Package 'GreedyExperimentalDesign'

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Type Package

Title Greedy Experimental Design Construction

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Description Computes experimental designs for two-arm experiments with covariates using multiple methods, including: (0) complete randomization and randomization with forced-balance; (1) greedy optimization of a balance objective function via pairwise switching; (2) numerical optimization via 'gurobi'; (3) rerandomization; (4) Karp's method for one covariate; (5) exhaustive enumeration for small sample sizes; (6) binary pair matching using 'nbpMatching'; (7) binary pair matching plus method (1) to further optimize balance; (8) binary pair matching plus method (3) to further optimize balance; (9) Hadamard designs; and (10) simultaneous multiple kernels. For the greedy, rerandomization, and related methods, three objective functions are supported: Mahalanobis distance, standardized sums of absolute differences, and kernel distances via the 'kernlab' library. This package is the result of a stream of research that can be found in Krieger, A. M., Azriel, D. A., and Kapelner, A. (2019). ``Nearly Random Designs with Greatly Improved Balance." Biometrika 106(3), 695-701 <doi:10.1093/biomet/asz026>. Krieger, A. M., Azriel, D. A., and Kapelner, A. (2023). ``Better experimental design by hybridizing binary matching with imbalance optimization." Canadian Journal of Statistics, 51(1), 275-292 <doi:10.1002/cjs.11685>.

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LinkingTo Rcpp

Imports Rcpp, checkmate, nbpMatching, rlist, stringr, stringi, kernlab, ggplot2, graphics, grDevices, stats

Suggests testthat (>= 3.0.0), pkgload, R6

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URL https://github.com/kapelner/GreedyExperimentalDesign

RoxygenNote 7.3.3

NeedsCompilation yes

Repository CRAN

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Contents

`all_elements_same_cpp_wrap` *Tests if a vector has all elements the same*

Description

Tests if a vector has all elements the same

Usage

```
all_elements_same_cpp_wrap(w)
```

Arguments

w	The vector to be queried

Value

A boolean if it has all same elements

Author(s)

Adam Kapelner

Examples

```
## Not run:
all_elements_same_cpp_wrap(c(1, 1, 1))
all_elements_same_cpp_wrap(c(1, 2, 1))

## End(Not run)
```

---

complete_randomization

Implements complete randomization (without forced balance)

Description

For debugging, you can use `set.seed` to be assured of deterministic output.

Usage

```
complete_randomization(n, r, form = "one_zero")
```

Arguments

n	number of observations
r	number of randomized designs you would like
form	Which form should it be in? The default is `one_zero` for 1/0's or `pos_one_min_one` for +1/-1's.

Value

a matrix where each column is one of the `r` designs

Author(s)

Adam Kapelner

Examples

```
## Not run:
complete_randomization(n = 6, r = 2)

## End(Not run)
```

`complete_randomization_with_forced_balanced`
Implements forced balanced randomization

Description

For debugging, you can use `set.seed` to be assured of deterministic output.

Usage

```
complete_randomization_with_forced_balanced(
  n,
  r,
  form = "one_zero",
  seed = NULL
)
```

Arguments

`n`	number of observations
`r`	number of randomized designs you would like
`form`	Which form should it be in? The default is `one_zero` for 1/0's or `pos_one_min_one` for +1/-1's.
`seed`	An integer which is the seed to be set within C++. Default is `NULL` which means the seed is set from the system clock.

Value

a matrix where each column is one of the `r` designs

Author(s)

Adam Kapelner

Examples

```
## Not run:
complete_randomization_with_forced_balanced(n = 6, r = 2, seed = 1)

## End(Not run)
```

computeBinaryMatchStructure *Compute Binary Matching Strcuture*

Description

This method creates an object of type binary_match_structure and will compute pairs. You can then use the functions `initBinaryMatchExperimentalDesignSearchObject` and `resultsBinaryMatchSearch` to create randomized allocation vectors. For one column in X, we just sort to find the pairs trivially.

Usage

```
computeBinaryMatchStructure(
  X,
  mahal_match = FALSE,
  compute_dist_matrix = NULL,
  D = NULL,
  symmetry_tol = 1e-12,
  use_safe_inverse = FALSE
)
```

Arguments

`X`	The design matrix with n rows (one for each subject) and p columns (one for each measurement on the subject). This is the design matrix you wish to search for a more optimal design.
`mahal_match`	Match using Mahalanobis distance. Default is `FALSE`.
`compute_dist_matrix`	The function that computes the distance matrix between every two observations in `X`, its only argument. The default is `NULL` signifying euclidean squared distance optimized in C++.
`D`	A distance matrix precomputed. The default is `NULL` indicating the distance matrix should be computed.
`symmetry_tol`	Tolerance for symmetry check on `D`. Default is `1e-12`.
`use_safe_inverse`	Should a regularized inverse be used for the Mahalanobis objective? Default is `FALSE`.

Value

An object of type `binary_experimental_design` which can be further operated upon.

Author(s)

Adam Kapelner

Examples

```
## Not run:
set.seed(1)
X = matrix(rnorm(16), nrow = 8)
bms = computeBinaryMatchStructure(X)
bms$indicies_pairs

## End(Not run)
```

`compute_distance_matrix_cpp_wrap` *Computes a Euclidean-squared distance matrix rapidly*

Description

Computes a Euclidean-squared distance matrix rapidly

Usage

```
compute_distance_matrix_cpp_wrap(X)
```

Arguments

`X`	A numeric matrix with n rows representing each subject and p columns which are measurements on each subject

Value

The n x n Euclidean distances squared

Author(s)

Adam Kapelner

Examples

```
## Not run:
X = matrix(c(0, 1, 2, 3), nrow = 2)
compute_distance_matrix_cpp_wrap(X)

## End(Not run)
```

compute_gram_matrix *Gram Matrix Computation*

Description

Computes the Gram Matrix for a user-specified kernel using the library kernlab. Note that this function automatically standardizes the columns of the data entered.

Usage

```
compute_gram_matrix(X, kernel_type, params = c())
```

Arguments

X	The design matrix with n rows (one for each subject) and p columns (one for each measurement on the subject). This is the design matrix you wish to search for a more optimal design.
kernel_type	One of the following: "vanilla", "rbf", "poly", "tanh", "bessel", "laplace", "anova" or "spline".
params	A vector of numeric parameters. Each kernel_type has different numbers of parameters required. For more information see documentation for the kernlab library.

Value

The n x n gram matrix for the given kernel on the given data.

Author(s)

Adam Kapelner

Examples

```
## Not run:
set.seed(1)
X = matrix(rnorm(12), nrow = 6)
K = compute_gram_matrix(X, kernel_type = "rbf", params = 0.5)
dim(K)

## End(Not run)
```

compute_objective_val *Computes Objective Value From Allocation Vector*

Description

Returns the objective value given a design vector as well an an objective function. This is sometimes duplicated in Java. However, within Java, tricks are played to make optimization go faster so Java's objective values may not always be the same as the true objective function (e.g. logs or constants dropped).

Usage

```
compute_objective_val(
  X,
  indic_T,
  objective = "abs_sum_diff",
  inv_cov_X = NULL,
  use_safe_inverse = FALSE
)
```

Arguments

X	The n x p design matrix
indic_T	The n-length binary allocation vector
objective	The objective function to use. Default is abs_sum_diff and the other option is mahal_dist.
inv_cov_X	Optional: the inverse sample variance covariance matrix. Use this argument if you will be doing many calculations since passing this in will cache this data.
use_safe_inverse	Should a regularized inverse be used for the Mahalanobis objective? Default is FALSE.

Author(s)

Adam Kapelner

Examples

```
## Not run:
X = matrix(rnorm(12), nrow = 6)
indic_T = c(1, 0, 1, 0, 1, 0)
compute_objective_val(X, indic_T, objective = "abs_sum_diff")

## End(Not run)
```

compute_randomization_metrics

Computes Randomization Metrics (explained in paper) about a design algorithm

Description

Computes Randomization Metrics (explained in paper) about a design algorithm

Usage

```
compute_randomization_metrics(designs)
```

Arguments

designs	A matrix where each column is one design.

