Package ‘RCEIM’

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Type Package

Title R Cross Entropy Inspired Method for Optimization

Version 0.3

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Author Alberto Krone-Martins

Maintainer Alberto Krone-Martins <algol@sim.ul.pt>

Description An implementation of a stochastic heuristic method for performing multidimensional function optimization. The method is inspired in the Cross-Entropy Method. It does not relies on derivatives, neither imposes particularly strong requirements into the function to be optimized. Additionally, it takes profit from multi-core processing to enable optimization of time-consuming functions.

License GPL (>= 2)

Suggests parallel

NeedsCompilation no

Repository CRAN

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Contents

RCEIM-package *An R Cross Entropy Inspired Method for Optimization RCEIM*

Description

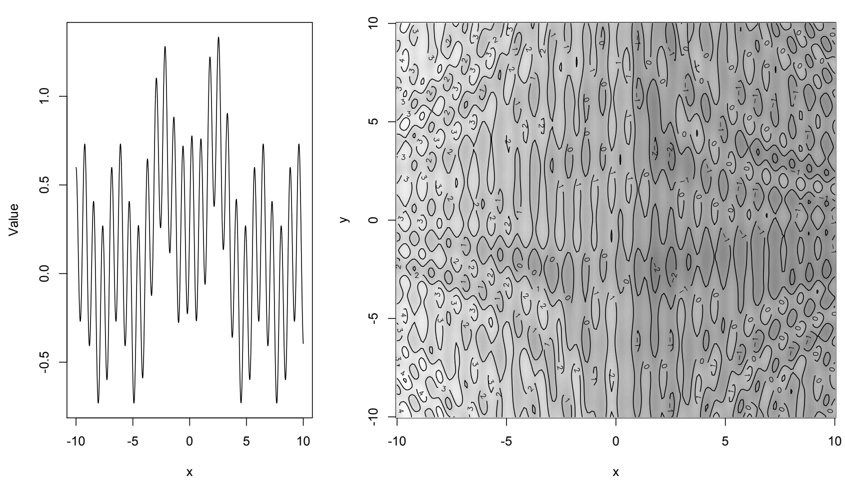
RCEIM is a package implementing a stochastic heuristic method for performing multidimensional function optimization. The method is inspired in the Cross-Entropy Method.

Details

Package:	RCEIM
Type:	Package
Version:	0.3
Date:	2015-02-19
License:	GPL (>= 2)

RCEIM implements a simple stochastic heuristic method for optimization in the function `ceimOpt`. This method starts from a random population of solutions, computes the values of the function and selects a fraction of these solutions - the elite members. Afterwards, based on the elite members it creates a gaussian distribution, samples new random solutions from it, and iterates until convergence is reached (this is controlled by an epsilon parameter) or other stopping criteria is fulfilled (such as the maximum number of iterations).

One advantage of this method is that it does not impose strong conditions on the function to be optimized. The function must written as an R function, but it does not need to be continuous, differentiable, neither analytic. Moreover, the method is ready for multicore processing, enabling the optimization of time-consuming functions.



Two examples of 1D and 2D functions that can be used as test problems for RCEIM (defined in `testFunOptimization` and `testFunOptimization2d`) are represented in the above figures.

Author(s)

