

Package ‘ROOT’

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Title ROOT (Rashomon Set of Optimal Trees)

Version 0.0.0.9000

Description ROOT (Rashomon Set of Optimal Trees) is a general framework for globally optimizing user-specified objective functionals over interpretable binary weight functions represented as sparse decision trees. It searches over candidate trees to construct a Rashomon set of near-optimal solutions and derives a summary tree highlighting stable patterns in the optimized weights. ROOT includes a built-in generalizability mode for identifying subgroups in trial settings for transportability analyses.

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characterize_tree	<i>Fit a shallow decision tree to characterize learned weights w</i>
--------------------------	--

Description

Trains a classification tree on the covariates X to predict the binary membership w . This provides an interpretable summary of how the weighted subgroup can be distinguished by X .

Usage

```
characterize_tree(X, w, max_depth = 3)
```

Arguments

<code>X</code>	A <code>data.frame</code> of covariates.
<code>w</code>	A vector of length <code>nrow(X)</code> that is binary. Accepts 0 and 1 or a factor with two levels.
<code>max_depth</code>	An <code>integer(1)</code> giving the maximum tree depth. Default is 3.

Details

The tree uses the Gini index for classification and no pruning with complexity parameter `cp = 0`. Depth control is through `max_depth`. If w is not a factor it is converted internally. The resulting rules indicate which covariates and splits separate the two classes defined by w .

Value

An `rpart` object that represents the fitted classification tree.

characterizing_underrep*Characterize under-represented subgroups (wrapper around ROOT)*

Description

A convenience wrapper around ROOT() for under-representation analyses. It takes a single data set and calls ROOT() either in generalizability_path mode (when generalizability_path = TRUE) or in general optimization mode (generalizability_path = FALSE).

Usage

```
characterizing_underrep(
  data,
  global_objective_fn = NULL,
  generalizability_path = FALSE,
  leaf_proba = 0.25,
  seed = 123,
  num_trees = 10,
  vote_threshold = 2/3,
  explore_proba = 0.05,
  feature_est = "Ridge",
  feature_est_args = list(),
  top_k_trees = FALSE,
  k = 10,
  cutoff = "baseline",
  verbose = FALSE
)
```

Arguments

<code>data</code>	A <code>data.frame</code> containing covariates and, in generalizability_path mode, also columns Y, Tr, and S.
<code>global_objective_fn</code>	function with signature <code>function(D) -> numeric</code> scoring the entire state and minimized by ROOT. If <code>NULL</code> , a default variance-based objective is used (see <code>objective_default()</code>).
<code>generalizability_path</code>	Logical. If <code>TRUE</code> , calls ROOT() with <code>generalizability_path = TRUE</code> and expects columns Y, Tr, and S in <code>data</code> . If <code>FALSE</code> , calls ROOT() in general optimization mode. Default <code>FALSE</code> .
<code>leaf_proba</code>	A <code>numeric(1)</code> tuning parameter that increases the chance a node stops splitting by selecting a synthetic "leaf" feature. Internally, the probability of choosing "leaf" is <code>leaf_proba / (1 + leaf_proba)</code> (assuming the covariate probabilities sum to 1). Default <code>0.25</code> .
<code>seed</code>	Random seed for reproducibility.
<code>num_trees</code>	Number of trees to grow.
<code>vote_threshold</code>	Majority vote threshold used for <code>w_opt</code> .
<code>explore_proba</code>	Exploration probability in tree growth.

feature_est Either "Ridge", "GBM", or a custom feature importance function.
feature_est_args List of extra arguments passed to **feature_est** when it is a function.
top_k_trees Logical; if TRUE, uses top k trees by objective, otherwise a cutoff rule.
k Number of trees when **top_k_trees** = TRUE.
cutoff Numeric or "baseline" Rashomon cutoff.
verbose Logical; if TRUE, prints progress/estimands from ROOT().

Details

When **generalizability_path** = TRUE, data must contain standardized columns:

- Y: outcome,
- Tr: treatment indicator (0/1),
- S: sample indicator (1 = trial, 0 = target).

Value

A characterizing_underrep S3 object (a list) with:

root The ROOT object returned by ROOT().
combined The input data (for continuity with prior API).
leaf_summary Data frame of terminal node rules and labels, or NULL.

