

SDSC8012: BAYESIAN REGRESSION MODELLING AND ANALYSIS

Effective Term

Semester A 2026/27

Part I Course Overview

Course Title

Bayesian Regression Modelling and Analysis

Subject Code

SDSC - Data Science

Course Number

8012

Academic Unit

Data Science (DS)

College/School

College of Computing (CC)

Course Duration

One Semester

Credit Units

3

Level

R8 - Research Degree

Medium of Instruction

English

Medium of Assessment

English

Prerequisites

Nil

Precursors

Nil

Equivalent Courses

Nil

Exclusive Courses

Nil

Part II Course Details

Abstract

This course aims to offer students rigorous and comprehensive knowledge of advanced Bayesian regression concepts, theory, and methods. It will develop students' abilities to apply Bayesian regression models to nonstandard and complex data analysis problems. Students will be trained to develop Bayesian models and apply software packages such as MATLAB R or WinBUGS to fit the developed models and perform Bayesian inference.

Course Intended Learning Outcomes (CILOs)

CILOs		Weighting (if app.)	DEC-A1	DEC-A2	DEC-A3
1	Explain and apply Bayes theorem, Bayesian decision theory, empirical Bayesian estimation, and types of prior distributions (conjugate, Jeffreys, and reference priors) in the context of Bayesian linear models.	20	x	x	
2	Describe and implement Bayesian linear regression models, Bayesian generalized linear models, Bayesian model averaging, and Bayesian variable selection methods.	25	x	x	
3	Apply Markov chain Monte Carlo algorithms and integrated nested Laplace approximations to perform Bayesian regression with the help of software.	15	x	x	
4	Describe and implement Gaussian process modelling, and experiment designs for fitting Gaussian process models.	20	x	x	
5	Describe and implement Bayesian optimization, and Bayesian quadrature.	20	x	x	

A1: Attitude

Develop an attitude of discovery/innovation/creativity, as demonstrated by students possessing a strong sense of curiosity, asking questions actively, challenging assumptions or engaging in inquiry together with teachers.

A2: Ability

Develop the ability/skill needed to discover/innovate/create, as demonstrated by students possessing critical thinking skills to assess ideas, acquiring research skills, synthesizing knowledge across disciplines or applying academic knowledge to real-life problems.

A3: Accomplishments

Demonstrate accomplishment of discovery/innovation/creativity through producing /constructing creative works/new artefacts, effective solutions to real-life problems or new processes.

Learning and Teaching Activities (LTAs)

LTAs		Brief Description	CILO No.	Hours/week (if applicable)
1	Lectures	Students will engage in formal lectures to gain knowledge about Bayesian regression modelling and analysis.	1, 2, 3, 4, 5	26 hours/semester

2	Demonstration of MATLAB/R/ WinBUGS codes	Students will develop an understanding of the MATLAB/R/ WinBUGS codes included in the course materials by following an in-class demonstration and explanation of the codes.	1, 2, 3, 4, 5	12 hours/semester
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Assessment Tasks / Activities (ATs)

ATs	CILO No.	Weighting (%)	Remarks ("- " for nil entry)	Allow Use of GenAI?	
1	Midterm Students will be assessed via the midterm their understanding of concepts learned in class, textbooks, and reading materials.	1, 2, 3, 4, 5	25	-	No
2	Two assignments Students will work individually or in teams to develop Bayesian regression models and apply the models to analyse data with the help of software.	1, 2, 3, 4, 5	50	-	Yes

Continuous Assessment (%)

75

Examination (%)

25

Examination Duration (Hours)

2

Minimum Continuous Assessment Passing Requirement (%)

0

Minimum Examination Passing Requirement (%)

30

Additional Information for ATs**Examination**

Students will be assessed via the examination their understanding of concepts learned in class, textbooks, and reading materials.

Assessment Rubrics (AR)**Assessment Task**

Coursework (for students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter)

Criterion

Midterm and assignments

Excellent

A+, A, A-

Good

B+, B, B-

Fair

C+, C, C-

Marginal

D

Failure

F

Assessment Task

Examination (for students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter)

Criterion

Close-book but open-notes exam

Excellent

A+, A, A-

Good

B+, B, B-

Fair

C+, C, C-

Marginal

D

Failure

F

Assessment Task

Coursework (for students admitted from Semester A 2022/23 to Summer Term 2024)

Criterion

Midterm and assignments

Excellent

A+, A, A-

Good

B+, B

Marginal

B-, C+, C

Failure

F

Assessment Task

Examination (for students admitted from Semester A 2022/23 to Summer Term 2024)

Criterion

Close-book but open-notes exam

Excellent

A+, A, A-

Good

B+, B

Marginal

B-, C+, C

Failure

F

Part III Other Information

Keyword Syllabus

- Likelihood, prior distribution, Bayes theorem, Bayesian linear regression model, utility/loss functions, quadratic loss function, zero-one loss function, admissibility, shortest credible intervals, empirical Bayesian estimation, conjugate prior, Jeffreys prior, reference prior, g-prior,
- Bayesian hierarchical linear model, Bayesian spline models,
- Bayesian model averaging, Bayesian variable selection methods, stochastic search variable selection, Bayesian LASSO, Bayesian generalized linear models, multivariate normal distribution, multivariate t distribution, Wishart and inverse Wishart distributions,
- Gibbs sampling, slice sampling, adaptive Metropolis-Hastings algorithms, integrated nested Laplace approximation, variational Bayesian methods
- Gaussian process regression, covariance functions, reproducing kernel Hilbert space, mean square continuity and differentiability, modelling with derivative information, Latin hypercube designs, maximum entropy sampling, maximin and minimax designs, separability and Cartesian product design
- Bayesian optimization, expected improvement, correlated knowledge gradient, noisy evaluations, multiobjective Bayesian optimization, Bayesian quadrature, Koksma-Hlawka inequality.

Reading List**Compulsory Readings**

Title	
1	Denison, D. G., Holmes, C. C., Mallick, B. K., & Smith, A. F. (2002). Bayesian methods for nonlinear classification and regression (Vol. 386). John Wiley & Sons.
2	Vidales, A. (2019). Machine learning with Matlab: Gaussian process regression, analysis of variance, and Bayesian optimization. Independently published.

3	Faraway, J. J., Wang, X., & Ryan, Y. Y. (2018). Bayesian Regression Modeling with INLA. Chapman and Hall/CRC.
4	Santner, T. J., Williams, B. J., Notz, W., & Williams, B. J. (2018). The design and analysis of computer experiments (2nd Edition). New York: Springer.
5	Rasmussen, C. E., & Williams, C. K. (2006). Gaussian Process Regression for Machine Learning. The MIT Press.
6	O'Hagan, A., & Forster, J. J. (2004). Kendall's advanced theory of statistics, volume 2B: Bayesian inference (Vol. 2). Arnold.

Additional Readings

	Title
1	Nil