Building R Packages

What are R Packages?

R Packages

1. Sets of Functions
2. Set of Functions + Documentation
3. Set of Functions + Documentation + Data
4. Set of Functions + Documentation + Data + Vignettes
5. Set of Functions + Documentation + Data + Vignettes + Versions
6. Set of Functions + Documentation + Data + Vignettes + Versions + Dependencies

Windows and RTools

If you have a Windows machine, you need to install RTools from https://cran.r-project.org/bin/windows/Rtools/ (choose the frozen one).

Using Rtools40 on Windows

Starting with R 4.0.0 (released April 2020), R for Windows uses a brand new toolchain bundle called **rtools40**.

This version of Rtools upgrades the mingw-w64 gcc toolchains to version 8.3.0, and introduces a new build system based on msys2, which makes easier to build and maintain R itself as well as the system libraries needed by R packages on Windows. For information about the latter, follow the links at the bottom of this document.

This documentation is about rtools40, the current version used for R 4.0.0 and newer. For information about previous versions of Rtools that can be used with R 3.6.3 or older, please visit this page.

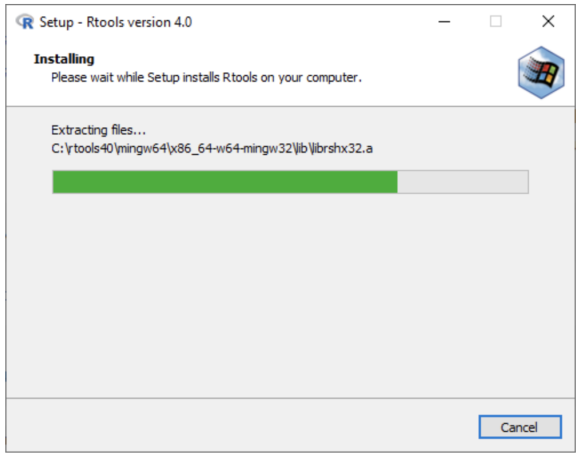
Installing Rtools40

Note that rtools40 is only needed build R packages with C/C++/Fortran code from source. By default, R for Windows installs the precompiled "binary packages" from CRAN, for which you do not need rtools!

To use rtools40, download the installer from CRAN:

- On Windows 64-bit: rtools40-x86_64.exe (recommended: includes both i386 and x64 compilers)
- On Windows 32-bit: rtools40-i686.exe (i386 compilers only)

Note for RStudio users: please check you are using the latest version of RStudio (at least `1.2.5042`) to work with rtools40.



Starting Up

Use RStudio and the `devtools` and `usethis` packages. It's easier.

```
install.packages(c("devtools", "usethis"))
```

In RStudio, File -> New Project -> New Directory -> R Package with devtools (scroll down), with a name:

- must start with letter
- no underscores
- periods allowable or use CamelCase
- can have numbers

Checking Package Names

Try the `available::available` function:

