Form 8

Research Result Report
ICRR Inter-University Research Program 2024

Research Subject:

Applications of machine learning technique on gravitational wave detection

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Summary of Research Result :

This report summarizes our progress on applying machine learning (ML) to gravitational wave (GW) detection in KAGRA, conducted under the FY2024 ICRR Inter-University Research Program.

Over the past year, we continued developing DeepClean, an ML-based tool for subtracting stationary background noise in KAGRA. We focused on the [364 Hz, 374 Hz] frequency band, analyzing the coherence between GW strain data and Physical Environmental Monitor (PEM) channels to identify noise sources. DeepClean was used to remove coherent noise, and comparisons between high and low coherence data provided insights into the noise evolution. We also tested the online implementation of DeepClean.

In parallel, we developed an unsupervised ML model to classify glitches in KAGRA O4a data. This led to the discovery of several new glitch types not observed in LIGO. Special attention was given to scattering light noise, caused by diffused light re-entering the main interferometer beam. This noise, degrading sensitivity in the 30–100 Hz range, appears as arch-shaped features with a ~2.5 s period in time-frequency maps. We identified high coherence between the strain and LSC-POP/REFL (MICH/PRCL) channels, which may allow efficient time tagging of scattering light events and aid the commissioning team in mitigation efforts.

We also evaluated GW-SkyLocator, an ML model for rapid sky localization of compact

binary coalescence (CBC) events. Compared to traditional methods like Bayestar, it significantly reduces computation time. Tests on 2,000 BNS events showed that including KAGRA (K1) data improved sky localization, reducing the predicted sky area when compared with results using only L1, H1, and V1.

Additionally, we introduced CCSNet, an ML model for detecting GW signals from core-collapse supernovae (CCSN). It effectively distinguishes CCSN signals from glitches, reducing the false alarm rate in GW detection.

The FY2024 funding supported participation in the 34th KAGRA Face-to-Face Meeting at ICRR (Dec 16–18, 2024). During the meeting:

- I presented our latest research progress.
- *Jheng-Min Chen* presented a poster: *Machine Learning on Gravitational Wave Sky Localization: GW-SkyLocator*.
- *Wong Nim Ki* presented a poster: *Coherence Analysis and Noise Reduction with DeepClean on O4a*.
- *Shih-Hong Hsu* presented a poster: *Investigation of Scattering Light Noise in the KAGRA Interferometer*.
- *Hong-Yin Chen* delivered an oral presentation: *Gravitational Wave Anomaly Detection Pipeline: GWAK*.

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