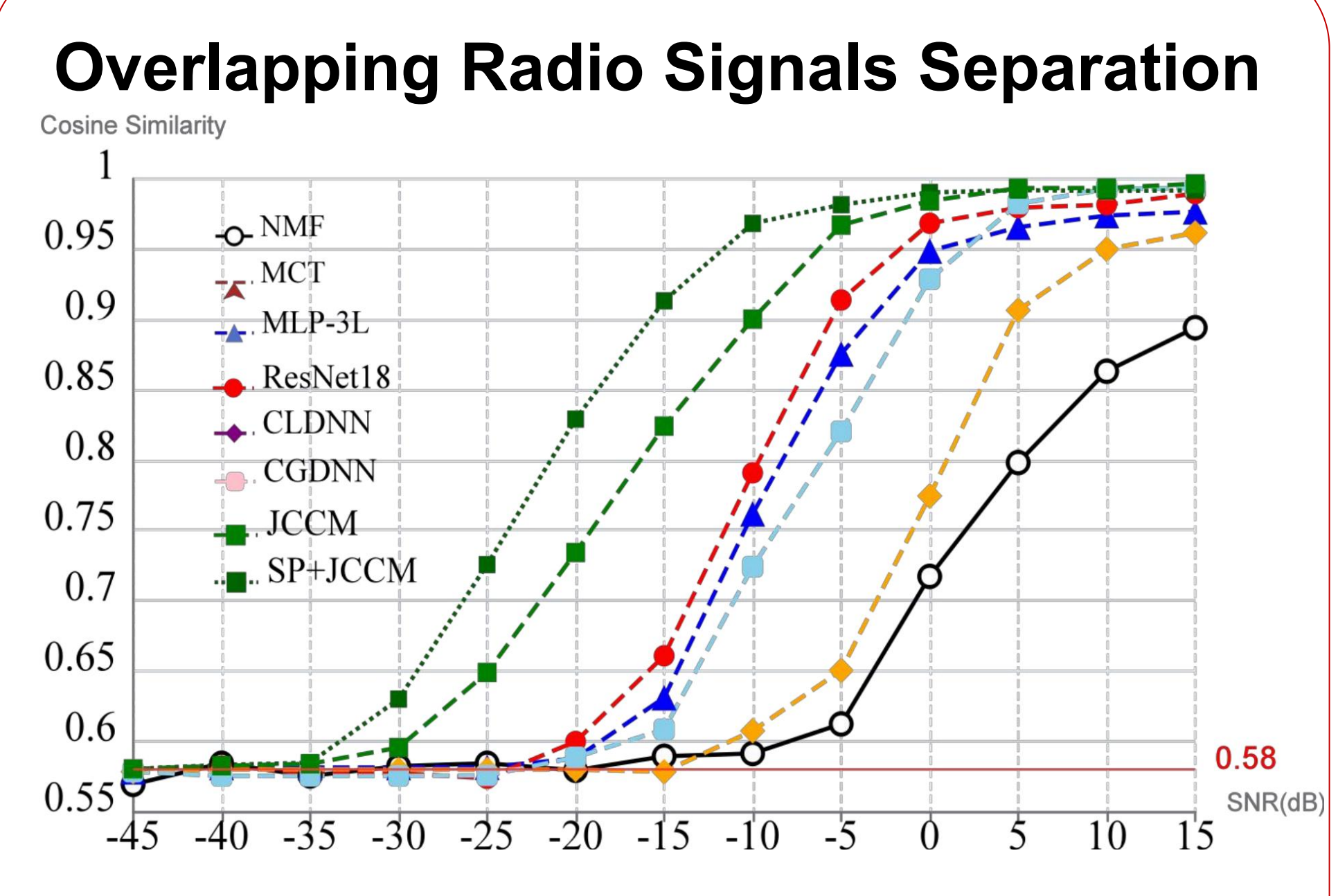
Figure 6 Cosine similarity on mixed signals separation.