Value

A list of resulting data: the probability estimates for each pair in the design of randomness where estmates close to ~0.5 represent random assignment, then the entropy metric the distance metric, the maximum eigenvalue of the allocation var-cov matrix (operator norm) and the squared Frobenius norm (the sum of the squared eigenvalues)

Author(s)

Adam Kapelner

Examples

```
## Not run:
designs = matrix(c(1, 0, 1, 0, 0, 1, 0, 1), nrow = 4, ncol = 2)
compute_randomization_metrics(designs)

## End(Not run)
```

create_all_ys_cpp_wrap

Create all binary Y's convenience function using a randomized design

Description

Create all binary Y's convenience function using a randomized design

Usage

```
create_all_ys_cpp_wrap(pCs, pTs, W, two_n, nY)
```

Arguments

pCs	Control-group success probabilities (length two_n)
pTs	Treatment-group success probabilities (length two_n)
W	Assignment matrix with nY rows and two_n columns
two_n	Total number of units
nY	Number of Y vectors to generate

Value

A matrix of boolean Y's

Author(s)

Adam Kapelner

Examples

```
## Not run:
pCs = rep(0.2, 4)
pTs = rep(0.8, 4)
W = matrix(c(1, 0, 1, 0, 0, 1, 0, 1), nrow = 2, byrow = TRUE)
create_all_ys_cpp_wrap(pCs, pTs, W, two_n = 4, nY = 2)

## End(Not run)
```

---

generate_block_design_cpp_wrap

Generates homogeneous block design allocations rapidly

Description

Generates homogeneous block design allocations rapidly

Usage

```
generate_block_design_cpp_wrap(B, nR, dummy_block)
```

Arguments

B	The number of blocks in the design
nR	The number of allocation vectors
dummy_block	The subvector of allocations in each block that will be permuted

Value

A matrix with rows being the nR random block allocation of sample size B x length(dummy_block).

Author(s)

Adam Kapelner

Examples

```
## Not run:
generate_block_design_cpp_wrap(B = 2, nR = 3, dummy_block = c(1, 0))

## End(Not run)
```

---

generate_stdzied_design_matrix

Generates a design matrix with standardized predictors.

Description

This function is useful for debugging.

Usage

```
generate_stdzied_design_matrix(n = 50, p = 1, covariate_gen = rnorm, ...)
```

Arguments

n	Number of rows in the design matrix
p	Number of columns in the design matrix
covariate_gen	The function to use to draw the covariate realizations (assumed to be iid). This defaults to rnorm for $N(0,1)$ draws.
...	Optional arguments to be passed to the covariate_dist function.

Value

THe design matrix

Author(s)

Adam Kapelner

Examples

```
## Not run:
X = generate_stdzied_design_matrix(n = 6, p = 2)
colMeans(X)

## End(Not run)
```

gen_pm_designs_cpp_wrap *Create PM designs*

Description

Create PM designs

Usage

```
gen_pm_designs_cpp_wrap(indicies_pairs, n, r)
```

Arguments

indicies_pairs	A matrix of n x 2 indicies where each row is a pair of subjects' indicies
n	Half the number of subjects i.e. the number of pairs
r	The number of assignments to generate

Value

A matrix of r x 2n PM designs of +1/-1 assignments

Author(s)

Adam Kapelner

Examples

```
## Not run:
indicies_pairs = matrix(c(1, 2, 3, 4), ncol = 2, byrow = TRUE)
gen_pm_designs_cpp_wrap(indicies_pairs, n = 2, r = 3)

## End(Not run)
```

gen_var_cov_matrix_block_designs *Computes varcov matrix for block designs*

Description

The varcov matrix for block designs consists of a block- diagonal matrix with B blocks (the number of blocks in the design) with off-diagonal entries = -1 / (n/B - 1) where n is the number of subjected in the study.

Usage

```
gen_var_cov_matrix_block_designs(n, prop_T, B, use_cache = TRUE)
```

Arguments

n	number of observations
prop_T	the proportion of treatments allocated
B	the number of blocks
use_cache	Cache results for repeated calls with identical inputs. Default is TRUE.

Value

varcov matrix for the specific block design

Author(s)

Adam Kapelner

Examples

```
## Not run:
gen_var_cov_matrix_block_designs(n = 12, prop_T = 0.5, B = 3)

## End(Not run)
```

GreedyExperimentalDesign

Greedy Experimental Design Search

Description

A tool to find many types of a priori experimental designs

Author(s)

Adam Kapelner <kapelner@qc.cuny.edu>

References

Kapelner, A

`greedy_orthogonalization_curation` *Curate More Orthogonal Vectors Greedily*

Description

This function takes a set of allocation vectors and pares them down one-by-one by eliminating the vector that can result in the largest reduction in Avg[|r_ij|]. It is recommended to begin with a set of unmirrored vectors for speed. Then add the mirrors later for whichever subset you wish.

Usage

```
greedy_orthogonalization_curation(W, Rmin = 2, verbose = FALSE)
```

Arguments

`W`	A matrix in in the set $-1, 1^{Rxn}$ which have R allocation vectors for an experiment of sample size n.
`Rmin`	The minimum number of vectors to consider in a design. The default is the true bottom, two.
`verbose`	Default is `FALSE` but if not, it will print out a message for each iteration.

Value

A list with two elements: (1) `avg_abs_rij_by_R` which is a data frame with R - Rmin + 1 rows and columns R and average absolute r_ij and (2) `Wsorted` which provides the collection of vectors in sorted by best average absolute r_ij in row order from best to worst.

Author(s)

Adam Kapelner

Examples

```
## Not run:
set.seed(1)
W = matrix(sample(c(-1, 1), 6 * 8, replace = TRUE), nrow = 6)
res = greedy_orthogonalization_curation(W, Rmin = 3, verbose = FALSE)
res$avg_abs_rij_by_R

## End(Not run)
```

`greedy_orthogonalization_curation2` *Curate More Orthogonal Vectors Greedily*

Description

This function takes a set of allocation vectors and pares them down one-by-one by eliminating the vector that can result in the largest reduction in Avg[|r_ij|]. It is recommended to begin with a set of unmirrored vectors for speed. Then add the mirrors later for whichever subset you wish.

Usage

```
greedy_orthogonalization_curation2(W, R0 = 100, verbose = FALSE)
```

Arguments

`W`	A matrix in $-1, 1^{Rxn}$ which have R allocation vectors for an experiment of sample size n.
`R0`	The minimum number of vectors to consider in a design. The default is the true bottom, two.
`verbose`	Default is `FALSE` but if not, it will print out a message for each iteration.

Value

A list with two elements: (1) `avg_abs_rij_by_R` which is a data frame with R - Rmin + 1 rows and columns R and average absolute r_ij and (2) `Wsorted` which provides the collection of vectors in sorted by best average absolute r_ij in row order from best to worst.

Author(s)

Adam Kapelner

Examples

```
## Not run:
set.seed(1)
W = matrix(sample(c(-1, 1), 6 * 8, replace = TRUE), nrow = 6)
W2 = greedy_orthogonalization_curation2(W, R0 = 4, verbose = FALSE)
dim(W2)

## End(Not run)
```

hadamardExperimentalDesign *Create a Hadamard Design*

Description

This method returns unique designs according to a Hadamard matrix. For debugging, you can use `set.seed` to be assured of deterministic output.

Usage

```
hadamardExperimentalDesign(X, strict = TRUE, form = "one_zero")
```

Arguments

`X`	The design matrix with n rows (one for each subject) and p columns (one for each measurement on the subject). The measurements aren't used to compute the Hadamard designs, only the number of rows.
`strict`	Hadamard matrices are not available for all n.
`form`	Which form should it be in? The default is `one_zero` for 1/0's or `pos_one_min_one` for +1/-1's.

Value

An matrix of dimension R x n where R is the number of Hadamard allocations.

