archivist: Tools for Storing, Restoring and Searching for R Objects

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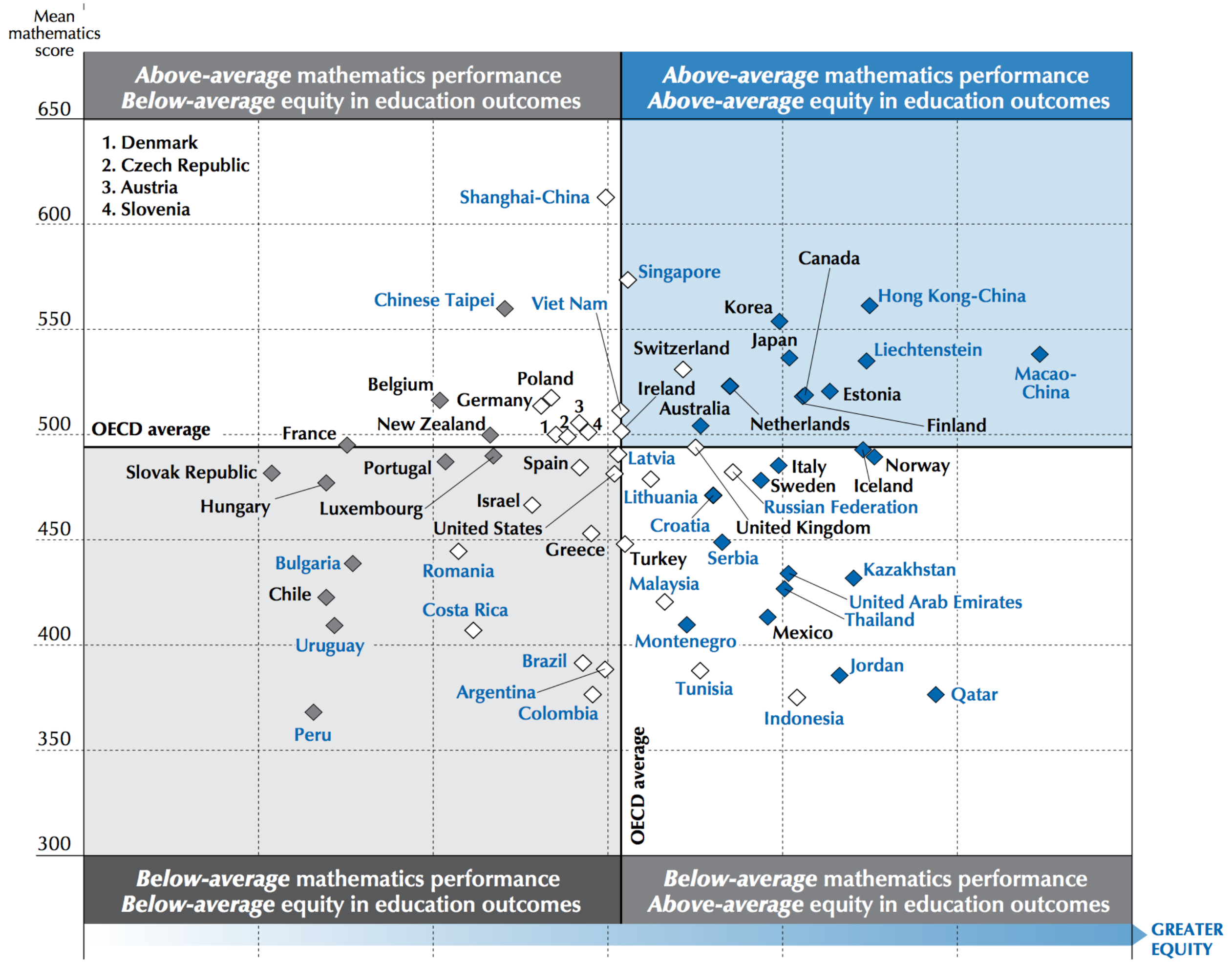
```
> sessionInfo()
[1] ”June 30 - July 3, 2015”
[2] ”Aalborg, Denmark”
```

Motivation: StatLink (at) OECD



Source: OECD, PISA 2012 Database, Table II.2.1.
StatLink http://dx.doi.org/10.1787/888932964794

Reproducible research

With great tools, like knitr or Sweave, one can prepare excellent and reproducible report/article.

However:

- sometimes raw data are large or with limited access,
- computations take a lot of time or require specialized hardware,
- require specific versions of packages,
- …

Instead of reproducing all results we may ask for only for scripts that retrieve required results.

How this may be useful?
Let’s see some examples.

Use Case 1:

We found an interesting plot/table in an article.

Is there a way to retrieve corresponding data?

