Package ‘dclone’

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complex models using data cloning and Bayesian
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Data Cloning

Description

Low level functions for implementing maximum likelihood estimating procedures for complex models using data cloning and Bayesian Markov chain Monte Carlo methods. Sequential and parallel MCMC support for JAGS, WinBUGS, OpenBUGS, and Stan.

Main functions include:

- **dclone, dcdim, dciid, dctr**: cloning R objects in various ways.
- **jags.fit, bugs.fit, stan.fit**: conveniently fit JAGS/BUGS/Stan models. **jags.parfit, bugs.parfit, stan.parfit** fits chains on parallel workers.
- **dc.fit**: iterative model fitting by the data cloning algorithm. **dc.parfit** is the parallelized version.
- **dtable, dcdiag**: helps evaluating data cloning convergence by descriptive statistics and diagnostic tools. (These are based on e.g. **chisq.diag** and **lambdamax.diag**.)
- **coef.mcmc.list, confint.mcmc.list, dcsd.mcmc.list, quantile.mcmc.list, vcov.mcmc.list**: methods for **mcmc.list** objects.
- **write.jags.model, clean.jags.model, custommodel**: convenient functions for handling JAGS/BUGS/Stan models.
- **jagsModel, codaSamples**: basic functions from **rjags** package rewrote to recognize data cloning attributes from data (**parJagsModel, parUpdate, parCodaSamples** are the parallel versions).

Author(s)

Author: Peter Solymos
Maintainer: Peter Solymos, <solymos@ualberta.ca>

References

Forum: [https://groups.google.com/forum/#!forum/dclone-users](https://groups.google.com/forum/#!forum/dclone-users)
Issues: [https://github.com/datacloning/dcmle/issues](https://github.com/datacloning/dcmle/issues)
Data cloning website: [http://datacloning.org](http://datacloning.org)
.dcFit

Internal function for iterative model fitting with data cloning

Description

This is the workhorse for dc.fit and dc.parfit.

Usage

.dcFit(data, params, model, inits, n.clones,
       multiply = NULL, unchanged = NULL,
       update = NULL, updatefun = NULL, initsfun = NULL,
       flavour = c("jags", "bugs", "stan"),
       n.chains=3, cl = NULL, parchains = FALSE,
       return.all=FALSE, ...)

Arguments

data A named list (or environment) containing the data.
params Character vector of parameters to be sampled. It can be a list of 2 vectors, 1st element is used as parameters to monitor, the 2nd is used as parameters to use in calculating the data cloning diagnostics.
model Character string (name of the model file), a function containing the model, or a custommodel object (see Examples).
inits Optional specification of initial values in the form of a list or a function (see Initialization at jags.model). If missing, will be treated as NULL and initial values will be generated automatically.
n.clones An integer vector containing the numbers of clones to use iteratively.
multiply Numeric or character index for list element(s) in the data argument to be multiplied by the number of clones instead of repetitions.
unchanged Numeric or character index for list element(s) in the data argument to be left unchanged.
update Numeric or character index for list element(s) in the data argument that has to be updated by updatefun in each iterations. This usually is for making priors more informative, and enhancing convergence. See Details and Examples.
updatefun A function to use for updating data[[update]]. It should take an 'mcmc.list' object as 1st argument, 2nd argument can be the number of clones. See Details and Examples.
initsfun A function to use for generating initial values, inits are updated by the object returned by this function from the second iteration. If initial values are not dependent on the previous iteration, this should be NULL, otherwise, it should take an 'mcmc.list' object as 1st argument, 2nd argument can be the number of clones. This feature is useful if latent nodes are provided in inits so it also requires to be cloned for subsequent iterations. See Details and Examples.
If "jags", the function `jags.fit` is called. If "bugs", the function `bugs.fit` is called. If "stan", the function `stan.fit` is called.

**n.chains**
Number of chains to generate.

**cl**
A cluster object created by `makeCluster`, or an integer, see `parDosa` and `evalParallelArgument`.

**parchains**
Logical. Whether parallel chains should be run.

**return.all**
Logical. If TRUE, all the MCMC list objects corresponding to the sequence `n.clones` are returned for further inspection (this only works with `parType = "parchains"`). Otherwise only the MCMC list corresponding to highest number of clones is returned with summary statistics for the rest.

Other values supplied to `jags.fit`, or `bugs.fit`, depending on the `flavour` argument.

**Value**

An object inheriting from the class 'mcmc.list'.

**Author(s)**

Peter Solymos, <solymos@ualberta.ca>, implementation is based on many discussions with Khurram Nadeem and Subhash Lele.

**See Also**

`dc.fit, dc.parfit`

---

`bugs.fit`  
*Fit BUGS models with cloned data*

**Description**

Convenient functions designed to work well with cloned data arguments and WinBUGS and OpenBUGS.

**Usage**

```r
bugs.fit(data, params, model, inits = NULL, n.chains = 3,
         format = c("mcmc.list", "bugs"),
         program = c("winbugs", "openbugs", "brugs"),
         seed, ...)
```

## S3 method for class 'bugs'

```r
as.mcmc.list(x, ...)
```
Arguments

- **data**: A list (or environment) containing the data.
- **params**: Character vector of parameters to be sampled.
- **model**: Character string (name of the model file), a function containing the model, or a custommodel object (see Examples).
- **inits**: Optional specification of initial values in the form of a list or a function. If NULL, initial values will be generated automatically.
- **n.chains**: Number of Markov chains.
- **format**: Required output format.
- **program**: The program to use, not case sensitive. winbugs calls the function bugs from package R2WinBUGS, openbugs calls the function bugs from package R2OpenBUGS (this has changed since delone version 1.8-1, this is now the preferred OpenBUGS interface), brugs calls the function openbugs from package R2WinBUGS and requires the CRAN package BRugs (this is provided for back compatibility purposes, but gives a warning because it is not the preferred interface to R2OpenBUGS).
- **seed**: Random seed (bugsNseed argument for bugs in package R2WinBUGS or bugs in package R2OpenBUGS, seed argument for openbugs). It takes the corresponding default values (NULL or 1) when missing.
- **x**: A fitted 'bugs' object.
- **...**: Further arguments of the bugs function, except for codapkg are passed also, most notably the ones to set up burn-in, thin, etc. (see Details).

Value

By default, an mcmc.list object. If data cloning is used via the data argument, summary returns a modified summary containing scaled data cloning standard errors (scaled by sqrt(n.clones)), and Rhat values (as returned by gelman.diag).

bugs.fit can return a bugs object if format = "bugs". In this case, summary is not changed, but the number of clones used is attached as attribute and can be retrieved by the function nclones.

The function as.mcmc.list.bugs converts a 'bugs' object into 'mcmc.list' and retrieves data cloning information as well.

Author(s)

Peter Solymos,<solymos@ualberta.ca>

See Also

Underlying functions: bugs in package R2WinBUGS, openbugs in package R2WinBUGS, bugs in package R2OpenBUGS

Methods: dcsp,confint.mcmc.list.dc,coef.mcmc.list,quantile.mcmc.list,vcov.mcmc.list,dc
Examples

### Not run:

#### fitting with WinBUGS, bugs example

```r
if (require(R2WinBUGS)) {
  dat <- list(J = nrow(schools),
              y = schools$estimate,
              sigma.y = schools$sd)
  bugs.model <- function()
    for (j in 1:J){
      y[j] ~ dnorm (theta[j], tau.y[j])
      theta[j] ~ dnorm (mu.theta, tau.theta)
      tau.y[j] <- pow(sigma.y[j], -2)
    }
    mu.theta ~ dnorm (0.0, 1.0E-6)
    tau.theta <- pow(sigma.theta, -2)
    sigma.theta ~ dunif (0, 1000)
  }
  inits <- function()
    list( theta=rnorm(nrow(schools), 0, 100),
          mu.theta=rnorm(1, 0, 100),
          sigma.theta=runif(1, 0, 100))
  param <- c("mu.theta", "sigma.theta")
  if (.Platform$OS.type == "windows") {
    sim <- bugs.fit(dat, param, bugs.model, inits)
    summary(sim)
  }
  dat2 <- dclone(dat, 2, multiply="J")
  if (.Platform$OS.type == "windows") {
    sim2 <- bugs.fit(dat2, param, bugs.model,
                     program="winbugs", n.iter=2000, n.thin=1)
    summary(sim2)
  }
}
```

```r
if (require(BRugs)) {
  ## fitting the model with OpenBUGS
  ## using the less preferred BRugs interface
  sim3 <- bugs.fit(dat2, param, bugs.model,
                   program="brugs", n.iter=2000, n.thin=1)
  summary(sim3)
}
if (require(R2OpenBUGS)) {
  ## fitting the model with OpenBUGS
  ## using the preferred R2OpenBUGS interface
  sim4 <- bugs.fit(dat2, param, bugs.model,
                   program="openbugs", n.iter=2000, n.thin=1)
  summary(sim4)
}
if (require(rjags)) {
  ## fitting the model with JAGS
  sim5 <- jags.fit(dat2, param, bugs.model)
  summary(sim5)
```
bugs.parfit

Parallel computing with WinBUGS/OpenBUGS

Description

Does the same job as bugs.fit, but parallel chains are run on parallel workers, thus computations can be faster (up to \(1/n\) chains) for long MCMC runs.

Usage

```r
bugs.parfit(cl, data, params, model, inits=NULL, n.chains = 3,
          seed, program=c("winbugs", "openbugs", "brugs"), ...)
```

Arguments

- **cl**: A cluster object created by `makeCluster`, or an integer, see `parDosa` and `evalParallelArgument`.
- **data**: A named list or environment containing the data. If an environment, `data` is coerced into a list.
- **params**: Character vector of parameters to be sampled.
- **model**: Character string (name of the model file), a function containing the model, or a custom model object (see Examples).
- **inits**: Specification of initial values in the form of a list or a function, can be missing. If this is a function and using `snow` type cluster as `cl`, the function must be self containing, i.e. not having references to R objects outside of the function, or the objects should be exported with `clusterExport` before calling `bugs.parfit`. Forking type parallelism does not require such attention.
- **n.chains**: Number of chains to generate, must be higher than 1. Ideally, this is equal to the number of parallel workers in the cluster.
- **seed**: Vector of random seeds, must have `n.chains` unique values. See Details.
- **program**: The program to use, not case sensitive. See `bugs.fit`.
- **...**: Other arguments passed to `bugs.fit`.

Details

Chains are run on parallel workers, and the results are combined in the end.

The seed must be supplied, as it is the user’s responsibility to make sure that pseudo random sequences do not seriously overlap.

The WinBUGS implementation is quite unsafe from this regard, because the pseudo-random number generator used by WinBUGS generates a finite (albeit very long) sequence of distinct numbers, which would eventually be repeated if the sampler were run for a sufficiently long time.
Thus it’s usage must be discouraged. That is the reason for the warning that is issued when program = "winbugs".

OpenBUGS (starting from version 3.2.2) implemented a system where internal state of the pseudo random number generator can be set to one of 14 predefined states (seed values in 1:14). Each predefined state is $10^{12}$ draws apart to avoid overlap in pseudo random number sequences.

Note: the default setting `working.directory = NULL` cannot be changed when running parallel chains with `bugs.parfit` because the multiple instances would try to read/write the same directory.

**Value**

An `mcmc.list` object.

**Author(s)**

Peter Solymos, <solymos@ualberta.ca>

**See Also**

Sequential version: `bugs.fit`

**Examples**

```r
## Not run:
## fitting with WinBUGS, bugs example
if (require(R2WinBUGS)) {
  data(schools)
  dat <- list(J = nrow(schools),
              y = schools$estimate,
              sigma.y = schools$sd)
  bugs.model <- function(){
    for (j in 1:J){
      y[j] ~ dnorm(theta[j], tau.y[j])
      theta[j] ~ dnorm(mu.theta, tau.theta)
      tau.y[j] <- pow(sigma.y[j], -2)
    }
    mu.theta ~ dnorm(0.0, 1.0E-6)
    tau.theta <- pow(sigma.theta, -2)
    sigma.theta ~ dunif (0, 1000)
  }
  param <- c("mu.theta", "sigma.theta")
  SEED <- floor(runif(3, 100000, 999999))
  cl <- makePSOCKcluster(3)
  if (.Platform$OS.type == "windows") {
    sim <- bugs.parfit(cl, dat, param, bugs.model, seed=SEED)
    summary(sim)
  }
  dat2 <- dclone(dat, 2, multiply="J")
  if (.Platform$OS.type == "windows") {
    sim2 <- bugs.parfit(cl, dat2, param, bugs.model,
                        program="winbugs", n.iter=2000, n.thin=1, seed=SEED)
    summary(sim2)
  }
```
clusterSize

### Description

These functions help in optimizing workload for the workers if problems are of different size.