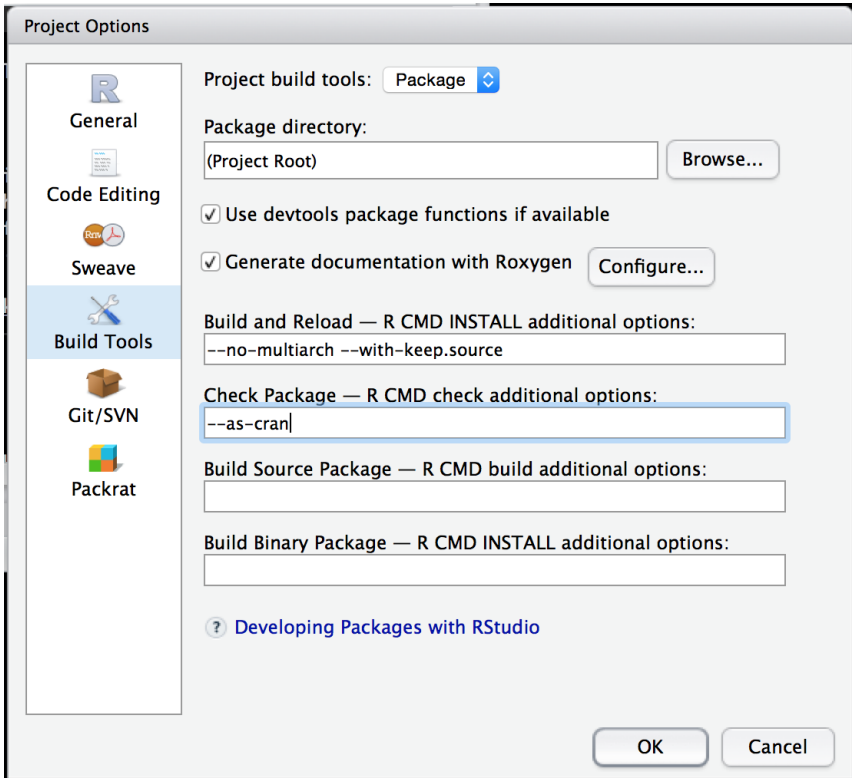
```
available::available("ggplot")
```

```
## ── ggplot ──────────────────────────────────────────────────────────────────────
## Name valid: ✔
## Available on CRAN: ✖
## Available on Bioconductor: ✔
## Available on GitHub:  ✔
## Abbreviations: http://www.abbreviations.com/ggplot
## Wikipedia: https://en.wikipedia.org/wiki/ggplot
## Wiktionary: https://en.wiktionary.org/wiki/ggplot
## Urban Dictionary:
##   Not found.
## Sentiment:???
```

Setting Up

Go to Build -> Configure Build Tools

Add `--as-cran` to “Check Package” (useful later)



Documentation is a pain

…but it's worthwhile. Writing out argument definitions makes it easier to identify if argument names make sense.

From https://imgflip.com/i/4mvkhl

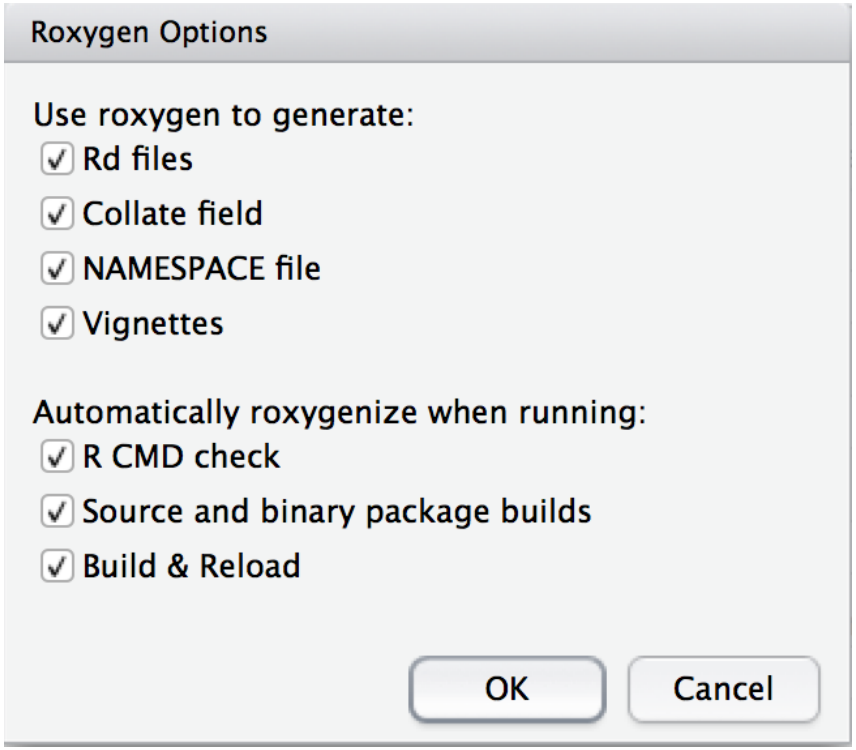
Documentation is a pain

https://twitter.com/kcranstn/status/370914072511791104

Use Roxygen2

Click Generate documents with Roxygen. If that is gray, install `roxygen2`:

```
install.packages("roxygen2")
```



Click “Configure” - click all the boxes.