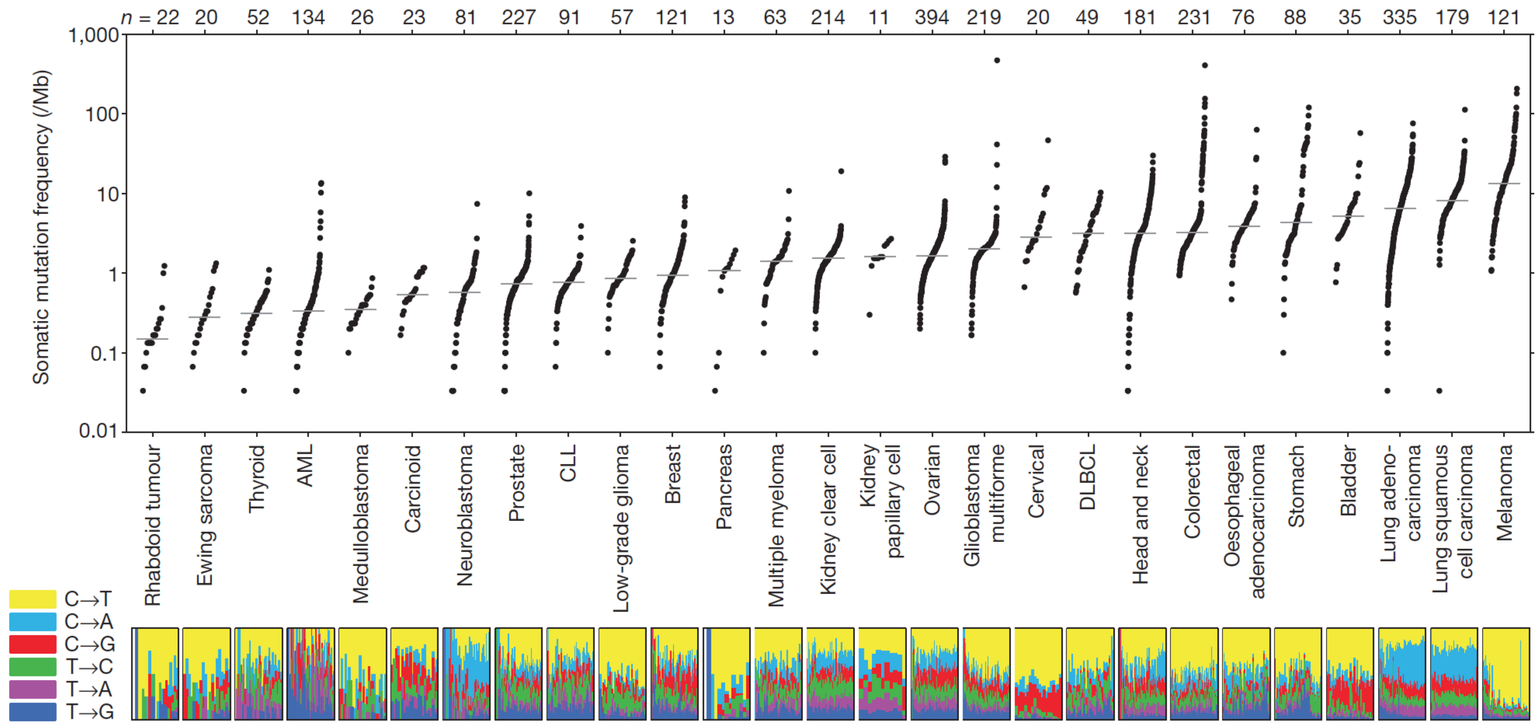
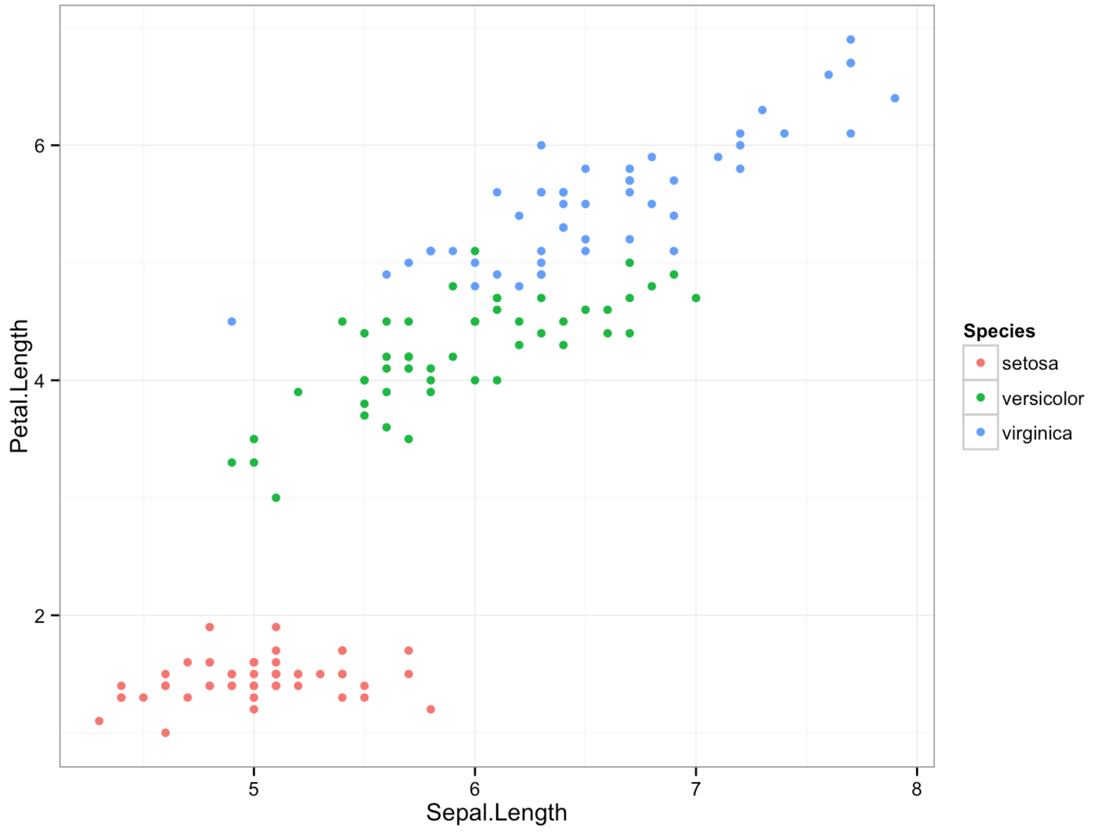


