

Confidence Distributions and a Unifying Framework for Meta-analysis

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Abstract

This paper develops a unifying framework, and a corresponding robust meta-analysis method, for combining information from independent sources. The device used in this combination is a confidence distribution (CD), also known as a “distribution estimator”. A CD contains a wealth of information for inferences and it is a useful device for combining information from different sources. It is illustrated that the CD combination framework can include as special examples both the classical meta-analysis of p-value combinations and the modern model-based meta-analysis under the settings of either fixed or random effects models. Furthermore, the proposed framework of CD combination can lead to development of new methodologies. Specifically, based on the CD combination framework, we develop two robust meta-analysis approaches with supporting asymptotic theories, one under the assumption that the study sizes go to infinity and the other under the assumption that the number of studies tends to infinity. These two robust meta-analysis have high breakdown points and can permit up to half of “bad” studies, and thus remove a critical constraint in current practice requiring all studies be of the same type and with the exact same parameter values. In addition, it is also shown that the first robust meta-analysis method can obtain asymptotically most efficient estimate in the fixed effects models with or without outlying studies; and the second one can retain $(3/\pi)^{1/2} \approx 97.7\%$ efficiency when there is no outlying studies. The new methodologies are demonstrated with numerical examples using simulations and real data on a treatment of stomach ulcers from published literature.

Key Words: Confidence distribution; meta-analysis; robust combination.

Running Title: Unifying framework for meta-analysis