Quantifying Sensitivity and Classifying Gravitational Waves: Machine Learning CNN Approach to Data Analysis and Interpretation

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The Laser Interferometer Gravitational-Wave Observatory (LIGO) is a ground-based interferometer designed to detect gravitational waves (GWs). The search for these waves in detector data faces challenges due to significant computational demands and the need for human verification, which can be time-consuming and prone to errors. This study presents preliminary results of a machine-learning approach, specifically a convolutional neural network (CNN). This algorithm is trained to differentiate between marginal and confident GW detections in the presence of noise overlay and data glitches. Using data from the Gravitational-Wave Transient Catalog (GTWC) releases during the O1, O2, and O3 observational runs, the 2D CNN analyzes spectrograms to categorize strains from the H1 and L1 LIGO detectors. It employs spectral analysis and 3-D GW strain images from the Gravitational Wave Open Science Center (GWOSC) to recognize detections, including under data augmentation conditions. After validation, the true positive rate (TPR) threshold is used to evaluate the model's robustness, while repetitive trials with original and noise-added data assess consistency. In brief, this approach utilizes trend recognition to improve GW detection, helping reduce false alarm rates in identification and eventually promote further extraterrestrial exploration.

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