

Package ‘coat’

July 11, 2023

Title Conditional Method Agreement Trees (COAT)

Version 0.2.0

Date 2023-07-06

Description Agreement of continuously scaled measurements made by two techniques, devices or methods is usually evaluated by the well-established Bland-Altman analysis or plot. Conditional method agreement trees (COAT), proposed by Karapetyan, Zeileis, Henriksen, and Hapfelmeier (2023) <[doi:10.48550/arXiv.2306.04456](https://doi.org/10.48550/arXiv.2306.04456)>, embed the Bland-Altman analysis in the framework of recursive partitioning to explore heterogeneous method agreement in dependence of covariates. COAT can also be used to perform a Bland-Altman test for differences in method agreement.

License GPL-2 | GPL-3

Depends R (>= 3.5.0)

Imports partykit, ggplot2, grid, ggparty, gridExtra, ggtext

Suggests disttree, MethComp

Additional_repositories <https://R-Forge.R-project.org>

Encoding UTF-8

RoxygenNote 7.2.3

NeedsCompilation no

Author Alexander Hapfelmeier [aut, cre]
(<<https://orcid.org/0000-0001-6765-6352>>),
Siranush Karapetyan [aut] (<<https://orcid.org/0000-0003-1831-9741>>),
Achim Zeileis [aut] (<<https://orcid.org/0000-0003-0918-3766>>)

Maintainer Alexander Hapfelmeier <Alexander.Hapfelmeier@mri.tum.de>

Repository CRAN

Date/Publication 2023-07-11 15:30:09 UTC

R topics documented:

batest	2
coat	3
diffs	6
print.coat	6

Index	10
--------------	-----------

batest	<i>Bland-Altman Test of Method Agreement</i>
--------	--

Description

Function to perform a Bland-Altman test of differences in method agreement. Additional functions are given for printing and plotting.

Usage

```
batest(formula, data, subset, na.action, weights, ...)

## S3 method for class 'batest'
print(x, digits = 2, type = c("test", "model", "both"), ...)

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

Arguments

formula	symbolic description of the model used to perform the Bland-Altman test of type $y_1 + y_2 \sim x$. The left-hand side should specify a pair of measurements (y_1 and y_2) to assess the agreement. The right-hand side should specify a factor with two levels indicating two independent groups or samples to be compared. Alternatively, multilevel factors or continuously scaled variables can be specified to perform a Bland-Altman test of association, followed by binary splitting into two subgroups.
data, subset, na.action	arguments controlling the formula processing via model.frame .
weights	optional numeric vector of weights (case/frequency weights, by default).
...	further control arguments, passed to ctree_control
x	an object as returned by batest .
digits	a numeric specifying the number of digits to display.
type	character string specifying whether "test" statistics (default), the "model" or "both" should be printed.

Value

Object of class `batest` with elements

`test` result of the Bland-Altman test.
`model` tree model used to perform the Bland-Altman test.

Methods (by generic)

- `print(batest)`: function to print the result of the Bland-Altman test.
- `plot(batest)`: function to plot the result of the Bland-Altman test.

Examples

```
## package and data (reshaped to wide format)
library("coat")
data("VitCap", package = "MethComp")
VitCap_wide <- reshape(VitCap, v.names = "y", timevar = "instrument",
                       idvar = c("item", "user"), drop = "meth", direction = "wide")

## two-sample BA-test
testresult <- batest(y.St + y.Exp ~ user, data = VitCap_wide)

## display
testresult
print(testresult, digits = 1, type = "both")
plot(testresult)
```

 coat

Conditional Method Agreement Trees (COAT)

Description

Tree models capturing the dependence of method agreement on covariates. The classic Bland-Altman analysis is used for modeling method agreement while the covariate dependency can be learned either nonparametrically via conditional inference trees (CTree) or using model-based recursive partitioning (MOB).

Usage

```
coat(
  formula,
  data,
  subset,
  na.action,
  weights,
  means = FALSE,
```

