

C4c: Quantitative Methods

Instructor: Jagdish Krishnaswamy (jagdish@atree.org);

Guest lectures by faculty within and outside ATREE.

Number of credits: 2

Course description

This course will introduce statistical methods with a critical view of frequentist approaches even as it introduces the fundamentals of a Bayesian approach and interpretation, with an increasing emphasis on parameter estimation and posterior probability of hypotheses. This course will consider and present statistics as an integral part of the scientific process rather than as an after thought. It will use R statistical software for all analyses and outputs.

Examples and applications will be drawn from both social and natural sciences.

Contact time: Approximately 3 hours a week, including statistical laboratory in R.

Pre-requisites: Basic Mathematics and Statistics exposure at Bachelors and Masters level. Should have cleared Maths prerequisite at ATREE.

Topics

1. Role of statistics in the scientific method.
2. Probability as an expression of uncertainty. Laws of Probability.
3. Concept of Likelihood. Bayes theorem and Bayesian approach.
4. Probability distributions (discrete and continuous): Bernoulli, Binomial, Poisson, Normal.
5. Exploratory data analyses for univariate, bivariate and multi-variate data.
6. Sampling distributions. Central Limit Theorem.
7. Fundamentals of frequentist Hypothesis testing. Type 1 and Type 2 errors. P-values. The pitfalls of significance testing and null hypotheses.
8. Expected and actual frequencies: Chi-square analyses
9. Bayesian approach and inference.
10. Study design and sampling.
11. Linear models
12. Generalized Linear models
13. Fixed and random effects models
14. Non-linear models. Generalized Additive Models.
15. Quantile regression to deal with expression of response at higher levels when multiple unmeasured factors are present
16. Fundamentals of Time-series analyses. Temporal auto-correlation. Seasonality. Trend analyses. Generalized Least Squares models with auto-correlated errors
17. Concepts of spatial data analyses (geostatistics).
18. Multi-variate data and dimension reduction: factor analyses and principal component analyses.

Course evaluation: Three assignments of 10 marks each, one mid-term quiz of 20 marks.

Final exam is of 50 marks.

Readings and Resources

1. Data Analyses and Graphics Using R. John Maindonald and John Braun. Second Edition. 2006. Cambridge Series in Statistical and Probabilistic Mathematics.
2. Introduction to Statistical Thought. Michael Lavine.
<http://www.math.umass.edu/~lavine/Book/book.html>
3. Hobbs, N.T., Hilborn, R., 2006. Alternatives to statistical hypothesis testing in ecology: a guide to self teaching. *Ecological Applications* 16, 5–19.
4. Johnson, Douglas H. 1999. The Insignificance of Statistical Significance Testing. *Journal of Wildlife Management* 63(3):763-772. Jamestown, ND: Northern Prairie Wildlife Research Center Online.
<http://www.npwrc.usgs.gov/resource/methods/statsig/index.htm>
(Version 16SEP99).
5. The Insignificance of Null Hypothesis Significance Testing *Political Research Quarterly* September 1999 52: 647-674.
6. Anderson, D.R., Burnham, K.P., Thompson, W.L., 2000. Null hypothesis testing: problems, prevalence, and an alternative. *The Journal of Wildlife Management*. 64, 912–923.

R Tutorials and Books for Help:

<http://tryr.codeschool.com/levels/1/challenges/5>

<http://www.cyclismo.org/tutorial/R/>

<http://www.statmethods.net/>

<http://cran.r-project.org/doc/manuals/R-intro.html>

Maindonald, J. and Braun, J. *Data Analyses and Graphics Using R*. Second Edition. 2006. Cambridge Series in Statistical and Probabilistic Mathematics.

Crawley, M. *The R Book*. John Wiley and Sons, UK.