### Usage

```r
clusterSize(size)
plotClusterSize(n, size,
  balancing = c("none", "load", "size", "both"),
  plot = TRUE, col = NA, xlim = NULL, ylim = NULL,
  main, ...)
```

### Arguments

- `n` Number of workers.
- `size` Vector of problem sizes (recycled if needed). The default 1 indicates equality of problem sizes.
- `balancing` Character, type of balancing to perform, one of c("none", "load", "size", "both").
- `plot` Logical, if a plot should be drawn.
clusterSplitSB

col  Color of the polygons for work load pieces.
xlim, ylim  Limits for the x and the y axis, respectively (optional).
main  Title of the plot, can be missing.
...  Other arguments passed to polygon.

Details

These functions help determine the optimal number of workers needed for different sized problems ('size' indicates approximate processing time here). The number of workers needed depends on the type of balancing.

For the description of the balancing types, see parDosa.

Value

clusterSize returns a data frame with approximate processing time as the function of the number of workers (rows, in 1:length(size)) and the type of balancing (c("none", "load", "size", "both")). Approximate processing time is calculated from values in size without taking into account any communication overhead.

plotClusterSize invisibly returns the total processing time needed for a setting given its arguments. As a side effect, a plot is produced (if plot = TRUE).

Author(s)

Peter Solymos, <solymos@ualberta.ca>

Examples

## determine the number of workers needed
clusterSize(1:5)
## visually compare balancing options
opar <- par(mfrow=c(2, 2))
plotClusterSize(2,1:5, "none")
plotClusterSize(2,1:5, "load")
plotClusterSize(2,1:5, "size")
plotClusterSize(2,1:5, "both")
par(opar)

---

clusterSplitSB  Size balancing

Description

Functions for size balancing.
Usage

```r
clusterSplitSB(cl = NULL, seq, size = 1)
parLapplySB(cl = NULL, x, size = 1, fun, ...)
parLapplySLB(cl = NULL, x, size = 1, fun, ...)
```

Arguments

- `cl` A cluster object created by `makeCluster` the the package parallel.
- `x, seq` A vector to split.
- `fun` A function or character string naming a function.
- `size` Vector of problem sizes (approximate processing times) corresponding to elements of `seq` (recycled if needed). The default `1` indicates equality of problem sizes.
- `...` Other arguments of `fun`.

Details

`clusterSplitSB` splits `seq` into subsets, with respect to `size`. In size balancing, the problem is re-ordered from largest to smallest, and then subsets are determined by minimizing the total approximate processing time. This splitting is deterministic (reproducible).

`parLapplySB` and `parLapplySLB` evaluates `fun` on elements of `x` in parallel, similarly to `parLapply`. `parLapplySB` uses size balancing (via `clusterSplitSB`). `parLapplySLB` uses size and load balancing. This means that the problem is re-ordered from largest to smallest, and then undeterministic load balancing is used (see `clusterApplyLB`). If `size` is correct, this is identical to size balancing. This splitting is non-deterministic (might not be reproducible).

Value

- `clusterSplitSB` returns a list of subsets split with respect to `size`.
- `parLapplySB` and `parLapplySLB` evaluates `fun` on elements of `x`, and return a result corresponding to `x`. Usually a list with results returned by the cluster.

Author(s)

Peter Solymos, <solymos@ualberta.ca>

See Also

Related functions without size balancing: `clusterSplit`, `parLapply`.

Underlying functions: `clusterApply`, `clusterApplyLB`.

Optimizing the number of workers: `clusterSize`, `plotClusterSize`. 
Examples

```r
# Not run:
cl <- makePSOCKcluster(2)
## equal sizes, same as clusterSplit(cl, 1:5)
clusterSplitSB(cl, 1:5)
## different sizes
clusterSplitSB(cl, 1:5, 5:1)
x <- list(1, 2, 3, 4)
parLapplySB(cl, x, function(z) z^2, size=1:4)
stopCluster(cl)
```

```
## End(Not run)
```

codaSamples

**Generate posterior samples in mcmc.list format**

Description

This function sets a trace monitor for all requested nodes, updates the model and coerces the output to a single `mcmc.list` object. This function uses `coda.samples` but keeps track of data cloning information supplied via the `model` argument.

Usage

codaSamples(model, variable.names, n.iter, thin = 1, na.rm = TRUE, ...)

Arguments

- `model` a `jags` model object
- `variable.names` a character vector giving the names of variables to be monitored
- `n.iter` number of iterations to monitor
- `thin` thinning interval for monitors
- `na.rm` logical flag that indicates whether variables containing missing values should be omitted. See details in help page of `coda.samples`.
- `...` optional arguments that are passed to the update method for `jags` model objects

Value

An `mcmc.list` object. An `n.clones` attribute is attached to the object, but unlike in `jags.fit` there is no `updated.model` attribute as it is equivalent to the input `jags` model object.

Author(s)

Peter Solymos, <solymos@ualberta.ca>
See Also

coda.samples, update.jags, jags.model

Parallel version: parCodaSamples

Examples

## Not run:
model <- function() {
  for (i in 1:N) {
    Y[i] ~ dnorm(mu[i], tau)
    mu[i] <- alpha + beta * (x[i] - x.bar)
  }
  x.bar <- mean(x[])
  alpha ~ dnorm(0.0, 1.0E-4)
  beta ~ dnorm(0.0, 1.0E-4)
  sigma <- 1.0/sqrt(tau)
  tau ~ dgamma(1.0E-3, 1.0E-3)
}
## data generation
set.seed(1234)
N <- 100
alpha <- 1
beta <- -1
sigma <- 0.5
x <- runif(N)
linpred <- crossprod(t(model.matrix(~x)), c(alpha, beta))
Y <- rnorm(N, mean = linpred, sd = sigma)
jdata <- dclone(list(N = N, Y = Y, x = x), 2, multiply="N")
jpara <- c("alpha", "beta", "sigma")
## jags model
res <- jagsModel(file=model, data=jdata, n.chains = 3, n.adapt=1000)
mclones(res)
update(res, n.iter=1000)
mclones(res)
m <- codaSamples(res, jpara, n.iter=2000)
summary(m)
mclones(m)

## End(Not run)

---

**dc.fit**

*Iterative model fitting with data cloning*

**Description**

*jags.fit* or *bugs.fit* is iteratively used to fit a model with increasing the number of clones.
Usage

dc.fit(data, params, model, inits, n.clones,
   multiply = NULL, unchanged = NULL,
   update = NULL, updatefun = NULL, initsfun = NULL,
   flavour = c("jags", "bugs", "stan"), n.chains = 3,
   return.all=FALSE, ...)

Arguments

data  A named list (or environment) containing the data.
params Character vector of parameters to be sampled. It can be a list of 2 vectors, 1st
element is used as parameters to monitor, the 2nd is used as parameters to use
in calculating the data cloning diagnostics.
model  Character string (name of the model file), a function containing the model, or a
custom model object (see Examples).
inits  Optional specification of initial values in the form of a list or a function (see
Initialization at jags.model). If missing, will be treated as NULL and initial
values will be generated automatically.
n.clones An integer vector containing the numbers of clones to use iteratively.
multiply Numeric or character index for list element(s) in the data argument to be multi-
plied by the number of clones instead of repetitions.
unchanged Numeric or character index for list element(s) in the data argument to be left
unchanged.
update Numeric or character index for list element(s) in the data argument that has to
be updated by updatefun in each iterations. This usually is for making priors
more informative, and enhancing convergence. See Details and Examples.
updatefun A function to use for updating data[[update]]. It should take an 'mcmc.list'
object as 1st argument, 2nd argument can be the number of clones. See Details
and Examples.
initsfun A function to use for generating initial values, inits are updated by the object
returned by this function from the second iteration. If initial values are not
dependent on the previous iteration, this should be NULL, otherwise, it should
take an 'mcmc.list' object as 1st argument, 2nd argument can be the number of
clones. This feature is useful if latent nodes are provided in inits so it also
requires to be cloned for subsequent iterations. See Details and Examples.
flavour If "jags", the function jags.fit is called. If "bugs", the function bugs.fit is
called. If "stan", the function stan.fit is called.
n.chains Number of chains to generate.
return.all Logical. If TRUE, all the MCMC list objects corresponding to the sequence
n.clones are returned for further inspection. Otherwise only the MCMC list
corresponding to highest number of clones is returned with summary statistics
for the rest.
... Other values supplied to jags.fit, or bugs.fit, depending on the flavour
argument.
Details

The function fits a JAGS/BUGS model with increasing numbers of clones, as supplied by the argument `nNclones`. Data cloning is done by the function `dclone` using the arguments `multiply` and `unchanged`. An updating function can be provided, see Examples.

Value

An object inheriting from the class `mcmc.list`.

Author(s)

Peter Solymos, <solymos@ualberta.ca>, implementation is based on many discussions with Khurram Nadeem and Subhash Lele.

References


See Also

Data cloning: `dclone`.

Parallel computations: `dcNparfit`

Model fitting: `jagsNfit, bugsNfit`

Convergence diagnostics: `dctable, dcdiag`

Examples

```r
## Not run:
## simulation for Poisson GLMM
set.seed(1234)
n <- 20
beta <- c(2, -1)
sigma <- 0.1
alpha <- rnorm(n, 0, sigma)
x <- runif(n)
X <- model.matrix(~x)
linpred <- crossprod(t(X), beta) + alpha
Y <- rpois(n, exp(linpred))
## JAGS model as a function
jfun1 <- function() {
  for (i in 1:n) {
    Y[i] ~ dpois(lambda[i])
  }
}
```
log(lambda[i]) <- alpha[i] + inprod(X[i,], beta)
alpha[i] ~ dnorm(0, 1/sigma^2)
}
for (j in 1:np) {
  beta[j] ~ dnorm(0, 0.001)
}
sigma ~ dlnorm(0, 0.001)
}

## data
jdata <- list(n = n, Y = Y, X = X, np = NCOL(X))
## inits with latent variable and parameters
ini <- list(alpha = rep(0, n), beta = rep(0, NCOL(X)))
## function to update inits
ifun <- function(model, n.clones) {
  list(alpha = dclone(rep(0, n), n.clones),
       beta = coef(model)[-length(coef(model))])
}

## iterative fitting
jmod <- dc.fit(jdata, c("beta", "sigma"), jfun, ini,
               n.clones = 1:5, multiply = "n", unchanged = "np",
initsfun = ifun)
## summary with DC SE and R hat
summary(jmod)
dct <- dctable(jmod)
plot(dct)

## How to use estimates to make priors more informative?
glmm.model.up <- function() {
  for (i in 1:n) {
    Y[i] ~ dpois(lambda[i])
    log(lambda[i]) <- alpha[i] + inprod(X[i,], beta[1,])
    alpha[i] ~ dnorm(0, 1/sigma^2)
  }
  for (j in 1:p) {
    beta[1,j] ~ dnorm(priors[j,1], priors[j,2])
  }
  sigma ~ dgamma(priors[(p+1),2], priors[(p+1),1])
}