Examples

```
## Not run:
char.output = characterizing_underrep(diabetes_data,generalizability_path = TRUE, seed = 123)

## End(Not run)
```

choose_feature *Randomly choose a split feature based on provided probabilities*

Description

Selects one feature name at random according to a probability vector that may include a special "leaf" entry.

Usage

```
choose_feature(split_feature, depth)
```

Arguments

split_feature A named numeric vector of feature selection probabilities. Names correspond to feature identifiers and may include "leaf".
depth An integer(1) giving the current tree depth. Present for parity with the Python version and does not change probabilities here.

Value

A character(1) which is the chosen feature name or "leaf".

Note

The factor $2^{(0\cdot\text{depth}/4)}$ present in the code equals 1 and does not change the first element weight. All probabilities are normalized to sum to 1 before sampling.

compute_transport_scores

Compute transport influence scores for generalization mode

Description

Internal helper used in the generalization path to construct glm-based, IPW-style scores for transporting trial effects to a target population without double machine learning.

Usage

```
compute_transport_scores(data, outcome, treatment, sample)
```

Arguments

data	A <code>data.frame</code> containing the outcome, treatment indicator, sample indicator, and covariates. All columns except <code>outcome</code> , <code>treatment</code> , and <code>sample</code> are treated as covariates X and must be suitable for use in <code>stats::glm()</code> with <code>family = binomial()</code> .
outcome	A length-1 character string giving the name of the outcome column in <code>data</code> . Must be numeric (e.g., a continuous outcome or a 0/1 indicator).
treatment	A length-1 character string giving the name of the treatment indicator column in <code>data</code> . Must be coded 0/1.
sample	A length-1 character string giving the name of the sample indicator column in <code>data</code> , with 1 for trial rows and 0 for target rows.

Details

The function treats `data` as a stacked dataset with a sample indicator S (`sample`) taking value 1 in the randomized trial and 0 in the target sample. It proceeds in three steps:

1. Fit a sampling model $P(S = 1|X)$ using logistic regression on all rows of `data`.
2. Within the trial subset $S = 1$, fit a treatment model $P(T = 1|X, S = 1)$ using logistic regression.
3. For each row, form the density ratio $r(X) = P(S = 0|X)/P(S = 1|X)$ and compute a Horvitz-Thompson-style transported score

$$v(X, T, Y) = r(X) \left[\frac{TY}{e(X)} - \frac{(1-T)Y}{1-e(X)} \right],$$

where $e(X) = P(T = 1|X, S = 1)$.

The resulting score vector `v` and its squared version `vsq` can be used as pseudo-outcomes for tree-based search over transported treatment effects.

Value

A list with two numeric vectors of length nrow(data):

- v The transported influence-style score.
- vsq The element-wise square of v, i.e., v^2 .

diabetes_data*Simulated diabetes dataset for examples***Description**

A toy dataset for illustrating ROOT examples and tests.

Usage

```
data(diabetes_data)
```

Format

A `data.frame` with one row per individual and the columns:

- Age45** Indicator in 0/1: age ≥ 45 .
- DietYes** Indicator in 0/1: on a diet program.
- Race_Black** Indicator in 0/1: race is Black.
- S** Sample indicator in 0/1: 1 means RCT or source, 0 means target.
- Sex_Male** Indicator in 0/1: male.
- Tr** Treatment assignment in 0/1.
- Y** Observed outcome (numeric or 0/1).

Abbreviations

RCT means randomized clinical trial. ATE means Average Treatment Effect.

gen_S*Generate sample indicator S drawn from a Bernoulli distribution***Description**

Generates a binary sample inclusion indicator S for each observation, using a logistic model influenced by a rectangular region in X0 and X1. In the ROOT generalizability path, S = 1 is interpreted as belonging to the trial sample and S = 0 as belonging to the target sample.

Usage

```
gen_S(X, seed = NULL)
```

Arguments

- X A `data.frame` of covariates that contains at least X_0 and X_1 .
 seed Optional `numeric(1)` seed. If `NULL` no seed is set.

Details

The inclusion probability is $p = plogis(a)$ where $a = 0.25 - 2 * I(X_0 \text{in}(0.5, 1) \text{and} X_1 \text{in}(0.5, 1))$.

