

Stat 544 – Spring 2005

Due on Wednesday 02/2

You should turn in your homework in the TA's office (315C Snedecor Hall) by 5:00pm of the due date.

Read the entire handout before attempting to do the homework. In particular, we introduce WinBugs in this assignment and a mini-tutorial is provided below.

Exercise 1

For this exercise you should provide the code written for a program that you are comfortable working with (R, S-plus, SAS, Mathematica, etc.), you do not have to provide the samples.

Your computer has been infected with a virus that has render useless any random number generating function other than the one that generates random numbers from a uniform distribution. Thus, using only this function do the following:

- a. Generate samples of size 1000 of X where:
 1. $X \sim \text{logistic}(\mu=10, \tau=2)$
 2. $X \sim \text{Pareto}(a=2, b=1)$
- b. Using the relationship between the exponential and the Weibull distribution generate samples of size 1000 from $X \sim \text{Weibull}(\alpha=2, \lambda=3)$.
- c. Using the relationship between the Poisson and the exponential distribution generate samples of size 1000 from $X \sim \text{Poisson}(5)$.
- d. Using the relationship between the exponential and the Gamma distribution generate samples of size 1000 from $X \sim \text{Gamma}(\alpha=3, \beta=5)$
- e. Using the relationship between the Beta and the Gamma distribution generate samples of size 1000 from $X \sim \text{Beta}(\alpha=3, \beta=5)$

Exercise 2

You have found that WinBugs has not been affected by the virus that infected your computer. At this moment you are not concerned about what WinBugs does or how it does it. Thus, you will use it as a “black box” to generate random numbers from a posterior distribution.

1. Generate a sample of 1000 values from $\mu|y$ where $y|\mu \sim N(\mu, 2)$, $\mu \sim N(5, 1)$ and you have observed the following values of y:

3.65, 4.01, 3.17, 3.48, 2.77, 4.28, 4.78, 4.03, 3.44, 3.09

2. Generate a sample of 1000 values from $p|y$ where $y|p \sim \text{Binomial}(10,p)$, $p \sim \text{Beta}(0.5,0.5)$ and you have observed the following values of y :

6, 5, 6, 7, 7, 4, 5, 8, 6, 9

3. Generate a sample of 1000 values from $\lambda|y$ where $y|\lambda \sim \text{Poisson}(\lambda)$ and $\lambda \sim \text{Gamma}(1, 0.001)$ and you have observed the following values of y :

6, 6, 2, 6, 5, 8, 3, 6, 4, 5

In each case, compute and report the posterior mean, standard deviation, and percentiles 0.025, 0.50, and 0.975. You should also attach your WinBugs programs.

Exercise 3

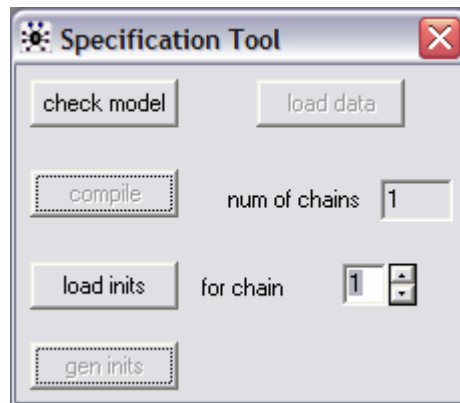
Do exercise 1.12.7 from the textbook (page 31)

Exercise 4

Do exercise 2.11.17 from the textbook (page 71)

The following is a mini tutorial on how to work with WinBugs.

1. **Running WinBugs:** WinBugs is available on all computer labs in Snedecor Hall. If you wish to install the program on your computer follow the link provided on the class web site (Software link). Please read the instructions provided on the WinBugs web site to obtain the key for unrestricted use.
2. Once you have clicked on the WinBugs icon, select File from the menu and then select New. Write your program and enter your data in the window that will open. An example program is given below.
3. After you have finished writing your program and entering your data select Model and then “Specification...” The following windows will open



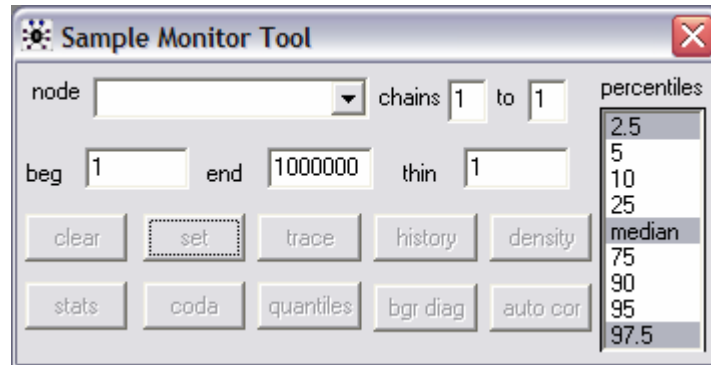
Follow these steps:

- a. On your program highlight the word “model” using the mouse and then click on “check model”.
- b. On your program highlight the word “list” that appears in your data definition and click on “load data”.
- c. Then click on “compile”.
- d. Click in “gen inits”. “gen inits” stands for “generate initial values”. We will learn about this later in the class.

