

Basics of ReportingTools

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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

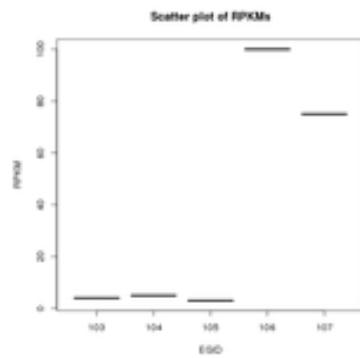
To add links, additional text or plots to a report, simply open the report with `HTMLReport`, write to it via the `publish` function and then call `publish` on the original data frame and `finish` the report. Below we make a simple plot and then add it and some descriptive text to our report.

```
> 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)
```

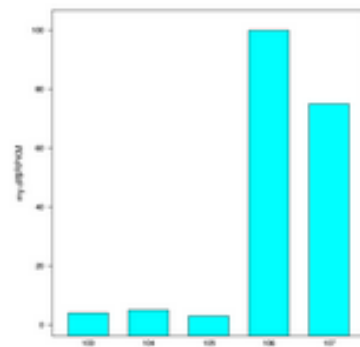
We can also publish existing images and text directly to sites with `hwriter` .

```
> 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



10 records per page Search all columns:

| 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

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 |

Showing 1 to 4 of 4 entries

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

10 records per page

Search all columns:

| Probeld | EntrezId | Symbol | GeneName | Image | mol.biolBCR/ABL logFC | mol.biolBCR/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`.