Figure 1 | Somatic mutation frequencies observed in exomes from 3,083 tumour–normal pairs. Each dot corresponds to a tumour–normal pair, with vertical position indicating the total frequency of somatic mutations in the exome. Tumour types are ordered by their median somatic mutation frequency, with the lowest frequencies (left) found in haematological and paediatric tumours, and the highest (right) in tumours induced by carcinogens such as tobacco smoke and ultraviolet light. Mutation frequencies vary more than 1,000-fold between lowest and highest across different cancers and also within several tumour types. The bottom panel shows the relative proportions of the six different possible base-pair substitutions, as indicated in the legend on the left. See also Supplementary Table 2.

Hooks to R objects

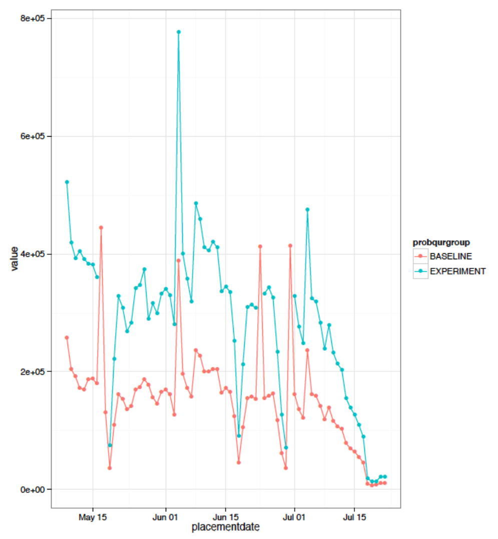
With archivist, for any data.frame, R plot, R object, one can generate a simple one line instruction that retrieves R object. Include it in figure/table caption, blog post, stackoverflow…

```
# the full object name is 32 characters long, but first few is enough
# archivist::aread("pbiecek/graphGallery/2166dfbd3a7a68a91a2f8e6df1a44111")
archivist::aread("pbiecek/graphGallery/2166d")
```



Hooks to R objects

With archivist, you can print calling cards for R objects and keep best objects in your wallet.



fe1dd9777fc4138314492258ec95e625

Use Case 2:

Saving objects should be as easy as possible.

Storing objects should be as easy as possible

Let’s create a plot.

```
library("ggplot2")
pl <- ggplot(iris, aes(y=Petal.Length, x=Sepal.Length, color=Species)) +
             geom_point() + theme_bw()
```

With archivist, saving an object is just a single call of `saveToRepo()`.

```
library("archivist")
repo <- "archivist_test"
createEmptyRepo(repo)
saveToRepo(pl, repo)
```

```
[1] "fcbbeae563766ce7fb042a57f4d44f28"
attr(,"data")
[1] "ff575c261c949d073b2895b05d1097c3"
```

Storing objects should be as easy as possible

Let’s create a plot.

```
library("ggplot2")
pl <- ggplot(iris, aes(y=Petal.Length, x=Sepal.Length, color=Species)) +
             geom_point() + theme_bw()
```

With archivist, saving an object is just a single call of `saveToRepo()`.

```
library("archivist")
repo <- "archivist_test"
createEmptyRepo(repo)
saveToRepo(pl, repo)
```

```
showLocalRepo(repo, "tags")
```

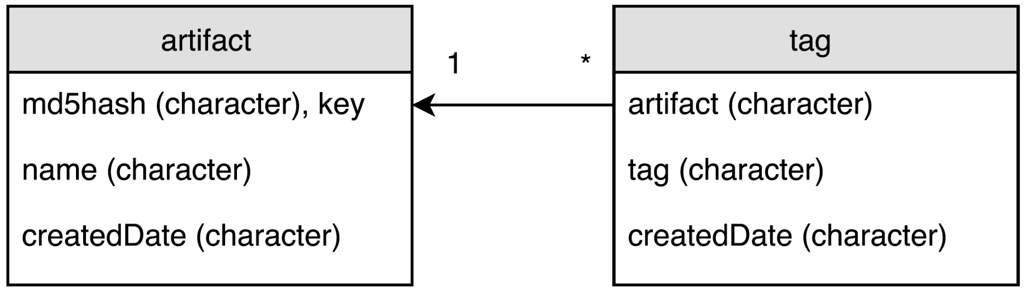
```
                          artifact                                         tag         createdDate
1 fcbbeae563766ce7fb042a57f4d44f28                        labelx:Sepal.Length 2015-07-01 08:42:28
2 fcbbeae563766ce7fb042a57f4d44f28                        labely:Petal.Length 2015-07-01 08:42:28
3 fcbbeae563766ce7fb042a57f4d44f28                                   class:gg 2015-07-01 08:42:28
4 fcbbeae563766ce7fb042a57f4d44f28                               class:ggplot 2015-07-01 08:42:28
5 fcbbeae563766ce7fb042a57f4d44f28                                    name:pl 2015-07-01 08:42:28
6 fcbbeae563766ce7fb042a57f4d44f28                   date:2015-07-01 08:42:28 2015-07-01 08:42:28
7 ff575c261c949d073b2895b05d1097c3 relationWith:fcbbeae563766ce7fb042a57f4d44f28 2015-07-01 08:42:28
```

How the repository looks like?

