Package ‘DunnettTests’

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Title Software implementation of step-down and step-up Dunnett test procedures

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Description For the implementation of the step-down or step-up Dunnett testing procedures, the package includes R functions to calculate critical constants and R functions to calculate adjusted P-values of the test statistics. In addition, the package also contains functions to evaluate testing powers and hence the necessary sample sizes specially for the classical problem of comparisons of several treatments with a control.

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DunnettTests-package *R implementation of step-down and step-up Dunnett test procedures*

Description

For the implementation of the step-down or step-up Dunnett test procedures, the package includes R functions to calculate critical constants and R functions to calculate adjusted P-values of test statistics. In addition, the package also contains functions to evaluate testing powers and hence the necessary sample sizes for the classic statistical problem of comparing multiple treatments with a control.

Details

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Author(s)

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References

Charles W Dunnett and Ajit C Tamhane. Step-down multiple tests for comparing treatments with a control in unbalanced one-way layouts. Statistics in Medicine, 10(6):939-947, 1991.

Charles W. Dunnett and Ajit C. Tamhane. A step-up multiple test procedure. Journal of the American Statistical Association, 87(417):162-170, 1992.

Charles W Dunnett and Ajit C Tamhane. Step-up multiple testing of parameters with unequally correlated estimates. Biometrics, pages 217-227, 1995.

Ajit C Tamhane and Charles W Dunnett. Stepwise multiple test procedures with biometric applications. Journal of statistical planning and inference, 82(1):55-68, 1999.

Koon Shing Kwong and Wei Liu. Calculation of critical values for dunnett and tamhane???s step-up multiple test procedure. Statistics & probability letters, 49(4):411-416, 2000.

Examples

```
#critical constants
cvSDDT(k=4,alpha=0.05,alternative="U",corr=0.5,df=30)
cvSUDT(k=4,alpha=0.05,alternative="U",corr=0.5,df=30)
```

```
#adjusted P-values
qvSDDT(teststats=c(2.20,1.47,2.00),alternative="B",corr=0.5,df=30)
## Not run:
qvSUDT(teststats=c(2.20,1.47,2.00),alternative="B",corr=0.5,df=30)
## End(Not run)

#testing power of SU Dunnett to reject at least one false null
powDT(1,4,mu=22,mu0=20,n=100,n0=80,"means",sigma=5,alpha=0.025,testcall="SU")

#sample size to achieve at least 90% power of rejecting all the
#false nulls for step-down Dunnett test procedure
## Not run:
nvDT(1,0.90,r=4,k=4,mu=0.7,mu0=0.5,"props",dist="zdist",testcall="SD")

## End(Not run)
```

`cvSDDT` *To calculate the critical constants for step-down Dunnett test procedure*

Description

The function applies to testing problem with either t distributed test statistics or (approximately) normally distributed test statistics. The function accomodates both equally correlated and unequally correlated test statistics.

Usage

```
cvSDDT(k,alpha=0.05,alternative="U",df = Inf,corr = 0.5,corr.matrix=NA)
```

Arguments

`k`	Number of hypotheses to be tested, $k \geq 2$ and $k \leq 16$.
`alpha`	The pre-specified overall significance level, default=0.05.
`alternative`	The alternative hypothesis: "U"=upper one-sided test (default); "B"=two-sided test. For lower one-sided tail test, specify alternative="U" and use the negations of the return critical constants.
`df`	Degree of freedom of the t-test statistics. When (approximately) normally distributed test statistics are applied, set df=Inf (default).
`corr`	Specified for equally correlated test statistics, which is the common correlation between the test statistics, default=0.5.
`corr.matrix`	Specified for unequally correlated test statistics, which is the correlation matrix of the test statistics, default=NA.

Value

Return a k-vector of critical constants from smallest to largest.

Author(s)

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References

Charles W Dunnett and Ajit C Tamhane. Step-down multiple tests for comparing treatments with a control in unbalanced one-way layouts. Statistics in Medicine, 10(6):939-947, 1991.