## function for updating, x is an MCMC object
upfun <- function(x) {
  if (missing(x)) {
    p <- ncol(X)
    return( cbind(c(rep(0, p), 0.001), rep(0.001, p+1)) )
  } else {
    par <- coef(x)
    return( cbind(par, rep(0.01, length(par))) )
  }
}
updat <- list(n = n, Y = Y, X = X, p = ncol(X), priors = upfun())
dcmmod <- dc.fit(updat, c("beta", "sigma"), glmm.model.up, n.clones = 1:5, multiply = "n", unchanged = "p",
                update = "priors", updatefun = upfun)
summary(dcmmod)
## time series example
```r
## data and model taken from Ponciano et al. 2009
## Ecology 90, 356-362.
pau.relia <- c(17, 29, 39, 63, 185, 258, 267, 392, 510, 570, 650, 560, 575, 650, 550, 480, 528, 500)
dat <- list(ncl=1, n=length(pau.relia), Y=dcdim(data.matrix(pau.relia)))
beverton.holt <- function() {
  for (k in 1:ncl) {
    for (i in 2:(n+1)) {
      ## observations
      Y[(i-1), k] ~ dpois(exp(X[i, k]))
      ## state
      X[i, k] ~ dnorm(mu[i, k], 1 / sigma^2)
      mu[i, k] <- X[(i-1), k] + log(lambda) - log(1 + beta * exp(X[(i-1), k]))
    }
    ## state at t0
    X[1, k] ~ dnorm(mu0, 1 / sigma^2)
  }
  # Priors on model parameters
  beta ~ dlnorm(-1, 1)
  sigma ~ dlnorm(0, 1)
  tmp ~ dlnorm(0, 1)
  lambda <- tmp + 1
  mu0 <- log(2) + log(lambda) - log(1 + beta * 2)
}
mod <- dc.fit(dat, c("lambda", "beta", "sigma"), beverton.holt,
n.clones=c(1, 2, 5, 10), multiply="ncl", unchanged="n")
## compare with results from the paper:
## beta = 0.00235
## lambda = 2.274
## sigma = 0.1274
summary(mod)

## Using WinBUGS/OpenBUGS
library(R2WinBUGS)
data(schools)
dat <- list(J = nrow(schools), y = schools$estimate,
           sigma.y = schools$sd)
bugs.model <- function() {
  for (j in 1:J) {
    y[j] ~ dnorm(theta[j], tau.y[j])
    theta[j] ~ dnorm(mu.theta, tau.theta)
    tau.y[j] <- pow(sigma.y[j], -2)
  }
  mu.theta ~ dnorm(0.0, 1.0e-6)
  tau.theta ~ pow(sigma.theta, -2)
  sigma.theta ~ dunif(0, 1000)
}
inits <- function() {
  list(theta=rnorm(nrow(schools), 0, 100),
       mu.theta=rnorm(1, 0, 100),
       sigma.theta=runif(1, 0, 100))
}
param <- c("mu.theta", "sigma.theta")
if (.Platform$OS.type == "windows") {
```
```r
sim2 <- dc.fit(dat, param, bugs.model, n.clones=1:2,
    flavour="bugs", program="WinBUGS", multiply="J",
    n.iter=2000, n.thin=1)
summary(sim2)
}
sim3 <- dc.fit(dat, param, bugs.model, n.clones=1:2,
    flavour="bugs", program="brugs", multiply="J",
    n.iter=2000, n.thin=1)
summary(sim3)
library(R2OpenBUGS)
sim4 <- dc.fit(dat, param, bugs.model, n.clones=1:2,
    flavour="bugs", program="openbugs", multiply="J",
    n.iter=2000, n.thin=1)
summary(sim4)

## Using Stan
if (require(rstan)) {
    model <- custommodel("data {
        int<lower=0> N;
        vector[N] y;
        vector[N] x;
    }
    parameters {
        real alpha;
        real beta;
        real<lower=0> sigma;
    }
    model {
        alpha ~ normal(0,10);
        beta ~ normal(0,10);
        sigma ~ cauchy(0,5);
        for (n in 1:N)
            y[n] ~ normal(alpha + beta * x[n], sigma);
    }")
}
N <- 100
alpha <- 1
beta <- -1
sigma <- 0.5
x <- runif(N)
y <- rnorm(N, alpha + beta * x, sigma)
dat <- list(N=N, y=y, x=x)
params <- c("alpha", "beta", "sigma")
## compile on 1st time only
fit0 <- stan.fit(dat, params, model)
## reuse compiled fit0
dcfit <- dc.fit(dat, params, model, n.clones=1:2,
    flavour="stan", multiply="N", fit=fit0)
summary(dcfit)
stan.model(dcfit)
dcdiag(dcfit)
}

## End(Not run)
```
dc.parfit

Parallel model fitting with data cloning

Description
Iterative model fitting on parallel workers with different numbers of clones.

Usage

dc.parfit(cl, data, params, model, inits, n.clones,
         multiply=NULL, unchanged=NULL,
         update = NULL, updatefun = NULL, initsfun = NULL,
         flavour = c("jags", "bugs", "stan"), n.chains = 3,
         partype=c("balancing", "parchains", "both"),
         return.all=FALSE, ...)

Arguments
cl  A cluster object created by makeCluster, or an integer, see parDosa and evalParallelArgument.
data A named list (or environment) containing the data.
params Character vector of parameters to be sampled. It can be a list of 2 vectors, 1st element is used as parameters to monitor, the 2nd is used as parameters to use in calculating the data cloning diagnostics. (partype = "both" currently cannot handle params as list.)
model Character string (name of the model file), a function containing the model, or a custommodel object (see Examples).
inits Optional specification of initial values in the form of a list or a function (see Initialization at jagsNmodel). If missing, will be treated as NULL and initial values will be generated automatically. If this is a function, it must be self containing, i.e. not having references to R objects outside of the function, or the objects should be exported with clusterExport before calling dc.parfit.
n.clones An integer vector containing the numbers of clones to use iteratively.
multiply Numeric or character index for list element(s) in the data argument to be multiplied by the number of clones instead of repetitions.
unchanged Numeric or character index for list element(s) in the data argument to be left unchanged.
update Numeric or character index for list element(s) in the data argument that has to be updated by updatefun in each iterations. This usually is for making priors more informative, and enhancing convergence. This argument is ignored if size balancing is used (default), and not ignored when multiple parallel chains are used.
updatefun A function to use for updating data[[update]]. It should take an 'mcmc.list' object as 1st argument, 2nd argument can be the number of clones. This argument is ignored if size balancing is used (default), and not ignored when multiple parallel chains are used.
dc.parfit

A function to use for generating initial values, inits are updated by the object returned by this function from the second iteration. If initial values are not dependent on the previous iteration, this should be NULL, otherwise, it should take an 'mcmc.list' object as 1st argument, 2nd argument can be the number of clones. This feature is useful if latent nodes are provided in inits so it also requires to be cloned for subsequent iterations. The 1st argument of the initsfun function is ignored if partype != "parchains" but the function must have a first argument regardless, see Examples.

flavour

If "jags", the function jags.fit is called. If "bugs", the function bugs.fit is called (available with partype = "balancing" only). If "stan", the function stan.fit is called. See Details.

partype

Type of parallel workload distribution, see Details.

n.chains

Number of chains to generate.

return.all

Logical. If TRUE, all the MCMC list objects corresponding to the sequence n.clones are returned for further inspection (this only works with partype = "parchains"). Otherwise only the MCMC list corresponding to highest number of clones is returned with summary statistics for the rest.

... Other values supplied to jags.fit, or bugs.fit, depending on the flavour argument.

Details

The dc.parfit is a parallel computing version of dc.fit. After parallel computations, temporary objects passed to workers and the dclone package is cleaned up. It is not guaranteed that objects already on the workers and independently loaded packages are not affected. Best to start new instances beforehand.

partype="balancing" distributes each model corresponding to values in n.clones as jobs to workers according to size balancing (see parDosa). partype="parchains" makes repeated calls to jags.parfit for each value in n.clones. partype="both" also calls jags.parfit but each chain of each cloned model is distributed as separate job to the workers.

The vector n.clones is used to determine size balancing. If load balancing is also desired besides size balancing (e.g. due to unequal performance of the workers, the option "dclone.LB" should be set to TRUE (by using options("dclone.LB" = TRUE)). By default, the "dclone.LB" option is FALSE for reproducibility reasons.

Some arguments from dc.fit are not available in parallel version (update, updatefun, initsfun) when size balancing is used (partype is "balancing" or "both"). These arguments are evaluated only when partype="parchains".

Size balancing is recommended if n.clones is a relatively long vector, while parallel chains might be more efficient when n.clones has few elements. For efficiency reasons, a combination of the two (partype="both") is preferred if cluster size allows it.

Additionally loaded JAGS modules (e.g. "glm") need to be loaded to the workers.

Value

An object inheriting from the class 'mcmc.list'.
Author(s)
Peter Solymos, <solymos@ualberta.ca>

References


See Also
Sequential version: *dc.fit*.
Optimizing the number of workers: *clusterSize, plotClusterSize*.
Underlying functions: *jags.fit, bugs.fit*.

Examples
```r
## Not run:
set.seed(1234)
n <- 20
x <- runif(n, -1, 1)
X <- model.matrix(~x)
beta <- c(2, -1)
mu <- crossprod(t(X), beta)
Y <- rpois(n, exp(mu))
glm.model <- function() {
  for (i in 1:n) {
    Y[i] ~ dpois(lambda[i])
    log(lambda[i]) <- inprod(X[i,], beta[1,])
  }
  for (j in 1:np) {
    beta[1,j] ~ dnorm(0, 0.001)
  }
}
dat <- list(Y=Y, X=X, n=n, np=ncol(X))
k <- 1:3
## sequential version
dcm <- dc.fit(dat, "beta", glm.model, n.clones=k, multiply="n",
unchanged="np")
## parallel version
cl <- makePSOCKcluster(3)
pdcm <- dc.parfit(cl, dat, "beta", glm.model, n.clones=k,
multiply="n", unchanged="np",
particle="balancing")
pdcm2 <- dc.parfit(cl, dat, "beta", glm.model, n.clones=k,
mult...
multiply="n", unchanged="np",
  partype="parchains")
pdcm3 <- dc.parfit(cl, dat, "beta", glm.model, n.clones=k,
  multiply="n", unchanged="np",
  partype="both")
summary(dcm)
summary(pdcm1)
summary(pdcm2)
summary(pdcm3)
stopCluster(cl)
## multicore type forking
if (.Platform$OS.type != "windows") {
mccdcm1 <- dc.parfit(3, dat, "beta", glm.model, n.clones=k,
  multiply="n", unchanged="np",
  partype="balancing")
mccdcm2 <- dc.parfit(3, dat, "beta", glm.model, n.clones=k,
  multiply="n", unchanged="np",
  partype="parchains")
mccdcm3 <- dc.parfit(3, dat, "beta", glm.model, n.clones=k,
  multiply="n", unchanged="np",
  partype="both")
}
## Using WinBUGS/OpenBUGS
library(R2WinBUGS)
data(schools)
dat <- list(J = nrow(schools), y = schools$estimate,
  sigma.y = schools$sd)
bugs.model <- function(){
  for (j in 1:J){
    y[j] ~ dnorm (theta[j], tau.y[j])
    theta[j] ~ dnorm (mu.theta, tau.theta)
    tau.y[j] <- pow(sigma.y[j], -2)
  }
  mu.theta ~ dnorm (0.0, 1.0E-6)
  tau.theta <- pow(sigma.theta, -2)
  sigma.theta ~ dunif (0, 1000)
}
inits <- function(){
  list(theta=rnorm(nrow(schools), 0, 100), mu.theta=rnorm(1, 0, 100),
  sigma.theta=runif(1, 0, 100))
}
param <- c("mu.theta", "sigma.theta")
cl <- makePsockCluster(2)
if (.Platform$OS.type == "windows") {
sim2 <- dc.parfit(cl, dat, param, bugs.model, n.clones=1:2,
  flavour="bugs", program="WinBUGS", multiply="J",
  n.iter=2000, n.thin=1)
summary(sim2)
}
sim3 <- dc.parfit(cl, dat, param, bugs.model, n.clones=1:2,
  flavour="bugs", program="brugs", multiply="J",
  n.iter=2000, n.thin=1)
summary(sim3)
library(R2OpenBUGS)
sim4 <- dc.parfit(cl, dat, param, bugs.model, n.clones=1:2,
  flavour="bugs", program="openbugs", multiply="J",
  n.iter=2000, n.thin=1)
summary(sim4)
stopCluster(cl)

## simulation for Poisson GLMM with inits
set.seed(1234)
n <- 5
beta <- c(2, -1)
sigma <- 0.1
alpha <- rnorm(n, 0, sigma)
x <- runif(n)
X <- model.matrix(~x)
linpred <- crossprod(t(X), beta) + alpha
Y <- rpois(n, exp(linpred))
## JAGS model as a function
jfun1 <- function() {
  for (i in 1:n) {
    Y[i] ~ dpois(lambda[i])
    log(lambda[i]) <- alpha[i] + inprod(X[i,], beta)
    alpha[i] ~ dnorm(0, 1/sigma^2)
  }
  for (j in 1:np) {
    beta[j] ~ dnorm(0, 0.001)
  }
  sigma ~ dlnorm(0, 0.001)
}
## data
jdata <- list(n = n, Y = Y, X = X, np = NCOL(X))
## inits with latent variable and parameters
ini <- list(alpha=rep(0,n), beta=rep(0, NCOL(X)))
## model arg is necessary as 1st arg,
## but not used when partype!="parchains"
ifun <- function(model, n.clones) {
  list(alpha=dclone(rep(0,n), n.clones),
    beta=c(0,0))
}
## make cluster
cl <- makePSOCKcluster(2)
## pass global n variable used in ifun to workers
tmp <- clusterExport(cl, "n")
## fit the model
jmod2 <- dc.parfit(cl, jdata, c("beta", "sigma"), jfun1, ini,
  n.clones = 1:2, multiply = "n", unchanged = "np",
  initsfun=ifun, partype="balancing")
stopCluster(cl)
## Using Stan
if (require(rstan)) {

model <- custommodel("data {
  int<lower=0> N;
  vector[N] y;
  vector[N] x;
}
parameters {
  real alpha;
  real beta;
  real<lower=0> sigma;
}
model {
  alpha ~ normal(0,1);
  beta ~ normal(0,1);
  sigma ~ cauchy(0,5);
  for (n in 1:N)
    y[n] ~ normal(alpha + beta * x[n], sigma);
}"
)
N <- 100
alpha <- 1
beta <- -1
sigma <- 0.5
x <- runif(N)
y <- rnorm(N, alpha + beta * x, sigma)
dat <- list(N=N, y=y, x=x)
params <- c("alpha", "beta", "sigma")
## compile on 1st time only
fit0 <- stan.fit(dat, params, model)
if (.Platform$OS.type != "windows") {
  ## utilize compiled fit0
  dcfit <- dc.parfit(cl=2, dat, params, model, n.clones=1:2,
                     flavour="stan", multiply="N", fit=fit0)
  summary(dcfit)
  stan.model(dcfit)
  dcdiag(dcfit)
}
## End(Not run)

dclone

**Cloning R objects**

**Description**

Makes clones of R objects, that is values in the object are repeated n times, leaving the original structure of the object intact (in most of the cases).

**Usage**

`dclone(x, n.clones=1, ...)`
## Default S3 method:
dclone(x, n.clones = 1, attrib=TRUE, ...)

## S3 method for class 'dcdim'
dclone(x, n.clones = 1, attrib=TRUE, ...)

## S3 method for class 'dciid'
dclone(x, n.clones = 1, attrib=TRUE, ...)

## S3 method for class 'dctr'
dclone(x, n.clones = 1, attrib=TRUE, ...)

## S3 method for class 'list'
dclone(x, n.clones = 1,
       multiply = NULL, unchanged = NULL, attrib=TRUE, ...)

## S3 method for class 'environment'
dclone(x, n.clones = 1,
       multiply = NULL, unchanged = NULL, attrib=TRUE, ...)

dcdim(x, drop = TRUE, perm = NULL)
dciid(x, iid=character(0))
dctr(x)

### Arguments

- **x**: An R object to be cloned, or a cloned object to print.
- **n.clones**: Number of clones.
- **multiply**: Numeric or character index for list element(s) to be multiplied by `n.clones` instead of repetitions (as done by `dclone.default`).
- **unchanged**: Numeric or character index for list element(s) to be left unchanged.
- **attrib**: Logical, `TRUE` if attributes are to be attached.
- **drop**: Logical, if `TRUE`, deletes the last dimension of an array if that have only one level.
- **perm**: The subscript permutation value, if the cloning dimension is not the last.
- **iid**: Character (or optionally numeric or logical). Column(s) to be treated as i.i.d. observations. Ignored when `x` is a vector.
- **...**: Other arguments passed to function.

### Details

dclone is a generic function for cloning objects. It is separate from `rep`, because there are different ways of cloning, depending on the BUGS code implementation:

1. **Unchanged**: no cloning at all (for e.g. constants).
2. **Repeat**: this is the most often used cloning method, repeating the observations row-wise as if there were more samples. The `dctr` option allows repeating the data column-wise.
3. **Multiply**: sometimes it is enough to multiply the numbers (e.g. for Binomial distribution).
4. **Add dimension**: under specific circumstances, it is easier to add another dimension for clones, but otherwise repeat the observations (e.g. in case of time series, or for addressing special indexing conventions in the BUGS code, see examples `dcdim` and `dclone.dcdim`).
(5) Repeat pattern (i.i.d.): this is useful for example when a grouping variable is considered, and more i.i.d. groups are to be added to the data set. E.g. \( c(1, 1, 2, 2) \) is to be cloned as \( c(1, 1, 2, 2, 3, 3, 4, 4) \) instead of \( c(1, 1, 2, 2, 1, 1, 2, 2) \).

Value

An object with class attributes "dclone" plus the original one(s). Dimensions of the original object might change according to \( n \) clones. The function tries to take care of names, sometimes replacing those with the combination of the original names and an integer for number of clones.

dcdim sets the class attribute of an object to "dcdim", thus dclone will clone the object by adding an extra dimension for the clones.

dciid sets the class attribute of an object to "dciid", thus dclone will clone the object by treating columns defined by the iid argument as i.i.d. observations. These columns must be numeric. This aims to facilitates working with the INLA package to generate approximate marginals based on DC. Columns specified by iid will be replaced by an increasing sequence of values respecting possible grouping structure (see Examples).

Lists (i.e. BUGS data objects) are handled differently to enable element specific determination of the mode of cloning. This can be done via the unchanged and multiply arguments, or by setting the behaviour by the dcdim function.

Environments are coerced into a list, and return value is identical to dclone(as.list(x), ...).

Author(s)

Peter Solymos, <solymos@ualberta.ca>, implementation is based on many discussions with Khurram Nadeem and Subhash Lele.

References


Examples

