Package ‘lhs’

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augmentLHS

Augment a Latin Hypercube Design

Description

Augments an existing Latin Hypercube Sample, adding points to the design, while maintaining the latin properties of the design.

Usage

augmentLHS(lhs, m = 1)

Arguments

lhs

The Latin Hypercube Design to which points are to be added. Contains an existing latin hypercube design with a number of rows equal to the points in the design (simulations) and a number of columns equal to the number of variables (parameters). The values of each cell must be between 0 and 1 and uniformly distributed.

m

The number of additional points to add to matrix lhs

Details

Augments an existing Latin Hypercube Sample, adding points to the design, while maintaining the latin properties of the design. Augmentation is performed in a random manner.

The algorithm used by this function has the following steps. First, create a new matrix to hold the candidate points after the design has been re-partitioned into \((n + m)^2\) cells, where \(n\) is number of points in the original \(lhs\) matrix. Then randomly sweep through each column \((1...k)\) in the
repartitioned design to find the missing cells. For each column (variable), randomly search for an empty row, generate a random value that fits in that row, record the value in the new matrix. The new matrix can contain more filled cells than \( m \) unless \( m = 2n \), in which case the new matrix will contain exactly \( m \) filled cells. Finally, keep only the first \( m \) rows of the new matrix. It is guaranteed to have \( m \) full rows in the new matrix. The deleted rows are partially full. The additional candidate points are selected randomly due to the random search for empty cells.

**Value**

An \( n \) by \( k \) Latin Hypercube Sample matrix with values uniformly distributed on \([0,1]\)

**Author(s)**

Rob Carnell

**References**


**See Also**

[randomLHS()], [geneticLHS()], [improvedLHS()], [maximinLHS()], and [optimumLHS()]] to generate Latin Hypercube Samples. [optAugmentLHS()] and [optSeededLHS()] to modify and augment existing designs.

**Examples**

```r
set.seed(1234)
a <- randomLHS(4, 3)
b <- augmentLHS(a, 2)
```

**createAddelKemp**

Create an orthogonal array using the Addelman-Kempthorne algorithm.

**Description**

The `addelkemp` program produces \( OA( 2q^2, k, q, 2 ) \), \( k \leq 2q+1 \), for odd prime powers \( q \).

**Usage**

createAddelKemp(q, ncol, bRandom = TRUE)

**Arguments**

- `q` : the number of symbols in the array
- `ncol` : number of parameters or columns
- `bRandom` : should the array be randomized
createAddelKemp3

Details

From Owen: An orthogonal array \( A \) is a matrix of \( n \) rows, \( k \) columns with every element being one of \( q \) symbols \( 0, \ldots, q-1 \). The array has strength \( t \) if, in every \( n \) by \( t \) submatrix, the \( q^t \) possible distinct rows, all appear the same number of times. This number is the index of the array, commonly denoted \( \lambda \). Clearly, \( \lambda q^t = n \). The notation for such an array is \( \text{OA}(n, k, q, t) \).

Value

an orthogonal array

References


See Also

Other methods to create orthogonal arrays [createBoseBush()], [createBose()], [createAddelKemp3()], [createAddelKempN()], [createBush()], [createBoseBushl()]

Examples

\[
A \leftarrow \text{createAddelKemp}(3, 3, \text{TRUE})
\]
\[
B \leftarrow \text{createAddelKemp}(3, 5, \text{FALSE})
\]

createAddelKemp3

Create an orthogonal array using the Addelman-Kempthorne algorithm with \( 2q^3 \) rows.

Description

The addelkemp3 program produces \( \text{OA}(2q^3, k, q, 2) \), \( k \leq 2q^2+2q+1 \), for prime powers \( q \). \( q \) may be an odd prime power, or \( q \) may be 2 or 4.

