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GWAK: Low-Latency Machine Learning for Real-Time Detection of Unmodeled Gravitational Wave Transients

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Matched-filtering detection techniques for gravitational-wave (GW) signals in ground-based interferometers rely on having well-modeled templates of the GW emission. Such techniques have been traditionally used in searches for compact binary coalescences (CBCs) and have been employed in all known GW detections so far. However, interesting science cases aside from compact mergers do not yet have accurate enough modeling to make matched filtering possible, including core-collapse supernovae and sources where stochasticity may be involved. Therefore, the development of techniques to identify sources of these types is of significant interest.

We present a method of anomaly detection based on deep recurrent autoencoders to enhance the search region to unmodeled transients. Our approach, which we name "Gravitational Wave Anomalous Knowledge" (GWAK), employs a semi-supervised strategy designed for low-latency machine learning applications. GWAK runs in real time, offering a faster alternative to matched filtering and other classical burst identification techniques by leveraging the efficiency of deep learning algorithms.

While the semi-supervised nature of the problem comes with a cost in terms of accuracy compared to supervised techniques, there is a qualitative advantage in generalizing experimental sensitivity beyond pre-computed signal templates. We construct a low-dimensional embedded space using the GWAK method, capturing the physical signatures of distinct signals on each axis of the space. By introducing signal priors that capture some of the salient features of GW signals, we allow for the recovery of sensitivity even when an unmodeled anomaly is encountered.

We then show the newly public results for the GWAK algorithm on the third LIGO observing run (O3), including events not identified by any previous burst-detection algorithms.

Focus areas

MMA

Primary authors: MORENO, Eric Anton (Massachusetts Institute of Technology (US)); GOVORKOVA, Katya (Massachusetts Inst. of Technology (US)); HARRIS, Philip Coleman (Massachusetts Inst. of Technology (US)); RAIKMAN, Ryan (Massachusetts Institute of Technology)

Presenter: MORENO, Eric Anton (Massachusetts Institute of Technology (US))

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