```r
## scalar
dclone(4, 2)
## vector
(x <- 1:6)
dclone(x, 2)
## matrix
(m <- matrix(x, 2, 3))
dclone(m, 2)
## data frame
```
Manipulating dclone environments

Description

Manipulating dclone environments.

Usage

pullDcloneEnv(x, type = c("model", "results"))
pushDcloneEnv(x, value, type = c("model", "results"))
clearDcloneEnv(..., list = character(),
          type = c("model", "results"))
listDcloneEnv(type = c("model", "results"))
existsDcloneEnv(x, type = c("model", "results"),
               mode = "any", inherits = TRUE)

Arguments

x                a variable name, given as a character string. No coercion is done, and the first
element of a character vector of length greater than one will be used, with a
warning.

value            a value to be assigned to x.

type             character, the type of environment to be accessed, see Details.
the objects to be removed, as names (unquoted) or character strings (quoted).

list a character vector naming objects to be removed.

mode the mode or type of object sought: see the \texttt{exists}.

inherits logical, should the enclosing frames of the environment be searched?

Details

type = "model" manipulates the \texttt{DcloneEnvModel} environment, which is meant to store temporary objects for model fitting with 'snow' type parallelism (see \texttt{parDosa} for the implementation). This is swiped clean after use.

The \texttt{type = "results"} manipulates the \texttt{DcloneEnvResults} environment, which is meant to store result objects on the workers. This is \textit{not} swiped clean after use.

\texttt{pullDcloneEnv} pulls an object from these environments, similar to \texttt{get} in effect.

\texttt{pushDcloneEnv} pushes an object to these environments, similar to \texttt{assign} in effect.

\texttt{clearDcloneEnv} removes object(s) from these environments, similar to \texttt{rm} in effect.

\texttt{listDcloneEnv} lists name(s) of object(s) in these environments, similar to \texttt{ls} in effect.

\texttt{existsDcloneEnv} tests if an object exists in these environments, similar to \texttt{exists} in effect.

Value

For \texttt{pullDcloneEnv}, the object found. If no object is found an error results.

\texttt{pushDcloneEnv} is invoked for its side effect, which is assigning \texttt{value} to the variable \texttt{x}.

For \texttt{clearDcloneEnv} its is the side effect of an object removed. No value returned.

\texttt{listDcloneEnv} returns a character vector.

\texttt{existsDcloneEnv} returns logical, \texttt{TRUE} if and only if an object of the correct name and mode is found.

Author(s)

Peter Solymos, <solymos@ualberta.ca>

See Also

\texttt{parDosa}
dcoptions  

Setting Options

Description
Setting options.

Usage
dcoptions(...)

Arguments
...  Arguments in tag = value form, or a list of tagged values. The tags must come from the parameters described below.

Details
dcoptions is a convenient way of handling options related to the package.

Value
When parameters are set by dcoptions, their former values are returned in an invisible named list. Such a list can be passed as an argument to dcoptions to restore the parameter values. Tags are the following:

- autoburnin: logical, to use in gelman.diag (default is TRUE).
- diag: critical value to use for data cloning convergence diagnostics, default is 0.05.
- LB: logical, should load balancing be used, default is FALSE.
- overwrite: logical, should existing model file be overwritten, default is TRUE.
- rhat: critical value for testing chain convergence, default is 1.1.
- RNG: parallel RNG type, either "none" (default), or "RNGstream", see clusterSetRNGStream.
- verbose: integer, should output be verbose (>0) or not (0), default is 1.

Author(s)
Peter Solymos, <solymos@ualberta.ca>

Examples
## set LB option, but store old value
ov <- dcoptions("LB"=TRUE)
## this is old value
ov
## this is new value
getOption("dcoptions")
## reset to old value
dctable

Retrieve descriptive statistics from fitted objects to evaluate convergence

Description

The function is used to retrieve descriptive statistics from fitted objects in order to evaluate convergence of the data cloning algorithm. This is best done via visual display of the results, separately for each parameter of interest.

Usage

dctable(x, ...)
## Default S3 method:
dctable(x, ...)
## S3 method for class 'dctable'
plot(x, which = 1:length(x),
    type = c("all", "var", "log.var"),
    position = "topright", box.cex = 0.75, box.bg, ...)
extractdctable(x, ...)
## Default S3 method:
extractdctable(x, ...)

dcdiag(x, ...)
## Default S3 method:
dcdiag(x, ...)
## S3 method for class 'dcdiag'
plot(x, which = c("all", "lambda.max", "ms.error", "r.squared", "log.lambda.max"),
    position = "topright", ...)
extractdcdiag(x, ...)
## Default S3 method:
extractdcdiag(x, ...)

Arguments

x An MCMC or a 'dctable' object.

... Optionally more fitted model objects for function dctable.

which What to plot. For dctable, character names or integer indices of the estimated parameters are accepted. For dcdiag it should be one of c("all", "lambda.max", "ms.error", "r.squared", "log.lambda.max").

type Type of plot to be drawn. See Details.
position  Position for the legend, as for `legend`.
box.cex  Scaling factor for the interquartile boxes.
box.bg  Background color for the interquartile boxes.

Details
dctable returns the "dctable" attribute of the MCMC object, or if it is `NULL`, calculates the dctable summaries. If more than one fitted objects are provided, summaries are calculated for all objects, and results are ordered by the number of clones.

The `plot` method for dctable helps in graphical representation of the descriptive statistics. `type = "all"` results in plotting means, standard deviations and quantiles against the number of clones as boxplot. `type = "var"` results in plotting the scaled variances against the number of clones. In this case variances are divided by the variance of the model with smallest number of clones, `min(n.clones)`. `type = "log.var"` is the same as "var", but on the log scale. Along with the values, the `min(n.clones) / n.clones` line is plotted for reference.

Lele et al. (2010) introduced diagnostic measures for checking the convergence of the data cloning algorithm which are based on the joint posterior distribution and not only on single parameters. These include to calculate the largest eigenvalue of the posterior variance covariance matrix (`lambda.max` as returned by `lambdamax.diag`), or to calculate mean squared error (`ms.error`) and another correlation-like fit statistic (r.squared) based on a Chi-squared approximation (as returned by `chisq.diag`). The maximum eigenvalue reflects the degenerateness of the posterior distribution, while the two fit measures reflect if the Normal approximation is adequate. All three statistics should converge to zero as the number of clones increases. If this happens, different prior specifications are no longer influencing the results (Lele et al., 2007, 2010). These are conveniently collected by the `dcdiag` function.

IMPORTANT! Have you checked if different prior specifications lead to the same results?

Value
An object of class 'dctable'. It is a list, and contains as many data frames as the number of parameters in the fitted object. Each data frame contains descriptives as the function of the number of clones.

dcdiag returns a data frame with convergence diagnostics.
The `plot` methods produce graphs as side effect.

Author(s)
Peter Solymos, <solymos@ualberta.ca>, implementation is based on many discussions with Khurram Nadeem and Subhash Lele.

References


### See Also

Data cloning: dclone

Model fitting: jags.fit, bugs.fit, dc.fit

### Examples

