Package ‘TMB’

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Description  With this tool, a user should be able to quickly implement complex random effect models through simple C++ templates. The package combines 'CppAD' (C++ automatic differentiation), 'Eigen' (templated matrix-vector library) and 'CHOLMOD' (sparse matrix routines available from R) to obtain an efficient implementation of the applied Laplace approximation with exact derivatives. Key features are: Automatic sparseness detection, parallelism through 'BLAS' and parallel user templates.
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as.list.sdreport  Convert estimates to original list format.

Description
Get estimated parameters or standard errors in the same shape as the original parameter list.

Usage
## S3 method for class 'sdreport'
as.list(x, what = "", report = FALSE, ...)

Arguments
x  Output from sdreport.
what  Select what to convert (Estimate / Std. Error).
report  Get AD reported variables rather than model parameters ?
...  Passed to summary.sdreport.

Details
This function converts the selected column what of summary(x, select = c("fixed", "random"), ...) to the same format as the original parameter list (re-ordered as the template parameter order). The argument what is partially matched among the column names of the summary table. The actual match is added as an attribute to the output.

Value
List of same shape as original parameter list.

Examples
## Not run:
example(sdreport)

## Estimates as a parameter list:
as.list(rep, "Est")

## Std Errors in the same list format:
as.list(rep, "Std")

## p-values in the same list format:
as.list(rep, "Pr", p.value=TRUE)

## AD reported variables as a list:
as.list(rep, "Estimate", report=TRUE)

## Bias corrected AD reported variables as a list:
```r
as.list(rep, "Est. (bias.correct)", report=TRUE)

## End(Not run)
```

---

**benchmark**

*Benchmark parallel templates*

**Description**

Benchmark parallel templates

Plot result of parallel benchmark

**Usage**

```r
benchmark(obj, n = 10, expr = NULL, cores = NULL)
```

```r
## S3 method for class 'parallelBenchmark'
plot(x, type = "b", ..., show = c("speedup", "time"), legendpos = "topleft")
```

**Arguments**

- `obj` Object from MakeADFun
- `n` Number of replicates to obtain reliable results.
- `expr` Optional expression to benchmark instead of default.
- `cores` Optional vector of cores.
- `x` Object to plot
- `type` Plot type
- `...` Further plot arguments
- `show` Plot relative speedup or relative time?
- `legendpos` Position of legend

**Details**

By default this function will perform timings of the most critical parts of an AD model, specifically

1. Objective function of evaluated template.
2. Gradient of evaluated template.
4. Cholesky factorization of sparse hessian.

(for pure fixed effect models only the first two). Expressions to time can be overwritten by the user (`expr`). A plot method is available for Parallel benchmarks.
checkConsistency

Examples

## Not run:
runExample("linreg_parallel",thisR=TRUE)  ## Create obj
ben <- benchmark(obj,n=100,cores=1:4)
plot(ben)
ben <- benchmark(obj,n=10,cores=1:4,expr=expression(do.call("optim",obj)))
plot(ben)

## End(Not run)

checkConsistency  Check consistency and Laplace accuracy

Description

Check consistency of various parts of a TMB implementation. Requires that user has implemented simulation code for the data and optionally random effects. (Beta version; may change without notice)

Usage

cHECKCONSISTENCY(
  obj,                
  par = NULL,        
  hessian = FALSE,   
  estimate = FALSE,  
  n = 100,           
  observation.name = NULL
)

Arguments

  obj  Object from MakeADFun
  par  Parameter vector (θ) for simulation. If unspecified use the best encountered parameter of the object.
  hessian  Calculate the hessian matrix for each replicate?
  estimate  Estimate parameters for each replicate?
  n  Number of simulations
  observation.name  Optional; Name of simulated observation
Details

This function checks that the simulation code of random effects and data is consistent with the implemented negative log-likelihood function. It also checks whether the approximate marginal score function is central indicating whether the Laplace approximation is suitable for parameter estimation.

Denote by $u$ the random effects, $\theta$ the parameters and by $x$ the data. The main assumption is that the user has implemented the joint negative log likelihood $f_\theta(u, x)$ satisfying

$$\int \int \exp(-f_\theta(u, x)) \, du \, dx = 1$$

It follows that the joint and marginal score functions are central:

1. $E_{u,x} [\nabla_\theta f_\theta(u, x)] = 0$
2. $E_x [\nabla_\theta - \log (\int \exp(-f_\theta(u, x)) \, du)] = 0$

For each replicate of $u$ and $x$ joint and marginal gradients are calculated. Appropriate centrality tests are carried out by `summary.checkConsistency`. An asymptotic $\chi^2$ test is used to verify the first identity. Power of this test increases with the number of simulations $n$. The second identity holds approximately when replacing the marginal likelihood with its Laplace approximation. A formal test would thus fail eventually for large $n$. Rather, the gradient bias is transformed to parameter scale (using the estimated information matrix) to provide an estimate of parameter bias caused by the Laplace approximation.

Value

List with gradient simulations (joint and marginal)

Simulation/re-estimation

A full simulation/re-estimation study is performed when `estimate=TRUE`. By default `nlminb` will be used to perform the minimization, and output is stored in a separate list component 'estimate' for each replicate. Should a custom optimizer be needed, it can be passed as a user function via the same argument (estimate). The function (estimate) will be called for each simulation as `estimate(obj)` where `obj` is the simulated model object. Current default corresponds to `estimate = function(obj) nlminb(obj$par, obj$fn, obj$gr)`.

See Also

`summary.checkConsistency`, `print.checkConsistency`

Examples

```R
## Not run:
runExample("simple")
chk <- checkConsistency(obj)
chk
## Get more details
s <- summary(chk)
s$marginal$p.value  ## Laplace exact for Gaussian models
## End(Not run)
```
Compile a C++ template to DLL suitable for MakeADFun.

Description

Compile a C++ template into a shared object file. OpenMP flag is set if the template is detected to be parallel.

