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Some optimization-theoretic issues in analysis of interval-valued data

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Interval-valued data are often encountered in practice, namely when only upper and lower bounds on observations are available. As a simple example, consider a random sample $x_1, \ldots, x_n$ from a distribution Φ; the task is to estimate some of the characteristics of Φ, such as moments or quantiles. Assume that the data $x_1, \ldots, x_n$ are not observable; we have only bounds $\underline{x}_i \leq x_i \leq \overline{x}_i$ a.s. and all estimators and statistics are allowed to be functions of $\underline{x}_i, \overline{x}_i$ only, but not x_i. The analysis very much depends on whether we are able to make additional assumptions about the joint distribution of $(\underline{x}_i, x_i, \overline{x}_i)$ (for example, a strong distributional assumption could have the form
$\mathsf{E}[x_i|\underline{x}_i, \overline{x}_i] = \frac{1}{2}(\underline{x}_i + \overline{x}_i)$). Without such assumptions, a statistic $S(x_1, \ldots, x_n)$ can only be replaced by the pair of tight bounds $\overline{S} = \sup\{S(\xi_1, \ldots, \xi_n)|\underline{x}_i \leq \xi_i \leq \overline{x}_i\ \forall i\}$ and
$\underline{S} = \inf\{S(\xi_1, \ldots, \xi_n)|\underline{x}_i \leq \xi_i \leq \overline{x}_i\ \forall i\}$. We report some of our recent results on the algorithms for the computation of $\underline{S}, \overline{S}$. In particular, when S is the sample variance, it can be shown that the computation of $\overline{S}$ is an NP-hard problem. We study a method based on Ferson et al., which works in exponential time in the worst case, while it is almost linear on average (under certain regularity assumptions), showing that the NP-hardness result need not be too restrictive for practical data analysis.

Keywords

interval data; statistical computing

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