Author(s)

Adam Kapelner

Examples

```
## Not run:
set.seed(1)
X = matrix(rnorm(16), nrow = 8)
W = hadamardExperimentalDesign(X, strict = TRUE, form = "one_zero")
dim(W)

## End(Not run)
```

`imbalanced_block_designs` *Implements unequally allocated block designs*

Description

For debugging, you can use `set.seed` to be assured of deterministic output. The following quantities in this design must be integer valued or an error will be thrown: n_B := n / B and n_B * prop_T

Usage

```
imbalanced_block_designs(n, prop_T, B, r, form = "one_zero", seed = NULL)
```

Arguments

`n`	number of observations
`prop_T`	the proportion of treatments allocated
`B`	the number of blocks
`r`	number of randomized designs you would like
`form`	Which form should it be in? The default is `one_zero` for 1/0's or `pos_one_min_one` for +1/-1's.
`seed`	An integer which is the seed to be set within C++. Default is `NULL` which means the seed is set from the system clock.

Value

a matrix where each column is one of the `r` designs

Author(s)

Adam Kapelner

Examples

```
## Not run:
imbalanced_block_designs(n = 12, prop_T = 0.5, B = 3, r = 2, seed = 1)

## End(Not run)
```

`imbalanced_complete_randomization` *Implements unequally allocated complete randomization*

Description

For debugging, you can use `set.seed` to be assured of deterministic output.

Usage

```
imbalanced_complete_randomization(n, prop_T, r, form = "one_zero", seed = NULL)
```

Arguments

`n`	number of observations
`prop_T`	the proportion of treatments needed
`r`	number of randomized designs you would like
`form`	Which form should it be in? The default is `one_zero` for 1/0's or `pos_one_min_one` for +1/-1's.
`seed`	An integer which is the seed to be set within C++. Default is `NULL` which means the seed is set from the system clock.

Value

a matrix where each column is one of the `r` designs

Author(s)

Adam Kapelner

Examples

```
## Not run:
imbalanced_complete_randomization(n = 10, prop_T = 0.3, r = 2, seed = 1)

## End(Not run)
```

`initBinaryMatchExperimentalDesignSearchObject` *Begin a Binary Match Search*

Description

This method creates an object of type pairwise_matching_experimental_design_search and will immediately initiate a search through allocation space for pairwise match designs based on the structure computed in the function `computeBinaryMatchStructure`. For debugging, you can use set the `seed` parameter and `num_cores = 1` to be assured of deterministic output.

Usage

```
initBinaryMatchExperimentalDesignSearchObject(
  binary_match_structure,
  max_designs = 1000,
  wait = FALSE,
  start = TRUE,
  num_cores = 1,
  seed = NULL,
  prop_flips = 1,
  verbose = TRUE
)
```

Arguments

`binary_match_structure`	The `binary_experimental_design` object where the pairs are computed.
`max_designs`	How many random allocation vectors you wish to return. The default is 1000.
`wait`	Should the `R` terminal hang until all `max_designs` vectors are found? The default is `FALSE`.
`start`	Should we start searching immediately (default is `TRUE`).
`num_cores`	The number of CPU cores you wish to use during the search. The default is `1`.
`seed`	The set to set for deterministic output. This should only be set if `num_cores = 1` otherwise the output will not be deterministic. Default is `NULL` for no seed set.
`prop_flips`	Proportion of flips. Default is all. Lower for more correlated assignments (useful for research only).
`verbose`	Should the algorithm emit progress output? Default is `TRUE`.

Author(s)

Adam Kapelner

Examples

```
## Not run:
set.seed(1)
X = matrix(rnorm(16), nrow = 8)
bms = computeBinaryMatchStructure(X)
bm = initBinaryMatchExperimentalDesignSearchObject(
  bms,
  max_designs = 4,
  num_cores = 1,
  start = TRUE,
  wait = TRUE,
  seed = 1,
  verbose = FALSE
)
bm

## End(Not run)
```

`initBinaryMatchFollowedByGreedyExperimentalDesignSearchObject` *Begin a Search for Binary Matching Followed by Greedy Switch Designs*

Description

This method creates an object of type binary_then_greedy_experimental_design and will find optimal matched pairs which are then greedily switched in order to further minimize a balance metric. You can then use the function `resultsBinaryMatchThenGreedySearch` to obtain the randomized allocation vectors. For one column in X, the matching just sorts the values to find the pairs trivially.

Usage

```
initBinaryMatchFollowedByGreedyExperimentalDesignSearchObject(
  X,
  diff_method = FALSE,
  compute_dist_matrix = NULL,
  verbose = TRUE,
  ...
)
```

Arguments

`X`	The design matrix with n rows (one for each subject) and p columns (one for each measurement on the subject). This is the design matrix you wish to search for a more optimal design.
`diff_method`	Once the subjects (i.e. row vectors) are paired, do we create a set of n/2 difference vectors and feed that into greedy? If `TRUE`, this technically breaks the objective function, but it is shown to have better performance. The default is thus `FALSE`.

`compute_dist_matrix`
: The function that computes the distance matrix between every two observations in `X`, its only argument. The default is `NULL` signifying euclidean squared distance optimized in C++.

`verbose`
: Should the algorithm emit progress output? Default is `TRUE`.

`...`
: Arguments passed to `initGreedyExperimentalDesignObject`. It is recommended to set `max_designs` otherwise it will default to 10,000.

Value

An object of type `binary_experimental_design` which can be further operated upon.

Author(s)

Adam Kapelner

Examples

```
## Not run:
set.seed(1)
X = matrix(rnorm(16), nrow = 8)
obj = initBinaryMatchFollowedByGreedyExperimentalDesignSearchObject(
  X,
  max_designs = 4,
  num_cores = 1,
  objective = "abs_sum_diff",
  start = TRUE,
  wait = TRUE,
  verbose = FALSE
)
obj

## End(Not run)
```

`initBinaryMatchFollowedByRerandomizationDesignSearchObject` *Begin a Search for Binary Matching Followed by Rerandomization*

Description

This method creates an object of type binary_then_rerandomization_experimental_design and will find optimal matched pairs which are then rerandomized in order to further minimize a balance metric. You can then use the function `resultsBinaryMatchThenRerandomizationSearch` to obtain the randomized allocation vectors. For one column in X, the matching just sorts the values to find the pairs trivially.

Usage

```
initBinaryMatchFollowedByRerandomizationDesignSearchObject(
  X,
  compute_dist_matrix = NULL,
  verbose = TRUE,
  ...
)
```

Arguments

X	The design matrix with n rows (one for each subject) and p columns (one for each measurement on the subject). This is the design matrix you wish to search for a more optimal design.
compute_dist_matrix	The function that computes the distance matrix between every two observations in X, its only argument. The default is NULL signifying euclidean squared distance optimized in C++.
verbose	Should the algorithm emit progress output? Default is TRUE.
...	Arguments passed to initGreedyExperimentalDesignObject. It is recommended to set max_designs otherwise it will default to 10,000.

Value

An object of type binary_experimental_design which can be further operated upon.

Author(s)

Adam Kapelner

Examples

```
## Not run:
set.seed(1)
X = matrix(rnorm(16), nrow = 8)
obj = initBinaryMatchFollowedByRerandomizationDesignSearchObject(
  X,
  max_designs = 4,
  num_cores = 1,
  objective = "abs_sum_diff",
  obj_val_cutoff_to_include = Inf,
  start = TRUE,
  wait = TRUE,
  verbose = FALSE
)
obj

## End(Not run)
```

`initGreedyExperimentalDesignObject` *Begin A Greedy Pair Switching Search*

Description

This method creates an object of type greedy_experimental_design and will immediately initiate a search through allocation space for forced balance designs. For debugging, you can use set the `seed` parameter and `num_cores = 1` to be assured of deterministic output.

Usage

```
initGreedyExperimentalDesignObject(
  X = NULL,
  nT = NULL,
  max_designs = 10000,
  objective = "mahal_dist",
  indicies_pairs = NULL,
  Kgram = NULL,
  wait = FALSE,
  start = TRUE,
  max_iters = Inf,
  semigreedy = FALSE,
  diagnostics = FALSE,
  num_cores = 1,
  seed = NULL,
  verbose = TRUE,
  use_safe_inverse = FALSE
)
```

Arguments

`X`	The design matrix with n rows (one for each subject) and p columns (one for each measurement on the subject). This is the design matrix you wish to search for a more optimal design. This parameter must be specified unless you choose objective type `"kernel"` in which case, the `Kgram` parameter must be specified.
`nT`	The number of treatments to assign. Default is `NULL` which is for forced balance allocation i.e. nT = nC = n / 2 where n is the number of rows in X (or Kgram if X is unspecified).
`max_designs`	The maximum number of designs to be returned. Default is 10,000. Make this large so you can search however long you wish as the search can be stopped at any time by using the `stopSearch` method
`objective`	The objective function to use when searching design space. This is a string with valid values `"mahal_dist"` (the default), `"abs_sum_diff"` or `"kernel"`.

