

# Package: optimx (via r-universe)

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**Title** Expanded Replacement and Extension of the 'optim' Function

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**Description** Provides a replacement and extension of the `optim()` function to call to several function minimization codes in R in a single statement. These methods handle smooth, possibly box constrained functions of several or many parameters. Note that function 'optimr()' was prepared to simplify the incorporation of minimization codes going forward. Also implements some utility codes and some extra solvers, including safeguarded Newton methods. Many methods previously separate are now included here. This is the version for CRAN.

**License** GPL-2

**URL** <https://github.com/nashjc/optimx>

**BugReports** <https://github.com/nashjc/optimx/issues>

**LazyLoad** Yes

**Imports** numDeriv, nloptr, pracma

**NeedsCompilation** no

**Suggests** knitr, rmarkdown, setRNG, BB, ucminf, minqa, dfoptim, lbfgsb3c, lbfgs, subplex, marqLevAlg, testthat (>= 3.0.0), R.rsp

**VignetteBuilder** R.rsp

**Config/testthat/edition** 3

**Repository** <https://nashjc.r-universe.dev>

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optimx-package	<i>A replacement and extension of the <code>optim()</code> function, plus various optimization tools</i>
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## Description

`optimx` provides a replacement and extension of the `link{optim()}` function to unify and streamline optimization capabilities in R for smooth, possibly box constrained functions of several or many parameters

The three functions `ufn`, `ugr` and `uhess` wrap corresponding user functions `fn`, `gr`, and `hess` so that these functions can be executed safely (via `try()`) and also so parameter or function scaling can be applied. The wrapper functions also allow for maximization of functions (via minimization of the negative of the function) using the logical parameter `maximize`.

There are three test functions, `fnchk`, `grchk`, and `hesschk`, to allow the user function to be tested for validity and correctness. However, no set of tests is exhaustive, and extensions and improvements are welcome. The package `numDeriv` is used for generation of numerical approximations to derivatives.

## Details

Index:

<code>axsearch</code>	Perform an axial search optimality check
<code>bmchk</code>	Check bounds and masks for parameter constraints
<code>bmstep</code>	Compute the maximum step along a search direction.
<code>checksolver</code>	Checks if method is available in <code>allmeth</code>
<code>ctrldefault</code>	Sets the default values of elements of the <code>control()</code> list
<code>dispdefault</code>	To display default control settings
<code>fnchk</code>	Test validity of user function
<code>gHgen</code>	Compute gradient and Hessian as a given set of parameters
<code>gHgenb</code>	Compute gradient and Hessian as a given set of parameters applying bounds and masks
<code>grback</code>	Backward numerical gradient approximation
<code>grcentral</code>	Central numerical gradient approximation
<code>grchk</code>	Check that gradient function evaluation matches numerical gradient
<code>grfwd</code>	Forward numerical gradient approximation
<code>grnd</code>	Gradient approximation using <code>\code{numDeriv}</code>
<code>grpracma</code>	Gradient approximation using <code>\code{pracma}</code>
<code>hesschk</code>	Check that Hessian function evaluation matches numerical approximation
<code>hjn</code>	A didactic example code of the Hooke and Jeeves algorithm
<code>kktchk</code>	Check the Karush-Kuhn-Tucker optimality conditions
<code>multistart</code>	Try a single method with multiple starting parameter sets
<code>ncg</code>	Revised CG solver

nvm	Revised Variable Metric solver
opm	Wrapper that allows multiple minimizers to be applied to a given objective function
optchk	Check supplied objective function
optimr	Wrapper that allows different (single) minimizers to be applied to a given objective function using a common syntax like that of optim()
optimx	Wrapper that allows multiple minimizers to be applied to a given objective function. Complexity of the code made this function difficult to maintain, and opm() is the suggested replacement, but optimx() is retained for backward compatibility.
optimx.check	a component of optimx()
optimx-package	a component of optimx()
optimx.run	a component of optimx()
optimx.setup	a component of optimx()
optsp	An environment to hold some globally useful items used by optimization programs. Created on loading package with zzz.R
polyopt	Allows sequential application of methods to a given problem.
proptimr	compact output of optimr() result object
Rcgmin	Conjugate gradients minimization
Rcgminb	Bounds constrained conjugate gradients minimization
Rcgminu	Unconstrained conjugate gradients minimization
Rtnmin-package	Internal functions for the S.G.Nash truncated newton method
Rvmmmin	Variable metric minimization method
Rvmmminb	Bounds constrained variable metric minimization method
Rvmmminu	Unconstrained variable metric minimization method
scalechk	Check scale of initial parameters and bounds
snewtm	Demonstration Newton-Marquardt minimization method
snewton	Demonstration safeguarded Newton minimization method
snewtonmb	Bounds constrained safeguarded Newton method
tnbc	Bounds constrained truncated Newton method
tn	Unconstrained truncated Newton method

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### References

Nash, John C. and Varadhan, Ravi (2011) Unifying Optimization Algorithms to Aid Software System Users: optimx for R, Journal of Statistical Software, publication pending.

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axsearch	<i>Perform axial search around a supposed MINIMUM and provide diagnostics</i>
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### Description

Nonlinear optimization problems often terminate at points in the parameter space that are not satisfactory optima. This routine conducts an axial search, stepping forward and backward along each parameter and computing the objective function. This allows us to compute the `tilt` and `radius` of curvature or `roc` along that parameter axis.

`axsearch` assumes that one is MINIMIZING the function `fn`. If you are working with a maximization, it is suggested that you write your own function that is to be minimized, that is,  $(-1) * (\text{function to be maximized})$ . All discussion here is in terms of minimization.

Axial search may find parameters with a function value lower than that at the supposed minimum, i.e., lower than `fmin`.

In this case `axsearch` exits immediately with the new function value and parameters. This can be used to restart an optimizer, as in the `optimx` wrapper.

### Usage

```
axsearch(par, fn=NULL, fmin=NULL, lower=NULL, upper=NULL, bdmsk=NULL,
         control=list(), ...)
```

### Arguments

<code>par</code>	A numeric vector of values of the optimization function parameters that are at a supposed minimum.
<code>fn</code>	The user objective function
<code>fmin</code>	The presumed value of the objective function at the parameters <code>par</code> . NOTE: This is NOT checked. Caution!. However, if <code>fmin==NULL</code> on call, <code>axsearch</code> will compute the value.
<code>lower</code>	A vector of lower bounds on the parameters.
<code>upper</code>	A vector of upper bounds on the parameters.
<code>bdmsk</code>	An indicator vector, having 1 for each parameter that is "free" or unconstrained, and 0 for any parameter that is fixed or MASKED for the duration of the optimization. Partly for historical reasons, we use the same array during the progress of optimization as an indicator that a parameter is at a lower bound ( <code>bdmsk</code> element set to -3) or upper bound (-1).
<code>control</code>	Algorithm controls as per <code>ctrldefault</code> . See details.
<code>...</code>	Extra arguments for the user function.

## Details

The axial search MAY give a lower function value, in which case, one can restart an optimization. However, it is left to the user to do this. Its primary use is in presenting some features of the function surface in the tilt and radius of curvature measures returned. However, better measures should be possible, and this function should be regarded as largely experimental.

Note: As of December 2021, the calling syntax has changed from `axsearch(par, fn=NULL, fmin=NULL, lower=NULL, upper=NULL, bdmsk=NULL, trace=0, ...)`

In case any user has code employing the older function, it is to be found in `inst/doc/replaced2021/axsearch2018.R`.

The new syntax has `trace` replaced with `control=list{}`, where the defaults are found from the function `ctrldefault()`. This routine uses three particular elements:

`trace` is 0 if no intermediate output is desired, non-zero otherwise.

`bigval` is a large number used to provide a value for the objective function when the parameters are inadmissible.

`reltest` is used to test for equality of small numbers by comparing their sums with `reltest`.

`grtesttol` is a small quantity, but it is used when multiplied by `reltest` to give `epst`, the axial step control. Each parameter is stepped by an amount `epst*(abs(parameter_value)+epst)`. Note that the author has never found it necessary to adjust these values from the defaults generated by `ctrldefault()`.

## Value

A list with components:

<code>bestfn</code>	The lowest (best) function value found during the axial search, else the original <code>fmin</code> value. (This is actively set in that case.)
<code>par</code>	The vector of parameters at the best function value.
<code>details</code>	A data frame reporting the original parameters, the forward step and backward step function values, the size of the step taken for a particular parameter, the tilt and the roc (radius of curvature). Some elements will be NA if we find a lower function value during the axial search.

## Examples

```
#####
# require(optimx)
# Simple bounds test for n=4
bt.f<-function(x){
  sum(x*x)
}

bt.g<-function(x){
  gg<-2.0*x
}

n<-4
lower<-rep(0,n)
upper<-lower # to get arrays set
```

```

bdmsk<-rep(1,n)
# bdmsk[(trunc(n/2)+1)]<-0
for (i in 1:n) {
  lower[i]<-1.0*(i-1)*(n-1)/n
  upper[i]<-1.0*i*(n+1)/n
}
xx<-0.5*(lower+upper)

cat("lower bounds:")
print(lower)
cat("start:      ")
print(xx)
cat("upper bounds:")
print(upper)

abtrvm <- list() # ensure we have the structure

cat("Rvmmmin \n\n")
# Note: trace set to 0 below. Change as needed to view progress.

# Following can be executed if package optimx available
# abtrvm <- optimr(xx, bt.f, bt.g, lower=lower, upper=upper, method="Rvmmmin",
#               control=list(trace=0))
# Note: use lower=lower etc. because there is a missing hess= argument
# print(abtrvm)

abtrvm$par <- c(0.00, 0.75, 1.50, 2.25)
abtrvm$value <- 7.875
cat("Axial search")
axabtrvm <- axsearch(abtrvm$par, fn=bt.f, fmin=abtrvm$value, lower, upper, bdmsk=NULL)
print(axabtrvm)

abtrvm1 <- optimr(xx, bt.f, bt.g, lower=lower, upper=upper, method="Rvmmmin",
                 control=list(maxit=1, trace=0))
proptimr(abtrvm1)

abtrvm1$value <- 8.884958
abtrvm1$par <- c(0.625, 1.625, 2.625, 3.625)

cat("Axial search")
axabtrvm1 <- axsearch(abtrvm1$par, fn=bt.f, fmin=abtrvm1$value, lower, upper, bdmsk=NULL)
print(axabtrvm1)

cat("Do NOT try axsearch() with maximize\n")

```

## Description

Nonlinear optimization problems often have explicit or implicit upper and lower bounds on the parameters of the function to be minimized or maximized. These are called bounds or box constraints. Some of the parameters may be fixed for a given problem or for a temporary trial. These fixed, or masked, parameters are held at one value during a specific 'run' of the optimization.

It is possible that the bounds are inadmissible, that is, that at least one lower bound exceeds an upper bound. In this case we set the flag `admissible` to `FALSE`.

Parameters that are outside the bounds are moved to the nearest bound and the flag `parchanged` is set `TRUE`. However, we **DO NOT** change masked parameters, and they may be outside the bounds. This is an implementation choice, since it may be useful to test objective functions at point outside the bounds.

The package `bmchk` is essentially a test of the R function `bmchk()`, which is likely to be incorporated within optimization codes.

## Usage

```
bmchk(par, lower=NULL, upper=NULL, bdmsk=NULL, trace=0, offset=100, shift2bound=TRUE)
```

## Arguments

<code>par</code>	A numeric vector of starting values of the optimization function parameters.
<code>lower</code>	A vector of lower bounds on the parameters.
<code>upper</code>	A vector of upper bounds on the parameters.
<code>bdmsk</code>	An indicator vector, having 1 for each parameter that is "free" or unconstrained, and 0 for any parameter that is fixed or MASKED for the duration of the optimization. Partly for historical reasons, we use the same array during the progress of optimization as an indicator that a parameter is at a lower bound ( <code>bdmsk</code> element set to -3) or upper bound (-1).
<code>trace</code>	An integer that controls whether diagnostic information is displayed. A positive value displays information, 0 (default) does not.
<code>offset</code>	If provided, is used to detect equality of numbers. That is, two values <code>a</code> and <code>b</code> are taken as equal if <code>a + offset</code> is equal to <code>b + offset</code> . Default value is 100. Note that in previous versions of this code a tolerance <code>tol</code> was used.
<code>shift2bound</code>	If <code>TRUE</code> , non-masked parameters outside bounds are adjusted to the nearest bound. We then set <code>parchanged = TRUE</code> which implies the original parameters were infeasible.

## Details

The `bmchk` function will check that the bounds exist and are admissible, that is, that there are no lower bounds that exceed upper bounds.

There is a check if lower and upper bounds are very close together, in which case a mask is imposed and `maskadded` is set `TRUE`. NOTE: it is generally a **VERY BAD IDEA** to have bounds close together in optimization, but here we use a tolerance based on the double precision machine epsilon. Thus it is not a good idea to rely on `bmchk()` to test if bounds constraints are well-posed.



**Value**

A list with components:

bvec	The vector of parameters, possibly adjusted to bounds. Parameters outside bounds are adjusted to the nearest bound. We let $n$ be the length of this vector.
bdmsk	adjusted input masks
bchar	a set of indicators that give information about the parameters, that is, if they are out-of-bounds-low ("-"), at a lower bound ("L"), free ("F"), at an upper bound ("U"), out-of-bounds-high ("+"), masked (fixed) ("M"), of unknown characteristics ("?"), or inadmissible ("!").
lower	(adjusted) lower bounds. If there are no lower bounds, a vector of values equal to $-\text{Inf}$ is substituted. Similarly, a single value is expanded to a complete vector. If any upper and lower bounds are equal (as mediated by <code>offset</code> ), we create a mask.
upper	(adjusted) upper bounds
nolower	TRUE if no lower bounds, FALSE otherwise
noupper	TRUE if no upper bounds, FALSE otherwise
bounds	TRUE if there are any bounds, FALSE otherwise
admissible	TRUE if bounds are admissible, FALSE otherwise This means no lower bound exceeds an upper bound. That is the bounds themselves are sensible. This condition has nothing to do with the starting parameters.
maskadded	TRUE when a mask has been added because bounds are very close or equal, FALSE otherwise. See the code for the implementation.
parchanged	TRUE if parameters are changed by bounds, FALSE otherwise. Note that <code>parchanged = TRUE</code> implies the input parameter values were infeasible, that is, violated the bounds constraints.
feasible	TRUE if parameters are within or on bounds, FALSE otherwise.
onbound	TRUE if any parameter is on a bound, FALSE otherwise. Note that <code>parchanged = TRUE</code> implies <code>onbound = TRUE</code> , but this is not used inside the function. This output value may be important, for example, in using the optimization function <code>nmkb</code> from package <code>dfoptim</code> .

**Examples**

```
#####

## cat("25-dimensional box constrained function\n")
## flb <- function(x)
##   { p <- length(x); sum(c(1, rep(4, p-1)) * (x - c(1, x[-p])^2)^2) }

start<-rep(2, 25)
cat("\n start:")
print(start)
lo<-rep(2,25)
cat("\n lo:")
```

```

print(lo)
hi<-rep(4,25)
cat("\n hi:")
print(hi)
bt<-bmchk(start, lower=lo, upper=hi, trace=1)
print(bt)

```

---

bmstep

---

*Compute the maximum step along a search direction.*


---

### Description

Nonlinear optimization problems often have explicit or implicit upper and lower bounds on the parameters of the function to be minimized or maximized. These are called bounds or box constraints. Some of the parameters may be fixed for a given problem or for a temporary trial. These fixed, or masked, parameters are held at one value during a specific 'run' of the optimization.

The `bmstep()` function computes the maximum step possible (which could be infinite) along a particular search direction from current parameters to bounds.

### Usage

```
bmstep(par, srchdirn, lower=NULL, upper=NULL, bdmsk=NULL, trace=0)
```

### Arguments

<code>par</code>	A numeric vector of starting values of the optimization function parameters.
<code>srchdirn</code>	A numeric vector giving the search direction.
<code>lower</code>	A vector of lower bounds on the parameters.
<code>upper</code>	A vector of upper bounds on the parameters.
<code>bdmsk</code>	An indicator vector, having 1 for each parameter that is "free" or unconstrained, and 0 for any parameter that is fixed or MASKED for the duration of the optimization. Partly for historical reasons, we use the same array during the progress of optimization as an indicator that a parameter is at a lower bound (bdmsk element set to -3) or upper bound (-1).
<code>trace</code>	An integer that controls whether diagnostic information is displayed. A positive value displays information, 0 (default) does not.

### Details

The `bmstep` function will compute and return (as a double or `Inf`) the maximum step to the bounds.

### Value

A double precision value or `Inf` giving the maximum step to the bounds.

**Examples**

```
#####
xx <- c(1, 1)
lo <- c(0, 0)
up <- c(100, 40)
sdir <- c(4,1)
bm <- c(1,1) # both free
ans <- bmstep(xx, sdir, lo, up, bm, trace=1)
# stepsize
print(ans)
# distance
print(ans*sdir)
# New parameters
print(xx+ans*sdir)
```

---

checksolver

*Test if requested solver is present*


---

**Description**

Test if requested solver is present.

**Usage**

```
checksolver(method, allmeth, allpkg)
checkallsolvers()
```

**Arguments**

method	Character string giving the name of the solver requested.
allmeth	Character vector giving the names of the methods optimr can use.
allpkg	Character vector giving the names of the packages where solvers are found.

**Value**

If the solver defined by character string in `method` is available, then `checksolver` returns this string, else `NULL`.

`checkallsolvers()` returns a vector of strings that are the names of missing solvers, else `NULL` if all solvers specified in `allmeth` are present where `allmeth` is returned from a call to `ctrldefault(n)` where `n` is some integer.

**Examples**

```

allmeth <- c("Rvmin", "nlminb", "ipopttest")
allpkg <- c("Rvmin", "stats", "ipoptr")

print(checksolver("nlminb", allmeth, allpkg))
# If Rvmin NOT available, get msg that PACKAGE not available.
print(checksolver("Rvmin", allmeth, allpkg))
# Get message that SOLVER not found
print(checksolver("notasolver", allmeth, allpkg))

```

---

coef

*Summarize opm object*


---

**Description**

Summarize an "opm" object.

**Usage**

```

## S3 method for class 'opm'
coef(object, ...)
## S3 replacement method for class 'opm'
coef(x) <- value

```

**Arguments**

object	Object returned by opm.
...	Further arguments to be passed to the function. Currently not used.
x	An opm object.
value	Set parameters equal to this value.

**Value**

coef.opm returns the best parameters found by each method that returned such parameters. The returned coefficients are in the form of a matrix with the rows named by the relevant methods and the columns named according to parameter names provided by the user in the vector of starting values, or else by "p1", "p2", ..., if names are not provided.

**Examples**

```

ans <- opm(fn = function(x) sum(x*x), par = 1:2, method="ALL", control=list(trace=0))
print(coef(ans))

ansx <- optimx(fn = function(x) sum(x*x), par = 1:2, control=list(all.methods=TRUE, trace=0))
print(coef(ansx))

```

```
## Not run:
proj <- function(x) x/sum(x)
f <- function(x) -prod(proj(x))
ans <- opm(1:2, f)
print(ans)
coef(ans) <- apply(coef(ans), 1, proj)
print(ans)

## End(Not run)
```

---

ctrldefault	<i>set control defaults</i>
-------------	-----------------------------

---

### Description

Set control defaults.

### Usage

```
ctrldefault(npar)
```

```
dispdefault(ctrl)
```

### Arguments

npar	Number of parameters to optimize.
ctrl	A list (likely generated by ‘ctrldefault’) of default settings to ‘optimx’.

### Value

ctrldefault returns the default control settings for optimization tools.  
dispdefault provides a compact display of the contents of a control settings list.

---

fnchk	<i>Run tests, where possible, on user objective function</i>
-------	--

---

### Description

fnchk checks a user-provided R function, ffn.

### Usage

```
fnchk(xpar, ffn, trace=0, ... )
```

**Arguments**

xpar	the (double) vector of parameters to the objective function
ffn	a user-provided function to compute the objective function
trace	set >0 to provide output from fnchk to the console, 0 otherwise
...	optional arguments passed to the objective function.

**Details**

fnchk attempts to discover various errors in function setup in user-supplied functions primarily intended for use in optimization calculations. There are always more conditions that could be tested!

