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Searching for gravitational waves from stellar-mass binary black holes early inspiral

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The early inspiral from stellar-mass black hole binaries can emit milli-Hertz gravitational wave signals, making them detectable sources for space-borne gravitational wave missions like TianQin. However, the traditional matched filtering technique poses a significant challenge for analyzing these kinds of signals, as it requires an impractically high number of templates ranging from 10^31 to 10^40.
Our proposed search strategy comprises two key elements: firstly, we employ incremental principal component analysis (IPCA) to reduce the dimensionality of simulated signals. Subsequently, we analyze the data using convolutional neural networks (CNN).
The trained IPCA model demonstrates high compression efficiency, achieving a cumulative variance ratio of 95.6% when applied to 10^6 simulated sBBH signals.
To evaluate the CNN detection model, we generate a receiver operating characteristic curve using test signals with varying signal-to-noise ratios. At a false alarm rate of 0.01, the corresponding true alarm rate for signals with a signal-to-noise ratio of 50 is 87.2%.

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