Syllabus

Bayesian Statistics: From Concept to Data Analysis

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1. Course Description

a. Pre-requisites

The Course is to be based on the acquisition of the following Courses:

- Mathematical analysis;
- Linear algebra;
- Statistics;

b. Abstract

This course introduces the Bayesian approach to statistics, starting with the concept of probability and moving to the analysis of data. We will learn about the philosophy of the Bayesian approach as well as how to implement it for common types of data. We will compare the Bayesian approach to the more commonly-taught Frequentist approach, and see some of the benefits of the Bayesian approach. In particular, the Bayesian approach allows for better accounting of uncertainty, results that have more intuitive and interpretable meaning, and more explicit statements of assumptions. This course combines lecture videos, computer demonstrations, readings, exercises, and discussion boards to create an active learning experience. For computing, you have the choice of using Microsoft Excel or the open-source, freely available statistical package R, with equivalent content for both options. The lectures provide some of the basic mathematical development as well as explanations of philosophy and interpretation.

c. Course Type

Blended learning

2. Learning Objectives

The objective of this course is to form a foundation of Bayesian Statistics and its application.

3. Learning Outcomes

Completion of this course gives an understanding of the concepts of the Bayesian approach, understanding the key differences between Bayesian and Frequentist approaches, and the ability to do basic data analyses.

4. Course Plan

Topic 1. Probability and Bayes' Theorem.

We review the basics of probability and Bayes' theorem. First, we introduce the different paradigms or definitions of probability and discuss why probability provides a coherent framework for dealing with uncertainty. Then we review the rules of conditional probability and introduce Bayes' theorem. And then review common probability distributions for discrete and continuous random variables.

Topic 2. Statistical Inference.

This topic introduces concepts of statistical inference from both frequentist and Bayesian perspectives. This topic takes the frequentist view, demonstrating maximum likelihood estimation and confidence intervals for binomial data. Then it introduces the fundamentals of Bayesian inference. Beginning with a binomial likelihood and prior probabilities for simple hypotheses, you will learn how to use Bayes' theorem to update the prior with data to obtain posterior probabilities. This framework is extended with the continuous version of Bayes theorem to estimate continuous model parameters, and calculate posterior probabilities and credible intervals.

Topic 3. Priors and Models for Discrete Data.

We will learn methods for selecting prior distributions and building models for discrete data. This topic introduces prior selection and predictive distributions as a means of evaluating priors. Then it demonstrates Bayesian analysis of Bernoulli data and introduces the computationally convenient concept of conjugate priors. And then it builds a conjugate model for Poisson data and discusses strategies for selection of prior hyperparameters.

Topic 4. Models for Continuous Data.

This topic covers conjugate and objective Bayesian analysis for continuous data. It presents the conjugate model for exponentially distributed data. This topic discusses models for normally distributed data, which play a central role in statistics. In next point, we return to prior selection and discuss 'objective' or 'non-informative' priors. Then this topic presents Bayesian linear regression with non-informative priors, which yield results comparable to those of classical regression.

5. Reading List

All materials in https://www.coursera.org/learn/bayesian-statistics

6. Grading System

The student's final assessment consists of the assessment of the exam A_{exam} and the accumulated assessment A_{acc} obtained on the platform https://www.coursera.org/learn/bayesian-statistics as follows: $A_{final} = (A_{acc} + A_{exam})/2$.

7. Examination Type

Oral examination. Control elements are not blocking.

8. Methods of Instruction

The course is being studied on the online platform
https://www.coursera.org/learn/bayesian-statistics

9. Special Equipment and Software Support (if required)

Not required