Package ‘interferenceCI’

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Type Package

Title Exact Confidence Intervals in the Presence of Interference

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Author Joseph Rigdon

Maintainer Joseph Rigdon <jrigdon@bios.unc.edu>

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Description Computes large sample confidence intervals of Liu and Hudgens (2014), exact confidence intervals of Tchetgen Tchetgen and VanderWeele (2012), and exact confidence intervals of Rigdon and Hudgens (2014) for treatment effects on a binary outcome in two-stage randomized experiments with interference.

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`interferenceCI-package` *Exact confidence intervals in the presence of interference*

Description

Computes large sample confidence intervals of Liu and Hudgens (2014), conservative exact confidence intervals of Tchetgen Tchetgen and VanderWeele (2012), and exact confidence intervals of Rigdon and Hudgens (2014) for treatment effects on a binary outcome in two-stage randomized experiments with interference.

Details

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Author(s)

Joseph Rigdon <jrigdon@bios.unc.edu>

References

Hudgens, M.G. and Halloran, M.E. "Toward causal inference with interference." Journal of the American Statistical Association 2008 103:832-842.

Tchetgen Tchetgen, E. and VanderWeele, T.J. "On causal inference in the presence of interference." Statistical Methods in Medical Research 2012 21:55-75.

Liu, L. and Hudgens, M.G. "Large sample randomization inference of causal effects in the presence of interference." Journal of the American Statistical Association 2014 109, 288-301.

Rigdon, J. and Hudgens, M.G. "Exact confidence intervals in the presence of interference." Submitted to Statistics and Probability Letters 2014.

`bd` *Function to ensure that probability lies in interval* $[0, 1]$

Description

Used by targeted sampling algorithm in `exactCI`

Usage

```
bd(x)
```

Arguments

x	Real number

Value

Function returns 0 if $x < 0$, x if $0 \leq x \leq 1$, and 1 if $x > 1$

Author(s)

Joseph Rigdon <jrigdon@bios.unc.edu>

See Also

exactCI

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estbound *Estimates and bounds for treatment effects on a binary outcome in a two-stage randomized experiment with interference*

Description

Computes the estimators of Hudgens and Halloran (2008) and bounds of Rigdon and Hudgens (2014) for treatment effects on a binary outcome in a two-stage randomized experiment with interference

Usage

```
estbound(g, data, m.a0, m.a1)
```

Arguments

g	1st stage of randomization vector where element $i = 1, \ldots, k$ is equal to 1 if group i was randomized to strategy α_1 and 0 if randomized to strategy α_0
data	$2 \times 2 \times k$ array of 2×2 table data where row 1 is treatment=yes, row 2 is treatment=no, column 1 is outcome=yes, and column 2 is outcome=no
m.a0	α_0 randomization vector where element $i = 1, \ldots, k$ is equal to the number of subjects in group i who would receive treatment if group i was randomized to strategy α_0
m.a1	α_1 randomization vector where element $i = 1, \ldots, k$ is equal to the number of subjects in group i who would receive treatment if group i was randomized to strategy α_1

Details

Function will return many values (to be used by other functions in this package), but the only important value here is tab.eff

Value

`tab.eff` Labeled table of estimates and bounds

Author(s)

Joseph Rigdon <jrigdon@bios.unc.edu>

References

Hudgens, M.G. and Halloran, M.E. “Toward causal inference with interference.” Journal of the American Statistical Association 2008 103:832-842.

Rigdon, J. and Hudgens, M.G. “Exact confidence intervals in the presence of interference.” Submitted to Statistics and Probability Letters 2014.

Examples

```
#Made up example with 10 groups of 10 where half are randomized to a0 and half to a1
#a0 is assign 3 of 10 to treatment and half to a1 is assign 6 of 10 to treatment
d = c(1,1,5,3,0,6,3,1,0,4,3,3,0,5,3,2,1,1,5,3,2,2,4,2,1,5,2,2,2,3,4,1,1,1,5,3,1,5,2,2)
data.ex = array(d,c(2,2,10))
assign.ex = c(1,0,0,0,1,1,0,1,1,0)

#Estimates and bounds
e = estbound(assign.ex,data.ex,rep(3,10),rep(6,10))
e$tab.eff
```

`exactCI` *Exact confidence intervals for treatment effects on a binary outcome in a two-stage randomized experiment with interference*

Description

Finds exact confidence intervals for treatment effects on a binary outcome in a two-stage randomized experiment with interference. See Section 4.2 of Rigdon and Hudgens (2014) for details.

