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Exploring Multi-Band Imaging for Identifying z > 6.5 Quasars: A Contrastive Learning Approach Using HSC Data

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Quasars at z>6 are powerful laboratories to study the growth and evolution of supermassive black holes and massive galaxies, the properties of the intergalactic medium, and the formation of large-scale structures within the first Gyr from the Big Bang. Although these distant objects are the most luminous non-transient sources in the universe, it is challenging to find them because they are scarce (< 1 per Gpc^3 at z > 6). The last years have seen a significant increase in quasar demographics at z~6, but the number of quasars at z>6.5 is still low (and only three quasars known at z>7.5) and biased to the brightest sources. Here, we capitalize on the current large-area sky surveys and recently demonstrated unsupervised learning capabilities to perform a novel search of quasars at z>6.5 by applying a Simple Framework for Contrastive Learning of Visual Representations (SimCLR) to multi-band optical imaging data from the Hyper Suprime-Cam (HSC). With this convolutional neural network based method combined with Uniform Manifold Approximation and Projection (UMAP), we derive a latent representation of the data which enables the selection of a sample of z>6.5 QSO candidates. A QSO evolutionary track, as well as brown dwarfs and stars clusters were identified in the latent space. The extension of our methodology to future surveys like Euclid, opens up a wealth of prospects to probe the high-redshift universe and underscores the importance of machine learning-driven approaches in expanding traditional astronomical techniques for identifying these rare and distant astrophysical objects, while addressing challenges posed by small and biased training datasets.

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