



VISUALIZATION & SHINY

CEPE GENES

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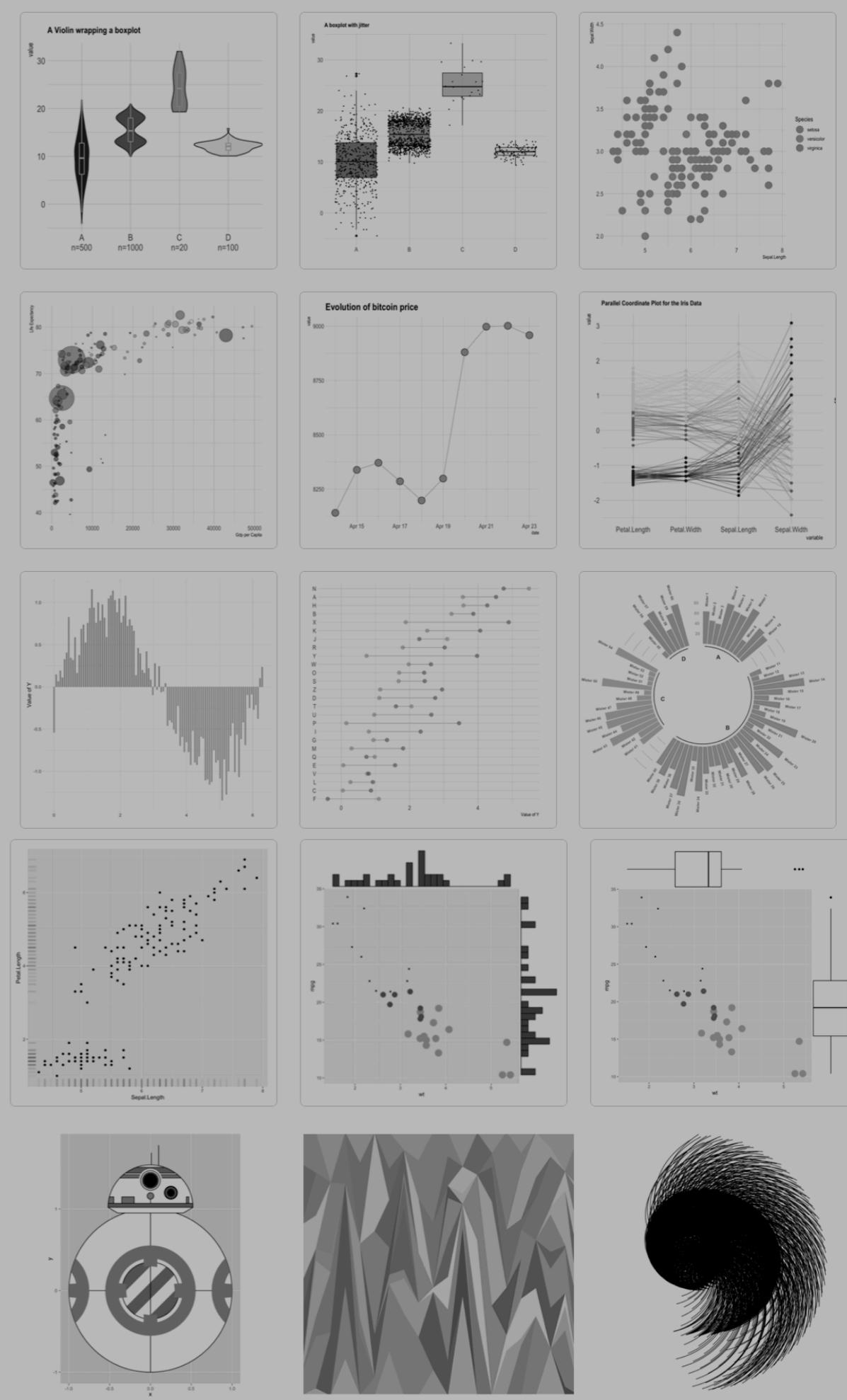
Date: Sep 2022

Program

- Visualization : building graphs with ggplot2
 - Why ggplot2 ?
 - Grammar of Graphics : data, aesthetics, geometry, design, facetting
 - Going through different geometries [practice]
 - Improving design [practice]
 - Practice
- Building dashboard and web apps with Shiny
 - Starting off with an example, UI vs Server [practice]
 - Overall code development strategy
 - Inputs & outputs [practice]
 - Creating (re)actions [practice]
 - (Meta)data management [practice]
 - Tips & ressources

VISUALIZATION

BUILDING GRAPHS WITH



Why ggplot2 ?

R packages - what is out there ??