```r
## Not run:  
## simulation for Poisson GLMM  
set.seed(1234)  
n <- 20  
beta <- c(2, -1)  
sigma <- 0.1  
alpha <- rnorm(n, 0, sigma)  
x <- runif(n)  
X <- model.matrix(~ x)  
linpred <- crossprod(t(X), beta) + alpha  
Y <- rpois(n, exp(linpred))  
## JAGS model as a function  
jfun1 <- function() {  
  for (i in 1:n) {  
    Y[i] ~ dpois(lambda[i])  
    log(lambda[i]) <- alpha[i] + inprod(X[i,], beta[1:])  
    alpha[i] ~ dnorm(0, 1/sigma^2)  
  }  
  for (j in 1:n) {  
    beta[1,j] ~ dnorm(0, 0.001)  
  }  
  sigma ~ dlnorm(0, 0.001)  
}  
## data  
jdata <- list(n = n, Y = Y, X = X, np = NCOL(X))  
## number of clones to be used, etc.  
## iterative fitting  
jmod <- dc.fit(jdata, c("beta", "sigma"), jfun1,  
n.clones = 1:5, multiply = "n", unchanged = "np")  
## summary with DC SE and R hat  
summary(jmod)  
dct <- dctable(jmod)  
plot(dct)  
## How to use estimates to make priors more informative?  
glmm.model.up <- function() {  
  for (i in 1:n) {  
    Y[i] ~ dpois(lambda[i])  
    log(lambda[i]) <- alpha[i] + inprod(X[i,], beta[1:])  
    alpha[i] ~ dnorm(0, 1/sigma^2)  
  }  
  for (j in 1:n) {  
    beta[1,j] ~ dnorm(0, 0.001)  
  }  
  sigma ~ dlnorm(0, 0.001)  
}  
## data  
jdata <- list(n = n, Y = Y, X = X, np = NCOL(X))  
## number of clones to be used, etc.  
## iterative fitting  
jmod <- dc.fit(jdata, c("beta", "sigma"), jfun1,  
n.clones = 1:5, multiply = "n", unchanged = "np")  
## summary with DC SE and R hat  
summary(jmod)  
dct <- dctable(jmod)  
plot(dct)  
## How to use estimates to make priors more informative?  
glmm.model.up <- function() {  
  for (i in 1:n) {  
    Y[i] ~ dpois(lambda[i])  
    log(lambda[i]) <- alpha[i] + inprod(X[i,], beta[1:])  
    alpha[i] ~ dnorm(0, 1/sigma^2)  
  }  
  for (j in 1:n) {  
    beta[1,j] ~ dnorm(0, 0.001)  
  }  
  sigma ~ dlnorm(0, 0.001)  
}  
```

errlines

Plot error bars

Description

The function plots error bars to existing plot.

Usage

errlines(x, ...)

## Default S3 method:
errlines(x, y, type = "l", code = 0,
width = 0, vertical = TRUE, col = 1, bg = NA, ...)

Arguments

x

Numeric vector with coordinates along the horizontal axis (if vertical = FALSE, this sets the vertical axis).

y

A matrix-like object with 2 columns for lower and upper values on the vertical axis (if vertical = FALSE, this sets the horizontal axis).

type

Character, "l" for lines, "b" for boxes to be drawn.

code

Integer code, determining the kind of ticks to be drawn. See Details.
errlines

width
vertical
col
bg
...

Numeric, width of the ticks (if type = "1") or width of the boxes (if type = "b").
Logical, if errorbars should be plotted vertically or horizontally.
Color of the error lines to be drawn, recycled if needed.
If type = "b" the background color of the boxes. By default, no background color used.
Other arguments passed to the function lines.

Details
The errlines function uses lines to draw error bars to existing plot when type = "l". polygon is used for boxes when type = "b".
If code = 0 no ticks are drawn, if code = 1, only lower ticks are drawn, if code = 2 only lower ticks are drawn, if code = 3 both lower and upper ticks are drawn.

Value
Adds error bars to an existing plot as a side effect. Returns NULL invisibly.

Author(s)
Peter Solymos, <solymos@ualberta.ca>

See Also
lines, polygon

Examples
x <- 1:10
a <- rnorm(10,10)
a <- a[order(a)]
b <- runif(10)
y <- cbind(a-b, a+b+rev(b))
par <- par(mfrow=c(2, 3))
plot(x, a, ylim = range(y))
errlines(x, y)
plot(x, a, ylim = range(y))
errlines(x, y, width = 0.5, code = 1)
plot(x, a, ylim = range(y), col = 1:10)
errlines(x, y, width = 0.5, code = 3, col = 1:10)
plot(x, a, ylim = range(y))
errlines(x, y, width = 0.5, code = 2, type = "b")
plot(x, a, ylim = range(y))
errlines(x, y, width = 0.5, code = 3, type = "b")
plot(x, a, ylim = range(y), type = "n")
errlines(x, y, width = 0.5, code = 3, type = "b", bg = 1:10)
errlines(x, cbind(a-b/2, a+b/2+rev(b)/2))
points(x, a)
par(opar)
evalParallelArgument  Evaluates parallel argument

Description

Evaluates parallel argument.

Usage

evalParallelArgument(cl, quit = FALSE)

Arguments

cl  NULL, a cluster object or an integer. Can be missing.
quit Logical, whether it should stop with error when ambiguous parallel definition is found (conflicting default environmental variable settings).

Value

NULL for sequential evaluation or the original value of cl if parallel evaluation is meaningful.

Author(s)

Peter Solymos, <solymos@ualberta.ca>

Examples

evalParallelArgument()
evalParallelArgument(NULL)
evalParallelArgument(1)
evalParallelArgument(2)
c1 <- makePSOCKcluster(2)
evalParallelArgument(c1)
stopCluster(c1)
oop <- options("mc.cores"=2)
evalParallelArgument()
options(oop)
Description

Convenient functions designed to work well with cloned data arguments and JAGS.

Usage

jags.fit(data, params, model, inits = NULL, n.chains = 3,
         n.adapt = 1000, n.update = 1000, thin = 1, n.iter = 5000,
         updated.model = TRUE, ...)

Arguments

data  A named list or environment containing the data. If an environment, data is
       coerced into a list.
params  Character vector of parameters to be sampled.
model  Character string (name of the model file), a function containing the model, or a
       or custommodel object (see Examples).
inits  Optional specification of initial values in the form of a list or a function (see
       Initialization at jags.model). If NULL, initial values will be generated automatically.
       It is an error to supply an initial value for an observed node.
n.chains  Number of chains to generate.
n.adapt  Number of steps for adaptation.
n.update  Number of updates before iterations. It is usually a bad idea to use n.update=0
           if n.adapt>0, so a warning is issued in such cases.
thin  Thinning value.
n.iter  Number of iterations.
updated.model  Logical, if the updated model should be attached as attribute (this can be used
               to further update if convergence was not satisfactory, see updated.model and
               update.mcmc.list).
...

Value

An mcmc.list object. If data cloning is used via the data argument, summary returns a modified
summary containing scaled data cloning standard errors (scaled by sqrt(n.clones), see dcsd),
and Rhat values (as returned by gelman.diag).

Author(s)

Peter Solymos, <solymos@ualberta.ca>
See Also

Underlying functions: \texttt{jags.model}, \texttt{update.jags}, \texttt{coda.samples}

Parallel chain computations: \texttt{jags.parfit}

Methods: \texttt{dcsd}, \texttt{confint.mcmc.list.dc}, \texttt{coef.mcmc.list}, \texttt{quantile.mcmc.list}, \texttt{vcov.mcmc.list.dc}

Examples

```r
## Not run:
if (require(rjags)) {
  ## simple regression example from the JAGS manual
  jfun <- function() {
    for (i in 1:N) {
      Y[i] ~ dnorm(mu[i], tau)
      mu[i] <- alpha + beta * (x[i] - x.bar)
    }
    x.bar <- mean(x[])
    alpha ~ dnorm(0.0, 1.0E-4)
    beta ~ dnorm(0.0, 1.0E-4)
    sigma <- 1.0/sqrt(tau)
    tau ~ dgamma(1.0E-3, 1.0E-3)
  }
  ## data generation
  set.seed(1234)
  N <- 100
  alpha <- 1
  beta <- -1
  sigma <- 0.5
  x <- runif(N)
  linpred <- crossprod(t(model.matrix(~x)), c(alpha, beta))
  Y <- rnorm(N, mean = linpred, sd = sigma)
  ## list of data for the model
  jdata <- list(N = N, Y = Y, x = x)
  ## what to monitor
  jpara <- c("alpha", "beta", "sigma")
  ## fit the model with JAGS
  regmod <- jags.fit(jdata, jpara, jfun, n.chains = 3)
  ## model summary
  summary(regmod)
  ## data cloning
  dcdata <- dclone(jdata, 5, multiply = "N")
  dcm2 <- jags.fit(dcdata, jpara, jfun, n.chains = 3)
  summary(dcm2)
}
## End(Not run)
```

\textbf{jags.parfit}  \hspace{1cm} \textit{Parallel computing with JAGS}
**Description**

Does the same job as `jags.fit`, but parallel chains are run on parallel workers, thus computations can be faster (up to $1/n\text{.chains}$) for long MCMC runs.

**Usage**

```r
jags.parfit(cl, data, params, model, inits = NULL, n.chains = 3, ...)
```

**Arguments**

- `cl` A cluster object created by `makeCluster`, or an integer, see `parDosa` and `evalParallelArgument`.
- `data` A named list or environment containing the data. If an environment, `data` is coerced into a list.
- `params` Character vector of parameters to be sampled.
- `model` Character string (name of the model file), a function containing the model, or a `custommodel` object (see Examples).
- `inits` Specification of initial values in the form of a list or a function, can be missing. Missing value setting can include RNG seed information, see Initialization at `jags.model`. If this is a function and using 'snow' type cluster as `cl` argument, the function must be self containing, i.e. not having references to R objects outside of the function, or the objects should be exported with `clusterExport` before calling `jags.parfit`. Forking type parallelism does not require such attention.
- `n.chains` Number of chains to generate, must be higher than 1. Ideally, this is equal to the number of parallel workers in the cluster.
- `...` Other arguments passed to `jags.fit`.

**Details**

Chains are run on parallel workers, and the results are combined in the end.

No update method is available for parallel `mcmc.list` objects. See `parUpdate` and related parallel functions (`parJagsModel`, `parCodaSamples`) for such purpose.

Additionally loaded JAGS modules (e.g. "glm", "lecuyer") need to be loaded to the workers when using 'snow' type cluster as `cl` argument. See Examples.

The use of the "lecuyer" module is recommended when running more than 4 chains. See Examples and `parallel.inits`.

**Value**

An `mcmc.list` object.

**Author(s)**

Peter Solymos, <solymos@ualberta.ca>
See Also

Sequential version: `jags.fit`

Function for stepwise modeling with JAGS: `parJagsModel, parUpdate, parCodaSamples`

Examples

```r
## Not run:
if (require(rjags)) {
  set.seed(1234)
  n <- 20
  x <- runif(n, -1, 1)
  X <- model.matrix(~x)
  beta <- c(2, -1)
  mu <- crossprod(t(X), beta)
  Y <- rpois(n, exp(mu))
  glm.model <- function() {
    for (i in 1:n) {
      Y[i] ~ dpois(lambda[i])
      log(lambda[i]) <- inprod(X[i, ], beta[1, ])
    }
    for (j in 1:n) {
      beta[1, j] ~ dnorm(0, 0.001)
    }
  }
  dat <- list(Y=Y, X=X, n=n, np=ncol(X))
  load.module("glm")
  m <- jags.fit(dat, "beta", glm.model)
  cl <- makePsockCluster(3)
  ## load glm module
  tmp <- clusterEvalQ(cl, library(dclone))
  parLoadModule(cl, "glm")
  pm <- jags.parfit(cl, dat, "beta", glm.model)
  ## chains are not identical -- this is good
  pm[1:2,]
  summary(pm)
  ## examples on how to use initial values
  ## fixed initial values
  inits <- list(list(beta=matrix(c(0,1,1,2)),
                   list(beta=matrix(c(1,0,1,2)),
                   list(beta=matrix(c(0,0,1,2)))))
  pm2 <- jags.parfit(cl, dat, "beta", glm.model, inits)
  ## random numbers generated prior to jags.parfit
  inits <- list(list(beta=matrix(rnorm(2),1,2)),
                 list(beta=matrix(rnorm(2),1,2)),
                 list(beta=matrix(rnorm(2),1,2)))
  pm3 <- jags.parfit(cl, dat, "beta", glm.model, inits)
  ## self contained function
  inits <- function() list(beta=matrix(rnorm(2),1,2))
  pm4 <- jags.parfit(cl, dat, "beta", glm.model, inits)
  ## function pointing to the global environment
  fun <- function() list(beta=matrix(rnorm(2),1,2))
  inits <- function() fun()
```
clusterExport(cl, "fun")
## using the L’Ecuyer module with 6 chains
load.module("lecuyer")
parLoadModule(cl,"lecuyer")
pm5 <- jags.parfit(cl, dat, "beta", glm.model, inits,
     n.chains=6)
nchain(pm5)
unload.module("lecuyer")
parUnloadModule(cl,"lecuyer")
stopCluster(cl)
## multicore type forking
if (.Platform$OS.type != "windows") {
  pm6 <- jags.parfit(3, dat, "beta", glm.model)
}
}

## End(Not run)

---

**jagsModel**  
*Create a JAGS model object*

**Description**

`jagsModel` is used to create an object representing a Bayesian graphical model, specified with a BUGS-language description of the prior distribution, and a set of data. This function uses `jags.model` but keeps track of data cloning information supplied via the `data` argument. The `model` argument can also accept functions or `custommodel` objects.

**Usage**

