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Astronomical Object Classification

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Abstract : We present a photometric method for identifying stars, galaxies and quasars in multi-color surveys, which uses a library of ~> 65000 color templates for comparison with observed objects. The method aims for extracting the information content of object colors in a statistically correct way, and performs a classification as well as a redshift estimation for galaxies and quasars in a unified approach based on the same probability density functions. For the redshift estimation, we employ an advanced version of the Minimum Error Variance estimator which determines the redshift error from the redshift dependent probability density function itself. The method was originally developed for the Calar Alto Deep Imaging Survey (CADIS), but is now used in a wide variety of survey projects. We checked its performance by spectroscopy of CADIS objects, where the method provides high reliability (6 errors among 151 objects with R < 24), especially for the quasar selection, and redshifts accurate within σz ≈ 0.03 for galaxies and σz ≈ 0.1 for quasars. For an optimization of future survey efforts, a few model surveys are compared, which are designed to use the same total amount of telescope time but different sets of broad-band and medium-band filters. Their performance is investigated by Monte-Carlo simulations as well as by analytic evaluation in terms of classification and redshift estimation. If photon noise were the only error source, broad-band surveys and medium-band surveys should perform equally well, as long as they provide the same spectral coverage. In practice, medium-band surveys show superior performance due to their higher tolerance for calibration errors and cosmic variance. Finally, we discuss the relevance of color calibration and derive important conclusions for the issues of library design and choice of filters. The calibration accuracy poses strong constraints on an accurate classification, which are most critical for surveys with few, broad and deeply exposed filters, but less severe for surveys with many, narrow and less deep filters.

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