Alberto Krone-Martins, Laurent Gallucio

Maintainer: Alberto Krone-Martins <algol@sim.ul.pt>

See Also

ceimOpt

Examples

```
# Solve a simple optimization problem and shows the results
po <- ceimOpt(OptimFunction=function(x){(x[1]+1)^2+(x[2]+2)^2}, maxIter=100, epsilon=0.3,
      nParams=2)
plotEliteDistrib(po$EliteMembers)
rm(po)

# A harder problem in 1D
po <- ceimOpt(OptimFunction="testFunOptimization", maxIter=10, epsilon=0.3,
      nParams=1, verbose=TRUE)
dev.new()
xx <- seq(-10,10,by=0.01)
plot(xx, testFunOptimization(xx), type="l", xlab="x", ylab="Value")
points(po$BestMember[1], po$BestMember[2], col="red")
rm(list=c('xx','po'))

# A harder problem in 2D
po <- ceimOpt(OptimFunction="testFunOptimization2d", maxIter=20, epsilon=0.3,
      nParams=2, verbose=TRUE)
dev.new()
xx <- seq(-10,10,by=0.1)
yy <- seq(-10,10,by=0.1)
zz <- matrix(nrow=length(yy), ncol=length(xx))
for(i in 1:length(xx)){
    for(j in 1:length(yy)){
        zz[i,j] <- testFunOptimization2d( c(xx[i],yy[j]) )
    }
}
image(xx,yy,zz, col=gray((50:100)/100), xlab="x", ylab="y")
contour(xx,yy,zz, add=TRUE)
points(po$BestMember[1], po$BestMember[2], col="red", pch=19, cex=0.5)
rm(list=c('xx','yy','zz'))

# Example of multicore processing
slowFunction <- function(x) {
  p<-runif(50000)
  return((x+3)^2)
}
system.time(po <- ceimOpt(OptimFunction="slowFunction", maxIter=10,
    Ntot=100, epsilon=0.3, nParams=1, verbose=FALSE, parallel=FALSE))
print(po$BestMember)
system.time(po <- ceimOpt(OptimFunction="slowFunction", maxIter=10,
    Ntot=100, epsilon=0.3, nParams=1, verbose=FALSE, parallel=TRUE))
```

```
print(po$BestMember)
rm(po)
```

---

ceimOpt *A Cross Entropy Inspired Method for Optimization*

Description

This is a Cross-Entropy Inspired Method for optimization.

Usage

```
ceimOpt(OptimFunction = "testFunOptimization", nParams = 1, minimize = TRUE,
    Ntot = 1000, N_elite = floor(Ntot/4), N_super = 1, alpha = 1, epsilon = 0.1,
    q = 2, maxIter = 50, waitGen = maxIter, boundaries = t(matrix(rep(c(-10, 10),
    nParams), ncol = nParams)),plotConvergence = FALSE, chaosGen = maxIter,
    handIterative = FALSE, verbose = FALSE, plotResultDistribution = FALSE,
    parallelVersion = FALSE)
```

Arguments

OptimFunction	A string with the name of the function that will be optimized.
nParams	An integer with the number of parameters of the function that will be optimized.
minimize	A boolean indicating if the OptimFunction should be minimized or maximized.
Ntot	An integer with the number of individuals per iteration.
N_elite	An integer with the number of elite individuals, or in other words, the individuals used to define the individuals of the new iteration.
N_super	An integer with the number of super-individuals, or those individuals with the best fitness values, that are directly replicated to the next iteration.
alpha	A parameter of the CE method used to control the convergence rate, and to prevent early convergence.
epsilon	A convergence control parameter: if the maximum st.dev. of the parameters of the elite individuals divided by its average value is smaller than this number, the method considers that it converged.
q	A parameter of the CE method used to control the convergence rate, and to prevent early convergence.
maxIter	The maximum number of iterations that the method will run before stop.
waitGen	The number of iterations that the method will wait: after "waitGen" without any improvement in the best individual, the method gives up and return the best individual as an answer.
boundaries	A matrix with as many rows as there are parameters and two columns the first column stores the minimum value, while the second, the maximum.

`plotConvergence`
: A flag to indicate if the user wants to visually check the convergence of the method.

`chaosGen`
: The number of iterations before the method replaces all the solutions, but the super-individuals, by a new random trial.

`handIterative`
: A flag to indicate if the user wants to press enter between the each generation.

`verbose`
: A flag to indicate if the user wants to receive some convergence and distribution information printed on the screen.

`plotResultDistribution`
: A flag to indicate if the user wants to see the resulting distribution of elite members (black curve), the value of the fittest member (red line) and of the average member (blue line), for each parameter.

`parallelVersion`
: A flag to indicate if the user wants to use all the cores in his/her computer to compute the fitness functions.

Details

This is a simple stochastic heuristic method for optimization. It starts from a random population of points, computes the values of the function and selects a fraction of the points - the elite members. Then, based on these fittest points, it constructs a gaussian distribution, samples new random points from it, and iterates until convergence is reached (this is controlled by the epsilon parameter) or other stopping criteria is fulfilled (such as the maximum number of iterations).

The method does not impose strong conditions on the function to be optimized. The function must written as an R function, but it does not need to be neither continuous, differentiable or analytic. Moreover, the method is ready for multicore processing, enabling the optimization of time-consuming functions.

Value

A list that contains:

`BestMember`
: The parameters and the fitness value of the best member.