**Value**

The output is a list consisting of list(fval=fval, infeasible=infeasible, excode=excode, msg=msg)

fval	The calculated value of the function at parameters xpar if the function can be evaluated.
infeasible	FALSE if the function can be evaluated, TRUE if not.
excode	An exit code, which has a relationship to
msg	A text string giving information about the result of the function check: Messages and the corresponding values of excode are: <b>fnchk OK;</b> excode = 0; infeasible = FALSE <b>Function returns INADMISSIBLE;</b> excode = -1; infeasible = TRUE <b>Function returns a vector not a scalar;</b> excode = -4; infeasible = TRUE <b>Function returns a list not a scalar;</b> excode = -4; infeasible = TRUE <b>Function returns a matrix list not a scalar;</b> excode = -4; infeasible = TRUE <b>Function returns an array not a scalar;</b> excode = -4; infeasible = TRUE <b>Function returned not length 1, despite not vector, matrix or array;</b> excode = -4; infeasible = TRUE <b>Function returned non-numeric value;</b> excode = 0; excode = -1; infeasible = TRUE <b>Function returned Inf or NA (non-computable);</b> excode = -1; infeasible = TRUE

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**Examples**

```
# Want to illustrate each case.
# Ben Bolker idea for a function that is NOT scalar
# rm(list=ls())
# library(optimx)
sessionInfo()
```

```

benbad<-function(x, y){
  # y may be provided with different structures
  f<-(x-y)^2
} # very simple, but ...

y<-1:10
x<-c(1)
cat("fc01: test benbad() with y=1:10, x=c(1)\n")
fc01<-fnchk(x, benbad, trace=4, y)
print(fc01)

y<-as.vector(y)
cat("fc02: test benbad() with y=as.vector(1:10), x=c(1)\n")
fc02<-fnchk(x, benbad, trace=1, y)
print(fc02)

y<-as.matrix(y)
cat("fc03: test benbad() with y=as.matrix(1:10), x=c(1)\n")
fc03<-fnchk(x, benbad, trace=1, y)
print(fc03)

y<-as.array(y)
cat("fc04: test benbad() with y=as.array(1:10), x=c(1)\n")
fc04<-fnchk(x, benbad, trace=1, y)
print(fc04)

y<-"This is a string"
cat("test benbad() with y a string, x=c(1)\n")
fc05<-fnchk(x, benbad, trace=1, y)
print(fc05)

cat("fnchk with Rosenbrock\n")
fr <- function(x) { ## Rosenbrock Banana function
  x1 <- x[1]
  x2 <- x[2]
  100 * (x2 - x1 * x1)^2 + (1 - x1)^2
}
xtrad<-c(-1.2,1)
ros1<-fnchk(xtrad, fr, trace=1)
print(ros1)
npar<-2
opros<-list2env(list(fn=fr, gr=NULL, hess=NULL, MAXIMIZE=FALSE, PARSCALE=rep(1,npar), FNSCALE=1,
                    KFN=0, KGR=0, KHESS=0, dots=NULL))
uros1<-fnchk(xtrad, fr, trace=1)
print(uros1)

```

**Description**

gHgen is used to generate the gradient and Hessian of an objective function used for optimization. If a user-provided gradient function `gr` is available it is used to compute the gradient, otherwise package `numDeriv` is used. If a user-provided Hessian function `hess` is available, it is used to compute a Hessian. Otherwise, if `gr` is available, we use the function `jacobian()` from package `numDeriv` to compute the Hessian. In both these cases we check for symmetry of the Hessian. Computational Hessians are commonly NOT symmetric. If only the objective function `fn` is provided, then the Hessian is approximated with the function `hessian` from package `numDeriv` which guarantees a symmetric matrix.

**Usage**

```
gHgen(par, fn, gr=NULL, hess=NULL,
      control=list(ktrace=0), ...)
```

**Arguments**

<code>par</code>	Set of parameters, assumed to be at a minimum of the function <code>fn</code> .
<code>fn</code>	Name of the objective function.
<code>gr</code>	(Optional) function to compute the gradient of the objective function. If present, we use the Jacobian of the gradient as the Hessian and avoid one layer of numerical approximation to the Hessian.
<code>hess</code>	(Optional) function to compute the Hessian of the objective function. This is rarely available, but is included for completeness.
<code>control</code>	A list of controls to the function. Currently <code>asymptol</code> (default of <code>1.0e-7</code> which tests for asymmetry of Hessian approximation (see code for details of the test); <code>ktrace</code> , a logical flag which, if <code>TRUE</code> , monitors the progress of <code>gHgen</code> (default <code>FALSE</code> ), and <code>stoponerror</code> , defaulting to <code>FALSE</code> to NOT stop when there is an error or asymmetry of Hessian. Set <code>TRUE</code> to stop.
<code>...</code>	Extra data needed to compute the function, gradient and Hessian.

**Details**

None

**Value**

ansout a list of four items,

`gn` The approximation to the gradient vector.

`Hn` The approximation to the Hessian matrix.

`gradOK` `TRUE` if the gradient has been computed acceptably. `FALSE` otherwise.

`hessOK` `TRUE` if the gradient has been computed acceptably and passes the symmetry test. `FALSE` otherwise.

`nbm` Always 0. The number of active bounds and masks. Present to make function consistent with `gHgenb`.



**Examples**

```

# genrose function code
genrose.f<- function(x, gs=NULL){ # objective function
## One generalization of the Rosenbrock banana valley function (n parameters)
  n <- length(x)
  if(is.null(gs)) { gs=100.0 }
  fval<-1.0 + sum (gs*(x[1:(n-1)]^2 - x[2:n])^2 + (x[2:n] - 1)^2)
  return(fval)
}

genrose.g <- function(x, gs=NULL){
# vectorized gradient for genrose.f
# Ravi Varadhan 2009-04-03
  n <- length(x)
  if(is.null(gs)) { gs=100.0 }
  gg <- as.vector(rep(0, n))
  tn <- 2:n
  tn1 <- tn - 1
  z1 <- x[tn] - x[tn1]^2
  z2 <- 1 - x[tn]
  gg[tn] <- 2 * (gs * z1 - z2)
  gg[tn1] <- gg[tn1] - 4 * gs * x[tn1] * z1
  return(gg)
}

genrose.h <- function(x, gs=NULL) { ## compute Hessian
  if(is.null(gs)) { gs=100.0 }
  n <- length(x)
  hh<-matrix(rep(0, n*n),n,n)
  for (i in 2:n) {
    z1<-x[i]-x[i-1]*x[i-1]
    # z2<-1.0-x[i]
    hh[i,i]<-hh[i,i]+2.0*(gs+1.0)
    hh[i-1,i-1]<-hh[i-1,i-1]-4.0*gs*z1-4.0*gs*x[i-1]*(-2.0*x[i-1])
    hh[i,i-1]<-hh[i,i-1]-4.0*gs*x[i-1]
    hh[i-1,i]<-hh[i-1,i]-4.0*gs*x[i-1]
  }
  return(hh)
}

trad<-c(-1.2,1)
ans100fgh<- gHgen(trad, genrose.f, gr=genrose.g, hess=genrose.h,
  control=list(ktrace=1))
print(ans100fgh)
ans100fg<- gHgen(trad, genrose.f, gr=genrose.g,
  control=list(ktrace=1))
print(ans100fg)
ans100f<- gHgen(trad, genrose.f, control=list(ktrace=1))
print(ans100f)
ans10fgh<- gHgen(trad, genrose.f, gr=genrose.g, hess=genrose.h,
  control=list(ktrace=1), gs=10)
print(ans10fgh)

```

```
ans10fg<- gHgen(trad, genrose.f, gr=genrose.g,
               control=list(ktrace=1), gs=10)
print(ans10fg)
ans10f<- gHgen(trad, genrose.f, control=list(ktrace=1), gs=10)
print(ans10f)
```

---

gHgenb

*Generate gradient and Hessian for a function at given parameters.*


---

### Description

gHgenb is used to generate the gradient and Hessian of an objective function used for optimization. If a user-provided gradient function `gr` is available it is used to compute the gradient, otherwise package `numDeriv` is used. If a user-provided Hessian function `hess` is available, it is used to compute a Hessian. Otherwise, if `gr` is available, we use the function `jacobian()` from package `numDeriv` to compute the Hessian. In both these cases we check for symmetry of the Hessian. Computational Hessians are commonly NOT symmetric. If only the objective function `fn` is provided, then the Hessian is approximated with the function `hessian` from package `numDeriv` which guarantees a symmetric matrix.

### Usage

```
gHgenb(par, fn, gr=NULL, hess=NULL, bdmsk=NULL, lower=NULL, upper=NULL,
       control=list(ktrace=0), ...)
```

### Arguments

<code>par</code>	Set of parameters, assumed to be at a minimum of the function <code>fn</code> .
<code>fn</code>	Name of the objective function.
<code>gr</code>	(Optional) function to compute the gradient of the objective function. If present, we use the Jacobian of the gradient as the Hessian and avoid one layer of numerical approximation to the Hessian.
<code>hess</code>	(Optional) function to compute the Hessian of the objective function. This is rarely available, but is included for completeness.
<code>bdmsk</code>	An integer vector of the same length as <code>par</code> . When an element of this vector is 0, the corresponding parameter value is fixed (masked) during an optimization. Non-zero values indicate a parameter is free (1), at a lower bound (-3) or at an upper bound (-1), but this routine only uses 0 values.
<code>lower</code>	Lower bounds for parameters in <code>par</code> .
<code>upper</code>	Upper bounds for parameters in <code>par</code> .
<code>control</code>	A list of controls to the function. Currently <code>asymptol</code> (default of 1.0e-7 which tests for asymmetry of Hessian approximation (see code for details of the test); <code>ktrace</code> , a logical flag which, if TRUE, monitors the progress of <code>gHgenb</code> (default FALSE), and <code>stoponerror</code> , defaulting to FALSE to NOT stop when there is an error or asymmetry of Hessian. Set TRUE to stop.
<code>...</code>	Extra data needed to compute the function, gradient and Hessian.

**Details**

None

**Value**

ansout a list of four items,

gn The approximation to the gradient vector.

Hn The approximation to the Hessian matrix.

gradOK TRUE if the gradient has been computed acceptably. FALSE otherwise.

hessOK TRUE if the gradient has been computed acceptably and passes the symmetry test. FALSE otherwise.

nbm The number of active bounds and masks.

**Examples**

```
require(numDeriv)
# genrose function code
genrose.f<- function(x, gs=NULL){ # objective function
## One generalization of the Rosenbrock banana valley function (n parameters)
  n <- length(x)
  if(is.null(gs)) { gs=100.0 }
  fval<-1.0 + sum (gs*(x[1:(n-1)]^2 - x[2:n])^2 + (x[2:n] - 1)^2)
  return(fval)
}

genrose.g <- function(x, gs=NULL){
# vectorized gradient for genrose.f
# Ravi Varadhan 2009-04-03
  n <- length(x)
  if(is.null(gs)) { gs=100.0 }
  gg <- as.vector(rep(0, n))
  tn <- 2:n
  tn1 <- tn - 1
  z1 <- x[tn] - x[tn1]^2
  z2 <- 1 - x[tn]
  gg[tn] <- 2 * (gs * z1 - z2)
  gg[tn1] <- gg[tn1] - 4 * gs * x[tn1] * z1
  return(gg)
}

genrose.h <- function(x, gs=NULL) { ## compute Hessian
  if(is.null(gs)) { gs=100.0 }
  n <- length(x)
  hh<-matrix(rep(0, n*n),n,n)
  for (i in 2:n) {
    z1<-x[i]-x[i-1]*x[i-1]
    z2<-1.0-x[i]
    hh[i,i]<-hh[i,i]+2.0*(gs+1.0)
    hh[i-1,i-1]<-hh[i-1,i-1]-4.0*gs*z1-4.0*gs*x[i-1]*(-2.0*x[i-1])
  }
}
```

```

        hh[i,i-1]<-hh[i,i-1]-4.0*gs*x[i-1]
        hh[i-1,i]<-hh[i-1,i]-4.0*gs*x[i-1]
    }
    return(hh)
}

maxfn<-function(x, top=10) {
    n<-length(x)
    ss<-seq(1,n)
    f<-top-(crossprod(x-ss))^2
    f<-as.numeric(f)
    return(f)
}

negmaxfn<-function(x) {
    f<-(-1)*maxfn(x)
    return(f)
}

parx<-rep(1,4)
lower<-rep(-10,4)
upper<-rep(10,4)
bdmsk<-c(1,1,0,1) # masked parameter 3
fval<-genrose.f(parx)
gval<-genrose.g(parx)
Ahess<-genrose.h(parx)
gennog<-gHgenb(parx,genrose.f)
cat("results of gHgenb for genrose without gradient code at ")
print(parx)
print(gennog)
cat("compare to g =")
print(gval)
cat("and Hess\n")
print(Ahess)
cat("\n\n")
geng<-gHgenb(parx,genrose.f,genrose.g)
cat("results of gHgenb for genrose at ")
print(parx)
print(gennog)
cat("compare to g =")
print(gval)
cat("and Hess\n")
print(Ahess)
cat("*****\n")
parx<-rep(0.9,4)
fval<-genrose.f(parx)
gval<-genrose.g(parx)
Ahess<-genrose.h(parx)
gennog<-gHgenb(parx,genrose.f,control=list(ktrace=TRUE), gs=9.4)
cat("results of gHgenb with gs=",9.4," for genrose without gradient code at ")
print(parx)
print(gennog)

```

```

cat("compare to g =")
print(gval)
cat("and Hess\n")
print(Ahess)
cat("\n\n")
geng<-gHgenb(parx,genrose.f,genrose.g, control=list(ktrace=TRUE))
cat("results of gHgenb for genrose at ")
print(parx)
print(gennog)
cat("compare to g =")
print(gval)
cat("and Hess\n")
print(Ahess)
gst<-5
cat("\n\nTest with full calling sequence and gs=",gst,"\n")
gengall<-gHgenb(parx,genrose.f,genrose.g,genrose.h, control=list(ktrace=TRUE),gs=gst)
print(gengall)

top<-25
x0<-rep(2,4)
cat("\n\nTest for maximization and top=",top,"\n")
cat("Gradient and Hessian will have sign inverted")
maxt<-gHgen(x0, maxfn, control=list(ktrace=TRUE), top=top)
print(maxt)

cat("test against negmaxfn\n")
gneg <- grad(negmaxfn, x0)
Hneg<-hessian(negmaxfn, x0)
# gdiff<-max(abs(gneg-maxt$gn))/max(abs(maxt$gn))
# Hdiff<-max(abs(Hneg-maxt$Hn))/max(abs(maxt$Hn))
# explicitly change sign
gdiff<-max(abs(gneg-(-1)*maxt$gn))/max(abs(maxt$gn))
Hdiff<-max(abs(Hneg-(-1)*maxt$Hn))/max(abs(maxt$Hn))
cat("gdiff = ",gdiff," Hdiff=",Hdiff,"\n")

```

---

grback

*Backward difference numerical gradient approximation.*


---

### Description

grback computes the backward difference approximation to the gradient of user function userfn.

### Usage

```
grback(par, userfn, fbase=NULL, env=optsp, ...)
```

**Arguments**

par	parameters to the user objective function userfn
userfn	User-supplied objective function
fbase	The value of the function at the parameters, else NULL. This is to save recomputing the function at this point.
env	Environment for scratchpad items (like deps for approximation control in this routine). Default optsp.
...	optional arguments passed to the objective function.

**Details**

Package: grback  
 Depends: R (>= 2.6.1)  
 License: GPL Version 2.

**Value**

grback returns a single vector object `df` which approximates the gradient of `userfn` at the parameters `par`. The approximation is controlled by a global value `optderi veps` that is set when the package is attached.

**Author(s)**

John C. Nash

**Examples**

```
cat("Example of use of grback\n")

myfn<-function(xx, shift=100){
  ii<-1:length(xx)
  result<-shift+sum(xx^ii)
}

xx<-c(1,2,3,4)
ii<-1:length(xx)
print(xx)
gn<-grback(xx,myfn, shift=0)
print(gn)
ga<-ii*xx^(ii-1)
cat("compare to analytic gradient:\n")
print(ga)

cat("change the step parameter to 1e-4\n")
optsp$deps <- 1e-4
```

```
gn2<-grback(xx,myfn, shift=0)
print(gn2)
```

---

**grcentral***Central difference numerical gradient approximation.*

---

**Description**

grcentral computes the central difference approximation to the gradient of user function userfn.

**Usage**

```
grcentral(par, userfn, fbase=NULL, env=optsp, ...)
```

**Arguments**

par	parameters to the user objective function userfn
userfn	User-supplied objective function
fbase	The value of the function at the parameters, else NULL. This is to save recomputing the function at this point.
env	Environment for scratchpad items (like deps for approximation control in this routine). Default optsp.
...	optional arguments passed to the objective function.

**Details**

Package: grcentral  
Depends: R (>= 2.6.1)  
License: GPL Version 2.

**Value**

grcentral returns a single vector object df which approximates the gradient of userfn at the parameters par. The approximation is controlled by a global value optderivps that is set when the package is attached.

**Author(s)**

John C. Nash

**Examples**

```

cat("Example of use of grcentral\n")

myfn<-function(xx, shift=100){
  ii<-1:length(xx)
  result<-shift+sum(xx^ii)
}
xx<-c(1,2,3,4)
ii<-1:length(xx)
print(xx)
gn<-grcentral(xx,myfn, shift=0)
print(gn)
ga<-ii*xx^(ii-1)
cat("compare to\n")
print(ga)

```

---

grchk	<i>Run tests, where possible, on user objective function and (optionally) gradient and hessian</i>
-------	--

---

**Description**

grchk checks a user-provided R function, ffn.

**Usage**

```
grchk(xpar, ffn, ggr, trace=0, testtol=(.Machine$double.eps)^(1/3), ...)
```

**Arguments**

xpar	parameters to the user objective and gradient functions ffn and ggr
ffn	User-supplied objective function
ggr	User-supplied gradient function
trace	set >0 to provide output from grchk to the console, 0 otherwise
testtol	tolerance for equality tests
...	optional arguments passed to the objective function.

**Details**

Package:	grchk
Depends:	R (>= 2.6.1)
License:	GPL Version 2.

numDeriv is used to numerically approximate the gradient of function ffn and compare this to the result of function ggr.



**Value**

grchk returns a single object gradOK which is TRUE if the differences between analytic and approximated gradient are small as measured by the tolerance testtol.

This has attributes "ga" and "gn" for the analytic and numerically approximated gradients, and "maxdiff" for the maximum absolute difference between these vectors.

At the time of preparation, there are no checks for validity of the gradient code in ggr as in the function fnchk.

**Author(s)**

John C. Nash

**Examples**

```
# Would like examples of success and failure. What about "near misses"?
cat("Show how grchk works\n")
require(numDeriv)
# require(optimx)

jones<-function(xx){
  x<-xx[1]
  y<-xx[2]
  ff<-sin(x*x/2 - y*y/4)*cos(2*x-exp(y))
  ff<- -ff
}

jonesg <- function(xx) {
  x<-xx[1]
  y<-xx[2]
  gx <- cos(x * x/2 - y * y/4) * ((x + x)/2) * cos(2 * x - exp(y)) -
    sin(x * x/2 - y * y/4) * (sin(2 * x - exp(y)) * 2)
  gy <- sin(x * x/2 - y * y/4) * (sin(2 * x - exp(y)) * exp(y)) - cos(x *
    x/2 - y * y/4) * ((y + y)/4) * cos(2 * x - exp(y))
  gg <- - c(gx, gy)
}

jonesg2 <- function(xx) {
  gx <- 1
  gy <- 2
  gg <- - c(gx, gy)
}

xx <- c(1, 2)

gcans <- grchk(xx, jones, jonesg, trace=1, testtol=(.Machine$double.eps)^(1/3))
gcans

gcans2 <- grchk(xx, jones, jonesg2, trace=1, testtol=(.Machine$double.eps)^(1/3))
gcans2
```

---

`grfwd`*Forward difference numerical gradient approximation.*

---

**Description**

`grfwd` computes the forward difference approximation to the gradient of user function `userfn`.