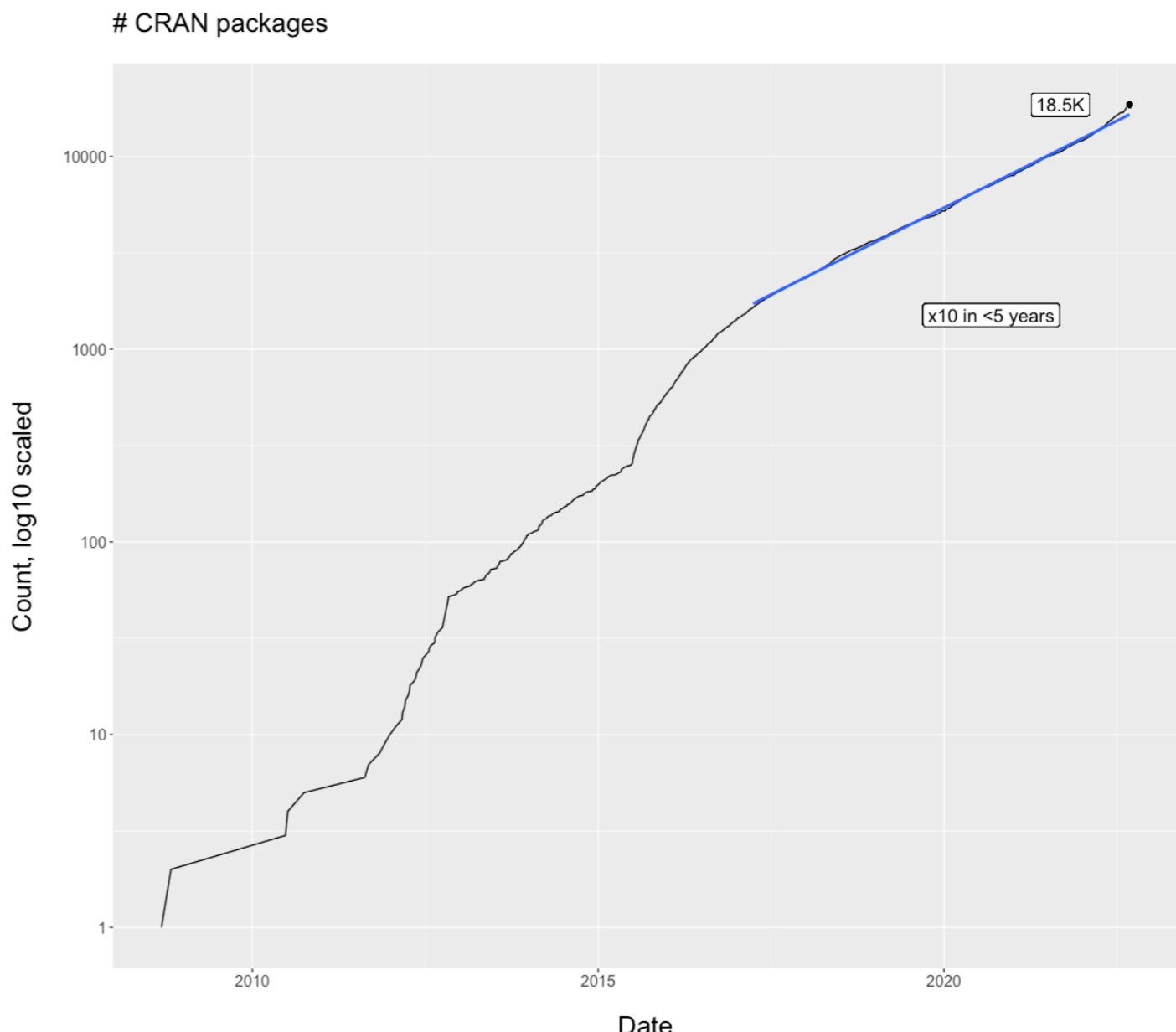
.....

A lot of base methods to know

So many packages (see plot beside), it's so hard to keep up.

Search + stack overflow + R vignettes can help get some clues as to what to use.

Since ~10 years, a new standard package arose for anything data related : the tidyverse package



And that's not counting other package repositories and packages hosted on GitHub !

Why ggplot2 ?

R packages - the tidyverse

tidyverse

opinionated collection of R packages designed for data science

`library(tidyverse)`

- **ggplot2**: data visualization
- **dplyr**: data wrangling
- **tidyr**: data tidying
- **readr**: data reading/writing
- **forcats**: working with factors
- **stringr**: working with strings
- **tibble**: modern data frames
- **purrr**: functional programming

`install.packages(tidyverse)` above + a few more



Why ggplot2 ?

R packages - the dataviz landscape

ggplot2



The Standard package for data visualization

3 300K Monthly Downloads

Extremely readable syntax (grammar of graphics)

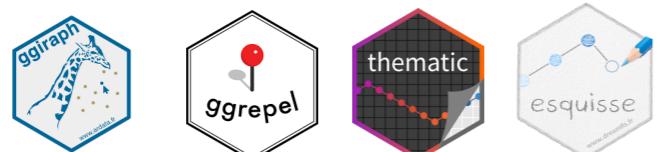
Cost of entry : medium

Maintained by RStudio and co, part of the tidyverse

#1 choice of R community and the standard of graphics

can be re-used in Python via nineplot

so many packages are built as add-ons of ggplot2 :



Base plots

Installed by default

Hard/customized plots : nightmare

Syntax quickly becomes unreadable

Not the nicest designs

Lattice, DiagrammeR, igraph, ...

so many packages, often doing single-type plot

far less used than ggplot2 and extensions

most of what they do can be done via ggplot2 and extensions

often require less ‘work’ than ggplot2 for quick tests

Package	Nb monthly downloads
Cowplot	280K
Lattice	155K
LatticeExtra	240K
ggrepel*	500K

*ggplot2 add-on, adding nice annotation to graph

Plotly, Echarts4, ...