```r
jagsModel(file, data=sys.frame(sys.parent()), inits, n.chains = 1,
           n.adapt=1000, quiet=FALSE)
```

**Arguments**

- **file**: the name of the file containing a description of the model in the JAGS dialect of the BUGS language. Alternatively, `file` can be a readable text-mode connection, or a complete URL. It can be also a function or a `custommodel` object.
- **data**: a list or environment containing the data. Any numeric objects in `data` corresponding to node arrays used in `file` are taken to represent the values of observed nodes in the model.
- **inits**: optional specification of initial values in the form of a list or a function. If omitted, initial values will be generated automatically. It is an error to supply an initial value for an observed node.
- **n.chains**: the number of chains for the model.
- **n.adapt**: the number of iterations for adaptation. See `adapt` for details. If `n.adapt = 0` then no adaptation takes place.
- **quiet**: if TRUE then messages generated during compilation will be suppressed.
Value

parJagsModel returns an object inheriting from class jags which can be used to generate dependent samples from the posterior distribution of the parameters.

An object of class jags is a list of functions that share a common environment, see jags.model for details.

An n.clones attribute is attached to the object when applicable.

Author(s)

Peter Solymos, <solymos@ualberta.ca>

See Also

Underlying functions: jags.model, update.jags
See example on help page of codaSamples.
Parallel version: parJagsModel

Description

These functions calculates diagnostics for evaluating data cloning convergence.

Usage

lambdamax.diag(x, ...)
## S3 method for class 'mcmc.list'
lambdamax.diag(x, ...)

chisq.diag(x, ...)
## S3 method for class 'mcmc.list'
chisq.diag(x, ...)

Arguments

x An object of class mcmc or mcmc.list.

... Other arguments to be passed.
Details

These diagnostics can be used to test for the data cloning convergence (Lele et al. 2007, 2010). Asymptotically the posterior distribution of the parameters approaches a degenerate multivariate normal distribution. As the distribution is getting more degenerate, the maximal eigenvalue ($\lambda_{max}$) of the unscaled covariance matrix is decreasing. There is no critical value under which $\lambda_{max}$ is good enough. By default, 0.05 is used (see getOption("dclone\$diag").

Another diagnostic tool is to check if the joint posterior distribution is multivariate normal. It is done by chisq.diag as described by Lele et al. (2010).

Value

lambdamax.diag returns a single value, the maximum of the eigenvalues of the unscaled variance covariance matrix of the estimated parameters.

chisq.diag returns two test statistic values (mean squared error and r-squared) with empirical and theoretical quantiles.

Author(s)

Khurram Nadeem, <knadeem@math.ualberta.ca>
Peter Solymos, <solymos@ualberta.ca>

References


See Also

Eigen decomposition: eigen

Examples

data(regmod)
lambdamax.diag(regmod)
chisq.diag(regmod)
**Description**

Matrix symmetry might depend on numerical precision issues. The older version of JAGS had a bug related to this issue for multivariate normal nodes. This simple function can fix the issue, but new JAGS versions do not require such intervention.

**Usage**

```r
make.symmetric(x)
```

**Arguments**

- `x` A square matrix.

**Details**

The function takes the average as `(x[i, j] + x[j, i]) / 2` for each off diagonal cells.

**Value**

A symmetric square matrix.

**Note**

The function works for any matrix, even for those not intended to be symmetric.

**Author(s)**

Peter Solymos, <solymos@ualberta.ca>

**Examples**

```r
x <- as.matrix(as.dist(matrix(1:25, 5, 5)))
diag(x) <- 100
x[lower.tri(x)] <- x[lower.tri(x)] - 0.1
x[upper.tri(x)] <- x[upper.tri(x)] + 0.1
x
make.symmetric(x)
```
mclapplySB

Size balancing version of mclapply

Description

mclapplySB is a size balancing version of mclapply.

Usage

mclapplySB(X, FUN, ..., 
mc.preschedule = TRUE, mc.set.seed = TRUE, 
mc.silent = FALSE, mc.cores = 1L, 
mc.cleanup = TRUE, mc.allow.recursive = TRUE, 
size = 1)

Arguments

X a vector (atomic or list) or an expressions vector. Other objects (including 
classed objects) will be coerced by as.list.
FUN the function to be applied to each element of X
... optional arguments to FUN
mc.preschedule see mclapply 
mc.set.seed see mclapply 
mc.silent see mclapply 
mc.cores The number of cores to use, i.e. how many processes will be spawned (at most)
mc.cleanup see mclapply 
mc.allow.recursive see mclapply 
size Vector of problem sizes (or relative performance information) corresponding to 
elements of X (recycled if needed). The default 1 indicates equality of problem 
sizes.

Details

mclapply gives details of the forking mechanism.
mclapply is used unmodified if sizes of the jobs are equal (length(unique(size)) == 1). Size 
balancing (as described in parDosa) is used to balance workload on the child processes otherwise.

Value

A list.

Author(s)

Peter Solymos
See Also

mclapply, parDosa

**mcmc.list-methods**

**Methods for the 'mcmc.list' class**

---

**Description**

Methods for `mcmc.list` objects.

**Usage**

```r
dcsd(object, ...)
## S3 method for class 'mcmc.list'
dcsd(object, ...)
## S3 method for class 'mcmc.list'
coeff(object, ...)
## S3 method for class 'mcmc.list.dc'
confint(object, parm, level = 0.95, ...)
## S3 method for class 'mcmc.list'
vcov(object, ...)
## S3 method for class 'mcmc.list.dc'
vcov(object, invfisher = TRUE, ...)
## S3 method for class 'mcmc.list'
quantile(x, ...)
```

**Arguments**

- `x, object` MCMC object to be processed.
- `parm` A specification of which parameters are to be given confidence intervals, either a vector of numbers or a vector of names. If missing, all parameters are considered.
- `level` The confidence level required.
- `...` Further arguments passed to functions.
- `invfisher` Logical, if the inverse of the Fisher information matrix (TRUE) should be returned instead of the variance-covariance matrix of the joint posterior distribution (FALSE).

**Value**

dcsd returns the data cloning standard errors of a posterior MCMC chain calculated as standard deviation times the square root of the number of clones.

The coeff method returns mean of the posterior MCMC chains for the monitored parameters.

The confint method returns Wald-type confidence intervals for the parameters assuming asymptotic normality.
The `vcov` method returns the inverse of the Fisher information matrix (`invfisher = TRUE`) or the covariance matrix of the joint posterior distribution (`invfisher = FALSE`). The `invfisher` is valid only for `mcmc.list.dc` (data cloned) objects.

The `quantile` method returns quantiles for each variable.

**Note**

Some functions only available for the 'mcmc.list.dc’ class which inherits from class ‘mcmc.list’.

**Author(s)**

Peter Solymos, <solymos@ualberta.ca>

**See Also**

`jags.fit, bugs.fit`

**Examples**

```r
## Not run:
## simple regression example from the JAGS manual
jfun <- function() {
  for (i in 1:N) {
    Y[i] ~ dnorm(mu[i], tau)
    mu[i] <- alpha + beta * (x[i] - x.bar)
  }
  x.bar <- mean(x)
  alpha ~ dnorm(0.0, 1.0E-4)
  beta ~ dnorm(0.0, 1.0E-4)
  sigma <- 1.0/sqrt(tau)
  tau ~ dgamma(1.0E-3, 1.0E-3)
}
## data generation
set.seed(1234)
N <- 100
alpha <- 1
beta <- -1
sigma <- 0.5
x <- runif(N)
linpred <- crossprod(t(model.matrix(~x)), c(alpha, beta))
Y <- rnorm(N, mean = linpred, sd = sigma)
## data for the model
dcdata <- dclone(list(N = N, Y = Y, x = x), 5, multiply = "N")
## data cloning
dcmat <- jags.fit(dcdata, c("alpha", "beta", "sigma"), jfun, n.chains = 3)
summary(dcmat)
coef(dcmat)
dcsd(dcmat)
confint(dcmat)
vcov(dcmat)
vcov(dcmat, invfisher = FALSE)
```
Calculations on 'mcmc.list' objects

Description
Conveniently calculates statistics for mcmc.list objects.

Usage
mcmcapply(x, FUN, ...)
   ## S3 method for class 'mcmc.list'
   stack(x, ...)

Arguments
  x          Objects of class mcmc.list.
  FUN        A function to be used in the calculations, returning a single value.
  ...        Other arguments passed to FUN.

Details
mcmcapply returns a certain statistics based on FUN after coercing into a matrix. FUN can be missing, in this case mcmcapply is equivalent to calling as.matrix on an 'mcmc.list' object.
stack can be used to concatenates 'mcmc.list' objects into a single vector along with index variables indicating where each observation originated from (e.g. iteration, variable, chain).

Value
mcmcapply returns statistic value for each variable based on FUN, using all values in all chains of the MCMC object.
stack returns a data frame with columns: iter, variable, chain, value.

Author(s)
Peter Solymos, <solymos@ualberta.ca>
Examples

```r
data(regmod)
mcmcapply(regmod, mean)
mcmcapply(regmod, sd)

x <- stack(regmod)
head(x)
summary(x)
library(lattice)
xyplot(value ~ iter | variable, data=x,
    type="l", scales = "free", groups=chain)
```

<table>
<thead>
<tr>
<th>nclones</th>
<th>Number of Clones</th>
</tr>
</thead>
</table>

Description

Retrieves the number of clones from an object.

Usage

```r
nclones(x, ...)
```  
## Default S3 method:
nclones(x, ...)

## S3 method for class ’list’
nclones(x, ...)

Arguments

- `x` An object.
- `...` Other arguments to be passed.

Value

Returns the number of clones, or NULL.

Author(s)

Peter Solymos, <solymos@ualberta.ca>

See Also

dclone

Examples

```r
x <- dclone(1:10, 10)
nclones(x)
nclones(1:10) # this is NULL
```
**Description**

The data set contains observations (point counts) of 198 sites of the Alberta Biodiversity Monitoring Institute.

- **count**: integer, ovenbird counts per site.
- **site, year**: numeric, site number and year of data collection.
- **ecosite**: factor with 5 levels, ecological categorization of the sites.
- **uplow**: factor with 2 levels, ecological categorization of the sites (same as ecosite but levels are grouped into upland and lowland).
- **dsucc, dalien, thd**: numeric, percentage of successional, alienating and total human disturbance based on interpreted 3 x 7 km photoplots centered on each site.
- **long, lat**: numeric, public longitude/latitude coordinates of the sites.

**Usage**

```r
data(ovenbird)
```

**Source**

Alberta Biodiversity Monitoring Institute, http://www.abmi.ca

**Examples**

```r
data(ovenbird)
summary(ovenbird)
str(ovenbird)
```

---

**pairs.mcmc.list**

*Scatterplot Matrices for 'mcmc.list' Objects*

**Description**

A matrix of scatterplots is produced.

**Usage**

```r
## S3 method for class 'mcmc.list'
pairs(x, n = 25, col = 1:length(x),
      col.hist = "gold", col.image = terrain.colors(50),
      density = TRUE, contour = TRUE, mean = TRUE, ...)
```
**pairs.mcmc.list**

**Arguments**

- `x`: an `mcmc.list` object.
- `n`: number of grid points in each direction for two-dimensional kernel density estimation. Can be scalar or a length-2 integer vector.
- `col`: color for chains in upper panel scatterplots.
- `col.hist`: color for histogram fill in diagonal panels.
- `col.image`: color palette for image plot in lower panel scatterplots.
- `density`: logical, if image plot based on the two-dimensional kernel density estimation should be plotted in lower panel.
- `contour`: logical, if contour plot based on the two-dimensional kernel density estimation should be plotted in lower panel.
- `mean`: logical, if lines should indicate means of the posterior densities in the panels.
- `...`: additional graphical parameters/arguments.

**Details**

The function produces a scatterplot matrix for `mcmc.list` objects. Diagonal panels are posterior densities with labels and rug on the top. Upper panels are pairwise bivariate scatterplots with coloring corresponding to chains, thus highlighting mixing properties although not as clearly as trace plots. Lower panels are two-dimensional kernel density estimates based on `kde2d` function of `MASS` package using `image` and `contour`.

**Value**

The function returns `NULL` invisibly and produces a plot as a side effect.

**Author(s)**

Peter Solymos, <solymos@ualberta.ca>

**See Also**

- `pairs`, `plot.mcmc.list`

Two-dimensional kernel density estimation: `kde2d` in `MASS` package

**Examples**

```r
data(regmod)
pairs(regmod)
```
parallel.inits

Parallel RNGs for initial values

Description

This function takes care of initial values with safe RNGs based on parallel.seeds of the rjags package.

Usage

parallel.inits(inits, n.chains)

Arguments

inits Initial values (see Initialization at jags.model). If NULL, an empty list of length n.chains will be generated and seeded (RNG type and seed).
n.chains Number of chains to generate.

Details

Initial values are handled similar to as it is done in jags.model.
RNGs are based on values returned by parallel.seeds.
If the "lecuyer" JAGS module is active, RNGs are based on the "lecuyer::RngStream" factory, otherwise those are based on the "base::BaseRNG" factory.

Value

Returns a list of initial values with RNGs.

Author(s)

Peter Solymos, <solymos@ualberta.ca>. Based on Martyn Plummer’s parallel.seeds function and code in jags.model for initial value handling in the rjags package.

See Also

parallel.seeds, jags.model

This seeding function is used in all of declone’s parallel functions that do initialization: parJagsModel, jags.parfit, dc.parfit
parCodaSamples

Examples

```r
if (require(rjags)) {
  ## "base::BaseRNG" factory.
  parallel.inits(NULL, 2)
  ## "lecuyer::RngStream" factory
  load.module("lecuyer")
  parallel.inits(NULL, 2)
  unload.module("lecuyer")
  ## some non NULL inits specifications
  parallel.inits(list(a=0), 2)
  parallel.inits(list(list(a=0), list(a=0)), 2)
  parallel.inits(function() list(a=0), 2)
  parallel.inits(function(chain) list(a=chain), 2)
}
```

parCodaSamples  Generate posterior samples in 'mcmc.list' format on parallel workers

Description

This function sets a trace monitor for all requested nodes, updates the model on each workers. Finally, it return the chains to the master and coerces the output to a single mcmc.list object.

Usage

```r
parCodaSamples(cl, model, variable.names, n.iter, thin = 1, na.rm = TRUE, ...)```

Arguments

- **cl**: A cluster object created by `makeCluster`, or an integer. It can also be NULL, see `parDosa`.
- **model**: character, name of a jags model object
- **variable.names**: a character vector giving the names of variables to be monitored
- **n.iter**: number of iterations to monitor
- **thin**: thinning interval for monitors
- **na.rm**: logical flag that indicates whether variables containing missing values should be omitted. See details in help page of `coda.samples`.
- **...**: optional arguments that are passed to the update method for jags model objects

Value

An mcmc.list object with possibly an n.clones attribute.