Usage

```r
compile(
  file,
  flags = "",
  safebounds = TRUE,
  safeunload = TRUE,
  openmp = isParallelTemplate(file[1]),
  libtmb = TRUE,
  libinit = TRUE,
  tracesweep = FALSE,
  framework = getOption("tmb.ad.framework"),
  supernodal = FALSE,
  longint = FALSE,
  eigen.disable.warnings = TRUE,
  max.order = NULL,
  ...
)
```

Arguments

- **file**: C++ file.
- **flags**: Character with compile flags.
- **safebounds**: Turn on preprocessor flag for bound checking?
- **safeunload**: Turn on preprocessor flag for safe DLL unloading?
- **openmp**: Turn on openmp flag? Auto detected for parallel templates.
- **libtmb**: Use precompiled TMB library if available (to speed up compilation)?
- **libinit**: Turn on preprocessor flag to register native routines?
- **tracesweep**: Turn on preprocessor flag to trace AD sweeps? (Silently disables libtmb)
- **framework**: Which AD framework to use (‘TMBad’ or ‘CppAD’)
- **supernodal**: Turn on preprocessor flag to use supernodal sparse Cholesky/Inverse from system wide suitesparse library
- **longint**: Turn on preprocessor flag to use long integers for Eigen’s SparseMatrix StorageIndex
eigen.disable.warnings
   Turn on preprocessor flag to disable nuisance warnings. Note that this is not
   allowed for code to be compiled on CRAN.
max.order
   Maximum derivative order of compiler generated atomic special functions - see
details.
...
   Passed as Makeconf variables.

Details

TMB relies on R’s built in functionality to create shared libraries independent of the platform. A
template is compiled by `compile("template.cpp")`, which will call R’s makefile with appropriate
preprocessor flags. Compiler and compiler flags can be stored in a configuration file. In order of
precedence either via the file pointed at by `R_MAKEVARS_USER` or the file `~/R/Makevars` if it
exists. Additional configuration variables can be set with the `flags` and `...` arguments, which will
override any previous selections.

Using a custom SuiteSparse installation

Sparse matrix calculations play an important role in TMB. By default TMB uses a small subset
of SuiteSparse available through the R package `Matrix`. This is sufficient for most use cases,
however for some very large models the following extra features are worth considering:

- Some large models benefit from an extended set of graph reordering algorithms (especially
  METIS) not part of `Matrix`. It is common that these orderings can provide quite big speedups.
- Some large models need sparse matrices with number of nonzeros exceeding the current 32
  bit limitation of `Matrix`. Normally such cases will result in the cholmod error 'problem too
  large'. SuiteSparse includes 64 bit integer routines to address this problem.

Experimental support for linking to a custom SuiteSparse installation is available through two
arguments to the `compile` function. The first argument `supernodal=TRUE` tells TMB to use the
supernodal Cholesky factorization from the system wide SuiteSparse on the C++ side. This will
affect the speed of the Laplace approximation when run internally (using arguments `intern` or
integrate to MakeADFun).

The second argument `longint=TRUE` tells TMB to use 64 bit integers for sparse matrices on the
C++ side. This works in combination with `supernodal=TRUE` from Eigen version 3.4.

On Windows a SuiteSparse installation can be obtained using the Rtools package manager. Start
'Rtools Bash' terminal and run:

```bash
pacman -Sy
pacman -S mingw-w64-\{i686,x86_64\}-suitesparse
```

On Linux one should look for the package `libsuitesparse-dev`.

Selecting the AD framework

TMB supports two different AD libraries ‘CppAD’ and ‘TMBad’ selected via the argument `framework`
which works as a switch to set one of two C++ preprocessor flags: ‘CPPAD_FRAMEWORK’ or
‘TMBAD_FRAMEWORK’. The default value of `framework` can be set from R by options("tmb.ad.framework")
or alternatively from the shell via the environment variable 'TMB_AD_FRAMEWORK'. Packages
linking to TMB should set one of the two C++ preprocessor flags in Makevars.
Order of compiler generated atomic functions

The argument `max.order` controls the maximum derivative order of special functions (e.g. `pbeta`) generated by the compiler. By default the value is set to 3 which is sufficient to obtain the Laplace approximation (order 2) and its derivatives (order 3). However, sometimes a higher value may be needed. For example `framework='TMBad'` allows one to calculate the Hessian of the Laplace approximation, but that requires 4th order derivatives of special functions in use. A too small value will cause the runtime error ‘increase TMB_MAX_ORDER’. Note that compilation time and binary size increases with `max.order`.

See Also

`precompile`

---

**config**

Get or set internal configuration variables

**Description**

Get or set internal configuration variables of user’s DLL.

**Usage**

```r
config(..., DLL = getUserDLL())
```

**Arguments**

- `...` Variables to set
- `DLL` Name of user’s DLL. Auto-detected if missing.

**Details**

A model compiled with the TMB C++ library has several configuration variables set by default. The variables can be read and modified using this function. The meaning of the variables can be found in the Doxygen documentation.

**Value**

List with current configuration

**Examples**

```r
## Not run:
## Load library
dyn.load(dynlib("mymodel"))
## Read the current settings
config(DLL="mymodel")
## Reduce memory peak of a parallel model by creating tapes in serial
config(tape.parallel=0, DLL="mymodel")
```
obj <- MakeADFun(..., DLL="mymodel")
## End(Not run)

confint.tmbprofile  Profile based confidence intervals.

Description
Calculate confidence interval from a likelihood profile.

Usage
## S3 method for class 'tmbprofile'
confint(object, parm, level = 0.95, ...)

Arguments
object  Output from tmbprofile.
parm    Not used
level   Confidence level.
...     Not used

Value
Lower and upper limit as a matrix.

dynlib Add dynlib extension

Description
Add the platform dependent dynlib extension. In order for examples to work across platforms DLLs should be loaded by dyn.load(dynlib("name")).

Usage
dynlib(name)

Arguments
name    Library name without extension

Value
Character
FreeADFun

Free memory allocated on the C++ side by MakeADFun.

Description
Free memory allocated on the C++ side by MakeADFun.

Usage
FreeADFun(obj)

Arguments
obj Object returned by MakeADFun

Details
An object returned by MakeADFun contains pointers to structures allocated on the C++ side. These are managed by R’s garbage collector which for the most cases is sufficient. However, because the garbage collector is unaware of the C++ object sizes, it may fail to release memory to the system as frequently as necessary. In such cases one can manually call FreeADFun(obj) to release the resources.

Memory management
Memory allocated on the C++ side by MakeADFun is represented by external pointers. Each such pointer has an associated 'finalizer' (see reg.finalizer) that deallocates the external pointer when gc() decides the pointer is no longer needed. Deallocated pointers are recognized on the R side as external null pointers <pointer: (nil>). This is important as it provides a way to prevent the finalizers from freeing pointers that have already been deallocated even if the deallocation C-code has been unloaded. The user DLL maintains a list of all external pointers on the C side. Three events can reduce the list:

- Garbage collection of an external pointer that is no longer needed (triggers corresponding finalizer).
- Explicit deallocation of external pointers using FreeADFun() (corresponding finalizers are untriggered but harmless).
- Unload/reload of the user’s DLL deallocates all external pointers (corresponding finalizers are untriggered but harmless).

Note
This function is normally not needed.