Cross-platform

Very pretty outputs

Interactivity

Similar grammar to ggplot2

Much less support



300K Monthly
Downloads



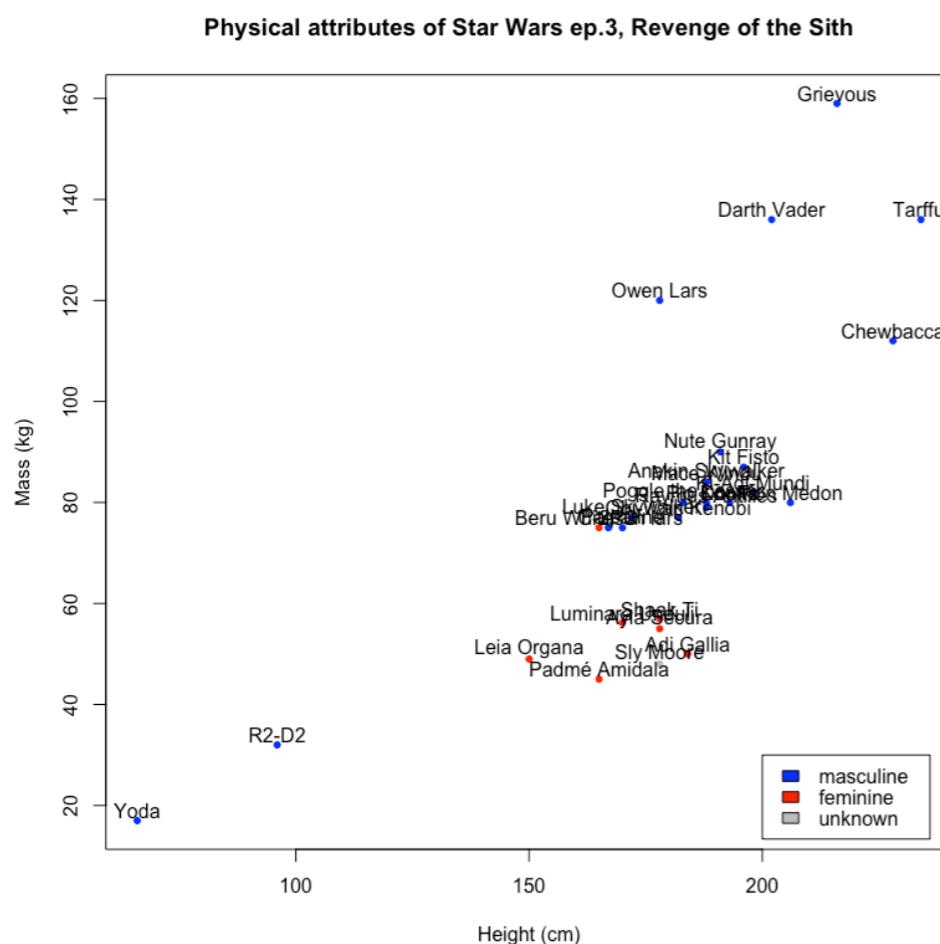
3K Monthly
Downloads

Why ggplot2 ?

From base to ggplot2 - radical change of grammar, for the best

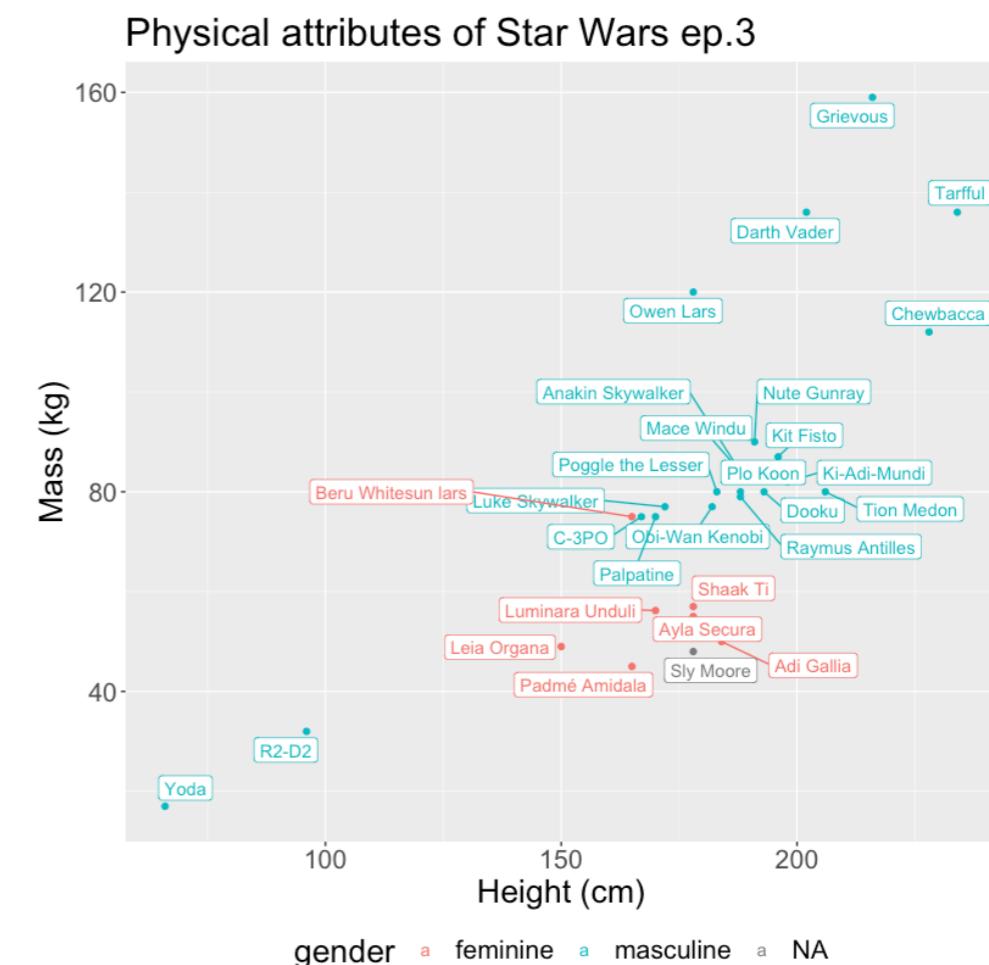
base

```
1 l = c('masculine' = 'blue', 'feminine' = 'red')
2 plot(x = starwars_ep3$height, y = starwars_ep3$mass,
3       col = map_var(l, starwars_ep3$gender, 'gray'), pch = 20,
4       main = 'Physical attributes of Star Wars ep.3',
5       xlab = 'Height (cm)', ylab = 'Mass (kg)')
6 text(x = starwars_ep3$height, y = starwars_ep3$mass + 2,
7       labels = starwars_ep3$name)
8 legend(x = 200, y = 30, fill = c(as.character(l), 'gray'),
9        legend = c(names(l), 'unknown'))
```



ggplot2

```
9 ggplot(data = starwars_ep3) +
10   aes(x = height, y = mass, label = name, col = gender) +
11   geom_point() +
12   geom_label_repel() +
13   labs(title = 'Physical attributes of Star Wars ep.3',
14        x = 'Height (cm)', y = 'Mass (kg}') +
15   theme(text = element_text(size = 20), legend.position = 'bottom')
```



gender a feminine a masculine a NA



How ggplot2 ?