`indicies_pairs` A matrix of size $n/2$ times 2 whose rows are indicies pairs. The values of the entire matrix must enumerate all indicies $1, ..., n$. The default is `NULL` meaning to use all possible pairs.

`Kgram` If the `objective = kernel`, this argument is required to be an `n x n` matrix whose entries are the evaluation of the kernel function between subject i and subject j. Default is `NULL`.

`wait` Should the `R` terminal hang until all `max_designs` vectors are found? The deafult is `FALSE`.

`start` Should we start searching immediately (default is `TRUE`).

`max_iters` Should we impose a maximum number of greedy switches? The default is `Inf` which a flag for "no limit."

`semigreedy` Should we use a fully greedy approach or the quicker semi-greedy approach? The default is `FALSE` corresponding to the fully greedy approach.

`diagnostics` Returns diagnostic information about the iterations including (a) the initial starting vectors, (b) the switches at every iteration and (c) information about the objective function at every iteration (default is `FALSE` to decrease the algorithm's run time).

`num_cores` The number of CPU cores you wish to use during the search. The default is `1`.

`seed` The set to set for deterministic output. This should only be set if `num_cores = 1` otherwise the output will not be deterministic. Default is `NULL` for no seed set.

`verbose` Should the algorithm emit progress output? Default is `TRUE`.

`use_safe_inverse` Should a regularized inverse be used for the Mahalanobis objective? Default is `FALSE`.

Value

An object of type `greedy_experimental_design_search` which can be further operated upon

Author(s)

Adam Kapelner

Examples

```
## Not run:
set.seed(1)
X = matrix(rnorm(20), nrow = 10)
ged = initGreedyExperimentalDesignObject(
  X,
  max_designs = 5,
  num_cores = 1,
  objective = "abs_sum_diff",
  start = TRUE,
  wait = TRUE,
  verbose = FALSE
)
```

```
ged

## End(Not run)
```

`initGreedyMultipleKernelExperimentalDesignObject` *Begin A Greedy Pair Multiple Kernel Switching Search*

Description

This method creates an object of type greedy_multiple_kernel_experimental_design and will immediately initiate a search through allocation space for forced balance designs. For debugging, you can use set the `seed` parameter and `num_cores = 1` to be assured of deterministic output.

Usage

```
initGreedyMultipleKernelExperimentalDesignObject(
  X = NULL,
  max_designs = 10000,
  objective = "added_pct_reduction",
  kernel_pre_num_designs = 2000,
  kernel_names = NULL,
  Kgrams = NULL,
  maximum_gain_scaling = 1.1,
  kernel_weights = NULL,
  wait = FALSE,
  start = TRUE,
  max_iters = Inf,
  semigreedy = FALSE,
  diagnostics = FALSE,
  num_cores = 1,
  seed = NULL,
  verbose = TRUE,
  use_safe_inverse = FALSE
)
```

Arguments

`X`	The design matrix with n rows (one for each subject) and p columns (one for each measurement on the subject). This is the design matrix you wish to search for a more optimal design. We will standardize this matrix by column internally.
`max_designs`	The maximum number of designs to be returned. Default is 10,000. Make this large so you can search however long you wish as the search can be stopped at any time by using the `stopSearch` method
`objective`	The method used to aggregate the kernel objective functions together. Default is "added_pct_reduction".

kernel_pre_num_designs
: How many designs per kernel to run to explore the space of kernel objective values. Default is 2000.

kernel_names
: An array with the kernels to compute with default parameters. Must have elements in the following set: "mahalanobis", "poly_s" where the "s" is a natural number 1 or greater, "exponential", "laplacian", "inv_mult_quad", "gaussian". Default is NULL to indicate the kernels are specified manually using the Kgrams parameter.

Kgrams
: A list of M >= 1 elements where each is a n x n matrix whose entries are the evaluation of the kernel function between subject i and subject j. Default is NULL to indicate this was specified using the convenience parameter kernel_names.

maximum_gain_scaling
: This controls how much the percentage of possible improvement on a kernel objective function should be scaled by. The minimum is 1 which allows for designs that could potentially have >=100 improvement over original. We recommend 1.1 which means that a design that was found to be the best of the kernel_pre_num_designs still has 1/1.1 = 9% room to grow making it highly unlikely that any design could be >= 100%.

kernel_weights
: A vector with positive weights (need not be normalized) where each element represents the weight of each kernel. The default is NULL for uniform weighting.

wait
: Should the R terminal hang until all max_designs vectors are found? The deafult is FALSE.

start
: Should we start searching immediately (default is TRUE).

max_iters
: Should we impose a maximum number of greedy switches? The default is Inf which a flag for "no limit."

semigreedy
: Should we use a fully greedy approach or the quicker semi-greedy approach? The default is FALSE corresponding to the fully greedy approach.

diagnostics
: Returns diagnostic information about the iterations including (a) the initial starting vectors, (b) the switches at every iteration and (c) information about the objective function at every iteration (default is FALSE to decrease the algorithm's run time).

num_cores
: The number of CPU cores you wish to use during the search. The default is 1.

seed
: The set to set for deterministic output. This should only be set if num_cores = 1 otherwise the output will not be deterministic. Default is NULL for no seed set.

verbose
: Should the algorithm emit progress output? Default is TRUE.

use_safe_inverse
: Should a regularized inverse be used for the Mahalanobis objective? Default is FALSE.

Value

An object of type greedy_experimental_design_search which can be further operated upon

Author(s)

Adam Kapelner

Examples

```
## Not run:
set.seed(1)
X = matrix(rnorm(20), nrow = 10)
mk = initGreedyMultipleKernelExperimentalDesignObject(
  X,
  max_designs = 4,
  kernel_pre_num_designs = 4,
  num_cores = 1,
  kernel_names = c("mahalanobis", "gaussian"),
  start = TRUE,
  wait = TRUE,
  verbose = FALSE
)
mk

## End(Not run)
```

`initGurobiNumericalOptimizationExperimentalDesignObject`
Begin Gurobi Optimized Search

Description

This method creates an object of type optimal_experimental_design and will immediately initiate a search through allocation space for forced balance designs. Make sure you setup Gurobi properly first. This means applying for a license, downloading, installing, registering it on your computer using the `grbgetkey` command with the license file in the default directory. Then, in R, install the package from the file in your gurobi directory.

Usage

```
initGurobiNumericalOptimizationExperimentalDesignObject(
  X = NULL,
  objective = "mahal_dist",
  Kgram = NULL,
  num_cores = 2,
  w_0 = NULL,
  initial_time_limit_sec = 5 * 60,
  restart_time_limit_sec = 60,
  max_number_of_restarts = 0,
  max_no_good_cuts = 0,
  verbose = TRUE,
  gurobi_params = list(),
  use_safe_inverse = FALSE,
  r,
  pool_solutions = NULL,
  pool_gap = 0.2,
```

```
  pool_gap_abs = NULL,
  pool_search_mode = 2,
  mip_gap = 1e-04,
  mip_gap_abs = 1e-10,
  mip_focus = 1,
  heuristics = 0.2,
  cuts = 2,
  presolve = 2
)
```