Modifying the Skeleton

Things to do:

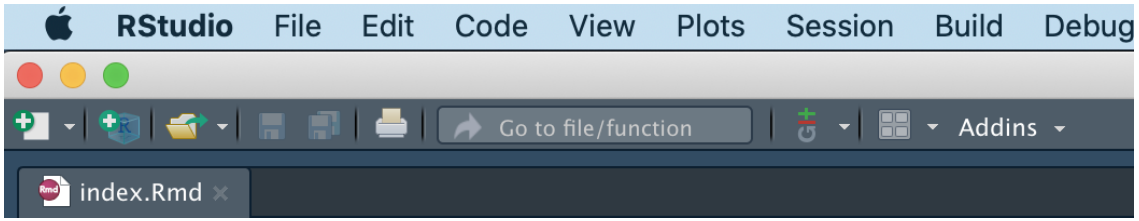
1. Delete `R/hello.R` (skip if used devtools)
2. Delete `man/hello.Rd` (skip if used devtools)
3. In RStudio, `Build → Configure Build Tools → Generate Documentation with Roxygen`, make sure that's clicked. I click `Vignettes` and `Build and Reload`.
4. In RStudio, add `--as-cran` under the "Check options" in `Build → Configure Build Tools`.
5. Delete the `NAMESPACE` file (skip devtools). If building fails, add an empty file with `# Generated by roxygen2: do not edit by hand` at the top and rerun.

DESCRIPTION file

In the RStudio project, go to “Go to file/function” search bar on the menu bar.

- This searches through the files in the package.
    - Also searches for **function names** and can go to that function in the file

Type “DESCRIPTION” and open that file.



DESCRIPTION file

- "Title - What the Package Does (Title Case)
- “Author: YOURNAME”
- “Maintainer: YOURNAME your@email.com” -> we will remove this
- “Description: Use paragraph prose here. Don’t start with word package” Use four spaces when indenting paragraphs within the Description.
- “License:”, one of GPL-2 GPL-3 LGPL-2 LGPL-2.1 LGPL-3 AGPL-3 Artistic-2.0 BSD_2_clause BSD_3_clause MIT

Authors

I add this to the `DESCRIPTION` file:

```
Authors@R: c(person(given = "John",
             family = "Muschelli",
             email = "muschellij2@gmail.com",
             role = c("aut", "cre"),
             comment = c(ORCID = "0000-0001-6469-1750")))
```

Use `Authors@R` even if there is only one author.

License

```
usethis::use_gpl3_license("John Muschelli")
```

- https://www.r-project.org/Licenses/

DESCRIPTION file: additional fields

- You do not use `library` or `require` in functions in a package
- Imports: package1, package2
  - packages with specific functions called in package
  - Anything other than `base` package needs to be imported (`stats`, `methods`)
- Depends: package3, package5
  - packages with **ALL** functions loaded from package
- Suggests: package4, package6
  - used in **examples** or **vignettes**

```
usethis::use_package("tidyr", type = "Imports")
usethis::use_package("dplyr", type = "Suggests")
```

Description

- Change the `Description` so that it's a sentence and it ends with a period.
- Pu single quotes around weird words (like science-specific).
- Make sure to put links in angle brackets (`<http...>`). Use DOIs if you can.
- If you go too long on a line, indent it with 4 spaces `"    "`.

```
Type: Package
Package: SummarizedActigraphy
Title: Coerce 'Actigraphy' to Summarized Experiments
Version: 0.3.0
Authors@R: c(
    person(given = "John",
           family = "Muschelli",
           role = c("aut", "cre"),
           email = "muschellij2@gmail.com",
           comment = c(ORCID = "0000-0001-6469-1750"))
    )
Description: Provides functions for coercing 'actigraphy' data into
    'SummarizedExperiment' objects used for genomic analysis.  This
    conversion enables the use of functions that work on the
    'SummarizedExperiment' class.
License: GPL-3
```

Roxygen2

Roxygen allows for functions and documentation in the same file. Let's make a function:

```
top = function(x, n) {
  xx = x[1:n, 1:n]
  hist(xx)
  print(xx)
}
```

Save this to `top.R` file in `R/` (where R functions are).