**Usage**

```
grfwd(par, userfn, fbase=NULL, env=optsp, ...)
```

**Arguments**

<code>par</code>	parameters to the user objective function <code>userfn</code>
<code>userfn</code>	User-supplied objective function
<code>fbase</code>	The value of the function at the parameters, else <code>NULL</code> . This is to save recomputing the function at this point.
<code>env</code>	Environment for scratchpad items (like <code>deps</code> for approximation control in this routine). Default <code>optsp</code> .
<code>...</code>	optional arguments passed to the objective function.

**Details**

Package: `grfwd`  
Depends: `R (>= 2.6.1)`  
License: `GPL Version 2.`

**Value**

`grfwd` returns a single vector object `df` which approximates the gradient of `userfn` at the parameters `par`. The approximation is controlled by a global value `optderiveps` that is set when the package is attached.

**Author(s)**

John C. Nash

**Examples**

```
cat("Example of use of grfwd\n")

myfn<-function(xx, shift=100){
  ii<-1:length(xx)
  result<-shift+sum(xx^ii)
}
xx<-c(1,2,3,4)
ii<-1:length(xx)
print(xx)
gn<-grfwd(xx,myfn, shift=0)
print(gn)
ga<-ii*xx^(ii-1)
cat("compare to\n")
print(ga)
```

---

grnd

*A reorganization of the call to numDeriv grad() function.*

---

**Description**

Provides a wrapper for the numDeriv approximation to the gradient of a user supplied objective function userfn.

**Usage**

```
grnd(par, userfn, ...)
```

**Arguments**

par	A vector of parameters to the user-supplied function fn
userfn	A user-supplied function
...	Other data needed to evaluate the user function.

**Details**

The Richardson method is used in this routine.

**Value**

grnd returns an approximation to the gradient of the function userfn

## Examples

```
cat("Example of use of grnd\n")
require(numDeriv)
myfn<-function(xx, shift=100){
  ii<-1:length(xx)
  result<-shift+sum(xx^ii)
}
xx<-c(1,2,3,4)
ii<-1:length(xx)
print(xx)
gn<-grnd(xx,myfn, shift=0)
print(gn)
ga<-ii*xx^(ii-1)
cat("compare to\n")
print(ga)
```

---

grpracma

*A reorganization of the call to numDeriv grad() function.*

---

## Description

Provides a wrapper for the numDeriv approximation to the gradient of a user supplied objective function userfn.

## Usage

```
grpracma(par, userfn, ...)
```

## Arguments

par	A vector of parameters to the user-supplied function fn
userfn	A user-supplied function
...	Other data needed to evaluate the user function.

## Details

The Richardson method is used in this routine.

## Value

grpracma returns an approximation to the gradient of the function userfn

**Examples**

```

cat("Example of use of grpracma\n")
require(numDeriv)
myfn<-function(xx, shift=100){
  ii<-1:length(xx)
  result<-shift+sum(xx^ii)
}
xx<-c(1,2,3,4)
ii<-1:length(xx)
print(xx)
gn<-grpracma(xx,myfn, shift=0)
print(gn)
ga<-ii*xx^(ii-1)
cat("compare to\n")
print(ga)

```

---

hesschk	<i>Run tests, where possible, on user objective function and (optionally) gradient and hessian</i>
---------	--

---

**Description**

hesschk checks a user-provided R function, ffn.

**Usage**

```
hesschk(xpar, ffn, ggr, hhess, trace=0, testtol=(.Machine$double.eps)^(1/3), ...)
```

**Arguments**

xpar	parameters to the user objective and gradient functions ffn and ggr
ffn	User-supplied objective function
ggr	User-supplied gradient function
hhess	User-supplied Hessian function
trace	set >0 to provide output from hesschk to the console, 0 otherwise
testtol	tolerance for equality tests
...	optional arguments passed to the objective function.

**Details**

Package:	hesschk
Depends:	R (>= 2.6.1)
License:	GPL Version 2.

numDeriv is used to compute a numerical approximation to the Hessian matrix. If there is no analytic gradient, then the hessian() function from numDeriv is applied to the user function ffn. Otherwise, the jacobian() function of numDeriv is applied to the ggr function so that only one level of differencing is used.

### Value

The function returns a single object hessOK which is TRUE if the analytic Hessian code returns a Hessian matrix that is "close" to the numerical approximation obtained via numDeriv; FALSE otherwise.

hessOK is returned with the following attributes:

**"nullhess"** Set TRUE if the user does not supply a function to compute the Hessian.

**"asym"** Set TRUE if the Hessian does not satisfy symmetry conditions to within a tolerance. See the hesschk for details.

**"ha"** The analytic Hessian computed at paramters xpar using h Hess.

**"hn"** The numerical approximation to the Hessian computed at paramters xpar.

**"msg"** A text comment on the outcome of the tests.

### Author(s)

John C. Nash

### Examples

```
# genrose function code
genrose.f<- function(x, gs=NULL){ # objective function
## One generalization of the Rosenbrock banana valley function (n parameters)
  n <- length(x)
  if(is.null(gs)) { gs=100.0 }
  fval<-1.0 + sum (gs*(x[1:(n-1)]^2 - x[2:n])^2 + (x[2:n] - 1)^2)
  return(fval)
}

genrose.g <- function(x, gs=NULL){
# vectorized gradient for genrose.f
# Ravi Varadhan 2009-04-03
  n <- length(x)
  if(is.null(gs)) { gs=100.0 }
  gg <- as.vector(rep(0, n))
  tn <- 2:n
  tn1 <- tn - 1
  z1 <- x[tn] - x[tn1]^2
  z2 <- 1 - x[tn]
  gg[tn] <- 2 * (gs * z1 - z2)
  gg[tn1] <- gg[tn1] - 4 * gs * x[tn1] * z1
  return(gg)
}

genrose.h <- function(x, gs=NULL) { ## compute Hessian
```

```

    if(is.null(gs)) { gs=100.0 }
    n <- length(x)
    hh<-matrix(rep(0, n*n),n,n)
    for (i in 2:n) {
      z1<-x[i]-x[i-1]*x[i-1]
      # z2<-1.0-x[i]
      hh[i,i]<-hh[i,i]+2.0*(gs+1.0)
      hh[i-1,i-1]<-hh[i-1,i-1]-4.0*gs*z1-4.0*gs*x[i-1]*(-2.0*x[i-1])
      hh[i,i-1]<-hh[i,i-1]-4.0*gs*x[i-1]
      hh[i-1,i]<-hh[i-1,i]-4.0*gs*x[i-1]
    }
    return(hh)
  }

trad<-c(-1.2,1)
ans100<-hesschk(trad, genrose.f, genrose.g, genrose.h, trace=1)
print(ans100)
ans10<-hesschk(trad, genrose.f, genrose.g, genrose.h, trace=1, gs=10)
print(ans10)

```

hjn

*Compact R Implementation of Hooke and Jeeves Pattern Search Optimization*

## Description

The purpose of hjn is to minimize an unconstrained or bounds (box) and mask constrained function of several parameters by a Hooke and Jeeves pattern search. This didactic code is entirely in R to allow users to explore and understand the method. It also allows bounds (or box) constraints and masks (equality constraints) to be imposed on parameters.

## Usage

```
hjn(par, fn, lower=-Inf, upper=Inf, bdmk=NULL, control = list(trace=0), ...)
```

## Arguments

par	A numeric vector of starting estimates.
fn	A function that returns the value of the objective at the supplied set of parameters par using auxiliary data in .... The first argument of fn must be par.
lower	A vector of lower bounds on the parameters.
upper	A vector of upper bounds on the parameters.
bdmsk	An indicator vector, having 1 for each parameter that is "free" or unconstrained, and 0 for any parameter that is fixed or MASKED for the duration of the optimization.
control	An optional list of control settings.
...	Further arguments to be passed to fn.

## Details

Functions `fn` must return a numeric value.

The control argument is a list.

**maxfeval** A limit on the number of function evaluations used in the search.

**trace** Set 0 (default) for no output, >0 for trace output (larger values imply more output).

**eps** Tolerance used to calculate numerical gradients. Default is 1.0E-7. See source code for `hjn` for details of application.

`dowarn = TRUE` if we want warnings generated by `optimx`. Default is `TRUE`.

`tol` Tolerance used in testing the size of the pattern search step.

Note that the control `maximize` should NOT be used.

## Value

A list with components:

<code>par</code>	The best set of parameters found.
<code>value</code>	The value of the objective at the best set of parameters found.
<code>counts</code>	A two-element integer vector giving the number of calls to <code>'fn'</code> and <code>'gr'</code> respectively. This excludes those calls needed to compute the Hessian, if requested, and any calls to <code>'fn'</code> to compute a finite-difference approximation to the gradient.
<code>convergence</code>	An integer code. <code>'0'</code> indicates successful convergence. <code>'1'</code> indicates that the function evaluation count <code>'maxfeval'</code> was reached.
<code>message</code>	A character string giving any additional information returned by the optimizer, or <code>'NULL'</code> .

## References

Nash JC (1979). Compact Numerical Methods for Computers: Linear Algebra and Function Minimisation. Adam Hilger, Bristol. Second Edition, 1990, Bristol: Institute of Physics Publications.

## See Also

[optim](#)

## Examples

```
#####
## Rosenbrock Banana function
fr <- function(x) {
  x1 <- x[1]
  x2 <- x[2]
  100 * (x2 - x1 * x1)^2 + (1 - x1)^2
}

ansrosenbrock0 <- hjn(fn=fr, par=c(1,2), control=list(maxfeval=2000, trace=0))
print(ansrosenbrock0) # use print to allow copy to separate file that
```



```

# can be called using source()
#####
genrose.f<- function(x, gs=NULL){ # objective function
## One generalization of the Rosenbrock banana valley function (n parameters)
  n <- length(x)
  if(is.null(gs)) { gs=100.0 }
  fval<-1.0 + sum (gs*(x[1:(n-1)]^2 - x[2:n])^2 + (x[2:n] - 1)^2)
  return(fval)
}

xx<-rep(pi,10)
lower<-NULL
upper<-NULL
bdmsk<-NULL

cat("timings B vs U\n")
lo<-rep(-100,10)
up<-rep(100,10)
bdmsk<-rep(1,10)
tb<-system.time(ab<-hjn(xx,genrose.f, lower=lo, upper=up,
  bdmsk=bdmsk, control=list(trace=0, maxfeval=2000)))[1]
tu<-system.time(au<-hjn(xx,genrose.f, control=list(maxfeval=2000, trace=0)))[1]
cat("times U=",tu," B=",tb,"\n")
cat("solution hjnu\n")
print(au)
cat("solution hjnb\n")
print(ab)
cat("diff fu-fb=",au$value-ab$value,"\n")
cat("max abs parameter diff = ", max(abs(au$par-ab$par)),"\n")

##### One dimension test
sqtst<-function(xx) {
  res<-sum((xx-2)*(xx-2))
}

nn<-1
startx<-rep(0,nn)
onepar<-hjn(startx,sqtst,control=list(trace=1))
print(onepar)

```

---

kktchk

---

*Check Kuhn Karush Tucker conditions for a supposed function minimum*


---

### Description

Provide a check on Kuhn-Karush-Tucker conditions based on quantities already computed. Some of these used only for reporting.

**Usage**

```
kktchk(par, fn, gr, hess=NULL, upper=NULL, lower=NULL,
       maximize=FALSE, control=list(dowarn=TRUE), ...)
```

**Arguments**

par	A vector of values for the parameters which are supposedly optimal.
fn	The objective function
gr	The gradient function
hess	The Hessian function
upper	Upper bounds on the parameters
lower	Lower bounds on the parameters
maximize	Logical TRUE if function is being maximized. Default FALSE.
control	A list of controls for the function
...	The dot arguments needed for evaluating the function and gradient and hessian

**Details**

kktchk computes the gradient and Hessian measures for BOTH unconstrained and bounds (and masks) constrained parameters, but the kkt measures are evaluated only for the constrained case.

Note that evaluated Hessians are often not symmetric, and many, possibly most, examples will fail the `is.Symmetric()` function. In such cases, the check on the Hessian uses the mean of the Hessian and its transpose.

**Value**

The output is a list consisting of

gmax	The absolute value of the largest gradient component in magnitude.
evratio	The ratio of the smallest to largest Hessian eigenvalue. Note that this may be negative.
kkt1	A logical value that is TRUE if we consider the first (i.e., gradient) KKT condition to be satisfied. <b>WARNING:</b> The decision is dependent on tolerances and scaling that may be inappropriate for some problems.
kkt2	A logical value that is TRUE if we consider the second (i.e., positive definite Hessian) KKT condition to be satisfied. <b>WARNING:</b> The decision is dependent on tolerances and scaling that may be inappropriate for some problems.
hev	The calculated hessian eigenvalues, sorted largest to smallest. Sorting is a property of the <code>eigen()</code> function.
ngatend	The computed (unconstrained) gradient at the solution parameters.
nmatend	The computed (unconstrained) hessian at the solution parameters.

**See Also**

[optim](#)

**Examples**

```

cat("Show how kktc works\n")

# require(optimx)

jones<-function(xx){
  x<-xx[1]
  y<-xx[2]
  ff<-sin(x*x/2 - y*y/4)*cos(2*x-exp(y))
  ff<- -ff
}

jonesg <- function(xx) {
  x<-xx[1]
  y<-xx[2]
  gx <- cos(x * x/2 - y * y/4) * ((x + x)/2) * cos(2 * x - exp(y)) -
    sin(x * x/2 - y * y/4) * (sin(2 * x - exp(y)) * 2)
  gy <- sin(x * x/2 - y * y/4) * (sin(2 * x - exp(y)) * exp(y)) - cos(x *
    x/2 - y * y/4) * ((y + y)/4) * cos(2 * x - exp(y))
  gg <- - c(gx, gy)
}

ans <- list() # to ensure structure available
# If optimx package available, the following can be run.
# xx<-0.5*c(pi,pi)
# ans <- optimr(xx, jones, jonesg, method="Rvmmin")
# ans

ans$par <- c(3.154083, -3.689620)

# 2023-8-23 need dowarn specified or get error
# Note: may want to set control=list(dowarn=TRUE)
kkans <- kktchk(ans$par, jones, jonesg)
kkans

```

---

multistart

*General-purpose optimization - multiple starts*


---

**Description**

Multiple initial parameter wrapper function that calls other R tools for optimization, including the existing `optimr()` function.

**Usage**

```
multistart(parmat, fn, gr=NULL, lower=-Inf, upper=Inf,
```

```
method=NULL, hessian=FALSE,
control=list(),
...)
```

### Arguments

parmat	a matrix of which each row is a set of initial values for the parameters for which optimal values are to be found. Names on the elements of this vector are preserved and used in the results data frame.
fn	A function to be minimized (or maximized), with first argument the vector of parameters over which minimization is to take place. It should return a scalar result.
gr	A function to return (as a vector) the gradient for those methods that can use this information. If 'gr' is NULL, a finite-difference approximation will be used. An open question concerns whether the SAME approximation code used for all methods, or whether there are differences that could/should be examined?
lower, upper	Bounds on the variables for methods such as "L-BFGS-B" that can handle box (or bounds) constraints.
method	A character string giving the name of the optimization method to be applied. See the list allmeth in file ctrldefault.R which is part of this package.
hessian	A logical control that if TRUE forces the computation of an approximation to the Hessian at the final set of parameters. If FALSE (default), the hessian is calculated if needed to provide the KKT optimality tests (see kkt in 'Details' for the control list). This setting is provided primarily for compatibility with optim().
control	A list of control parameters. See 'Details'.
...	For optimx further arguments to be passed to fn and gr; otherwise, further arguments are not used.

### Details

Note that arguments after ... must be matched exactly.

See optimr() for other details.

### Value

An array with one row per set of starting parameters. Each row contains:

par	The best set of parameters found.
value	The value of 'fn' corresponding to 'par'.
counts	A two-element integer vector giving the number of calls to 'fn' and 'gr' respectively. This excludes those calls needed to compute the Hessian, if requested, and any calls to 'fn' to compute a finite-difference approximation to the gradient.
convergence	An integer code. '0' indicates successful completion

message	A character string giving any additional information returned by the optimizer, or 'NULL'.
hessian	Always NULL for this routine.

### Source

See the manual pages for `optim()` and the packages the DESCRIPTION suggests.

### Examples

```
fnR <- function (x, gs=100.0)
{
  n <- length(x)
  x1 <- x[2:n]
  x2 <- x[1:(n - 1)]
  sum(gs * (x1 - x2^2)^2 + (1 - x2)^2)
}
grR <- function (x, gs=100.0)
{
  n <- length(x)
  g <- rep(NA, n)
  g[1] <- 2 * (x[1] - 1) + 4*gs * x[1] * (x[1]^2 - x[2])
  if (n > 2) {
    ii <- 2:(n - 1)
    g[ii] <- 2 * (x[ii] - 1) + 4 * gs * x[ii] * (x[ii]^2 - x[ii +
      1]) + 2 * gs * (x[ii] - x[ii - 1])^2)
  }
  g[n] <- 2 * gs * (x[n] - x[n - 1]^2)
  g
}

pm <- rbind(rep(1,4), rep(pi, 4), rep(-2,4), rep(0,4), rep(20,4))
pm <- as.matrix(pm)
cat("multistart matrix:\n")
print(pm)

ans <- multistart(pm, fnR, grR, method="Rvmin", control=list(trace=0))
ans
```

### Description

General-purpose optimization wrapper function that calls multiple other R tools for optimization, including the existing `optim()` function tools.

Because SANN does not return a meaningful convergence code (`conv`), `opm()` does not call the SANN method, but it can be invoked in `optimr()`.

There is a pseudo-method "ALL" that runs all available methods. Note that this is upper-case. This function is a replacement for `optimx()` from the `optimx` package. `opm()` calls the `optimr()` function for each solver in the method list.

### Usage

```
opm(par, fn, gr=NULL, hess=NULL, lower=-Inf, upper=Inf,
    method=c("Nelder-Mead", "BFGS"), hessian=FALSE,
    control=list(),
    ...)
```

### Arguments

<code>par</code>	a vector of initial values for the parameters for which optimal values are to be found. Names on the elements of this vector are preserved and used in the results data frame.
<code>fn</code>	A function to be minimized (or maximized), with a first argument the vector of parameters over which minimization is to take place. It should return a scalar result.
<code>gr</code>	A function to return (as a vector) the gradient for those methods that can use this information. If 'gr' is NULL, whatever default actions are supplied by the methods specified will be used. However, some methods REQUIRE a gradient function, so will fail in this case. <code>opm()</code> will generally return with convergence set to 9998 for such methods. If 'gr' is a character string, this character string will be taken to be the name of an available gradient approximation function. Examples are "grfwd", "grback", "grcentral" and "grnd", with the last name referring to the default method of package <code>numDeriv</code> .
<code>hess</code>	A function to return (as a symmetric matrix) the Hessian of the objective function for those methods that can use this information.
<code>lower, upper</code>	Bounds on the variables for methods such as "L-BFGS-B" that can handle box (or bounds) constraints. These are vectors.
<code>method</code>	A vector of the methods to be used, each as a character string. Note that this is an important change from <code>optim()</code> that allows just one method to be specified. See 'Details'. If <code>method</code> has just one element, "ALL" (capitalized), all available and appropriate methods will be tried.
<code>hessian</code>	A logical control that if TRUE forces the computation of an approximation to the Hessian at the final set of parameters. If FALSE (default), the hessian is calculated if needed to provide the KKT optimality tests (see <code>kkt</code> in 'Details' for the control list). This setting is provided primarily for compatibility with <code>optim()</code> .
<code>control</code>	A list of control parameters. See 'Details'. There is a spreadsheet <code>/inst/doc/optcontrol.xls</code> that is an ongoing attempt to document the different controls used in the various methods.
<code>...</code>	For <code>optimx</code> further arguments to be passed to <code>fn</code> and <code>gr</code> ; otherwise, further arguments are not used.

## Details

Note that arguments after `...` must be matched exactly.

For details of how `opm()` calls the methods, see the documentation and code for `optimr()`. The documentation and code for individual methods may also be useful. Note that some simplification of the calls may have been necessary, for example, to provide reasonable default values for method controls that are consistent across several methods, though this is not always possible to guarantee. The documentation for `optimr` and the source code of the quite simple routine `ctrldefault.R` may be useful.