Key elements of the Grammar of Graphics

INIT GGPlot

Specifying a Tibble as data

AESTHETICS

What to put in x, y, color
(contour), fill (filling
color), shape, size

GEOMETRY

geom_point

geom_line

geom_hist

geom_boxplot

...

DESIGN

labs, theme

FACETTING
split graphic by
categories



Operator to combine
ggproto objects

```
1 library(tidyverse)
2 library(ggrepel)
3
4 data("starwars")
5
6 starwars_ep3 = starwars %>%
7   filter(map_lgl(films, function(x) "Revenge of the Sith" %in% x))
8
9 ggplot(data = starwars_ep3) +
10  aes(x = height, y = mass, label = name, col = gender) +
11  geom_point() +
12  geom_label_repel() +
13  labs(title = 'Physical attributes of Star Wars ep.3',
14       x = 'Height (cm)', y = 'Mass (kg)') +
15  theme(text = element_text(size = 20), legend.position = 'bottom')
```

LET's PRACTICE !

How ggplot2 ?

Practice & Tips

Some Ressources



<https://raw.githubusercontent.com/rstudio/cheatsheets/main/pngs/data-visualization.png>

<https://ggplot2.tidyverse.org>

<https://www.r-graph-gallery.com>

<https://www.r-pkg.org/search.html?q=visualization>

Some tips & common issues

- > add interactivity easily : transform ggplot to plotly graph
- > check error message
- > color/fill are often confused
- > R interprets code without regard of line indexes, so make sure you don't have open code before, and that all '+' signs are present