Each repository has following structure:

- SQLite database stored in the file `backpack.db`
- directory named `gallery`, with objects and miniatures (rda, png and txt files).

Tags and artifact’s meta data are stored in two tables.



Use Case 3:

Few weeks ago we have created an R object
and now we would like to find it.

How we can find it?

Searching in the repository

With archivist, you can search for artefacts by pointing their properties, like class, object’s attributes, variable names and others.

Let’s find all objects of the class gg

```
plots <- asearch("pbiecek/graphGallery",
                 patterns = "class:gg")
length(plots)
```

```
[1] 4
```

Searching in the repository

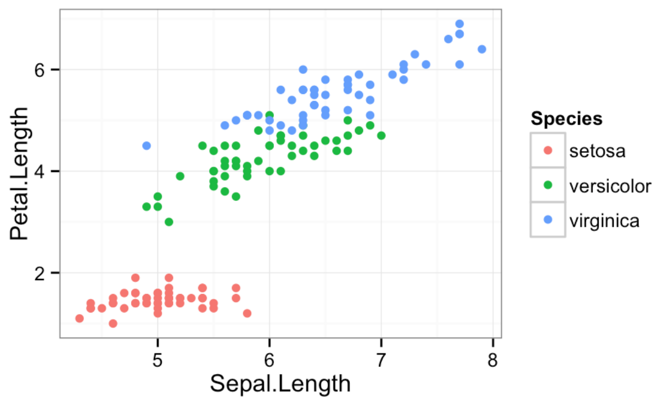
With archivist, you can search for artefacts by pointing their properties, like class, object’s attributes, variable names and others.

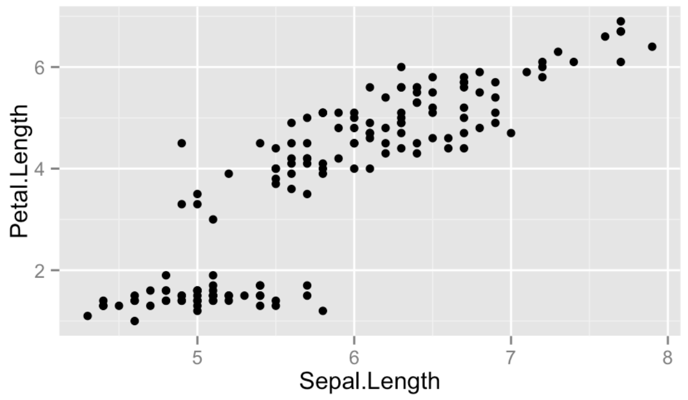
Let’s find all objects of the class gg

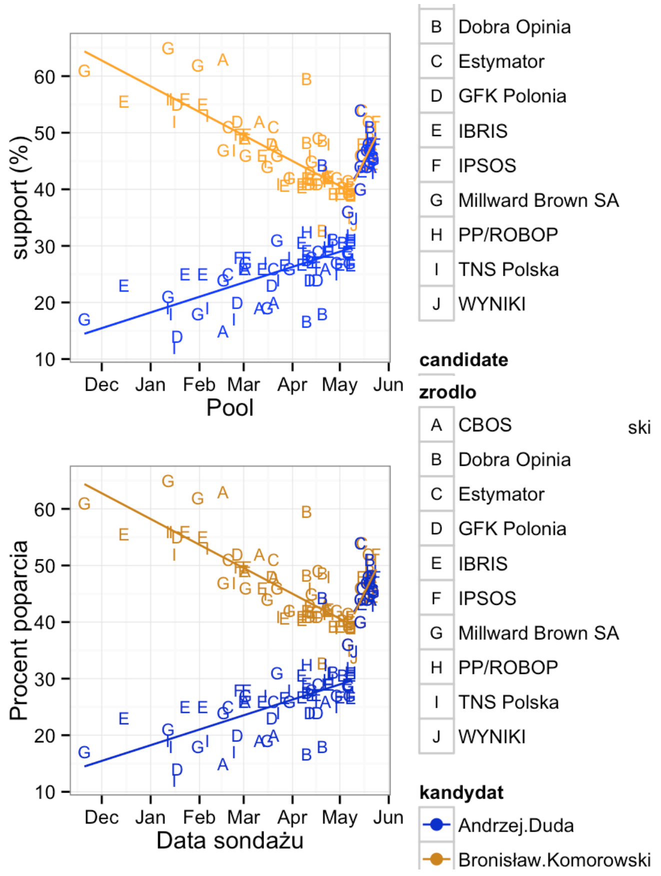
```
plots <- asearch("pbiecek/graphGallery",
                 patterns = "class:gg")
length(plots)
```

After retrieving all plots that fit given pattern, you can plot them all.

```
library(gridExtra)
do.call(grid.arrange,  plots)
```