Some of the commonly useful elements of the control list are:

- `trace` Non-negative integer. If positive, tracing information on the progress of the optimization is produced. Higher values may produce more tracing information: for method "L-BFGS-B" there are six levels of tracing, `trace = 0` gives no output (To understand exactly what these do see the source code: higher levels give more detail.)
- `maxfeval` For methods that can use this control, a limit on the number of function evaluations. This control is simply passed through. It is not checked by `opm`.
- `maxit` For methods that can use this control, a limit on the number of gradient evaluations or major iterations.
- `fnscale` An overall scaling to be applied to the value of `fn` and `gr` during optimization. If negative, turns the problem into a maximization problem. Optimization is performed on `fn(par)/fnscale`. For methods from the set in `optim()`. Note potential conflicts with the control `maximize`.
- `parscale` A vector of scaling values for the parameters. Optimization is performed on `par/parscale` and these should be comparable in the sense that a unit change in any element produces about a unit change in the scaled value. For `optim`.
- `save.failures = TRUE` (default) if we wish to keep "answers" from runs where the method does not return `convergence==0`. `FALSE` otherwise.
- `maximize = TRUE` if we want to maximize rather than minimize a function. (Default `FALSE`). Methods `nlm`, `nlminb`, `ucminf` cannot maximize a function, so the user must explicitly minimize and carry out the adjustment externally. However, there is a check to avoid usage of these codes when `maximize` is `TRUE`. See `fnscale` below for the method used in `optim` that we deprecate.
- `all.methods = TRUE` if we want to use all available (and suitable) methods. This is equivalent to setting `method="ALL"`
- `kkt = FALSE` if we do NOT want to test the Kuhn, Karush, Tucker optimality conditions. The default is generally `TRUE`. However, because the Hessian computation may be very slow, we set `kkt` to be `FALSE` if there are more than 50 parameters when the gradient function `gr` is not provided, and more than 500 parameters when such a function is specified. We return logical values `KKT1` and `KKT2` `TRUE` if first and second order conditions are satisfied approximately. Note, however, that the tests are sensitive to scaling, and users may need to perform additional verification. If `hessian` is `TRUE`, this overrides control `kkt`.
- `all.methods = TRUE` if we want to use all available (and suitable) methods.
- `kkttol = value` to use to check for small gradient and negative Hessian eigenvalues. Default = `.Machine$double.eps^(1/3)`
- `kkt2tol = Tolerance` for eigenvalue ratio in KKT test of positive definite Hessian. Default same as for `kkttol`

`dowarn = FALSE` if we want to suppress warnings generated by `opm()` or `optimr()`. Default is `TRUE`.

`badval` = The value to set for the function value when `try(fn())` fails. The value is then a signal of failure when execution continues with other methods. It may also, in non-standard usage, be helpful in heuristic search methods like "Nelder-Mead" to avoid parameter regions that are unwanted or inadmissible. It is inappropriate for gradient methods. Default is  $(0.5) * \text{Machine}\$double.xmax$

There may be control elements that apply only to some of the methods. Using these may or may not "work" with `opm()`, and errors may occur with methods for which the controls have no meaning. However, it should be possible to call the underlying `optimr()` function with these method-specific controls.

Any names given to `par` will be copied to the vectors passed to `fn` and `gr`. Note that no other attributes of `par` are copied over. (We have not verified this as at 2009-07-29.)

## Value

If there are `npar` parameters, then the result is a dataframe having one row for each method for which results are reported, using the method as the row name, with columns

`par_1`, ..., `par_npar`, `value`, `fevals`, `gevals`, `niter`, `convergence`, `kkt1`, `kkt2`, `xtimes` where

**par\_1 ..**

**par\_npar** The best set of parameters found.

**value** The value of `fn` corresponding to `par`.

**fevals** The number of calls to `fn`. NOT reported for method `lbfgs`.

**gevals** The number of calls to `gr`. This excludes those calls needed to compute the Hessian, if requested, and any calls to `fn` to compute a finite-difference approximation to the gradient. NOT reported for method `lbfgs`.

**convergence** An integer code. 0 indicates successful convergence. Various methods may or may not return sufficient information to allow all the codes to be specified. An incomplete list of codes includes

1 indicates that the iteration limit `maxit` had been reached.

20 indicates that the initial set of parameters is inadmissible, that is, that the function cannot be computed or returns an infinite, `NULL`, or `NA` value.

21 indicates that an intermediate set of parameters is inadmissible.

10 indicates degeneracy of the Nelder-Mead simplex.

51 indicates a warning from the "L-BFGS-B" method; see component message for further details.

52 indicates an error from the "L-BFGS-B" method; see component message for further details.

9998 indicates that the method has been called with a `NULL` 'gr' function, and the method requires that such a function be supplied.

9999 indicates the method has failed.

**kkt1** A logical value returned `TRUE` if the solution reported has a "small" gradient.



**kkt2** A logical value returned TRUE if the solution reported appears to have a positive-definite Hessian.

**xtimes** The reported execution time of the calculations for the particular method.

The attribute "details" to the returned answer object contains information, if computed, on the gradient (ngatend) and Hessian matrix (nhatend) at the supposed optimum, along with the eigenvalues of the Hessian (hev), as well as the message, if any, returned by the computation for each method, which is included for each row of the details. If the returned object from `optimx()` is `ans`, this is accessed via the construct `attr(ans, "details")`

This object is a matrix based on a list so that if `ans` is the output of `optimx` then `attr(ans, "details")[1, ]` gives the first row and `attr(ans,"details")["Nelder-Mead", ]` gives the Nelder-Mead row. There is one row for each method that has been successful or that has been forcibly saved by `save.failures=TRUE`.

There are also attributes

**maximize** to indicate we have been maximizing the objective

**npar** to provide the number of parameters, thereby facilitating easy extraction of the parameters from the results data frame

**follow.on** to indicate that the results have been computed sequentially, using the order provided by the user, with the best parameters from one method used to start the next. There is an example (`ans9`) in the script `ox.R` in the demo directory of the package.

## Note

Most methods in `optimx` will work with one-dimensional pars, but such use is NOT recommended. Use `optimize` or other one-dimensional methods instead.

There are a series of demos available. Once the package is loaded (via `require(optimx)` or `library(optimx)`), you may see available demos via

```
demo(package="optimx")
```

The demo `'brown_test'` may be run with the command `demo(brown_test, package="optimx")`

The package source contains several functions that are not exported in the `NAMESPACE`. These are

`optimx.setup()` which establishes the controls for a given run;

`optimx.check()` which performs bounds and gradient checks on the supplied parameters and functions;

`optimx.run()` which actually performs the optimization and post-solution computations;

`scalechk()` which actually carries out a check on the relative scaling of the input parameters.

Knowledgeable users may take advantage of these functions if they are carrying out production calculations where the setup and checks could be run once.

## Source

See the manual pages for `optim()` and the packages the `DESCRIPTION` suggests.

## References

See the manual pages for `optim()` and the packages the DESCRIPTION suggests.

Nash JC, and Varadhan R (2011). Unifying Optimization Algorithms to Aid Software System Users: **optimx** for R., *Journal of Statistical Software*, 43(9), 1-14., URL <http://www.jstatsoft.org/v43/i09/>.

Nash JC (2014). On Best Practice Optimization Methods in R., *Journal of Statistical Software*, 60(2), 1-14., URL <http://www.jstatsoft.org/v60/i02/>.

## See Also

[spg](#), [nlm](#), [nlminb](#), [bobyqa](#), [ucminf](#), [nmkb](#), [hjk](#). [optimize](#) for one-dimensional minimization; [constrOptim](#) or [spg](#) for linearly constrained optimization.

## Examples

```
require(graphics)
cat("Note possible demo(ox) for extended examples\n")

## Show multiple outputs of optimx using all.methods
# genrose function code
genrose.f<- function(x, gs=NULL){ # objective function
## One generalization of the Rosenbrock banana valley function (n parameters)
  n <- length(x)
  if(is.null(gs)) { gs=100.0 }
  fval<-1.0 + sum (gs*(x[1:(n-1)]^2 - x[2:n])^2 + (x[2:n] - 1)^2)
  return(fval)
}

genrose.g <- function(x, gs=NULL){
# vectorized gradient for genrose.f
# Ravi Varadhan 2009-04-03
  n <- length(x)
  if(is.null(gs)) { gs=100.0 }
  gg <- as.vector(rep(0, n))
  tn <- 2:n
  tn1 <- tn - 1
  z1 <- x[tn] - x[tn1]^2
  z2 <- 1 - x[tn]
  gg[tn] <- 2 * (gs * z1 - z2)
  gg[tn1] <- gg[tn1] - 4 * gs * x[tn1] * z1
  return(gg)
}

genrose.h <- function(x, gs=NULL) { ## compute Hessian
  if(is.null(gs)) { gs=100.0 }
  n <- length(x)
  hh<-matrix(rep(0, n*n),n,n)
  for (i in 2:n) {
    z1<-x[i]-x[i-1]*x[i-1]
    z2<-1.0-x[i]
    hh[i,i]<-hh[i,i]+2.0*(gs+1.0)
```

```

        hh[i-1,i-1]<-hh[i-1,i-1]-4.0*gs*z1-4.0*gs*x[i-1]*(-2.0*x[i-1])
        hh[i,i-1]<-hh[i,i-1]-4.0*gs*x[i-1]
        hh[i-1,i]<-hh[i-1,i]-4.0*gs*x[i-1]
    }
    return(hh)
}

startx<-4*seq(1:10)/3.
ans8<-opm(startx,fn=genrose.f,gr=genrose.g, hess=genrose.h,
  method="ALL", control=list(save.failures=TRUE, trace=0), gs=10)
# Set trace=1 for output of individual solvers
ans8
ans8[, "gevals"]
ans8["spg", ]
summary(ans8, par.select = 1:3)
summary(ans8, order = value)[1, ] # show best value
head(summary(ans8, order = value)) # best few
## head(summary(ans8, order = "value")) # best few -- alternative syntax

## order by value. Within those values the same to 3 decimals order by fevals.
## summary(ans8, order = list(round(value, 3), fevals), par.select = FALSE)
summary(ans8, order = "list(round(value, 3), fevals)", par.select = FALSE)

## summary(ans8, order = rownames, par.select = FALSE) # order by method name
summary(ans8, order = "rownames", par.select = FALSE) # same

summary(ans8, order = NULL, par.select = FALSE) # use input order
## summary(ans8, par.select = FALSE) # same

```

---

opm2optimr

*Extract optim() solution for one method of opm() result*


---

## Description

A function that attempts to extract a solution found for one of the multiple solvers used to obtain results of minimization or maximization using the opm() multi-solver wrapper.

## Usage

```
opm2optimr(opmobj, rid)
```

## Arguments

opmobj	the object returned by opm() from trying to solve an optimization problem with multiple solvers
rid	The identifier of the solver for which the solution should be extracted. This may be a "row ID" in the form of an integer or else a character string for the corresponding solver.

**Details**

We do not extract the true "message" for a method.

**Value**

A list of the following items:

**par** The best set of parameters found.

**value** The value of fn corresponding to par.

**counts** A two-element integer vector giving the number of calls to fn and gr respectively. This excludes those calls needed to compute the Hessian even though the opm() result will have these counts

**convergence** An integer code. 0 indicates successful completion

**message** A character string which for optim() or optimr() may give additional information returned by the optimizer, or NULL. Here will be "Result of conversion from opm() result"

**Examples**

```
fr <- function(x) { ## Rosenbrock Banana function
  x1 <- x[1]
  x2 <- x[2]
  100 * (x2 - x1 * x1)^2 + (1 - x1)^2
}
grr <- function(x) { ## Gradient of 'fr'
  x1 <- x[1]
  x2 <- x[2]
  c(-400 * x1 * (x2 - x1 * x1) - 2 * (1 - x1),
    200 * (x2 - x1 * x1))
}
mset <- c("nCG", "nvm", "anms", "tnewt")
mychk <- opm(par=c(-1.2,1), fr, grr, method=mset)
cat("Summary output from opm\n")
print(summary(mychk))
cat("extract result for method 3\n")
print(opm2optimr(mychk, 3))
cat("Alternatively for method nvm\n")
print(opm2optimr(mychk, "nvm"))
cat("Bad inputs check for character method \n")
print(try(opm2optimr(mychk, "nvv")))
cat("Bad inputs check for out of range integer")
print(try(opm2optimr(mychk, 6)))
```

**Description**

A wrapper function that attempts to check the objective function, and optionally the gradient and hessian functions, supplied by the user for optimization. It also tries to check the scale of the parameters and bounds to see if they are reasonable.

**Usage**

```
optchk(par, fn, gr=NULL, hess=NULL, lower=-Inf, upper=Inf,
       control=list(), ...)
```

**Arguments**

par	a vector of initial values for the parameters for which optimal values are to be found. Names on the elements of this vector are preserved and used in the results data frame.
fn	A function to be minimized (or maximized), with first argument the vector of parameters over which minimization is to take place. It should return a scalar result.
gr	A function to return (as a vector) the gradient for those methods that can use this information.
hess	A function to return (as a symmetric matrix) the Hessian of the objective function for those methods that can use this information.
lower, upper	Bounds on the variables for methods such as "L-BFGS-B" that can handle box (or bounds) constraints.
control	A list of control parameters. See 'Details'.
...	For <code>optimx</code> further arguments to be passed to <code>fn</code> and <code>gr</code> ; otherwise, further arguments are not used.

**Details**

Note that arguments after ... must be matched exactly.

While it can be envisaged that a user would have an analytic hessian but not an analytic gradient, we do NOT permit the user to test the hessian in this situation.

Any names given to `par` will be copied to the vectors passed to `fn` and `gr`. Note that no other attributes of `par` are copied over. (We have not verified this as at 2009-07-29.)

**Value**

A list of the following items:

**grOK** TRUE if the analytic gradient and a numerical approximation via `numDeriv` agree within the `control$grtesttol` as per the R code in function `grchk`. NULL if no analytic gradient function is provided.

**hessOK** TRUE if the analytic hessian and a numerical approximation via `numDeriv::jacobian` agree within the `control$hesstesttol` as per the R code in function `hesschk`. NULL if no analytic hessian or no analytic gradient is provided. Note that since an analytic gradient must

be available for this test, we use the Jacobian of the gradient to compute the Hessian to avoid one level of differencing, though the hesschk function can work without the gradient.

**scalebad** TRUE if the larger of the scaleratios exceeds control\$scaletol

**scaleratios** A vector of the parameter and bounds scale ratios. See the function code of scalechk for the computation of these values.

## References

See the manual pages for `optim()` and the packages the DESCRIPTION suggests.

Nash JC, and Varadhan R (2011). Unifying Optimization Algorithms to Aid Software System Users: **optimx** for R., *Journal of Statistical Software*, 43(9), 1-14., URL <http://www.jstatsoft.org/v43/i09/>.

Nash JC (2014). On Best Practice Optimization Methods in R., *Journal of Statistical Software*, 60(2), 1-14., URL <http://www.jstatsoft.org/v60/i02/>.

## Examples

```
fr <- function(x) { ## Rosenbrock Banana function
  x1 <- x[1]
  x2 <- x[2]
  100 * (x2 - x1 * x1)^2 + (1 - x1)^2
}
grr <- function(x) { ## Gradient of 'fr'
  x1 <- x[1]
  x2 <- x[2]
  c(-400 * x1 * (x2 - x1 * x1) - 2 * (1 - x1),
    200 * (x2 - x1 * x1))
}

myctrl<- ctrldefault(2)
myctrl$trace <- 3
mychk <- optchk(par=c(-1.2,1), fr, grr, lower=rep(-10,2), upper=rep(10,2), control=myctrl)
cat("result of optchk\n")
print(mychk)
```

---

optimr

*General-purpose optimization*

---

## Description

General-purpose optimization wrapper function that calls other R tools for optimization, including the existing `optim()` function. `optimr` also tries to unify the calling sequence to allow a number of tools to use the same front-end, in fact using the calling sequence of the R function `optim()`.

## Usage

```
optimr(par, fn, gr=NULL, hess=NULL, method=NULL, lower=-Inf, upper=Inf,
       hessian=FALSE, control=list(), ...)
```

**Arguments**

par	a vector of initial values for the parameters for which optimal values are to be found. Names on the elements of this vector are preserved and used in the results data frame.
fn	A function to be minimized (or maximized), with first argument the vector of parameters over which minimization is to take place. It should return a scalar result.
gr	A function to return (as a vector) the gradient for those methods that can use this information.  If gr is NULL, then this is passed forward and whatever default action is specified for the chosen method for the case of a null gradient code is used. For many methods, this is a finite-difference approximation, but some methods require user input for the gradient and will fail otherwise. In such cases, we try to return convergence of 9998.  If gr is a character string, then that string is taken as the name of a gradient approximation function, for example, "grfwd", "grback" and "grcentral" for standard forward, backward and central approximations. Method "grnd" uses the grad() function from package numDeriv.
hess	A function to return (as a matrix) the hessian for those methods that can use this information.  If hess is the character string "approx", then ??  If hess is NULL, then this is passed forward and whatever default action is specified for the chosen method for the case of a null gradient code is used.
lower, upper	Bounds on the variables for methods such as "L-BFGS-B" that can handle box (or bounds) constraints. A small set of methods can handle masks, that is, fixed parameters, and these can be specified by making the lower and upper bounds equal to the starting value. (It is possible that the starting value could be different from the lower/upper bounds set, but this behaviour has NOT yet been defined and users are cautioned.)
method	A character string giving the name of the optimization method to be applied. See the list allmeth in file ctrldefault.R which is part of this package.
hessian	A logical control that if TRUE forces the computation of an approximation to the Hessian at the final set of parameters. Note that this will NOT necessarily use the same approximation as may be provided by the method called. Instead, the function hessian() from package numDeriv is used if no gradient gr is supplied, else the function jacobian() from numDeriv is applied to the gradient function gr.
control	A list of control parameters. See 'Details'.
...	Further arguments to be passed to fn and gr if needed for computation of these quantities; otherwise, further arguments are not used.

**Details**

Note that arguments after ... should be matched exactly.

By default `optimr` performs minimization, but it will maximize if `control$maximize` is `TRUE`. The original `optim()` function allows `control$fnscale` to be set negative to accomplish this, and this control can be used with `optimr` but is deprecated. Moreover, if `control$maximize` is set, it will take precedence over `control$fnscale`. Generally it is a BAD IDEA to use both mechanisms simultaneously.

Possible method choices are specified by the list `allmeth` in the file `ctrldefault.R` which is part of this package.

If no method is specified, the method specified by `defmethod` in file `ctrldefault.R` (which is part of this package) will be attempted.

Function `fn` must return a finite scalar value at the initial set of parameters. Some methods can handle a returned value `NA` or `Inf` if the function cannot be evaluated at the supplied value. However, other methods, of which "L-BFGS-B" is known to be a case, require that the values returned should always be finite. It is recommended that user functions ALWAYS return a usable value. Note that the control `badval` in `ctrldefault.R` give a possible number that could be returned.

For details of methods, please consult the documentation of the individual methods. (The NAMESPACE file lists the packages from which functions are imported.) Note that method "hjn" is a conservative implementation of a Hooke and Jeeves (1961) and is part of this package. It is provided as a simple example of a very crude optimization method; it is NOT intended as a production method, but may be useful for didactic purposes.

The `control` argument is a list that can supply any of the components in the file `ctrldefault.R` which is part of this package. It may supply controls that are useful or required for particular methods, but users are warned to be careful to ensure that extraneous or incorrect components and values are not passed. Some `control` elements apply only to some methods. See individual packages for details. `optimr` does not support all the possible controls for all methods.

A particular case is the method "bobyqa", where the control `rhobeg=0` gives a set of controls that depend on the bounds supplied. This choice is only in the current package. Unspecified or negative control `rhobeg=0` gives the `minqa` defaults. Positive value of this control (and optionally control `rhoend`) supply those values. See `inst/doc/examples/specctrlhobbs.R`.

Any names given to `par` will be copied to the vectors passed to `fn` and `gr`. Apparently no other attributes of `par` are copied over, but this may need to be verified, especially if parameters are passed to non-R routines.

