Package ‘edesign’

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Title Maximum Entropy Sampling

Version 1.0-13

Description An implementation of maximum entropy sampling for spatial data is provided. An exact branch-and-bound algorithm as well as greedy and dual greedy heuristics are included.

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NeedsCompilation yes

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`dualgreedy` *Dual-greedy algorithm for maximum entropy sampling*

Description

Starting point is a network A[F] with nf points. Now one has to select ns points of a set of candidate sites to augment the existing network. The aim of maximum entropy sampling is to select a feasible D-optimal design that maximizes the logarithm of the determinant of all principal submatrices of A arising by this expansion.

It is also possible to construct a completely new network, that means $nf = 0$.

This dual-greedy algorithm starts with the matrix A and deletes the worst candidate of each of the stages $(1..ns)$ to reduce this matrix.

Usage

```
dualgreedy(A, nf, ns, etol=0, mattest=TRUE)
```

Arguments

`A`	Spatial covariance matrix A.
`nf`	Number of stations are forced into every feasible solution.
`ns`	Number of stations have to be added to the existing network.
`etol`	Tolerance for checking positve definiteness (default 0)
`mattest`	Toggles testing matrix `A` for symmetry and positive definiteness (default `T`)

Details

$A[F]$ denotes the principal submatrix of A having rows and columns indexed by $1..nf$.

Value

A object of class `monet` containing the following elements:

`S`	Vector containing the indices of the added sites in the solution or 0 for the other sites.
`det`	Determinant of the principal submatrix indexed by the solution.

Author(s)

C. Gebhardt

References

Ko, Lee, Queyranne, An exact algorithm for maximum entropy sampling, Operations Research 43 (1995), 684-691.

Gebhardt, C.: Bayessche Methoden in der geostatistischen Versuchsplanung. PhD Thesis, Univ. Klagenfurt, Austria, 2003

O.P. Baume, A. Gebhardt, C. Gebhardt, G.B.M. Heuvelink and J. Pilz: Network optimization algorithms and scenarios in the context of automatic mapping. Computers & Geosciences 37 (2011) 3, 289-294

See Also

greedy, interchange, maxentropy

Examples

```
x <- c(0.97900601,0.82658702,0.53105628,0.91420190,0.35304969,
       0.14768239,0.58000004,0.60690101,0.36289026,0.82022147,
       0.95290664,0.07928365,0.04833764,0.55631735,0.06427738,
       0.31216689,0.43851418,0.34433556,0.77699357,0.84097327)
y <- c(0.36545512,0.72144122,0.95688671,0.25422154,0.48199229,
       0.43874199,0.90166634,0.60898628,0.82634713,0.29670695,
       0.86879093,0.45277452,0.09386800,0.04788365,0.20557817,
       0.61149264,0.94643855,0.78219937,0.53946353,0.70946842)
A <- outer(x, x, "-")^2 + outer(y, y, "-")^2
A <- (2 - A)/10
diag(A) <- 0
diag(A) <- 1/20 + apply(A, 2, sum)

dualgreedy(A,5,5)
```

`edesign-internal` *Internal functions of library edsign*

Description

Internal functions of library edsign

Details

These functions are not intended to be called by the user.

`greedy` *Greedy algorithm for maximum entropy sampling*

Description

Starting point is a network $A[F]$ with nf points. Now one has to select ns points of a set of candidate sites to augment the existing network. The aim of maximum entropy sampling is to select a feasible D-optimal design that maximizes the logarithm of the determinant of all principal submatrices of A arising by this expansion.

It is not possible to construct a completely new network, that means $nf > 0$. Use the dual greedy heuristic for this purpose.

This greedy algorithm starts with the submatrix $A[F]$ and selects the best candidate of each of the stages $(1..ns)$ to expand this matrix.

Usage

```
greedy(A, nf, ns, etol=0, mattest=TRUE)
```

Arguments

`A`	Spatial covariance matrix A.
`nf`	Number of stations are forced into every feasible solution.
`ns`	Number of stations have to be added to the existing network.
`etol`	Tolerance for checking positve definiteness (default 0)
`mattest`	Toggles testing matrix `A` for symmetry and positive definiteness (default `T`)

Details

$A[F]$ denotes the principal submatrix of A having rows and columns indexed by $1..nf$.