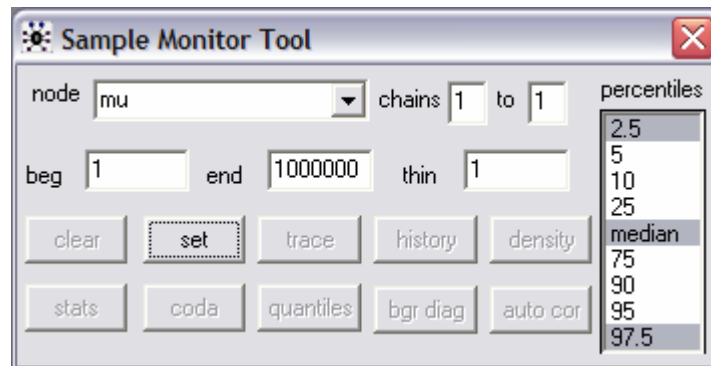
After implementing each of the steps above WinBugs will let you know whether you have errors in your code by writing a short message on the bottom left corner of your screen. If there are no errors, WinBugs will tell you the following:

After you click on	This message will indicate no errors
check model	model is syntactically correct
load data	data loaded
compile	model compiled
gen inits	Initial values generated, model initialized

4. After completing the previous step, from the menu Inference select “Samples...”. The following window will pop up:

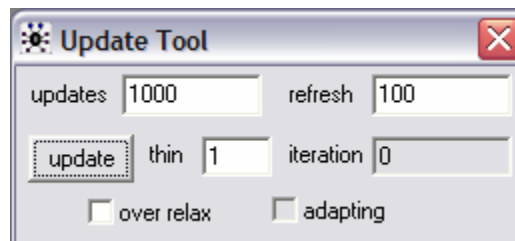


In the node field enter the name of the parameter for which you wish to obtain a sample from the posterior. For example, in part 1 of exercise 2 you may have used “mu” to denote the mean μ , in which case you would enter mu in node. If you are entering a valid name in “node” the word “set” will now be active and you will be able to click on it to tell WinBugs that you wish to obtain samples of mu:



You can enter more than one parameter name in “node” and in this case, WinBugs will draw samples from the joint posterior distribution. We have not yet discussed multiparameter models in class.

5. After completing the previous step, select “Update” from the menu Model and the following window will pop up:



In the field labeled “updates” enter the number of samples that you wish to draw from the posterior. Then click on “update”. After WinBugs is done drawing the samples the field “iteration” should show the total number of samples that you have drawn. For example, if you enter in “updates” the number 5000 and then you click once on the “update” button, when WinBugs has finished on the field “iteration” will appear the number 5000. If you click once more on “update” then the number 10000 will appear.

- Go again to the “Sample monitor tool” window (the one that you opened in step 4). Choose the node that you wish to draw inferences on. For example, choose mu if you are working on problem 2, part 1. Now several options will become active. At this time, the only ones you will be using are “density” and “stats”.



If you click on “density” you will see an approximation to the posterior distribution of the parameter in the node window obtained from the draws sampled by WinBugs.

If you click on “stats” you will find a summary of the posterior distribution of the parameter in “node”. Stats will give you the posterior mean, the posterior standard deviation, and the posterior 2.5, 50, and 97.5 percentiles (highlighted at the right in the Sample Monitor Tool window).

Writing a WinBugs program

WinBugs programs typically have three parts: model, data, and initial values. For this homework assignment we will declare only the model and the data and will let WinBugs choose initial values for us. Do not worry about what exactly it is that we are initializing, we will learn all about this when we begin with Chapter 10 and 11. If you wish to read about WinBugs, please refer to the online help and manual, or ask the class TA or instructor for help. While no formal training in WinBugs is planned, we will discuss several examples implemented in WinBugs during the semester.

Model declaration

The model is always declared in the following way:

```
model{ ...model statements... }
```

Data

Data can be declared using the following statement:

```
list( .....)
```

For example, the WinBugs code to do part 1 of exercise 2 is the following:

```
model{ for (i in 1:10){ y[i] ~ dnorm(mu,.5) }
```

```
mu ~ dnorm(5,1)
```

```
}
```

```
list(y=c(3.65,4.01,3.17,3.48,2.77,4.28,4.78,4.03,3.44,3.09))
```

The syntax is very similar to that used by R. Note that the subscript i above indicates a loop over the y values, and the `dnorm` simply says that y has a normal density with mean μ and **precision** 0.5. In WinBugs, the normal distribution is parameterized in terms of the mean and the **inverse of the variance**, also called the precision, whereas in R the normal distribution is parameterized in terms of the mean and the standard deviation.