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Machine Learning-based Search of High-redshift Quasars

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High-redshift (z > 5) quasars provide effective probes for the study of galaxy evolution and cosmology, hence it is critical to obtain a large sample of high-redshift quasars to study the intergalactic medium, circumgalactic medium and the co-evolution of supermassive black holes and their host galaxies. Here we present a machine learning search for high-redshift (5.0 < z < 6.5) quasars using the combined photometric data from the DESI Imaging Legacy Surveys and the WISE survey. We discuss the imputation of missing values for high-redshift quasars, analyze the feature selections, compare different machine learning algorithms, and investigate the selections of class ensemble for the training sample. The 11-class random forest model can achieve a precision of 96.43% and a recall of 91.53% for high-redshift quasars for the test set. Using MUSE and DESI-EDR public spectra, we find that 14 true high-redshift quasars (11 in the training sample) out of 21 candidates are correctly identified for MUSE, and 20 true high-redshift quasars (11 in the training sample) out of 21 candidates are correctly identified for DESI-EDR. Additionally, we estimate photometric redshift for the high-redshift quasar candidates using random forest regression model with a high precision. We also demonstrate that the deeper images and more photometric measurements from the future imaging surveys such as CSST, RST, EST and LSST would significantly improve the performance of the random forest model. Utilizing the gravitational lensing effect, we estimate the quasar luminosity function at the faint end at 4 < z < 6.5.

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