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False Discovery Rate Control under Archimedean Copula

Taras Bodnar, Thorsten Dickhaus

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We prove that the linear step-up procedure $\vp^{LSU}$ considered by Benjamini and Hochberg (1995) controls the false discovery rate (FDR) in the case of dependent p-values whose dependency structure is determined by an Archimedean copula. In fact, the FDR of $\vp^{LSU}$ is under the assumption of an Archimedean p-value copula upper-bounded by the same constant as in the case of independent p-values. Namely, the upper bound is given by $m_0 q / m$, where m denotes the total number of hypotheses, m_0 the number of true null hypotheses, and q the nominal FDR level. Furthermore, we establish a sharper upper bound for the FDR of $\vp^{LSU}$ as well as a non-trivial lower bound. Application of the sharper upper bound to parametric subclasses of Archimedean p-value copulae allows us to increase the power of $\vp^{LSU}$ by pre-estimating the copula parameter and adjusting q. Based on the lower bound, a sufficient condition is obtained under which the FDR of $\vp^{LSU}$ is exactly equal to $m_0 q / m$. Finally, we deal with high-dimensional multiple test problems with exchangeable test statistics by proving that the dependency structure of the corresponding vector of p-values can always be expressed by an Archimedean copula. The theoretical results are applied to important copula families, including Clayton copulae and Gumbel copulae.

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