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Editorial

Meta-Analysis and Machine Learning: Advancement of Analytic Methodology

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Recently introduced statistical methods for analyzing big data include meta-analysis (MA) and machine learning (ML), a branch of artificial intelligence. These methods offer innovative opportunities in critical applications such as personalized medicine, diagnostics, and the development of prediction models in medical research. Similar to the emergence of MA, studies using ML have been exponentially increasing. However, it is important to note that the manner in which these methods control confounding variables and derive results differs from traditional statistical approaches, requiring careful consideration when interpreting results.

MA has a scientific meaning because it is based on a systematic review of all available data in the world. It is crucial to document the search procedure in studies to guarantee the process's reproducibility. Because of the systematic review, the differences between each study, namely heterogeneity, are considered nullified in the analysis. ML recognizes data patterns through higher-dimensional computations and predicts results. It considers multiple variables simultaneously using higher-order functions. Common ML models are decision trees, random forests, support vector machines, and K-nearest neighbors. The choice of a specific model is based on the nature of the problem, the characteristics of the data, and other considerations. In contrast to traditional statistics, the analytic process of ML is referred to as a "black box," which indicates that the internal workings of ML are not transparent or easily understandable by humans. The results generated by ML are challenging to validate by humans. The principle of "not mixing apples and oranges" in MA advises against indiscriminately combining studies with different characteristics or effects. The quality of training data is also critical for coherent and reliable results in ML.

The fusion of MA and ML brings in a new era in neurosurgical research. MA provides the foundation by synthesizing existing knowledge, while ML algorithms provide a fresh perspective to uncover hidden insights within the compiled data. This symbiotic relationship enhances the precision and predictive power of medical research, paving the way for more informed decision-making in clinical practice. Among the subcategories of MA, diagnostic test accuracy MA uses data in the form of 2 by 2 tables (true positive, false positive, false negative, and true negative). Studies using either MA or ML need this data form to analyze.[1-3] Despite the promises, challenges persist in integrating MA and ML. Heterogeneities in study designs, data formats, data quality, and various ML models pose significant obstacles. However, these challenges also present opportunities for innovation. Standardizing data reporting, developing robust MA methodologies, and refining ML algorithms are critical steps in overcoming these hurdles.

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