CAUTION: because there is a seldom-used parameter `hess`, you should NOT make a call like

```
ans <- optimr(start, myf, myg, lower, upper)
```

or you will likely get wrong results. Instead use

```
ans <- optimr(start, myf, myg, lower=lower, upper=upper)
```

## Value

A list with components:

**par** The best set of parameters found.

**value** The value of 'fn' corresponding to 'par'.

**counts** A two-element integer vector giving the number of calls to 'fn' and 'gr' respectively. This excludes those calls needed to compute the Hessian, if requested, and any calls to 'fn' to compute a finite-difference approximation to the gradient. NOT available to be reported for some methods, e.g., `lbfgs`.



**convergence** An integer code. '0' indicates successful completion. The documentation for function `optim()` gives some other possible values and their meaning.

**message** A character string giving any additional information returned by the optimizer, or 'NULL'.

**hessian** If requested, an approximation to the hessian of 'fn' at the final parameters.

## References

See the manual pages for `optim()`.

Hooke R. and Jeeves, TA (1961). Direct search solution of numerical and statistical problems. *Journal of the Association for Computing Machinery (ACM)*. 8 (2): 212–229.

Nash JC, and Varadhan R (2011). Unifying Optimization Algorithms to Aid Software System Users: **optimx** for R., *Journal of Statistical Software*, 43(9), 1-14., URL <http://www.jstatsoft.org/v43/i09/>.

Nocedal J, and Wright SJ (1999). Numerical optimization. New York: Springer. 2nd Edition 2006.

## Examples

```
# Simple Test Function 1:
simfun.f = function(x) {
  fun <- sum(x^2 )
## if (trace) ... to be fixed
  print(c(x = x, fun = fun))
  fun
}
simfun.g = function(x) {
  grad<-2.0*x
  grad
}
simfun.h = function(x) {
  n<-length(x)
  t<-rep(2.0,n)
  hess<-diag(t)
}

# library(optimx) ## May be needed for independent running.
strt <- c(1,2,3)
ansfgh <- optimr(strt, simfun.f, simfun.g, simfun.h, method="nlm",
  hessian=TRUE, control=list(trace=2))
proptimr(ansfgh) # compact output of result
cat("nlm does not return good counts\n")
cat("ansfgh$counts:")
print(ansfgh$counts)
```

optimx

*General-purpose optimization***Description**

General-purpose optimization wrapper function that calls other R tools for optimization, including the existing `optim()` function. `optimx` also tries to unify the calling sequence to allow a number of tools to use the same front-end. These include `spg` from the `BB` package, `ucminf`, `nlm`, and `nlmminb`. Note that `optim()` itself allows Nelder–Mead, quasi-Newton and conjugate-gradient algorithms as well as box-constrained optimization via L-BFGS-B. Because SANN does not return a meaningful convergence code (`conv`), `optimx()` does not call the SANN method.

Note that package `optimr` allows solvers to be called individually by the `optim()` syntax, with the `parscale` control to scale parameters applicable to all methods. However, running multiple methods, or using the `follow.on` capability has been moved to separate routines in the `optimr` package.

Cautions:

- 1) Using some control list options with different or multiple methods may give unexpected results.
- 2) Testing the KKT conditions can take much longer than solving the optimization problem, especially when the number of parameters is large and/or analytic gradients are not available. Note that the default for the control `kkt` is `TRUE`.

**Usage**

```
optimx(par, fn, gr=NULL, hess=NULL, lower=-Inf, upper=Inf,
       method=c("Nelder-Mead", "BFGS"), itnmax=NULL, hessian=FALSE,
       control=list(),
       ...)
```

**Arguments**

<code>par</code>	a vector of initial values for the parameters for which optimal values are to be found. Names on the elements of this vector are preserved and used in the results data frame.
<code>fn</code>	A function to be minimized (or maximized), with first argument the vector of parameters over which minimization is to take place. It should return a scalar result.
<code>gr</code>	A function to return (as a vector) the gradient for those methods that can use this information. If <code>'gr'</code> is <code>NULL</code> , a finite-difference approximation will be used. An open question concerns whether the SAME approximation code used for all methods, or whether there are differences that could/should be examined?
<code>hess</code>	A function to return (as a symmetric matrix) the Hessian of the objective function for those methods that can use this information.
<code>lower, upper</code>	Bounds on the variables for methods such as "L-BFGS-B" that can handle box (or bounds) constraints.

method	A list of the methods to be used. Note that this is an important change from <code>optim()</code> that allows just one method to be specified. See ‘Details’.
itnmax	If provided as a vector of the same length as the list of methods <code>method</code> , gives the maximum number of iterations or function values for the corresponding method. If a single number is provided, this will be used for all methods. Note that there may be control list elements with similar functions, but this should be the preferred approach when using <code>optimx</code> .
hessian	A logical control that if TRUE forces the computation of an approximation to the Hessian at the final set of parameters. If FALSE (default), the hessian is calculated if needed to provide the KKT optimality tests (see <code>kkt</code> in ‘Details’ for the control list). This setting is provided primarily for compatibility with <code>optim()</code> .
control	A list of control parameters. See ‘Details’.
...	For <code>optimx</code> further arguments to be passed to <code>fn</code> and <code>gr</code> ; otherwise, further arguments are not used.

## Details

Note that arguments after ... must be matched exactly.

By default this function performs minimization, but it will maximize if `control$maximize` is TRUE. The original `optim()` function allows `control$fnscale` to be set negative to accomplish this. DO NOT use both methods.

Possible method codes at the time of writing are ‘Nelder-Mead’, ‘BFGS’, ‘CG’, ‘L-BFGS-B’, ‘nlm’, ‘nlnmb’, ‘spg’, ‘ucminf’, ‘newuoa’, ‘bobyqa’, ‘nmkb’, ‘hjk’, ‘Rcgmin’, or ‘Rvmmin’.

The default methods for unconstrained problems (no lower or upper specified) are an implementation of the Nelder and Mead (1965) and a Variable Metric method based on the ideas of Fletcher (1970) as modified by him in conversation with Nash (1979). Nelder-Mead uses only function values and is robust but relatively slow. It will work reasonably well for non-differentiable functions. The Variable Metric method, “BFGS” updates an approximation to the inverse Hessian using the BFGS update formulas, along with an acceptable point line search strategy. This method appears to work best with analytic gradients. (“Rvmmin” provides a box-constrained version of this algorithm.

If no method is given, and there are bounds constraints provided, the method is set to “L-BFGS-B”.

Method “CG” is a conjugate gradients method based on that by Fletcher and Reeves (1964) (but with the option of Polak–Ribiere or Beale–Sorenson updates). The particular implementation is now dated, and improved yet simpler codes are being implemented (as at June 2009), and furthermore a version with box constraints is being tested. Conjugate gradient methods will generally be more fragile than the BFGS method, but as they do not store a matrix they may be successful in much larger optimization problems.

Method “L-BFGS-B” is that of Byrd *et. al.* (1995) which allows *box constraints*, that is each variable can be given a lower and/or upper bound. The initial value must satisfy the constraints. This uses a limited-memory modification of the BFGS quasi-Newton method. If non-trivial bounds are supplied, this method will be selected, with a warning.

Nocedal and Wright (1999) is a comprehensive reference for the previous three methods.

Function `fn` can return NA or Inf if the function cannot be evaluated at the supplied value, but the initial value must have a computable finite value of `fn`. However, some methods, of which “L-BFGS-B” is known to be a case, require that the values returned should always be finite.

While `optim` can be used recursively, and for a single parameter as well as many, this may not be true for `optimx`. `optim` also accepts a zero-length `par`, and just evaluates the function with that argument.

Method `"nlm"` is from the package of the same name that implements ideas of Dennis and Schnabel (1983) and Schnabel et al. (1985). See `nlm()` for more details.

Method `"nlnmb"` is the package of the same name that uses the minimization tools of the PORT library. The PORT documentation is at <URL: <http://netlib.bell-labs.com/cm/cs/ctr/153.pdf>>. See `nlnmb()` for details. (Though there is very little information about the methods.)

Method `"spg"` is from package `BB` implementing a spectral projected gradient method for large-scale optimization with simple constraints due R adaptation, with significant modifications, by Ravi Varadhan, Johns Hopkins University (Varadhan and Gilbert, 2009), from the original FORTRAN code of Birgin, Martinez, and Raydan (2001).

Method `"Rcgmin"` is from the package of that name. It implements a conjugate gradient algorithm with the Dai and Yuan (2001) update and also allows bounds constraints on the parameters. (`Rcgmin` also allows mask constraints – fixing individual parameters.)

Methods `"bobyqa"`, `"uobyqa"` and `"newuoa"` are from the package `"minqa"` which implement optimization by quadratic approximation routines of the similar names due to M J D Powell (2009). See package `minqa` for details. Note that `"uobyqa"` and `"newuoa"` are for unconstrained minimization, while `"bobyqa"` is for box constrained problems. While `"uobyqa"` may be specified, it is NOT part of the `all.methods = TRUE` set.

The control argument is a list that can supply any of the following components:

`trace` Non-negative integer. If positive, tracing information on the progress of the optimization is produced. Higher values may produce more tracing information: for method `"L-BFGS-B"` there are six levels of tracing. `trace = 0` gives no output (To understand exactly what these do see the source code: higher levels give more detail.)

`follow.on` = TRUE or FALSE. If TRUE, and there are multiple methods, then the last set of parameters from one method is used as the starting set for the next.

`save.failures` = TRUE if we wish to keep "answers" from runs where the method does not return `convcode==0`. FALSE otherwise (default).

`maximize` = TRUE if we want to maximize rather than minimize a function. (Default FALSE). Methods `nlm`, `nlnmb`, `ucminf` cannot maximize a function, so the user must explicitly minimize and carry out the adjustment externally. However, there is a check to avoid usage of these codes when `maximize` is TRUE. See `fnscale` below for the method used in `optim` that we deprecate.

`all.methods` = TRUE if we want to use all available (and suitable) methods.

`kkt` =FALSE if we do NOT want to test the Kuhn, Karush, Tucker optimality conditions. The default is TRUE. However, because the Hessian computation may be very slow, we set `kkt` to be FALSE if there are more than 50 parameters when the gradient function `gr` is not provided, and more than 500 parameters when such a function is specified. We return logical values `KKT1` and `KKT2` TRUE if first and second order conditions are satisfied approximately. Note, however, that the tests are sensitive to scaling, and users may need to perform additional verification. If `kkt` is FALSE but `hessian` is TRUE, then `KKT1` is generated, but `KKT2` is not.

`all.methods` = TRUE if we want to use all available (and suitable) methods.

`kkttol` = value to use to check for small gradient and negative Hessian eigenvalues. Default =  $.Machine\$double.eps^{(1/3)}$

`kkt2tol` = Tolerance for eigenvalue ratio in KKT test of positive definite Hessian. Default same as for `kkttol`

`starttests` = TRUE if we want to run tests of the function and parameters: feasibility relative to bounds, analytic vs numerical gradient, scaling tests, before we try optimization methods. Default is TRUE.

`dowarn` = TRUE if we want warnings generated by `optimx`. Default is TRUE.

`badval` = The value to set for the function value when `try(fn())` fails. Default is  $(0.5)*.Machine\$double.xmax$

`useNumDeriv` = TRUE if the `numDeriv` function `grad()` is to be used to compute gradients when the argument `gr` is NULL or not supplied.

The following control elements apply only to some of the methods. The list may be incomplete. See individual packages for details.

`fnscale` An overall scaling to be applied to the value of `fn` and `gr` during optimization. If negative, turns the problem into a maximization problem. Optimization is performed on  $fn(par)/fnscale$ . For methods from the set in `optim()`. Note potential conflicts with the control `maximize`.

`parscale` A vector of scaling values for the parameters. Optimization is performed on  $par/parscale$  and these should be comparable in the sense that a unit change in any element produces about a unit change in the scaled value. For `optim`.

`ndeps` A vector of step sizes for the finite-difference approximation to the gradient, on  $par/parscale$  scale. Defaults to  $1e-3$ . For `optim`.

`maxit` The maximum number of iterations. Defaults to 100 for the derivative-based methods, and 500 for "Nelder-Mead".

`abstol` The absolute convergence tolerance. Only useful for non-negative functions, as a tolerance for reaching zero.

`reltol` Relative convergence tolerance. The algorithm stops if it is unable to reduce the value by a factor of  $reltol * (abs(val) + reltol)$  at a step. Defaults to  $\sqrt{.Machine\$double.eps}$ , typically about  $1e-8$ . For `optim`.

`alpha, beta, gamma` Scaling parameters for the "Nelder-Mead" method. `alpha` is the reflection factor (default 1.0), `beta` the contraction factor (0.5) and `gamma` the expansion factor (2.0).

`REPORT` The frequency of reports for the "BFGS" and "L-BFGS-B" methods if `control$trace` is positive. Defaults to every 10 iterations for "BFGS" and "L-BFGS-B".

`type` for the conjugate-gradients method. Takes value 1 for the Fletcher-Reeves update, 2 for Polak-Ribiere and 3 for Beale-Sorenson.

`lmm` is an integer giving the number of BFGS updates retained in the "L-BFGS-B" method, It defaults to 5.

`factr` controls the convergence of the "L-BFGS-B" method. Convergence occurs when the reduction in the objective is within this factor of the machine tolerance. Default is  $1e7$ , that is a tolerance of about  $1e-8$ .

`pgtol` helps control the convergence of the "L-BFGS-B" method. It is a tolerance on the projected gradient in the current search direction. This defaults to zero, when the check is suppressed.

Any names given to `par` will be copied to the vectors passed to `fn` and `gr`. Note that no other attributes of `par` are copied over. (We have not verified this as at 2009-07-29.)

There are `[.optimx`, `as.data.frame.optimx`, `coef.optimx` and `summary.optimx` methods available.

Note: Package `optimr` is a derivative of this package. It was developed initially to overcome maintenance difficulties with the current package related to avoiding confusion if some multiple options were specified together, and to allow the `optim()` function syntax to be used consistently, including the `parscale` control. However, this package does perform well, and is called by a number of popular other packages.

## Value

If there are `npar` parameters, then the result is a dataframe having one row for each method for which results are reported, using the method as the row name, with columns

`par_1`, ..., `par_npar`, `value`, `fevals`, `gevals`, `niter`, `convcode`, `kkt1`, `kkt2`, `xtimes`  
where

**par\_1** ..

**par\_npar** The best set of parameters found.

**value** The value of `fn` corresponding to `par`.

**fevals** The number of calls to `fn`.

**gevals** The number of calls to `gr`. This excludes those calls needed to compute the Hessian, if requested, and any calls to `fn` to compute a finite-difference approximation to the gradient.

**niter** For those methods where it is reported, the number of “iterations”. See the documentation or code for particular methods for the meaning of such counts.

**convcode** An integer code. 0 indicates successful convergence. Various methods may or may not return sufficient information to allow all the codes to be specified. An incomplete list of codes includes

1 indicates that the iteration limit `maxit` had been reached.

20 indicates that the initial set of parameters is inadmissible, that is, that the function cannot be computed or returns an infinite, NULL, or NA value.

21 indicates that an intermediate set of parameters is inadmissible.

10 indicates degeneracy of the Nelder–Mead simplex.

51 indicates a warning from the “L-BFGS-B” method; see component message for further details.

52 indicates an error from the “L-BFGS-B” method; see component message for further details.

**kkt1** A logical value returned TRUE if the solution reported has a “small” gradient.

**kkt2** A logical value returned TRUE if the solution reported appears to have a positive-definite Hessian.

**xtimes** The reported execution time of the calculations for the particular method.

The attribute "details" to the returned answer object contains information, if computed, on the gradient (ngatend) and Hessian matrix (nhatend) at the supposed optimum, along with the eigenvalues of the Hessian (hev), as well as the message, if any, returned by the computation for each method, which is included for each row of the details. If the returned object from optimx() is ans, this is accessed via the construct `attr(ans, "details")`

This object is a matrix based on a list so that if ans is the output of optimx then `attr(ans, "details")[1, ]` gives the first row and `attr(ans, "details")["Nelder-Mead", ]` gives the Nelder-Mead row. There is one row for each method that has been successful or that has been forcibly saved by `save.failures=TRUE`.

There are also attributes

**maximize** to indicate we have been maximizing the objective

**npar** to provide the number of parameters, thereby facilitating easy extraction of the parameters from the results data frame

**follow.on** to indicate that the results have been computed sequentially, using the order provided by the user, with the best parameters from one method used to start the next. There is an example (ans9) in the script `ox.R` in the demo directory of the package.

## Note

Most methods in `optimx` will work with one-dimensional pars, but such use is NOT recommended. Use `optimize` or other one-dimensional methods instead.

There are a series of demos available. Once the package is loaded (via `require(optimx)` or `library(optimx)`), you may see available demos via

```
demo(package="optimx")
```

The demo 'brown\_test' may be run with the command `demo(brown_test, package="optimx")`

The package source contains several functions that are not exported in the NAMESPACE. These are

`optimx.setup()` which establishes the controls for a given run;

`optimx.check()` which performs bounds and gradient checks on the supplied parameters and functions;

`optimx.run()` which actually performs the optimization and post-solution computations;

`scalecheck()` which actually carries out a check on the relative scaling of the input parameters.

Knowledgeable users may take advantage of these functions if they are carrying out production calculations where the setup and checks could be run once.

## Source

See the manual pages for `optim()` and the packages the DESCRIPTION suggests.

## References

See also the manual pages for `optim()` and the packages the DESCRIPTION suggests.

Byrd RH, Lu P, Nocedal J (1995) A Limited Memory Algorithm for Bound Constrained Optimization, *SIAM Journal on Scientific Computing*, 16 (5), 1190–1208.

Y. H. Dai and Y. Yuan, (2001) An Efficient Hybrid Conjugate Gradient Method for Unconstrained Optimization, *Annals of Operations Research*, 103, pp 33–47, URL <http://dx.doi.org/10.1023/A:1012930416777>.

Dennis JE and Schnabel RB (1983) *Numerical Methods for Unconstrained Optimization and Non-linear Equations*, Englewood Cliffs NJ: Prentice-Hall.

Fletcher R (1970) A New Approach to Variable Metric Algorithms, *Computer Journal*, 13 (3), 317–322.

Nash JC, and Varadhan R (2011). Unifying Optimization Algorithms to Aid Software System Users: **optimx** for R., *Journal of Statistical Software*, 43(9), 1-14., URL <http://www.jstatsoft.org/v43/i09/>.

Nash JC (2014). On Best Practice Optimization Methods in R., *Journal of Statistical Software*, 60(2), 1-14., URL <http://www.jstatsoft.org/v60/i02/>.

Nelder JA and Mead R (1965) A Simplex Method for Function Minimization, *Computer Journal*, 7 (4), 308–313.

Powell MJD (2009) The BOBYQA algorithm for bound constrained optimization without derivatives, [http://www.damtp.cam.ac.uk/user/na/NA\\_papers/NA2009\\_06.pdf](http://www.damtp.cam.ac.uk/user/na/NA_papers/NA2009_06.pdf)

## See Also

[spg](#), [nlm](#), [nlminb](#), [bobyqa](#), [ucminf](#), [nmkb](#), [hjkb](#). [optimize](#) for one-dimensional minimization; [constrOptim](#) or [spg](#) for linearly constrained optimization.