Examples

```
#To test four hypotheses, the test statistics are
#2.2 (H1), 2.7 (H2), 2.1(H3), 0.85(H4), respectively.
#The test statistcis are equally correlated at 0.6 and have df=30.
#At overall one-sided significance level 0.05, the critical constants are given by:

cvSDDT(k=4,df=30,corr=0.6)

#based on the critical values, we reject H2, H1, H3 in a sequence and accept H4.
```

`cvSUDT` *To calculate the critical constants for step-up Dunnett test procedure*

Description

The function applies to testing problem with either t distributed test statistics or (approximately) normally distributed test statistics. The function accomodates both equally correlated and unequally correlated test statistics. The calculation relies on recursive formulas as proposed in Kwong and Liu (2000) that the calculation needs increasing computation time with the increasing number of hypotheses to be tested. The function fastly calculate critical constants for up to 16 hypotheses.

Usage

```
cvSUDT(k,alpha=0.05,alternative="U",df=Inf,corr=0.5,corr.matrix=NA,mcs=1e+05)
```

Arguments

`k`	Number of hypotheses to be tested, $k \geq 2$ and $k \leq 16$.
`alpha`	The pre-specified overall significance level, default=0.05.
`alternative`	The alternative hypothesis: "U"=upper one-sided test (default); "B"=two-sided test. For lower one-sided tail test, specify alternative="U" and use the negations of the return critical constants.
`df`	Degree of freedom of the t-test statistics. When (approximately) normally distributed test statistics are applied, set df=Inf (default).
`corr`	Specified for equally correlated test statistics, which is the common correlation between the test statistics, default=0.5.

`corr.matrix` Specified for unequally correlated test statistics, which is the correlation matrix of the test statistics, default=NA.

`mcs` The number of monte carlo sample points to numerically approximate the probability that to solve critical values, refer to Equation (3.3) in Dunnett and Tamhane (1992) or Equation (2) in Kwong and Liu (2000), default=1e+05.

Value

Return a k-vector of critical constants from smallest to largest.

Author(s)

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References

Charles W. Dunnett and Ajit C. Tamhane. A step-up multiple test procedure. Journal of the American Statistical Association, 87(417):162-170, 1992.

Charles W Dunnett and Ajit C Tamhane. Step-up multiple testing of parameters with unequally correlated estimates. Biometrics, pages 217-227, 1995.

Koon Shing Kwong and Wei Liu. Calculation of critical values for dunnett and tamhane???s step-up multiple test procedure. Statistics & probability letters, 49(4):411-416, 2000.

Examples

```
#Compare four treatment arms to one control
#with test statistics 2.2(H1), 2.7(H2), 2.1(H3), 0.85(H4).
n=c(100,80,80,60)
n0=60
corr.matrix<-matrix(0,4,4)
diag(corr.matrix)=rep(1,4)
for(i in 1:3){
   for(j in (i+1):4){
     corr.matrix[i,j]=(1/n0)/(sqrt(1/n[i]+1/n0)*sqrt(1/n[j]+1/n0))
     corr.matrix[j,i]= corr.matrix[i,j]
   }
}
#The critical constants are given by

cvSUDT(k=4,df=sum(n)+n0-5,corr.matrix=corr.matrix)

#At overall one-sided significance level 0.05,
#accepy H4 but reject H3 and hence H1 and H2.
```

nvDT *To calculate the least sample size required to achieve a certain power*

Description

For the problem of comparing means of k treatment groups to the mean of one control group, the implementation of the function needs the following three assumptions: 1. The k treatment groups have identical treatment effect size. 2. The sample allocation ratio is pre-specified, and meanwhile the samples to be assigned to each of the k treatment groups are expected to be equal at size n. 3. The alternative hypotheses are one-sided. With the violations assumption 2, the sample size could not be evaluated numerically, and with the violation of assumption 1 and 3, the evaluation of sample size needs great computational effort and thus not implemented. In the situation, simulation-based evaluation is suggested.