`Convergence`
: A boolean indicating if the method reached convergence.

`Criteria`
: Stopping criterion.

`Iterations`
: The amount of iterations.

`EliteMembers`
: The parameters and fitness values of the elite members at the last iteration.

Author(s)

Alberto Krone-Martins

Examples

```
# Solve a simple optimization problem and shows the results
po <- ceimOpt(OptimFunction=function(x){(x[1]+1)^2+(x[2]+2)^2}, maxIter=100, epsilon=0.3,
      nParams=2)
```

```
plotEliteDistrib(po$EliteMembers)
rm(po)

# A harder problem in 1D
po <- ceimOpt(OptimFunction="testFunOptimization", maxIter=10, epsilon=0.3,
      nParams=1, verbose=TRUE)
dev.new()
xx <- seq(-10,10,by=0.01)
plot(xx, testFunOptimization(xx), type="l", xlab="x", ylab="Value")
points(po$BestMember[1], po$BestMember[2], col="red")
rm(list=c('xx','po'))

# A harder problem in 2D
po <- ceimOpt(OptimFunction="testFunOptimization2d", maxIter=20, epsilon=0.3,
      nParams=2, verbose=TRUE)
dev.new()
xx <- seq(-10,10,by=0.1)
yy <- seq(-10,10,by=0.1)
zz <- matrix(nrow=length(yy), ncol=length(xx))
for(i in 1:length(xx)){
    for(j in 1:length(yy)){
        zz[i,j] <- testFunOptimization2d( c(xx[i],yy[j]) )
    }
}
image(xx,yy,zz, col=gray((50:100)/100), xlab="x", ylab="y")
contour(xx,yy,zz, add=TRUE)
points(po$BestMember[1], po$BestMember[2], col="red", pch=19, cex=0.5)
rm(list=c('xx','yy','zz'))

# Example of multicore processing
slowFunction <- function(x) {
  p<-runif(50000)
  return((x+3)^2)
}
system.time(po <- ceimOpt(OptimFunction="slowFunction", maxIter=10,
    Ntot=100, epsilon=0.3, nParams=1, verbose=FALSE, parallel=FALSE))
print(po$BestMember)
system.time(po <- ceimOpt(OptimFunction="slowFunction", maxIter=10,
    Ntot=100, epsilon=0.3, nParams=1, verbose=FALSE, parallel=TRUE))
print(po$BestMember)
rm(po)
```

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enforceDomainOnParameters

Enforce domain boundaries

Description

A small function to assure that the domains are respected during the optimization process. If any of them not respected, the ofending parameters are replaced by the value of the nearest border.

Usage

```
enforceDomainOnParameters(paramsArray, domain)
```

Arguments

paramsArray	The array with the parameters to check.
domain	The domain boudaries.

Value

The parameter array, with ofending values replaced if necessary.

Author(s)

Alberto Krone-Martins

Examples

```
# Creates a random set of parameters in an interval larger than a certain domain
# and apply the enforceDomainOnParameters function and represent graphically
# the parameters before and after the function.
dev.new()
paramArr <- matrix((runif(100)-0.5)/0.5*13, nrow=50)
domain <- matrix(c(-10, -10, 10, 10), ncol=2)
newParamArr <- enforceDomainOnParameters(paramArr, domain)
plot(paramArr[,1], paramArr[,2], xlab="x", ylab="y", main="black: input\n red: output")
points(newParamArr[,1], newParamArr[,2], col="red", pch=19, cex=0.7)
```

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overPlotErrorPolygon *Overplot an error polygon*

Description

A simple function to overplot an error polygon around a curve. Note that the error is considered as symmetric, and exclusively on y. The polygon will be created from the coordinate tuples $(x,(y-err_y))$ and $(x,(y+err_y))$.

Usage

```
overPlotErrorPolygon(x, y, err_y, col = "grey", logPlot = FALSE, ...)
```

Arguments

x	A vector containing the x coordinate of the data.
y	A vector containing the y coordinate of the data.
err_y	A vector containing the error in y.
col	The color that will be used for filling the polygon.
logPlot	A boolean indicating if the plot is in logscale.
...	Further arguments to be passed to polygon().

Value

A polygon is overplotted in the active graphics device.