Usage

\[
\text{createAddelKemp3}(q, \text{ncol}, \text{bRandom} = \text{TRUE})
\]

Arguments

\[
q \quad \text{the number of symbols in the array}
\]

\[
\text{ncol} \quad \text{number of parameters or columns}
\]

\[
\text{bRandom} \quad \text{should the array be randomized}
\]
createAddelKempN

Details
From Owen: An orthogonal array $\mathbf{A}$ is a matrix of $n$ rows, $k$ columns with every element being one of $q$ symbols 0, ..., $q-1$. The array has strength $t$ if, in every $n$ by $t$ submatrix, the $q^t$ possible distinct rows, all appear the same number of times. This number is the index of the array, commonly denoted $\lambda$. Clearly, $\lambda \cdot q^t = n$. The notation for such an array is $\text{OA}(n,k,q,t)$.

Value
an orthogonal array

References

See Also
Other methods to create orthogonal arrays [createBushBush()], [createBose()], [createAddelKemp()], [createAddelKempN()], [createBush()], [createBoseBushl()]

Examples
A <- createAddelKemp3(3, 3, TRUE)
B <- createAddelKemp3(3, 5, FALSE)

createAddelKempN
Create an orthogonal array using the Addelman-Kempthorne algorithm with alternate strength with $2q^n$ rows.

Description
The addelkempn program produces $\text{OA}(2 \cdot q^n,k,q,2)$, $k \leq 2(q^n - 1)/(q-1)-1$, for prime powers q. q may be an odd prime power, or q may be 2 or 4.

Usage
createAddelKempN(q, ncol, exponent, bRandom = TRUE)

Arguments
q the number of symbols in the array
ncol number of parameters or columns
exponent the exponent on q
bRandom should the array be randomized
createBose

Details
From Owen: An orthogonal array $A$ is a matrix of $n$ rows, $k$ columns with every element being one of $q$ symbols $0, \ldots, q-1$. The array has strength $t$ if, in every $n$ by $t$ submatrix, the $q^t$ possible distinct rows, all appear the same number of times. This number is the index of the array, commonly denoted $\lambda$. Clearly, $\lambda q^t = n$. The notation for such an array is $OA(n, k, q, t)$.

Value
an orthogonal array

See Also
Other methods to create orthogonal arrays [createBoseBush()], [createBose()], [createBush()], [createAddelKemp()], [createAddelKemp3()], [createBusht()], [createBoseBushl()]

Examples
A <- createAddelKempN(3, 4, 3, TRUE)
B <- createAddelKempN(3, 4, 4, TRUE)

createBose(q, ncol, bRandom = TRUE)

Arguments
q 
the number of symbols in the array
ncol 
number of parameters or columns
bRandom 
should the array be randomized

Details
From Owen: An orthogonal array $A$ is a matrix of $n$ rows, $k$ columns with every element being one of $q$ symbols $0, \ldots, q-1$. The array has strength $t$ if, in every $n$ by $t$ submatrix, the $q^t$ possible distinct rows, all appear the same number of times. This number is the index of the array, commonly denoted $\lambda$. Clearly, $\lambda q^t = n$. The notation for such an array is $OA(n, k, q, t)$.

Value
an orthogonal array
createBoseBush

References


See Also

Other methods to create orthogonal arrays [createBush()], [createBoseBush()], [createAddelKemp()], [createAddelKemp3()], [createAddelKempN()], [createBusht()], [createBoseBushl()]

Examples

A <- createBose(3, 3, FALSE)
B <- createBose(5, 4, TRUE)

createBoseBush

Create an orthogonal array using the Bose-Bush algorithm.

Description

The bosebush program produces OA( 2q^2,k,q,2 ), k <= 2q+1, for powers of 2, q=2^r.

Usage

createBoseBush(q, ncol, bRandom = TRUE)

Arguments

- q: the number of symbols in the array
- ncol: number of parameters or columns
- bRandom: should the array be randomized

Details

From Owen: An orthogonal array A is a matrix of n rows, k columns with every element being one of q symbols 0,\ldots,q-1. The array has strength t if, in every n by t submatrix, the q^t possible distinct rows, all appear the same number of times. This number is the index of the array, commonly denoted lambda. Clearly, lambda*q^t=n. The notation for such an array is OA( n,k,q,t ).

Value

an orthogonal array

References

createBoseBushl

Create an orthogonal array using the Bose-Bush algorithm with alternate strength >= 3.

