

BAYESIAN STATISTICS

Chapter 1

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1. Introduction to Bayesian Statistics

1.1. What is “Bayesian Statistics?”

Bayesian statistics is developed based on the assumption that (1) all of statistical interest (parameter, missing values, etc.) are *uncertain* and (2) this uncertainty can be described in terms of *probability*

In Bayesian statistics, we build the probability of the uncertainty for unknown parameters of interest

In traditional statistics, for example, parameters are unknown but fixed

Example: (Coin Tossing) Suppose we are interested in the probability of head when I toss a coin right now.

- Objective probability: If the coin is fair, the probability of head is *expected* to be $1/2$ with the common speculation. It may be supported by the repeated coin tossing experiment.
- Subjective probability: what is the probability of head with the bent coin if the repeated experiment is not available?
- The best way to figure out is to combine the subjective probability of the uncertainty with the objective evidence from the data, if available.

1.2. Basic structure of Bayesian Statistics

Two important concepts for Bayesian Statistics:

- **Prior distribution:** the probability that describing the personal opinion on the parameter uncertainty
- **Posterior distribution:** the probability of the parameter uncertainty which is *updated* by considering the observed data from the probabilistic experiment

Bayesian Statistics consists of three steps:

- 1 Choosing the prior distribution for the parameters
- 2 Computing the posterior distribution using the prior distribution and data
- 3 Parameter inference based on the posterior distribution

1.3. Why do we need Bayesian Statistics?

- Bayesian statistics yields the results that are interpreted more easily than the results from the traditional statistics and that are appealing to our intuition
- In many real applications, the prior information is available
- Bayesian inference is conformable to the traditional statistical inference when the sample size is large
- The complicated problems are easily solved in Bayesian statistics

1.4. History of Bayesian statistics



Thomas Bayes
(1701-1761)



Pierre-Simon Laplace
(1749-1827)

[Click the images to go to wikipedia](#)

1.5. Applications of Bayesian statistics

Bayesian statistics is widely used in various area of social science, natural science, and engineering.

- pattern recognition
- statistical genetics
- many others