Website for R software:

www.r-project.org

Session-wise time-table

(Thursdays – 10:00-10:50am and 11:00-11:50 pm and Fridays-10:00-10:50am)

Date	Day	Course (10-10:50AM)	Course (11-11:50 PM)	Topic(s)
09-01-2014	Thursday	Quantitative Methods (C4c)	Quantitative Methods (C4c)	Role of statistics in the scientific method.
10-01-2014	Friday	Quantitative Methods (C4c)		Probability as an expression of uncertainty. Laws of Probability.
16-01-2014	Thursday	Quantitative Methods (C4c)	Quantitative Methods (C4c)	Probability and probability distributions (discrete and continuous): Bernoulli, Binomial, Poisson, Normal
17-01-2014	Friday	Quantitative Methods (C4c)		" "
23-01-2014	Thursday	Quantitative Methods (C4c)	Quantitative Methods (C4c)	Concept of Likelihood. Bayes theorem and Bayesian approach
24-01-2014	Friday	Quantitative Methods (C4c)		" "
30-01-2014	Thursday	Quantitative Methods (C4c)	Quantitative Methods (C4c)	Exploratory data analyses for univariate, bivariate and multi-variate data
31-01-2014	Friday	Quantitative Methods (C4c)		" "
06-02-2014	Thursday	Quantitative Methods (C4c)	Quantitative Methods (C4c)	Sampling distributions. Central Limit Theorem
07-02-2014	Friday	Quantitative Methods (C4c)		" "
13-02-2014	Thursday	Quantitative Methods (C4c)	Quantitative Methods (C4c)	Fundamentals of frequentist Hypothesis testing. Type 1 and Type 2 errors. P-values. The pitfalls of significance testing and null hypotheses.
14-02-2014	Friday	Quantitative Methods (C4c)		" "
20-02-2014	Thursday	Quantitative Methods (C4c)	Quantitative Methods (C4c)	Expected and actual frequencies: Chi-square analyses
21-02-2014	Friday	Quantitative Methods (C4c)		" "
06-03-2014	Thursday	Quantitative Methods (C4c)	Quantitative Methods (C4c)	Study design and sampling methods – GUEST LECTURE
07-03-2014	Friday	Quantitative Methods (C4c)		" "
13-03-2014	Thursday	Quantitative Methods (C4c)	Quantitative Methods (C4c)	Bayesian approach and inference

14-03-2014	Friday	Quantitative Methods (C4c)		" "
20-03-2014	Thursday	Quantitative Methods (C4c)	Quantitative Methods (C4c)	Linear models
21-03-2014	Friday	Quantitative Methods (C4c)		" "
27-03-2014	Thursday	Quantitative Methods (C4c)	Quantitative Methods (C4c)	Generalized Linear models
28-03-2014	Friday	Quantitative Methods (C4c)		" "
03-04-2014	Thursday	Quantitative Methods (C4c)	Quantitative Methods (C4c)	Fixed and random effects models
04-04-2014	Friday	Quantitative Methods (C4c)		" "
10-04-2014	Thursday	Quantitative Methods (C4c)	Quantitative Methods (C4c)	Non-linear models. Generalized Additive Models
11-04-2014	Friday	Quantitative Methods (C4c)		Quantile regression to deal with expression of response at higher levels when multiple unmeasured factors are present
17-04-2014	Thursday	Quantitative Methods (C4c)	Quantitative Methods (C4c)	Multivariate data and dimension reduction: factor analyses and principal component analyses.
18-04-2014	Friday	Quantitative Methods (C4c)		" "
24-04-2014	Thursday	Quantitative Methods (C4c)	Quantitative Methods (C4c)	Fundamentals of Time-series analyses. Temporal auto-correlation. Seasonality. Trend analyses. Generalized Least Squares models with auto-correlated errors
25-04-2014	Friday	Quantitative Methods (C4c)		" "
01-05-2014	Thursday	Quantitative Methods (C4c)	Quantitative Methods (C4c)	Concepts of spatial data analyses (geostatistics).
02-05-2014	Friday	Quantitative Methods (C4c)		Final Overview

R tutorials and exercises will be held on Thursdays 11-12 PM