Description

The bosebushl program produces OA(\(\lambda q^2, k, q, 2\)), \(k \leq \lambda q + 1\) for prime powers \(q\) and \(\lambda > 1\). Both \(q\) and \(\lambda\) must be powers of the same prime.

Usage

createBoseBushl(q, ncol, lambda, bRandom = TRUE)

Arguments

- **q**: the number of symbols in the array
- **ncol**: number of parameters or columns
- **lambda**: the lambda of the BoseBush algorithm
- **bRandom**: should the array be randomized

Details

From Owen: An orthogonal array \(A\) is a matrix of \(n\) rows, \(k\) columns with every element being one of \(q\) symbols \(0, \ldots, q-1\). The array has strength \(t\) if, in every \(n\) by \(t\) submatrix, the \(q^t\) possible distinct rows, all appear the same number of times. This number is the index of the array, commonly denoted \(\lambda\). Clearly, \(\lambda q^t = n\). The notation for such an array is \(OA(n, k, q, t)\).

Value

an orthogonal array

References

**createBush**

Create an orthogonal array using the Bush algorithm.

**Description**

The `bush` program produces $\text{OA}( q^3, k, q, 3 )$, $k \leq q+1$ for prime powers $q$.

**Usage**

```r
createBush(q, ncol, bRandom = TRUE)
```

**Arguments**

- `q`: the number of symbols in the array
- `ncol`: number of parameters or columns
- `bRandom`: should the array be randomized

**Details**

From Owen: An orthogonal array $A$ is a matrix of $n$ rows, $k$ columns with every element being one of $q$ symbols $0, \ldots, q-1$. The array has strength $t$ if, in every $n$ by $t$ submatrix, the $q^t$ possible distinct rows, all appear the same number of times. This number is the index of the array, commonly denoted $\lambda$. Clearly, $\lambda q^t = n$. The notation for such an array is $\text{OA}( n, k, q, t )$.

**Value**

an orthogonal array

**References**


**See Also**

Other methods to create orthogonal arrays [createBoseBush()], [createBose()], [createBush()], [createAddelKemp()], [createAddelKemp3()], [createAddelKempN()], [createBusht()], [createBoseBushl()]
Examples
A <- createBush(3, 3, FALSE)
B <- createBush(4, 5, TRUE)

createBusht

Create an orthogonal array using the Bush algorithm with alternate strength.

Description
The busht program produces $OA( q^t, k, q, t )$, $k \leq q+1$, $t \geq 3$, for prime powers $q$.

Usage
createBusht(q, ncol, strength, bRandom = TRUE)

Arguments
- **q**: the number of symbols in the array
- **ncol**: number of parameters or columns
- **strength**: the strength of the array to be created
- **bRandom**: should the array be randomized

Details
From Owen: An orthogonal array $A$ is a matrix of $n$ rows, $k$ columns with every element being one of $q$ symbols $0, \ldots, q-1$. The array has strength $t$ if, in every $n$ by $t$ submatrix, the $q^t$ possible distinct rows, all appear the same number of times. This number is the index of the array, commonly denoted $\lambda$. Clearly, $\lambda q^t = n$. The notation for such an array is $OA( n, k, q, t )$.

Value
an orthogonal array

References

See Also
Other methods to create orthogonal arrays [createBoseBush()], [createBose()], [createAddelKemp()], [createAddelKemp3()], [createAddelKempN()], [createBoseBushl()]
create_galois_field

Examples

```r
set.seed(1234)
A <- createBusht(3, 4, 2, TRUE)
B <- createBusht(3, 4, 3, FALSE)
G <- createBusht(3, 4, 3, TRUE)
```

create_galois_field

Create a Galois field

Description

Create a Galois field

Usage

```r
create_galois_field(q)
```

Arguments

- `q` - The order of the Galois Field \( q = p^n \)