Petal.Length
Sepal.Length
Species
setosa
versicolor
virginica

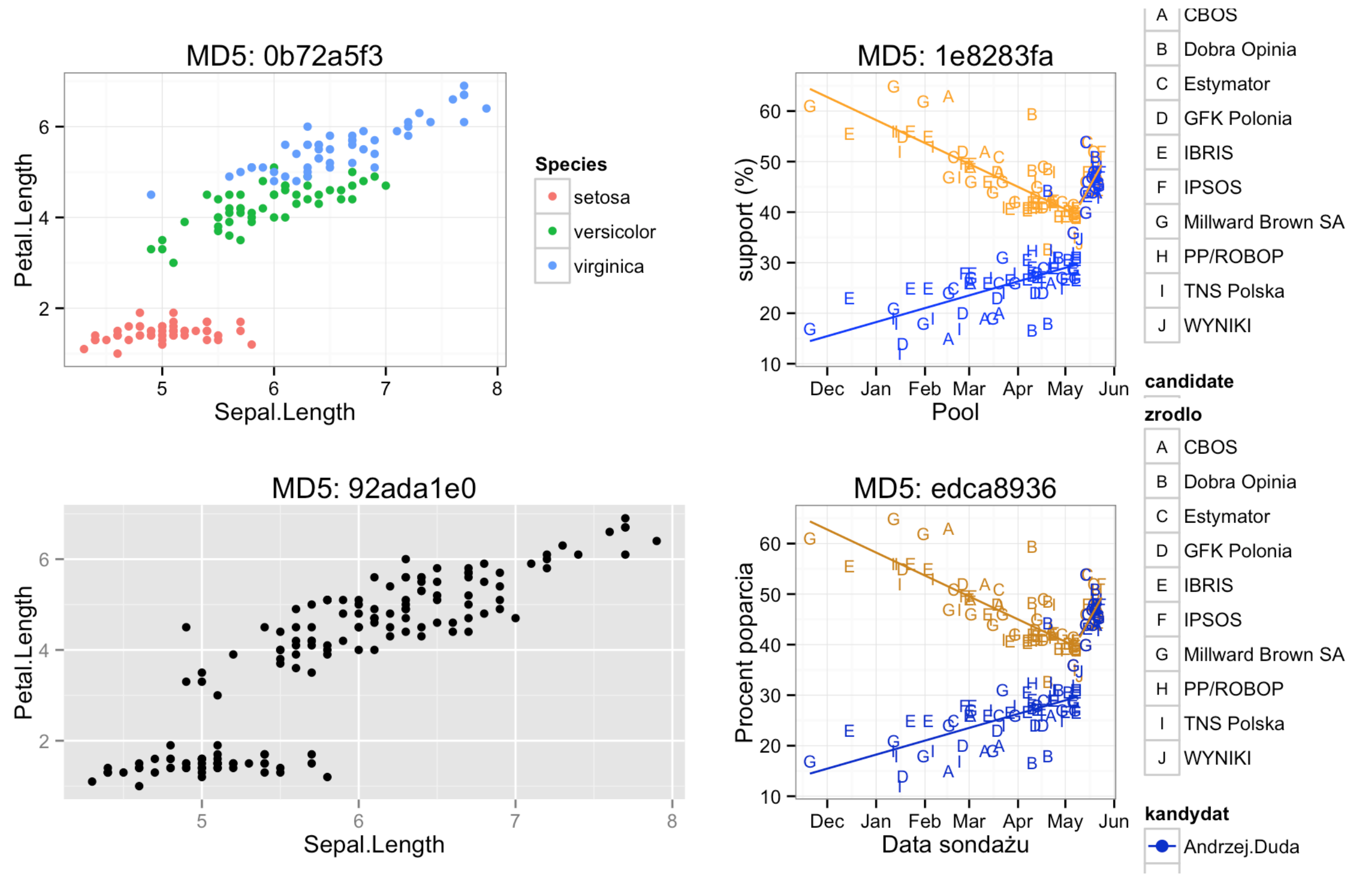

Petal.Length
Sepal.Length


support (%)
Pool
Dec
Jan
Feb
Mar
Apr
May
Jun
B Dobra Opinia
C Estymator
D GFK Polonia
E IBRIS
F IPSOS
G Millward Brown SA
H PP/ROBOP
I TNS Polska
J WYNIKI
candidate
zrodlo
A CBOS
ski
B Dobra Opinia
C Estymator
D GFK Polonia
E IBRIS
F IPSOS
G Millward Brown SA
H PP/ROBOP
I TNS Polska
J WYNIKI
kandydat
Andrzej.Duda
Bronisław.Komorowski
Procent poparcia
Data sondażu

Retrieved objects might be updated

Objects may be also updated or additionally tagged. Here we add titles with plot's MD5 hashes for each plot.

```
plots2 <- lapply(plots,
                 function(x)
                   x + ggtitle(paste("MD5:",substr(digest::digest(x), 1, 8))))
do.call(grid.arrange,  plots2)
```