Arguments

X	The design matrix with n rows (one for each subject) and p columns (one for each measurement on the subject). This is the design matrix you wish to search for a more optimal design.
objective	The objective function to use when searching design space. This is a string with valid values "mahal_dist" (the default) or "kernel".
Kgram	If the objective = kernel, this argument is required to be an n x n matrix whose entries are the evaluation of the kernel function between subject i and subject j. Default is NULL.
num_cores	Number of cores to use during search. Default is 2.
w_0	The initial starting location (optional).
initial_time_limit_sec	The maximum amount of time the optimizer can run for in seconds. The default is 5 * 60.
restart_time_limit_sec	The maximum amount of time each restart can run for in seconds. The default is 60.
max_number_of_restarts	The maximum number of restarts to attempt if too few unique solutions are returned. Default is 0.
max_no_good_cuts	The maximum number of no-good cuts to attempt. Default is 0 (disabled).
verbose	Should Gurobi log to console? Default is TRUE.
gurobi_params	A list of optional parameters to be passed to Gurobi (see their documentation online).
use_safe_inverse	Should a regularized inverse be used for the Mahalanobis objective? Default is FALSE.
r	Number of solution vectors to request from the Gurobi pool.
pool_solutions	Number of solutions to request from the Gurobi pool. Defaults to 10 * r.
pool_gap	Relative optimality gap for the pool. Default is 0.2. Use NULL to skip.
pool_gap_abs	Absolute optimality gap for the pool. Default is NULL to skip.
pool_search_mode	Solution pool search mode. Default is 2 for diverse solutions.

mip_gap	Relative MIP gap target (stops when |best-bound - best-incumbent| / |best-incumbent| <= mip_gap). Lower values force deeper search. Default is 1e-4.
mip_gap_abs	Absolute MIP gap target (stops when |best-bound - best-incumbent| <= mip_gap_abs). Lower values force deeper search. Default is 1e-10.
mip_focus	Search focus: 0 (balance), 1 (find feasible solutions), 2 (prove optimality), 3 (bound improvement). Default is 1.
heuristics	Heuristics effort in [0,1] where higher values spend more time on heuristics. Default is 0.2.
cuts	Cut aggressiveness: -1 (automatic), 0 (off), 1 (conservative), 2 (aggressive), 3 (very aggressive). Default is 2.
presolve	Presolve aggressiveness: -1 (automatic), 0 (off), 1 (conservative), 2 (aggressive). Default is 2.

Details

Currently, this method does not return multiple vectors. This will be improved in a later version. If you want this functionality now, use the hacked-up method gurobi_multiple_designs.

Value

A list object which houses the results from Gurobi. Depending on the gurobi_parms, the data within will be different. The most relevant tags are x for the best found solution and objval for the object

Author(s)

Adam Kapelner

Examples

```
## Not run:
if ("gurobi" %in% loadedNamespaces()) {
  set.seed(1)
  X = matrix(rnorm(12), nrow = 6)
  gobj = initGurobiNumericalOptimizationExperimentalDesignObject(
    X,
    r = 2,
    num_cores = 1,
    initial_time_limit_sec = 5,
    verbose = FALSE
  )
  gobj$n
}

## End(Not run)
```

initKarpExperimentalDesignObject
Begin Karp Search

Description

This method creates an object of type karp_experimental_design and will immediately initiate a search through allocation space. Note that the Karp search only works for one covariate (i.e. $p=1$) and the objective "abs_sum_diff".

Usage

```
initKarpExperimentalDesignObject(
  X,
  wait = FALSE,
  balanced = TRUE,
  start = TRUE,
  verbose = TRUE
)
```

Arguments

X	The design matrix with n rows (one for each subject) and p columns (one for each measurement on the subject). This is the design matrix you wish to search for a more karp design.
wait	Should the R terminal hang until all max_designs vectors are found? The deafult is FALSE.
balanced	Should the final vector be balanced? Default and recommended is TRUE.
start	Should we start searching immediately (default is TRUE).
verbose	Should the algorithm emit progress output? Default is TRUE.

Value

An object of type karp_experimental_design_search which can be further operated upon

Author(s)

Adam Kapelner

Examples

```
## Not run:
set.seed(1)
X = matrix(rnorm(10), nrow = 10)
kobj = initKarpExperimentalDesignObject(
  X,
  start = TRUE,
```

```
  wait = TRUE,
  balanced = TRUE,
  verbose = FALSE
)
kobj

## End(Not run)
```

`initOptimalExperimentalDesignObject` *Begin a Search for the Optimal Solution*

Description

This method creates an object of type optimal_experimental_design and will immediately initiate a search through allocation space. Since this search takes exponential time, for most machines, this method is futile beyond 28 samples. You've been warned! For debugging, you can use set `num_cores = 1` to be assured of deterministic output.

Usage

```
initOptimalExperimentalDesignObject(
  X = NULL,
  objective = "mahal_dist",
  Kgram = NULL,
  wait = FALSE,
  start = TRUE,
  num_cores = 1,
  verbose = TRUE,
  use_safe_inverse = FALSE
)
```

Arguments

`X`	The design matrix with n rows (one for each subject) and p columns (one for each measurement on the subject). This is the design matrix you wish to search for a more optimal design.
`objective`	The objective function to use when searching design space. This is a string with valid values `"mahal_dist"` (the default), `"abs_sum_diff"` or `"kernel"`.
`Kgram`	If the `objective = kernel`, this argument is required to be an `n x n` matrix whose entries are the evaluation of the kernel function between subject i and subject j. Default is `NULL`.
`wait`	Should the `R` terminal hang until all `max_designs` vectors are found? The deafult is `FALSE`.
`start`	Should we start searching immediately (default is `TRUE`).
`num_cores`	The number of CPU cores you wish to use during the search. The default is `1`.

verbose Should the algorithm emit progress output? Default is TRUE.

use_safe_inverse
Should a regularized inverse be used for the Mahalanobis objective? Default is FALSE.

Value

An object of type optimal_experimental_design_search which can be further operated upon

Author(s)

Adam Kapelner

Examples

```
## Not run:
set.seed(1)
X = matrix(rnorm(12), nrow = 6)
obj = initOptimalExperimentalDesignObject(
  X,
  objective = "abs_sum_diff",
  num_cores = 1,
  start = TRUE,
  wait = TRUE,
  verbose = FALSE
)
obj

## End(Not run)
```

---

initRerandomizationExperimentalDesignObject

Begin a Rerandomization Search

Description

This method creates an object of type rerandomization_experimental_design and will immediately initiate a search through allocation space for forced-balance designs. For debugging, you can use set the seed parameter and num_cores = 1 to be assured of deterministic output.

Usage

```
initRerandomizationExperimentalDesignObject(
  X = NULL,
  obj_val_cutoff_to_include,
  max_designs = 1000,
  objective = "mahal_dist",
  Kgram = NULL,
```

```
  wait = FALSE,
  start = TRUE,
  num_cores = 1,
  seed = NULL,
  verbose = TRUE,
  use_safe_inverse = FALSE
)
```

Arguments

X	The design matrix with n rows (one for each subject) and p columns (one for each measurement on the subject). This is the design matrix you wish to search for a more optimal design.
obj_val_cutoff_to_include	Only allocation vectors with objective values lower than this threshold will be returned. If the cutoff is infinity, you are doing BCRD and you should use the complete_randomization_with_forced_balanced function instead.
max_designs	The maximum number of designs to be returned. Default is 10,000. Make this large so you can search however long you wish as the search can be stopped at any time by using the stopSearch method
objective	The objective function to use when searching design space. This is a string with valid values "mahal_dist" (the default), "abs_sum_diff" or "kernel".
Kgram	If the objective = kernel, this argument is required to be an n x n matrix whose entries are the evaluation of the kernel function between subject i and subject j. Default is NULL.
wait	Should the R terminal hang until all max_designs vectors are found? The default is FALSE.
start	Should we start searching immediately (default is TRUE).
num_cores	The number of CPU cores you wish to use during the search. The default is 1.
seed	The set to set for deterministic output. This should only be set if num_cores = 1 otherwise the output will not be deterministic. Default is NULL for no seed set.
verbose	Should the algorithm emit progress output? Default is TRUE.
use_safe_inverse	Should a regularized inverse be used for the Mahalanobis objective? Default is FALSE.

Value

An object of type rerandomization_experimental_design_search which can be further operated upon.

Author(s)

Adam Kapelner

Examples

```
## Not run:
set.seed(1)
X = matrix(rnorm(20), nrow = 10)
obj = initRerandomizationExperimentalDesignObject(
  X,
  max_designs = 5,
  num_cores = 1,
  objective = "abs_sum_diff",
  obj_val_cutoff_to_include = Inf,
  start = TRUE,
  wait = TRUE,
  verbose = FALSE
)
obj

## End(Not run)
```

---

optimize_asymmetric_treatment_assignment

Compute Optimal Number of Treatments/Controls

Description

Given a total budget and asymmetric treatment and control costs, calculate the number of treatments and controls that optimize the variance of the estimator. The number of treatments is rounded up by default.