Value

- a GaloisField object containing
  - `n` \( q = p^n \)
  - `p` The prime modulus of the field \( q = p^n \)
  - `q` The order of the Galois Field \( q = p^n \). \( q \) must be a prime power.
  - `xton` coefficients of the characteristic polynomial where the first coefficient is on \( x^0 \), the second is on \( x^1 \) and so on
  - `inv` An index for which row of `poly` (zero based) is the multiplicative inverse of this row. An NA indicates that this row of `poly` has no inverse. e.g. \( c(3, 4) \) means that row 4=3+1 is the inverse of row 1 and row 5=4+1 is the inverse of row 2
  - `neg` An index for which row of `poly` (zero based) is the negative or additive inverse of this row. An NA indicates that this row of `poly` has no negative. e.g. \( c(3, 4) \) means that row 4=3+1 is the negative of row 1 and row 5=4+1 is the negative of row 2
  - `root` An index for which row of `poly` (zero based) is the square root of this row. An NA indicates that this row of `poly` has no square root. e.g. \( c(3, 4) \) means that row 4=3+1 is the square root of row 1 and row 5=4+1 is the square root of row 2
  - `plus` sum table of the Galois Field
  - `times` multiplication table of the Galois Field
  - `poly` rows are polynomials of the Galois Field where the entries are the coefficients of the polynomial where the first coefficient is on \( x^0 \), the second is on \( x^1 \) and so on

Examples

```r
gf <- create_galois_field(4);
```
create_oalhs \hspace{1cm} \textit{Create an orthogonal array Latin hypercube}

\begin{description}
\item[Description] Create an orthogonal array Latin hypercube
\item[Usage] \texttt{create_oalhs(n, k, bChooseLargerDesign, bverbose)}
\item[Arguments]
\begin{itemize}
\item \texttt{n} \hspace{1cm} the number of samples or rows in the LHS (integer)
\item \texttt{k} \hspace{1cm} the number of parameters or columns in the LHS (integer)
\item \texttt{bChooseLargerDesign} \hspace{1cm} should a larger oa design be chosen than the n and k requested?
\item \texttt{bverbose} \hspace{1cm} should information be printed with execution
\end{itemize}
\item[Value] a numeric matrix which is an orthogonal array Latin hypercube sample
\item[Examples]  
\begin{verbatim}
set.seed(34)
A <- create_oalhs(9, 4, TRUE, FALSE)
B <- create_oalhs(9, 4, TRUE, FALSE)
\end{verbatim}
\end{description}

\begin{description}
\item[Description] \textit{Latin Hypercube Sampling with a Genetic Algorithm}
\item[Description] Draws a Latin Hypercube Sample from a set of uniform distributions for use in creating a Latin Hypercube Design. This function attempts to optimize the sample with respect to the S optimality criterion through a genetic type algorithm.
Usage

```r
geneticLHS(
  n = 10,
  k = 2,
  pop = 100,
  gen = 4,
  pMut = 0.1,
  criterium = "S",
  verbose = FALSE
)
```

Arguments

- **n**: The number of partitions (simulations or design points or rows)
- **k**: The number of replications (variables or columns)
- **pop**: The number of designs in the initial population
- **gen**: The number of generations over which the algorithm is applied
- **pMut**: The probability with which a mutation occurs in a column of the progeny
- **criterium**: The optimality criterium of the algorithm. Default is `S`. Maximin is also supported
- **verbose**: Print informational messages. Default is `FALSE`

Details

Latin hypercube sampling (LHS) was developed to generate a distribution of collections of parameter values from a multidimensional distribution. A square grid containing possible sample points is a Latin square iff there is only one sample in each row and each column. A Latin hypercube is the generalisation of this concept to an arbitrary number of dimensions. When sampling a function of `k` variables, the range of each variable is divided into `n` equally probable intervals. `n` sample points are then drawn such that a Latin Hypercube is created. Latin Hypercube sampling generates more efficient estimates of desired parameters than simple Monte Carlo sampling.

This program generates a Latin Hypercube Sample by creating random permutations of the first `n` integers in each of `k` columns and then transforming those integers into `n` sections of a standard uniform distribution. Random values are then sampled from within each of the `n` sections. Once the sample is generated, the uniform sample from a column can be transformed to any distribution by using the quantile functions, e.g. `qnorm()`. Different columns can have different distributions.