Examples
runExample("simple", thisR = TRUE) ## Create ‘obj’
FreeADFun(obj) ## Free external pointers
obj$fn() ## Re-allocate external pointers
gdbsource

Source R-script through gdb to get backtrace.

Description

Source R-script through gdb to get backtrace.

If `gdbsource` is run non-interactively (the default) only the relevant information will be printed.

Usage

```r
gdbsource(file, interactive = FALSE)
```

```r
## S3 method for class 'backtrace'
print(x, ...)  
```

Arguments

- `file` Your R script
- `interactive` Run interactive gdb session?
- `x` Backtrace from gdbsource
- `...` Not used

Details

This function is useful for debugging templates. If a script aborts e.g. due to an out-of-bound index operation it should be fast to locate the line that caused the problem by running `gdbsource(file)`. Alternatively, if more detailed debugging is required, then `gdbsource(file, TRUE)` will provide the full backtrace followed by an interactive gdb session where the individual frames can be inspected. Note that templates should be compiled without optimization and with debug information in order to provide correct line numbers:

- On Linux/OS X use `compile(cppfile,"-O0 -g")`.
- On Windows use `compile(cppfile,"-O1 -g",DLLFLAGS="")` (lower optimization level will cause errors).

Value

Object of class backtrace
Gauss Kronrod configuration

Description
Helper function to specify parameters used by the Gauss Kronrod integration available through the argument integrate to MakeADFun.

Usage
GK(...)

Arguments
... See source code

MakeADFun Construct objective functions with derivatives based on a compiled C++ template.

Description
Construct objective functions with derivatives based on the users C++ template.

Usage
MakeADFun(
  data,
  parameters,
  map = list(),
  type = c("ADFun", "Fun", "ADGrad"[!intern & & (!is.null(random) || !is.null(profile))]),
  random = NULL,
  profile = NULL,
  random.start = expression(last.par.best[random]),
  hessian = FALSE,
  method = "BFGS",
  inner.method = "newton",
  inner.control = list(maxit = 1000),
  MCcontrol = list(doMC = FALSE, seed = 123, n = 100),
  ADreport = FALSE,
  atomic = TRUE,
  LaplaceNonZeroGradient = FALSE,
  DLL = getUserDLL(),
  checkParameterOrder = TRUE,
  regexp = FALSE,
silent = FALSE,
intern = FALSE,
integrate = NULL,
...)

Arguments

data List of data objects (vectors, matrices, arrays, factors, sparse matrices) required by the user template (order does not matter and un-used components are allowed).

parameters List of all parameter objects required by the user template (both random and fixed effects).

map List defining how to optionally collect and fix parameters - see details.

type Character vector defining which operation stacks are generated from the users template - see details.

random Character vector defining the random effect parameters. See also regexp.

profile Parameters to profile out of the likelihood (this subset will be appended to random with Laplace approximation disabled).

random.start Expression defining the strategy for choosing random effect initial values as function of previous function evaluations - see details.

hessian Calculate Hessian at optimum?

method Outer optimization method.

inner.method Inner optimization method (see function "newton").

inner.control List controlling inner optimization.

MCcontrol List controlling importance sampler (turned off by default).

ADreport Calculate derivatives of macro ADREPORT(vector) instead of objective_function return value?

atomic Allow tape to contain atomic functions?

LaplaceNonZeroGradient Allow Taylor expansion around non-stationary point?

DLL Name of shared object file compiled by user (without the conventional extension, ‘.so’, ‘.dll’, ...).

checkParameterOrder Optional check for correct parameter order.

regexp Match random effects by regular expressions?

silent Disable all tracing information?

intern Do Laplace approximation on C++ side? See details (Experimental - may change without notice)

integrate Specify alternative integration method(s) for random effects (see details)

... Currently unused.
Details

A call to `MakeADFun` will return an object that, based on the users DLL code (specified through DLL), contains functions to calculate the objective function and its gradient. The object contains the following components:

- `par` A default parameter.
- `fn` The likelihood function.
- `gr` The gradient function.
- `report` A function to report all variables reported with the REPORT() macro in the user template.
- `env` Environment with access to all parts of the structure.

and is thus ready for a call to an R optimizer, such as `nlminb` or `optim`. Data (data) and parameters (parameters) are directly read by the user template via the macros beginning with DATA_ and PARAMETER_. The order of the PARAMETER_ macros defines the order of parameters in the final objective function. There are no restrictions on the order of random parameters, fixed parameters or data in the template.

Value

List with components (fn, gr, etc) suitable for calling an R optimizer, such as `nlminb` or `optim`.

Parameter mapping

Optionally, a simple mechanism for collecting and fixing parameters from R is available through the `map` argument. A map is a named list of factors with the following properties:

- names(map) is a subset of names(parameters).
- For a parameter "p" length(map$p) equals length(parameters$p).
- Parameter entries with NAs in the factor are fixed.
- Parameter entries with equal factor level are collected to a common value.

More advanced parameter mapping, such as collecting parameters between different vectors etc., must be implemented from the template.

Specifying random effects

Random effects are specified via the argument `random`: A component of the parameter list is marked as random if its name is matched by any of the characters of the vector random (Regular expression match is performed if regexp=TRUE). If some parameters are specified as random effects, these will be integrated out of the objective function via the Laplace approximation. In this situation the functions fn and gr automatically perform an optimization of random effects for each function evaluation. This is referred to as the 'inner optimization'. Strategies for choosing initial values of the inner optimization can be controlled via the argument `random.start`. The default is expression(last.par.best[random]) where last.par.best is an internal full parameter vector corresponding to the currently best likelihood. An alternative choice could be expression(last.par[random]) i.e. the random effect optimum of the most recent - not necessarily best - likelihood evaluation. Further control of the inner optimization can be obtained by
the argument inner.control which is a list of control parameters for the inner optimizer newton. Depending of the inner optimization problem type the following settings are recommended:

1. Quasi-convex: smartsearch=TRUE (the default).
3. Quadratic: smartsearch=FALSE and maxit=1.

The model environment env

Technically, the user template is processed several times by inserting different types as template parameter, selected by argument type:

- "ADFun" Run through the template with AD-types and produce a stack of operations representing the objective function.
- "Fun" Run through the template with ordinary double-types.
- "ADGrad" Run through the template with nested AD-types and produce a stack of operations representing the objective function gradient.

Each of these are represented by external pointers to C++ structures available in the environment env.

Further objects in the environment env:

- validpar Function defining the valid parameter region (by default no restrictions). If an invalid parameter is inserted fn immediately return NaN.
- parList Function to get the full parameter vector of random and fixed effects in a convenient list format.
- random An index vector of random effect positions in the full parameter vector.
- last.par Full parameter of the latest likelihood evaluation.
- last.par.best Full parameter of the best likelihood evaluation.
- tracepar Trace every likelihood evaluation ?
- tracemgc Trace maximum gradient component of every gradient evaluation ?
- silent Pass 'silent=TRUE' to all try-calls ?