Author(s)

Peter Solymos, <solymos@ualberta.ca>
See Also

Original sequential function in rjags: coda.samples
Sequential dclone-ified version: codaSamples

Examples

```r
## Not run:
if (require(rjags)) {
  model <- function() {
    for (i in 1:N) {
      Y[i] ~ dnorm(mu[i], tau)
      mu[i] <- alpha + beta * (x[i] - x.bar)
    }
    x.bar <- mean(x[])
    alpha ~ dnorm(0.0, 1.0E-4)
    beta ~ dnorm(0.0, 1.0E-4)
    sigma <- 1.0/sqrt(tau)
    tau ~ dgamma(1.0E-3, 1.0E-3)
  }
  ## data generation
  set.seed(1234)
  N <- 100
  alpha <- 1
  beta <- -1
  sigma <- 0.5
  x <- runif(N)
  linpred <- crossprod(t(model.matrix(~x)), c(alpha, beta))
  Y <- rnorm(N, mean = linpred, sd = sigma)
  jdata <- list(N = N, Y = Y, x = x)
  jpara <- c("alpha", "beta", "sigma")
  ## jags model on parallel workers
  ## n.chains must be <= no. of workers
  cl <- makePSOCKcluster(4)
  parJagsModel(cl, name="res", file=model, data=jdata,
               n.chains = 2, n.adapt=1000)
  parUpdate(cl, "res", n.iter=1000)
  m <- parCodaSamples(cl, "res", jpara, n.iter=2000)
  stopifnot(2==nchain(m))
  ## with data cloning
  dcdata <- dclone(list(N = N, Y = Y, x = x), 2, multiply="N")
  parJagsModel(cl, name="res2", file=model, data=dcdata,
               n.chains = 2, n.adapt=1000)
  parUpdate(cl, "res2", n.iter=1000)
  m2 <- parCodaSamples(cl, "res2", jpara, n.iter=2000)
  stopifnot(2==nchain(m2))
  nclones(m2)
  stopCluster(cl)
}
```

## End(Not run)
**parDosa**

*Parallel wrapper function to call from within a function*

**Description**

parDosa is a wrapper function around many functionalities of the **parallel** package. It is designed to work closely with MCMC fitting functions, e.g. can easily be called from inside of a function.

**Usage**

```r
parDosa(cl, seq, fun, cldata,
       lib = NULL, dir = NULL, evalq=NULL,
       size = 1, balancing = c("none", "load", "size", "both"),
       rng.type = c("none", "RNGstream"),
       cleanup = TRUE, unload = FALSE, iseed=NULL, ...)
```

**Arguments**

- **cl**
  A cluster object created by `makeCluster`, or an integer. It can also be NULL, see Details.
- **seq**
  A vector to split.
- **fun**
  A function or character string naming a function.
- **cldata**
  A list containing data. This list is then exported to the cluster by `clusterExport`. It is stored in a hidden environment. Data in cldata can be used by fun.
- **lib**
  Character, name of package(s). Optionally packages can be loaded onto the cluster. More than one package can be specified as character vector. Packages already loaded are skipped.
- **dir**
  Working directory to use, if NULL working directory is not set on workers (default). Can be a vector to set different directories on workers.
- **evalq**
  Character, expressions to evaluate, e.g. for changing global options (passed to `clusterevalq`). More than one expressions can be specified as character vector.
- **balancing**
  Character, type of balancing to perform (see Details).
- **size**
  Vector of problem sizes (or relative performance information) corresponding to elements of seq (recycled if needed). The default 1 indicates equality of problem sizes.
- **rng.type**
  Character, "none" will not set any seeds on the workers, "RNGstream" selects the "L'Ecuyer-CMRG" RNG and then distributes streams to the members of a cluster, optionally setting the seed of the streams by set.seed(iseed) (otherwise they are set from the current seed of the master process: after selecting the L’Ecuyer generator). See `clusterSetRNGStream`. The logical value !(rng.type == "none") is used for forking (e.g. when cl is integer).
- **cleanup**
  logical, if cldata should be removed from the workers after applying fun. If TRUE, effects of dir argument is also cleaned up.
- **unload**
  logical, if pkg should be unloaded after applying fun.
iseed integer or NULL, passed to `clusterSetRNGStream` to be supplied to `set.seed` on the workers, or NULL not to set reproducible seeds.

... Other arguments of `fun`, that are simple values and not objects. (Arguments passed as objects should be specified in `cldata`, otherwise those are not exported to the cluster by this function.)

Details

The function uses 'snow' type clusters when `cl` is a cluster object. The function uses 'multicore' type forking (shared memory) when `cl` is an integer. The value from `getOption("mc.cores")` is used if the argument is NULL.

The function sets the random seeds, loads packages `lib` onto the cluster, sets the working directory as `dir`, exports `cldata` and evaluates `fun` on `seq`.

No balancing (balancing = "none") means, that the problem is split into roughly equal subsets, without respect to size (see `clusterSplit`). This splitting is deterministic (reproducible).

Load balancing (balancing = "load") means, that the problem is not splitted into subsets a priori, but subsequent items are placed on the worker which is empty (see `clusterApplyLB` for load balancing). This splitting is non-deterministic (might not be reproducible).

Size balancing (balancing = "size") means, that the problem is splitted into subsets, with respect to size (see `clusterSplitSB` and `parLapplySB`). In size balancing, the problem is re-ordered from largest to smallest, and then subsets are determined by minimizing the total approximate processing time. This splitting is deterministic (reproducible).

Size and load balancing (balancing = "both") means, that the problem is re-ordered from largest to smallest, and then undeterministic load balancing is used (see `parLapplySLB`). If size is correct, this is identical to size balancing. This splitting is non-deterministic (might not be reproducible).

Value

Usually a list with results returned by the cluster.

Author(s)

Peter Solymos, <solymos@ualberta.ca>

See Also

Size balancing: `parLapplySB`, `parLapplySLB`, `mclapplySB`

Optimizing the number of workers: `clusterSize`, `plotClusterSize`.

`parDosa` is used internally by parallel `dclone` functions: `jags.parfit`, `dc.parfit`, `parJagsModel`, `parUpdate`, `parCodaSamples`.

`parDosa` manipulates specific environments described on the help page `DcloneEnv`. 
parJagsModel

Create a JAGS model object on parallel workers

Description

parJagsModel is used to create an object representing a Bayesian graphical model, specified with a BUGS-language description of the prior distribution, and a set of data.

Usage

parJagsModel(cl, name, file, data=sys.frame(sys.parent()),
             inits, n.chains = 1, n.adapt=1000, quiet=FALSE)

Arguments

cl A cluster object created by makeCluster, or an integer. It can also be NULL, see parDosa. Size of the cluster must be equal to or larger than n.chains.
name character, name for the model to be assigned on the workers.
file the name of the file containing a description of the model in the JAGS dialect of the BUGS language. Alternatively, file can be a readable text-mode connection, or a complete URL. It can be also a function or a custommodel object.
data a list or environment containing the data. Any numeric objects in data corresponding to node arrays used in file are taken to represent the values of observed nodes in the model
inits optional specification of initial values in the form of a list or a function (see initialization on help page of jagsModel). If omitted, initial values will be generated automatically. It is an error to supply an initial value for an observed node.
n.chains the number of parallel chains for the model
n.adapt the number of iterations for adaptation. See adapt for details. If n.adapt = 0 then no adaptation takes place.
quiet if TRUE then messages generated during compilation will be suppressed. Effect of this argument is not visible on the master process.

Value

parJagsModel returns an object inheriting from class jags which can be used to generate dependent samples from the posterior distribution of the parameters. These jags models are residing on the workers, thus updating/sampling is possible.

Length of cl must be equal to or greater than n.chains. RNG seed generation takes place first on the master, and chains then initialized on each worker by distributing inits and single chained models.

An object of class jags is a list of functions that share a common environment, see jagsModel for details. Data cloning information is attached to the returned object if data argument has n.clones attribute.
Description

A JAGS module is a dynamically loaded library that extends the functionality of JAGS. These functions load and unload JAGS modules and show the names of the currently loaded modules on parallel workers.

Usage

```r
parLoadModule(cl, name, path, quiet=FALSE)
parUnloadModule(cl, name, quiet=FALSE)
parListModules(cl)
```

Arguments

- `cl` a cluster object created by the `parallel` package.
- `name` character, name of the module to be loaded
- `path` file path to the location of the DLL. If omitted, the option `jags.moddir` is used to locate the modules. It can be a vector of length `length(cl)` to set different DLL locations on each worker
- `quiet` a logical. If TRUE, no message will be printed about loading the module

Author(s)

Peter Solymos, <solymos@ualberta.ca>

See Also

`list.modules, load.module, unload.module`
Examples

```r
## Not run:
if (require(rjags)) {
  cl <- makePSOCKcluster(3)
  parListModules(cl)
  parLoadModule(cl, "glm")
  parListModules(cl)
  parUnloadModule(cl, "glm")
  parListModules(cl)
  stopCluster(cl)
}

## End(Not run)
```

---

**parSetFactory**

*Advanced control over JAGS on parallel workers*

**Description**

JAGS modules contain factory objects for samplers, monitors, and random number generators for a JAGS model. These functions allow fine-grained control over which factories are active on parallel workers.

**Usage**

```r
parListFactories(cl, type)
parSetFactory(cl, name, type, state)
```

**Arguments**

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>cl</td>
<td>a cluster object created by the <code>parallel</code> package.</td>
</tr>
<tr>
<td>name</td>
<td>name of the factory to set</td>
</tr>
<tr>
<td>type</td>
<td>type of factory to query or set. Possible values are &quot;sampler&quot;, &quot;monitor&quot;, or &quot;rng&quot;</td>
</tr>
<tr>
<td>state</td>
<td>a logical. If TRUE then the factory will be active, otherwise the factory will become inactive.</td>
</tr>
</tbody>
</table>

**Value**

`parListFactories` returns a list of data frame with two columns per each worker, the first column shows the names of the factory objects in the currently loaded modules, and the second column is a logical vector indicating whether the corresponding factory is active or not.

`parSetFactory` is called to change the future behaviour of factory objects. If a factory is set to inactive then it will be skipped.
parUpdate

Note
When a module is loaded, all of its factory objects are active. This is also true if a module is unloaded and then reloaded.

Author(s)
Peter Solymos, <solymos@ualberta.ca>

See Also
listNmodules, setNfactory

Examples
```r
## Not run:
if (require(rjags)) {
  cl <- makePSOCKcluster(3)
  parListFactories(cl, "sampler")
  parListFactories(cl, "monitor")
  parListFactories(cl, "rng")
  parSetFactory(cl, "base::Slice", "sampler", FALSE)
  parListFactories(cl, "sampler")
  parSetFactory(cl, "base::Slice", "sampler", TRUE)
  stopCluster(cl)
}
## End(Not run)
```

parUpdate

**Update jags models on parallel workers**

Description
Update the Markov chain associated with the model on parallel workers. (This represents the ‘burn-in’ phase when nodes are not monitored.)