S-optimality seeks to maximize the mean distance from each design point to all the other points in the design, so the points are as spread out as possible.

Genetic Algorithm:

1. Generate `pop` random Latin hypercube designs of size `n` by `k`
2. Calculate the S optimality measure of each design
3. Keep the best design in the first position and throw away half of the rest of the population
4. Take a random column out of the best matrix and place it in a random column of each of the other matrices, and take a random column out of each of the other matrices and put it in copies of the best matrix thereby causing the progeny
5. For each of the progeny, cause a genetic mutation \( \rho_{\text{mut}} \) percent of the time. The mutation is accomplished by switching two elements in a column.

**Value**

An \( n \) by \( k \) Latin Hypercube Sample matrix with values uniformly distributed on [0,1]

**Author(s)**

Rob Carnell

**References**


**See Also**

[randomLHS()], [improvedLHS()], [maximinLHS()], and [optimumLHS()] to generate Latin Hypercube Samples. [optAugmentLHS()] [optSeededLHS()], and [augmentLHS()] to modify and augment existing designs.

**Examples**

```r
set.seed(1234)
A <- geneticLHS(4, 3, 50, 5, .25)
```

---

**Description**

Get version information for all libraries in the lhs package

**Usage**

```r
get_library_versions()
```

**Value**

a character string containing the versions

**Examples**

```r
get_library_versions()
```
Improved Latin Hypercube Sample

**Description**

Draws a Latin Hypercube Sample from a set of uniform distributions for use in creating a Latin Hypercube Design. This function attempts to optimize the sample with respect to an optimum euclidean distance between design points.

**Usage**

\[
\text{improvedLHS}(n, k, \text{dup} = 1)
\]

**Arguments**

- **n**: The number of partitions (simulations or design points or rows)
- **k**: The number of replications (variables or columns)
- **dup**: A factor that determines the number of candidate points used in the search. A multiple of the number of remaining points than can be added.

**Details**

Latin hypercube sampling (LHS) was developed to generate a distribution of collections of parameter values from a multidimensional distribution. A square grid containing possible sample points is a Latin square iff there is only one sample in each row and each column. A Latin hypercube is the generalisation of this concept to an arbitrary number of dimensions. When sampling a function of \( k \) variables, the range of each variable is divided into \( n \) equally probable intervals. \( n \) sample points are then drawn such that a Latin Hypercube is created. Latin Hypercube sampling generates more efficient estimates of desired parameters than simple Monte Carlo sampling.

This program generates a Latin Hypercube Sample by creating random permutations of the first \( n \) integers in each of \( k \) columns and then transforming those integers into \( n \) sections of a standard uniform distribution. Random values are then sampled from within each of the \( n \) sections. Once the sample is generated, the uniform sample from a column can be transformed to any distribution by using the quantile functions, e.g. \( \text{qnorm()} \). Different columns can have different distributions.

This function attempts to optimize the sample with respect to an optimum euclidean distance between design points.

\[
\text{Optimumdistance} = \frac{1.0}{\text{dup}}
\]

**Value**

An \( n \) by \( k \) Latin Hypercube Sample matrix with values uniformly distributed on [0,1]
maximinLHS

References


This function is based on the MATLAB program written by John Burkardt and modified 16 Feb 2005 https://people.math.sc.edu/Burkardt/m_src/ihs/ihs.html

See Also

[randomLHS()], [geneticLHS()], [maximinLHS()], and [optimumLHS()] to generate Latin Hypercube Samples. [optAugmentLHS()], [optSeededLHS()], and [augmentLHS()] to modify and augment existing designs.

Examples

```r
set.seed(1234)
A <- improvedLHS(4, 3, 2)
```

maximinLHS  

**Maximin Latin Hypercube Sample**

Description

Draws a Latin Hypercube Sample from a set of uniform distributions for use in creating a Latin Hypercube Design. This function attempts to optimize the sample by maximizing the minimum distance between design points (maximin criteria).