The argument intern

By passing intern=TRUE the entire Laplace approximation (including sparse matrix calculations) is done within the AD machinery on the C++ side. This requires the model to be compiled using the 'TMBad framework' - see compile. For any serious use of this option one should consider compiling with supernodal=TRUE - again see compile - in order to get performance comparable to R’s matrix calculations. The benefit of the ‘intern’ LA is that it may be faster in some cases and that it provides an autodiff hessian (obj$hessian) wrt. the fixed effects which would otherwise not work for random effect models. Another benefit is that it gives access to fast computations with certain hessian structures that do not meet the usual sparsity requirement. A detailed list of options are found in the online doxygen documentation in the 'newton' namespace under the 'newton_config' struct. All these options can be passed from R via the ‘inner.control’ argument. However, there are some drawbacks of running the LA on the C++ side. Notably, random effects are no longer visible in the model environment which may break assumptions on the layout of internal vectors (‘par’, ‘last.par’, etc). In addition, model debugging becomes harder when calculations are moved to C++. 
Controlling tracing

A high level of tracing information will be output by default when evaluating the objective function and gradient. This is useful while developing a model, but may eventually become annoying. Disable all tracing by passing silent=TRUE to the MakeADFun call.

Note

Do not rely upon the default arguments of any of the functions in the model object obj$fn, obj$gr, obj$he, obj$report. I.e. always use the explicit form obj$fn(obj$par) rather than obj$fn().

description

Generalized newton optimizer used for the inner optimization problem.

Usage

newton(
  par,  
  fn,   
  gr,   
  he,   
  trace = 1, 
  maxit = 100, 
  tol = 1e-08, 
  alpha = 1, 
  smartsearch = TRUE, 
  mgcmax = 1e+60, 
  super = TRUE, 
  silent = TRUE, 
  ustep = 1, 
  power = 0.5, 
  u0 = 1e-04, 
  grad.tol = tol, 
  step.tol = tol, 
  tol10 = 0.001, 
  env = environment(), 
... 
)

Arguments

par  Initial parameter.

fn   Objective function.
gr
Gradient function.

he
Sparse hessian function.

trace
Print tracing information?

maxit
Maximum number of iterations.

tol
Convergence tolerance.

alpha
Newton stepsize in the fixed stepsize case.

smartsearch
Turn on adaptive stepsize algorithm for non-convex problems?

mgcmax
Refuse to optimize if the maximum gradient component is too steep.

super
Supernodal Cholesky?

silent
Be silent?

ustep
Adaptive stepsize initial guess between 0 and 1.

power
Parameter controlling adaptive stepsize.

u0
Parameter controlling adaptive stepsize.

grad.tol
Gradient convergence tolerance.

step.tol
Stepsize convergence tolerance.

tol10
Try to exit if last 10 iterations not improved more than this.

env
Environment for cached Cholesky factor.

... Currently unused.

Details

If smartsearch=FALSE this function performs an ordinary newton optimization on the function fn using an exact sparse hessian function. A fixed stepsize may be controlled by alpha so that the iterations are given by:

\[ u_{n+1} = u_n - \alpha f''(u_n)^{-1} f'(u_n) \]

If smartsearch=TRUE the hessian is allowed to become negative definite preventing ordinary newton iterations. In this situation the newton iterations are performed on a modified objective function defined by adding a quadratic penalty around the expansion point u0:

\[ f_t(u) = f(u) + \frac{t}{2} \|u - u_0\|^2 \]

This function’s hessian \( f''(u) + tI \) is positive definite for t sufficiently large. The value t is updated at every iteration: If the hessian is positive definite t is decreased, otherwise increased. Detailed control of the update process can be obtained with the arguments ustep, power and u0.

Value

List with solution similar to optim output.

See Also

newtonOption
newtonOption

Set newton options for a model object.

Description

Inner-problem options can be set for a model object using this function.

Usage

newtonOption(obj, ...)

Arguments

- **obj**: Object from MakeADFun for which to change settings.
- **...**: Parameters for the newton optimizer to set.

Value

List of updated parameters.

normalize

Normalize process likelihood using the Laplace approximation.

Description

If the random effect likelihood contribution of a model has been implemented without proper normalization (i.e. lacks the normalizing constant), then this function can perform the adjustment automatically. In order for this to work, the model must include a flag that disables the data term so that the un-normalized random effect (negative log) density is returned from the model template. Automatic process normalization may be useful if either the normalizing constant is difficult to implement, or if its calculation involves so many operations that it becomes infeasible to include in the AD machinery.

Usage

normalize(obj, flag, value = 0)

Arguments

- **obj**: Model object from MakeADFun without proper normalization of the random effect likelihood.
- **flag**: Flag to disable the data term from the model.
- **value**: Value of 'flag' that signifies to not include the data term.

Value

Modified model object that can be passed to an optimizer.
oneStepPredict

Calculate one-step-ahead (OSA) residuals for a latent variable model.

Description

Calculate one-step-ahead (OSA) residuals for a latent variable model. (Beta version; may change without notice)

Usage

oneStepPredict(
  obj,
  observation.name = NULL,
  data.term.indicator = NULL,
  method = c("oneStepGaussianOffMode", "fullGaussian", "oneStepGeneric",
             "oneStepGaussian", "cdf"),
  subset = NULL,
  conditional = NULL,
  discrete = NULL,
  discreteSupport = NULL,
  range = c(-Inf, Inf),
  seed = 123,
  parallel = FALSE,
  trace = TRUE,
  reverse = (method == "oneStepGaussianOffMode"),
  splineApprox = TRUE,
  ...
)

Arguments

obj Output from MakeADFun.
observation.name Character naming the observation in the template.
data.term.indicator Character naming an indicator data variable in the template (not required by all methods - see details).
method Method to calculate OSA (see details).
subset Index vector of observations that will be added one by one during OSA. By default 1:length(observations) (with conditional subtracted).
conditional Index vector of observations that are fixed during OSA. By default the empty set.
discrete Logical; Are observations discrete? (assumed FALSE by default).
discreteSupport Possible outcomes of discrete part of the distribution (method="oneStepGeneric" and method="cdf" only).
**Details**

Given a TMB latent variable model this function calculates OSA standardized residuals that can be used for goodness-of-fit assessment. The approach is based on a factorization of the joint distribution of the observations \( X_1, \ldots, X_n \) into successive conditional distributions. Denote by

\[
F_n(x_n) = \Pr(X_n \leq x_n | X_1 = x_1, \ldots, X_{n-1} = x_{n-1})
\]

the one-step-ahead CDF, and by

\[
p_n(x_n) = \Pr(X_n = x_n | X_1 = x_1, \ldots, X_{n-1} = x_{n-1})
\]

the corresponding point probabilities (zero for continuous distributions). In case of continuous observations the sequence

\[
\Phi^{-1}(F_1(X_1)), \ldots, \Phi^{-1}(F_n(X_n))
\]

will be iid standard normal. These are referred to as the OSA residuals. In case of discrete observations draw (unit) uniform variables \( U_1, \ldots, U_n \) and construct the randomized OSA residuals

\[
\Phi^{-1}(F_1(X_1) - U_1 p_1(X_1)), \ldots, \Phi^{-1}(F_n(X_n) - U_n p_n(X_n))
\]

These are also iid standard normal.

