

# Package: SCCDdesign (via r-universe)

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**Title** Construction of Screening Designs for Mixed Level Continuous and Categorical Factors

**Version** 0.2.0

**Description** Constructs screening designs for experiments involving continuous and categorical factors with multiple levels. The package implements methods for constructing mixed-level screening designs, involving factors with more than two levels. It also evaluates the statistical performance of screening designs through dev power to identify active effects and Type I error rates. The package implements three methods proposed by Jones, B., Lekivetz, R., Majumdar, D. and Nachtsheim, C. (2025) <doi:10.1080/00401706.2024.2362149> for generating efficient screening designs involving three-level continuous and two-level categorical factors for even run sizes. It also includes Paley Type I and Type II constructions for conference matrices and pseudo conference matrices obtained using the coordinate exchange algorithm by Jones, B. and Nachtsheim, C. J. (2011) <doi:10.1080/00224065.2011.11917841> which are used in the development of these screening designs.

**License** GPL-3

**Encoding** UTF-8

**RoxygenNote** 8.0.0

**Imports** pracma, AlgDesign, leaps, stats

**NeedsCompilation** no

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|------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| conferenceMatrix | <i>Constructs a conference matrix of a specified order using a direct construction for order 2 and Paley-based constructions for supported odd prime or prime-power values of <math>q = n - 1</math>.</i> |
|------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

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Description

Constructs a conference matrix of a specified order using a direct construction for order 2 and Paley-based constructions for supported odd prime or prime-power values of  $q = n - 1$ .

Usage

conferenceMatrix(n)

Arguments

|   |                                                                                                      |
|---|------------------------------------------------------------------------------------------------------|
| n | A single finite integer specifying the order of the conference matrix. The value must be at least 2. |
|---|------------------------------------------------------------------------------------------------------|

Details

For  $n = 2$ , the conference matrix is constructed directly. For larger orders, the function sets  $q = n - 1$  and determines whether  $q$  is a supported odd prime or odd prime power. Depending on the value of  $q$  modulo 4, the corresponding Paley construction is used. An error is returned when the supplied order does not satisfy the requirements of the implemented construction.

Value

A numeric  $n \times n$  conference matrix.

Examples

conferenceMatrix(6)

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|                  |                                                                                                                                                   |
|------------------|---------------------------------------------------------------------------------------------------------------------------------------------------|
| dOptimalTwoLevel | <i>Constructs a D-optimal two-level design with <math>m</math> runs and <math>m - 1</math> factors. The factor levels are coded as -1 and +1.</i> |
|------------------|---------------------------------------------------------------------------------------------------------------------------------------------------|

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**Description**

Constructs a D-optimal two-level design with  $m$  runs and  $m - 1$  factors. The factor levels are coded as -1 and +1.

**Usage**

```
dOptimalTwoLevel(m)
```

**Arguments**

|     |                                                                           |
|-----|---------------------------------------------------------------------------|
| $m$ | A positive integer specifying the number of runs. The minimum value is 3. |
|-----|---------------------------------------------------------------------------|

**Details**

The candidate set is generated using all possible combinations of -1 and +1 for the factors. The D-optimal design is selected using `AlgDesign::optFederov()`.

**Value**

A numeric matrix containing the D-optimal two-level design.

**Examples**

```
dOptimalTwoLevel(4)
dOptimalTwoLevel(8)
```

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|                |                                                                                                    |
|----------------|----------------------------------------------------------------------------------------------------|
| hadamardMatrix | <i>Constructs a Hadamard matrix of order <math>n</math> using <code>pracma::hadamard()</code>.</i> |
|----------------|----------------------------------------------------------------------------------------------------|

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**Description**

Constructs a Hadamard matrix of order  $n$  using `pracma::hadamard()`.

**Usage**

```
hadamardMatrix(n)
```

**Arguments**

|     |                                                        |
|-----|--------------------------------------------------------|
| $n$ | A positive integer specifying the order of the matrix. |
|-----|--------------------------------------------------------|

### Details

A Hadamard matrix contains only +1 and -1, and its rows are mutually orthogonal. The supported orders are of the forms  $2^e$ ,  $12(2^e)$ , and  $20(2^e)$ .

### Value

A Hadamard matrix of order n.