Usage

```r
maximinLHS(
  n, 
  k, 
  method = "build", 
  dup = 1, 
  eps = 0.05, 
  maxIter = 100, 
  optimize.on = "grid", 
  debug = FALSE
)
```

Arguments

- **n**  
The number of partitions (simulations or design points or rows)

- **k**  
The number of replications (variables or columns)

- **method**  
build or iterative is the method of LHS creation. build finds the next best point while constructing the LHS. iterative optimizes the resulting sample on [0,1] or sample grid on [1,N]
maximinLHS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>dup</td>
<td>A factor that determines the number of candidate points used in the search. A multiple of the number of remaining points than can be added. This is used when method=&quot;build&quot;.</td>
</tr>
<tr>
<td>eps</td>
<td>The minimum percent change in the minimum distance used in the iterative method.</td>
</tr>
<tr>
<td>maxIter</td>
<td>The maximum number of iterations to use in the iterative method.</td>
</tr>
<tr>
<td>optimize.on</td>
<td>grid or result gives the basis of the optimization. grid optimizes the LHS on the underlying integer grid. result optimizes the resulting sample on [0,1].</td>
</tr>
<tr>
<td>debug</td>
<td>Prints additional information about the process of the optimization.</td>
</tr>
</tbody>
</table>

**Details**

Latin hypercube sampling (LHS) was developed to generate a distribution of collections of parameter values from a multidimensional distribution. A square grid containing possible sample points is a Latin square iff there is only one sample in each row and each column. A Latin hypercube is the generalisation of this concept to an arbitrary number of dimensions. When sampling a function of \( k \) variables, the range of each variable is divided into \( n \) equally probable intervals. \( n \) sample points are then drawn such that a Latin Hypercube is created. Latin Hypercube sampling generates more efficient estimates of desired parameters than simple Monte Carlo sampling.

This program generates a Latin Hypercube Sample by creating random permutations of the first \( n \) integers in each of \( k \) columns and then transforming those integers into \( n \) sections of a standard uniform distribution. Random values are then sampled from within each of the \( n \) sections. Once the sample is generated, the uniform sample from a column can be transformed to any distribution by using the quantile functions, e.g. `qnorm()`. Different columns can have different distributions.

Here, values are added to the design one by one such that the maximin criteria is satisfied.

**Value**

An \( n \) by \( k \) Latin Hypercube Sample matrix with values uniformly distributed on [0,1].

**References**


This function is motivated by the MATLAB program written by John Burkardt and modified 16 Feb 2005 [https://people.math.sc.edu/Burkardt/m_src/ihs/ihs.html](https://people.math.sc.edu/Burkardt/m_src/ihs/ihs.html)

**See Also**

[randomLHS()], [geneticLHS()], [improvedLHS()] and [optimumLHS()] to generate Latin Hypercube Samples. [optAugmentLHS()], [optSeededLHS()], and [augmentLHS()] to modify and augment existing designs.

**Examples**

```r
set.seed(1234)
A1 <- maximinLHS(4, 3, dup=2)
A2 <- maximinLHS(4, 3, method="build", dup=2)
```
A3 <- maximinLHS(4, 3, method="iterative", eps=0.05, maxIter=100, optimize.on="grid")
A4 <- maximinLHS(4, 3, method="iterative", eps=0.05, maxIter=100, optimize.on="result")

---

**oa_to_oalhs**  
*Create a Latin hypercube from an orthogonal array*

### Description
Create a Latin hypercube from an orthogonal array

### Usage

```r
oa_to_oalhs(n, k, oa)
```

### Arguments

- `n`: the number of samples or rows in the LHS (integer)
- `k`: the number of parameters or columns in the LHS (integer)
- `oa`: the orthogonal array to be used as the basis for the LHS (matrix of integers) or data.frame of factors

### Value

a numeric matrix which is a Latin hypercube sample

### Examples

```r
oa <- createBose(3, 4, TRUE)
B <- oa_to_oalhs(9, 4, oa)
```

---

**optAugmentLHS**  
*Optimal Augmented Latin Hypercube Sample*

### Description
Augments an existing Latin Hypercube Sample, adding points to the design, while maintaining the *latin* properties of the design. This function attempts to add the points to the design in an optimal way.