Usage

```
nvDT(ratio,power,r,k,mu,mu0,contrast,sigma=NA,dist,alpha=0.05,mcs=1e+05,testcall)
```

Arguments

`ratio`	The pre-specified ratio of sample size in each of the treatment groups to the sample size in the control group
`power`	The power required to be achieved.
`r`	The least number of null hypotheses to be rejected, e.g.,when r=1, the sample size is evaluated on disjunctive power and when r=k, the sample size is evaluated on conjunctive power.
`k`	Number of hypotheses to be tested, $k \geq 2$ and $k \leq 16$.
`mu`	Assumed population mean in each of the k treatment groups.
`mu0`	Assumed population mean in the control group.
`contrast`	If mu and mu0 are concerned of means of continous outcome, specify contrast="means"; if mu and mu0 are concerned of proportions of binary outcome, specify contrast="props".
`sigma`	The population error variance, which should be specified when contrast="means"; if contrast="props", set sigma=NA as default and it will be calculated based on mu and mu0 specified within the function.
`dist`	Whether the sample size is calculated for t-distributed test statistics (dist="tdist") or standard normally distributed test statistics (dist="zdist").
`alpha`	The pre-specified overall significance level, default=0.05.
`mcs`	The number of monte-carlo sample points to numerically approximate the power for a given sample size, refer to Equation (4.3) and Equation (4.5) in Dunnett and Tamhane (1992).
`testcall`	The applied Dunnett test procedure: "SD"=step-down Dunnett test; "SU"=step-up Dunnett test.

Value

Return a LIST containing:

"least sample size required in each treatment groups"
: value of n

"least sample size required in the control group"
: value of n0

Author(s)

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References

Charles W. Dunnett and Ajit C. Tamhane. A step-up multiple test procedure. Journal of the American Statistical Association, 87(417):162-170, 1992.

See Also

powDT

Examples

```
nvDT(2, 0.95, r=1, k=3, mu=0.7, mu0=0.5, contrast="props",dist="zdist", testcall="SD")
```

---

powDT — *To calculate the testing power for step-down or step-up Dunnett procedure numerically*

Description

For the problem of comparing means of k treatment groups to the mean of one control group. The implementation of the function needs the following three assumptions: 1. The k treatment groups have identical treatment effect size. 2. The samples to be assigned to each of the k treatment groups are expected to be equal at size n. 3. The alternative hypotheses are one-sided. With the violations of either of the assumptions, simulation-based power evaluation is suggested.

Usage

```
powDT(r,k,mu,mu0,n,n0,contrast,sigma=NA,df=Inf,alpha=0.05,mcs=1e+05,testcall)
```

Arguments

r	The least number of null hypotheses to be rejected, e.g.,when r=1, the disjunctive power is returned and when r=k, the conjunctive power is returned.
k	Number of hypotheses to be tested, $k \geq 2$ and $k \leq 16$.
mu	Assumed population mean in each of the k treatment groups.
mu0	Assumed population mean in the control group.
n	Sample size in each of the k treatment groups
n0	Sample size in the control group
contrast	If mu and mu0 are concerned of mean of a continous outcome, specify contrast="means"; if mu and mu0 are concerned of proportion of binary outcome, specify contrast="props".
sigma	The population error variance, which should be specified when contrast="means"; if contrast="props", set sigma=NA as default and it will be calculated based on mu and mu0 specified within the function.
df	Degree of freedom of the t-test statistics. When (approximately) normally distributed test statistics are applied, set df=Inf (default).
alpha	The pre-specified overall significance level, default=0.05.
mcs	The number of monte-carlo sample points to numerically approximate the power for a given sample size, refer to Equation (4.3) and Equation (4.5) in Dunnett and Tamhane (1992).
testcall	The applied Dunnett test procedure: "SD"=step-down Dunnett test; "SU"=step-up Dunnett test.

Value

Return the power of rejecting at least r out of the k false null hypotheses.

Author(s)

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References

Charles W. Dunnett and Ajit C. Tamhane. A step-up multiple test procedure. Journal of the American Statistical Association, 87(417):162-170, 1992.