Principal Signal Classification
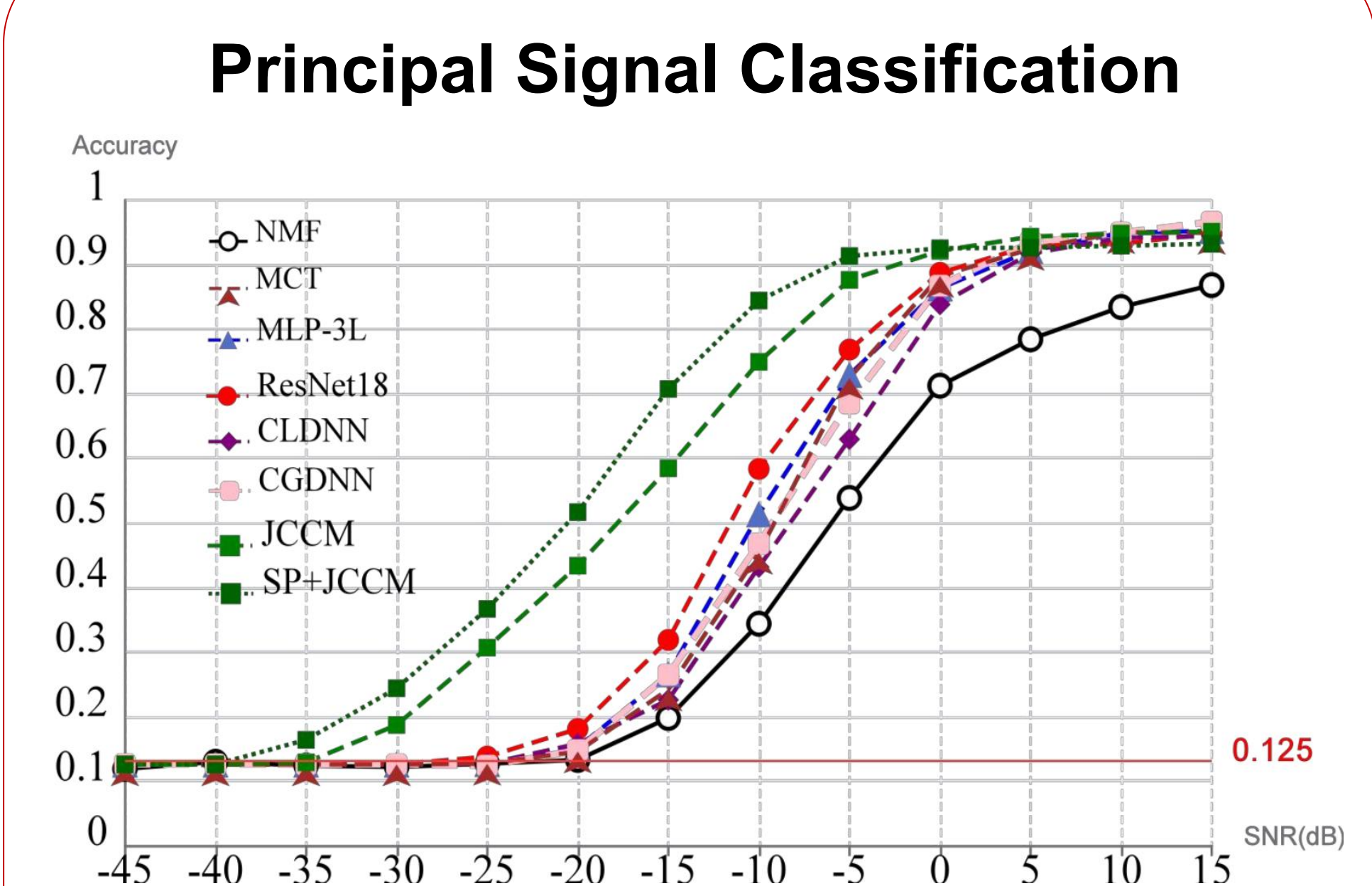
Figure 7 Principal signal classification accuracy on mixed signals.

Conclusions

JCCM performs feature extraction by using the multi-headed self-attention of conformer to generate feature maps and decodes by taking advantage of CNN's global and local feature perception. Through applying JCCM, signal separation, keep scaling and principal signal classification for the overlapping radio signals are achieved simultaneously.