Value

A object of class `monet` containing the following elements:

`S`	Vector containing the indices of the added sites in the solution or 0 for the other sites.
`det`	Determinant of the principal submatrix indexed by the solution.

Author(s)

C. Gebhardt

References

Ko, Lee, Queyranne, An exact algorithm for maximum entropy sampling, Operations Research 43 (1995), 684-691.

Gebhardt, C.: Bayessche Methoden in der geostatistischen Versuchsplanung. PhD Thesis, Univ. Klagenfurt, Austria, 2003

O.P. Baume, A. Gebhardt, C. Gebhardt, G.B.M. Heuvelink and J. Pilz: Network optimization algorithms and scenarios in the context of automatic mapping. Computers & Geosciences 37 (2011) 3, 289-294

See Also

greedy, dualgreedy, maxentropy

Examples

```
x <- c(0.97900601,0.82658702,0.53105628,0.91420190,0.35304969,
       0.14768239,0.58000004,0.60690101,0.36289026,0.82022147,
       0.95290664,0.07928365,0.04833764,0.55631735,0.06427738,
       0.31216689,0.43851418,0.34433556,0.77699357,0.84097327)
y <- c(0.36545512,0.72144122,0.95688671,0.25422154,0.48199229,
       0.43874199,0.90166634,0.60898628,0.82634713,0.29670695,
       0.86879093,0.45277452,0.09386800,0.04788365,0.20557817,
       0.61149264,0.94643855,0.78219937,0.53946353,0.70946842)
A <- outer(x, x, "-")^2 + outer(y, y, "-")^2
A <- (2 - A)/10
diag(A) <- 0
diag(A) <- 1/20 + apply(A, 2, sum)

greedy(A,5,5)
```

---

interchange *Interchange algorithm for maximum entropy sampling*

Description

Starting point is a network $A[F]$ with nf points. Now one has to select ns points of a set of candidate sites to augment the existing network. The aim of maximum entropy sampling is to select a feasible D-optimal design that maximizes the logarithm of the determinant of all principal submatrices of A arising by this expansion.

The interchange algorithm improves a feasible initial solution directly given or obtained by the greedy or dual greedy algorithm for maximum entropy sampling.

It is also possible to improve the initial solution for the construction of a completely new network, that means $nf = 0$, but in this case the interchange algorithm fails for $ns = 1$.

Usage

```
interchange(A, nf, ns, S.start, etol=0, mattest = TRUE)
```

Arguments

A	Spatial covariance matrix A.
nf	Number of stations are forced into every feasible solution.
ns	Number of stations have to be added to the existing network.
S.start	Vector that gives the ns indices contained in the initial solution of the dimension $dim(A)[1] - nf$ that should to be improved.
etol	Tolerance for checking positve definiteness (default 0)
mattest	Toggles testing matrix A for symmetry and positive definiteness (default T)

Details

$A[F]$ denotes the principal submatrix of A having rows and columns indexed by $1..nf$.

Value

A object of class monet containing the following elements:

S.start	Vector containing the indices of the added sites in the initial solution or 0 for the other sites.
S	Vector containing the indices of the added sites in the solution or 0 for the other sites.
det	Determinant of the principal submatrix indexed by the initial solution.

Author(s)

C. Gebhardt

References

Ko, Lee, Queyranne, An exact algorithm for maximum entropy sampling, Operations Research 43 (1995), 684-691.

Gebhardt, C.: Bayessche Methoden in der geostatistischen Versuchsplanung. PhD Thesis, Univ. Klagenfurt, Austria, 2003

O.P. Baume, A. Gebhardt, C. Gebhardt, G.B.M. Heuvelink and J. Pilz: Network optimization algorithms and scenarios in the context of automatic mapping. Computers & Geosciences 37 (2011) 3, 289-294

