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Deblending galaxies with variational autoencoders

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The apparent superposition of galaxies with other astrophysical objects along the line of sight, a problem known as blending, will be a major challenge for upcoming, ground-based, deep, photometric galaxy surveys, such as the Large Synoptic Survey Telescope (LSST). Blending contributes to the systematic error budget of weak lensing studies by perturbing object detection and affecting photometric and shape measurements. Existing deblenders suffer from the lack of flexible yet accurate models of galaxy morphologies and therefore rely on assumptions (analytic profiles, symmetry, sparsity in a profile basis) to isolate galaxies within a blended scene. In this paper, we propose instead to use generative models based on deep neural networks, namely variational autoencoders (VAE), to learn a Bayesian model directly from data, which we then use as a prior to perform deblending. Specifically, we train a VAE on images of centered, isolated galaxies, which we reuse in a second VAE-like neural network in charge of deblending galaxies. We train our networks on simulated images, created with the GalSim software from a catalog of Hubble Space Telescope observations in the COSMOS field, including all six LSST bandpass filters as well as the visible and near-infrared bands of the Euclid satellite, as our method naturally generalizes to multi-bands and multi-instruments data. We validate our model and quantify deblending performances by measuring reproduction errors in galaxy shapes and magnitudes, as a function of signal-to-noise ratio (SNR) and two blendedness metrics. We obtain median errors on ellipticities between ± 0.01 and on r-band magnitude between ± 0.05 in most cases and shear multiplicative biases under 10^{-2} in the optimal configuration. We also study the impact of decentering as deblending is tightly coupled to the detection pipeline performances and show the method to be robust, expectedly degrading with decentering and at low SNR. Finally, we discuss future challenges about training on real data (for instance from deep fields) and suggest to apply transfer learning.

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