### Examples

```
hadamardMatrix(4)
hadamardMatrix(8)
hadamardMatrix(12)
```

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|                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|--------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| mixed_level_design | <i>Constructs an orthogonal design for two types of factors with different numbers of levels. Three construction cases are considered: even-even level factors, odd-even level factors and odd-odd level factors. The appropriate construction is selected automatically according to the parity of the numbers of levels of the two factors. Hadamard matrices are used for even-level factors, while conference matrices are used for odd-level factors. The order of both the Hadamard and conference matrices is m. For the even-even case, the design contains m - 1 factors of each type. For the odd-even case, the design contains m odd-level factors and m - 1 even-level factors. For the odd-odd case, the design contains m factors of each type.</i> |
|--------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

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### Description

Constructs an orthogonal design for two types of factors with different numbers of levels. Three construction cases are considered: even-even level factors, odd-even level factors and odd-odd level factors. The appropriate construction is selected automatically according to the parity of the numbers of levels of the two factors. Hadamard matrices are used for even-level factors, while conference matrices are used for odd-level factors. The order of both the Hadamard and conference matrices is m. For the even-even case, the design contains m - 1 factors of each type. For the odd-even case, the design contains m odd-level factors and m - 1 even-level factors. For the odd-odd case, the design contains m factors of each type.

### Usage

```
mixed_level_design(a, b, m)
```

### Arguments

|   |                                                                                                  |
|---|--------------------------------------------------------------------------------------------------|
| a | Number of levels of the first factor.                                                            |
| b | Number of levels of the second factor.                                                           |
| m | Order of the Hadamard and conference matrices used in the construction. Must be a multiple of 4. |

**Value**

A matrix containing the constructed orthogonal design. The total number of factors depends on the construction case:  $2(m - 1)$  for the even-even case,  $2m - 1$  for the odd-even case, and  $2m$  for the odd-odd case.

**Examples**

```
mixed_level_design(a = 4, b = 2, m = 4)
mixed_level_design(a = 3, b = 2, m = 8)
mixed_level_design(a = 5, b = 3, m = 4)
```

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|                  |                                                                                                     |
|------------------|-----------------------------------------------------------------------------------------------------|
| pseudoConference | <i>Constructs a pseudo-conference matrix of order n using a determinant-based search procedure.</i> |
|------------------|-----------------------------------------------------------------------------------------------------|

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**Description**

Constructs a pseudo-conference matrix of order n using a determinant-based search procedure.

**Usage**

```
pseudoConference(n, starts = 1000, max.iter = 100)
```

**Arguments**

|          |                                                                         |
|----------|-------------------------------------------------------------------------|
| n        | A positive integer specifying the order of the matrix.                  |
| starts   | Number of random starting matrices used in the search. Default is 1000. |
| max.iter | Maximum number of iterations for each starting matrix. Default is 100.  |

**Details**

The matrix has zero diagonal elements and off-diagonal elements equal to -1 or +1. The search selects a matrix by maximizing the determinant criterion.

**Value**

A list containing the pseudo-conference matrix and the corresponding log-determinant value.

**Examples**

```
result <- pseudoConference(6, starts = 10, max.iter = 10)
result$Matrix
result$LogDet
```

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|      |                                                                                                                                                                  |
|------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| SCCD | <i>Constructs an SCCD for a specified number of runs (<math>n=2m</math>). The construction method is selected automatically according to the number of runs.</i> |
|------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|

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**Description**

Constructs an SCCD for a specified number of runs ( $n=2m$ ). The construction method is selected automatically according to the number of runs.

**Usage**

```
SCCD(n)
```

**Arguments**

`n` A positive even integer specifying the number of runs.

**Details**

Method I is used when  $n$  is divisible by 8. Method II is used when  $n$  is divisible by 4 but not by 8. Method III is used when  $n$  is even but not divisible by 4.

**Value**

A numeric SCCD matrix containing  $m$  continuous and  $m-1$  categorical factors.

**Examples**

```
SCCD(16)
```

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|            |                                                                                                                                                              |
|------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|
| simulation | <i>Performs a simulation study to evaluate the ability of a design to identify active main effects using best-subsets regression and the AICc criterion.</i> |
|------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|

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**Description**

Performs a simulation study to evaluate the ability of a design to identify active main effects using best-subsets regression and the AICc criterion.

**Usage**

```
simulation(X, SNR, n.active, nrep = 1000)
```

**Arguments**

|          |                                                                               |
|----------|-------------------------------------------------------------------------------|
| X        | A design matrix containing the mixed-level factors.                           |
| SNR      | A numeric value specifying the signal-to-noise ratio.                         |
| n.active | An integer specifying the number of active factors.                           |
| nrep     | An integer specifying the number of simulation replications. Default is 1000. |

**Value**

A data frame containing the SNR, number of active factors, power, and Type I error rate.

**Examples**

```
## Not run:  
X <- matrix(rnorm(20 * 5), nrow = 20, ncol = 5)  
simulation(X, SNR = 1, n.active = 2, nrep = 100)  
  
## End(Not run)
```

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