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EINSTEIN EQUATIONS: PHYSICAL AND MATHEMATICAL ASPECTS OF GENERAL RELATIVITY

SHORT TALKS

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Using machine learning to detect gravitational waves from young neutron stars

We present a new study on the effectiveness of artificial and convolutional neural networks (ANNs and CNNs) to detect long duration transient gravitational waves, signals lasting for hours-days, from isolated neutron stars.
These signals could come from a remnant of a binary neutron star merger (GW170817) or from a core-collapse supernova, which are likely to be seen in LIGO/Virgo's third observing run. While much work has been done on developing ANNs/CNNs for gravitational wave detection of binary black hole signals, these algorithms have not yet been expanded to long duration transient signals from isolated neutron stars, nor has there been a study on the application of such methods to a real search and the limitations that one would encounter, such as a finite amount of training data and nonstationary noise.
We first quantify how robust the ANNs/CNNs are towards different signal morphologies, specifically showing that they can detect a signal whose frequency evolution follows a different power law than the signals on which the ANNs/CNNs were trained.
Then, we demonstrate that the non-stationary noise decreases the ANNs'/CNNs' detection efficiency and thus the changing noise needs to be considered in a real search.
Additionally we show that an ANN trained on injections in white noise can still achieve decent detection efficiencies when used on real noise, implying that simulated data may be able to supplement limited training data.
We also determine that using an ensemble of ANNs, where each ANN is trained on different portions of the input images, can reduce the false alarm probability, an output of the analysis that in conventional methods is typically easy to control.
Finally we compare the detection efficiencies and false alarm probabilities of the ANNs/CNNs to the Generalized FrequencyHough (GFH), a pattern-recognition technique that can search for signals whose frequencies follow a power-law behavior.
Even though the ANNs/CNNs are less sensitive than the GFH, they are more robust and much faster than the GFH after training.