Introduction to Bayesian learning

Master Data-Science (Mathématiques et Applications),

Institut polytechnique de Paris

Anne Sabourin

fall semester, 2019

This course is an introduction to Bayesian methods for machine learning. As a first go, the main ingredients of Bayesian thinking are presented and typical situations where a Bayesian treatment of the learning task is useful are exemplified. Particular attention is payed to the links between regularization methods and specification of a prior distribution. The second part of this course concerns the computational challenges of Bayesian analysis. Major approximation methods such as variational Bayes, Monte-Carlo-Markov-Chain sampling and sequential sampling schemes are introduced and implemented in lab session.

Format

6×3.5 hours + exam

Programing language

`R`

Grading

mini-project (lab) (40%) + written exam (60%)

Syllabus

- **Week 1: Bayesian learning: basics**.
  Bayesian model, prior-posterior, examples.

Point and interval estimation.
Prior choice, examples, exponential family
A glimpse at asymptotics and at computational challenges

Reading: Berger (2013), chapter 1; Bishop (2006) chapters 1 and 2, Robert (2007) chapter 1, Ghosh et al. (2007), chapter 2 and Robert and Casella (2010), chapter 1 for basic R programming.

- **Week 2: Bayesian modeling and decision theory**
  Naïve Bayes, KNN
  Bayesian Linear Regression
  Bayesian decision theory.

  Reading: Bishop (2006), chapter 3; Berger (2013) chapter 4; Robert (2007) chapter 2.

- **Week 3: Lab session**

- **Weeks 4: Approximation methods** EM and Variational Bayes, examples.

  Reading: Bishop (2006), Chapter 10.

- **Week 5 : Sampling methods** Monte-Carlo methods, importance samplnig, MCMC (Metropolis-Hastings and Gibs), examples.
  If time allows it: sequential methods (particle filtering)

  Reading Robert and Casella (2010), (bits of) chapters 3, 4, 6, 7, 8.

- **Week 6: Lab session**.
  approximation and sampling methods.

References

Berger, J. O. (2013). *Statistical decision theory and Bayesian analysis.* Springer Science & Business Media.

Bishop, C. M. (2006). *Pattern recognition and machine learning.* springer.

Ghosh, J. K., Delampady, M., and Samanta, T. (2007). *An introduction to Bayesian analysis: theory and methods.* Springer Science & Business Media.

Robert, C. (2007). *The Bayesian choice: from decision-theoretic foundations to computational implementation.* Springer Science & Business Media.

Robert, C. and Casella, G. (2010). *Introducing Monte Carlo Methods with R.* Springer Science & Business Media.