Usage
```
parUpdate(cl, object, n.iter=1, ...)
```

Arguments
- **cl**: A cluster object created by `makeCluster`, or an integer. It can also be NULL, see `parDosa`.
- **object**: character, name of a jags model object
- **n.iter**: number of iterations of the Markov chain to run
- **...**: additional arguments to the update method, see `update.jags`
Value

The parUpdate function modifies the original object on parallel workers and returns NULL.

Author(s)

Peter Solymos, <solymos@ualberta.ca>

See Also

update.jags
See example on help page of parCodaSamples.

Description

This data set was made via the jags.fit function.

Usage

data(regmod)

Source

See Example.

Examples

data(regmod)
summary(regmod)
plot(regmod)

## Not run:
## DATA GENERATION
## simple regression example from the JAGS manual
jfun <- function() {
  for (i in 1:N) {
    Y[i] ~ dnorm(mu[i], tau)
    mu[i] <- alpha + beta * (x[i] - x.bar)
  }
  x.bar <- mean(x[])
  alpha ~ dnorm(0.0, 1.0E-4)
  beta ~ dnorm(0.0, 1.0E-4)
  sigma <- 1.0/sqrt(tau)
  tau ~ dgamma(1.0E-3, 1.0E-3)
}
## data generation
set.seed(1234)
N <- 100
alpha <- 1
beta <- -1
sigma <- 0.5
x <- runif(N)
linpred <- crossprod(t(model.matrix(~x)), c(alpha, beta))
Y <- rnorm(N, mean = linpred, sd = sigma)
## list of data for the model
jdata <- list(N = N, Y = Y, x = x)
## what to monitor
jpara <- c("alpha", "beta", "sigma")
## fit the model with JAGS
regmod <- jags.fit(jdata, jpara, jfun, n.chains = 3,
                   updated.model = FALSE)

## End(Not run)

---

**stan.fit**  
*Fit Stan models with cloned data*

**Description**

Convenient functions designed to work well with cloned data arguments and Stan.

**Usage**

```r
stan.fit(data, params, model, inits = NULL,
         seed = sample.int(.Machine$integer.max, 1),
         n.chains = 3,
         format = c("mcmc.list", "stanfit"),
         stan.model = TRUE, fit = NA, ...)
```

```r
stan.parfit(cl, data, params, model, inits = NULL,
            seed = sample.int(.Machine$integer.max, n.chains),
            n.chains = 3,
            format = c("mcmc.list", "stanfit"),
            stan.model = TRUE, fit = NA, ...)
```

**Arguments**

- **data**: A list (or environment) containing the data.
- **params**: Character vector of parameters to be sampled.
- **model**: Character string (name of the model file), a function containing the model, or a `custommodel` object.
- **inits**: Optional specification of initial values in the form of a list or a function. If `NULL`, initial values will be generated automatically.
- **seed**: Random seed.
- **n.chains**: number of Markov chains.
format   Desired output format.
stan.model   Logical, if stanmodel object should be returned.
fit   Fitted Stan object.
cl   A cluster object created by makeCluster, or an integer, see parDosa and evalParallelArgument.
object   A fitted MCMC object ('mcmc.list' class for example), with "stan.model" attribute.
...   Further arguments.

Value

By default, an stan.fit returns an mcmc.list object. If data cloning is used via the data argument, summary returns a modified summary containing scaled data cloning standard errors (scaled by \( \sqrt{\text{n.clones}} \)), and \( R_{\text{hat}} \) values (as returned by gelman.diag).

stan.model returns the stanmodel object.

stan.parfit runs chains using multiple cores when cl is an integer. Using a cluster object leads to recompiling the model (therefore fit is ignored), and might not be very quick to run.

Author(s)

Peter Solymos, <solymos@ualberta.ca>

See Also

Underlying functions: stan and stanfit in package rstan

Methods: dcsd, confint.mcmc.list, coef.mcmc.list, quantile.mcmc.list, vcov.mcmc.list

Examples

```r
## Not run:
if (require(rstan)) {
  model <- custommodel("data {
    int<lower=0> N;
    vector[N] y;
    vector[N] x;
  }
  parameters {
    real alpha;
    real beta;
    real<lower=0> sigma;
  }
  model {
    alpha ~ normal(0,10);
    beta ~ normal(0,10);
    sigma ~ cauchy(0,5);
    for (n in 1:N)
      y[n] ~ normal(alpha + beta * x[n], sigma);
  }")
  N <- 100
  alpha <- 1
```
beta <- -1
sigma <- 0.5
x <- runif(N)
y <- rnorm(N, alpha + beta * x, sigma)
dat <- list(N=N, y=y, x=x)
params <- c(“alpha”, “beta”, “sigma”)
## compile on 1st time only
fit0 <- stan.fit(dat, params, model)
## reuse compiled fit0
fit <- stan.fit(dat, params, model, fit=fit0)
sm <- stan.model(fit)
summary(fit)
sm

## data cloning
dcdat <- dclone(dat, n.clones=2, multiply=”N”)
dcfit <- stan.fit(dcdat, params, model, fit=fit0)
summary(dcfit)
nclones(dcfit)

## using parallel options
c1 <- makeCluster(2)
## cannot utilize compiled fit0
fit2 <- stan.parfit(cl=c1, dat, params, model)
stopCluster(c1)
if (Platform$OS.type != “windows”) {
## utilize compiled fit0
  fit3 <- stan.parfit(cl=2, dat, params, model, fit=fit0)
}

## End(Not run)

**update.mcmc.list**  
*Automatic updating of an MCMC object from JAGS*

**Description**

Automatic updating of an MCMC object until a desired statistic value reached.

**Usage**

```r
updated.model(object, ...)
## S3 method for class 'mcmc.list'
update(object, fun,
    times = 1, n.update = 0, n.iter, thin, ...)
```
Arguments

object  
A fitted MCMC object ("mcmc.list" class for example), with "updated.model" attribute.

fun  
A function that evaluates convergence of the MCMC chains, must return logical result. See Examples. The iterative updating quits when return value is TRUE. Can be missing, in which case there is no stopping rule.

times  
Number of times the updating should be repeated. If fun returns TRUE, updating is finished and MCMC object is returned.

n.update  
Number of updating iterations. The default 0 indicates, that only n.iter iterations are used.

n.iter  
Number of iterations for sampling and evaluating fun. If missing, value is taken from object.

thin  
Thinning value. If missing, value is taken from object.

...  
Other arguments passed to coda.samples.

Details

updated.model can be used to retrieve the updated model from an MCMC object fitted via the function jags.fit and dc.fit (with flavour = "jags"). The update method is a wrapper for this purpose, specifically designed for the case when MCMC convergence is problematic. A function is evaluated on the updated model in each iteration of the updating process, and an MCMC object is returned when iteration ends, or when the evaluated function returns TRUE value.

n.update and n.iter can be vectors, if lengths are shorter then times, values are recycled.

Data cloning information is preserved.

Value

updated.model returns the state of the JAGS model after updating and sampling. This can be further updated by the function update.jags and sampled by coda.samples if convergence diagnostics were not satisfactory.

update returns an MCMC object with "updated.model" attribute.

Author(s)

Peter Solymos, <solymos@ualberta.ca>

See Also

jags.fit, coda.samples, update.jags

Examples

## Not run:
## simple regression example from the JAGS manual
jfun <- function() {
  for (i in 1:N) {
    Y[i] ~ dnorm(mu[i], tau)
mu[i] <- alpha + beta * (x[i] - x.bar)
}
x.bar <- mean(x[])
alpha ~ dnorm(0.0, 1.0E-4)
beta ~ dnorm(0.0, 1.0E-4)
sigma <- 1.0/sqrt(tau)
tau ~ dgamma(1.0E-3, 1.0E-3)
}
## data generation
set.seed(1234)
N <- 100
alpha <- 1
beta <- -1
sigma <- 0.5
x <- runif(N)
linpred <- crossprod(t(model.matrix(~x)), c(alpha, beta))
Y <- rnorm(N, mean = linpred, sd = sigma)
## list of data for the model
jdata <- list(N = N, Y = Y, x = x)
## what to monitor
jpara <- c("alpha", "beta", "sigma")
## fit the model with JAGS
regmod <- jags.fit(jdata, jpara, jfun, n.chains = 3)
## get the updated model
upmod <- updated.model(regmod)
upmod
## automatic updating
## using R_hat < 1.1 as criteria
critfun <- function(x)
  all(gelman.diag(x)$psrf[1] < 1.1)
mod <- update(regmod, critfun, 5)
## update just once
mod2 <- update(regmod)
summary(mod)

## End(Not run)

---

**write.jags.model**  
*Write and remove model file*

**Description**

Writes or removes a BUGS model file to or from the hard drive.

**Usage**

```r
write.jags.model(model, filename = "model.txt", digits = 5,  
dir = tempdir(), overwrite =getOption("dcoptions")$overwrite)
clean.jags.model(filename = "model.txt")
custommodel(model, exclude = NULL, digits = 5)
```
**write.jags.model**

**Arguments**

- **model**: JAGS model to write onto the hard drive (see Example). For `write.jags.model`, it can be name of a file or a function, or it can be an 'custommodel' object returned by `custommodel`. `custommodel` can take its `model` argument as function. If model is not function, its is coerced as character.

- **digits**: Number of significant digits used in the output.

- **filename**: Character, the name of the file to write/remove. It can be a `link{connection}`.

- **dir**: Optional argument for directory where to write the file. The default is to use a temporary directory and use `file.path(dir, filename)`. When NULL, it uses the current working directory (`getwd()`).

- **overwrite**: Logical, if TRUE the filename will be forced and existing file with same name will be overwritten.

- **exclude**: Numeric, lines of the model to exclude (see Details).

**Details**

`write.jags.model` is built upon the function `write.model` of the **R2WinBUGS** package.

`clean.jags.model` is built upon the function `file.remove`, and intended to be used internally to clean up the JAGS model file after estimating sessions, ideally via the `on.exit` function. It requires the full path as returned by `write.jags.model`.

The function `custommodel` can be used to exclude some lines of the model. This is handy when there are variations of the same model. `write.jags.model` accepts results returned by `custommodel`. This is also the preferred way of including BUGS models into R packages, because the function form often includes undefined functions.

Use the `%_%` operator if the model is a function and the model contains truncation (I() in WinBUGS, T() in JAGS). See explanation on help page of `write.model`.

**Value**

`write.jags.model` invisibly returns the name of the file that was written eventually (possibly including random string). The return value includes the full path.

`clean.jags.model` invisibly returns the result of `file.remove` (logical).

`custommodel` returns an object of class 'custommodel', which is a character vector.

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**See Also**

`write.model, file.remove`
Examples

```r
## Not run:
## simple regression example from the JAGS manual
jfun <- function() {
  for (i in 1:N) {
    Y[i] ~ dnorm(mu[i], tau)
    mu[i] <- alpha + beta * (x[i] - x.bar)
  }
  x.bar <- mean(x)
  alpha ~ dnorm(0.0, 1.0E-4)
  beta ~ dnorm(0.0, 1.0E-4)
  sigma <- 1.0/sqrt(tau)
  tau ~ dgamma(1.0E-3, 1.0E-3)
}

## data generation
set.seed(1234)
N <- 100
alpha <- 1
beta <- -1
sigma <- 0.5
x <- runif(N)
linpred <- crossprod(t(model.matrix(~x)), c(alpha, beta))
Y <- rnorm(N, mean = linpred, sd = sigma)

## list of data for the model
jdata <- list(N = N, Y = Y, x = x)

## what to monitor
jpara <- c("alpha", "beta", "sigma")

## write model onto hard drive
jmodnam <- write.jags.model(jfun)

## fit the model
regmod <- jags.fit(jdata, jpara, jmodnam, n.chains = 3)

## cleanup
clean.jags.model(jmodnam)

## model summary
summary(regmod)

## End(Not run)
## let's customize this model
jfun2 <- structure(
  c("model {",
    "  for (i in 1:n) { ",
      "    Y[i] ~ dpois(lambda[i]) ",
      "    Y[i] <- alpha[i] + inprod(X[i,], beta[1,]) ",
      "    log(lambda[i]) <- alpha[i] + inprod(X[i,], beta[1,]) ",
      "    alpha[i] ~ dnorm(0, 1/sigma^2) ",
      "  } ",
    "  for (j in 1:np) { ",
      "    beta[1,j] ~ dnorm(0, 0.001) ",
      "  } ",
    "  sigma ~ dlnorm(0, 0.001) ",
  "})",
  class = "custommodel")
```
custommodel(jfun2)
## GLMM
custommodel(jfun2, 4)
## LM
custommodel(jfun2, c(3,5))
## deparse when print
print(custommodel(jfun2), deparse=TRUE)
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