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Latent space out-of-distribution detection of galaxies for deblending in weak lensing surveys

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Upcoming photometric surveys such as the Legacy Survey of Space and Time (LSST) will image billions of galaxies, an amount required for extracting the faint weak lensing signal at a large range of cosmological distances. The combination of depth and area coverage of the imagery will be unprecedented ($r \sim 27.5$, $\sim 20\,000\,\mathrm{deg}^2$), and processing it will be fraught with many challenges. One of the most pressing issues is the fact that roughly 50% of the galaxies will be "blended", where its projection on our detectors will overlap with other astronomical objects along the same line of sight. Without appropriate "deblending"algorithms, the blends introduce an unacceptable error on the weak lensing signal.
Several deblending algorithms have emerged up the past years, of which the most promising are based on deep neural networks (DNNs). DNNs are known to be highly sensitive to a difference in the distributions of the training and validation datasets. As the true deblended image of a blend, needed for supervised learning, is in most cases unobtainable due to the line of sight projection, training data has to be generated algorithmically. This training data will by its nature have a limited coverage of the high dimensional space that spans all galaxies that will be observed with the LSST. In other words, many galaxies and blends observed by the LSST will be out of distribution (OOD) and the DNNs will perform poorly on them. We have developed a method to classify blends on being OOD or in-distribution (IID) based on the distribution of an input blend sample in the latent space of a β-VAE, compared to the latent space distribution of the training sample. We will present the results of the OOD flagging, demonstrating that the latent space is indeed a useful tool for identifying OOD samples. Furthermore, we will discuss the ensuing reduction on the error of shear and photometry measurements when rejecting OOD samples for the weak lensing analysis.
Though core components of our method build on an existing deblending algorithm by Arcelin et al. (2021), the addition of this successful OOD detection technique is essential for its proper functioning on future LSST imagery. The blends flagged as OOD can, in future pipelines, be separated from the IID blends to prevent contamination of the weak lensing signal or be deblended with a method specifically tuned to OOD blends.

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