

Basics of ReportingTools

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January 4, 2019

Contents

1	Introduction	2
2	Basics of Reporting	2
3	Adding plots or text to a report	3
4	Adding plots or links to a report table	5
5	Multiple Tables to the same page	6
6	Publishing other types of data and more advanced features	7
7	References	7

1 Introduction

Frequently, when performing an analysis, it is helpful to be able to share these results in several formats at once: as HTML tables, csv files or even as R data packages. `ReportingTools` attempts to make this as painless as possible. At its heart, `ReportingTools` is based on a number of pieces of interlocking machinery that transform popular `Bioconductor` objects into reports.

In this vignette we will highlight the fundamentals of `ReportingTools`. `ReportingTools` has several methods for displaying microarray and RNA-seq results and can also be incorporated into `shiny` applications and `knitr` reports; for more details, please refer to the corresponding vignettes (`knitr.Rmd` and `shiny.Rnw`, respectively) or the `ReportingTools` site.

For more information on `ReportingTools`, please see Huntley, Larson, *et al.* (2013).

2 Basics of Reporting

The easiest type of report to generate is a csv file. This is done using the `CSVFile` class and the `publish` method. To start we'll create a `data.frame` that we'll use throughout the vignette.

```
> my.df <- data.frame(EGID = c("103", "104", "105", "106", "107"),
+                      RPKM = c(4, 5, 3, 100, 75),
+                      DE = c("Yes", "Yes", "No", "No", "No"))
> my.df
```

	EGID	RPKM	DE
1	103	4	Yes
2	104	5	Yes
3	105	3	No
4	106	100	No
5	107	75	No

Next, we'll create the `CSVFile` object to which we'll publish our results. We output the results to a new directory called `reports`. Note that `ReportingTools` will create this directory for you if it does not exist already.

```
> library(ReportingTools)
> csvFile <- CSVFile(shortName = "my_csv_file",
+                    reportDirectory = "./reports")
> publish(my.df, csvFile)
```

Obviously, this isn't much less work than just calling `write.csv` on the `data.frame` itself, but this is really just a toy example. We can also publish the `data.frame` as an HTML report.

```
> htmlRep <- HTMLReport(shortName = "my_html_file",
+                       reportDirectory = "./reports")
> publish(my.df, htmlRep)
> finish(htmlRep)
```

It's necessary to call `finish` on the `HTMLReport`, to allow the contents to be written to the file.

It's also possible to publish the same object in two separate formats at once.

```
> csvFile2 <- CSVFile(shortName = "my_csv_file2",
+                    reportDirectory = "./reports")
```

my_html_file

EGID	RPKM	DE
103	4	Yes
104	5	Yes
105	3	No
106	100	No
107	75	No

Figure 1: Resulting page created by `publish` for `my.df`.

```
> htmlRep2 <- HTMLReport(shortName = 'my_html_file2',
+   title="Publishing a data frame and csv file together",
+   reportDirectory = "./reports")
> publish(my.df, list(csvFile2, htmlRep2))
> finish(htmlRep2)
```

The same few lines of code could be used to publish, for example, the results of a `limma` differential expression analysis, or the results of a Gene Ontology analysis, all without worrying about coercing the objects to a tabular format ourselves. For more information, see the microarray and RNA-seq vignettes.

3 Adding plots or text to a report

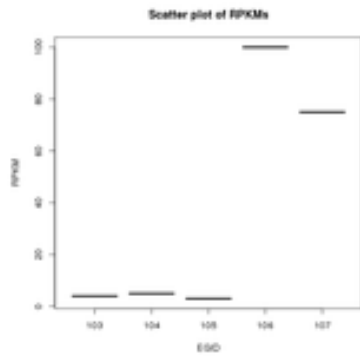
To add links, additional text or plots to a report, simply open the report with `HTMLReport`, write to it via the `publish` function and then call `publish` on the original data frame and `finish` the report. Below we make a simple plot and then add it and some descriptive text to our report.

```
> plot(my.df$EGID, my.df$RPKM, xlab="EGID",
+   ylab="RPKM", main="Scatter plot of RPKMs", col="blue")
> scatterPlot <- recordPlot()
> library(lattice)
> barPlot <- barchart(my.df$RPKM~my.df$EGID) ##lattice plots behave slightly differently
> htmlRep3 <- HTMLReport(shortName = "my_html_file3", title="Adding a plot directly to the page",
+   reportDirectory = "./reports")
> publish(scatterPlot, htmlRep3, name = "scatterPlot")
> publish("This is a bar plot", htmlRep3)
> publish(barPlot, htmlRep3, name = "barPlot")
> publish(my.df, htmlRep3, name="Table")
> finish(htmlRep3)
```