Author(s)

Alberto Krone-Martins

Examples

```
# Shows a simple random curve and overplots a randomly created error bar.
dev.new()
xx <- 1:10
yy <- (1:10)/5 + 4 + (runif(10)-0.5)/0.5*2
plot(xx, yy, type="l", xlab="x", ylab="y", ylim=c(0,10))
err_yy <- 1.5 + (runif(10)-0.5)/0.5
overPlotErrorPolygon(xx,yy,err_yy, col=rgb(0,0,1,0.3), border=NA)
```

`plotEliteDistrib` *Plot the distribution of elite members*

Description

A simple function to create distribution plots of the elite members after the optimization procedure. The distribution is graphically represented using a kernel density estimation. Aditionally, this function also indicates the best and average members.

Usage

```
plotEliteDistrib(elite)
```

Arguments

`elite`	A matrix containing parameters of the elite members.

Value

A graphic representation of the elite members and also of the best and average members.

Author(s)

Alberto Krone-Martins

See Also

`ceimOpt`

Examples

```
# Solve a simple 2D problem and show the distribution of the parameters
po <- ceimOpt(OptimFunction=function(x){(x[1]+1)^2+(x[2]+2)^2}, maxIter=100,
      epsilon=0.1, nParams=2)
plotEliteDistrib(po$EliteMembers)
rm(po)
```

---

sortDataFrame *Sorting a data frame by a key*

Description

A simple function to sort a data frame based on a certain keyword. This function was posted by r-fanatic at a dzone forum (the webpage is not available anymore).

Usage

```
sortDataFrame(x, key, ...)
```

Arguments

x	The data frame to be sorted.
key	The key by which the data frame will be sorted.
...	Further arguments to be passed to the order function.

Value

The sorted data frame.

Author(s)

r-fanatic

References

The original webpage where r-fanatic posted the code is not available as of 3rd April 2017.

Examples

```
# Create a simple data frame and order using the "B" key
ppp <- data.frame(A=1:10,B=10:1)
ppp
sortDataFrame(ppp,"B")
ppp
```

testFunOptimization — *1D test problem for RCEIM*

Description

An one-dimension problem for testing optimization methods.

This function was created for demonstrating the RCEIM package. It has the form:

$$f(x) = \exp(-((x-2)^2)) + 0.9 * \exp(-((x+2)^2)) + 0.5 * \sin(8 * x) + 0.25 * \cos(2 * x)$$

Usage

```
testFunOptimization(x)
```

Arguments

x	The point where the function is computed.

Value

The value of the function at x.

Author(s)

Alberto Krone-Martins

See Also

testFunOptimization2d

Examples

```
# Create a graphical representation of the problem with a line plot
dev.new()
xx <- seq(-10,10,by=0.01)
plot(xx, testFunOptimization(xx), type="l", xlab="x", ylab="Value")
rm(list=c('xx'))
```

testFunOptimization2d *2D test problem for RCEIM*

Description

A two-dimensional problem for testing optimization methods.

This function was created for demonstrating the RCEIM package. It has the form:

$$f(x_1, x_2) = \frac{(x_1-4)^2 + (x_2+2)^2}{50} - \frac{(x_1+2)^2 + (x_2+4)^2}{90}$$
$$-\exp(-(x_1-2)^2) - 0.9 * \exp(-(x_2+2)^2) - 0.5 * \sin(8 * x_1) - 0.25 * \cos(2 * x_2)$$
$$+0.25 * \sin(\frac{x_1 * x_2}{2}) + 0.5 * \cos(\frac{x_2 * x_1}{2.5})$$

Usage

```
testFunOptimization2d(x)
```

Arguments

x	a vector with the point where the function is computed.

Value

The value of the function at the requested point (x_1, x_2).

Author(s)

Alberto Krone-Martins

See Also

testFunOptimization

Examples

```
# Create a graphical representation of the problem with a contour plot
dev.new()
xx <- seq(-10,10,by=0.1)
yy <- seq(-10,10,by=0.1)
zz <- matrix(nrow=length(yy), ncol=length(xx))
for(i in 1:length(xx)){
for(j in 1:length(yy)){
zz[i,j] <- testFunOptimization2d( c(xx[i],yy[j]) )
}
}
image(xx,yy,zz, col=gray((50:100)/100), xlab="x", ylab="y")
contour(xx,yy,zz, add=TRUE)
rm(list=c('xx','yy','zz'))
```

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