Usage

```
optimize_asymmetric_treatment_assignment(
  c_treatment = NULL,
  c_control = NULL,
  c_total_max = NULL,
  n = NULL
)
```

Arguments

c_treatment	The cost of a treatment assignment. Default is NULL for symmetric costs.
c_control	The cost of a control assignment. Default is NULL for symmetric costs.
c_total_max	The total cost constraint of any allocation. Either this or n must be specified. Default is NULL.
n	The total cost constraint as specified by the total number of subjects. Either this or c_total must be specified. Default is NULL.

Value

A list with three keys: n, nT, nC plus specified arguments

Author(s)

Adam Kapelner

Examples

```
## Not run:
optimize_asymmetric_treatment_assignment(n = 100)
optimize_asymmetric_treatment_assignment(n = 100, c_treatment = 2, c_control = 1)
optimize_asymmetric_treatment_assignment(c_total_max = 50, c_treatment = 2, c_control = 1)

## End(Not run)
```

---

plot.greedy_experimental_design_search

Plots a summary of a greedy search object object

Description

Plots a summary of a greedy search object object

Usage

```
## S3 method for class 'greedy_experimental_design_search'
plot(x, ...)
```

Arguments

x	The greedy search object object to be summarized in the plot
...	Other parameters to pass to the default plot function

Value

An array of order statistics from plot_obj_val_order_statistic as a list element

Author(s)

Adam Kapelner

plot.greedy_multiple_kernel_experimental_design

Plots a summary of a `greedy_multiple_kernel_experimental_design` *object*

Description

Plots a summary of a `greedy_multiple_kernel_experimental_design` object

Usage

```
## S3 method for class 'greedy_multiple_kernel_experimental_design'
plot(x, ...)
```

Arguments

`x`	The `greedy_multiple_kernel_experimental_design` object to be summarized in the plot
`...`	Other parameters to pass to the default plot function

Value

An array of order statistics from plot_obj_val_order_statistic as a list element

Author(s)

Adam Kapelner

plot_obj_val_by_iter *Plots the objective value by iteration*

Description

Plots the objective value by iteration

Usage

```
plot_obj_val_by_iter(res, runs = NULL)
```

Arguments

`res`	Results from a greedy search object
`runs`	A vector of run indices you would like to see plotted (default is to plot the first up to 9)

Author(s)

Adam Kapelner

Examples

```
## Not run:
set.seed(1)
X = matrix(rnorm(20), nrow = 10)
ged = initGreedyExperimentalDesignObject(
  X,
  max_designs = 5,
  num_cores = 1,
  diagnostics = TRUE,
  objective = "abs_sum_diff",
  start = TRUE,
  wait = TRUE,
  verbose = FALSE
)
res = resultsGreedySearch(ged, max_vectors = 2)
plot_obj_val_by_iter(res)

## End(Not run)
```

---

plot_obj_val_order_statistic

Plots an order statistic of the object value as a function of number of searches

---

Description

Plots an order statistic of the object value as a function of number of searches

Usage

```
plot_obj_val_order_statistic(
  obj,
  order_stat = 1,
  skip_every = 5,
  type = "o",
  ...
)
```

Arguments

obj	The greedy search object object whose search history is to be visualized
order_stat	The order statistic that you wish to plot. The default is 1 for the minimum.
skip_every	Plot every nth point. This makes the plot generate much more quickly. The default is 5.

type	The type parameter for plot.
...	Other arguments to be passed to the plot function.

Value

An array of order statistics as a list element

Author(s)

Adam Kapelner

Examples

```
## Not run:
set.seed(1)
X = matrix(rnorm(20), nrow = 10)
ged = initGreedyExperimentalDesignObject(
  X,
  max_designs = 5,
  num_cores = 1,
  objective = "abs_sum_diff",
  start = TRUE,
  wait = TRUE,
  verbose = FALSE
)
plot_obj_val_order_statistic(ged, order_stat = 1, skip_every = 1)

## End(Not run)
```

---

print.binary_match_structure

Prints a summary of a binary_match_structure *object*

Description

Prints a summary of a binary_match_structure object

Usage

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

Arguments

x	The binary_match_structure object to be summarized in the console
...	Other parameters to pass to the default print function

Author(s)

Adam Kapelner

`print.binary_then_greedy_experimental_design` *Prints a summary of a* `binary_then_greedy_experimental_design` *object*

Description

Prints a summary of a `binary_then_greedy_experimental_design` object

Usage

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

Arguments

`x`	The `binary_then_greedy_experimental_design` object to be summarized in the console
`...`	Other parameters to pass to the default print function

Author(s)

Adam Kapelner

`print.binary_then_rerandomization_experimental_design` *Prints a summary of a* `binary_then_rerandomization_experimental_design` *object*

Description

Prints a summary of a `binary_then_rerandomization_experimental_design` object

Usage

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

Arguments

`x`	The `binary_then_rerandomization_experimental_design` object to be summarized in the console
`...`	Other parameters to pass to the default print function

Author(s)

Adam Kapelner

print.greedy_experimental_design_search

Prints a summary of a `greedy_experimental_design_search` *object*

Description

Prints a summary of a `greedy_experimental_design_search` object

Usage

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

Arguments

`x`	The `greedy_experimental_design_search` object to be summarized in the console
`...`	Other parameters to pass to the default print function

Author(s)

Adam Kapelner

print.greedy_multiple_kernel_experimental_design

Prints a summary of a `greedy_multiple_kernel_experimental_design` *object*

Description

Prints a summary of a `greedy_multiple_kernel_experimental_design` object

Usage

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

Arguments

`x`	The `greedy_multiple_kernel_experimental_design` object to be summarized in the console
`...`	Other parameters to pass to the default print function

Author(s)

Adam Kapelner

print.karp_experimental_design_search *Prints a summary of a* karp_experimental_design_search *object*

Description

Prints a summary of a karp_experimental_design_search object

Usage

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

Arguments

x	The karp_experimental_design_search object to be summarized in the console
...	Other parameters to pass to the default print function

Author(s)

Adam Kapelner

print.optimal_experimental_design_search *Prints a summary of a* optimal_experimental_design_search *object*

Description

Prints a summary of a optimal_experimental_design_search object

Usage

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

Arguments

x	The optimal_experimental_design_search object to be summarized in the console
...	Other parameters to pass to the default print function

Author(s)

Adam Kapelner

print.pairwise_matching_experimental_design_search

Prints a summary of a `pairwise_matching_experimental_design_search` *object*

Description

Prints a summary of a `pairwise_matching_experimental_design_search` object

Usage

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

Arguments

`x`	The `pairwise_matching_experimental_design_search` object to be summarized in the console
`...`	Other parameters to pass to the default print function

Author(s)

Adam Kapelner

print.rerandomization_experimental_design_search

Prints a summary of a `rerandomization_experimental_design_search` *object*

Description

Prints a summary of a `rerandomization_experimental_design_search` object

Usage

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

Arguments

`x`	The `rerandomization_experimental_design_search` object to be summarized in the console
`...`	Other parameters to pass to the default print function

Author(s)

Adam Kapelner

`resultsBinaryMatchSearch` *Binary Pair Match Search*

Description

Returns the results (thus far) of the binary pair match design search

Usage

```
resultsBinaryMatchSearch(obj, form = "one_zero")
```

Arguments

`obj`	The `pairwise_matching_experimental_design_search` object that is currently running the search
`form`	Which form should the assignments be in? The default is `one_zero` for 1/0's or `pos_one_min_one` for +1/-1's.