Value

A `data.frame` with one column S of values in 0 or 1.

gen_T

Generate treatment indicator Tr drawn from a Bernoulli distribution

Description

Assigns treatment indicators combining a randomized design for $S == 1$ (trial sample) and an observational assignment driven by X_0 for $S == 0$ (target sample).

Usage

```
gen_T(X, S, seed = NULL)
```

Arguments

- X A `data.frame` of covariates.
 S A `data.frame` with column S in 0 or 1. This should be the output of `gen_S()`.
 seed Optional `numeric(1)` seed. If `NULL` no seed is set.

Details

For $S == 1$ the treatment probability is 0.5. For $S == 0$ the treatment probability is `plogis(X_0)`. The combined probability is $pi_i = S_i * 0.5 + (1 - S_i) * plogis(X_0_i)$.

Value

A list with:

- Tr `data.frame` with one column Tr in 0 or 1.
 pi `numeric` vector of assignment probabilities per observation.

gen_XY	<i>Generate covariates X and potential outcomes (Y0, Y1)</i>
--------	--

Description

Simulates a regression problem based on Friedman number one and defines a heterogeneous treatment effect. Uses `mlbench.friedman1` to generate feature matrix `X` and a baseline outcome `Y0`. The treatment potential outcome `Y1` is defined as $Y1 = Y0 + \log(Y0 + 1)$.

Usage

```
gen_XY(n = 1000, seed = NULL)
```

Arguments

- | | |
|-------------------|--|
| <code>n</code> | A numeric(1) or integer(1) giving the number of observations to simulate. Must be positive. |
| <code>seed</code> | Optional numeric(1) for the random number generator seed. If <code>NULL</code> no seed is set. |

Details

The `mlbench.friedman1` generator creates ten continuous features and a baseline outcome `Y0` with additive noise. The potential outcome `Y1` adds a nonlinear term $\log(Y0 + 1)$ to `Y0`.

Value

A list with two components:

- | | |
|----------------|---|
| <code>X</code> | <code>data.frame</code> of simulated covariates with columns <code>X0, X1, ...</code> |
| <code>Y</code> | <code>data.frame</code> with columns <code>Y0</code> and <code>Y1</code> . |

get_data	<i>Convenience wrapper to generate a full simulated dataset</i>
----------	---

Description

Generates covariates, sample inclusion, treatment assignments, and observed outcomes for a given sample size by calling `gen_XY()`, `gen_S()`, and `gen_T()`. The returned data element is ready for use with `ROOT(data = ..., generalizability_path = TRUE)`, since it contains columns `Y`, `Tr`, and `S` in the expected format.

Usage

```
get_data(n = 1000, seed = NULL)
```

Arguments

- | | |
|-------------------|---|
| <code>n</code> | A numeric(1) or integer(1) sample size. |
| <code>seed</code> | Optional numeric(1) base seed. If provided, internal generators use simple offsets for reproducibility. |

Value

A list with:

data	data.frame of length n with covariates X0, X1, ..., observed outcome Y, sample indicator S, and treatment indicator Tr. This is directly usable by ROOT in generalizability_path = TRUE mode.
Y	data.frame of potential outcomes with columns Y0 and Y1.

Examples

```
sim <- get_data(n = 100, seed = 599)
dim(sim$data)
head(sim$data$Y)
head(sim$Y)
```

loss_from_objective *Backward and fast path micro evaluator adaptor*

Description

Wraps a global objective `global_objective_fn(D)` into a splitter compatible loss function `loss_fn(val, indices, D)` by calling `objective_if` on a temporary copy of D.

Usage

```
loss_from_objective(global_objective_fn)
```

Arguments

<code>global_objective_fn</code>	A function with signature <code>function(D) -> numeric</code> that returns a scalar to be minimized. For example <code>objective_default</code> .
----------------------------------	--

Value

A function `loss_fn(val, indices, D)` suitable for use in `ROOT` and `split_node`. It sets `w = val` on `indices` without mutation of the original D and then returns `global_objective_fn(D)`.

midpoint *Compute the midpoint of a numeric vector*

Description

Calculates the midpoint defined as $(\max(X) + \min(X))/2$ while ignoring any NA values in X.

Usage

```
midpoint(X)
```

Arguments

`X` A numeric vector.