DASHBOARDS & WEBAPPS

WITH



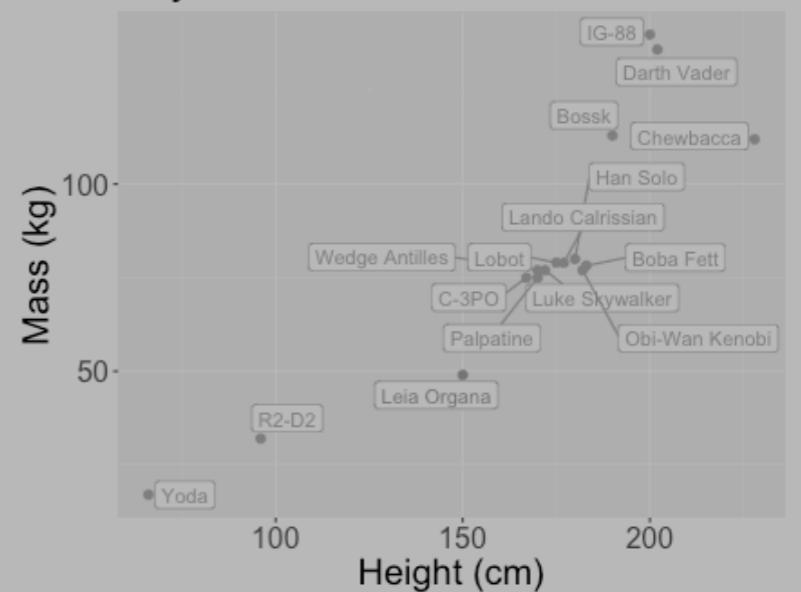
Star Wars characters

Film

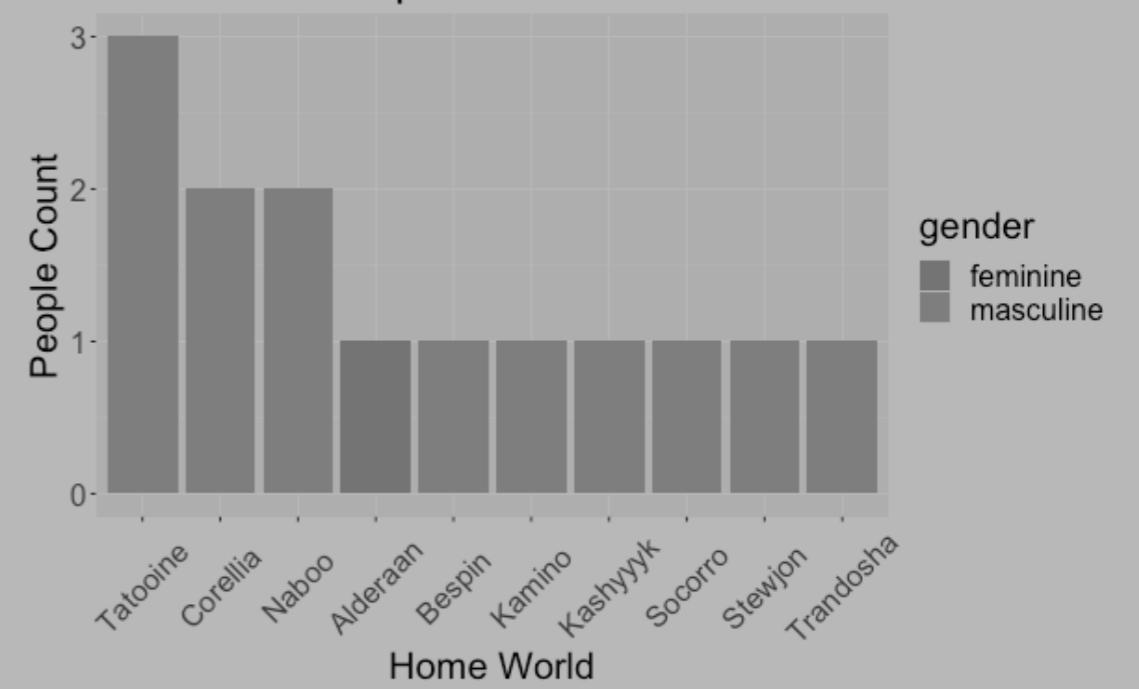
The Empire Strikes Back

	name	birth_year	species
1	Luke Skywalker	19	Human
2	C-3PO	112	Droid
3	R2-D2	33	Droid
4	Darth Vader	41.9	Human

Physical attributes of Star Wars



Home World representation



Objective

Learn how to build such beautiful apps, with (mostly) R code.

Radiant Data Design ▾ Basics ▾ Model ▾ Multivariate ▾ Report ▾ 🔍 ⚡ ⚡ ? ▾

Datasets:
diamonds

Add/edit data description
 Rename data

Display:
 preview str summary

Load data of type:
rds | rda | rdata

No file selected

Save data to type:
rds

Show R-code

Manage View Visualize Pivot Explore Transform Combine

Data preview

price	carat	clarity	cut	color	depth	table	x	y	z	date
580	0.32	VS1	Ideal	H	61.00	56.00	4.43	4.45	2.71	2012-02-26
650	0.34	SI1	Very Good	G	63.40	57.00	4.45	4.42	2.81	2012-02-26
630	0.30	VS2	Very Good	G	63.10	58.00	4.27	4.23	2.68	2012-02-26
706	0.35	VVS2	Ideal	H	59.20	56.00	4.60	4.65	2.74	2012-02-26
1080	0.40	VS2	Premium	F	62.60	58.00	4.72	4.68	2.94	2012-02-26
3082	0.60	VVS1	Ideal	E	62.50	53.70	5.35	5.43	3.38	2012-02-26
3328	0.88	SI1	Ideal	I	61.70	56.00	6.14	6.18	3.80	2012-02-26
4229	0.93	SI1	Premium	E	61.40	57.00	6.34	6.23	3.86	2012-02-26
1895	0.51	VVS2	Very Good	G	63.40	57.00	5.09	5.06	3.22	2012-02-26
3546	1.01	SI2	Good	E	63.90	58.00	6.31	6.37	4.05	2012-02-26

10 of 3,000 rows shown. See View-tab for details.

Diamond prices

Prices of 3,000 round cut diamonds

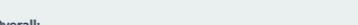
The ten most similar players - Pro Evolution Soccer 2019

Graphic About Developers

Apply filters

Choose a player:

Overall:



50 100

Height (cm):



155 203

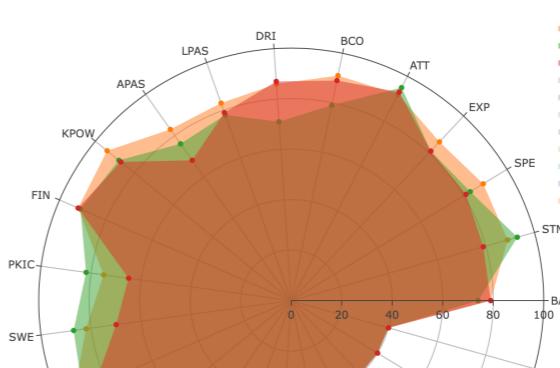
Position:

GK CB RB LB DMF CMF AMF
 RMF LMF RWF LWF SS CF

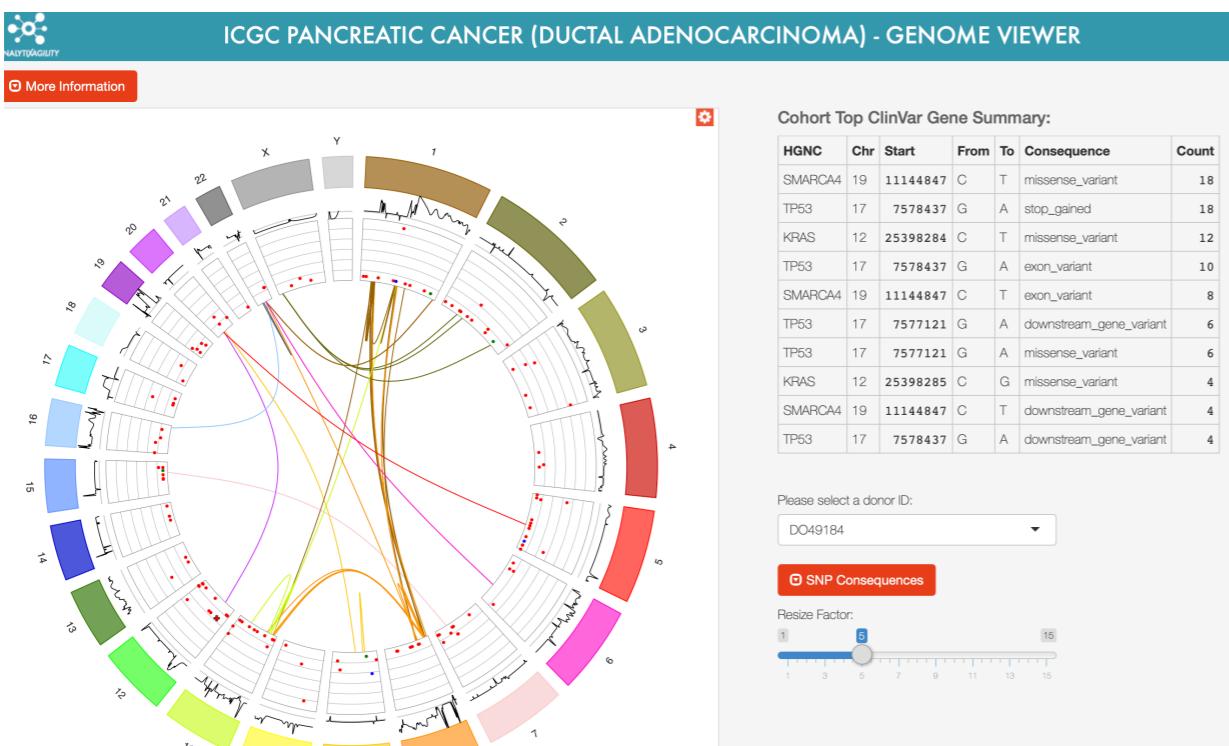
Foot:

Right foot Left foot

Update filters



- C. RONALDO
- E. CAVANI
- R. LEWANDOWSKI
- M. ICARDI
- G. HIGUAIN
- P. AUBAMEYANG
- H. KANE
- R. LUKAKU
- A. GRIEZMANN
- L. SUÁREZ



 Living in the Lego World

Demographics Fashion Moods Ecology

Ethnicity and gender Ethnic diversity and gender parity by theme Find sets with a specific ethnicity or gender

Filter to one or more themes:
Star Wars (1258)

Filter to one or more genders:
Nothing selected

Large graphs (e.g., of the full dataset) may take a few seconds to render. The first graph may take up to two minutes if the app is retrieving new data from Rebrickable.

Hover to see the part name.

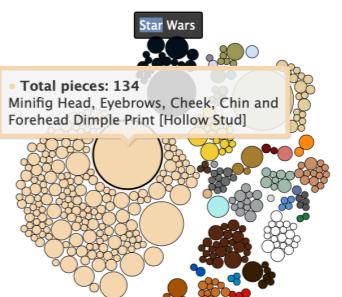
Each circle represents a **unique minifigure or minidoll head**.

Area is proportional to the **number of pieces** across all sets.

"**Ethnicity**" is the color of the piece. Yes, it's silly.

Gender is inferred from keywords in the part name ("Male", "Female", etc., plus references to facial hair).

Some heads are not labeled male/female but contain the name of a character of known gender (e.g., "Han Solo"). Incorporating this information would require a hand-maintained list of character names and their genders; I haven't done this.





Basic elements

An app can be decomposed in five essentials:

- Inputs : where the user can specify information
- Outputs : where information is displayed and visualized
- Reactivity links : defining how some element is affected by another (e.g. an output by an input)
- Layout : how inputs and outputs and other fixed material (e.g. logo) is displayed on the app
- Custom design : font and color choices for the app

Radiant Data Design Basics Model Multivariate Report ☰ ⚡ ?

Datasets:

diamonds

Add/edit data description
 Rename data

Display:

preview str summary

Load data of type:

rds | rda | rdata

Browse... No file selected

Save data to type:

rds

Save

Show R-code

Manage View Visualize Pivot Explore Transform Combine

Data preview

price	carat	clarity	cut	color	depth	table	x	y	z	date
580	0.32	VS1	Ideal	H	61.00	56.00	4.43	4.45	2.71	2012-02-26
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1080	0.40	VS2	Premium	F	62.60	58.00	4.72	4.68	2.94	2012-02-26
3082	0.60	VVS1	Ideal	E	62.50	53.70	5.35	5.43	3.38	2012-02-26
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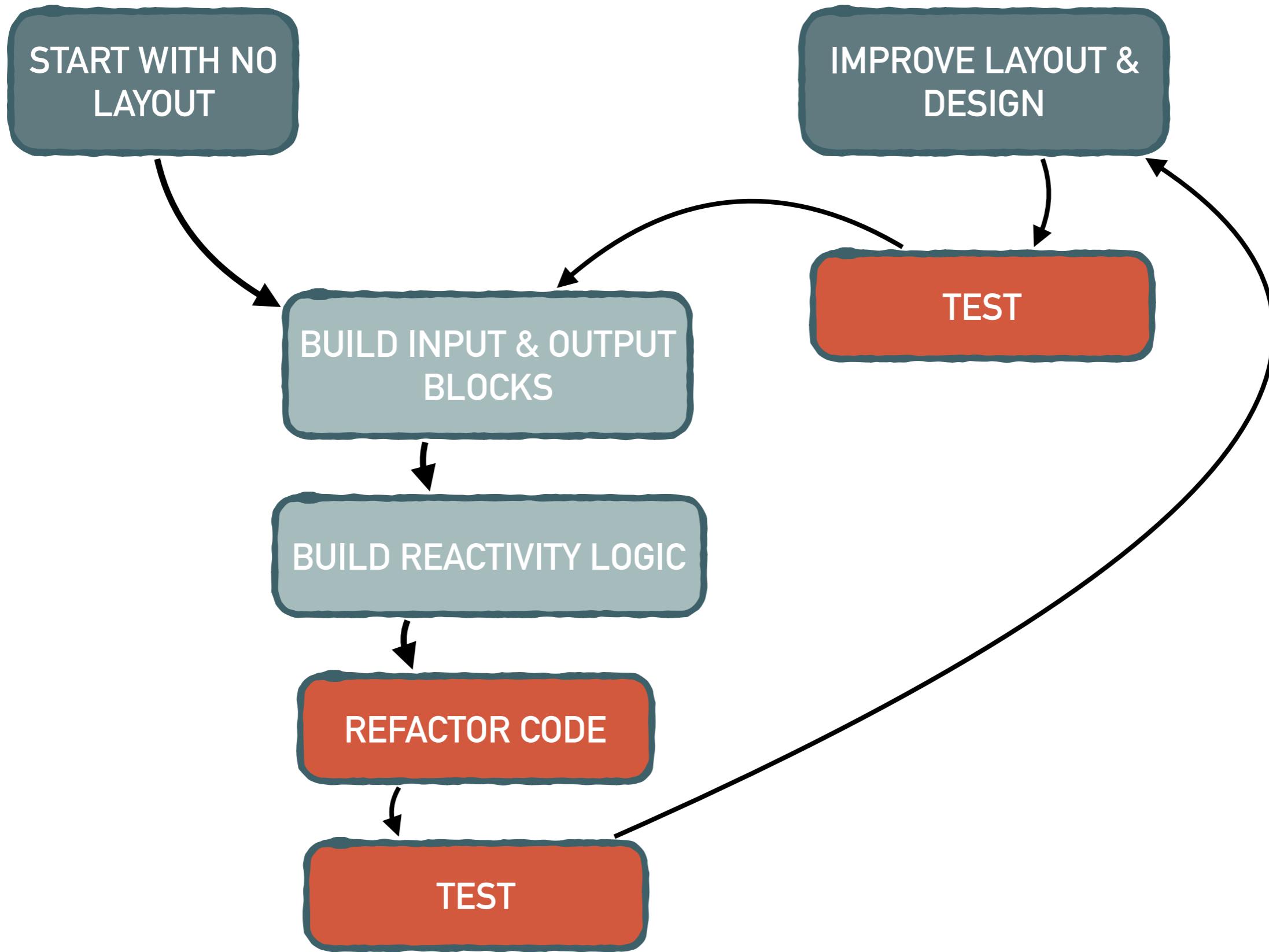
10 of 3,000 rows shown. See View-tab for details.