Usage

```
exactCI(eff, g, data, m.a0, m.a1, B2, C2, level)
```

Arguments

`eff`	treatment effect of interest; either "DEa0", "DEa1", "IE", "TE", or "OE"
`g`	1st stage of randomization vector where element $i = 1, \ldots, k$ is equal to 1 if group i was randomized to strategy α_1 and 0 if randomized to strategy α_0
`data`	$2 \times 2 \times k$ array of 2×2 table data where row 1 is treatment=yes, row 2 is treatment=no, column 1 is outcome=yes, and column 2 is outcome=no
`m.a0`	α_0 randomization vector where element $i = 1, \ldots, k$ is equal to the number of subjects in group i who would receive treatment if group i was randomized to strategy α_0
`m.a1`	α_0 randomization vector where element $i = 1, \ldots, k$ is equal to the number of subjects in group i who would receive treatment if group i was randomized to strategy α_1
`B2`	number of sharp nulls to test in the targeted sampling algorithm
`C2`	number of re-randomizations (experiments) to conduct in computing the null distribution of the estimator
`level`	significance level of hypothesis tests, i.e., method yields a 1-level confidence interval

Details

See Section 4.2 of Rigdon and Hudgens (2014) for detailed description. Please plot the p-values against the effect as a check of targeted sampling algorithm performance.

Value

`B1`	total number of hypotheses that could be tested
`C1`	total number of re-randomizations (experiments) that could be performed
`frac.NA`	fraction of hypothesized sharp nulls that are not tested
`prob1`	final value of targeting parameter q_{p_l} in finding lower confidence limit
`prob2`	final value of targeting parameter q_{p_u} in finding upper confidence limit
`effect`	vector of sharp null hypotheses
`p`	vector of p-values corresponding to the sharp null hypotheses
`lower`	lower limit to confidence interval
`upper`	upper limit to confidence interval

Author(s)

Joseph Rigdon <jrigdon@bios.unc.edu>

References

Rigdon, J. and Hudgens, M.G. "Exact confidence intervals in the presence of interference." Submitted to Statistics and Probability Letters 2014.

Examples

```
#Made up example with 10 groups of 10 where half are randomized to a0 and half to a1
#a0 is assign 3 of 10 to treatment and half to a1 is assign 6 of 10 to treatment
d = c(1,1,5,3,0,6,3,1,0,4,3,3,0,5,3,2,1,1,5,3,2,2,4,2,1,5,2,2,2,3,4,1,1,1,5,3,1,5,2,2)
data.ex = array(d,c(2,2,10))
assign.ex = c(1,0,0,0,1,1,0,1,1,0)

#Inference for overall effect
l1 = exactCI('OE',assign.ex,data.ex,rep(3,10),rep(6,10),100,100,0.05)

#Check algorithm using a plot
plot(l1$effect,l1$p)
```

HH — *Large sample confidence intervals for treatment effects on a binary outcome in a two-stage randomized experiment with interference*

Description

Computes the large sample confidence intervals of Liu and Hudgens (2014) for treatment effects on a binary outcome in a two-stage randomized experiment with interference

Usage

```
HH(eff, g, data, m.a0, m.a1, level)
```

Arguments

`eff`	treatment effect of interest; either "DEa0", "DEa1", "IE", "TE", or "OE"
`g`	1st stage of randomization vector where element $i = 1, \ldots, k$ is equal to 1 if group i was randomized to strategy α_1 and 0 if randomized to strategy α_0
`data`	$2 \times 2 \times k$ array of 2×2 table data where row 1 is treatment=yes, row 2 is treatment=no, column 1 is outcome=yes, and column 2 is outcome=no
`m.a0`	α_0 randomization vector where element $i = 1, \ldots, k$ is equal to the number of subjects in group i who would receive treatment if group i was randomized to strategy α_0
`m.a1`	α_1 randomization vector where element $i = 1, \ldots, k$ is equal to the number of subjects in group i who would receive treatment if group i was randomized to strategy α_1
`level`	significance level, i.e., method yields a 1-level confidence interval

Value

est	estimated treatment effect
v	estimated variance
lower.w	lower limit to Wald confidence interval
upper.w	upper limit to Wald confidence interval
lower.ch	lower limit to Chebyshev confidence interval
upper.ch	upper limit to Chebyshev confidence interval

Author(s)

Joseph Rigdon <jrigdon@bios.unc.edu>

References

Hudgens, M.G. and Halloran, M.E. "Toward causal inference with interference." Journal of the American Statistical Association 2008 103:832-842.

Liu, L. and Hudgens, M.G. "Large sample randomization inference of causal effects in the presence of interference." Journal of the American Statistical Association 2014 109:288-301.

