# Package 'MFRCD'

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**Type** Package

**Title** Optimal Row-Column Designs for Asymmetrical Factorial Experiments

**Version** 0.1.0

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**Description** Constructs and analyzes optimal row-column designs for mixed-level factorial experiments under two field situations like square field layouts, where the number of rows and columns are equal, and rectangular field layouts, where one blocking direction is determined by a selected block size. For square field layouts, the package implements direct common-factor constructions by first forming two component treatment arrays, one for each factor or super-factor, and then combining them through a symbolic cell-wise product following Gopinath, Parsad and Mandal (2018) <doi:10.1080/03610926.2017.1376091>. For rectangular field layouts, the package constructs designs by extracting a balanced principal block from a mixed-level block design derived from r package mixedfact, treating it as the principal column, taking the complete treatment set as the principal row, and generating the full row-column design by cyclic modular development. The package also provides diagnostic tools for connectedness, orthogonal factorial structure, balance, estimability, A-, D-, and E-efficiency, E-optimality, and MV-optimality criterion values. These designs are practically useful in agricultural, industrial, and biological experiments where treatments have factorial structure and heterogeneity must be controlled simultaneously in two directions.

**License** GPL-3

**Encoding** UTF-8

**Depends** R (>= 4.0.0)

**Imports** stats

**Suggests** mixedfact, roxygen2, testthat (>= 3.0.0)

**RoxygenNote** 7.3.3

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**NeedsCompilation** no

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**Repository** CRAN

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`check_row_column_balance` *Check row and column level balance*

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## Description

Computes factor-level counts in each row and column and reports exact row balance and as-balanced-as-possible column balance.

## Usage

```
check_row_column_balance(arr, levels)
```

## Arguments

| | |
|---|---|
| `arr` | Three-dimensional numeric design array with dimensions rows, columns, and factors. |
| `levels` | Integer vector of factor levels. |

## Value

A list containing row and column count tables and balance indicators.

## Examples

```
obj <- rc_method2(2, 4)
check_row_column_balance(obj$numeric_design, c(2, 4))$row_balanced_exact
```

## level_balance_diagnostics *Detailed factor-level balance diagnostics*

### Description

Computes exact and as-balanced-as-possible row and column balance diagnostics for each factor.

### Usage

```
level_balance_diagnostics(arr, levels)
```

### Arguments

| | |
|---|---|
| arr | Three-dimensional numeric design array. |
| levels | Integer vector of factor levels. |

### Value

A list containing per-factor row and column counts and aggregate balance indicators.

### Examples

```
obj <- rc_method2(2, 4)
level_balance_diagnostics(obj$numeric_design, c(2, 4))$row_exact_all
```

## mfrcd *Generate a mixed-factor row-column design*

### Description

Main user-facing function for generating mixed-factor row-column designs. Without `block_size`, the function first attempts the direct Method 1/2 construction through super-factor grouping. When `block_size` is supplied, or when no direct construction is available, it uses a `mixedfact` principal-block construction.

### Usage

```
mfrcd(
  levels,
  block_size = NULL,
  sep = "",
  details = FALSE,
  check_properties = FALSE,
  use_mixedfact = TRUE,
  mixedfact_method = "auto",
```

```
  choose_block = "best",
  group1 = NULL,
  group2 = NULL,
  prefer = c("auto", "direct", "mixedfact"),
  tol = 1e-07
)
```

## Arguments

| | |
|---|---|
| levels | Integer vector giving the number of levels of the factors. |
| block_size | Optional block size. If supplied, the mixedfact principal-block route is used and the block size becomes the number of rows. |
| sep | Character separator for printed treatment labels. |
| details | Logical. If TRUE, return full construction details. If FALSE, return a compact design or compact verification output. |
| check_properties | Logical. If TRUE, verify connectedness, OFS, balance, estimability, and efficiency properties. |
| use_mixedfact | Logical. If TRUE, allow use of mixedfact for principal-block construction. |
| mixedfact_method | Method argument passed to mixedfact::mixedfact(). |
| choose_block | Principal-block selection rule, either "best" or "first". |
| group1 | Optional integer vector of factor indices for the first super-factor in direct construction. |
| group2 | Optional integer vector of factor indices for the second super-factor in direct construction. |
| prefer | Construction route preference, one of "auto", "direct", or "mixedfact". |
| tol | Numerical tolerance for verification checks. |

## Value

If check_properties = FALSE and details = FALSE, a character matrix containing the row-column design. If check_properties = TRUE, a compact list containing the design and verification tables. If details = TRUE, a full construction object is returned.

## Examples

```
mfrcd(c(2, 4))
out <- mfrcd(c(2, 4), check_properties = TRUE)
out$design_checks
if (requireNamespace("mixedfact", quietly = TRUE)) {
  mfrcd(c(3, 5), block_size = 5)
}
```

## rc_factorial_n *Construct a row-column design for multiple factors by super-factor grouping*

### Description

Groups an n-factor mixed-level factorial experiment into two super-factors, applies Method 1 or Method 2 when possible, and expands the super-factor levels back to the original factor levels by mixed-radix representation.