Inputs

Output

Prices of 3,000 round cut diamonds

Simple process for building the app



Geyser example

Follow these steps :

1. File > New File > Shiny Web App
2. A popup appears : put a random name (modifiable after), and click on `Single file`
3. A folder is created with an `app` R file. Open it. `<!> install.packages('shiny')`
4. Click on the RunApp button to see the result !

User Interface

```
12 # Define UI for application that draws a histogram
13 ui <- fluidPage(
14
15   # Application title
16   titlePanel("Old Faithful Geyser Data"),
17
18   # Sidebar with a slider input for number of bins
19   sidebarLayout(
20     sidebarPanel(
21       sliderInput("bins",
22         "Number of bins:",
23         min = 1,
24         max = 50,
25         value = 30)
26     ),
27
28   # Show a plot of the generated distribution
29   mainPanel(
30     plotOutput("distPlot")
31   )
32 )
33 )
```

Check value of ui to see html code

Server

```
35 # Define server logic required to draw a histogram
36 server <- function(input, output) {
37
38   output$distPlot <- renderPlot({
39     # generate bins based on input$bins from ui.R
40     x <- faithful[, 2]
41     bins <- seq(min(x), max(x), length.out = input$bins + 1)
42
43     # draw the histogram with the specified number of bins
44     hist(x, breaks = bins, col = 'darkgray', border = 'white')
45   })
46 }
47
48 # Run the application
49 shinyApp(ui = ui, server = server)
```

LAYOUT INPUT OUTPUT

Three basic components with
which you'll be working

Plan

- Playing with basic inputs and outputs
- Event reactivity
- Handling data properly
- Create your own Shiny App !

Handling outputs

Outputs are specified in UI (e.g. `textOutput`) and the rendering is specified in server
(e.g. `output$some_output_id <- renderOutput({ ... })`)

Creating :	In UI	In server
Raw HTML	<code>htmlOutput('id')</code> <code>uiOutput('id')</code>	<code>output\$id = renderUI({ ... })</code>
Text	<code>textOutput('id')</code> <code>verbatimTextOutput('id')</code>	<code>output\$id = renderText({ ... })</code> <code>output\$id = renderPrint({ ... })</code>
Table	<code>tableOutput('id')</code>	<code>output\$id = renderTable({ ... })</code>
DataTable	<code>dataTableOutput('id')</code>	<code>output\$id = renderDataTable({ ... })</code>
Image	<code>imageOutput('id')</code>	<code>output\$id = renderImage({ ... })</code>
Plot	<code>plotOutput('id')</code>	<code>output\$id = renderPlot({ ... })</code>
Plotly	<code>plotlyOutput('id')</code>	<code>output\$id = renderPlotly({ ... })</code>

Render your plots interactive, with hovering and clicking options

<https://shiny.rstudio.com/articles/plot-interaction.html>

The need for refactoring

Before

```

18- server = shinyServer(function(input, output) {
19
20   df <- reactive({ starwars %>% filter(map_lgl(films, function(x) input$film %in% x)) })
21
22- output$table1 <- renderDataTable({
23   datatable(head(df(),c('name', 'birth_year', 'species')), 4),
24     options = list(dom = 't'))
25 })
26
27- output$physic1 <- renderPlot({
28   h = df()
29   print(h)
30   ggplot(data = h) +
31     aes(x = height, y = mass, label = name, col = gender) +
32     geom_point(cex = 2) +
33     geom_label_repel() +
34     coord_fixed() +
35     labs(title = 'Physical attributes of Star Wars',
36          x = 'Height (cm)', y = 'Mass (kg)') +
37     theme(text = element_text(size = 20), legend.position = 'bottom')
38 })
39
40- output$physic2 <- renderPlot({
41   hh = df() %>%
42     filter(is.na(homeworld) == FALSE) %>%
43     count(homeworld, gender) %>%
44     group_by(homeworld) %>%
45     mutate(nn = sum(n)) %>%
46     slice_max(order_by = nn, n = 10)
47   ggplot(data = hh) +
48     aes(x = reorder(homeworld, -n), y = n, fill = gender) +
49     geom_bar(stat = 'identity') +
50     labs(x = 'Home World', y = 'People Count', title = 'Home World representation') +
51     theme(text = element_text(size = 20),
52           axis.text.x = element_text(vjust = 0.5, angle = 45))
53 })
54
55 })