**Value**

data.frame with OSA standardized residuals in column `residual`. In addition, depending on the method, the output includes selected characteristics of the predictive distribution (current row) given past observations (past rows), notably the conditional

- **mean**  Expectation of the current observation
- **sd**   Standard deviation of the current observation
- **Fx**  CDF at current observation
- **px**  Density at current observation
- **nll**  Negative log density at current observation
- **nlcdf.lower**  Negative log of the lower CDF at current observation
- **nlcdf.upper**  Negative log of the upper CDF at current observation

Given past observations. If column `randomize` is present, it indicates that randomization has been applied for the row.
Choosing the method

The user must specify the method used to calculate the residuals - see detailed list of method descriptions below. We note that all the methods are based on approximations. While the default 'oneStepGaussianoffMode' often represents a good compromise between accuracy and speed, it cannot be assumed to work well for all model classes. As a rule of thumb, if in doubt whether a method is accurate enough, you should always compare with the 'oneStepGeneric' which is considered the most accurate of the available methods.

**method="fullGaussian"**  This method assumes that the joint distribution of data and random effects is Gaussian (or well approximated by a Gaussian). It does not require any changes to the user template. However, if used in conjunction with subset and/or conditional a data.term.indicator is required - see the next method.

**method="oneStepGeneric"**  This method calculates the one-step conditional probability density as a ratio of Laplace approximations. The approximation is integrated (and re-normalized for improved accuracy) using 1D numerical quadrature to obtain the one-step CDF evaluated at each data point. The method works in the continuous case as well as the discrete case (discrete=TRUE).

It requires a specification of a data.term.indicator explained in the following. Suppose the template for the observations given the random effects (u) looks like

```
DATA_VECTOR(x);
...  
nll -= dnorm(x(i), u(i), sd(i), true);
...  
```

Then this template can be augmented with a data.term.indicator = "keep" by changing the template to

```
DATA_VECTOR(x);
DATA_VECTOR_INDICATOR(keep, x);
...  
nll -= keep(i) * dnorm(x(i), u(i), sd(i), true);
...  
```

The new data vector (keep) need not be passed from R. It automatically becomes a copy of x filled with ones.

Some extra parameters are essential for the method. Pay special attention to the integration domain which must be set either via range (continuous case) or discreteSupport (discrete case). Both of these can be set simultaneously to specify a mixed continuous/discrete distribution. For example, a non-negative distribution with a point mass at zero (e.g. the Tweedie distribution) should have range=c(0,Inf) and discreteSupport=0. Several parameters control accuracy and appropriate settings are case specific. By default, a spline is fitted to the one-step density before integration (splineApprox=TRUE) to reduce the number of density evaluations. However, this setting may have negative impact on accuracy. The spline approximation can then either be disabled or improved by noting that ... arguments are passed to tmbprofile: Pass e.g. ystep=20, ytol=0.1. Finally, it may be useful to look at the one step predictive distributions on either log scale (trace=2) or natural scale (trace=3) to determine which alternative methods might be appropriate.
method="oneStepGaussian" This is a special case of the generic method where the one step conditional distribution is approximated by a Gaussian (and can therefore be handled more efficiently).

method="oneStepGaussianOffMode" This is an approximation of the "oneStepGaussian" method that avoids locating the mode of the one-step conditional density.

method="cdf" The generic method can be slow due to the many function evaluations used during the 1D integration (or summation in the discrete case). The present method can speed up this process but requires more changes to the user template. The above template must be expanded with information about how to calculate the negative log of the lower and upper CDF:

```
DATA_VECTOR(x);
DATA_VECTOR_INDICATOR(keep, x);
...
  nll -= keep(i) * dnorm(x(i), u(i), sd(i), true);
  nll -= keep.cdf_lower(i) * log( pnorm(x(i), u(i), sd(i)) );
  nll -= keep.cdf_upper(i) * log( 1.0 - pnorm(x(i), u(i), sd(i)) );
...
```

The specialized members keep.cdf_lower and keep.cdf_upper automatically become copies of x filled with zeros.

Examples

```
# Gaussian case
runExample("simple")
osa.simple <- oneStepPredict(obj, observation.name = "x", method="fullGaussian")
qqnorm(osa.simple$residual); abline(0,1)
```

```
## Not run:
# Poisson case (First 100 observations)
runExample("ar1xar1")
osa.ar1xar1 <- oneStepPredict(obj, "N", "keep", method="cdf", discrete=TRUE, subset=1:100)
qqnorm(osa.ar1xar1$residual); abline(0,1)
```

Description

Control number of OpenMP threads used by a TMB model.

Usage

```
openmp(n = NULL, max = FALSE, autopar = NULL, DLL = getUserDLL())
```
Arguments

n
- Requested number of threads, or NULL to just read the current value.

max
- Logical; Set n to OpenMP runtime value `omp_get_max_threads()`?

autopar
- Logical; use automatic parallelization - see details.

DLL
- DLL of a TMB model.

Details

This function controls the number of parallel threads used by a TMB model compiled with OpenMP. The number of threads is part of the configuration list `config()` of the DLL. The value only affects parallelization of the DLL. It does not affect BLAS/LAPACK specific parallelization which has to be specified elsewhere.

When a DLL is loaded, the number of threads is set to 1 by default. To activate parallelization you have to explicitly call `openmp(nthreads)` after loading the DLL. Calling `openmp(max=TRUE)` should normally pick up the environment variable `OMP_NUM_THREADS`, but this may be platform dependent.

An experimental option `autopar=TRUE` can be set to parallelize models automatically. This requires the model to be compiled with `framework="TMBad"` and `openmp=TRUE` without further requirements on the C++ code. If the C++ code already has explicit parallel constructs these will be ignored if automatic parallelization is enabled.