Examples

```
#Table 3 from Hudgens and Halloran (2008)
hh = array(c(16,18,12541-16,12541-18,26,54,11513-26,11513-54,17,119,10772-17,
     25134-119,22,122,8883-22,20727-122,15,92,5627-15,13130-92),c(2,2,5))
e1 = HH('OE',c(1,1,0,0,0),hh,round(0.3*c(25082,23026,35906,29610,18757),0),
     round(0.5*c(25082,23026,35906,29610,18757),0),0.05)
round(1000*e1$est,3)
round(1000000*e1$v,3)
```

---

lsolve *Local linear interpolation function*

Description

Computes intersection of a line drawn from (x_1, y_1) to (x_2, y_2) and a horizontal line at level

Usage

```
lsolve(x1, y1, x2, y2, level)
```

Arguments

x1	x-coordinate for first point
y1	y-coordinate for first point
x2	x-coordinate for second point
y2	y-coordinate for second point
level	y-coordinate for horizontal line

Value

Returns x-coordinate of intersection point

Author(s)

Joseph Rigdon <jrigdon@bios.unc.edu>

See Also

exactCI

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nchoosem *Compute randomization matrix*

Description

Returns the $\binom{n}{m}$ row randomization matrix; uses combinations function in **gtools**

Usage

```
nchoosem(n, m)
```

Arguments

n	total number of subjects
m	number assigned to treatment in experiment

Value

matrix with $\binom{n}{m}$ rows of randomizations

Author(s)

Joseph Rigdon <jrigdon@bios.unc.edu>

`pval` *Computes permutation test p-value*

Description

Returns permutation test p-value; used in the construction of exact confidence intervals by the function `exactCI`

Usage

```
pval(eff, est, null, y0.a0, y1.a0, y0.a1, y1.a1, h, n, m.a0, m.a1, C2)
```

Arguments

`eff`	treatment effect of interest; either “DEa0”, “DEa1”, “IE”, “TE”, or “OE”
`est`	estimated treatment effect using estimators from Hudgens and Halloran (2008)
`null`	value of treatment effect of interest under the sharp null hypothesis
`y0.a0`	hypothesized vector $\vec{y}(0; \alpha_0)$ under the sharp null hypothesis
`y1.a0`	hypothesized vector $\vec{y}(1; \alpha_0)$ under the sharp null hypothesis
`y0.a1`	hypothesized vector $\vec{y}(0; \alpha_1)$ under the sharp null hypothesis
`y1.a1`	hypothesized vector $\vec{y}(1; \alpha_1)$ under the sharp null hypothesis
`h`	the number of groups out of k total to be randomized to strategy α_1
`n`	group size vector where element $i = 1, \ldots, k$ is equal to the number of subjects in group i
`m.a0`	α_0 randomization vector where element $i = 1, \ldots, k$ is equal to the number of subjects in group i who would receive treatment if group i was randomized to strategy α_0
`m.a1`	α_1 randomization vector where element $i = 1, \ldots, k$ is equal to the number of subjects in group i who would receive treatment if group i was randomized to strategy α_1
`C2`	number of re-randomizations (experiments) to conduct in computing the null distribution of the estimator

Details

See equation (6) in Rigdon and Hudgens (2014)

Author(s)

Joseph Rigdon `<jrigdon@bios.unc.edu>`

References

Hudgens, M.G. and Halloran, M.E. "Toward causal inference with interference." Journal of the American Statistical Association 2008 103:832-842.

Rigdon, J. and Hudgens, M.G. "Exact confidence intervals in the presence of interference." Submitted to Statistics and Probability Letters 2014.

See Also

`exactCI`

`rand` *Compute single* $\binom{n}{m}$ *randomization*

Description

Returns vector of length n with exactly m 1s and $n - m$ 0s

Usage

```
rand(n, m)
```

Arguments

`n`	total number of subjects
`m`	number assigned to treatment in experiment

Value

vector of length n with exactly m 1s and $n - m$ 0s

Author(s)

Joseph Rigdon `<jrigdon@bios.unc.edu>`

`sample.n` *Targeted sampling of sharp null hypotheses*

Description

Fills in missingness in $\vec{y}(z;\alpha_s)$ for $z, s = 0, 1$ based on targeted sampling algorithm described in Section 4.2 of Rigdon and Hudgens (2014)

Usage

```
sample.n(eff, y0.a0, y1.a0, y0.a1, y1.a1, p00, p10, p01, p11, n, m.a0, m.a1)
```

