User's Guide for FDRsampsize pacakge to Perform Power and Sample Size calculations for Microarray Studies

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Purpose

The purpose of the software is to provide a way to easily implement the general approach of power and sample size calculations described by Pounds and Cheng (2005) for microarray experiments with a variety of designs. Pounds and Onar (2015) developed and describe this software library.

License

Getting Started

You will need to install the freely available R software on your machine. See www.r-project.org for more details on how to do this.

Next, you will need to download the FDRsampsize.targ.gz package and *fdr-sampsize-demo.R* from http://www.stjuderesearch.org/site/depts/biostats/FDRsampsize and save them on your machine. Then execute the command install.packages("download.dir/FDRsampsize_1.0.tar.gz",repos=NULL,type="source") in R, where download.dir is the directory to which the file was saved. Also, you may wish to execute *fdr-sampsize-demo.R* one line at a time as an example of how to use the library.

Routines of Interest

The package FDRsampsize defines 7 routines that are of primary interest to the end user. Each of these routines is described in greater detail below.

The fdr.sampsize Function

The *fdr.sampsize* function requires the user to specify a desired level of FDR control, a desired average power, an effect size vector, and the name of a function to compute the statistical power for the test of interest. It returns an object with the results of the sample size calculation. This object includes an indicator of whether the specified requirements were satisfied, the computed sample size, the anticipated p-value cut-off for significance in the final analysis, the anticipated value of the FDR estimate at that p-value cut-off, the anticipated actual FDR at that cut-off, the anticipated value of the estimate of the

proportion of tests with a true null (i.e., the null proportion), and the actual null proportion. Table 1 gives details for all arguments and all components of the results object.

The fdr.power Function

The *fdr.power* function requires the user to specify the desired level of FDR control, a sample size, an effect size vector, and the name of the R function that computes statistical power. It returns a scalar with the computed average power. Table 2 provides details for all arguments and the results of the *fdr.power* routine.

Power Routines for Specific Statistical Tests

We have defined seven R functions to compute the power of specific statistical tests for use in conjunction with *fdr.sampsize* and *fdr.power*. The functions *power.cox*, *power.onesampt*, *power.twosampt*, *power.oneway*, *power.tcorr*, *power.ranksum*, and *power.signtest* return the power of Cox regression, the one sample t-test, the equal-variance two-sample t-test, one-way analysis of variance (ANOVA), the t-test for nonzero correlation, the rank-sum test, and the sign test, respectively. The routine *power.cox* is based on the power formula of Hsieh and Lavori (2000). The routines *power.ranksum* and *power.signtest* are based on the power formula of Noether (1987). The other routines are based on classical power functions. Each function returns an unnamed vector giving the statistical power for the test corresponding to the same element of the input effect size vector. Table 3 outlines the names and arguments of these functions.

Performing the Calculations

The file *fdr-sampsize-demo.R* gives examples of how to use each of these power functions in conjunction with *fdr.sampsize* and *fdr.power* to perform sample size and power calculations, respectively. The commands are issued and the results can be saved to an object if desired. One can then use the name of the object and the $-sign notation to extract the components of interest.

Using the Routines with User-Defined Power Functions

The *fdr.sampsize* and *fdr.power* functions can be used to perform power calculations for other experiments. The user simply needs to define an R function that computes the power function of interest. This power function must accept a scalar sample size as its first argument, a scalar p-value cut-off as its second argument, and an effect size vector as its third argument. It may accept additional arguments so long as they do not duplicate the arguments of *fdr.sampsize* or *fdr.power*. Then, the calculations can be performed in the same way that is shown in *fdr-sampsize-demo.R*.

Lower-level Routines

The file *fdr-sampsize-library.R* defines a number of lower level routines that may be of interest to developers. The arguments and result components for each routine are documented in the comments of the code. These routines typically utilize bisection or numerical differentiation to solve for specific quantities of interest.

