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Signal recognition and background suppression by matched filters and neural networks for Tunka-Rex

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The Tunka Radio Extension (Tunka-Rex) is a digital antenna array, which measures the radio emission of the cosmic-ray air-showers in the frequency band of 30-80 MHz. Tunka-Rex is co-located with TAIGA experiment in Siberia consists of 63 antennas, 57 of it in a densely instrumented area of about 1 km². In the present work we discuss the improvements of the signal reconstruction applied for the Tunka-Rex. At the first stage we implemented matched filtering using averaged signals as templates. The simulation study has shown that matched filtering allows one to decrease the threshold of signal detection and increase its purity. However, the maximum performance of matched filtering is achievable only in case of white noise, while in reality the noise is not fully random due to different reasons. To recognize hidden features of the noise and treat them, we decided to use convolutional neural network with autoencoder architecture. Convolution filters take into account different features of noise, while autoencoder is unsupervised neural network with compressed representation, which decodes main features of reconstructed signal. Taking the recorded trace as an input, the autoencoder returns denoised trace, i.e. removes all signal-unrelated amplitudes. We tested designed network using standard validation control with train/test split of CoREAS traces noised with Tunka-Rex background library. The test has shown that neural networks have a potential of lowering the threshold even better than with matched filtering. We present the comparison between standard method of signal reconstruction, matched filtering and autoencoder, and discuss the prospects of application of neural networks for lowering the threshold of digital antenna arrays for cosmic-ray detection.

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