### Usage

```r
optAugmentLHS(lhs, m = 1, mult = 2)
```
optimumLHS

Arguments

lhs The Latin Hypercube Design to which points are to be added
m The number of additional points to add to matrix lhs
mult m*mult random candidate points will be created.

Details

Augments an existing Latin Hypercube Sample, adding points to the design, while maintaining the latin properties of the design. This function attempts to add the points to the design in a way that maximizes S optimality.

S-optimality seeks to maximize the mean distance from each design point to all the other points in the design, so the points are as spread out as possible.

Value

An n by k Latin Hypercube Sample matrix with values uniformly distributed on [0,1]

References


See Also

[randomLHS()], [geneticLHS()], [improvedLHS()], [maximinLHS()], and [optimumLHS()] to generate Latin Hypercube Samples. [optSeededLHS()] and [augmentLHS()] to modify and augment existing designs.

Examples

```r
set.seed(1234)
a <- randomLHS(4,3)
b <- optAugmentLHS(a, 2, 3)
```

optimumLHS Optimum Latin Hypercube Sample

Description

Draws a Latin Hypercube Sample from a set of uniform distributions for use in creating a Latin Hypercube Design. This function uses the Columnwise Pairwise (CP) algorithm to generate an optimal design with respect to the S optimality criterion.

Usage

```r
optimumLHS(n = 10, k = 2, maxSweeps = 2, eps = 0.1, verbose = FALSE)
```
Arguments

- **n**: The number of partitions (simulations or design points or rows)
- **k**: The number of replications (variables or columns)
- **maxSweeps**: The maximum number of times the CP algorithm is applied to all the columns.
- **eps**: The optimal stopping criterion. Algorithm stops when the change in optimality measure is less than eps*100% of the previous value.
- **verbose**: Print informational messages

Details

Latin hypercube sampling (LHS) was developed to generate a distribution of collections of parameter values from a multidimensional distribution. A square grid containing possible sample points is a Latin square iff there is only one sample in each row and each column. A Latin hypercube is the generalisation of this concept to an arbitrary number of dimensions. When sampling a function of \( k \) variables, the range of each variable is divided into \( n \) equally probable intervals. \( n \) sample points are then drawn such that a Latin Hypercube is created. Latin Hypercube sampling generates more efficient estimates of desired parameters than simple Monte Carlo sampling.

This program generates a Latin Hypercube Sample by creating random permutations of the first \( n \) integers in each of \( k \) columns and then transforming those integers into \( n \) sections of a standard uniform distribution. Random values are then sampled from within each of the \( n \) sections. Once the sample is generated, the uniform sample from a column can be transformed to any distribution by using the quantile functions, e.g. `qnorm()`. Different columns can have different distributions.

S-optimality seeks to maximize the mean distance from each design point to all the other points in the design, so the points are as spread out as possible.

This function uses the CP algorithm to generate an optimal design with respect to the S optimality criterion.

Value

An \( n \times k \) Latin Hypercube Sample matrix with values uniformly distributed on \([0,1]\)

References


See Also

- `randomLHS()`, `geneticLHS()`, `improvedLHS()` and `maximinLHS()` to generate Latin Hypercube Samples.
- `optAugmentLHS()`, `optSeededLHS()`, and `augmentLHS()` to modify and augment existing designs.

Examples

```
A <- optimumLHS(4, 3, 5, .05)
```
Optimum Seeded Latin Hypercube Sample

Description

Augments an existing Latin Hypercube Sample, adding points to the design, while maintaining the *latin* properties of the design. This function then uses the columnwise pairwise (CP) algorithm to optimize the design. The original design is not necessarily maintained.

Usage

```r
optSeededLHS(seed, m = 0, maxSweeps = 2, eps = 0.1, verbose = FALSE)
```

Arguments

- **seed**: The number of partitions (simulations or design points)
- **m**: The number of additional points to add to the seed matrix seed. Default value is zero. If m is zero then the seed design is optimized.
- **maxSweeps**: The maximum number of times the CP algorithm is applied to all the columns.
- **eps**: The optimal stopping criterion
- **verbose**: Print informational messages

Details

Augments an existing Latin Hypercube Sample, adding points to the design, while maintaining the *latin* properties of the design. This function then uses the CP algorithm to optimize the design. The original design is not necessarily maintained.

