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A Review of Different Parameterizations Used in R and BUGS

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Abstract

The ability to generate models in the BUGS language simplifies the development and analysis of Bayesian models. Software written in the BUGS language includes **OpenBUGS**, **WinBUGS**, and **JAGS**.

However, the R and BUGS use inconsistent representations of common probability distributions, creating the potential for error and confusion when writing conducting statistical analyses that use both languages. Here we provide an overview of the different parameterizations, documentation of the transformations, and an R package **r2bugs** that implements these transformations. As a demonstration of **r2bugs**, the function `bugs.rdist` implements random sampling functions in JAGS that are analogous to the `rdist` functions in R such as `rnorm`.

Keywords: bayesian, R, BUGS, JAGS.

1. Introduction

Many software packages provide an interface to software written in the BUGS language, enabling users to leverage the power of R when pre-processing data and analyzing model output.

However, many common probability distributions have different default parameterizations in the R versus BUGS languages. As part of a semi-automated meta-analysis module in the PEcAn workflow (LeBauer et al. 2012), we developed a function to transform parameterizations between the R and BUGS languages. Although the probability distribution functions are documented in the respective software, we are not aware of any comprehensive treatment of the different parameterizations used by BUGS and R, or a single location in which transformations between these languages are documented. Here we provide an overview of distributions for which the default parameterizations used by R and BUGS are different, including the transformations required to convert from one language to another and a R function that encapsulates these transformations.

Table 1 summarizes the different parameterizations used in R (R Development Core Team 2011) and BUGS (Plummer 2011).

Table 1: Summary of different parameterizations of common distributions used by R and BUGS. The random variable x is implicit in all of the BUGS "Use" parameterizations. * non-default parameterizations in R - these are not used in the `r2bugs.distributions` function; to use these parameterizations, the second argument *must* be named. For clarity and ease of reference, parameterizations follow the **JAGS** and R documentation; thus, the table includes some equivalent variables with different names (e.g. for Gamma, r in BUGS and a in R are precisely the same), and equivalent expressions with different forms (which motivates this article).

Distribution	Language	Parameterization	Use
Normal	R	$\frac{1}{\sqrt{2\pi}\sigma}\exp(-\frac{(x-\mu)^2}{2\sigma^2})$	`dnorm(x, μ, σ)`
	BUGS	$\sqrt{\frac{\tau}{2\pi}}\exp(-(x-\mu)^2\tau)$	`dnorm(μ, τ)`
log-Normal	R	$\frac{1}{\sqrt{2\pi}\sigma x}\exp(-\frac{(logx-\mu)^2}{(2\sigma^2)})$	`dlnorm(x, μ, σ)`
	BUGS	$\frac{\sqrt{\tau}}{x}\exp(\frac{-\tau(log(x)-\mu)^2}{2})$	`dlnorm(μ, τ)`
Binomial	R	$\binom{n}{x}p^x(1-p)^{n-x}$	`dbinom(x, n, p)`
	BUGS	same	`dbin(p, n)`
Negative Binomial	R	$\frac{\Gamma(x+n)}{\Gamma(n)x!}p^n(1-p)^x$	`dnbinom(x, n, p)`
	R*	$\frac{\Gamma(k+x)}{\Gamma(k)x!}(\frac{k}{k+\mu})^k\frac{\mu}{(k+\mu)^x}$	`dnbinom(x, n, mu = μ)`*
	BUGS	$\binom{x+r-1}{x}p^r(1-p)^x$	`dnegbin(p, r)`
Weibull	R	$\frac{a}{b}(\frac{x}{b})^{a-1}\exp(-(\frac{x}{b})^a)$	`dweibull(x, a, b)`
	BUGS	$\nu\lambda x^{\nu-1}\exp(-\lambda x^\nu)$	`dweib(ν, λ)`
Gamma	R	$\frac{r^a}{\Gamma(a)}x^{a-1}\exp(-xr)$	`dgamma(x, a, r)`
	R*	$\frac{1}{s^a\Gamma(a)}x^{a-1}\exp(-x/s)$	`dgamma(x, a, scale = s)`*
	BUGS	$\frac{\lambda^r x^{r-1}\exp(-\lambda x)}{\Gamma(r)}$	`dgamma(r, λ)`

2. Converting from R to BUGS parameterizations

The Normal and log-normal are parameterized in terms of τ (precision) by BUGS and in terms of σ (standard deviation) or σ^2 (variance) by R. The Negative binomial distribution size parameter is discrete in BUGS (size, prob), but the size parameter is continuous in R (size, mu). The Weibull distribution has parameters (ν = shape, λ = lambda) in BUGS, in R, it has either (a=shape, b=scale) or (a=shape,b=rate). The default parameterization of the Gamma in R is (a=shape, r = rate) whereas in BUGS the parameterization is (r = rate, λ = shape). Thus, the order of the shape and rate parameters is reversed in BUGS (which uses rate, shape). R also allows the Gamma to accept (shape, scale) but this requires that the scale argument is named (e.g. `dgamma(x, a, scale = b)`).

The Beta, Poisson, Exponential, and Uniform distributions have the same parameterizations in both BUGS and R. A summary of these distributions is provided in table 1; the conversions required to transform parameters from R to BUGS (and BUGS to R) is provided in the table

2 and the functions `r2bugs` and `bugs2r` in the appendix.

It is also important to note that order matters, particularly in BUGS which doesn't have named arguments. For example, the R prarmeterization of the Binomial distribution, `dbinom(x, size, prob)`, has the same parameters but they are in reversed order in the BUGS distribution, `dbin(p,n)`.

Table 2 summarizes transformations that can be used to convert between R and BUGS parameterizations.

Table 2: Equations used to transform parameters from R to BUGS parameterizations

Distribution	R to BUGS conversion
Normal, log-Normal	$\tau = 1/\sigma^2$
Binomial	reverse parameter order
Negative Binomial	reverse parameter order
Weibull	$\lambda = (1/b)^a$
Gamma	$r = a$; $\lambda = r$ (reverse order)

In addition to different parameterizations, four distributions have different naming conventions, as listed in Table 2.

Table 3: Differences in naming of common distributions in the R and BUGS languages

Distribution	R	BUGS
Binomial	`dbinom`	`dbin`
Negative Binomial	`dnbinom`	`dnegbin`
χ^2	`dchisq`	`dchisqr`
Weibull	`dweibull`	`dweib`

3. Implementation

As a simple example, we will compare the use of R and BUGS to sample from a normal distribution, $N(\mu = 10, \sigma = 2)$

```
library(r2bugs)
n.iter <- 1e+05
set.seed(0)
## define a N(10,2) in R
r.distn <- data.frame(distn = "norm", parama = 10, paramb = 2)
## sample from the distribution
Y.R <- do.call(paste("r", r.distn$distn, sep = ""), list(n.iter/4, r.distn$parama,
    r.distn$paramb))
## convert R parameterization to BUGS parameterization
bugs.dist <- r2bugs.distributions(r.distn)
## sample from the BUGS distribution using JAGS
Y.BUGS <- bugs.rdist(bugs.dist, n.iter = n.iter)
```

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4. Appendix

R functions `r2bugs` and `bugs2r` convert from R to BUGS parameterizations, and `bugs.rdist` samples from a distribution using **JAGS**.

The **r2bugs** package is available from www.github.com/dlebauer/r2bugs

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