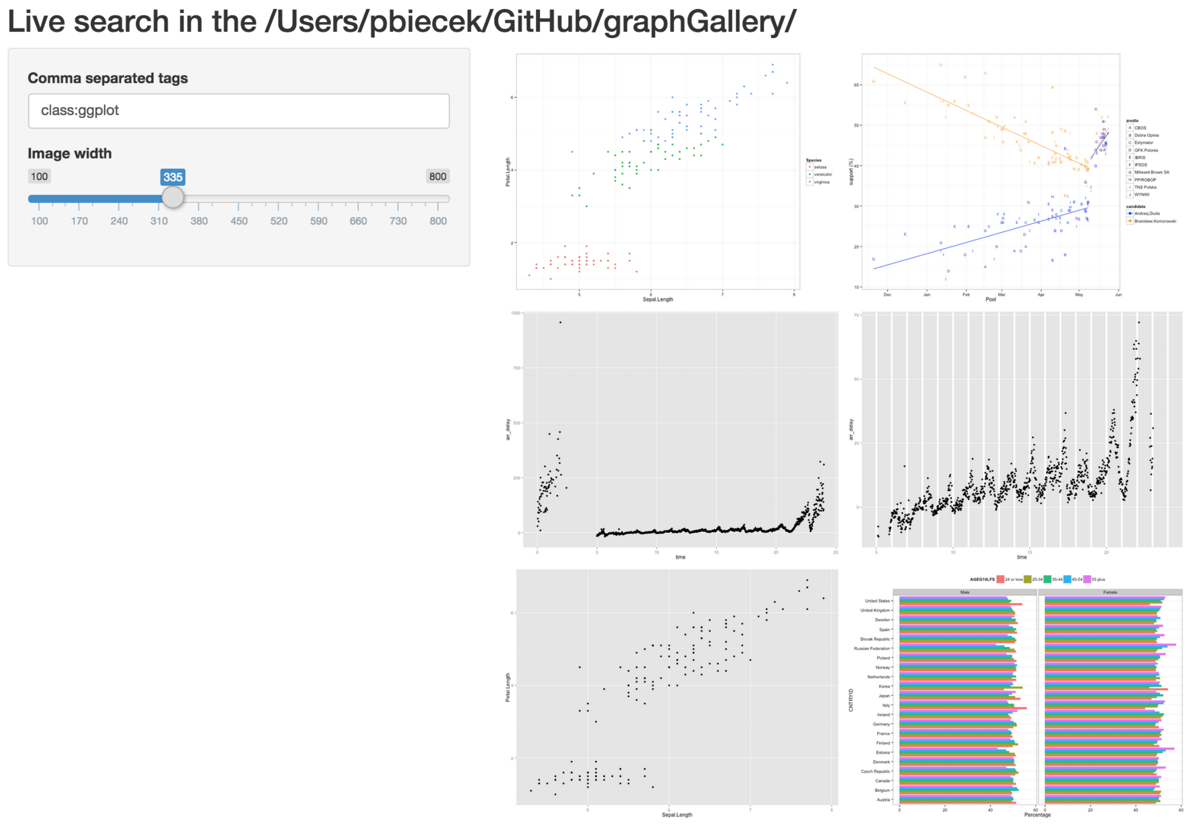
Use Case 4:

Explore the repository in an interactive fashion

Interactive browser for R objects

With archivist, you can interactively explore artefacts in the repository with the shiny app created on-the-fly.

```
repo <- "/Users/pbiecek/GitHub/graphGallery/"
shinySearchInLocalRepo(repo)
```



Live search in the /Users/pbiecek/GitHub/graphGallery/

Comma separated tags

class:ggplot

Image width

100 335 800

100 170 240 310 380 450 520 590 660 730 800

Use Case 5:

We have an R object.

Is there a way to check how the object was created?

Object’s pedigree

We have extended the `%>%` operator from magrittr. The new operator saves all calls and results with additional meta information that allow to recreate a path from which the object was created.

If this operator is used, then for any resulting object we can restore it’s pedigree.

```r
library("dplyr")
setLocalRepo("/Users/pbiecek/GitHub/graphGallery/")

iris %a%
   filter(Sepal.Length < 6) %a%
   lm(Petal.Length~Species, data=.) %a%
   summary() -> tmp
```

Object's pedigree

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library("dplyr")
setLocalRepo("/Users/pbiecek/GitHub/graphGallery/")

iris %a%
   filter(Sepal.Length < 6) %a%
   lm(Petal.Length~Species, data=.) %a%
   summary() -> tmp
```

Calls and partial results are stored as tags in archivist repository.

```
ahistory(tmp)
```

```
   iris                                   [ff575c261c949d073b2895b05d1097c3]
-> filter(Sepal.Length < 6)               [d3696e13d15223c7d0bbccb33cc20a11]
-> lm(Petal.Length ~ Species, data = .)   [990861c7c27812ee959f10e5f76fe2c3]
-> summary()                              [050e41ec3bc40b3004bc6bdd356acae7]
```

```
ahistory(md5hash = "050e41ec3bc40b3004bc6bdd356acae7")
```

```
   iris                                   [ff575c261c949d073b2895b05d1097c3]
-> filter(Sepal.Length < 6)               [d3696e13d15223c7d0bbccb33cc20a11]
-> lm(Petal.Length ~ Species, data = .)   [990861c7c27812ee959f10e5f76fe2c3]
-> summary()                              [050e41ec3bc40b3004bc6bdd356acae7]
```

Use Case 6:

We have an approved scoring model.

We want to make sure that exactly this model is used.

We need a way to check if we are using the right model.

Verification of identity of an object

In archivist, unique MD5 hashes identify objects. Hashes can be easily verified.

```r
library("archivist")
model <- aread("pbiecek/graphGallery/2a6e492cb6982f230e48cf46023e2e4f")
digest::digest(model)
```

```
[1] "2a6e492cb6982f230e48cf46023e2e4f"
```

Verification of identity of an object

In archivist, unique MD5 hashes identify objects. Hashes can be easily verified.

