Package 'LA'

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Type Package

Title Lioness Algorithm (LA)

Version 0.1.2

Description
Contains Lioness Algorithm (LA) for finding optimal designs over continuous design space, optimal Latin hypercube designs, and optimal order-of-addition designs. LA is a brand new nature-inspired meta-heuristic optimization algorithm. Detailed methodologies of LA and its implementation on numerical simulations can be found at Hongzhi Wang, Qian Xiao and Abhyuday Mandal (2021) <arXiv:2010.09154>.

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Imports stats, LHD (>= 1.3.3), utils

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R topics documented:

LA_LHD *Lioness Algorithm for Latin hypercube design*

Description

LA_LHD returns a n by k Latin hypercube design matrix generated by lioness algorithm (LA)

Usage

```
LA_LHD(
  n,
  k,
  m = 10,
  N = 10,
  prun = 1/(k - 1),
  OC = "phi_p",
  p = 15,
  q = 1,
  maxtime = 5
)
```

Arguments

n	A positive integer, which stands for the number of rows (or run size).
k	A positive integer, which stands for the number of columns (or factor size).
m	A positive integer, which stands for the number of starting lionesses agents. The default is set to be 10, and it is recommended to be no greater than 100.
N	A positive integer, which stands for the number of iterations. The default is set to be 10. A large value of N will result a high CPU time, and it is recommended to be no greater than 500.
prun	A probability, which stands for the probability of "prey runs away", and it is denoted as p* in the original paper. The default is set to be 1/(k - 1).
OC	An optimality criterion. The default setting is "phi_p", and it could be one of the following: "phi_p", "AvgAbsCor", "MaxAbsCor", "MaxProCriterion".
p	A positive integer, which is the parameter in the phi_p formula, and p is prefered to be large. The default is set to be 15.
q	The default is set to be 1, and it could be either 1 or 2. If q is 1, the Manhattan (rectangular) distance will be used. If q is 2, the Euclidean distance will be used.
maxtime	A positive number, which indicates the expected maximum CPU time given by user, and it is measured by minutes. For example, maxtime=3.5 indicates the CPU time will be no greater than three and half minutes. The default is set to be 5.

Value

If all inputs are logical, then the output will be a n by k LHD.

Examples

```
#generate a 6 by 3 maximin distance LHD with the default setting
try=LA_LHD(n=6,k=3)
try
LHD::phi_p(try)   #calculate the phi_p of "try".

#Another example
#generate a 9 by 4 nearly orthogonal LHD
try2=LA_LHD(n=9,k=4,OC="AvgAbsCor")
try2
LHD::AvgAbsCor(try2)  #calculate the average absolute correlation.
```

LA_OofA *Lioness Algorithm for order-of-addition design*

Description

LA_OofA returns a n by k order-of-addition design matrix generated by lioness algorithm (LA)

Usage

```
LA_OofA(
  n = factorial(k),
  k,
  m = 10,
  N = 10,
  prun = 1/(n - 1),
  OC = "D",
  maxtime = 5
)
```

Arguments

n	A positive integer, which stands for the number of rows (or run size). The default setting of n is k factorial, which yields a full order-of-addition design matrix. Note that the maximum of n cannot be greater than k factorial.
k	A positive integer, which stands for the number of columns (or factor size).
m	A positive integer, which stands for the number of starting lionesses agents. The default is set to be 10, and it is recommended to be no greater than 100.
N	A positive integer, which stands for the number of iterations. The default is set to be 10. A large value of N will result a high CPU time, and it is recommended to be no greater than 500.

prun	A probability, which stands for the probability of "prey runs away", and it is denoted as p* in the original paper. The default is set to be 1/(n - 1).
OC	An optimality criterion. The default setting is "D", which stands for the D-optimality criterion, and in the future we would add other criteria such as A-optimality criterion and E-optimality criterion.
maxtime	A positive number, which indicates the expected maximum CPU time given by user, and it is measured by minutes. For example, maxtime=3.5 indicates the CPU time will be no greater than three and half minutes. The default is set to be 5.

Value

If all inputs are logical, then the output will be a n by k order-of-addition design.

Examples

```
#generate a D-optimal full OofA with 4 factors.
try=LA_OofA(k=4)
try
det(MOM(try))  #the determinant of the moment matrix of try

#Another example
#generate a D-optimal 11-run OofA with 4 factors.
try2=LA_OofA(n=11,k=4)
try2
det(MOM(try2)) #the determinant of the moment matrix of try2
```

LA_opt *Lioness Algorithm for experimental designs with continuous input and function optimization*

Description

LA_opt returns optimal designs with continuous input or optimal solutions for function optimization

Usage

```
LA_opt(
  of = NULL,
  n = NULL,
  lb,
  ub,
  m = 10,
  N = 10,
  OC = NULL,
  type = "mini",
  maxtime = 5
)
```