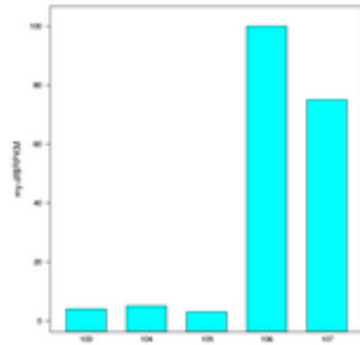
We can also publish existing images and text directly to sites with `hwriter` .

```
> png(filename="reports/barplot.png")
> barplot(my.df$RPKM, names.arg=my.df$EGID, xlab="EGID",
+   ylab="RPKM", main="Bar plot of RPKMs", col="blue")
> dev.off()
```

Adding a plot directly to the page



This is a bar plot



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EGID	RPKM	DE
103	4	Yes
104	5	Yes
105	3	No
106	100	No
107	75	No

Showing 1 to 5 of 5 entries ← Previous 1 Next →

Figure 2: Resulting page created after adding additional figures and text with publish.

```

> library(hwriter)
> htmlRep4 <- HTMLReport(shortName = "my_html_file4", title="Adding a link, text and image",
+   reportDirectory = "./reports")
> publish(hwrite("This is a link to Bioconductor", link = "http://www.bioconductor.org"), htmlRep4)
> publish(hwrite("Bar chart of results", heading=2), htmlRep4)
> himg <- hwriteImage("barplot.png", link="barplot.png")
> publish(hwrite(himg, br=TRUE), htmlRep4)
> publish(hwrite("Results Table", heading=2), htmlRep4)
> publish(my.df, htmlRep4)
> finish(htmlRep4)

```

4 Adding plots or links to a report table

To add additional plots or links to a report table, we can create a new data frame with the path to the plots and our links of interest. We then `publish` this data frame.

Below we make a set of simple plots and then add the images along with new links to the NCBI gene database to our data frame.

```

> imagename <- c()
> for (i in 1:nrow(my.df)){
+   imagename[i] <- paste0("plot", i, ".png")
+   png(filename = paste0("reports/", imagename[i]))
+   plot(my.df$RPKM[i], ylab="RPKM", xlab = my.df$EGID[i], main = "RPKM Plot", col = "blue")
+   dev.off()
+ }
> my.df$Image <- hwriteImage(imagename, link = imagename, table = FALSE, width=100, height=100)
> my.df$link <- hwrite(as.character(my.df$EGID), link = paste("http://www.ncbi.nlm.nih.gov/gene/",
+   as.character(my.df$EGID), sep = ''), table=FALSE)
> htmlRep5 <- HTMLReport(shortName = "my_html_file5",
+   title = "Adding images and links to data frame directly",
+   reportDirectory = "./reports")
> publish(my.df, htmlRep5)
> finish(htmlRep5)

```

We can also update our data frame by editing, adding and removing columns with functions. We then include these functions in our `publish` call as a list with `.modifyDF` and `.toHTML`. `.modifyDF` uses the basic data frame as its default object and then modifies it with the corresponding function.

```

> ##this function adds 5 to each value of my.df$RPKM
> add5 <- function(object,...){
+   object$plus5 <- object$RPKM+5
+   return(object)
+ }
> ##this function replaces the scatter plot images with new plots
> makeNewImages<-function(object,...){
+   imagename <- c()
+   for (i in 1:nrow(object)){
+     imagename[i] <- paste0("plotNew", i, ".png")
+     png(filename = paste0("reports/", imagename[i]))
+     plot(object$RPKM[i], ylab = "RPKM", xlab = object$EGID[i],
+       main = "New RPKM Plot", col = "red", pch = 15, cex=3)

```

Manipulating the data frame directly

EGID	RPKM	DE	Image	plus5
103	4	Yes		9
104	5	Yes		10
105	3	No		8
106	100	No		105

Figure 3: Resulting page created after adding figures and links to table with `.modifyDF`.

