STAT40380/40390 - Bayesian Analysis

Computer Lab 1 – Introduction to WinBUGS

1 What is WinBUGS?

WinBUGS is a free, open-source computer programme for fitting Bayesian statistical models. It is part of a more general language known as BUGS – *Bayesian inference Using Gibbs' Sampling*. WinBUGS is the Windows version of the BUGS software. Other versions are available which run on the Mac or Unix machines, or through the free software package `R`.

2 Downloading and installing WinBUGS

To install WinBUGS on a USB stick for use on UCD computers:

- Insert a USB stick into a USB port on the computer.
- Download the file `WinBUGS14.zip` from the WinBUGS blackboard folder, and unzip it to your USB stick.
- Navigate to the file `WinBUGS14.exe` on your USB stick and double click on it to start WinBUGS.

On starting WinBUGS you will be greeted with a license agreement which you can close immediately.

To install WinBUGS on your own laptop:

- Download the file `WinBUGS14.zip` from the WinBUGS blackboard folder, and unzip it somewhere on your computer (e.g. C:\Program Files).
- Navigate to the file `WinBUGS14.exe` and double click on it to start WinBUGS.

On starting WinBUGS you will be greeted with a license agreement which you can close immediately.

3 Getting help

The help menu in WinBUGS provides a number of useful links:

- The WinBUGS user manual. This is the main port of call for any problems or error messages. Perhaps the most useful section is that of the probability distributions implemented by WinBUGS.
- Doodle help. DoodleBUGS is part of WinBUGS that allows for creating models from graphical relationships. We will not be covering this aspect of WinBUGS.
- Examples I and II. These examples are a treasure-trove of useful information. Almost all the different models we will try and fit can be created from these examples rather than starting from scratch. Many examples are annotated and provide detailed background information as to the calculations being performed.

4 Basic properties of a WinBUGS file

Task:

- Download the file `Dating.odc` from the WinBUGS files directory on blackboard and load it up in WinBUGS.

WinBUGS files always have the file extension `.odc`. You should see that the file Dating.odc (which implements the dating volcanic rock example we met in Lecture 2) contains 3 sections:

- A *model* section containing details of the likelihood and prior to be fitted. WinBUGS uses code similar (but not exactly the same as) the `R` environment.
- A *data* section containing the data and other fixed parameters.
- An *initial values* section. This is an optional section for specifying a first guess as to the values of the parameters.

The format of an `odc` file can be changed in the *Attributes* menu by highlighting text and choosing a size and/or colour. A *fold* can be created allowing different parts of the text to be expanded or collapsed. You can create a fold by highlighting some text and clicking Tools > Create Fold. You can apply the fold by clicking on the arrows, and add text between the arrows when the fold is closed.

Tasks:

- Try playing with the different attributes by re-sizing and changing the colour of fonts, and by creating and removing folds. Getting a WinBUGS file into a presentable format is vital for being able to understand WinBUGS code, especially when someone else has written it!
- Try clicking File > New, and re-creating the Dating.odc file exactly without using any cut/copy/paste commands.

5 WinBUGS language syntax

Writing computer code in WinBUGS is different from other languages as the order in which commands are issued is relatively unimportant. However, there are some specific requirements for your code to run:

- The model section must start with the line `model` and contain any subsequent code in curly brackets.
- If a variable is to follow a distribution, the term `~` must be used.
- If a a variable is to equal a function of another variable, then `<-` must be used. This is the WinBUGS equivalent of the equals sign.
- If a distribution is to be used, it is usually prefixed with a `d`. For example, the normal distribution is `dnorm`, the gamma distribution is `dgamma`. More distributions can be found in the relevant section of the user manual. Remember: when specifying a normal distribution in WinBUGS the second argument is the precision rather than the variance. Be careful!
- The data and initial values sections must start with `list` and then contain each of the data values separated by a comma. Vector data observations can be included via, eg, `list(x=c(2,4,6,8),y=c(1,3,5,7))`.
- Inside the model commands, comments can be added by prefixing them with `#`.
- Outside of the modelling, data and initial value sections, comments (and pictures) can be inserted without any prefixes.

6 Running a WinBUGS model

Assuming your WinBUGS file is syntactically correct you can run a file by the following procedure. Note that after each step WinBUGS will display whether the command worked or not in the bottom left-hand corner.

1. Click Model > Specification
2. Highlight the word `model` and click 'check model'
3. Highlight the word `list` in the data section and click 'load data'
4. Click 'compile'
5. Highlight the word `list` in the initial values section and click 'load inits'
6. Click Inferences > Samples
7. Type the name of the parameters you are interested in and click 'set' after each one. (In the `Dating.odc` file the only parameter is `theta`)
8. Click Model > Update
9. Click 'Update'

The model will now run for 1000 iterations. You can see it updating in the iteration box.

Task:

- Follow the steps above to run the dating model for 1000 iterations. Familiarise yourself with the process for running the model.

7 Analysing the WinBUGS output

After running the model for a number of iterations, we can explore the output by returning to the sample monitor tool we opened earlier. Simply enter `*` in the 'node' box and:

- Click 'density' for an estimate of the probability density of the posterior distribution for all the parameters in the model.
- Click 'history' for a graph of the values sampled by WinBUGS for the posterior. (Note: in later lectures we will cover the methods used to create these simulated values)
- Click 'stats' to see a selection of summary statistics for the posterior distribution.

Tasks:

- Run the model for 1000 iterations and look at the density and summary statistics. Run the model for a further 10,000 iterations and confirm that the model is converging to approximately the correct values we found in class ($N(413, 7^2)$)
- Try changing the initial values and look at the effect on the summary statistics. Does it affect your posterior mean and standard deviation?
- Try changing the prior values (ie `theta0` and `phi0`) and look at the effect on the posterior mean and standard deviation. What happens if the prior is very precise/diverse?