Value

Number of threads.

Description

Plot (negative log) likelihood profile with confidence interval added.

Usage

```r
## S3 method for class 'tmbprofile'
plot(x, type = "l", level = 0.95, ...)
```

Arguments

x
- Output from `tmbprofile`.

type
- Plot type.

level
- Add horizontal and vertical lines depicting this confidence level (NULL disables the lines).

... Additional plot arguments.
**precompile**

Precompile the TMB library in order to speed up compilation of templates.

---

**Description**

Precompile the TMB library

**Usage**

```r
precompile(all = TRUE, clean = FALSE, trace = TRUE, get.header = FALSE, ...)
```

**Arguments**

- **all**: Precompile all or just the core parts of TMB?
- **clean**: Remove precompiled libraries?
- **trace**: Trace precompilation process?
- **get.header**: Create files 'TMB.h' and 'TMB.cpp' in current working directory to be used as part of a project?
- **...**: Not used.

**Details**

Precompilation can be used to speed up compilation of templates. It is only necessary to run `precompile()` once, typically right after installation of TMB. The function prepares TMB for precompilation, while the actual pre-compilation takes place the first time you compile a model after running `precompile()`.

Note that the precompilation requires write access to the TMB package folder. Three versions of the library will be prepared: Normal, parallel and a debugable version.

Precompilation works the same way on all platforms. The only known side-effect of precompilation is that it increases the file size of the generated binaries.

**Examples**

```r
## Not run:
## Prepare precompilation
precompile()
## Perform precompilation by running a model
runExample(all = TRUE)
```

## End(Not run)
print.checkConsistency

Print output from checkConsistency

Description

Print diagnostics output from checkConsistency

Usage

### S3 method for class 'checkConsistency'
print(x, ...)

Arguments

x  Output from checkConsistency
...
Not used

print.sdreport

Print brief model summary

Description

Print parameter estimates and give convergence diagnostic based on gradient and Hessian.

Usage

### S3 method for class 'sdreport'
print(x, ...)

Arguments

x  Output from sdreport
...
Not used
Rinterface

Create minimal R-code corresponding to a cpp template.

Description

Create a skeleton of required R-code once the cpp template is ready.

Usage

Rinterface(file)

Arguments

- **file**: cpp template file.

Examples

```r
file <- system.file("examples/simple.cpp", package = "TMB")
Rinterface(file)
```

runExample

Run one of the test examples.

Description

Compile and run a test example (runExample() shows all available examples).

Usage

```r
runExample(
  name = NULL,
  all = FALSE,
  thisR = TRUE,
  clean = FALSE,
  exfolder = NULL,
  dontrun = FALSE,
  subarch = TRUE,
  ...
)
```
**Arguments**

- **name**  Character name of example.
- **all**  Run all the test examples?
- **thisR**  Run inside this R?
- **clean**  Cleanup before compile?
- **exfolder**  Alternative folder with examples.
- **dontrun**  Build only (don’t run) and remove temporary object files ?
- **subarch**  Build in sub-architecture specific folder ?
- ...  Passed to `compile`.

---

**runSymbolicAnalysis**  *Run symbolic analysis on sparse Hessian*

---

**Description**

Aggressively tries to reduce fill-in of sparse Cholesky factor by running a full suite of ordering algorithms. NOTE: requires a specialized installation of the package. More information is available at the package URL.

**Usage**

```r
runSymbolicAnalysis(obj)
```

**Arguments**

- **obj**  Output from `MakeADFun`

---

**sdreport**  *General sdreport function.*

---

**Description**

After optimization of an AD model, sdreport is used to calculate standard deviations of all model parameters, including non linear functions of random effects and parameters specified through the ADREPORT() macro from the user template.
sdreport

Usage

sdreport(
  obj,
  par.fixed = NULL,
  hessian.fixed = NULL,
  getJointPrecision = FALSE,
  bias.correct = FALSE,
  bias.correct.control = list(sd = FALSE, split = NULL, nsplit = NULL),
  ignore.parm.uncertainty = FALSE,
  getReportCovariance = TRUE,
  skip.delta.method = FALSE
)

Arguments

  obj          Object returned by MakeADFun
  par.fixed    Optional. Parameter estimate (will be known to obj when an optimization has
                been carried out).
  hessian.fixed Optional. Hessian wrt. parameters (will be calculated from obj if missing).
  getJointPrecision Optional. Return full joint precision matrix of random effects and parameters?
  bias.correct logical indicating if bias correction should be applied
  bias.correct.control a list of bias correction options; currently sd, split and nsplit are used - see
details.
  ignore.parm.uncertainty Optional. Ignore estimation variance of parameters?
  getReportCovariance Get full covariance matrix of ADREPORTed variables?
  skip.delta.method   Skip the delta method? (FALSE by default)

Details

First, the Hessian wrt. the parameter vector ($\theta$) is calculated. The parameter covariance matrix is
approximated by

$$V(\hat{\theta}) = -\nabla^2 l(\hat{\theta})^{-1}$$

where $l$ denotes the log likelihood function (i.e. -obj$\text{fn}$). If ignore.parm.uncertainty=TRUE then the Hessian calculation is omitted and a zero-matrix is used in place of $V(\hat{\theta})$.

For non-random effect models the standard delta-method is used to calculate the covariance matrix
of transformed parameters. Let $\phi(\theta)$ denote some non-linear function of $\theta$. Then

$$V(\phi(\hat{\theta})) = \nabla\phi V(\hat{\theta}) \nabla\phi'$$

The covariance matrix of reported variables $V(\phi(\hat{\theta}))$ is returned by default. This can cause high
memory usage if many variables are ADREPORTed. Use getReportCovariance=FALSE to only
return standard errors. In case standard deviations are not required one can completely skip the delta method using `skip.delta.method=TRUE`.

For random effect models a generalized delta-method is used. First the joint covariance of random effect and parameter estimation error is approximated by

$$ V \left( \frac{\hat{u} - u}{\hat{\theta} - \theta} \right) \approx \begin{pmatrix} H^{-1} & 0 \\ 0 & 0 \end{pmatrix} + JV(\hat{\theta})J' $$

where $H_{uu}$ denotes random effect block of the full joint Hessian of `obj$env$f` and $J$ denotes the Jacobian of $\left( \frac{\hat{u}(\theta)}{\theta} \right)$ wrt. $\theta$. Here, the first term represents the expected conditional variance of the estimation error given the data and the second term represents the variance of the conditional mean of the estimation error given the data.