Value

A numeric(1) giving the midpoint of the finite values in `X`. Returns `NA_real_` when `X` is empty or has no finite values.

<code>objective_default</code>	<i>Generic objective interface</i>
--------------------------------	------------------------------------

Description

Default objective that serves as a proxy for standard error in weighted transported average treatment effect (WTATE) and population average treatment effect (PATE).

Usage

```
objective_default(D)
```

Arguments

`D` A `data.frame` with at least numeric columns `vsq` and `w`.

Details

Computes `sqrt(sum(vsq_i * w_i)) / (sum(w_i))^2`. Requires columns `vsq` and `w` in `D`. The goal is to minimize the value. Supply your own function(`D`) -> `numeric` to use a different objective.

Value

A numeric(1) objective value. Returns `Inf` when undefined.

<code>objective_if</code>	<i>Helper to evaluate the objective after a hypothetical local change</i>
---------------------------	---

Description

Evaluates `global_objective_fn` on a temporary copy of `D` after setting `w = val` for the rows selected by `indices`.

Usage

```
objective_if(val, indices, D, global_objective_fn)
```

Arguments

val	A numeric(1) that must be either 0 or 1.
indices	An integer vector of row indices or a character vector of row names that receive val.
D	A data.frame used by global_objective_fn. Must contain columns w and vsq.
global_objective_fn	A function with signature function(D) -> numeric.

Value

A numeric(1) objective value after the hypothetical change.

plot.characterizing_underrep

Plot Under represented Population Characterization

Description

Visualizes the decision tree derived from the ROOT analysis. Highlights which subgroups are represented where $w = 1$ versus underrepresented where $w = 0$ in generalization mode, or simply $w(x)$ in $\{0, 1\}$ in general optimization mode.

Usage

```
## S3 method for class 'characterizing_underrep'
plot(
  x,
  main = "Subgroup Characterization from Final Characterized Tree from Rashomon Set",
  cex.main = 1.2,
  ...
)
```

Arguments

x	A characterizing_underrep S3 object with x\$root\$f present as an rpart object for the summary or characterization tree.
main	Character string for the plot title. Default is "Underrepresented Population Characterization".
cex.main	Numeric scaling factor for the title text size. Default is 1.2.
...	Additional arguments passed to rpart.plot::prp().

Value

NULL. The plot is drawn to the active graphics device.

Examples

```
## Not run:
char.output = characterizing_underrep(diabetes_data, generalizability_path = TRUE, seed = 123)
plot(char.output)
plot(char.output, main = "My Custom Title", cex.main = 1.5)

## End(Not run)
```

plot.ROOT

Plot the ROOT summary tree

Description

Visualizes the decision tree that characterizes the weighted subgroup (the weight function $w(d)$ in $\{0, 1\}$) identified by `ROOT()`, using `rpart.plot::prp()`.

Usage

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

Arguments

- x A "ROOT" S3 object returned by `ROOT()` with `x$f` an `rpart` object representing the summary / characterization tree.
- ... Additional arguments passed to `rpart.plot::prp()`.

Value

No return value; the plot is drawn to the active graphics device.

Examples

```
## Not run:
ROOT.output = ROOT(diabetes_data, generalizability_path = TRUE, seed = 123)
plot(ROOT.output)

## End(Not run)
```

reduce_weight

Reduce a feature selection weight by one half and renormalize

Description

Lowers the probability weight of a given feature by one half and then renormalizes the full vector to sum to one.

Usage

```
reduce_weight(fj, split_feature)
```

Arguments

- `fj` A character(1) feature name that must be present in `names(split_feature)`.
`split_feature` A named numeric vector of probabilities for features as used in splitting.

Details

This is used when a feature split was rejected. The feature probability is halved to reduce the chance of immediate reselection which encourages exploration of other features. If `fj` equals "leaf" its weight is also halved.

Value

A numeric vector of the same length as `split_feature` that sums to 1.

ROOT

Ensemble of weighted trees for general optimization and Rashomon selection

Description

Builds multiple weighted trees, then identifies a "Rashomon set" of top-performing trees and aggregates their weight assignments by majority vote.

