



Bayesian Methods

LABORATORY

Lesson 2: Jan 31 2002

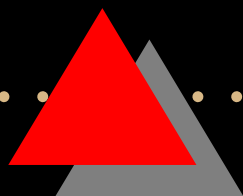
Software: BUGS

*An introduction to BUGS and Bayesian updating, inference
and prediction in 2 standard data models: Normal and
Poisson*



BUGS

Bayesian inference Using Gibbs Sampling





BUGS

Bayesian inference Using Gibbs Sampling

- is a piece of computer software for the *Bayesian analysis* of *complex statistical models* using *Markov chain Monte Carlo (MCMC)* methods.



BUGS

Bayesian inference Using Gibbs Sampling

- is a piece of computer software for the *Bayesian analysis* of *complex statistical models* using *Markov chain Monte Carlo (MCMC)* methods.
- It grew from a statistical research project at the MRC BIostatistics Unit in Cambridge, but now is developed jointly with the Imperial College School of Medicine at St Mary's, London.



Software

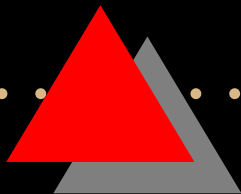
- The Classic BUGS program uses text-based model description and a command-line interface, and versions are available for major computer platforms (Sparc, Dos).

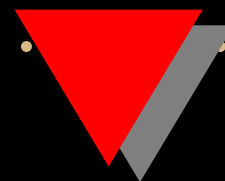


Software

- The Classic BUGS program uses text-based model description and a command-line interface, and versions are available for major computer platforms (Sparc, Dos).
- A Windows version, WinBUGS, has an option of a graphical user interface, the standard 'point-and-click' windows interface, and has on-line monitoring and convergence diagnostics.

CODA and BOA are a suite of $S - plus / R$ functions for convergence diagnostics.





software version: **WinBUGS 1.3**

The last **WinBUGS** has a number of new features which are not part of **Classic BUGS**. These include a more general **Metropolis sampler** (**Slice sampling** and **current point Metropolis**) and simplifications to the syntax.

a reference text: **Bayesian Statistical Modelling** by *Peter Congdon*

The book reviews **several major areas of statistical application and modelling** with a view to implementing **Bayesian perspective** and to developing the wide range of possibilities opened up by the **BUGS software**.

BUGS, in fact, offers a large **programming flexibility** and does make a **great demand on the researcher's own initiative**.





Examples

*Two educational BUGS examples for
ONE-DIMENSIONAL parameter models*

1. The univariate Normal model with **unknown mean μ** , but known variance σ^2
2. The Poisson model for **event counts**

UNIVARIATE NORMAL

Congdon 's book, pag. 17, Example 2.1

Program 2.1 Systolic Blood Pressure

- Suppose we take a random sample of 20 systolic blood pressure readings y_i from a subpopulation of adult men, that might be a particular diagnostic group.
- We know from national surveys that $\sigma = 13$.
- We are interested in estimating μ , the mean blood pressure in our group, and predicting its likely level in a typical new patient in the same group.
- Suppose we select a non informative prior for μ .



normal example continues ...

- Suppose we know the typical blood pressure for all adult males is 125, and we wish to test whether the particular diagnostic group has above or below average pressure
- These questions may be answered directly from normal probabilities ...

As the likelihood $p(y|\theta) \equiv L(\mu; y)$ is $\propto \exp(-1/2\tau (y - \mu)^2)$ if the prior is of the same form, e.g., $p(\theta)$ is $\propto \exp(-1/2\tau_0 (y - \mu_0)^2)$, then the posterior will also keep this form. In fact, $p(\theta|y)$ is $\propto \exp(-1/2 \{ \tau_0 (\mu - \mu_0)^2 + \tau (y - \mu)^2 \})$

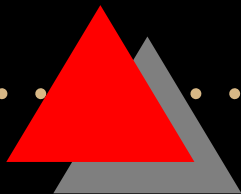
-> the NORMAL prior distribution is a conjugate family for the NORMAL likelihood ...

- but a sampling perspective is equally possible.



Bugs: model specification

- Construction of a **Directed Acyclic Graph**





Bugs: model specification

- Construction of a **Directed Acyclic Graph**

- Nodes:

Constants

Stochastic nodes

Deterministic nodes



Bugs: model specification

- Construction of a **Directed Acyclic Graph**

- Nodes:

Constants

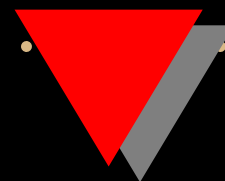
Stochastic nodes

Deterministic nodes

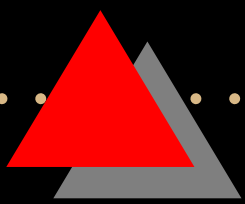
- Arrows:

stochastic dependence

logical function



The lesson continues opening WINbugs, clicking on the **User Manual** at the Help menu (to be read !!), and simulating the bugs model in **norm1.b** at the course web page.



POISSON

Congdon 's book, pag. 36, Example 2.15

Program 2.15 Trent Leukaemia Mortality

- Comparing mortality between areas after standardizing for age, factor affecting mortality risk.
- Data consist in myeloid leukaemia **deaths** (1989) in Derby, denoted y_1 , and in the remainder of the Trent region of England, y_2 , of which Derby is a part.
- Let $y_{i,j}$ denote observed deaths, and n_{ij} populations in **area i** for **age groups j**. where $p_j^* = n_{Ij} / (n_{Ij} + n_{Sj})$ is the share of the total



poisson example continues ...

by you !! simulating the bugs model in **pois.b** at the course web page.

There are 2 models: A) (simple) extracted from B) that is the one written by Congdon in *Program 2.15*