## Examples

```
require(graphics)
cat("Note demo(ox) for extended examples\n")

## Show multiple outputs of optimx using all.methods
# genrose function code
genrose.f<- function(x, gs=NULL){ # objective function
## One generalization of the Rosenbrock banana valley function (n parameters)
  n <- length(x)
  if(is.null(gs)) { gs=100.0 }
  fval<-1.0 + sum (gs*(x[1:(n-1)]^2 - x[2:n])^2 + (x[2:n] - 1)^2)
  return(fval)
}

genrose.g <- function(x, gs=NULL){
# vectorized gradient for genrose.f
# Ravi Varadhan 2009-04-03
  n <- length(x)
  if(is.null(gs)) { gs=100.0 }
  gg <- as.vector(rep(0, n))
  tn <- 2:n
  tn1 <- tn - 1
```



```

z1 <- x[tn] - x[tn1]^2
z2 <- 1 - x[tn]
gg[tn] <- 2 * (gs * z1 - z2)
gg[tn1] <- gg[tn1] - 4 * gs * x[tn1] * z1
return(gg)
}

genrose.h <- function(x, gs=NULL) { ## compute Hessian
  if(is.null(gs)) { gs=100.0 }
  n <- length(x)
  hh<-matrix(rep(0, n*n),n,n)
  for (i in 2:n) {
    z1<-x[i]-x[i-1]*x[i-1]
    z2<-1.0-x[i]
    hh[i,i]<-hh[i,i]+2.0*(gs+1.0)
    hh[i-1,i-1]<-hh[i-1,i-1]-4.0*gs*z1-4.0*gs*x[i-1]*(-2.0*x[i-1])
    hh[i,i-1]<-hh[i,i-1]-4.0*gs*x[i-1]
    hh[i-1,i]<-hh[i-1,i]-4.0*gs*x[i-1]
  }
  return(hh)
}

startx<-4*seq(1:10)/3.
ans8<-optimx(startx,fn=genrose.f,gr=genrose.g, hess=genrose.h,
  control=list(all.methods=TRUE, save.failures=TRUE, trace=0), gs=10)
ans8
ans8[, "gevals"]
ans8["spg", ]
summary(ans8, par.select = 1:3)
summary(ans8, order = value)[1, ] # show best value
head(summary(ans8, order = value)) # best few
## head(summary(ans8, order = "value")) # best few -- alternative syntax

## order by value. Within those values the same to 3 decimals order by fevals.
## summary(ans8, order = list(round(value, 3), fevals), par.select = FALSE)
summary(ans8, order = "list(round(value, 3), fevals)", par.select = FALSE)

## summary(ans8, order = rownames, par.select = FALSE) # order by method name
summary(ans8, order = "rownames", par.select = FALSE) # same

summary(ans8, order = NULL, par.select = FALSE) # use input order
## summary(ans8, par.select = FALSE) # same

```

**Description**

Multiple minimization methods are applied in sequence to a single problem, with the output parameters of one method being used to start the next.

**Usage**

```
polyopt(par, fn, gr=NULL, lower=-Inf, upper=Inf,
        methcontrol=NULL, hessian=FALSE,
        control=list(),
        ...)
```

**Arguments**

par	a vector of initial values for the parameters for which optimal values are to be found. Names on the elements of this vector are preserved and used in the results data frame.
fn	A function to be minimized (or maximized), with first argument the vector of parameters over which minimization is to take place. It should return a scalar result.
gr	A function to return (as a vector) the gradient for those methods that can use this information. If 'gr' is NULL, a finite-difference approximation will be used. An open question concerns whether the SAME approximation code used for all methods, or whether there are differences that could/should be examined?
lower, upper	Bounds on the variables for methods such as "L-BFGS-B" that can handle box (or bounds) constraints.
methcontrol	An data frame of which each row gives an optimization method, a maximum number of iterations and a maximum number of function evaluations allowed for that method. Each method will be executed in turn until either the maximum iterations or function evaluations are completed, whichever is first. The next method is then executed starting with the best parameters found so far, else the function exits.
hessian	A logical control that if TRUE forces the computation of an approximation to the Hessian at the final set of parameters. If FALSE (default), the hessian is calculated if needed to provide the KKT optimality tests (see kkt in 'Details' for the control list). This setting is provided primarily for compatibility with optim().
control	A list of control parameters. See 'Details'.
...	For optimx further arguments to be passed to fn and gr; otherwise, further arguments are not used.

**Details**

Note that arguments after ... must be matched exactly.

See `optimr()` for other details.

Note that this function does not (yet?) make use of a hess function to compute the hessian.

**Value**

An array with one row per method. Each row contains:

par	The best set of parameters found for the method in question.
value	The value of 'fn' corresponding to 'par'.
counts	A two-element integer vector giving the number of calls to 'fn' and 'gr' respectively. This excludes those calls needed to compute the Hessian, if requested, and any calls to 'fn' to compute a finite-difference approximation to the gradient.
convergence	An integer code. '0' indicates successful completion
message	A character string giving any additional information returned by the optimizer, or 'NULL'.
hessian	Always NULL for this routine.

### Source

See the manual pages for `optim()` and the packages the DESCRIPTION suggests.

### Examples

```
fnR <- function (x, gs=100.0)
{
  n <- length(x)
  x1 <- x[2:n]
  x2 <- x[1:(n - 1)]
  sum(gs * (x1 - x2^2)^2 + (1 - x2)^2)
}
grR <- function (x, gs=100.0)
{
  n <- length(x)
  g <- rep(NA, n)
  g[1] <- 2 * (x[1] - 1) + 4*gs * x[1] * (x[1]^2 - x[2])
  if (n > 2) {
    ii <- 2:(n - 1)
    g[ii] <- 2 * (x[ii] - 1) + 4 * gs * x[ii] * (x[ii]^2 - x[ii +
      1]) + 2 * gs * (x[ii] - x[ii - 1])^2)
  }
  g[n] <- 2 * gs * (x[n] - x[n - 1])^2)
  g
}

x0 <- rep(pi, 4)
mc <- data.frame(method=c("Nelder-Mead", "Rvmmin"), maxit=c(1000, 100), maxfeval= c(1000, 1000))

ans <- polyopt(x0, fnR, grR, methcontrol=mc, control=list(trace=0))
ans
mc <- data.frame(method=c("Nelder-Mead", "Rvmmin"), maxit=c(100, 100), maxfeval= c(100, 1000))

ans <- polyopt(x0, fnR, grR, methcontrol=mc, control=list(trace=0))
ans

mc <- data.frame(method=c("Nelder-Mead", "Rvmmin"), maxit=c(10, 100), maxfeval= c(10, 1000))

ans <- polyopt(x0, fnR, grR, methcontrol=mc, control=list(trace=0))
```

ans

---

proptimr *Compact display of an optimr() result object*

---

### Description

proptimr displays the contents of a result computed by optimr().

### Usage

```
proptimr(opres)
```

### Arguments

opres            the object returned by function optimr()

### Value

This function is intended for output only.

### Author(s)

John C. Nash

---

Rcgmin *An R implementation of a nonlinear conjugate gradient algorithm with the Dai / Yuan update and restart. Based on Nash (1979) Algorithm 22 for its main structure.*

---

### Description

The purpose of Rcgmin is to minimize an unconstrained or bounds (box) and mask constrained function of many parameters by a nonlinear conjugate gradients method. This code is entirely in R to allow users to explore and understand the method. It also allows bounds (or box) constraints and masks (equality constraints) to be imposed on parameters.

Rcgmin is a wrapper that calls Rcgminu for unconstrained problems, else Rcgminb.

### Usage

```
Rcgmin(par, fn, gr, lower, upper, bdmsk, control = list(), ...)
```

```
ncg(par, fn, gr, bds, control = list())
```

**Arguments**

<code>par</code>	A numeric vector of starting estimates.
<code>fn</code>	A function that returns the value of the objective at the supplied set of parameters <code>par</code> using auxiliary data in <code>...</code> . The first argument of <code>fn</code> must be <code>par</code> .
<code>gr</code>	<p>A function that returns the gradient of the objective at the supplied set of parameters <code>par</code> using auxiliary data in <code>...</code>. The first argument of <code>fn</code> must be <code>par</code>. This function returns the gradient as a numeric vector.</p> <p>If <code>gr</code> is not provided or is <code>NULL</code>, then the simple forward gradient code <code>grfwd</code> is used. However, we recommend carefully coded and checked analytic derivatives for <code>Rcgmin</code>.</p> <p>The use of numerical gradients for <code>Rcgmin</code> is discouraged. First, the termination test uses a size measure on the gradient, and numerical gradient approximations can sometimes give results that are too large. Second, if there are bounds constraints, the step(s) taken to calculate the approximation to the derivative are NOT checked to see if they are out of bounds, and the function may be undefined at the evaluation point.</p> <p>There is also the option of using the routines <code>grfwd</code>, <code>grback</code>, <code>grcentral</code> or <code>grnd</code>. The last of these calls the <code>grad()</code> function from package <code>numDeriv</code>. These are called by putting the name of the (numerical) gradient function in quotation marks, e.g.,</p> <pre>gr="grfwd"</pre> <p>to use the standard forward difference numerical approximation.</p> <p>Note that all but the <code>grnd</code> routine use a stepsize parameter that can be redefined in a special scratchpad storage variable <code>deps</code>. The default is <code>deps = 1e-07</code>. However, redefining this is discouraged unless you understand what you are doing.</p>
<code>lower</code>	A vector of lower bounds on the parameters.
<code>upper</code>	A vector of upper bounds on the parameters.
<code>bdmsk</code>	An indicator vector, having 1 for each parameter that is "free" or unconstrained, and 0 for any parameter that is fixed or MASKED for the duration of the optimization.
<code>bds</code>	A list of information resulting from function <code>bmchk</code> giving information on the status of the parameters and bounds and masks.
<code>control</code>	An optional list of control settings.
<code>...</code>	Further arguments to be passed to <code>fn</code> .

**Details**

Functions `fn` must return a numeric value.

Note that `ncg` is to be called from `optimr` and does NOT allow dot arguments. It is intended to use the internal functions `efn` and `egr` generated inside `optimr()` along with bounds information from `bmchk()` available there.

The `control` argument is a list.

**maxit** A limit on the number of iterations (default 500). Note that this is used to compute a quantity  $\text{maxfeval} \leftarrow \text{round}(\sqrt{n+1} * \text{maxit})$  where  $n$  is the number of parameters to be minimized.

**trace** Set 0 (default) for no output, >0 for trace output (larger values imply more output).

**eps** Tolerance used to calculate numerical gradients. Default is 1.0E-7. See source code for Rcgmin for details of application.

**dowarn** = TRUE if we want warnings generated by optimx. Default is TRUE.

**tol** Tolerance used in testing the size of the square of the gradient. Default is 0 on input, which uses a value of  $\text{tolgr} = \text{npar} * \text{npar} * \text{Machine}\$double.eps$  in testing if  $\text{crossprod}(g) \leq \text{tolgr} * (\text{abs}(fmin) + \text{reltest})$ . If the user supplies a value for **tol** that is non-zero, then that value is used for **tolgr**.

**reltest=100** is only alterable by changing the code. **fmin** is the current best value found for the function minimum value.

Note that the scale of the gradient means that tests for a small gradient can easily be mismatched to a given problem. The defaults in Rcgmin are a "best guess".

**checkgrad** = TRUE if we want gradient function checked against numerical approximations. Default is FALSE.

**checkbounds** = TRUE if we want bounds verified. Default is TRUE.

As of 2011-11-21 the following controls have been REMOVED

**usenumDeriv** There is now a choice of numerical gradient routines. See argument **gr**.

**maximize** To maximize **user\_function**, supply a function that computes  $(-1) * \text{user\_function}$ . An alternative is to call Rcgmin via the package **optimx**, where the **MAXIMIZE** field of the **OPCON** structure in package **optfntools** is used.

## Value

A list with components:

<b>par</b>	The best set of parameters found.
<b>value</b>	The value of the objective at the best set of parameters found.
<b>counts</b>	A two-element integer vector giving the number of calls to 'fn' and 'gr' respectively. This excludes those calls needed to compute the Hessian, if requested, and any calls to 'fn' to compute a finite-difference approximation to the gradient.
<b>convergence</b>	An integer code. '0' indicates successful convergence. '1' indicates that the function evaluation count 'maxfeval' was reached. '2' indicates initial point is infeasible.
<b>message</b>	A character string giving any additional information returned by the optimizer, or 'NULL'.
<b>bdmsk</b>	Returned index describing the status of bounds and masks at the proposed solution. Parameters for which <b>bdmsk</b> are 1 are unconstrained or "free", those with <b>bdmsk</b> 0 are masked i.e., fixed. For historical reasons, we indicate a parameter is at a lower bound using -3 or upper bound using -1.

## References

Dai, Y. H. and Y. Yuan (2001). An efficient hybrid conjugate gradient method for unconstrained optimization. *Annals of Operations Research* 103 (1-4), 33–47.

Nash JC (1979). *Compact Numerical Methods for Computers: Linear Algebra and Function Minimisation*. Adam Hilger, Bristol. Second Edition, 1990, Bristol: Institute of Physics Publications.

Nash, J. C. and M. Walker-Smith (1987). *Nonlinear Parameter Estimation: An Integrated System in BASIC*. New York: Marcel Dekker. See <https://www.nashinfo.com/nlpe.htm> for a downloadable version of this plus some extras.

## See Also

[optim](#)

## Examples

```
#####
require(numDeriv)
## Rosenbrock Banana function
fr <- function(x) {
  x1 <- x[1]
  x2 <- x[2]
  100 * (x2 - x1 * x1)^2 + (1 - x1)^2
}

grr <- function(x) { ## Gradient of 'fr'
  x1 <- x[1]
  x2 <- x[2]
  c(-400 * x1 * (x2 - x1 * x1) - 2 * (1 - x1),
    200 * (x2 - x1 * x1))
}

grn<-function(x){
  gg<-grad(fr, x)
}

ansrosenbrock0 <- Rcgmin(fn=fr,gr=grn, par=c(1,2))
print(ansrosenbrock0) # use print to allow copy to separate file that
# can be called using source()
#####
# Simple bounds and masks test
bt.f<-function(x){
  sum(x*x)
}

bt.g<-function(x){
  gg<-2.0*x
}

n<-10
xx<-rep(0,n)
```

```

lower<-rep(0,n)
upper<-lower # to get arrays set
bdmsk<-rep(1,n)
bdmsk[(trunc(n/2)+1)]<-0
for (i in 1:n) {
  lower[i]<-1.0*(i-1)*(n-1)/n
  upper[i]<-1.0*i*(n+1)/n
}
xx<-0.5*(lower+upper)
ansbt<-Rcgmin(xx, bt.f, bt.g, lower, upper, bdmsk, control=list(trace=1))

print(ansbt)

#####
genrose.f<- function(x, gs=NULL){ # objective function
## One generalization of the Rosenbrock banana valley function (n parameters)
  n <- length(x)
  if(is.null(gs)) { gs=100.0 }
  fval<-1.0 + sum (gs*(x[1:(n-1)]^2 - x[2:n])^2 + (x[2:n] - 1)^2)
  return(fval)
}
genrose.g <- function(x, gs=NULL){
# vectorized gradient for genrose.f
# Ravi Varadhan 2009-04-03
  n <- length(x)
  if(is.null(gs)) { gs=100.0 }
  gg <- as.vector(rep(0, n))
  tn <- 2:n
  tn1 <- tn - 1
  z1 <- x[tn] - x[tn1]^2
  z2 <- 1 - x[tn]
  gg[tn] <- 2 * (gs * z1 - z2)
  gg[tn1] <- gg[tn1] - 4 * gs * x[tn1] * z1
  gg
}

# analytic gradient test
xx<-rep(pi,10)
lower<-NULL
upper<-NULL
bdmsk<-NULL
genrosea<-Rcgmin(xx,genrose.f, genrose.g, gs=10)
genrosen<-optimr(xx, genrose.f, "grfwd", method="Rcgmin", gs=10)
genrosenn<-try(Rcgmin(xx,genrose.f, gs=10)) # use local numerical gradient
cat("genrosea uses analytic gradient\n")
print(genrosea)
cat("genrosen uses default gradient approximation\n")
print(genrosen)

cat("timings B vs U\n")
lo<-rep(-100,10)
up<-rep(100,10)
bdmsk<-rep(1,10)

```



```

tb<-system.time(ab<-Rcgminb(xx,genrose.f, genrose.g, lower=lo, upper=up, bdmsk=bdmsk))[1]
tu<-system.time(au<-Rcgminu(xx,genrose.f, genrose.g))[1]
cat("times U=",tu," B=",tb,"\n")
cat("solution Rcgminu\n")
print(au)
cat("solution Rcgminb\n")
print(ab)
cat("diff fu-fb=",au$value-ab$value,"\n")
cat("max abs parameter diff = ", max(abs(au$par-ab$par)), "\n")

maxfn<-function(x) {
  n<-length(x)
  ss<-seq(1,n)
  f<-10-(crossprod(x-ss))^2
  f<-as.numeric(f)
  return(f)
}

gmaxfn<-function(x) {
  gg<-grad(maxfn, x)
}

negmaxfn<-function(x) {
  f<-(-1)*maxfn(x)
  return(f)
}

cat("test that maximize=TRUE works correctly\n")

n<-6
xx<-rep(1,n)
ansmax<-Rcgmin(xx,maxfn, gmaxfn, control=list(maximize=TRUE,trace=1))
print(ansmax)

cat("using the negmax function should give same parameters\n")
ansnegmaxn<-optimr(xx,negmaxfn, "grfwd", method="Rcgmin", control=list(trace=1))
print(ansnegmaxn)

##### From Rvmin.Rd
cat("test bounds and masks\n")
nn<-4
startx<-rep(pi,nn)
lo<-rep(2,nn)
up<-rep(10,nn)
grbds1<-Rcgmin(startx,genrose.f, gr=genrose.g,lower=lo,upper=up)
print(grbds1)

cat("test lower bound only\n")
nn<-4

```

```

startx<-rep(pi,nn)
lo<-rep(2,nn)
grbds2<-Rcgmin(startx,genrose.f, gr=genrose.g,lower=lo)
print(grbds2)

cat("test lower bound single value only\n")
nn<-4
startx<-rep(pi,nn)
lo<-2
up<-rep(10,nn)
grbds3<-Rcgmin(startx,genrose.f, gr=genrose.g,lower=lo)
print(grbds3)

cat("test upper bound only\n")
nn<-4
startx<-rep(pi,nn)
lo<-rep(2,nn)
up<-rep(10,nn)
grbds4<-Rcgmin(startx,genrose.f, gr=genrose.g,upper=up)
print(grbds4)

cat("test upper bound single value only\n")
nn<-4
startx<-rep(pi,nn)
grbds5<-Rcgmin(startx,genrose.f, gr=genrose.g,upper=10)
print(grbds5)

cat("test masks only\n")
nn<-6
bd<-c(1,1,0,0,1,1)
startx<-rep(pi,nn)
grbds6<-Rcgmin(startx,genrose.f, gr=genrose.g,bdmsk=bd)
print(grbds6)

cat("test upper bound on first two elements only\n")
nn<-4
startx<-rep(pi,nn)
upper<-c(10,8, Inf, Inf)
grbds7<-Rcgmin(startx,genrose.f, gr=genrose.g,upper=upper)
print(grbds7)

cat("test lower bound on first two elements only\n")
nn<-4
startx<-rep(0,nn)
lower<-c(0,1.1, -Inf, -Inf)
grbds8<-Rcgmin(startx,genrose.f,genrose.g,lower=lower, control=list(maxit=2000))
print(grbds8)

cat("test n=1 problem using simple squares of parameter\n")

```

```

sqtst<-function(xx) {
  res<-sum((xx-2)*(xx-2))
}

gsqtst<-function(xx) {
  gg<-2*(xx-2)
}

##### One dimension test
nn<-1
startx<-rep(0,nn)
onepar<-Rcgmin(startx,sqtst, gr=gsqtst,control=list(trace=1))
print(onepar)

cat("Suppress warnings\n")
oneparnw<-Rcgmin(startx,sqtst, gr=gsqtst,control=list(dowarn=FALSE,trace=1))
print(oneparnw)

```

---

Rcgminb	<i>An R implementation of a bounded nonlinear conjugate gradient algorithm with the Dai / Yuan update and restart. Based on Nash (1979) Algorithm 22 for its main structure. CALL THIS VIA Rcgmin AND DO NOT USE DIRECTLY.</i>
---------	--

---

## Description

The purpose of Rcgminb is to minimize a bounds (box) and mask constrained function of many parameters by a nonlinear conjugate gradients method. This code is entirely in R to allow users to explore and understand the method. It allows bounds (or box) constraints and masks (equality constraints) to be imposed on parameters.

This code should be called through Rcgmin which selects Rcgminb or Rcgminu according to the presence of bounds and masks.

## Usage

```
Rcgminb(par, fn, gr, lower, upper, bdmsk, control = list(), ...)
```

## Arguments

par	A numeric vector of starting estimates.
fn	A function that returns the value of the objective at the supplied set of parameters par using auxiliary data in .... The first argument of fn must be par.
gr	A function that returns the gradient of the objective at the supplied set of parameters par using auxiliary data in .... The first argument of fn must be par. This function returns the gradient as a numeric vector. The use of numerical gradients for Rcgminb is <b>STRONGLY</b> discouraged.

lower	A vector of lower bounds on the parameters.
upper	A vector of upper bounds on the parameters.
bdmsk	An indicator vector, having 1 for each parameter that is "free" or unconstrained, and 0 for any parameter that is fixed or MASKED for the duration of the optimization.
control	An optional list of control settings.
...	Further arguments to be passed to fn.

