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Robust Low-z Hubble Constant Determination Using Machine Learning Assisted Outlier Detection of Type Ia Supernovae from the NED-D Dataset

Abstract

Context: Accurate determination of the Hubble constant (H0) using low-redshift Type Ia supernovae (SNIa) is critical for precision cosmology. Outliers in distance measurements act like noise in high-precision experimental data, potentially biasing results, similar to errors in beam-based imaging systems.

Purpose: We develop a reproducible pipeline for low-z H0 estimation, explicitly motivated by applications requiring high-precision, noise-resilient measurements in imaging-intensive experimental setups. The goal is to minimize the impact of anomalous SNIa while ensuring reliable results.

Methods: The NED-D SNIa dataset is analyzed using Isolation Forests to detect and remove outliers with inconsistent distances or velocities. Weighted H0 is calculated from the cleaned sample, and bootstrap resampling is employed to quantify uncertainties. An interactive exploration of outliers is provided, highlighting SNIa that strongly influence H0.

Findings: The cleaned sample yields H0 ≈ 66–68 km/s/Mpc with uncertainties around 1 km/s/Mpc. Outlier removal significantly reduces bias and variance. The ranked outlier table identifies influential supernovae, analogous to pinpointing critical deviations in experimental imaging systems.

Significance: Machine learning-assisted outlier detection combined with reproducible uncertainty quantification provides a robust framework for high-precision cosmological measurements. This approach mirrors strategies in beam diagnostics and imaging experiments, where reliable anomaly detection and uncertainty control are crucial for accurate interpretation.

Keywords: Hubble constant; Low-redshift supernovae; Isolation Forest; Bootstrap uncertainty; Weighted H0; Robust measurement; Imaging diagnostics.

Author: SHARMA, Anshu (Patna Women's College)

Co-authors: Dr N/A, Amrita (Patna Women's College); Ms SINGH, Kanishka (Patna Women's College)

Presenters: Dr N/A, Amrita (Patna Women's College); SHARMA, Anshu (Patna Women's College); Ms SINGH, Kanishka (Patna Women's College)