Now the delta method can be applied on a general non-linear function $\phi(u, \theta)$ of random effects $u$ and parameters $\theta$:

$$ V \left( \phi(\hat{u}, \hat{\theta}) - \phi(u, \theta) \right) \approx \nabla \phi V \left( \frac{\hat{u} - u}{\hat{\theta} - \theta} \right) \nabla \phi' $$

The full joint covariance is not returned by default, because it may require large amounts of memory. It may be obtained by specifying `getJointPrecision=TRUE`, in which case $V \left( \frac{\hat{u} - u}{\hat{\theta} - \theta} \right)^{-1}$ will be part of the output. This matrix must be manually inverted using `solve(jointPrecision)` in order to get the joint covariance matrix. Note, that the parameter order will follow the original order (i.e. `obj$env$par`).

Using $\phi(\hat{u}, \theta)$ as estimator of $\phi(u, \theta)$ may result in substantial bias. This may be the case if either $\phi$ is non-linear or if the distribution of $u$ given $x$ (data) is sufficiently non-symmetric. A generic correction is enabled with `bias.correct=TRUE`. It is based on the identity

$$ E_\theta[\phi(u, \theta)|x] = \partial_\varepsilon \left( \log \int \exp(-f(u, \theta) + \varepsilon \phi(u, \theta)) \, du \right)_{\varepsilon=0} $$

stating that the conditional expectation can be written as a marginal likelihood gradient wrt. a nuisance parameter $\epsilon$. The marginal likelihood is replaced by its Laplace approximation. If `bias.correct.control$sd=TRUE` the variance of the estimator is calculated using

$$ V_\theta[\phi(u, \theta)|x] = \partial^2_\varepsilon \left( \log \int \exp(-f(u, \theta) + \varepsilon \phi(u, \theta)) \, du \right)_{\varepsilon=0} $$

A further correction is added to this variance to account for the effect of replacing $\theta$ by the MLE $\hat{\theta}$ (unless `ignore.parm.uncertainty=TRUE`).

Bias correction can be be performed in chunks in order to reduce memory usage or in order to only bias correct a subset of variables. First option is to pass a list of indices as `bias.correct.control$split`. E.g. a list `list(1:2, 3:4)` calculates the first four ADREPORTed variables in two chunks. The internal function `obj$env$ADreportIndex()` gives an overview of the possible indices of ADREPORTed variables.

Second option is to pass the number of chunks as `bias.correct.control$nsplit` in which case all ADREPORTed variables are bias corrected in the specified number of chunks. Also note that `skip.delta.method` may be necessary when bias correcting a large number of variables.
Value

Object of class sdreport

See Also

summary.sdreport, print.sdreport, as.list.sdreport

Examples

## Not run:
runExample("linreg_parallel", thisR = TRUE) ## Non-random effect example
sdreport(obj)
## End(Not run)

runExample("simple", thisR = TRUE) ## Random effect example
rep <- sdreport(obj)
summary(rep, "random") ## Only random effects
summary(rep, "fixed", p.value = TRUE) ## Only non-random effects
summary(rep, "report") ## Only report

## Bias correction
rep <- sdreport(obj, bias.correct = TRUE)
summary(rep, "report") ## Include bias correction

---

SR

Sequential reduction configuration

Description

Helper function to specify an integration grid used by the sequential reduction algorithm available through the argument integrate to MakeADFUn.

Usage

SR(x, discrete = FALSE)

Arguments

x

Breaks defining the domain of integration

discrete

Boolean defining integration wrt Lebesgue measure (discrete=FALSE) or counting measure discrete=TRUE.
summary.sdreport

Summary output from checkConsistency

Description

Summarize output from checkConsistency

Usage

```r
## S3 method for class 'checkConsistency'
summary(object, na.rm = FALSE, ...)
```

Arguments

- **object**: Output from `checkConsistency`
- **na.rm**: Logical; Remove failed simulations?
- **...**: Not used

Value

List of diagnostics

summary.sdreport

Summary tables of model parameters

Description

Extract parameters, random effects and reported variables along with uncertainties and optionally Chi-square statistics. Bias corrected quantities are added as additional columns if available.

Usage

```r
## S3 method for class 'sdreport'
summary(
  object,
  select = c("all", "fixed", "random", "report"),
  p.value = FALSE,
  ...)
```
Arguments

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>object</td>
<td>Output from <code>sdreport</code></td>
</tr>
<tr>
<td>select</td>
<td>Parameter classes to select. Can be any subset of &quot;fixed&quot; ($\hat{\theta}$), &quot;random&quot; ($\hat{u}$) or &quot;report&quot; ($\phi(\hat{u}, \hat{\theta})$) using notation as <code>sdreport</code>.</td>
</tr>
<tr>
<td>p.value</td>
<td>Add column with approximate p-values</td>
</tr>
<tr>
<td>...</td>
<td>Not used</td>
</tr>
</tbody>
</table>

Value

```
matrix
```

---

**template**

*Create cpp template to get started.*

---

**Description**

Create a cpp template to get started.

**Usage**

```
template(file = NULL)
```

**Arguments**

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>file</td>
<td>Optional name of cpp file.</td>
</tr>
</tbody>
</table>

**Details**

This function generates a C++ template with a header and include statement. Here is a brief overview of the C++ syntax used to code the objective function. For a full reference see the Doxygen documentation (more information at the package URL).

Macros to read data and declare parameters:

<table>
<thead>
<tr>
<th>Template Syntax</th>
<th>C++ type</th>
<th>R type</th>
</tr>
</thead>
<tbody>
<tr>
<td>DATA_VECTOR(name)</td>
<td>vector&lt;Type&gt;</td>
<td>vector</td>
</tr>
<tr>
<td>DATA_MATRIX(name)</td>
<td>matrix&lt;Type&gt;</td>
<td>matrix</td>
</tr>
<tr>
<td>DATA_SCALAR(name)</td>
<td>Type</td>
<td>numeric(1)</td>
</tr>
<tr>
<td>DATA_INTEGER(name)</td>
<td>int</td>
<td>integer(1)</td>
</tr>
<tr>
<td>DATA_FACTOR(name)</td>
<td>vector&lt;int&gt;</td>
<td>factor</td>
</tr>
<tr>
<td>DATA_IVECTOR(name)</td>
<td>vector&lt;int&gt;</td>
<td>integer</td>
</tr>
<tr>
<td>DATA_SPARSE_MATRIX(name)</td>
<td>Eigen::SparseMatrix&lt;Type&gt;</td>
<td>dgTMatrix</td>
</tr>
<tr>
<td>DATA_ARRAY(name)</td>
<td>array&lt;Type&gt;</td>
<td>array</td>
</tr>
<tr>
<td>PARAMETER_MATRIX(name)</td>
<td>matrix&lt;Type&gt;</td>
<td>matrix</td>
</tr>
<tr>
<td>PARAMETER_VECTOR(name)</td>
<td>vector&lt;Type&gt;</td>
<td>vector</td>
</tr>
<tr>
<td>PARAMETER_ARRAY(name)</td>
<td>array&lt;Type&gt;</td>
<td>array</td>
</tr>
<tr>
<td>PARAMETER(name)</td>
<td>Type</td>
<td>numeric(1)</td>
</tr>
</tbody>
</table>
Basic calculations:

<table>
<thead>
<tr>
<th>Template Syntax</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>REPORT(x)</td>
<td>Report x back to R</td>
</tr>
<tr>
<td>ADREPORT(x)</td>
<td>Report x back to R with derivatives</td>
</tr>
<tr>
<td>vector&lt;Type&gt; v(n1);</td>
<td>R equivalent of v=numeric(n1)</td>
</tr>
<tr>
<td>matrix&lt;Type&gt; m(n1,n2);</td>
<td>R equivalent of m=matrix(0,n1,n2)</td>
</tr>
<tr>
<td>array&lt;Type&gt; a(n1,n2,n3);</td>
<td>R equivalent of a=array(0,c(n1,n2,n3))</td>
</tr>
<tr>
<td>v+v,v-v,v*v,v/v</td>
<td>Pointwise binary operations</td>
</tr>
<tr>
<td>m*v</td>
<td>Matrix-vector multiply</td>
</tr>
<tr>
<td>a.col(i)</td>
<td>R equivalent of a[,]i</td>
</tr>
<tr>
<td>a.col(i),col(j)</td>
<td>R equivalent of a[,]j,i</td>
</tr>
<tr>
<td>a(i,j,k)</td>
<td>R equivalent of a[,]j,k</td>
</tr>
<tr>
<td>exp(v)</td>
<td>Pointwise math</td>
</tr>
<tr>
<td>m(i,j)</td>
<td>R equivalent of m[,]j</td>
</tr>
<tr>
<td>v.sum()</td>
<td>R equivalent of sum(v)</td>
</tr>
<tr>
<td>m.transpose()</td>
<td>R equivalent of t(m)</td>
</tr>
</tbody>
</table>

Some distributions are available as C++ templates with syntax close to R’s distributions:

<table>
<thead>
<tr>
<th>Function header</th>
<th>Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>dnbinom2(x,mu,var,int give_log=0)</td>
<td>Negative binomial with mean and variance</td>
</tr>
<tr>
<td>dpois(x,lambda,int give_log=0)</td>
<td>Poisson distribution as in R</td>
</tr>
<tr>
<td>dlgamma(y,shape,scale,int give_log=0)</td>
<td>log-gamma distribution</td>
</tr>
<tr>
<td>dnorm(x,mean,sd,int give_log=0)</td>
<td>Normal distribution as in R</td>
</tr>
</tbody>
</table>

Examples

template()

tmbprofile

Adaptive likelihood profiling.

Description

Calculate 1D likelihood profiles wrt. single parameters or more generally, wrt. arbitrary linear combinations of parameters (e.g. contrasts).

Usage

tmbprofile(
    obj,
    name,
    lincomb,
    h = 1e-04,
)
\begin{verbatim}
ytol = 2,
ystep = 0.1,
maxit = ceiling(5 * ytol/ystep),
parm.range = c(-Inf, Inf),
slice = FALSE,
trace = TRUE,
...
)
\end{verbatim}

**Arguments**

- **obj**: Object from MakeADFun that has been optimized.
- **name**: Name or index of a parameter to profile.
- **lincomb**: Optional linear combination of parameters to profile. By default a unit vector corresponding to `name`.
- **h**: Initial adaptive stepsize on parameter axis.
- **ytol**: Adjusts the range of the likelihood values.
- **ystep**: Adjusts the resolution of the likelihood profile.
- **maxit**: Max number of iterations for adaptive algorithm.
- **parm.range**: Valid parameter range.
- **slice**: Do slicing rather than profiling?
- **trace**: Trace progress? (TRUE, or a numeric value of 1, gives basic tracing: numeric values > 1 give more information)
- **...**: Unused

**Details**

Given a linear combination

\[ t = \sum_{i=1}^{n} v_i \theta_i \]

of the parameter vector \( \theta \), this function calculates the likelihood profile of \( t \). By default \( v \) is a unit vector determined from `name`. Alternatively the linear combination may be given directly (lincomb).

**Value**

data.frame with parameter and function values.

**See Also**

`plot.tmbprofile`, `confint.tmbprofile`
Examples

```r
## Not run:
runExample("simple",thisR=TRUE)
## Parameter names for this model:
## beta  beta  logsdu  logsd0

## Profile wrt. sigma0:
prof <- tmbprofile(obj,"logsd0")
plot(prof)
confint(prof)

## Profile the difference between the beta parameters (name is optional):
prof2 <- tmbprofile(obj,name="beta1 - beta2",lincomb = c(1,-1,0,0))
plot(prof2)
confint(prof2)

## End(Not run)
```

tmbroot

Compute likelihood profile confidence intervals of a TMB object by root-finding

Description

Compute likelihood profile confidence intervals of a TMB object by root-finding in contrast to `tmbprofile`, which tries to compute somewhat equally spaced values along the likelihood profile (which is useful for visualizing the shape of the likelihood surface), and then (via `confint.tmbprofile`) extracting a critical value by linear interpolation.

Usage

```r
tmbroot(
  obj,
  name,
  target = 0.5 * qchisq(0.95, df = 1),
  lincomb,
  parm.range = c(NA, NA),
  sd.range = 7,
  trace = FALSE,
  continuation = FALSE
)
```

Arguments

- `obj`: Object from MakeADFun that has been optimized.
- `name`: Name or index of a parameter to profile.
- `target`: desired deviation from minimum log-likelihood. Default is set to retrieve the 95 if the objective function is a negative log-likelihood function.
lincomb  Optional linear combination of parameters to profile. By default a unit vector corresponding to name.
parm.range  lower and upper limits; if NA, a value will be guessed based on the parameter value and sd.range
sd.range  in the absence of explicit parm.range values, the range chosen will be the parameter value plus or minus sd.range times the corresponding standard deviation. May be specified as a two-element vector for different ranges below and above the parameter value.
trace  report information?
continuation  use continuation method, i.e. set starting parameters for non-focal parameters to solutions from previous fits?

Value

a two-element numeric vector containing the lower and upper limits (or NA if the target is not achieved in the range), with an attribute giving the total number of function iterations used

Examples

```r
## Not run:
runExample("simple",thisR=TRUE)
logsd0.ci <- tmbroot(obj,"logsd0")

## End(Not run)
```
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