### Details

Functions `fn` must return a numeric value.

The `control` argument is a list.

**maxit** A limit on the number of iterations (default 500). Note that this is used to compute a quantity  $\text{maxfeval} < -\text{round}(\sqrt{n+1}) * \text{maxit}$  where  $n$  is the number of parameters to be minimized.

**trace** Set 0 (default) for no output, >0 for trace output (larger values imply more output).

**eps** Tolerance used to calculate numerical gradients. Default is 1.0E-7. See source code for `Rcgminb` for details of application.

`dowarn = TRUE` if we want warnings generated by `optimx`. Default is `TRUE`.

**Note:** The source code `Rcgminb` for `R` is likely to remain a work in progress for some time, so users should watch the console output.

As of 2011-11-21 the following controls have been REMOVED

**usenumDeriv** There is now a choice of numerical gradient routines. See argument `gr`.

**maximize** To maximize `user_function`, supply a function that computes  $(-1) * \text{user\_function}$ . An alternative is to call `Rcgmin` via the package `optimx`.

### Value

A list with components:

<code>par</code>	The best set of parameters found.
<code>value</code>	The value of the objective at the best set of parameters found.
<code>counts</code>	A two-element integer vector giving the number of calls to 'fn' and 'gr' respectively. This excludes those calls needed to compute the Hessian, if requested, and any calls to 'fn' to compute a finite-difference approximation to the gradient.
<code>convergence</code>	An integer code. '0' indicates successful convergence. '1' indicates that the function evaluation count 'maxfeval' was reached. '2' indicates initial point is infeasible.
<code>message</code>	A character string giving any additional information returned by the optimizer, or 'NULL'.
<code>bdmsk</code>	Returned index describing the status of bounds and masks at the proposed solution. Parameters for which <code>bdmsk</code> are 1 are unconstrained or "free", those with <code>bdmsk</code> 0 are masked i.e., fixed. For historical reasons, we indicate a parameter is at a lower bound using -3 or upper bound using -1.

## References

See Rcgmin documentation. Note that bounds and masks were adapted from the work by Nash and Walker-Smith(1987).

## See Also

[optim](#)

---

Rcgminu	<i>An R implementation of an unconstrained nonlinear conjugate gradient algorithm with the Dai / Yuan update and restart. Based on Nash (1979) Algorithm 22 for its main structure. CALL THIS VIA Rcgmin AND DO NOT USE DIRECTLY.</i>
---------	---

---

## Description

The purpose of Rcgminu is to minimize an unconstrained function of many parameters by a nonlinear conjugate gradients method. This code is entirely in R to allow users to explore and understand the method.

This code should be called through Rcgmin which selects Rcgminb or Rcgminu according to the presence of bounds and masks.

## Usage

```
Rcgminu(par, fn, gr, control = list(), ...)
```

## Arguments

par	A numeric vector of starting estimates.
fn	A function that returns the value of the objective at the supplied set of parameters par using auxiliary data in .... The first argument of fn must be par.
gr	A function that returns the gradient of the objective at the supplied set of parameters par using auxiliary data in .... The first argument of fn must be par. This function returns the gradient as a numeric vector. The use of numerical gradients for Rcgminu is <b>STRONGLY</b> discouraged.
control	An optional list of control settings.
...	Further arguments to be passed to fn.

## Details

Functions fn must return a numeric value.

The control argument is a list.

**maxit** A limit on the number of iterations (default 500). Note that this is used to compute a quantity  $\text{maxfeval} \leftarrow \text{round}(\sqrt{n+1} * \text{maxit})$  where n is the number of parameters to be minimized.

**trace** Set 0 (default) for no output, >0 for trace output (larger values imply more output).

**eps** Tolerance used to calculate numerical gradients. Default is 1.0E-7. See source code for Rcgminu for details of application.

dowarn = TRUE if we want warnings generated by optimx. Default is TRUE.

**Note:** The source code Rcgminu for R is likely to remain a work in progress for some time, so users should watch the console output.

As of 2011-11-21 the following controls have been REMOVED

**usenumDeriv** There is now a choice of numerical gradient routines. See argument gr.

**maximize** To maximize user\_function, supply a function that computes (-1)\*user\_function. An alternative is to call Rcgmin via the package optimx.

## Value

A list with components:

par	The best set of parameters found.
value	The value of the objective at the best set of parameters found.
counts	A two-element integer vector giving the number of calls to 'fn' and 'gr' respectively. This excludes those calls needed to compute the Hessian, if requested, and any calls to 'fn' to compute a finite-difference approximation to the gradient.
convergence	An integer code. '0' indicates successful convergence. '1' indicates that the function evaluation count 'maxfeval' was reached. '2' indicates initial point is infeasible.
message	A character string giving any additional information returned by the optimizer, or 'NULL'.
bdmsk	Returned index describing the status of bounds and masks at the proposed solution. Parameters for which bdmsk are 1 are unconstrained or "free", those with bdmsk 0 are masked i.e., fixed. For historical reasons, we indicate a parameter is at a lower bound using -3 or upper bound using -1.

## References

See Rcgmin documentation.

## See Also

[optim](#)

**Description**

A driver to call the unconstrained and bounds constrained versions of an R implementation of a variable metric method for minimization of nonlinear functions, possibly subject to bounds (box) constraints and masks (fixed parameters). The algorithm is based on Nash (1979) Algorithm 21 for main structure, which is itself drawn from Fletcher's (1970) variable metric code. This is also the basis of `optim()` method 'BFGS' which, however, does not deal with bounds or masks. In the present method, an approximation to the inverse Hessian ( $B$ ) is used to generate a search direction  $t = -B \%*\% g$ , a simple backtracking line search is used until an acceptable point is found, and the matrix  $B$  is updated using a BFGS formula. If no acceptable point can be found, we reset  $B$  to the identity i.e., the search direction becomes the negative gradient. If the search along the negative gradient is unsuccessful, the method terminates.

This set of codes is entirely in R to allow users to explore and understand the method. It also allows bounds (or box) constraints and masks (equality constraints) to be imposed on parameters.

**Usage**

```
Rvmmmin(par, fn, gr, lower, upper, bdmsk, control = list(), ...)
```

```
nvm(par, fn, gr, bds, control = list())
```

**Arguments**

- |                  |   |
|------------------|---|
| <code>par</code> | A numeric vector of starting estimates.   |
| <code>fn</code>  | A function that returns the value of the objective at the supplied set of parameters <code>par</code> using auxiliary data in <code>...</code> . The first argument of <code>fn</code> must be <code>par</code> .   |
| <code>gr</code>  | A function that returns the gradient of the objective at the supplied set of parameters <code>par</code> using auxiliary data in <code>...</code> . The first argument of <code>fn</code> must be <code>par</code> . This function returns the gradient as a numeric vector.<br><br>Note that a gradient function must generally be provided. However, to ensure compatibility with other optimizers, if <code>gr</code> is <code>NULL</code> , the forward gradient approximation from routine <code>grfwd</code> will be used.<br><br>The use of numerical gradients for <code>Rvmmmin</code> is discouraged. First, the termination test uses a size measure on the gradient, and numerical gradient approximations can sometimes give results that are too large. Second, if there are bounds constraints, the step(s) taken to calculate the approximation to the derivative are NOT checked to see if they are out of bounds, and the function may be undefined at the evaluation point.<br><br>There is also the option of using the routines <code>grfwd</code> , <code>grback</code> , <code>grcentral</code> or <code>grnd</code> . The last of these calls the <code>grad()</code> function from package <code>numDeriv</code> . These are called by putting the name of the (numerical) gradient function in quotation marks, e.g., |

	<code>gr="grfwd"</code>
	to use the standard forward difference numerical approximation.
	Note that all but the <code>grnd</code> routine use a stepsize parameter that can be redefined in a special scratchpad storage variable <code>deps</code> . The default is <code>deps = 1e-07</code> . However, redefining this is discouraged unless you understand what you are doing.
<code>bds</code>	A list of information resulting from function <code>bmchk</code> giving information on the status of the parameters and bounds and masks.
<code>lower</code>	A vector of lower bounds on the parameters.
<code>upper</code>	A vector of upper bounds on the parameters.
<code>bdmsk</code>	An indicator vector, having 1 for each parameter that is "free" or unconstrained, and 0 for any parameter that is fixed or MASKED for the duration of the optimization.
<code>control</code>	An optional list of control settings.
<code>...</code>	Further arguments to be passed to <code>fn</code> .

### Details

Note that `nvm` is to be called from `optimr` and does NOT allow dot arguments. It is intended to use the internal functions `efn` and `egr` generated inside `optimr()` along with bounds information from `bmchk()` available there.

The source codes `Rvmmmin` and `nvm` for R are still a work in progress, so users should watch the console output. The routine `nvm` attempts to use minimal checking and works only with a bounds constrained version of the algorithm, which may work as fast as a specific routine for unconstrained problems. This is an open question, and the author welcomes feedback.

Function `fn` must return a numeric value.

The `control` argument is a list.

The `control` argument is a list.

**maxit** A limit on the number of iterations (default  $500 + 2*n$  where  $n$  is the number of parameters). This is the maximum number of gradient evaluations allowed.

**maxfeval** A limit on the number of function evaluations allowed (default  $3000 + 10*n$ ).

**trace** Set 0 (default) for no output,  $> 0$  for diagnostic output (larger values imply more output).

**dowarn** = TRUE if we want warnings generated by `optimx`. Default is TRUE.

**checkgrad** = TRUE if we wish analytic gradient code checked against the approximations computed by `numDeriv`. Default is FALSE.

**checkbounds** = TRUE if we wish parameters and bounds to be checked for an admissible and feasible start. Default is TRUE.

**keepinputpar** = TRUE if we want bounds check to stop program when parameters are out of bounds. Else when FALSE, moves parameter values to nearest bound. Default is FALSE.

**maximize** To maximize `user_function`, supply a function that computes  $(-1)*user\_function$ . An alternative is to call `Rvmmmin` via the package `optimx`.



**eps** a tolerance used for judging small gradient norm (default = 1e-07). a gradient norm smaller than  $(1 + \text{abs}(\text{fmin})) * \text{eps} * \text{eps}$  is considered small enough that a local optimum has been found, where *fmin* is the current estimate of the minimal function value.

**acctol** To adjust the acceptable point tolerance (default 0.0001) in the test ( $f \leq \text{fmin} + \text{gradproj} * \text{steplength} * \text{acctol}$ ). This test is used to ensure progress is made at each iteration.

**stepredn** Step reduction factor for backtrack line search (default 0.2)

**reltest** Additive shift for equality test (default 100.0)

**stopbadupdate** A logical flag that if set TRUE will halt the optimization if the Hessian inverse cannot be updated after a steepest descent search. This indicates an ill-conditioned Hessian. A setting of FALSE causes Rvmmmin methods to be aggressive in trying to optimize the function, but may waste effort. Default TRUE.

As of 2011-11-21 the following controls have been REMOVED

**usenumDeriv** There is now a choice of numerical gradient routines. See argument *gr*.

## Value

A list with components:

<i>par</i>	The best set of parameters found.
<i>value</i>	The value of the objective at the best set of parameters found.
<i>counts</i>	A vector of two integers giving the number of function and gradient evaluations.
<i>convergence</i>	An integer indicating the situation on termination of the function. 0 indicates that the method believes it has succeeded. Other values: 0 indicates successful termination to an acceptable solution 1 indicates that the iteration limit <i>maxit</i> had been reached. 2 indicates that a point with a small gradient norm has been found, which is likely a solution. 20 indicates that the initial set of parameters is inadmissible, that is, that the function cannot be computed or returns an infinite, NULL, or NA value. 21 indicates that an intermediate set of parameters is inadmissible.
<i>message</i>	A description of the situation on termination of the function.
<i>bdmsk</i>	Returned index describing the status of bounds and masks at the proposed solution. Parameters for which <i>bdmsk</i> are 1 are unconstrained or "free", those with <i>bdmsk</i> 0 are masked i.e., fixed. For historical reasons, we indicate a parameter is at a lower bound using -3 or upper bound using -1.

## References

Fletcher, R (1970) A New Approach to Variable Metric Algorithms, *Computer Journal*, 13(3), pp. 317-322.

Nash, J C (1979, 1990) *Compact Numerical Methods for Computers: Linear Algebra and Function Minimisation*, Bristol: Adam Hilger. Second Edition, Bristol: Institute of Physics Publications.

**See Also**[optim](#)**Examples**

```
#####
## All examples for the Rvmmmin package are in this .Rd file
##

## Rosenbrock Banana function
fr <- function(x) {
  x1 <- x[1]
  x2 <- x[2]
  100 * (x2 - x1 * x1)^2 + (1 - x1)^2
}

ansrosenbrock <- Rvmmmin(fn=fr,gr="grfwd", par=c(1,2))
print(ansrosenbrock)
cat("\n")
cat("No gr specified as a test\n")
ansrosenbrock0 <- Rvmmmin(fn=fr, par=c(1,2))
print(ansrosenbrock0)
# use print to allow copy to separate file that can be called using source()

#####
# Simple bounds and masks test
#
# The function is a sum of squares, but we impose the
# constraints so that there are lower and upper bounds
# away from zero, and parameter 6 is fixed at the initial
# value

bt.f<-function(x){
  sum(x*x)
}

bt.g<-function(x){
  gg<-2.0*x
}

n<-10
xx<-rep(0,n)
lower<-rep(0,n)
upper<-lower # to get arrays set
bdmsk<-rep(1,n)
bdmsk[(trunc(n/2)+1)]<-0
for (i in 1:n) {
  lower[i]<-1.0*(i-1)*(n-1)/n
  upper[i]<-1.0*i*(n+1)/n
}
xx<-0.5*(lower+upper)
cat("Initial parameters:")
```

```

print(xx)
cat("Lower bounds:")
print(lower)
cat("upper bounds:")
print(upper)
cat("Masked (fixed) parameters:")
print(which(bdmsk == 0))

ansbt<-Rvmmmin(xx, bt.f, bt.g, lower, upper, bdmsk, control=list(trace=1))

print(ansbt)

#####
# A version of a generalized Rosenbrock problem
genrose.f<- function(x, gs=NULL){ # objective function
  ## One generalization of the Rosenbrock banana valley function (n parameters)
  n <- length(x)
  if(is.null(gs)) { gs=100.0 }
  fval<-1.0 + sum (gs*(x[1:(n-1)]^2 - x[2:n])^2 + (x[2:n] - 1)^2)
  return(fval)
}
genrose.g <- function(x, gs=NULL){
  # vectorized gradient for genrose.f
  # Ravi Varadhan 2009-04-03
  n <- length(x)
  if(is.null(gs)) { gs=100.0 }
  gg <- as.vector(rep(0, n))
  tn <- 2:n
  tn1 <- tn - 1
  z1 <- x[tn] - x[tn1]^2
  z2 <- 1 - x[tn]
  gg[tn] <- 2 * (gs * z1 - z2)
  gg[tn1] <- gg[tn1] - 4 * gs * x[tn1] * z1
  gg
}

# analytic gradient test
xx<-rep(pi,10)
lower<-NULL
upper<-NULL
bdmsk<-NULL
genrosea<-Rvmmmin(xx,genrose.f, genrose.g, gs=10)
genrosenf<-Rvmmmin(xx,genrose.f, gr="grfwd", gs=10) # use local numerical gradient
genrosenullgr<-Rvmmmin(xx,genrose.f, gs=10) # no gradient specified
cat("genrosea uses analytic gradient\n")
print(genrosea)
cat("genrosenf uses grfwd standard numerical gradient\n")
print(genrosenf)
cat("genrosenullgr has no gradient specified\n")
print(genrosenullgr)
cat("Other numerical gradients can be used.\n")

cat("timings B vs U\n")

```

```

lo<-rep(-100,10)
up<-rep(100,10)
bdmsk<-rep(1,10)
tb<-system.time(ab<-Rvmmminb(xx,genrose.f, genrose.g, lower=lo, upper=up, bdmsk=bdmsk))[1]
tu<-system.time(au<-Rvmmminu(xx,genrose.f, genrose.g))[1]
cat("times U=",tu," B=",tb,"\n")
cat("solution Rvmmminu\n")
print(au)
cat("solution Rvmmminb\n")
print(ab)
cat("diff fu-fb=",au$value-ab$value,"\n")
cat("max abs parameter diff = ", max(abs(au$par-ab$par)),"\n")

# Test that Rvmmmin will maximize as well as minimize

maxfn<-function(x) {
  n<-length(x)
  ss<-seq(1,n)
  f<-10-(crossprod(x-ss))^2
  f<-as.numeric(f)
  return(f)
}

negmaxfn<-function(x) {
  f<-(-1)*maxfn(x)
  return(f)
}

cat("test that maximize=TRUE works correctly\n")

n<-6
xx<-rep(1,n)
ansmax<-Rvmmmin(xx,maxfn, gr="grfwd", control=list(maximize=TRUE,trace=1))
print(ansmax)

cat("using the negmax function should give same parameters\n")
ansnegmax<-Rvmmmin(xx,negmaxfn, gr="grfwd", control=list(trace=1))
print(ansnegmax)

#####
cat("test bounds and masks\n")
nn<-4
startx<-rep(pi,nn)
lo<-rep(2,nn)
up<-rep(10,nn)
grbds1<-Rvmmmin(startx,genrose.f, genrose.g, lower=lo,upper=up)
print(grbds1)

cat("test lower bound only\n")
nn<-4
startx<-rep(pi,nn)

```

```

lo<-rep(2,nn)
grbds2<-Rvmmmin(startx,genrose.f, genrose.g, lower=lo)
print(grbds2)

cat("test lower bound single value only\n")
nn<-4
startx<-rep(pi,nn)
lo<-2
up<-rep(10,nn)
grbds3<-Rvmmmin(startx,genrose.f, genrose.g, lower=lo)
print(grbds3)

cat("test upper bound only\n")
nn<-4
startx<-rep(pi,nn)
lo<-rep(2,nn)
up<-rep(10,nn)
grbds4<-Rvmmmin(startx,genrose.f, genrose.g, upper=up)
print(grbds4)

cat("test upper bound single value only\n")
nn<-4
startx<-rep(pi,nn)
grbds5<-Rvmmmin(startx,genrose.f, genrose.g, upper=10)
print(grbds5)

cat("test masks only\n")
nn<-6
bd<-c(1,1,0,0,1,1)
startx<-rep(pi,nn)
grbds6<-Rvmmmin(startx,genrose.f, genrose.g, bdmsk=bd)
print(grbds6)

cat("test upper bound on first two elements only\n")
nn<-4
startx<-rep(pi,nn)
upper<-c(10,8, Inf, Inf)
grbds7<-Rvmmmin(startx,genrose.f, genrose.g, upper=upper)
print(grbds7)

cat("test lower bound on first two elements only\n")
nn<-4
startx<-rep(0,nn)
lower<-c(0,1.1, -Inf, -Inf)
grbds8<-Rvmmmin(startx,genrose.f,genrose.g,lower=lower, control=list(maxit=2000))
print(grbds8)

cat("test n=1 problem using simple squares of parameter\n")

sqtst<-function(xx) {

```

```

    res<-sum((xx-2)*(xx-2))
  }

  nn<-1
  startx<-rep(0,nn)
  onepar<-Rvmmmin(startx,sqtst, gr="grfwd", control=list(trace=1))
  print(onepar)

  cat("Suppress warnings\n")
  oneparnw<-Rvmmmin(startx,sqtst, gr="grfwd", control=list(dowarn=FALSE,trace=1))
  print(oneparnw)

```

---

Rvmmminb	<i>Variable metric nonlinear function minimization with bounds constraints</i>
----------	--

---

### Description

A bounds-constrained R implementation of a variable metric method for minimization of nonlinear functions subject to bounds (box) constraints and masks (fixed parameters).

See manual Rvmmmin.Rd for more details and examples.