Roxygen2

Highlight the following code:

```
top = function(x, n) {
```

Go to Code -> Insert Roxygen Skeleton

Roxygen Skeleton Output

```
#' Title
#'
#' @param x
#' @param n
#'
#' @return
#' @export
#' @examples
```

- `@param` stands for a parameter/argument for that function.
- `@return` denotes what the function returns. This is required.
- `@export` - when people install your package, can they use this function
  - non-exported functions are usually helpers, really small, or not fully formed yet
- `@examples` - code to show how the function works. Wrap functions in `\dontrun{}` if not wanted to run

Roxygen Skeleton:

You can add `@title` and `@description` tags:

```
#' @title
#' @description
#'
#' @param x
#' @param n
#'
#' @return
#' @export
#'
#' @examples
```

Roxygen Skeleton:

```
#' @title Print the top of a matrix
#' @description \code{top} is a small function to not just present the first rows
#' of a matrix, but also the first number of columns
#'
#' @param x a \code{matrix}
#' @param n Number of rows and columns to display of the matrix
#'
#' @return A \code{NULL}
#' @export
#'
#' @examples
#' mat = matrix(rnorm(100), nrow = 10)
#' top(mat, n = 4)
#' \dontrun{
#'    top(mat, n = 10)
#' }
```

Functions: a little style

1. Create a file for each function (preference) or at least group. Name file function name.
2. Optional arguments: Set to `NULL` and use `is.null()` to test
3. Put functions together: use `#' @rdname`.
4. See `#' @inheritParams` for different functions with the same arguments.
5. Add logical `verbose` argument for printing
6. Use `message` (not `cat`) for printing. Someone can use `suppressMessages` to stop the printing.
7. Pass `...` to a main function for additional options for the user.
8. Have examples (vignette too)
9. Learn `do.call(FUNCTION, args = list_of_arguments)`
10. Notify/warn/message whenever you have to.

NAMESPACE

The `NAMESPACE` files tells the R package what to import and export. In Roxygen:

- `@export` - adds this to the NAMESPACE file
  - when package is installed, users can call this function
- `@import` - in roxygen, if you want to import a **package**, you say `@import PACKAGENAME`
  - imports **ALL** functions from that package
  - if package is listed under Depends in DESCRIPTION, then the **whole package** is loaded when you load your package
  - otherwise it simply exposes them for your package to use them, but not the user, users still have to do `library(PACKAGENAME)`

NAMESPACE

- `@importFrom` - in roxygen, if you want to import a **function**, you say `@import PACKAGENAME func1 func2`
  - only imports these functions. Better way of doing things.
  - if `pkgA` has function `A` and `pkgB` has functions `A` and `B`, if `@import pkgA A`, `@import pkgB B`, then if you call `A()`, R knows it's from `pkgA`
  - you must import anything explicitly other than from the `base` package, includying anything from `stats` (e.g. `quantile`) or `graphics` (e.g. `hist`)

Add `@importFrom graphics hist` to your top.R file

NAMESPACE - alternative

```
> usethis::use_package("devtools")
✓ Adding 'devtools' to Imports field in DESCRIPTION
● Refer to functions with `devtools::fun()`
```

For every function you're using from a package, use `package::function()`

- Preferred way, especially only using infrequently
- Don't need an `@import` or `@importFrom` tag
- Annoying with frequent functions (e.g. `dplyr`), so you can use `import`

```
usethis::use_pipe()
```

Build and Reload

- Go to Build -> Build and Reload the package
  - First time you may see some warnings (no NAMESPACE file!)
  - Rerunning should get rid of these
  - look in the folders
- Then try Build -> Check Package

Using Data

The `data/` directory is where data goes, it **must** be named `.RData` or `rda`. The `use_data` function can do this for you:

```
usethis::use_data(DATAOBJECT, compress = "xz")
```

The output will be `DATAOBJECT.rda` in the `data` folder. You can use this in your package

Making Data

That's not reproducible!

The `data-raw` directory can be data you want to create (such as simulated data).

This will have scripts with `use_data` at the end to make the data.

```
usethis::usethis::use_data_raw()
```

Documenting Data

Note how `DATAOBJECT` is the name of the object/rda. Now we can document the data as follows:

```
#' @title Some object to document
#'
#' @description A list containing things
#'
#' @format A list with 7 elements, which are:
#' \describe{
#' \item{x}{first thing}
#' \item{y}{second thing}
#' }
"DATAOBJECT"
```

Different kinds of data

The `inst/` directory will copy any of the contents to the installed directory path. So if `blah.csv` was in `inst/` then it will be in the directory.