### Usage

```
rc_factorial_n(levels, sep = "", details = FALSE, group1 = NULL, group2 = NULL)
```

### Arguments

| | |
|---|---|
| levels | Integer vector giving the number of levels of the factors. |
| sep | Character separator for printed treatment labels. |
| details | Logical. If TRUE, returns the printed design, numeric array, grouping, route, and other construction details. If FALSE, returns only the printed design matrix. |
| group1 | Optional integer vector giving factor indices to place in the first super-factor. |
| group2 | Optional integer vector giving factor indices to place in the second super-factor. If omitted and group1 is supplied, the complement of group1 is used. |

### Value

If details = FALSE, a character matrix giving the row-column design. If details = TRUE, a list with design, numeric design, selected grouping, method, and parameters.

### Examples

```
rc_factorial_n(c(2, 4))
rc_factorial_n(c(2, 3, 2))
```

## rc_from_principal_block *Construct a row-column design from a principal block*

### Description

Constructs a row-column design by taking a principal block as the principal column, taking the complete treatment set as the principal row, and developing the design by component-wise modular addition. If principal_block is not supplied, it is obtained from mixedfact.

## Usage

```
rc_from_principal_block(
  levels,
  block_size,
  principal_block = NULL,
  use_mixedfact = TRUE,
  mixedfact_method = "auto",
  choose_block = "best",
  sep = "",
  details = FALSE
)
```

## Arguments

| | |
|---|---|
| `levels` | Integer vector giving factor levels. |
| `block_size` | Required number of rows, equal to the size of the principal block. |
| `principal_block` | Optional principal block as labels, matrix, or data frame. If `NULL`, `mixedfact` is used. |
| `use_mixedfact` | Logical. If `TRUE`, use `mixedfact` when `principal_block` is not supplied. |
| `mixedfact_method` | Method argument passed to `mixedfact::mixedfact()`. |
| `choose_block` | Selection rule for candidate blocks, either `"best"` or `"first"`. |
| `sep` | Character separator for printed treatment labels. |
| `details` | Logical. If `TRUE`, return construction details; otherwise return only the printed design. |

## Value

A character design matrix if `details = FALSE`; otherwise a list containing the design, numeric design, principal column, principal row, diagnostics, and `mixedfact` output.

## Examples

```
rc_from_principal_block(
  levels = c(2, 3),
  block_size = 3,
  principal_block = c("00", "12", "11")
)
```

## rc_method1 *Construct a two-factor row-column design by Method 1*

### Description

Generates a row-column design for a two-factor factorial experiment `s1 x s2` when the two numbers of levels have a common factor. The construction follows Method 1 of Gopinath, Parsad and Mandal for incomplete row-column designs with factorial treatment structure.

### Usage

```
rc_method1(s1, s2, f = NULL, sep = "")
```

### Arguments

| | |
|---|---|
| `s1` | Number of levels of the first factor. |
| `s2` | Number of levels of the second factor. |
| `f` | Optional common factor of `s1` and `s2`. If `NULL`, `gcd_int(s1, s2)` is used. |
| `sep` | Character separator for printed treatment labels. |

### Value

A list containing the construction method, parameters, component matrices `D1` and `D2`, the printed design, and a numeric design array.

### References

Gopinath, P. P., Parsad, R. and Mandal, B. N. (2018). Incomplete row-column designs with factorial treatment structure for estimating main effects with full efficiency. Communications in Statistics - Theory and Methods, 47, 4493-4502.

### Examples

```
rc_method1(3, 6)$design
```

## rc_method2 *Construct a two-factor row-column design by Method 2*

### Description

Generates a row-column design for a two-factor factorial experiment `s1 x s2` when `s2` is a multiple of `s1`. The construction follows Method 2 of Gopinath, Parsad and Mandal.

### Usage

```
rc_method2(s1, s2, sep = "")
```

### Arguments

| | |
|---|---|
| s1 | Number of levels of the first factor. |
| s2 | Number of levels of the second factor. Must be a multiple of s1. |
| sep | Character separator for printed treatment labels. |

### Value

A list containing the construction method, parameters, component matrices D1 and D2, the printed design, and a numeric design array.

### References

Gopinath, P. P., Parsad, R. and Mandal, B. N. (2018). Incomplete row-column designs with factorial treatment structure for estimating main effects with full efficiency. Communications in Statistics - Theory and Methods, 47, 4493-4502.

### Examples

```
rc_method2(2, 4)$design
```

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## verify_mfrcd *Verify row-column design properties*

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### Description

Computes OFS diagnostics, main-effect and two-factor-interaction estimability, connectedness, balance, A/D/E efficiencies, E-optimality value, and MV-optimality value for a generated MFRCD design.

### Usage

```
verify_mfrcd(
  x,
  levels = NULL,
  sep = "",
  tol = 1e-07,
  max_order = NULL,
  verbose = FALSE
)
```

### Arguments

| | |
|---|---|
| x | MFRCD details list, numeric design array, or printed design matrix. |
| levels | Optional integer vector of factor levels, required when x is a printed matrix or numeric array without metadata. |
| sep | Character separator used in treatment labels. |

| | |
|---|---|
| tol | Numerical tolerance for rank, eigenvalue, and orthogonality checks. |
| max_order | Maximum factorial-effect order to include. If NULL, all orders are included. |
| verbose | Logical. If TRUE, issue a short verification summary using message(). The default is FALSE so the function returns an object silently. |

## Value

A list containing summary checks, effect-level diagnostics, connectedness, efficiencies, optimality criteria, information matrices, and treatment frequencies.

## Examples

```
obj <- mfrcd(c(2, 4), details = TRUE)
chk <- verify_mfrcd(obj)
chk$summary$ofs
chk$main_effects_and_2fi
```

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