Arguments

of	An objective function to be evaluated. If user is seeking for optimal design rather than function optimization, of should be left with NULL, which is the default setting.
n	A positive integer, which stands for the number of rows (or run size) for a design. If user is seeking for optimal design, n should be the number of rows of the design matrix. If user is seeking for function optimization, n should be left with NULL, which is the default setting.
lb	A vector contains the lower bounds of all the input variables. For example, if there are 3 input variables whose lower bounds are 0, 5, and 15, lb should be lb=c(0,5,15).
ub	A vector contains the upper bounds of all the input variables. For example, if there are 3 input variables whose upper bounds are 10, 15, and 25, ub should be lb=c(10,15,25).
m	A positive integer, which stands for the number of starting lionesses agents. The default is set to be 10, and it is recommended to be no greater than 100.
N	A positive integer, which stands for the number of iterations. The default is set to be 10. A large value of N will result a high CPU time, and it is recommended to be no greater than 500.
OC	An optimality criterion. If user is seeking for optimal design, OC should be an optimality criterion for how to evaluate the design matrix. If user is seeking for function optimization, OC should be left with NULL, which is the default setting.
type	A logic input argument, which indicates the type of optimization. If type is mini (the default setting), minimization will be implemented in the algorithm. If type is maxi, maximization will be implemented in the algorithm.
maxtime	A positive number, which indicates the expected maximum CPU time given by user, and it is measured by minutes. For example, maxtime=3.5 indicates the CPU time will be no greater than three and half minutes. The default is set to be 5.

Value

If all inputs are logical, then the output will be either a n by length(lb) optimal design or a 1 by length(lb) vector of optimal solutions for function optimization.

Examples

```
#We start with function optimization
#Now define an objective function: Sum of Different Powers
SDP=function(x){i=1:length(x);y=sum(abs(x)^(i=1));return(y)}

#Use LA to find the optimal solution under 20-dimensional setting
#for SDP function with 10 iterations.
try=LA_opt(of=SDP,lb=rep(-1,20),ub=rep(1,20),m=10,N=10,type="mini")
SDP(try)  #Note that the true global optimum is 0, but we only have 10 iterations

#Another example
```

```
#Define an objective function: Cross-in-Tray
CiT=function(x){x1=x[1];x2=x[2];y=-0.0001*(abs(sin(x1)*sin(x2)*
exp(abs(100-sqrt(x1^2+x2^2)/pi)))+1)^0.1;return(y)}

#Use LA to find the optimal solution under 2-dimensional setting
#for CiT function with 10 iterations.
try2=LA_opt(of=CiT,lb=rep(-10,2),ub=rep(10,2),m=10,N=10,type="mini")
CiT(try2) #Note that the true global optimum is -2.06261, but we only have 10 iterations

#Next we introduce the optimal design part
#Assume in a simple linear regression model, we want to find a D-optimal
#20-run design, where the input variable takes values between 0 and 24.
#In theory, we know the optimal design is the following:
#matrix(c(rep(1,20),rep(0,10),rep(24,10)),ncol=2,nrow=20,byrow=FALSE)
#Let's see if LA is able to identify that.

#Define the D-optimality criterion in simple linear regression model:
D=function(x){IM=t(x)%*%x;return(det(IM))}

#Use LA to find the optimal solution for above problem.
#We want to maximize the determinant of the information matrix.
try3=LA_opt(n=20,lb=c(1,0),ub=c(1,24),m=10,N=10,OC=D,type="maxi")
try3 #with more iterations, LA would return even better result.
```

MOM *Calculate the moment matrix of an order-of-addition design*

Description

MOM returns the moment matrix of an order-of-addition design

Usage

```
MOM(X)
```

Arguments

X	A matrix object. X must be an order-of-addition design (OofA) matrix.

Value

If the input is logical, then the output will be a 1+{k \choose 2} by 1+{k \choose 2} matrix, where k is the factor size of the input OofA.

References

Lin, D. K., and Peng, J. (2019) Order-of-addition experiments: A review and some new thoughts. *Quality Engineering*, **31**, 49-59.

Examples

```
#create a full OofA with 3 factors.
toy=rOofA(k=3);toy

#Calculate the moment matrix of toy
MOM(X=toy)
```

PWO *Calculate the pairwise-order (PWO) of an order-of-addition design*

Description

PWO returns the pairwise-order matrix of an order-of-addition design

Usage

```
PWO(X)
```

Arguments

X	A matrix object. X must be an order-of-addition design (OofA) matrix.

Value

If the input is logical, then the output will be a n by {k \choose 2} matrix, where n and k are the run size and factor size of the input OofA. Each column of PWO represents one distinct pair of elements from the input OofA. For example, an OofA with 4 factors has the following pairs: {(1,2),(1,3),(1,4),(2,3),(2,4),(3,4)}.

References

Van Nostrand, R. C. (1995) Design of experiments where the order of addition is important. *ASA proceedings of the Section on Physical and Engineering Sciences*, 155-160.

Examples

```
#create a full OofA with 3 factors.
toy=rOofA(k=3);toy

#Calculate the pairwise-order of toy
PWO(X=toy)
```

rOofA *Generate a random order-of-addition design (OofA)*

Description

rOofA returns a random n by k order-of-addition design matrix

Usage

```
rOofA(n = factorial(k), k)
```

Arguments

n	A positive integer, which stands for the number of rows (or run size). The default setting of n is k factorial, which yields a full order-of-addition design matrix. Note that the maximum of n cannot be greater than k factorial.
k	A positive integer, which stands for the number of columns (or factor size).

Value

If all inputs are positive integer, then the output will be a n by k design matrix.

Examples

```
#generate a full OofA with 4 factors.
toy=rOofA(k=4);toy

#generate a 12-run random OofA with 4 factors.
toy=rOofA(n=12,k=4);toy
```

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