See Also

greedy, dualgreedy

Examples

```
x <- c(0.97900601,0.82658702,0.53105628,0.91420190,0.35304969,
       0.14768239,0.58000004,0.60690101,0.36289026,0.82022147,
       0.95290664,0.07928365,0.04833764,0.55631735,0.06427738,
       0.31216689,0.43851418,0.34433556,0.77699357,0.84097327)
y <- c(0.36545512,0.72144122,0.95688671,0.25422154,0.48199229,
       0.43874199,0.90166634,0.60898628,0.82634713,0.29670695,
       0.86879093,0.45277452,0.09386800,0.04788365,0.20557817,
       0.61149264,0.94643855,0.78219937,0.53946353,0.70946842)
A <- outer(x, x, "-")^2 + outer(y, y, "-")^2
A <- (2 - A)/10
diag(A) <- 0
diag(A) <- 1/20 + apply(A, 2, sum)

S.c<-c(0,7,0,9,0,11,0,13,14,0,0,0,0,0,0)
interchange(A,5,5,S.c)
interchange(A,5,5,greedy(A,5,5)$S)
interchange(A,5,5,dualgreedy(A,5,5)$S)
```

---

makematrix — *Covariance matrix*

Description

This function generates a symmetic positive definite (n, n) covariance matrix using the algorithm in Ko et al.

Usage

```
makematrix(n)
```

Arguments

n	number of rows and columns of the matrix

Value

(n, n) covariance matrix.

Author(s)

C. Gebhardt

References

Ko, Lee, Queyranne, An exact algorithm for maximum entropy sampling, Operations Research 43 (1995), 684-691. Gebhardt, C.: Bayessche Methoden in der geostatistischen Versuchsplanung. PhD Thesis, Univ. Klagenfurt, Austria, 2003 O.P. Baume, A. Gebhardt, C. Gebhardt, G.B.M. Heuvelink and J. Pilz: Network optimization algorithms and scenarios in the context of automatic mapping. Computers & Geosciences 37 (2011) 3, 289-294

Examples

```
x.cov<-makematrix(5)
```

`maxentropy` *Maximum entropy sampling*

Description

Starting point is a network $A[F]$ with nf points. Now one has to select ns points of a set of candidate sites to augment the existing network. The aim of maximum entropy sampling is to select a feasible D-optimal design that maximizes the logarithm of the determinant of all principal submatrices of A arising by this expansion.

This algorithm is based on the interlacing property of eigenvalues. It starts with an initial solution given directly or provided by the greedy or dual-greedy approach. It uses a branch-and-bound strategy to calculate an optimal solution.

It is also possible to construct a completely new network, that means $nf = 0$.

Usage

```
maxentropy(A,nf,ns,method="d",S.start=NULL,rtol=1e-6,mattest=TRUE,etol=0,verbose=FALSE)
```

Arguments

`A`	Spatial covariance matrix A.
`nf`	Number of stations are forced into every feasible solution.
`ns`	Number of stations have to be added to the existing network.
`method`	Method to determine the initial solution: `"d"`=dual-greedy algorithm, `"g"`=greedy algorithm, `"dc"`=dual-greedy + interchange algorithm, `"gc"`=greedy + interchange algorithm, `"c"`=interchange algorithm + directly given initial solution. Otherwise this algorithm has to be started with an directly given initial solution.
`S.start`	Vector that gives the ns indices contained in the initial solution of dimension $dim(A)[1] - nf$ that should to be improved.
`rtol`	The algorithm terminates if the optimal solution is obtained with a tolerance of $rtol$.
`mattest`	Logical, if `TRUE` a tes for for symmetry and positive definiteness of the matrix A isperformed (default is `TRUE`).
`etol`	Tolerance for checking positve definiteness (default 0).
`verbose`	Logical, if `TRUE` some information is printed per iteration (default is `FALSE`).

Details

$A[F]$ denotes the principal submatrix of A having rows and columns indexed by $1..nf$.

Value

A object of class `monet` containing the following elements:

`S`	Vector containing the indices of the added sites in the initial solution or 0 for the other sites.
`det.start`	Determinant of the principal submatrix indexed by the initial solution.
`det`	Determinant of the principal submatrix indexed by the optimal solution.
`maxcount`	Maximum of active subproblems.
`iter`	Number of iterations.

Author(s)

C. Gebhardt

References

Ko, Lee, Queyranne, An exact algorithm for maximum entropy sampling, Operations Research 43 (1995), 684-691.

