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Bayesian Statistics: Challenges and Opportunities

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Editorial

The problem of decision making from data is becoming more and more important and challenging in today's world. The basic objective of data science and its relevant applications in social sciences is to understand a process (natural or designed) for making better and reliable predictions. Of course, the accuracy and precision of the prediction depends on how accurately one estimates the underlying parameters of interest from the data.

In today's world, because of the advanced technology, the researchers have access to ultrahigh dimensional data and an efficient statistical methodology is required to analyze such "big-datasets". This problem is more serious and challenging now than it was perhaps a decade ago. Data cleaning, variable selections, clustering etc., the so-called standard methodologies for data analysis are being modified for high-dimensional case now. New datasets are motivating the researchers to develop advanced methods to handle such situations. For example, the successful completion of Human Genome Project (2003) and its derivative Hapmap Project (2005) have made a revolution in the genetic research and biomedical sciences in recent years. The focus in genetic research has dramatically changed from single gene mapping problems to Genome-Wide Association Studies (GWAS).

For ultrahigh dimensional data, one can use a complex model to handle the "big-data" issue, as it is quite evident that such complex algorithms are good for theoretical development but useless in practice. In reality, researchers would love to use a simple model but efficient estimation approach to draw precise and powerful scientific inferences. Traditional statistical methods, known as "Frequentist" approach are still performing well but Bayesian methods have become the center of attraction to model the underlying uncertainty of statistical models. Bayesians typically assume that the model parameters are not fixed but random variables coming from some "prior" distributions. These priors are usually based on the guess of the domain experts and then combining the prior with the data based likelihood function, posterior distributions are computed. All Bayesian inferences are based on such posterior densities which provide "shrinkage" estimators for the model parameters in some sense.

In current time, a natural process is assumed to be the realizations of some unknown functions and the Bayesians consider a prior on such unknown function to model the process effectively. Applications include but are not restricted to functional data analysis, time series analysis, spatial data analysis etc. The complex models generate complicated posterior densities and to sample from such distributions Monte Marlo Markov Chain, Monte Carlo EM, Slice sampling algorithms etc. have been proposed in Statistics literature. These algorithms have made the Bayesian analyses simpler and routine works.

The efficiency of the Bayesian approach is primarily on its appealing philosophy of combining the prior and the observed knowledge to estimate the parameters and predict the process for future. Recent literature shows that Bayesian approach is a flexible and very powerful alternative to the Frequentist approach. For GWAS and other biomedical "big-data" projects, Bayesian methods perform successfully better than the traditional methods and thus the social scientists are showing more interest in Bayesian models. This is a possible indication of gradually moving towards prior based big-data projects.

Since statistical models are extensively used now in various disciplines including basic sciences and social sciences, it's time for the researchers to grasp the Bayesian concepts more carefully and make proper use of it for the intended purposes. Bayesian computations are still challenging although the softwares like "Winbuggs" can be used for computation purpose. More methodological developments are needed for applying the Bayesian methods in different fields of study. It is expected that by next decade, Bayesian tools will be indispensable for statistical analyses and scientific research in general.

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