```

type = c("ctree", "mob"),
minsize = 10L,
minbucket = minsize,
minsplit = NULL,
...
)

```

Arguments

<code>formula</code>	symbolic description of the model of type $y_1 + y_2 \sim x_1 + \dots + x_k$. The left-hand side should specify a pair of measurements (y_1 and y_2) for the Bland-Altman analysis. The right-hand side can specify any number of potential split variables for the tree.
<code>data, subset, na.action</code>	arguments controlling the formula processing via <code>model.frame</code> .
<code>weights</code>	optional numeric vector of weights (case/frequency weights, by default).
<code>means</code>	logical. Should the intra-individual mean values of measurements be included as potential split variable?
<code>type</code>	character string specifying the type of tree to be fit. Either "ctree" (default) or "mob".
<code>minsize, minbucket</code>	integer. The minimum number of observations in a subgroup. Only one of the two arguments should be used (see also below).
<code>minsplit</code>	integer. The minimum number of observations to consider splitting. Must be at least twice the minimal subgroup size (<code>minsplit</code> or <code>minbucket</code>). If set to NULL (the default) it is set to be at least 2.5 times the minimal subgroup size.
<code>...</code>	further control arguments, either passed to <code>ctree_control</code> or <code>mob_control</code> , respectively.

Details

Conditional method agreement trees (COAT) employ unbiased recursive partitioning in order to detect and model dependency on covariates in the classic Bland-Altman analysis. One of two recursive partitioning techniques can be used to find subgroups defined by splits in covariates to a pair of measurements, either nonparametric conditional inference trees (CTree) or parametric model-based trees (MOB). In both cases, each subgroup is associated with two parameter estimates: the mean of the measurement difference ("Bias") and the corresponding sample standard deviation ("SD") which can be used to construct the limits of agreement (i.e., the corresponding confidence intervals).

The minimum number of observations in a subgroup defaults to 10, so that the mean and variance of the measurement differences can be estimated reasonably for the Bland-Altman analysis. The default can be changed with with the argument `minsize` or, equivalently, `minbucket`. (The different names stem from slightly different conventions in the underlying tree functions.) Consequently, the minimum number of observations to consider splitting (`minsplit`) must be, at the very least, twice the minimum number of observations per subgroup (which would allow only one possible split, though). By default, `minsplit` is 2.5 times `minsize`. Users are encouraged to consider whether for their application it is sensible to increase or decrease these defaults. Finally, further control

parameters can be specified through the `...` argument, see `ctree_control` and `mob_control`, respectively, for details.

In addition to the standard specification of the two response measurements in the formula via $y_1 + y_2 \sim \dots$, it is also possible to use $y_1 - y_2 \sim \dots$. The latter may be more intuitive for users that think of it as a model for the difference of two measurements. Finally `cbind(y1, y2) ~ ...` also works. Internally, all of these are processed in the same way, namely as a bivariate dependent variable that can then be modeled and plotted appropriately.

To add the means of the measurement pair as a potential splitting variable, there are also different equivalent strategies. The standard specification would be via the means argument: $y_1 + y_2 \sim x_1 + \dots$, `means = TRUE`. Alternatively, the user can also extend the formula argument via $y_1 + y_2 \sim x_1 + \dots + \text{means}(y_1, y_2)$.

The SD is estimated by the usual sample standard deviation in each subgroup, i.e., divided by the sample size $n - 1$. Note that the inference in the MOB algorithm internally uses the maximum likelihood estimate (divided by n) instead so the fluctuation tests for parameter instability can be applied.

Value

Object of class `coat`, inheriting either from `constparty` (if `ctree` is used) or `modelparty` (if `mob` is used).

References

Karapetyan S, Zeileis A, Henriksen A, Hapfelmeier A (2023). “Tree Models for Assessing Covariate-Dependent Method Agreement.” arXiv 2306.04456, *arXiv.org E-Print Archive*. doi:10.48550/arXiv.2306.04456

Examples

```
## package and data (reshaped to wide format)
library("coat")
data("scint", package = "MethComp")
scint_wide <- reshape(scint, v.names = "y", timevar = "meth", idvar = "item", direction = "wide")

## coat based on ctree() without and with mean values of paired measurements as predictor
tr1 <- coat(y.DTPA + y.DMSA ~ age + sex, data = scint_wide)
tr2 <- coat(y.DTPA + y.DMSA ~ age + sex, data = scint_wide, means = TRUE)

## display
print(tr1)
plot(tr1)

print(tr2)
plot(tr2)

## tweak various graphical arguments of the panel function (just for illustration):
## different colors, nonparametric bootstrap percentile confidence intervals, ...
plot(tr1, tp_args = list(
  xscale = c(0, 150), linecol = "deeppink",
```

```
  confint = TRUE, B = 250, cilevel = 0.5, cicol = "gold"  
)
```

diffs

Convenience Functions for Bland-Altman Analysis

Description

Auxiliary functions for obtain the differences and means of a measurement pair, as used in the classic Bland-Altman analysis.

Usage

```
diffs(y1, y2)
```

```
means(y1, y2)
```

Arguments

y1, y2 numeric. Vectors of numeric measurements of the same length.

Value

Numeric vector with the differences or means of y1 and y2, respectively.

Examples

```
## pair of measurements  
y1 <- 1:4  
y2 <- c(2, 2, 1, 3)  
  
## differences and means  
diffs(y1, y2)  
means(y1, y2)
```

print.coat

Methods for Conditional Method Agreement Trees (COAT)

Description

Extracting information from or visualization of conditional method agreement trees. Visualizations use trees with Bland-Altman plots in terminal nodes, drawn either via grid graphics directly or via ggplot2.

Usage

```
## S3 method for class 'coat'
print(
  x,
  digits = 2L,
  header = TRUE,
  footer = TRUE,
  title = "Conditional method agreement tree (COAT)",
  ...
)