Usage

```
ROOT(
  data,
  global_objective_fn = NULL,
  generalizability_path = FALSE,
  leaf_proba = 0.25,
  seed = NULL,
  num_trees = 10,
  vote_threshold = 2/3,
  explore_proba = 0.05,
  feature_est = "Ridge",
  feature_est_args = list(),
  top_k_trees = FALSE,
  k = 10,
  cutoff = "baseline",
  verbose = FALSE
)
```

Arguments

- `data` A data.frame containing the dataset.
 In *general optimization* mode (`generalizability_path = FALSE`), `data` can be any set of covariates and auxiliary columns. The user supplies a `global_objective_fn` that takes a data frame with a column `w` and returns a scalar loss.
 In *generalizability_path* mode (`generalizability_path = TRUE`), `data` must contain columns "Y" (outcome), "Tr" (treatment indicator, 0/1), and "S" (sample indicator, 1 = trial, 0 = target). ROOT internally constructs transportability scores and, if no custom objective is given, uses a default variance-based loss.

<code>global_objective_fn</code>	A function with signature <code>function(D) -> numeric</code> scoring the entire state and minimized by ROOT. If <code>NULL</code> , a default variance-based objective is used (see <code>objective_default()</code>).
<code>generalizability_path</code>	<code>Logical(1)</code> . If <code>TRUE</code> , use the built-in transportability objective based on <code>(Y, Tr, S)</code> . If <code>FALSE</code> , treat data as arbitrary and rely on <code>global_objective_fn</code> . Default <code>FALSE</code> .
<code>leaf_proba</code>	A numeric tuning parameter that increases the chance a node stops splitting by selecting a synthetic "leaf" feature. Internally, the probability of choosing "leaf" is <code>leaf_proba / (1 + leaf_proba)</code> (assuming the covariate probabilities sum to 1). Default <code>0.25</code> .
<code>seed</code>	An optional numeric seed for reproducibility.
<code>num_trees</code>	An integer number of trees to grow. Default <code>10</code> .
<code>vote_threshold</code>	A numeric in <code>(0.5, 1]</code> giving the majority vote threshold for final <code>w = 1</code> . Default <code>2/3</code> .
<code>explore_proba</code>	A numeric giving the exploration probability at leaves. Default <code>0.05</code> .
<code>feature_est</code>	Either a character(1) in <code>c("Ridge", "GBM")</code> or a function(<code>X, y, ...</code>) returning a named nonnegative numeric vector of importances with names matching columns of <code>X</code> . Used only to bias which covariates are chosen for splitting. If it fails, ROOT falls back to uniform feature sampling with a warning.
<code>feature_est_args</code>	A list of additional arguments passed to a user supplied <code>feature_est</code> function.
<code>top_k_trees</code>	<code>Logical(1)</code> . If <code>TRUE</code> , select top <code>k</code> trees by objective; otherwise use <code>cutoff</code> . Default <code>FALSE</code> .
<code>k</code>	An integer giving the number of top trees when <code>top_k_trees = TRUE</code> . Default <code>10</code> .
<code>cutoff</code>	A numeric or "baseline". Used as the Rashomon cutoff when <code>top_k_trees = FALSE</code> . "baseline" uses the objective at <code>w = 1</code> (all weights equal to 1).
<code>verbose</code>	<code>Logical(1)</code> . If <code>TRUE</code> , prints unweighted and (when available) weighted estimates and their standard errors in <code>generalizability_path</code> mode.

Details

The function is framed as a general functional optimization routine: given data D_n and a loss $L(w, D_n)$, ROOT searches over interpretable tree-based weight functions $w(d)$ in $\{\emptyset, 1\}$.

Value

An object of class "ROOT" (a list) with elements:

- `D_rash`: data frame with Rashomon-set votes and `w_opt`.
- `D_forest`: data frame with forest-level working columns.
- `w_forest`: list of per-tree results from `split_node()`.
- `rashomon_set`: indices of selected trees.
- `global_objective_fn`: the objective function used.
- `f`: summary classifier (e.g., rpart tree) or `NULL`.
- `testing_data`: data frame aligned to rows used to compute scores.
- `estimate`: (only if `generalizability_path = TRUE`) list with unweighted and weighted estimands, SEs, and a note about the SE.
- `generalizability_path`: logical flag.

Examples

```
## Not run:
ROOT.output = ROOT(diabetes_data,generalizability_path = TRUE, seed = 123)

## End(Not run)
```

split_node

Recursive split builder for weighted tree

Description

Recursively builds a weighted decision tree to optimize a global objective, using an exploration versus exploitation choice at leaves. Internal and used by ROOT().

