Photometric redshift calibration with simulated annealing and self-organising maps

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Abstract

Cosmological analyses are often performed tomographically, which requires dividing a sample of galaxies into bins based on their redshift. The redshift of galaxies is typically estimated via photometric methods, which, however, suffer from systematic biases and catastrophic outliers in the redshift estimation, leading to mismatches between the photometric redshift estimate and the true redshift of galaxies in each tomographic redshift bin. In this talk I present a calibration method that optimises the assignment of galaxies into redshift bins. This is achieved by combining simulated annealing, an optimisation algorithm inspired by solid-state physics, with an unsupervised machine learning method, a self-organising map (SOM) which is trained on the observed colours of galaxies. Therefore, the SOM can be used to select subsamples of galaxies that are expected to be close in redshift. Starting with a sample of galaxies that is divided into redshift bins based on their photometric redshift estimate, the simulated annealing algorithm repeatedly reassigns SOM-selected subsamples of galaxies to different redshift bins. In each step, the quality of the assignment is assessed by evaluating the cost function, which is defined as the cross-correlation signal between photometric galaxies and a reference sample of galaxies with well-calibrated redshifts. Depending on the effect on the cost function, the reassignment is either accepted or rejected. By repeatedly reassigning galaxies to redshift bins and dynamically scaling the resolution of the SOM, the algorithm eventually converges to a solution that minimises the number of mismatched galaxies in each tomographic redshift bin. This method is demonstrated on the CosmoDC2 catalogue, which is a synthetic galaxy catalogue used for the second data challenge carried out by the LSST Dark Energy Science Collaboration.
Slides: in PDF
Video: https://youtu.be/c7yZ3f6G_44

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