Most times, however, people put data in `inst/extdata` to separate folders out.

You can use `find.package` to find the installed directory:

```
find.package("readr")
```

```
## [1] "/Users/johnmuschelli/Library/R/4.0/library/readr"
```

To get files, though, you should use `system.file`:

```
system.file("extdata", package = "readr")
```

```
## [1] "/Users/johnmuschelli/Library/R/4.0/library/readr/extdata"
```

Different kinds of data

If you pass in multiple characters, it assumes you put it together with `file.path`:

```
system.file("extdata", "challenge.csv", package = "readr")
```

```
## [1] "/Users/johnmuschelli/Library/R/4.0/library/readr/extdata/challenge.csv"
```

The `mustWork` argument is useful for making sure the file exists:

```
system.file("extdata", "asdfsdf.csv", package = "readr", mustWork = TRUE)
```

```
## Error in system.file("extdata", "asdfsdf.csv", package = "readr", mustWork = TRUE): no file
```

Using the file system

1. `file.path` > `paste` for paths (or `fs` package)
2. Use `file.exists`. Use `any` and `all`
3. `file.remove` if you need to delete things
4. Make temporary (empty, non-existent) files, with extension: `tempfile(fileext = ".csv")`.
5. `dir.create` to create and `unlink` to destroy directories.
6. Using `tempdir()` for stuff that's intermediate.
7. Tempdir sub-directory: `tdir = tempfile(); dir.create(tdir); on.exit({ unlink(tdir) })`
8. `file.copy` and `file.rename`
9. `download.file` or `curl::curl_download`

Vignettes

- http://r-pkgs.had.co.nz/vignettes.html

A package has data + code + dependencies. A vignette can tie this together to tell you **how** to use the package. Typically it is an analysis.

- **THIS IS EXACTLY WHAT A REPRODUCIBLE PAPER IS!**

```
usethis::use_vignette("my-vignette")
```

- Can make private packages that are the workflow for your paper

Unit tests

The `testthat` package is great for unit testing. Put test scripts in `tests/testthat`, always named `test-DESCRIPTOR.R`. To set up `testthat`:

```
usethis::use_testthat()
```

And a specific test:

```
usethis::use_test("name of test")
```

General Rule: Any package issue turns into a test.

Unit tests

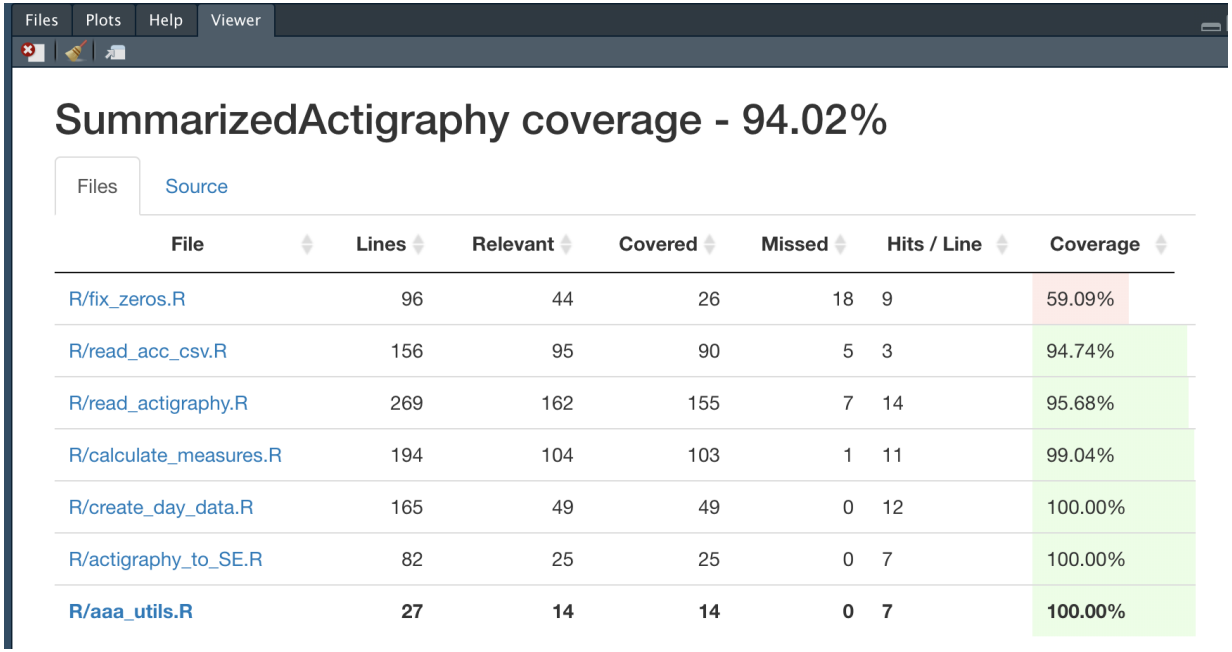
The `testthat` package is great for unit testing. Put test scripts in `tests/testthat`, always named `test-DESCRIPTOR.R`. To set up `testthat`:

```
testthat::context("OVERALL DESCRIPTION OF TESTS IN THIS FILE")
testthat::test_that("Description of this test", { MYCODE })
testthat::expect_equal(OUTPUT, 1234.34535)
testthat::expect_identcal(OUTPUT1, OUTPUT2)
testthat::expect_true(SOME_OUTPUT)
testthat::expect_silent({ no_warning_error_code })
testthat::expect_message({ some_warn }, "a[test]regexp")
```

