200611 - AB - Bayesian Analysis

Coordinating unit: 200 - FME - School of Mathematics and Statistics
Teaching unit: 715 - EIO - Department of Statistics and Operations Research
Academic year: 2018
Degree: MASTER'S DEGREE IN STATISTICS AND OPERATIONS RESEARCH (Syllabus 2013). (Teaching unit Optional)
ECTS credits: 5
Teaching languages: Spanish

Teaching staff
Coordinator: XAVIER PUIG ORIOL
Others: Segon quadrimestre:
JESUS CORRAL LOPEZ - A
XAVIER PUIG ORIOL - A

Prior skills
We start from scratch and hence there are no pre-requisites for this course. But having some basic knowledge of statistics will help get the best out of the course.

Degree competences to which the subject contributes

Specific:
3. CE-1. Ability to design and manage the collection of information and coding, handling, storing and processing it.

4. CE-3. Ability to formulate, analyze and validate models applicable to practical problems. Ability to select the method and / or statistical or operations research technique more appropriate to apply this model to the situation or problem.

5. CE-4. Ability to use different inference procedures to answer questions, identifying the properties of different estimation methods and their advantages and disadvantages, tailored to a specific situation and a specific context.

6. CE-6. Ability to use appropriate software to perform the necessary calculations in solving a problem.

7. CE-7. Ability to understand statistical and operations research papers of an advanced level. Know the research procedures for both the production of new knowledge and its transmission.

8. CE-8. Ability to discuss the validity, scope and relevance of these solutions and be able to present and defend their conclusions.


Transversal:
1. TEAMWORK: Being able to work in an interdisciplinary team, whether as a member or as a leader, with the aim of contributing to projects pragmatically and responsibly and making commitments in view of the resources that are available.

Teaching methodology
One half of the sessions will be in a regular classroom and one half of them will be in a computer lab.

Learning objectives of the subject
Abilities to be acquired:
**200611 - AB - Bayesian Analysis**

* Knowledge of the difference between Bayesian and non Bayesian statistical modelling, and of the role of the likelihood function.
* Understand the role of the prior distribution, the role of reference priors and how to go from prior to posterior distributions.
* Understand the difference between hierarchical and non-hierarchical Bayesian models.
* Understand how to check a Bayesian model, how to compare Bayesian models and how to use them for prediction.
* Understand the Montecarlo methods that allow one to simulate from the posterior and how to make inferences from those simulations.
* Posing and solving Bayesian inference problems analytically with exponential family statistical models and conjugate prior distributions.
* Posing and solving Bayesian inference problems numerically under complex situations using WinBugs, JAGS or STAN.

<table>
<thead>
<tr>
<th>Study load</th>
<th>Hours large group:</th>
<th>Hours medium group:</th>
<th>Hours small group:</th>
<th>Guided activities:</th>
<th>Self study:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total learning time: 125h</strong></td>
<td>30h</td>
<td>0h</td>
<td>15h</td>
<td>0h</td>
<td>80h</td>
</tr>
<tr>
<td>%</td>
<td>24.00%</td>
<td>0.00%</td>
<td>12.00%</td>
<td>0.00%</td>
<td>64.00%</td>
</tr>
</tbody>
</table>
## Content

<table>
<thead>
<tr>
<th>Module</th>
<th>Learning time:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1- Bayesian Model</strong></td>
<td>42h</td>
</tr>
<tr>
<td>Description:</td>
<td>Theory classes: 11h</td>
</tr>
<tr>
<td></td>
<td>Laboratory classes: 6h</td>
</tr>
<tr>
<td></td>
<td>Self study : 25h</td>
</tr>
<tr>
<td><strong>2- Bayesian Inference</strong></td>
<td>40h</td>
</tr>
<tr>
<td>Description:</td>
<td>Theory classes: 9h</td>
</tr>
<tr>
<td></td>
<td>Laboratory classes: 6h</td>
</tr>
<tr>
<td></td>
<td>Self study : 25h</td>
</tr>
<tr>
<td><strong>3- Bayesian computation</strong></td>
<td>13h</td>
</tr>
<tr>
<td>Description:</td>
<td>Theory classes: 2h</td>
</tr>
<tr>
<td></td>
<td>Laboratory classes: 1h</td>
</tr>
<tr>
<td></td>
<td>Self study : 10h</td>
</tr>
<tr>
<td><strong>4- Hierarchical Models</strong></td>
<td>13h</td>
</tr>
<tr>
<td>Description:</td>
<td>Theory classes: 2h</td>
</tr>
<tr>
<td></td>
<td>Laboratory classes: 1h</td>
</tr>
<tr>
<td></td>
<td>Self study : 10h</td>
</tr>
</tbody>
</table>

### 1. Bayesian Model
- What is a statistical model.
- The four problems in statistics.
- The Likelihood function.
- Bayesian model.
- Posterior distribution.
- Prior predictive and posterior predictive distributions.
- Choice of the prior distribution.

### 2. Bayesian Inference
- Posterior distribution as an estimator.
- Point estimation.
- Interval estimation.
- Two-hypothesis test.
- More than two-hypothesis test.

### 3. Bayesian computation
- The need for integration and for simulation.
- Markov chain Monte Carlo simulation.
- Monitoring Convergence.

### 4. Hierarchical Models
- Hierarchical Models.
5. Checking and defining the model

<table>
<thead>
<tr>
<th>Description:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Checking and defining the model</td>
</tr>
</tbody>
</table>

**Learning time:** 13h
- Theory classes: 2h
- Laboratory classes: 1h
- Self study: 10h

6- Applications

<table>
<thead>
<tr>
<th>Description:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Applications</td>
</tr>
</tbody>
</table>

**Learning time:** 4h
- Theory classes: 4h

Qualification system

Final grade = 0.2*Assignm + 0.2*Proj + 0.1*Midterm + 0.5*FinalExam

Regulations for carrying out activities

The midterm and the final exam will be closed book but you might need to bring a calculator.
## Bibliography

**Basic:**


**Complementary:**


Ntzoufras, I. Bayesian modeling using WinBUGS. Wiley. 2009.