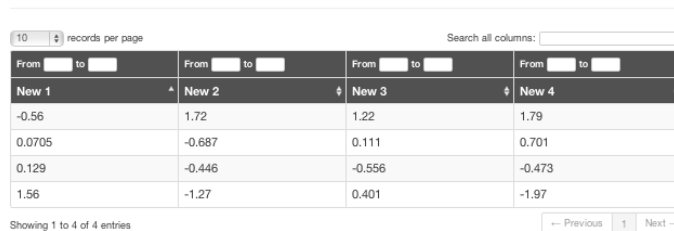
```
+           dev.off()
+       }
+       object$Image <- hwriteImage(imagename, link = imagename, table = FALSE, height=150, width=150)
+       return(object)
+   }
> ##This function removes the link column
> removeLink <- function(object, ...){
+     object <- subset(object, select = -Link)
+     return(object)
+ }
> ##This function links the EGID column to the entrez database
> addEGIDLink <- function(object, ...){
+     object$EGID <- hwrite(as.character(object$EGID),
+                           link = paste0("http://www.ncbi.nlm.nih.gov/gene/",
+                                           as.character(object$EGID)), table = FALSE)
+     return(object)
+ }
> htmlRep6 <- HTMLReport(shortName = "my_html_file6",
+                        title = "Manipulating the data frame directly",
+                        reportDirectory = "./reports")
> publish(my.df, htmlRep6,
+         .modifyDF = list(add5, makeNewImages, removeLink, addEGIDLink))
> finish(htmlRep6)
```

5 Multiple Tables to the same page

It is also possible to publish multiple tables to the same html page. We can change the order of the tables via `pos`.

```
> df2 <- data.frame(x = 1:5, y = 11:15)
> df3 <- data.frame(x = c("a", "b", "c"), y = 1:3)
> htmlRep7 <- HTMLReport(shortName = "my_html_file7", title = "Many tables, one page",
```

Publishing objects that are not data frames



From <input type="text"/> to <input type="text"/>	From <input type="text"/> to <input type="text"/>	From <input type="text"/> to <input type="text"/>	From <input type="text"/> to <input type="text"/>
New 1	New 2	New 3	New 4
-0.56	1.72	1.22	1.79
0.0705	-0.687	0.111	0.701
0.129	-0.446	-0.556	-0.473
1.56	-1.27	0.401	-1.97

Figure 4: Resulting page created after transforming a matrix to a data frame with `.toDF`.

```
+                               reportDirectory = "./reports")
> publish(my.df, htmlRep7,
+         .modifyDF = list(add5, makeNewImages, removeLink, addEGIDLink),
+         name = "Df1")
> publish(df2, htmlRep7, name = "Df2")
> publish(df3, htmlRep7, name = "Df3", pos = 2)
> finish(htmlRep7)
```

6 Publishing other types of data and more advanced features

To publish data that is not a data frame, there is a need to create and use a `.toDF` function. For example, suppose we have a matrix we would like to publish. `ReportingTools` will convert the basic matrix to a `data.frame` and then publish it.

```
> set.seed(123)
> my.mat <- matrix(rnorm(20), nrow=5)
> makeDF <- function(object, ...){
+   df <- as.data.frame(object[-2,])
+   names(df) <- paste0("New ", 1:4)
+   return(df)
+ }
> htmlRep8 <- HTMLReport(shortName = 'my_html_file8',
+                        title="Publishing objects that are not data frames",
+                        reportDirectory = "./reports")
> publish(my.mat, htmlRep8, .toDF = makeDF)
> finish(htmlRep8)
```

For publishing experimental results, including how to publish a `limma`-based linear model and a `edgeR` objects, please see the relevant vignettes. There are built-in `ReportingTools` methods to publish non-data frame objects typically encountered in microarray and RNA-seq analyses. Example output is shown below.

7 References

Huntley, M.A., Larson, J.L., Chaivorapol, C., Becker, G., Lawrence, M., Hackney, J.A., and J.S. Kaminker. (2013). `ReportingTools`: an automated results processing and presentation toolkit for high throughput genomic analyses. *Bioinformatics*. **29**(24): 3220-3221.

Analysis of BCR/ABL translocation differential expression

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Probeld	EntrezId	Symbol	GeneName	Image	mol.bioIBCR/ABL logFC	mol.bioIBCR/ABL Adjusted p-Value
40202_at	687	KLF9	Kruppel-like factor 9		2.420	1.01e-11
1635_at	25	ABL1	c-abl oncogene 1, non-receptor tyrosine kinase		1.170	3.48e-10
40504_at	5445	PON2	paraoxonase 2		1.220	9.77e-10

Figure 5: Resulting page created for analysis of a microarray study with `limma`.