## S3 method for class 'coat'
coef(object, node = NULL, drop = TRUE, ...)

## S3 method for class 'coat'
plot(x, terminal_panel = node_baplot, tnex = 2, drop_terminal = TRUE, ...)

node_baplot(
  obj,
  level = 0.95,
  digits = 2,
  pch = 1,
  cex = 0.5,
  col = 1,
  linecol = 4,
  lty = c(1, 2),
  bg = "white",
  confint = FALSE,
  B = 500,
  cilevel = 0.95,
  cicol = "lightgray",
  xscale = NULL,
  yscale = NULL,
  ylines = 3,
  id = TRUE,
  mainlab = NULL,
  gp = gpar()
)

## S3 method for class 'coat'
autoplot(
  object,
  digits = 2,
  xlim.max = NULL,
  level = 0.95,
  label.align = 0.95,
  ...
)
```

Arguments

x, object, obj	a coat object as returned by <code>coat</code> .
digits	numeric. Number of digits used for rounding the displayed coefficients or limits of agreement.
header, footer	logical. Should a header/footer be printed for the tree?
title	character with the title for the tree.
...	further arguments passed to methods.
node	integer. ID of the node for which the Bland-Altman parameters (coefficients) should be extracted.
drop	logical. Should the matrix attribute be dropped if the parameters from only a single node are extracted?
terminal_panel	a panel function or panel-generating function passed to <code>plot.party</code> . By default, <code>node_baplot</code> is used to generate a suitable panel function for drawing Bland-Altman plots based on the the provided coat object. It can be customized using the <code>tp_args</code> argument (passed through ...).
tnex	numeric specification of the terminal node extension relative to the inner nodes (default is twice the size).
drop_terminal	logical. Should all terminal nodes be "dropped" to the bottom row?
level	numeric level for the limits of agreement.
pch, cex, col, linecol, lty, bg	graphical parameters for the scatter plot and limits of agreement in the Bland-Altman plot (scatter plot character, character extension, plot color, line color, line types, and background color).
confint	logical. Should nonparametric bootstrap percentile confidence intervals be plotted?
B	numeric. Number of bootstrap samples to be used if <code>confint = TRUE</code> .
cilevel	numeric. Level of the confidence intervals if <code>confint = TRUE</code> .
cicol	color specification for the confidence intervals if <code>confint = TRUE</code> .
xscale, yscale	numeric specification of scale of x-axis and y-axis, respectively. By default the range of all scatter plots and limits of agreement across all nodes are used.
ylines	numeric. Number of lines for spaces in y-direction.
id	logical. Should node IDs be plotted?
mainlab	character or function. An optional title for the plots. Either a character or a function(<code>id, nobs</code>).
gp	grid graphical parameters.
xlim.max	numeric. Optional value to define the upper limit of the x-axis.
label.align	numeric. Specification between 0 and 1 for the alignment of labels relative to the plot width or <code>xlim.max</code> .

Details

Various methods are provided for trees fitted by `coat`, in particular `print`, `plot` (via `grid/partykit`), `autoplot` (via `ggplot2/ggparty`), `coef`. The `plot` method draws Bland-Altman plots in the terminal panels by default, using the function `node_baplot`. The `autoplot` draws very similar plots by customizing the `geom_node_plot` "from scratch".

In addition to these dedicated `coat` methods, further methods are inherited from `ctree` or `mob`, respectively, depending on which type of `coat` was fitted.

Value

The `print()` method returns the printed object invisibly. The `coef()` method returns the vector (for a single node) or matrix (for multiple nodes) of estimated parameters (bias and standard deviation). The `plot()` method returns NULL. The `node_baplot()` panel-generating function returns a function that can be plugged into the `plot()` method. The `autoplot()` method returns a `ggplot` object.

Examples

```
## package and data (reshaped to wide format)
library("coat")
data("scint", package = "MethComp")
scint_wide <- reshape(scint, v.names = "y", timevar = "meth", idvar = "item", direction = "wide")

## conditional method agreement tree
tr <- coat(y.DTPA + y.DMSA ~ age + sex, data = scint_wide)

## illustration of methods (including some customization)

## printing
print(tr)
print(tr, header = FALSE, footer = FALSE)

## extracting Bland-Altman parameters
coef(tr)
coef(tr, node = 1)

## visualization (via grid with node_baplot)
plot(tr)
plot(tr, ip_args = list(id = FALSE),
      tp_args = list(col = "slategray", id = FALSE, digits = 3, pch = 19))

## visualization (via ggplot2 with ggparty)
library("ggplot2")
autoplot(tr)
autoplot(tr, digits = 3) + ggtitle("Conditional method agreement tree") +
  theme(plot.title = element_text(hjust = 0.5))
```

Index

`autoplot.coat (print.coat)`, 6

`batest`, 2, 2

`coat`, 3, 8, 9

`coef.coat (print.coat)`, 6

`ctree`, 5, 9

`ctree_control`, 2, 4, 5

`diffs`, 6

`geom_node_plot`, 9

`means (diffs)`, 6

`mob`, 5, 9

`mob_control`, 4, 5

`model.frame`, 2, 4

`node_baplot (print.coat)`, 6

`plot.batest (batest)`, 2

`plot.coat (print.coat)`, 6

`plot.party`, 8

`print.batest (batest)`, 2

`print.coat`, 6