MACHINE LEARNING FOR ASTROPHYSICS
2ND EDITION CATANIA, 8-12 JULY, 2024

Contribution ID: **233** Type: **not specified**

A worthwhile detour via artificial spectra: galaxy properties from photometric images with diffusion models

Wednesday, 10 July 2024 10:00 (20 minutes)

Modern spectroscopic surveys can only target a small fraction of the vast amount of photometrically cataloged sources in wide-field surveys. Here, we report the development of a machine-learning framework capable of predicting optical galaxy spectra from photometric broad-band images alone. This method draws from the latest advances in diffusion models in combination with a contrastive network. We pass the entire multi-band galaxy images into the architecture to obtain optical spectra. From these, robust values for galaxy properties can be derived with standard population synthesis techniques and Lick indices.

When trained and tested on 64 × 64-pixel images from the last data release of the SDSS survey, the global bimodality of star-forming and quiescent galaxies in photometric space is recovered, as well as a mass-metallicity relation of star-forming galaxies. The comparison between the “”true”” observed SDSS spectra and the artificially created spectra shows good agreement in overall metallicity, age, Dn4000, and E(B-V) values. Photometric redshift estimates of our generative AI can compete with other specialized deep learning techniques. Additionally, we can predict the presence of an AGN up to an accuracy of 82%.

With our method, scientifically interesting galaxy properties, normally requiring spectroscopic inputs, can be estimated in future data sets from large-scale photometric surveys alone. The creation of artificial spectra can further assist in creating realistic mock catalogs.

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Session Classification: Time Domain / Multi-wavelength All-Sky Surveys