Usage

```
split_node(
  split_feature,
  X,
  D,
  parent_loss,
  depth,
  explore_proba = 0.05,
  choose_feature_fn = choose_feature,
  reduce_weight_fn = reduce_weight,
  global_objective_fn = objective_default,
  max_depth = 8,
  min_leaf_n = 5,
  log_fn = function(...) {
  },
  max_rejects_per_node = 1000
)
```

Arguments

split_feature	A named numeric vector of feature selection probabilities. Must include the name "leaf".
X	A data.frame of current observations. Includes candidate split feature columns and may include a working copy of weights w.
D	A data.frame representing the global state. Must include columns w and vsq. Row names must align to X.
parent_loss	A numeric(1) giving the loss of the parent node. Used to decide if a split improves the objective.
depth	An integer(1) giving the current tree depth.
explore_proba	A numeric(1) between 0 and 1 for the probability of flipping the exploit choice at a leaf.
choose_feature_fn	A function to choose the next feature. Default is choose_feature.

```

reduce_weight_fn
    A function to penalize the last tried feature on a rejected split. Default is
    reduce_weight.

global_objective_fn
    A function with signature function(D) -> numeric that scores the entire state.

max_depth
    An integer(1) giving the maximum depth. A node becomes a leaf at this
    depth.

min_leaf_n
    An integer(1) giving the minimum number of rows to attempt a split. Otherwise make a leaf.

log_fn
    A function for logging. Default is a function that performs no operation.

max_rejects_per_node
    An integer(1) giving the safety budget of rejected splits before forcing a leaf.

```

Value

A list representing the subtree. Includes updated D and a field named "local objective".

summary.characterizing_underrep
Summarize a characterizing_underrep fit

Description

Summarizes the ROOT summary which includes unweighted and (when in generalization mode) weighted estimates with standard errors, as reported by `summary.ROOT()`. Provides a brief overview of terminal rules from the annotated summary tree when available.

Usage

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

Arguments

object	A characterizing_underrep S3 object. Expected components include root which is a ROOT object (summarized by <code>summary.ROOT()</code>) and may contain f which is an rpart object for the summary tree, and leaf_summary which is a data.frame with one row per terminal node and may include a rule column of type character.
...	Currently unused. Included for S3 compatibility.

Details

Delegates core statistics and estimands to `summary(object$root)`. Previews up to ten terminal rules when a summary tree exists.

Value

object returned invisibly. Printed output is a human readable summary.

Abbreviations

ATE means Average Treatment Effect. RCT means Randomized Controlled Trial. SE means Standard Error. TATE means Transported ATE. WTATE means Weighted TATE. WATE means Weighted ATE. PATE means Population ATE.

Examples

```
## Not run:
char.output = characterizing_underrep(diabetes_data,generalizability_path = TRUE, seed = 123)
summary(char.output)

## End(Not run)
```

summary.ROOT

Summarize a ROOT fit

Description

Provides a human-readable summary of a ROOT object, including:

1. the summary characterization tree `f`,
2. the first few rows of `testing_data`,
3. the `global_objective_fn` used during optimization, and
4. in generalizability mode (`generalizability_path = TRUE`), the unweighted and weighted estimands with their standard errors and an explanatory note for the weighted SE.

Usage

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

Arguments

<code>object</code>	A "ROOT" S3 object returned by <code>ROOT()</code> .
<code>...</code>	Currently unused and included for S3 compatibility.

Details

When `generalizability_path = TRUE`, the unweighted estimand corresponds to a SATE-type quantity and the weighted estimand to a WTATE-type quantity for the transported target population. When `generalizability_path = FALSE`, `ROOT` is used for general functional optimization and no causal labels are imposed; the summary focuses on the tree and diagnostics.

Value

`object` returned invisibly. Printed output is for inspection.

Diagnostics

The summary also reports:

- the number of trees grown,
- the size of the Rashomon set,
- the percentage of observations with ensemble vote $w_{opt} == 1$.

Examples

```
## Not run:  
ROOT.output = ROOT(diabetes_data,generalizability_path = TRUE, seed = 123)  
summary(ROOT.output)  
  
## End(Not run)
```

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