Works Cited

Hsieh, FY and Lavori, PW (2000) Sample size calculations for the Cox proportional hazards model with nonbinary covariates. *Controlled Clinical Trials* 21: 552-560.

Noether, G.E. (1987) Sample Size Determination for Some Common Nonparametric Tests. *Journal of the American Statistical Association,* 82: 645-647.

Pounds, S and Cheng, C (2005). Sample Size Determination for the False Discovery Rate. *Bioinformatics*, 21: 4263-4271.

Pounds, S and Onar, A (2015) Software to Perform Power and Sample Size Calculations for Microarray Studies, manuscript.

Table 1. Arguments and Results of the *fdr.sampsize* function.

Arguments		Components of Results	
Name (Default)	**Description (Details)**	**Name**	**Description**
fdr	Required level of FDR control (scalar)	OK	indicates (T/F) if requirements are satisfied
ave.pow	Required average power (scalar)	alpha	estimated p-value cut-off in FDR control procedure (scalar)
eff.size	effect size vector (vector)	fdr.hat	approximated expected value of FDR estimate at alpha (scalar)
pow.func	name of R function to compute power for the statistical test of interest	act.fdr	approximate actual FDR (scalar)
max.n (500)	maximum sample size to consider (scalar)	ave.pow	approximated average power (scalar)
min.n (5)	minimum sample size to consider (scalar)	act.pi	actual proportion of tests with true null (scalar, from eff.size)
tol (0.00001)	tolerance for bisection algorithm to solve for alpha in iterations (scalar)	pi.hat	approximated expected value of the estimate of the null proportion (scalar)
eps (0.00001)	epsilon for numerical differentiation (scalar)	eff.size	input effect size vector
lam (0.95)	p-value at which to evaluate ensemble PDF (scalar)		
null.effect (0)	value of the effect size that corresponds to the null hypothesis. Set value to 0.5 for *power.signtest* and *power.ranksum*.		
…	additional arguments to pow.func		

Table 2. Arguments and Results of the *fdr.power* function.

Arguments		Components of Results	
Name (Default)	**Description (Details)**	**Name**	**Description**
fdr	level of FDR control (scalar)	[none]	average power (scalar)
n	sample size (scalar)		
eff.size	effect size vector (vector)		
pow.func	name of R function to compute power for the statistical test of interest		
lam (0.95)	p-value at which to evaluate ensemble PDF (scalar)		
eps (0.00001)	epsilon for numerical differentiation (scalar)		
tol (0.00001)	tolerance for bisection algorithm to solve for alpha in iterations (scalar)		
null.effect (0)	value of the effect size that corresponds to the null hypothesis. Set value to 0.5 for *power.signtest* and *power.ranksum*.		
…	additional arguments to pow.func		

Table 3. Statistical Power Functions.

Function	Argument (Default)	Description (Details)
power.cox	n	number of events
	alpha	p-value cut-off (scalar)
	logHR	vector of log hazard ratios
	v (1)	variance of covariate (scalar or vector)
power.onesampt	n	sample size (scalar)
	alpha	p-value cut-off (scalar)
	delta	difference between actual mean and null mean (vector)
	sigma (1)	standard deviation (scalar or vector)
power.twosampt	n	per-group sample size (scalar)
	alpha	p-value cut-off (scalar)
	delta	difference between group means (vector)
	sigma	standard deviation (scalar or vector)
power.oneway	n	per-group sample size
	alpha	p-value cut-off (scalar)
	theta	sum of squared deviations of group means from overall mean divided by variance (vector)
	k (2)	number of groups (scalar)
power.tcorr	n	Sample size (scalar)
	alpha	p-value cut-off (scalar)
	rho	correlation in population (vector)
power.ranksum	n	per-group sample size (scalar)
	alpha	p-value cut-off (scalar)
	p	Pr (X>Y) in Noether (1987)
power.signrank	n	sample size (scalar)
	alpha	p-value cut-off (scalar)
	p	Pr (X>Y) in Noether (1987)