Code Coverage: % Code covered in tests

Use `covr` package:

```
covr::package_coverage() # run tests
covr::report() # get a report
covr::report(covr::package_coverage(type = "all")) # run them all
```



File	Lines	Relevant	Covered	Missed	Hits / Line	Coverage
R/fix_zeros.R	96	44	26	18	9	59.09%
R/read_acc_csv.R	156	95	90	5	3	94.74%
R/read_actigraphy.R	269	162	155	7	14	95.68%
R/calculate_measures.R	194	104	103	1	11	99.04%
R/create_day_data.R	165	49	49	0	12	100.00%
R/actigraphy_to_SE.R	82	25	25	0	7	100.00%
R/aaa_utils.R	**27**	**14**	**14**	**0**	**7**	**100.00%**

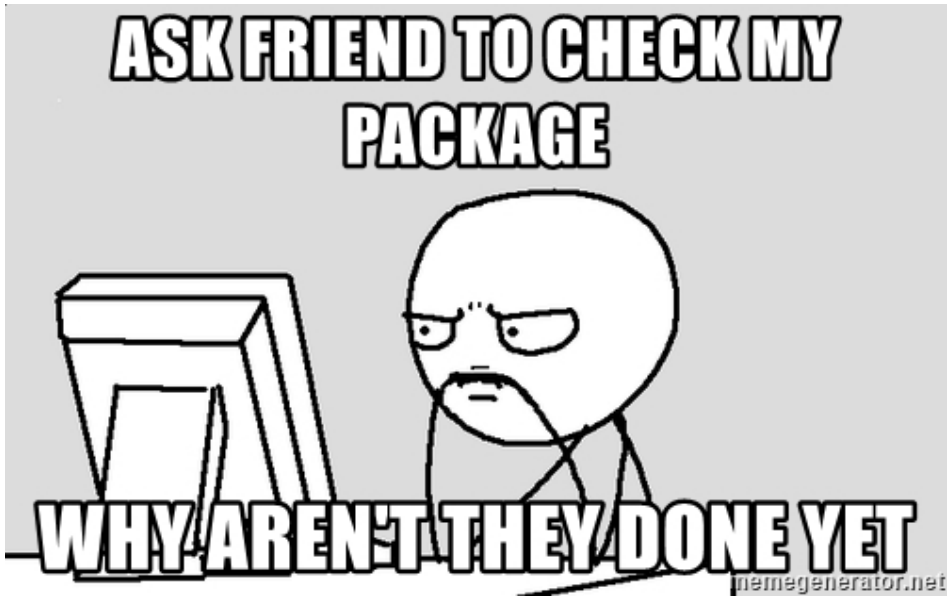
Process

- Go to Build → Load All to load all functions
- Change your code, write functions
- Build → Check Package
- Fix errors/notes
- Make tests
- Check code coverage
- Iterate