Arguments

`eff`	treatment effect of interest; either “DEa0”, “DEa1”, “IE”, “TE”, or “OE”
`y0.a0`	Observed $\vec{y}(0;\alpha_0)$; includes NAs where missing
`y1.a0`	Observed $\vec{y}(1;\alpha_0)$; includes NAs where missing
`y0.a1`	Observed $\vec{y}(0;\alpha_1)$; includes NAs where missing
`y1.a1`	Observed $\vec{y}(1;\alpha_1)$; includes NAs where missing
`p00`	Missingness in $\vec{y}(0;\alpha_0)$ is filled in by sampling from a Bernoulli distribution with mean p_{00}
`p10`	Missingness in $\vec{y}(1;\alpha_0)$ is filled in by sampling from a Bernoulli distribution with mean p_{10}
`p01`	Missingness in $\vec{y}(0;\alpha_1)$ is filled in by sampling from a Bernoulli distribution with mean p_{01}
`p11`	Missingness in $\vec{y}(1;\alpha_0)$ is filled in by sampling from a Bernoulli distribution with mean p_{11}
`n`	group size vector where element $i = 1, \ldots, k$ is equal to the number of subjects in group i
`m.a0`	α_0 randomization vector where element $i = 1, \ldots, k$ is equal to the number of subjects in group i who would receive treatment if group i was randomized to strategy α_0
`m.a1`	α_1 randomization vector where element $i = 1, \ldots, k$ is equal to the number of subjects in group i who would receive treatment if group i was randomized to strategy α_1

Value

`y0.a0`	value of $\vec{y}(0;\alpha_0)$ after missingness has been filled in using targeted sampling
`y1.a0`	value of $\vec{y}(1;\alpha_0)$ after missingness has been filled in using targeted sampling
`y0.a1`	value of $\vec{y}(0;\alpha_1)$ after missingness has been filled in using targeted sampling
`y1.a1`	value of $\vec{y}(1;\alpha_1)$ after missingness has been filled in using targeted sampling
`effect`	value of treatment effect of interested under sharp null after missingness filled in using targeted sampling

Author(s)

Joseph Rigdon <jrigdon@bios.unc.edu>

References

Rigdon, J. and Hudgens, M.G. "Exact confidence intervals in the presence of interference." Submitted to Statistics and Probability Letters 2014.

See Also

exactCI

TV *Conservative exact confidence intervals for treatment effects on a binary outcome in a two-stage randomized experiment with interference*

Description

Computes the conservative exact confidence intervals of Tchetgen Tchetgen and VanderWeele (2012) for treatment effects on a binary outcome in a two-stage randomized experiment with interference

Usage

```
TV(eff, g, data, m.a0, m.a1, level)
```

Arguments

`eff`	treatment effect of interest; either "DEa0", "DEa1", "IE", "TE", or "OE"
`g`	1st stage of randomization vector where element $i = 1, \ldots, k$ is equal to 1 if group i was randomized to strategy α_1 and 0 if randomized to strategy α_0
`data`	$2 \times 2 \times k$ array of 2×2 table data where row 1 is treatment=yes, row 2 is treatment=no, column 1 is outcome=yes, and column 2 is outcome=no
`m.a0`	α_0 randomization vector where element $i = 1, \ldots, k$ is equal to the number of subjects in group i who would receive treatment if group i was randomized to strategy α_0
`m.a1`	α_1 randomization vector where element $i = 1, \ldots, k$ is equal to the number of subjects in group i who would receive treatment if group i was randomized to strategy α_1
`level`	significance level, i.e., method yields a 1-level confidence interval

Details

Confidence intervals are based on a Hoeffding-type exponential inequality; see section 4.3.2 of Tchetgen Tchetgen and VanderWeele (2012)

Value

`est`	estimated treatment effect from Hudgens and Halloran (2008)
`v`	half-width of confidence interval
`lower`	lower limit of confidence interval
`upper`	upper limit of confidence interval

Author(s)

Joseph Rigdon <jrigdon@bios.unc.edu>

References

Hudgens, M.G. and Halloran, M.E. “Toward causal inference with interference.” Journal of the American Statistical Association 2008 103:832-842.

Tchetgen Tchetgen, E. and VanderWeele, T.J. “On causal inference in the presence of interference.” Statistical Methods in Medical Research 2012 21:55-75.

Examples

```
#Made up example with 10 groups of 10 where half are randomized to a0 and half to a1
#a0 is assign 3 of 10 to treatment and half to a1 is assign 6 of 10 to treatment
d = c(1,1,5,3,0,6,3,1,0,4,3,3,0,5,3,2,1,1,5,3,2,2,4,2,1,5,2,2,2,3,4,1,1,1,5,3,1,5,2,2)
data.ex = array(d,c(2,2,10))
assign.ex = c(1,0,0,0,1,1,0,1,1,0)

#Inference for overall effect
TV('OE',assign.ex,data.ex,rep(3,10),rep(6,10),0.05)
```

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