See Also

nvDT

Examples

```
#Compare group means of four treatment arms to a control arm (upper one-sided tests)
# Setting
k <- 4
mu <- 22 #assumed mean of each treatment arm
```

```
mu0 <- 20 #assumed mean of the control arm
n <- 100
n0 <- 80
sigma <- 5 #assumed population error variance
df <- n*k+n0-k-1 #consider the t distribution

# at one-sided significance level 0.05
# compare the testing powers of SD and SU Dunnett for rejecting at least one nulls
powSD <- powDT(r=1,k,mu,mu0,n,n0,"means",sigma=sigma,df=df,testcall="SD")
powSU <- powDT(r=1,k,mu,mu0,n,n0,"means",sigma=sigma,df=df,testcall="SU")
```

---

qvSDDT *To calculate adjusted P-values (Q-values) for step-down Dunnett test procedure*

Description

In multiple testing problem, the adjusted P-values correspond to test statistics can be used with any fixed alpha to dertermine which hypotheses to be rejected.

Usage

```
qvSDDT(teststats,alternative="U",df=Inf,corr = 0.5,corr.matrix = NA)
```

Arguments

`teststats`	The k-vector of test statistics, $k \geq 2$.
`alternative`	The alternative hypothesis: "U"=upper one-sided test (default); "L"=lower one-sided test; "B"=two-sided test. For lower one-sided tail test, use the negations of each of the test statistics.
`df`	Degree of freedom of the t-test statistics. When (approximately) normally distributed test statistics are applied, set df=Inf (default).
`corr`	Specified for equally correlated test statistics, which is the common correlation between the test statistics, default=0.5.
`corr.matrix`	Specified for unequally correlated test statistics, which is the correlation matrix of the test statistics, default=NA.

Value

Return a LIST containing:

`"ordered test statistics"`
: ordered test statistics from largest to smallest

`"Adjusted P-values of ordered test statistics"`
: adjusted P-values correspond to the ordered test statistics

Author(s)

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References

Charles W. Dunnett and Ajit C. Tamhane. A step-up multiple test procedure. Journal of the American Statistical Association, 87(417):162-170, 1992.

See Also

qvSUDT

Examples

```
qvSDDT(c(2.20,2.70,2.10,0.85),df=30)
```

---

qvSUDT *To calculate adjusted P-values (Q-values) for step-up Dunnett test procedure.*

Description

In multiple testing problem, the adjusted P-values correspond to test statistics can be used with any fixed alpha to dertermine which hypotheses to be rejected.

Usage

```
qvSUDT(teststats,alternative="U",df=Inf,corr=0.5,corr.matrix=NA,mcs=1e+05)
```

Arguments

teststats	The k-vector of test statistics, $k \geq 2$ and $k \leq 16$.
alternative	The alternative hypothesis: "U"=upper one-sided test (default); "L"=lower one-sided test; "B"=two-sided test. For lower one-sided tail test, use the negations of each of the test statistics.
df	Degree of freedom of the t-test statistics. When (approximately) normally distributed test statistics are applied, set df=Inf (default).
corr	Specified for equally correlated test statistics, which is the common correlation between the test statistics, default=0.5.
corr.matrix	Specified for unequally correlated test statistics, which is the correlation matrix of the test statistics, default=NA.
mcs	The number of monte carlo sample points to numerically approximate the probability that to solve critical values for a given P value, refer to Equation (3.3) in Dunnett and Tamhane (1992), default=1e+05.

Value

Return a LIST containing:

`"ordered test statistics"`
: ordered test statistics from smallest to largest

`"Adjusted P-values of ordered test statistics"`
: adjusted P-values correspond to the ordered test statistics

Author(s)

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References

Charles W. Dunnett and Ajit C. Tamhane. A step-up multiple test procedure. Journal of the American Statistical Association, 87(417):162-170, 1992.

See Also

`qvSDDT`

Examples

```
qvSUDT(c(2.20,2.70),df=30)
```

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