Author(s)

Adam Kapelner

Examples

```
## Not run:
set.seed(1)
X = matrix(rnorm(16), nrow = 8)
bms = computeBinaryMatchStructure(X)
bm = initBinaryMatchExperimentalDesignSearchObject(
  bms,
  max_designs = 4,
  num_cores = 1,
  start = TRUE,
  wait = TRUE,
  seed = 1,
  verbose = FALSE
)
res = resultsBinaryMatchSearch(bm, form = "one_zero")
dim(res)

## End(Not run)
```

`resultsBinaryMatchThenGreedySearch` *Returns unique allocation vectors that are binary matched*

Description

Returns unique allocation vectors that are binary matched

Usage

```
resultsBinaryMatchThenGreedySearch(
  obj,
  num_vectors = NULL,
  compute_obj_vals = FALSE,
  form = "one_zero",
  use_safe_inverse = FALSE
)
```

Arguments

`obj`	The `binary_then_greedy_experimental_design` object where the pairs are computed.
`num_vectors`	How many random allocation vectors you wish to return. The default is `NULL` indicating you want all of them.
`compute_obj_vals`	Should we compute all the objective values for each allocation? Default is `FALSE`.
`form`	Which form should it be in? The default is `one_zero` for 1/0's or `pos_one_min_one` for +1/-1's.
`use_safe_inverse`	Should a regularized inverse be used for the Mahalanobis objective? Default is `FALSE`.

Author(s)

Adam Kapelner

Examples

```
## Not run:
set.seed(1)
X = matrix(rnorm(16), nrow = 8)
obj = initBinaryMatchFollowedByGreedyExperimentalDesignSearchObject(
  X,
  max_designs = 4,
  num_cores = 1,
  objective = "abs_sum_diff",
```

```
  start = TRUE,
  wait = TRUE,
  verbose = FALSE
)
res = resultsBinaryMatchThenGreedySearch(obj, num_vectors = 3, form = "one_zero")
dim(res$indicTs)

## End(Not run)
```

`resultsBinaryMatchThenRerandomizationSearch` *Returns unique allocation vectors that are binary matched*

Description

Returns unique allocation vectors that are binary matched

Usage

```
resultsBinaryMatchThenRerandomizationSearch(
  obj,
  num_vectors = NULL,
  compute_obj_vals = FALSE,
  form = "one_zero",
  use_safe_inverse = FALSE
)
```

Arguments

`obj`	The `binary_then_greedy_experimental_design` object where the pairs are computed.
`num_vectors`	How many random allocation vectors you wish to return. The default is `NULL` indicating you want all of them.
`compute_obj_vals`	Should we compute all the objective values for each allocation? Default is `FALSE`.
`form`	Which form should it be in? The default is `one_zero` for 1/0's or `pos_one_min_one` for +1/-1's.
`use_safe_inverse`	Should a regularized inverse be used for the Mahalanobis objective? Default is `FALSE`.

Author(s)

Adam Kapelner

Examples

```
## Not run:
set.seed(1)
X = matrix(rnorm(16), nrow = 8)
obj = initBinaryMatchFollowedByRerandomizationDesignSearchObject(
  X,
  max_designs = 4,
  num_cores = 1,
  objective = "abs_sum_diff",
  obj_val_cutoff_to_include = Inf,
  start = TRUE,
  wait = TRUE,
  verbose = FALSE
)
res = resultsBinaryMatchThenRerandomizationSearch(obj, num_vectors = 3, form = "one_zero")
dim(res$indicTs)

## End(Not run)
```

`resultsGreedySearch` *Returns the results (thus far) of the greedy design search*

Description

Returns the results (thus far) of the greedy design search

Usage

```
resultsGreedySearch(obj, max_vectors = 9, form = "one_zero")
```

Arguments

`obj`	The `greedy_experimental_design` object that is currently running the search
`max_vectors`	The number of design vectors you wish to return. `NULL` returns all of them. This is not recommended as returning over 1,000 vectors is time-intensive. The default is 9.
`form`	Which form should it be in? The default is `one_zero` for 1/0's or `pos_one_min_one` for +1/-1's.

Author(s)

Adam Kapelner

Examples

```
## Not run:
set.seed(1)
X = matrix(rnorm(20), nrow = 10)
ged = initGreedyExperimentalDesignObject(
  X,
  max_designs = 5,
  num_cores = 1,
  objective = "abs_sum_diff",
  start = TRUE,
  wait = TRUE,
  verbose = FALSE
)
res = resultsGreedySearch(ged, max_vectors = 2)
res$obj_vals

## End(Not run)
```

---

resultsGurobiNumericalOptimizeSearch

Query the Gurobi Results

Description

Returns the results (thus far) of the Gurobi numerical optimization design search

Usage

```
resultsGurobiNumericalOptimizeSearch(obj)
```

Arguments

obj	The gurobi_numerical_optimization_experimental_design_search object that is currently running the search

Author(s)

Adam Kapelner

Examples

```
## Not run:
if ("gurobi" %in% loadedNamespaces()) {
  set.seed(1)
  X = matrix(rnorm(12), nrow = 6)
  gobj = initGurobiNumericalOptimizationExperimentalDesignObject(
    X,
    r = 2,
    num_cores = 1,
```

```
    initial_time_limit_sec = 5,
    verbose = FALSE
  )
  res = resultsGurobiNumericalOptimizeSearch(gobj)
  res$obj_vals
}

## End(Not run)
```

`resultsKarpSearch` *Returns the results (thus far) of the karp design search*

Description

Returns the results (thus far) of the karp design search

Usage

```
resultsKarpSearch(obj)
```

Arguments

`obj`	The `karp_experimental_design` object that is currently running the search

Author(s)

Adam Kapelner

Examples

```
## Not run:
set.seed(1)
X = matrix(rnorm(10), nrow = 10)
kobj = initKarpExperimentalDesignObject(
  X,
  start = TRUE,
  wait = TRUE,
  balanced = TRUE,
  verbose = FALSE
)
res = resultsKarpSearch(kobj)
res$obj_val

## End(Not run)
```

`resultsMultipleKernelGreedySearch` *Returns the results (thus far) of the greedy design search for multiple kernels*

Description

Returns the results (thus far) of the greedy design search for multiple kernels

Usage

```
resultsMultipleKernelGreedySearch(obj, max_vectors = 9, form = "one_zero")
```

Arguments

`obj`	The `greedy_multiple_kernel_experimental_design` object that is currently running the search
`max_vectors`	The number of design vectors you wish to return. `NULL` returns all of them. This is not recommended as returning over 1,000 vectors is time-intensive. The default is 9.
`form`	Which form should it be in? The default is `one_zero` for 1/0's or `pos_one_min_one` for +1/-1's.

Author(s)

Adam Kapelner

Examples

```
## Not run:
set.seed(1)
X = matrix(rnorm(20), nrow = 10)
mk = initGreedyMultipleKernelExperimentalDesignObject(
  X,
  max_designs = 4,
  kernel_pre_num_designs = 4,
  num_cores = 1,
  kernel_names = c("mahalanobis", "gaussian"),
  start = TRUE,
  wait = TRUE,
  verbose = FALSE
)
res = resultsMultipleKernelGreedySearch(mk, max_vectors = 2, form = "one_zero")
res$obj_vals

## End(Not run)
```

`resultsOptimalSearch` *Returns the results (thus far) of the optimal design search*

Description

Returns the results (thus far) of the optimal design search

Usage

```
resultsOptimalSearch(obj, num_vectors = 2, form = "one_zero")
```

Arguments

`obj`	The `optimal_experimental_design` object that is currently running the search
`num_vectors`	How many allocation vectors you wish to return. The default is 1 meaning the best vector. If `Inf`, it means all vectors.
`form`	Which form should it be in? The default is `one_zero` for 1/0's or `pos_one_min_one` for +1/-1's.

Author(s)

Adam Kapelner

Examples

```
## Not run:
set.seed(1)
X = matrix(rnorm(12), nrow = 6)
obj = initOptimalExperimentalDesignObject(
  X,
  objective = "abs_sum_diff",
  num_cores = 1,
  start = TRUE,
  wait = TRUE,
  verbose = FALSE
)
res = resultsOptimalSearch(obj, num_vectors = 2, form = "one_zero")
res$opt_obj_val

## End(Not run)
```

`resultsRerandomizationSearch` *Returns the results (thus far) of the rerandomization design search*

Description

Returns the results (thus far) of the rerandomization design search

Usage

```
resultsRerandomizationSearch(
  obj,
  include_assignments = FALSE,
  form = "one_zero"
)
```

Arguments

`obj`	The `rerandomization_experimental_design` object that is currently running the search
`include_assignments`	Do we include the assignments (takes time) and default is `FALSE`.
`form`	Which form should the assignments be in? The default is `one_zero` for 1/0's or `pos_one_min_one` for +1/-1's.

