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Title: BEAUTY Powered BEAST

Abstract: We study nonparametric dependence detection with the proposed binary expansion approximation of uniformity (BEAUTY) approach, which generalizes the celebrated Euler's formula, and approximates the characteristic function of any copula with a linear combination of expectations of binary interactions from marginal binary expansions. This novel theory enables a unification of many important tests through approximations from some quadratic forms of symmetry statistics, where the deterministic weight matrix characterizes the power properties of each test. To achieve a robust power, we study test statistics with data-adaptive weights, referred to as the binary expansion adaptive symmetry test (BEAST). By utilizing the properties of the binary expansion filtration, we show that the Neyman-Pearson test of uniformity can be approximated by an oracle weighted sum of symmetry statistics. The BEAST with this oracle provides a benchmark of feasible power against any alternative by leading all existing tests with a substantial margin. To approach this oracle power, we develop the BEAST through a regularized resampling approximation of the oracle test. The BEAST improves the empirical power of many existing tests against a wide spectrum of common alternatives and provides clear interpretation of the form of dependency when significant. This is joint work with Zhigen Zhao and Wen Zhou.