```r
library("archivist")
model <- aread("pbiecek/graphGallery/2a6e492cb6982f230e48cf46023e2e4f")
```

```r
digest::digest(model)
```

```
[1] "2a6e492cb6982f230e48cf46023e2e4f"
```

```r
summary(model)
```

```

Call:
lm(formula = Petal.Length ~ Sepal.Length + Species, data = iris)

Residuals:
     Min       1Q   Median       3Q      Max 
-0.76390 -0.17875  0.00716  0.17461  0.79954 

Coefficients:
                  Estimate Std. Error t value Pr(>|t|)    
(Intercept)       -1.70234    0.23013  -7.397 1.01e-11 ***
Sepal.Length       0.63211    0.04527  13.962  < 2e-16 ***
Speciesversicolor  2.21014    0.07047  31.362  < 2e-16 ***
Speciesvirginica   3.09000    0.09123  33.870  < 2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.2826 on 146 degrees of freedom
Multiple R-squared:  0.9749,	Adjusted R-squared:  0.9744 
F-statistic:  1890 on 3 and 146 DF,  p-value: < 2.2e-16
```

Use Case 7:

Can we use achivist to cache function results?

Cache

With archivist, you can use cache function to accumulate results from previous calls.

```
library(lubridate)
# a temporary directory as a repo
cacheRepo <- tempdir()
createEmptyRepo( cacheRepo )
# some toy function
fun <- function(n) {replicate(n, summary(lm(Sepal.Length~Species, iris))$r.squared)}

# first execution
system.time(   cache(cacheRepo, fun, 100)   )
```

```
   user  system elapsed
  0.148   0.002   0.150
```

Cache

With archivist, you can use cache function to accumulate results from previous calls.

```r
library(lubridate)
# a temporary directory as a repo
cacheRepo <- tempdir()
createEmptyRepo( cacheRepo )
# some toy function
fun <- function(n) {replicate(n, summary(lm(Sepal.Length~Species, iris))$r.squared)}

# first execution
system.time(   cache(cacheRepo, fun, 100)   )
```

```
   user  system elapsed
  0.159   0.005   0.165
```

```r
# second execution is much faster
system.time(   cache(cacheRepo, fun, 100)   )
```

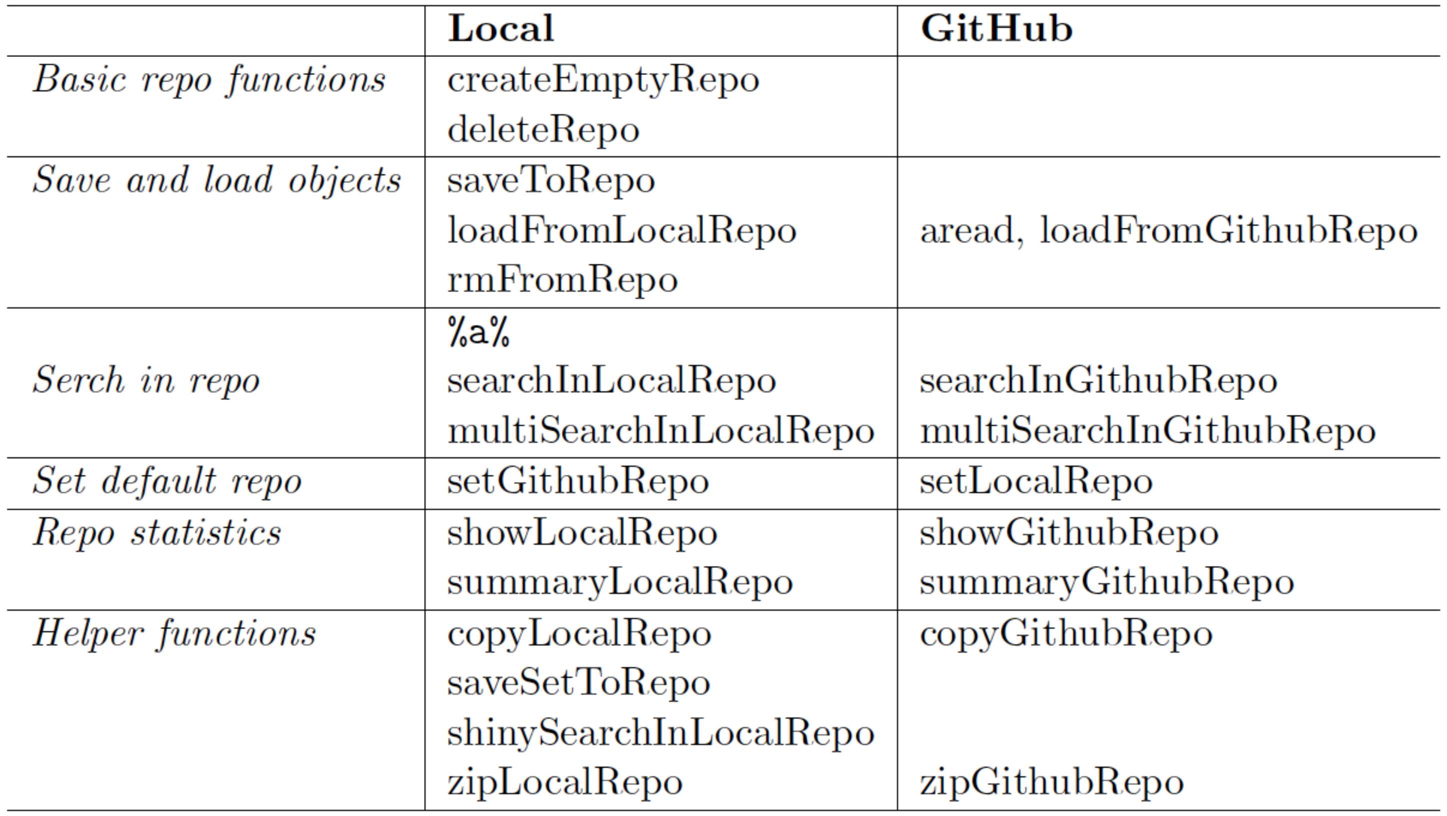
```
   user  system elapsed
  0.003   0.000   0.003
```