Value

An *n* by *k* Latin Hypercube Sample matrix with values uniformly distributed on [0,1]

References


See Also

[randomLHS()], [geneticLHS()], [improvedLHS()], [maximinLHS()], and [optimumLHS()]) to generate Latin Hypercube Samples. [optAugmentLHS()] and [augmentLHS()] to modify and augment existing designs.

Examples

```r
set.seed(1234)
a <- randomLHS(4, 3)
b <- optSeededLHS(a, 2, 2, .1)
```
poly2int

Convert polynomial to integer in \langle\text{code}\rangle0..q-1\langle/\text{code}\rangle

Description

Convert polynomial to integer in \langle\text{code}\rangle0..q-1\langle/\text{code}\rangle

Usage

poly2int(p, n, poly)

Arguments

\begin{itemize}
\item p \hspace{1cm} \text{modulus}
\item n \hspace{1cm} \text{the length of poly}
\item poly \hspace{1cm} \text{the polynomial vector}
\end{itemize}

Value

an integer

Examples

\begin{verbatim}
gf <- create_galois_field(4)
stopifnot(poly2int(gf$p, gf$n, c(0, 0)) == 0)
\end{verbatim}

poly_prod

Multiplication in polynomial representation

Description

Multiplication in polynomial representation

Usage

poly_prod(p, n, xton, p1, p2)

Arguments

\begin{itemize}
\item p \hspace{1cm} \text{modulus}
\item n \hspace{1cm} \text{length of polynomials}
\item xton \hspace{1cm} \text{characteristic polynomial vector for the field (x to the n power)}
\item p1 \hspace{1cm} \text{polynomial vector 1}
\item p2 \hspace{1cm} \text{polynomial vector 2}
\end{itemize}
Value

the product of \texttt{p1} and \texttt{p2}

Examples

\begin{verbatim}
gf <- create_galois_field(4)
a <- poly_prod(gf$p, gf$n, gf$xton, c(1, 0), c(0, 1))
stopifnot(all(a == c(0, 1)))
\end{verbatim}

poly_sum

Addition in polynomial representation

Description

Addition in polynomial representation

Usage

\begin{verbatim}
poly_sum(p, n, p1, p2)
\end{verbatim}

Arguments

\begin{itemize}
\item \texttt{p} \hspace{1cm} modulus
\item \texttt{n} \hspace{1cm} length of polynomial 1 and 2
\item \texttt{p1} \hspace{1cm} polynomial vector 1
\item \texttt{p2} \hspace{1cm} polynomial vector 2
\end{itemize}

Value

the sum of \texttt{p1} and \texttt{p2}

Examples

\begin{verbatim}
gf <- create_galois_field(4)
a <- poly_sum(gf$p, gf$n, c(1, 0), c(0, 1))
stopifnot(all(a == c(1, 1)))
\end{verbatim}
randomLHS

Construct a random Latin hypercube design

Description
randomLHS(4, 3) returns a 4x3 matrix with each column constructed as follows: A random permutation of (1,2,3,4) is generated, say (3,1,2,4) for each of K columns. Then a uniform random number is picked from each indicated quartile. In this example a random number between .5 and .75 is chosen, then one between 0 and .25, then one between .25 and .5, finally one between .75 and 1.

Usage
randomLHS(n, k, preserveDraw = FALSE)

Arguments
- n: the number of rows or samples
- k: the number of columns or parameters/variables
- preserveDraw: should the draw be constructed so that it is the same for variable numbers of columns?

Value
a Latin hypercube sample

Examples
a <- randomLHS(5, 3)

runifint
Create a Random Sample of Uniform Integers

Description
Create a Random Sample of Uniform Integers

Usage
runifint(n = 1, min_int = 0, max_int = 1)

Arguments
- n: The number of samples
- min_int: the minimum integer x >= min_int
- max_int: the maximum integer x <= max_int
runifint

Value

the sample sample of size n
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