Contribution ID: **278** Type: **Oral**

Exploring the Efficacy of Curriculum Learning in Training Neural Networks for Gravitational Wave Detection and Parameter Estimation in Near-Realistic Conditions

The detection and parameter estimation of compact binary coalescences (CBC) through the analysis of gravitational wave signals have been revolutionized by the advent of deep learning neural networks. Conventionally, curriculum learning, a method that progressively exposes a neural network to more challenging examples during training, has emerged as the de facto procedure for training these networks in the context of gravitational wave analysis. This approach capitalizes on the unique advantage of generating waveform data with desired signal-to-noise ratios (SNR) using well-established modules such as PyCBC.

This study diverges from the established paradigm by investigating the effectiveness of multiple deep learning neural networks, such as CNNs, RNNs, Autoencoders and Transformers, for gravitational wave detection and parameter estimation when curriculum training is not employed, and the noise conditions deviate from the typical Gaussian and stationary assumptions. In astrophysical scenarios, gravitational wave signals often encounter non-ideal conditions, including non-Gaussian noise and non-stationary backgrounds. Understanding and quantifying how neural networks perform under these realistic conditions is crucial for advancing the field of multi-messenger astronomy.

We present the results of comprehensive experiments that involve training deep learning models on datasets containing non-Gaussian and non-stationary noise profiles. We evaluate the networks' ability to accurately detect gravitational wave events and estimate their parameters in these challenging scenarios. Our findings shed light on the adaptability and robustness of neural networks in the face of real-world noise challenges and evaluate the resilience and fragility of deep learning algorithms for gravitational wave analysis.

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Session Classification: Gravitational Waves

Track Classification: Gravitational Waves