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Multi-Task Neural Nets with Monte Carlo Dropout for Spectral Analysis of Galaxies

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The upcoming era of large-scale astronomical surveys, exemplified by instruments like EUCLID and MOONS, demands innovative approaches for rapid and accurate analysis of extensive spectral data.
This talk introduces a pioneering deep learning tool that employs a multi-task convolutional neural network with residual learning to simultaneously derive key physical properties of galaxies, such as stellar mass, star formation rate, metallicity, and redshift, from their spectra. Our approach efficiently encodes spectral information into a latent space, employing distinct branches for each physical attribute, thereby harnessing the power of multi-task learning. To address the crucial aspect of uncertainty in predictions, we incorporate Monte Carlo Dropout, enabling the generation of probability distribution functions for each property by executing multiple inferences. A key feature of our methodology is its interpretability. By examining the latent space within the embedding layers, we demonstrate the model's capability to learn and distinguish important but unlabeled galaxy characteristics, such as differentiating between star-forming and quenched galaxies and identifying galaxy morphologies. We demonstrate preliminary results using simulated data of the MOONS instrument, which will be soon operating at the VLT telescope, showcasing the model's efficacy in accurately predicting redshift and physical properties for high-redshift galaxies, even at low-brightness regimes where traditional methods often struggle. Our model, thus, emerges as a powerful solution for the upcoming challenges in observational astronomy, combining precision, interpretability, and efficiency, crucial for the analysis of the massive datasets expected from next-generation instruments.

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