Package 'MixFrac'

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Type Package

Title Fractional Factorial Designs with Alias and Trend-Free Analysis

Version 1.0

Description Constructs mixed-level and regular fractional factorial designs using coordinate-exchange optimization and automatic generator search. Design quality is evaluated with J2 and balance (H-hat) criteria,
alias structures are computed via correlation-based chaining, and deterministic trend-free run orders can be produced following
Coster (1993) <doi:10.1214/aos/1176349410>. Mixed-level design construction follows the NONBPA approach of Pantoja-Pacheco et al. (2021) <doi:10.3390/math9131455>. Regular fraction identification follows Guo, Simpson and Pignatiello (2007)
<doi:10.1080/00224065.2007.11917691>. Alias structure computation follows
Rios-Lira et al.(2021) <doi:10.3390/math9233053>.

License GPL-3

Encoding UTF-8

RoxygenNote 7.3.3

Imports stats, utils

Suggests knitr, rmarkdown, testthat (>= 3.0.0)

VignetteBuilder knitr

Config/testthat/edition 3

NeedsCompilation no

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Contents

`generate_ff` *Generate Mixed-Level or Regular Fractional Factorial Designs*

Description

`generate_ff()` constructs mixed-level fractional factorial designs or, when all factors share the same number of levels s, automatically searches for a regular s^{k-p} fractional factorial using generator relations.

#' The function performs:

- **Part 1:** Design construction (regular or mixed-level)
- **Part 2:** Design diagnostics: balance (Hhat), J2, GBM, alias chains, and strong confounding summary
- **Part 3 (optional):** Deterministic trend-free run order based on Coster (1993)

Output printing can be controlled via the `parts` argument.

Usage

```
generate_ff(
  levels_spec,
  n_runs,
  max_iter = 100,
  a = 1,
  b = 1,
  max_int_order = 3,
  alias_min_abs_corr = 0.9,
  tf = FALSE,
  parts = c(1, 2, 3),
  verbose = TRUE
)
```

Arguments

`levels_spec`	A numeric vector such as `c(2,3,4)` (levels per factor), or a named list of level labels (e.g. `list(A = 1:2, B = 1:3, C = 1:4)`).
`n_runs`	Number of experimental runs required.
`max_iter`	Maximum number of iterations for coordinate exchange or unique-subset improvement (default: `100`).
`a`	Weight for the J2 near-orthogonality criterion.
`b`	Weight for the Hhat balance criterion.
`max_int_order`	Highest-order interaction used when building model matrices for alias calculations. Default is `3`.
`alias_min_abs_corr`	Minimum absolute correlation required for a pair of model terms to appear in the strong confounding summary table.

`tf`	Logical. When `TRUE`, computes a trend-free run order (Part 3) based on deterministic pairwise swapping.
`parts`	Integer vector selecting which sections to print: • `1` -> Part 1: Design • `2` -> Part 2: Properties & alias • `3` -> Part 3: Trend-free order To print all: `parts = c(1,2,3)` (default).
`verbose`	Logical. When `TRUE`, prints results. When `FALSE`, performs all computations silently.

Details

Automatic Regular Fractional Factorial Detection:

When all factors have the same number of levels s, and when $n\_runs = s^{k-p}$, the function attempts to find a regular s^{k-p} fraction via a heuristic generator search inspired by Guo et al. (2007). The objective minimized is:

The objective function minimized is `Z = a * J2 + b * Hhat`.

If no acceptable generator set is found, the algorithm reverts to a mixed-level design strategy.

Mixed-Level Fractional Factorials:

Mixed-level designs are constructed using the Pantoja-Pacheco et al. (2021) NONBPA skeleton for nonmultiple levels, followed by a Guo-style coordinate exchange improvement on the Z-criterion.

Alias Structure (Rios-Lira et al., 2021):

Alias relationships are computed from the correlation matrix of the model matrix (main effects + interactions). Chains are built by selecting the pair of terms with the highest absolute correlation, choosing the lower-order term as the chain leader.

Trend-Free Run Order (Coster, 1993):

When `tf = TRUE`, a deterministic pairwise-swap algorithm produces a run order orthogonal to polynomial time trends (linear by default).

Value

A list containing:

- `design_int` -> integer-coded design
- `design_labels` -> decoded factor levels
- `level_maps` -> internal mapping of coded levels
- `Hhat` -> balance measure
- `J2hat` -> near-orthogonality measure
- `GBM` -> general balance metric
- `gbm_resolution` -> smallest order with imbalance
- `model_matrix` -> model matrix with interactions

- `corr_matrix` -> correlation matrix
- `alias_chains` -> alias chain structure
- `alias_summary` -> strong confounding pairs
- `trend_free_result` -> (if `tf = TRUE`) run order, reordered design, and final trend objective

Returned invisibly unless assigned.

References

Guo, Y., Simpson, J. R., & Pignatiello, J. J. (2007). *Construction of Efficient Mixed-Level Fractional Factorial Designs.* Journal of Quality Technology, 39(3), 241-257. doi:10.1080/00224065.2007.11917691

Pantoja-Pacheco, Y. V. et al. (2021). *One Note for Fractionation and Increase for Mixed-Level Designs When the Levels Are Not Multiple.* Mathematics, 9(13), 1455. doi:10.3390/math9131455

Rios-Lira, A. J. et al. (2021). *Alias Structures and Sequential Experimentation for Mixed-Level Designs.* Mathematics, 9(23), 3053. doi:10.3390/math9233053

Coster, D. C. (1993). *Trend-Free Run Orders of Mixed-Level Fractional Factorial Designs.* Annals of Statistics, 21(4), 2072-2086. doi:10.1214/aos/1176349410

Examples

```
# Mixed-level design (2 x 3 x 4), 12 runs, all parts printed
generate_ff(c(2,3,4), 12, tf = TRUE)

# Only Part 1 (design)
generate_ff(c(2,3,4), 12, parts = 1, tf = FALSE)

# Parts 1 and 2 only
generate_ff(c(2,3,4), 12, parts = c(1,2), tf = FALSE)

# Only Part 3 (trend-free run order)
generate_ff(c(2,3,4), 12, parts = 3, tf = TRUE)
```

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