Author(s)

Adam Kapelner

Examples

```
## Not run:
set.seed(1)
X = matrix(rnorm(20), nrow = 10)
obj = initRerandomizationExperimentalDesignObject(
  X,
  max_designs = 5,
  num_cores = 1,
  objective = "abs_sum_diff",
  obj_val_cutoff_to_include = Inf,
  start = TRUE,
  wait = TRUE,
  verbose = FALSE
)
res = resultsRerandomizationSearch(obj, include_assignments = TRUE, form = "one_zero")
dim(res$ending_indicTs)

## End(Not run)
```

safe_cov_inverse *Computes a numerically stable inverse of a covariance matrix*

Description

Computes a numerically stable inverse of a covariance matrix

Usage

```
safe_cov_inverse(X, ridge = 1e-08, max_ridge_steps = 6)
```

Arguments

X	The n x p design matrix
ridge	Initial ridge penalty added to the diagonal
max_ridge_steps	Maximum number of ridge escalation attempts

Value

The inverse covariance matrix

Author(s)

Adam Kapelner

Examples

```
## Not run:
X = matrix(rnorm(20), nrow = 10)
Sinv = safe_cov_inverse(X)
dim(Sinv)

## End(Not run)
```

searchTimeElapsed *Returns the amount of time elapsed*

Description

Returns the amount of time elapsed

Usage

```
searchTimeElapsed(obj)
```

Arguments

obj	The experimental_design object that is currently running the search

Author(s)

Adam Kapelner

Examples

```
## Not run:
set.seed(1)
X = matrix(rnorm(20), nrow = 10)
ged = initGreedyExperimentalDesignObject(
  X,
  max_designs = 1,
  num_cores = 1,
  start = TRUE,
  wait = TRUE,
  objective = "abs_sum_diff",
  verbose = FALSE
)
searchTimeElapsed(ged)

## End(Not run)
```

---

shuffle_cpp_wrap *Shuffles a vector rapidly*

Description

Shuffles a vector rapidly

Usage

```
shuffle_cpp_wrap(w, seed = NA_integer_)
```

Arguments

w	The vector to be shuffled
seed	Optional integer seed; use NA to draw from the system clock

Value

The vector with elements shuffled

Author(s)

Adam Kapelner

Examples

```
## Not run:
shuffle_cpp_wrap(1:5, seed = 1)

## End(Not run)
```

`standardize_data_matrix` *Standardizes the columns of a data matrix.*

Description

Standardizes the columns of a data matrix.

Usage

```
standardize_data_matrix(X)
```

Arguments

`X`	The n x p design matrix

Value

The n x p design matrix with columns standardized

Author(s)

Adam Kapelner

Examples

```
## Not run:
X = matrix(rnorm(12), nrow = 6)
Xstd = standardize_data_matrix(X)
colMeans(Xstd)

## End(Not run)
```

startSearch *Starts the parallelized greedy design search.*

Description

Once begun, this function cannot be run again.

Usage

```
startSearch(obj)
```

Arguments

obj	The experimental_design object that will be running the search

Author(s)

Adam Kapelner

Examples

```
## Not run:
set.seed(1)
X = matrix(rnorm(20), nrow = 10)
ged = initGreedyExperimentalDesignObject(
  X,
  max_designs = 3,
  num_cores = 1,
  start = FALSE,
  wait = FALSE,
  objective = "abs_sum_diff",
  verbose = FALSE
)
startSearch(ged)
stopSearch(ged)

## End(Not run)
```

stopSearch *Stops the parallelized greedy design search.*

Description

Once stopped, it cannot be restarted.

Usage

```
stopSearch(obj)
```

Arguments

obj	The experimental_design object that is currently running the search

Author(s)

Adam Kapelner

Examples

```
## Not run:
set.seed(1)
X = matrix(rnorm(20), nrow = 10)
ged = initGreedyExperimentalDesignObject(
  X,
  max_designs = 3,
  num_cores = 1,
  start = TRUE,
  wait = FALSE,
  objective = "abs_sum_diff",
  verbose = FALSE
)
stopSearch(ged)

## End(Not run)
```

---

summary.binary_match_structure *Prints a summary of a* binary_match_structure *object*

Description

Prints a summary of a binary_match_structure object

Usage

```
## S3 method for class 'binary_match_structure'
summary(object, ...)
```

Arguments

object	The binary_match_structure object to be summarized in the console
...	Other parameters to pass to the default summary function

Author(s)

Adam Kapelner

`summary.binary_then_greedy_experimental_design` *Prints a summary of a* `binary_then_greedy_experimental_design` *object*

Description

Prints a summary of a `binary_then_greedy_experimental_design` object

Usage

```
## S3 method for class 'binary_then_greedy_experimental_design'
summary(object, ...)
```

Arguments

`object`	The `binary_then_greedy_experimental_design` object to be summarized in the console
`...`	Other parameters to pass to the default summary function

Author(s)

Adam Kapelner

`summary.binary_then_rerandomization_experimental_design` *Prints a summary of a* `binary_then_rerandomization_experimental_design` *object*

Description

Prints a summary of a `binary_then_rerandomization_experimental_design` object

Usage

```
## S3 method for class 'binary_then_rerandomization_experimental_design'
summary(object, ...)
```

Arguments

`object`	The `binary_then_rerandomization_experimental_design` object to be summarized in the console
`...`	Other parameters to pass to the default summary function

Author(s)

Adam Kapelner

summary.greedy_experimental_design_search *Prints a summary of a* greedy_experimental_design_search *object*

Description

Prints a summary of a greedy_experimental_design_search object

Usage

```
## S3 method for class 'greedy_experimental_design_search'
summary(object, ...)
```

Arguments

object	The greedy_experimental_design_search object to be summarized in the console
...	Other parameters to pass to the default summary function

Author(s)

Adam Kapelner

summary.greedy_multiple_kernel_experimental_design *Prints a summary of a* greedy_multiple_kernel_experimental_design *object*

Description

Prints a summary of a greedy_multiple_kernel_experimental_design object

Usage

```
## S3 method for class 'greedy_multiple_kernel_experimental_design'
summary(object, ...)
```

Arguments

object	The greedy_multiple_kernel_experimental_design object to be summarized in the console
...	Other parameters to pass to the default summary function

Author(s)

Adam Kapelner

`summary.karp_experimental_design_search`
Prints a summary of a `karp_experimental_design_search` *object*

Description

Prints a summary of a `karp_experimental_design_search` object

Usage

```
## S3 method for class 'karp_experimental_design_search'
summary(object, ...)
```

Arguments

`object`	The `karp_experimental_design_search` object to be summarized in the console
`...`	Other parameters to pass to the default summary function

Author(s)

Adam Kapelner

`summary.optimal_experimental_design_search`
Prints a summary of a `optimal_experimental_design_search` *object*

Description

Prints a summary of a `optimal_experimental_design_search` object

Usage

```
## S3 method for class 'optimal_experimental_design_search'
summary(object, ...)
```

Arguments

`object`	The `optimal_experimental_design_search` object to be summarized in the console
`...`	Other parameters to pass to the default summary function

Author(s)

Adam Kapelner

summary.pairwise_matching_experimental_design_search *Prints a summary of a* pairwise_matching_experimental_design_search *object*

Description

Prints a summary of a pairwise_matching_experimental_design_search object

Usage

```
## S3 method for class 'pairwise_matching_experimental_design_search'
summary(object, ...)
```

Arguments

object	The pairwise_matching_experimental_design_search object to be summarized in the console
...	Other parameters to pass to the default summary function

Author(s)

Adam Kapelner

summary.rerandomization_experimental_design_search *Prints a summary of a* rerandomization_experimental_design_search *object*

Description

Prints a summary of a rerandomization_experimental_design_search object

Usage

```
## S3 method for class 'rerandomization_experimental_design_search'
summary(object, ...)
```

Arguments

object	The rerandomization_experimental_design_search object to be summarized in the console
...	Other parameters to pass to the default summary function

Author(s)

Adam Kapelner

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