That’s a lot of it - next slides are gravy

Checking Packages in the Past

“But does it work on someone else’s machine or just mine?”



https://memegenerator.net/instance/85107524/thinking-stick-man-ask-friend-to-check-my-package-why-arent-they-done-yet

Continuous integration (Thoughtworks.com)

Continuous Integration (CI) is a development practice that requires developers to integrate code into a shared repository several times a day. Each check-in is then verified by an automated build, allowing teams to detect problems early.

Travis CI

GitHub

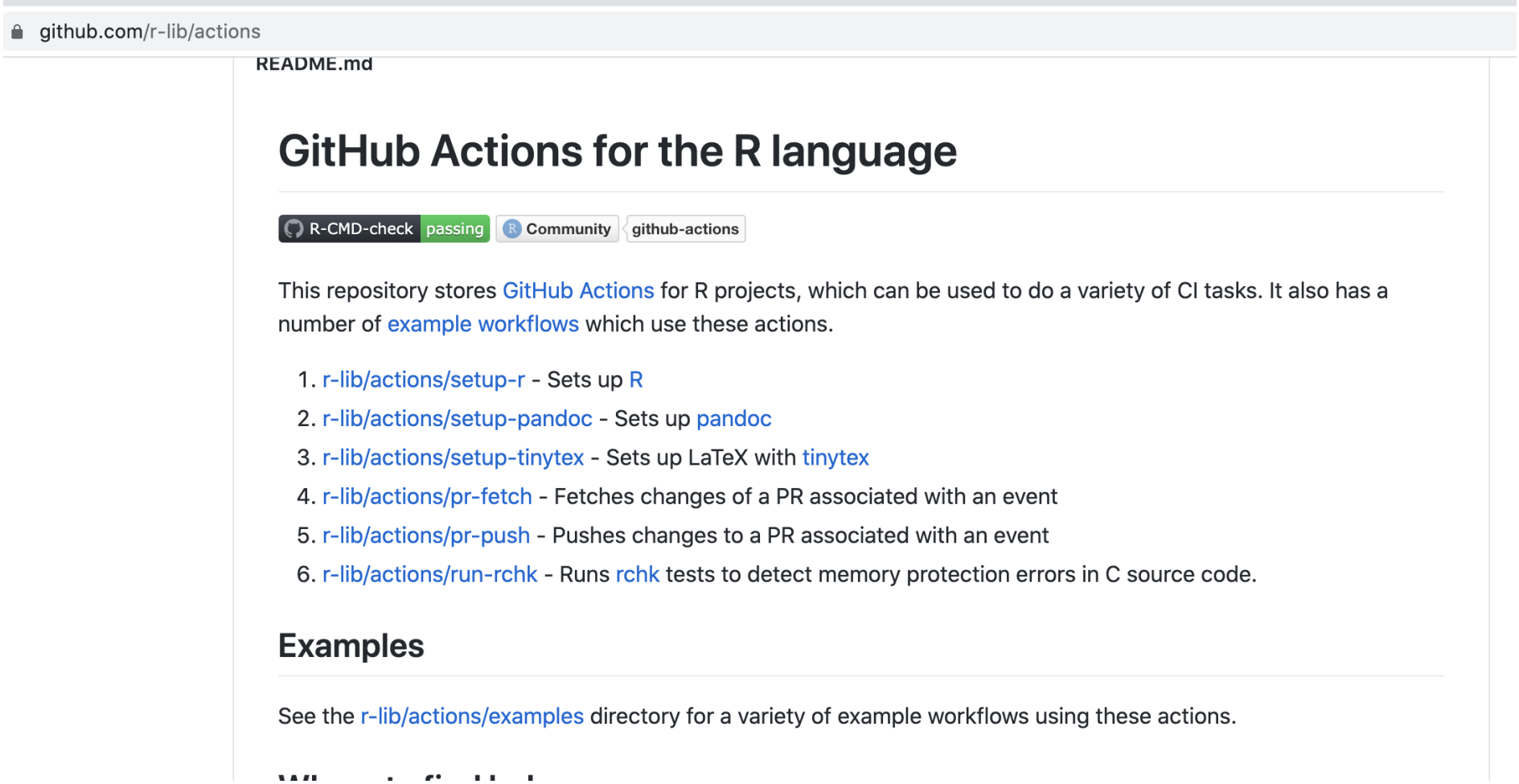
AppVeyor

Building CI and README

```
usethis::use_git() # make a Git repo
usethis::use_github() # must have GITHUB_PAT set up
usethis::use_github(protocol = "https") # must have GITHUB_PAT set up
usethis::use_readme_rmd() # make a readme
usethis::use_github_action_check_standard()
usethis::use_appveyor() # Windows - or use github action
usethis::use_travis()  # Linux/OSX - or use github action
```

GitHub Actions - Build all 3 OSes

https://github.com/r-lib/actions



GitHub Actions

```
usethis::use_github_action_check_standard()
```

- adds file to `.github/workflows/`

```
✔ Setting active project to '/Users/johnmuschelli/Dropbox/Packages/SummarizedActigraphy'
✔ Creating '.github/'
✔ Adding '^\\.github$' to '.Rbuildignore'
✔ Adding '*.html' to '.github/.gitignore'
✔ Creating '.github/workflows/'
✔ Writing '.github/workflows/R-CMD-check.yaml'
● Copy and paste the following lines into '/Users/johnmuschelli/Dropbox/Packages/SummarizedActigraphy/README.Rmd':
  <!-- badges: start -->
  [![R build status](https://github.com/muschellij2/SummarizedActigraphy/workflows/R-CMD-check/badge.svg)](https://github.com/muschellij2/SummarizedActigraphy/actions)
  <!-- badges: end -->
```

Configuring Travis

In `.travis.yml`, add the following lines:

```
os:
  - linux
  - osx

warnings_are_errors: true
after_success:
  - Rscript -e 'covr::codecov(type = "all")'
```

Configuring Appveyor

In `appveyor.yml`, add the following lines:

```
environment:
  global:
    WARNINGS_ARE_ERRORS: 1
```

Adding to the `README.Rmd`

These function adds following lines, changing `GITHUB_USERNAME/REPO` to the correct version

```
[![R build status](https://github.com/GITHUB_USERNAME/REPO/workflows/R-CMD-check/badge.svg)](ht
[![Travis-CI Build Status](https://travis-ci.com/GITHUB_USERNAME/REPO.svg?branch=master)](https
[![AppVeyor Build Status](https://ci.appveyor.com/api/projects/status/github/GITHUB_USERNAME/RE
```

or a general badge:

```
usethis::use_badge("Travis-CI Build Status",
src = "https://travis-ci.com/GITHUB_USERNAME/REPO.svg?branch=master",
href = "https://travis-ci.com/GITHUB_USERNAME/REPO")
```

to the `README.Rmd`.

S3, S4, Reference Classes

- S3 - simple - just say `class(x) = "myS3Class"`
  - Usually List of objects
  - http://adv-r.had.co.nz/S3.html
- S4 - more complex - see `new`
  - name, representation (slots), and inheritance (does it act like an array/list)
  - http://adv-r.had.co.nz/S4.html
- Reference Classes
  - very different, `class$method()`
  - http://adv-r.had.co.nz/R5.html

S3, S4 Methods

- S3 : `bar <- function(y) UseMethod("bar", y)`
  - `bar.myS3Class` will allow you to use `bar(x)`
- S4 : `setGeneric("myGeneric", function(x) standardGeneric("myGeneric"))`

```
setMethod("myGeneric", signature(x = "myS3Class"), function(x, y) {
 x@slot + y
})
```

Compiled Code: C and C++

See http://r-pkgs.had.co.nz/src.html

- The `src/` folder has compiled code.
- `cleanup` generally deletes intermediate or downloaded files run in `configure`.
- `configure` runs code before `make` is run
- `Makevars` or a `Makefile` gives direction for compiling code
- There are `configure.win` and `Makevars.win` for Windows-specific setup.
- See `.Call` for calling these compiled functions.

Using `Rcpp` is a different framework.

Questions?