```r
system.time(   cache(cacheRepo, fun, 100,    notOlderThan = now() - hours(1)))
```

```
   user  system elapsed
  0.008   0.001   0.007
```

```r
deleteRepo( cacheRepo )
rm( cacheRepo )
```

What other functions are available in archivist?

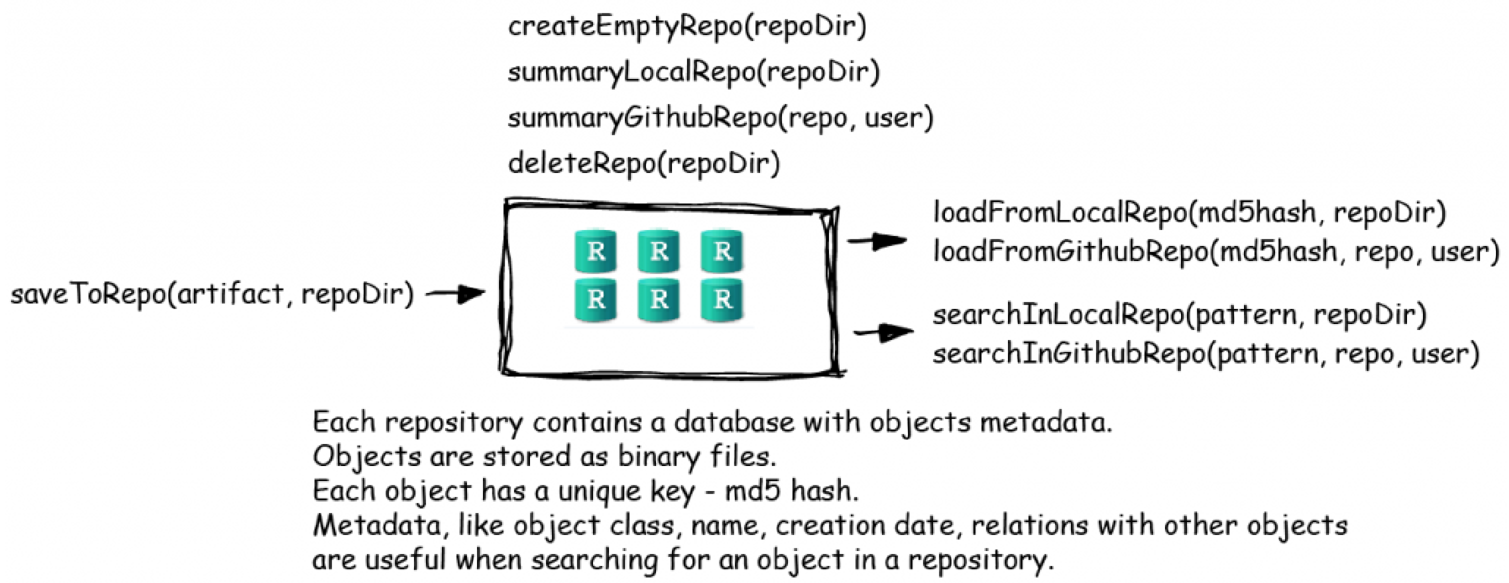


	Local	**GitHub**
Basic repo functions	createEmptyRepo deleteRepo	
Save and load objects	saveToRepo loadFromLocalRepo rmFromRepo	aread, loadFromGithubRepo
Serch in repo	%a% searchInLocalRepo multiSearchInLocalRepo	searchInGithubRepo multiSearchInGithubRepo
Set default repo	setGithubRepo	setLocalRepo
Repo statistics	showLocalRepo summaryLocalRepo	showGithubRepo summaryGithubRepo
Helper functions	copyLocalRepo saveSetToRepo shinySearchInLocalRepo zipLocalRepo	copyGithubRepo zipGithubRepo

Where I can find more?

The latest version (1.5) is available on GitHub and CRAN.

More information, examples, use-cases and documentation about this package is available on http://pbiecek.github.io/archivist/.


createEmptyRepo(repoDir)
summaryLocalRepo(repoDir)
summaryGithubRepo(repo, user)
deleteRepo(repoDir)
saveToRepo(artifact, repoDir)
R
loadFromLocalRepo(md5hash, repoDir)
loadFromGithubRepo(md5hash, repo, user)
searchInLocalRepo(pattern, repoDir)
searchInGithubRepo(pattern, repo, user)

Each repository contains a database with objects metadata.
Objects are stored as binary files.
Each object has a unique key - md5 hash.
Metadata, like object class, name, creation date, relations with other objects
are useful when searching for an object in a repository.

R