Gebhardt, C.: Bayessche Methoden in der geostatistischen Versuchsplanung. PhD Thesis, Univ. Klagenfurt, Austria, 2003

O.P. Baume, A. Gebhardt, C. Gebhardt, G.B.M. Heuvelink and J. Pilz: Network optimization algorithms and scenarios in the context of automatic mapping. Computers & Geosciences 37 (2011) 3, 289-294

See Also

`greedy`, `dualgreedy`, `interchange`

Examples

```
x <- c(0.97900601,0.82658702,0.53105628,0.91420190,0.35304969,
       0.14768239,0.58000004,0.60690101,0.36289026,0.82022147,
       0.95290664,0.07928365,0.04833764,0.55631735,0.06427738,
       0.31216689,0.43851418,0.34433556,0.77699357,0.84097327)
y <- c(0.36545512,0.72144122,0.95688671,0.25422154,0.48199229,
       0.43874199,0.90166634,0.60898628,0.82634713,0.29670695,
       0.86879093,0.45277452,0.09386800,0.04788365,0.20557817,
       0.61149264,0.94643855,0.78219937,0.53946353,0.70946842)
A <- outer(x, x, "-")^2 + outer(y, y, "-")^2
A <- (2 - A)/10
diag(A) <- 0
diag(A) <- 1/20 + apply(A, 2, sum)

S.entrp<-c(0,7,0,9,0,11,0,13,14,0,0,0,0,0,0)
maxentropy(A,5,5,S.start=S.entrp)
maxentropy(A,5,5,method="g")
maxentropy(A,5,5)
```

monet *Monet (Monitoring Network) object*

Description

An monet object is created with greedy, dualgreedy, interchange or maxentropy.

The object only contains indices of the rows/columns of the given covariance matrix A.

Indices of fixed stations start with 1, indices of fixed and eligible stations are not mixed, i.e. the last ne stations are the eligible ones, the first nf are the fixed ones.

The solution contains the indices counted absolute within all stations.

Arguments

	depending on the specific method more fields may exist, see apropriate help pages. All objects at least contain:
	covariance matrix of all stations
Aa	Number of all stations.
nf	Number of stations that are forced into every feasible solution.
ns	Number of stations that have to be added to the existing network.
ne	Number of eligible stations.
method	One of "greedy", "dual greedy", "interchange" (heuristics) or "maxentropy" (exact solution).
S	selected subset of the eligible points, use monet.selected to convert into reusable index vector.
det	determinant of selected covariance matrix

Author(s)

C. Gebhardt

See Also

print.monet

monet.selected *extract the selected station indices from a monet object*

Description

This function can be used to get an index vector containing the additionally selected (`monet.selected`) rows/columns of a covariance matrix used in `"greedy"`, `"dual greedy"`, `"interchange"` or `"maxentropy"` (or the complete network, `monet.solution`).

Usage

```
monet.selected(x)
monet.solution(x)
```

Arguments

`x`	object of class `monet`

Value

integer vector

Author(s)

C. Gebhardt

See Also

`monet`

Examples

```
x <- c(0.97900601,0.82658702,0.53105628,0.91420190,0.35304969,
       0.14768239,0.58000004,0.60690101,0.36289026,0.82022147,
       0.95290664,0.07928365,0.04833764,0.55631735,0.06427738,
       0.31216689,0.43851418,0.34433556,0.77699357,0.84097327)
y <- c(0.36545512,0.72144122,0.95688671,0.25422154,0.48199229,
       0.43874199,0.90166634,0.60898628,0.82634713,0.29670695,
       0.86879093,0.45277452,0.09386800,0.04788365,0.20557817,
       0.61149264,0.94643855,0.78219937,0.53946353,0.70946842)
A <- outer(x, x, "-")^2 + outer(y, y, "-")^2
A <- (2 - A)/10
diag(A) <- 0
diag(A) <- 1/20 + apply(A, 2, sum)

MN <- greedy(A,5,5)
# internal representaion in monet object:
MN$S
# reusable index, only added stations:
```

```
monet.selected(MN)
# ... complete network:
monet.solution(MN)
```

print.monet *Print a monet (monitoring network) object*

Description

prints a summary of "x"

Usage

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

Arguments

x	object of class "monet"
...	additional paramters for print

Value

None

Author(s)

C. Gebhardt

See Also

monet,

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