### Usage

```
Rvmmminb(par, fn, gr, lower, upper, bdmsk, control = list(), ...)
```

### Arguments

par	A numeric vector of starting estimates.
fn	A function that returns the value of the objective at the supplied set of parameters par using auxiliary data in ... The first argument of fn must be par.
gr	A function that returns the gradient of the objective at the supplied set of parameters par using auxiliary data in ... The first argument of fn must be par. This function returns the gradient as a numeric vector. Note that a gradient function <b>MUST</b> be provided. See the manual for Rvmmmin, which is the usual way Rvmmminb is called. The user must take responsibility for errors if Rvmmminb is called directly.
lower	A vector of lower bounds on the parameters.
upper	A vector of upper bounds on the parameters.
bdmsk	An indicator vector, having 1 for each parameter that is "free" or unconstrained, and 0 for any parameter that is fixed or MASKED for the duration of the optimization.
control	An optional list of control settings. See the manual Rvmmmin.Rd for details.
...	Further arguments to be passed to fn.

**Details**

This routine is intended to be called from Rvmmmin, which will, if necessary, supply a gradient approximation. However, some users will want to avoid the extra overhead, in which case it is important to provide an appropriate and high-accuracy gradient routine.

Note that bounds checking, if it is carried out, is done by Rvmmmin.

Functions `fn` must return a numeric value.

**Value**

A list with components:

<code>par</code>	The best set of parameters found.
<code>value</code>	The value of the objective at the best set of parameters found.
<code>counts</code>	A vector of two integers giving the number of function and gradient evaluations.
<code>convergence</code>	An integer indicating the situation on termination of the function. 0 indicates that the method believes it has succeeded. Other values: 1 indicates that the iteration limit <code>maxit</code> had been reached. 20 indicates that the initial set of parameters is inadmissible, that is, that the function cannot be computed or returns an infinite, NULL, or NA value. 21 indicates that an intermediate set of parameters is inadmissible.
<code>message</code>	A description of the situation on termination of the function.
<code>bdmsk</code>	Returned index describing the status of bounds and masks at the proposed solution. Parameters for which <code>bdmsk</code> are 1 are unconstrained or "free", those with <code>bdmsk</code> 0 are masked i.e., fixed. For historical reasons, we indicate a parameter is at a lower bound using -3 or upper bound using -1.

**See Also**

[optim](#)

**Examples**

```
## See Rvmmmin.Rd
```

---

Rvmmminu

*Variable metric nonlinear function minimization, unconstrained*

---

**Description**

An R implementation of a variable metric method for minimization of unconstrained nonlinear functions.

See the manual Rvmmmin.Rd for details.

**Usage**

```
Rvmmminu(par, fn, gr, control = list(), ...)
```

**Arguments**

par	A numeric vector of starting estimates.
fn	A function that returns the value of the objective at the supplied set of parameters par using auxiliary data in ... The first argument of fn must be par.
gr	A function that returns the gradient of the objective at the supplied set of parameters par using auxiliary data in ... The first argument of fn must be par. This function returns the gradient as a numeric vector. Note that a gradient function <b>MUST</b> be provided. See the manual for Rvmmmin, which is the usual way Rvmmminu is called. The user must take responsibility for errors if Rvmmminu is called directly.
control	An optional list of control settings. See the manual Rvmmmin.Rd for details. Some control elements apply only when parameters are bounds constrained and are not used in this function.
...	Further arguments to be passed to fn.

**Details**

This routine is intended to be called from Rvmmmin, which will, if necessary, supply a gradient approximation. However, some users will want to avoid the extra overhead, in which case it is important to provide an appropriate and high-accuracy gradient routine.

Functions fn must return a numeric value.

**Value**

A list with components:

par	The best set of parameters found.
value	The value of the objective at the best set of parameters found.
counts	A vector of two integers giving the number of function and gradient evaluations.
convergence	An integer indicating the situation on termination of the function. 0 indicates that the method believes it has succeeded. Other values: 1 indicates that the iteration limit maxit had been reached. 20 indicates that the initial set of parameters is inadmissible, that is, that the function cannot be computed or returns an infinite, NULL, or NA value. 21 indicates that an intermediate set of parameters is inadmissible.
message	A description of the situation on termination of the function.

**See Also**

[optim](#)



**Examples**

```
####in Rvmin.Rd ####
```

---

scalechk	<i>Check the scale of the initial parameters and bounds input to an optimization code used in nonlinear optimization</i>
----------	--

---

**Description**

Nonlinear optimization problems often have different scale for different parameters. This function is intended to explore the differences in scale. It is, however, an imperfect and heuristic tool, and could be improved.

At this time scalechk ignores parameters and bounds for fixed (masked) parameters for calculations of scaling measures. The rationale for this is that such parameters are outside the optimization process.

**Usage**

```
scalechk(par, lower = lower, upper = upper, bdmsk=NULL, dowarn = TRUE)
```

**Arguments**

par	A numeric vector of starting values of the optimization function parameters.
lower	A vector of lower bounds on the parameters.
upper	A vector of upper bounds on the parameters.
bdmsk	An indicator vector, having 1 for each parameter that is "free" or unconstrained, and 0 for any parameter that is fixed or MASKED for the duration of the optimization. May be NULL.
dowarn	Set TRUE to issue warnings. Otherwise this is a silent routine. Default TRUE.

**Details**

The scalechk function will check that the bounds exist and are admissible, that is, that there are no lower bounds that exceed upper bounds.

NOTE: Free paramters outside bounds are adjusted to the nearest bound. We then set parchanged = TRUE which implies the original parameters were infeasible.

**Value**

A list with components:

# Returns: # list(lpratio, lbratio) – the log of the ratio of largest to smallest parameters # and bounds intervals (upper-lower) in absolute value (ignoring Inf, NULL, NA)

lpratio	The log of the ratio of largest to smallest parameters in absolute value (ignoring Inf, NULL, NA)
lbratio	The log of the ratio of largest to smallest bounds intervals (upper-lower) in absolute value (ignoring Inf, NULL, NA)

**Examples**

```
#####
par <- c(-1.2, 1)
lower <- c(-2, 0)
upper <- c(100000, 10)
srat<-scalechk(par, lower, upper,dowarn=TRUE)
print(srat)
sratv<-c(srat$lpratio, srat$lbratio)
if (max(sratv,na.rm=TRUE) > 3) { # scaletol from ctrldefault in optimx
  warnstr<-"Parameters or bounds appear to have different scalings.\n
  This can cause poor performance in optimization. \n
  It is important for derivative free methods like BOBYQA, UOBYQA, NEWUOA."
  cat(warnstr,"\n")
}
```

snewton

*Safeguarded Newton methods for function minimization using R functions.*

**Description**

These versions of the safeguarded Newton solve the Newton equations with the R function solve(). In snewton a backtracking line search is used, while in snewtonm we rely on a Marquardt stabilization.

**Usage**

```
snewton(par, fn, gr, hess, control = list(trace=0, maxit=500), ...)
```

```
snewtm(par, fn, gr, hess, bds, control = list(trace=0, maxit=500))
```

**Arguments**

par	A numeric vector of starting estimates.
fn	A function that returns the value of the objective at the supplied set of parameters par using auxiliary data in .... The first argument of fn must be par.
gr	A function that returns the gradient of the objective at the supplied set of parameters par using auxiliary data in .... The first argument of fn must be par. This function returns the gradient as a numeric vector.
hess	A function to compute the Hessian matrix. This should be provided as a square, symmetric matrix.
bds	Result of bmchk() for the current problem. Contains lower and upper etc.
control	An optional list of control settings.
...	Further arguments to be passed to fn.

## Details

snewtm is intended to be called from `optimr()`.

Functions `fn` must return a numeric value. `gr` must return a vector. `hess` must return a matrix. The control argument is a list. See the code for `snewton.R` for completeness. Some of the values that may be important for users are:

**trace** Set 0 (default) for no output, > 0 for diagnostic output (larger values imply more output).

**watch** Set TRUE if the routine is to stop for user input (e.g., Enter) after each iteration. Default is FALSE.

**maxit** A limit on the number of iterations (default  $500 + 2*n$  where  $n$  is the number of parameters). This is the maximum number of gradient evaluations allowed.

**maxfeval** A limit on the number of function evaluations allowed (default  $3000 + 10*n$ ).

**eps** a tolerance used for judging small gradient norm (default =  $1e-07$ ). a gradient norm smaller than  $(1 + \text{abs}(fmin))*\text{eps}*\text{eps}$  is considered small enough that a local optimum has been found, where `fmin` is the current estimate of the minimal function value.

**acctol** To adjust the acceptable point tolerance (default 0.0001) in the test ( $f \leq fmin + \text{gradproj} * \text{steplength} * \text{acctol}$ ). This test is used to ensure progress is made at each iteration.

**stepdec** Step reduction factor for backtrack line search (default 0.2)

**defstep** Initial stepsize default (default 1)

**reltest** Additive shift for equality test (default 100.0)

The (unconstrained) solver `snewtonmu` proved to be slower than the bounded solver called without bounds, so has been withdrawn.

The `snewton` safeguarded Newton uses a simple line search but no linear solution stabilization and has demonstrated POOR performance and reliability. NOT recommended.

## Value

A list with components:

**par** The best set of parameters found.

**value** The value of the objective at the best set of parameters found.

**grad** The value of the gradient at the best set of parameters found. A vector.

**hessian** The value of the Hessian at the best set of parameters found. A matrix.

**counts** A vector of 4 integers giving number of Newton equation solutions, the number of function evaluations, the number of gradient evaluations and the number of hessian evaluations.

**message** A message giving some information on the status of the solution.

## References

Nash, J C (1979, 1990) Compact Numerical Methods for Computers: Linear Algebra and Function Minimisation, Bristol: Adam Hilger. Second Edition, Bristol: Institute of Physics Publications.

## See Also

[optim](#)

**Examples**

```

#Rosenbrock banana valley function
f <- function(x){
  return(100*(x[2] - x[1]*x[1])^2 + (1-x[1])^2)
}
#gradient
gr <- function(x){
  return(c(-400*x[1]*(x[2] - x[1]*x[1]) - 2*(1-x[1]), 200*(x[2] - x[1]*x[1])))
}
#Hessian
h <- function(x) {
  a11 <- 2 - 400*x[2] + 1200*x[1]*x[1]; a21 <- -400*x[1]
  return(matrix(c(a11, a21, a21, 200), 2, 2))
}

fg <- function(x){ #function and gradient
  val <- f(x)
  attr(val,"gradient") <- gr(x)
  val
}
fgh <- function(x){ #function and gradient
  val <- f(x)
  attr(val,"gradient") <- gr(x)
  attr(val,"hessian") <- h(x)
  val
}

x0 <- c(-1.2, 1)

sr <- snewton(x0, fn=f, gr=gr, hess=h, control=list(trace=1))
print(sr)
# Call through optimr to get correct calling sequence, esp. with bounds
srm <- optimr(x0, fn=f, gr=gr, hess=h, control=list(trace=1))
print(srm)

# bounds constrained example

lo <- rep((min(x0)-0.1), 2)
up <- rep((max(x0)+0.1), 2)
# Call through optimr to get correct calling sequence, esp. with bounds
srmb <- optimr(x0, fn=f, gr=gr, hess=h, lower=lo, upper=up, control=list(trace=1))
proptimr(srmb)

#Example 2: Wood function
#
wood.f <- function(x){
  res <- 100*(x[1]^2-x[2])^2+(1-x[1])^2+90*(x[3]^2-x[4])^2+(1-x[3])^2+
    10.1*((1-x[2])^2+(1-x[4])^2)+19.8*(1-x[2])*(1-x[4])
  return(res)
}
#gradient:

```

```

wood.g <- function(x){
  g1 <- 400*x[1]^3-400*x[1]*x[2]+2*x[1]-2
  g2 <- -200*x[1]^2+220.2*x[2]+19.8*x[4]-40
  g3 <- 360*x[3]^3-360*x[3]*x[4]+2*x[3]-2
  g4 <- -180*x[3]^2+200.2*x[4]+19.8*x[2]-40
  return(c(g1,g2,g3,g4))
}
#hessian:
wood.h <- function(x){
  h11 <- 1200*x[1]^2-400*x[2]+2;   h12 <- -400*x[1]; h13 <- h14 <- 0
  h22 <- 220.2; h23 <- 0;   h24 <- 19.8
  h33 <- 1080*x[3]^2-360*x[4]+2;   h34 <- -360*x[3]
  h44 <- 200.2
  H <- matrix(c(h11,h12,h13,h14,h12,h22,h23,h24,
                h13,h23,h33,h34,h14,h24,h34,h44),ncol=4)
  return(H)
}
#####
w0 <- c(-3, -1, -3, -1)

wd <- snewton(w0, fn=wood.f, gr=wood.g, hess=wood.h, control=list(trace=1))
print(wd)

# Call through optimr to get correct calling sequence, esp. with bounds
wdm <- optimr(w0, fn=wood.f, gr=wood.g, hess=wood.h, control=list(trace=1))
print(wdm)

```

---

summary.optimx

*Summarize optimx object*


---

## Description

Summarize an "optimx" object.

## Usage

```

## S3 method for class 'optimx'
summary(object, order = NULL, par.select = TRUE, ...)

```

## Arguments

object	Object returned by optimx.
order	A column name, character vector of columns names, R expression in terms of column names or a list of R expressions in terms of column names. NULL, the default, means no re-ordering. rownames can be used to alphabetic ordering by method name. NULL, the default, causes it not to be reordered. Note that if follow.on is TRUE re-ordering likely makes no sense. The result is ordered by

the order specification, each specified column in ascending order (except for value which is in descending order if the optimization problem is a maximization problem).

`par.select` a numeric, character or logical vector selecting those `par` values to display. For example, `par=1:5` means display only the first 5 parameters. Recycled so `par.select=FALSE` selects no parameters.

... Further arguments to be passed to the function. Currently not used.

### Details

If `order` is specified then the result is reordered by the specified columns, each in ascending order (except possibly for the value column which is re-ordered in descending order for maximization problems).

### Value

`summary.optimx` returns object with the rows ordered according to `order` and with those parameters selected by `par.select`.

### Examples

```
ans <- optimx(fn = function(x) sum(x*x), par = 1:2)

# order by method name.
summary(ans, order = rownames)

# order by objective value. Do not show parameter values.
summary(ans, order = value, par.select = FALSE)

# order by objective value and then number of function evaluations
# such that objectives that are the same to 3 decimals are
# considered the same. Show only first parameter.
summary(ans, order = list(round(value, 3), fevals), par.select = 1)
```

---

 tn

*Truncated Newton minimization of an unconstrained function.*

---

### Description

An R implementation of the Truncated Newton method of Stephen Nash for driver to call the unconstrained function minimization. The algorithm is based on Nash (1979)

This set of codes is entirely in R to allow users to explore and understand the method.

### Usage

```
tn(x, fgfun, trace, ...)
```

**Arguments**

x	A numeric vector of starting estimates.
fgfun	A function that returns the value of the objective at the supplied set of parameters par using auxiliary data in ... The gradient is returned as attribute "gradient". The first argument of fgfun must be par.
trace	> 0 if progress output is to be presented.
...	Further arguments to be passed to fn.

**Details**

Function fgfun must return a numeric value in list item f and a numeric vector in list item g.

**Value**

A list with components:

xstar	The best set of parameters found.
f	The value of the objective at the best set of parameters found.
g	The gradient of the objective at the best set of parameters found.
ierror	An integer indicating the situation on termination. 0 indicates that the method believes it has succeeded; 2 that more than maxfun (default 150*n, where there are n parameters); 3 if the line search appears to have failed (which may not be serious); and -1 if there appears to be an error in the input parameters.
nfng	A number giving a measure of how many conjugate gradient solutions were used during the minimization process.

**References**

Stephen G. Nash (1984) "Newton-type minimization via the Lanczos method", SIAM J Numerical Analysis, vol. 21, no. 4, pages 770-788.

For Matlab code, see <http://www.netlib.org/opt/tn>

**See Also**

[optim](#)

**Examples**

```
#####
## All examples are in this .Rd file
##
## Rosenbrock Banana function
fr <- function(x) {
  x1 <- x[1]
  x2 <- x[2]
  100 * (x2 - x1 * x1)^2 + (1 - x1)^2
}
gr <- function(x) {
```

```

    x1 <- x[1]
    x2 <- x[2]
    g1 <- -400 * (x2 - x1*x1) * x1 - 2*(1-x1)
    g2 <- 200*(x2 - x1*x1)
    gg<-c(g1, g2)
  }

  rosefg<-function(x){
    f<-fr(x)
    g<-gr(x)
    attr(f, "gradient") <- g
    f
  }

  x<-c(-1.2, 1)

  ansrosenbrock <- tn(x, rosefg)
  print(ansrosenbrock) # use print to allow copy to separate file that
  cat("Compare to optim\n")
  ansoptrose <- optim(x, fr, gr)
  print(ansoptrose)

  genrose.f<- function(x, gs=NULL){ # objective function
  ## One generalization of the Rosenbrock banana valley function (n parameters)
    n <- length(x)
    if(is.null(gs)) { gs=100.0 }
    fval<-1.0 + sum (gs*(x[1:(n-1)]^2 - x[2:n])^2 + (x[2:n] - 1)^2)
    return(fval)
  }
  genrose.g <- function(x, gs=NULL){
  # vectorized gradient for genrose.f
  # Ravi Varadhan 2009-04-03
    n <- length(x)
    if(is.null(gs)) { gs=100.0 }
    gg <- as.vector(rep(0, n))
    tn <- 2:n
    tn1 <- tn - 1
    z1 <- x[tn] - x[tn1]^2
    z2 <- 1 - x[tn]
    gg[tn] <- 2 * (gs * z1 - z2)
    gg[tn1] <- gg[tn1] - 4 * gs * x[tn1] * z1
    gg
  }

  grosefg<-function(x, gs=100.0) {
    f<-genrose.f(x, gs)
    g<-genrose.g(x, gs)
    attr(f, "gradient") <- g
    f
  }

  n <- 100

```



```

x <- (1:100)/20
groseu<-tn(x, grosefg, gs=10)
print(groseu)

groseuo <- optim(x, fn=genrose.f, gr=genrose.g, method="BFGS",
  control=list(maxit=1000), gs=10)
cat("compare optim BFGS\n")
print(groseuo)

lower<-1+(1:n)/100
upper<-5-(1:n)/100
xmid<-0.5*(lower+upper)

grosec<-tnbc(xmid, grosefg, lower, upper)
print(grosec)

cat("compare L-BFGS-B\n")
grosecl <- optim(par=xmid, fn=genrose.f, gr=genrose.g,
  lower=lower, upper=upper, method="L-BFGS-B")
print(grosec1)

```

---

tnbc

*Truncated Newton function minimization with bounds constraints*


---

### Description

A bounds-constrained R implementation of a truncated Newton method for minimization of non-linear functions subject to bounds (box) constraints.

### Usage

```
tnbc(x, fgfun, lower, upper, trace=0, ...)
```

### Arguments

x	A numeric vector of starting estimates.
fgfun	A function that returns the value of the objective at the supplied set of parameters par using auxiliary data in .... The gradient is returned as attribute "gradient". The first argument of fgfun must be par.
lower	A vector of lower bounds on the parameters.
upper	A vector of upper bounds on the parameters.
trace	Set >0 to cause intermediate output to allow progress to be followed.
...	Further arguments to be passed to fn.

**Details**

Function `fgfun` must return a numeric value in list item `f` and a numeric vector in list item `g`.

**Value**

A list with components:

<code>xstar</code>	The best set of parameters found.
<code>f</code>	The value of the objective at the best set of parameters found.
<code>g</code>	The gradient of the objective at the best set of parameters found.
<code>ierror</code>	An integer indicating the situation on termination. 0 indicates that the method believes it has succeeded; 2 that more than <code>maxfun</code> (default <code>150*n</code> , where there are <code>n</code> parameters); 3 if the line search appears to have failed (which may not be serious); and -1 if there appears to be an error in the input parameters.
<code>nfng</code>	A number giving a measure of how many conjugate gradient solutions were used during the minimization process.

**References**

Stephen G. Nash (1984) "Newton-type minimization via the Lanczos method", *SIAM J Numerical Analysis*, vol. 21, no. 4, pages 770-788.

For Matlab code, see <http://www.netlib.org/opt/tn>

**See Also**

[optim](#)

**Examples**

```
## See tn.Rd
```

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