```

After

```
1 height_vs_mass_graph <- function(filtered_df){  
11  
12 homeworld_count <- function(filtered_df){  
29  
  
48 server = shinyServer(function(input, output) {  
49  
50   df <- reactive({ starwars %>% filter(map_lgl(films, function(x) input$film %in% x)) })  
51  
52   output$table1 <- renderDataTable({  
53     datatable(head(df(),c('name', 'birth_year', 'species')), 4),  
54       options = list(dom = 't'))  
55   })  
56  
57   output$physic1 <- renderPlot({ height_vs_mass_graph(df()) })  
58  
59   output$physic2 <- renderPlot({ homeworld_count(df()) })  
60  
61 })
```

**Graph code and data process can render overall code readability a nightmare
=> create outside app functions for increased readability + testing**

The app can be organized in different ways :

- functions called can be in separate files, sourced at the beginning
- ui and server can be defined in separate files

You can even integrate it in markdown document !!

Introducing reactivity

	Reactivity functions	Objective	Output
Trigger	observe	Do some operations whenever a called input changes	None
	observeEvent	Do some operations whenever a trigger input is modified	None
	isolate	Isolate an input such that reactivity is not affected by change of its value	None
Data handling	reactive	Compute some data whenever a called input changes	Function
	eventReactive	Compute some data whenever a trigger input is modified	Function
	reactiveValues	Store data that you wish to be accessible and modifiable from any part of the server -> best way to handle loaded data on app	None

Check out <https://rstudio.github.io/reactlog/> to test your reactivity processes

Reactivity - Trigger

observe({}) - do some operations whenever a called input changes, no output

```
4 ui <- fluidPage(  
5  textInput(inputId = "free_input", label = "Free Input"),  
6   selectInput(inputId = "film", label = "Film",  
7               choices = unique(unlist(starwars$films)))  
8 )  
9  
10 random_code <- function(){  
11   paste0(sample(letters, 10), collapse = '')  
12 }  
13  
14 server <- function(input, output, session) {  
15  
16   observe({  
17     print(input$film)  
18     updateSliderInput(inputId = "free_input",  
19                         session = session,  
20                         value = random_code())  
21   })  
22  
23 }  
24  
25 shinyApp(ui, server)
```

LAYOUT

INPUT

OUTPUT

REACTIVITY

Reactivity - Trigger

observeEvent({}) : do some operations whenever a specific input is modified, no output

.....

```
3 ui <- fluidPage(  
4   actionButton("doMagicTrick", "Show something"),  
5   textOutput("myText")  
6 )  
7  
8 server <- function(input, output) {  
9   observeEvent(input$doMagicTrick, {  
10     output$myText <- renderText({  
11       paste0('You are ...', sample(starwars$name, 1), '!')  
12     })  
13   })  
14 }  
15  
16 shinyApp(ui, server)
```

Reactivity - Trigger / or not

isolate({}) - stop input modification from causing changes

.....

```
4 ui <- fluidPage(  
5  textInput(inputId = "free_input", label = "Free Input"),  
6   selectInput(inputId = "film", label = "Film", choices = unique(unlist(starwars$films))),  
7   textOutput('output_text')  
8 )  
9  
10 server <- function(input, output) {  
11  
12   output$output_text <- renderText({  
13     paste0(isolate(input$film), " - ", input$free_input)  
14   })  
15  
16 }  
17  
18 shinyApp(ui, server)
```

LAYOUT

INPUT

OUTPUT

REACTIVITY

Reactivity - Data handling

reactive({}) - update dataset required for several outputs when input changes

```
5 ui <- fluidPage(  
6   selectInput(inputId = "film", label = "Film", choices = unique(unlist(starwars$films))),  
7   textOutput('genericInfo'),  
8   br(),  
9   h5('First 4 characters : '),  
10  dataTableOutput("myTable")  
11 )  
12  
13 server <- function(input, output, session) {  
14  
15   df <- reactive({  
16     starwars %>%  
17     filter(map_lgl(films, function(x) input$film %in% x))  
18   })  
19  
20   output$genericInfo <- renderText({  
21     paste0('Nb of characters : ', nrow(df()))  
22   })  
23  
24   output$myTable <- renderDataTable({  
25     datatable(head(df(),c('name', 'birth_year', 'species')), 4),  
26     options = list(dom = 't'))  
27   })  
28  
29  
30 }  
31  
32 shinyApp(ui, server)
```

Note that reactive outputs a function
callable anywhere in server

LAYOUT

INPUT

OUTPUT

REACTIVITY

Reactivity - Data handling

eventReactive({}) : when a single input is modified, output new data

```
3 ui <- fluidPage(  
4   headerPanel("Example eventReactive"),  
5  
6   mainPanel(  
7  
8     # input field  
9    textInput("user_text", label = "Enter some text:", placeholder = "Please enter some text."),  
10  
11    # submit button  
12    actionButton("submit", label = "Submit"),  
13  
14    # display text output  
15    textOutput("text"))  
16 )  
17  
18 server <- function(input, output) {  
19  
20   # reactive expression  
21   text_reactive <- eventReactive(input$submit, {  
22     input$user_text  
23   })  
24  
25   # text output  
26   output$text <- renderText({  
27     text_reactive()  
28   })  
29 }
```

Note that eventReactive outputs a function callable anywhere in server

LAYOUT INPUT OUTPUT REACTIVITY

Reactivity - Data handling

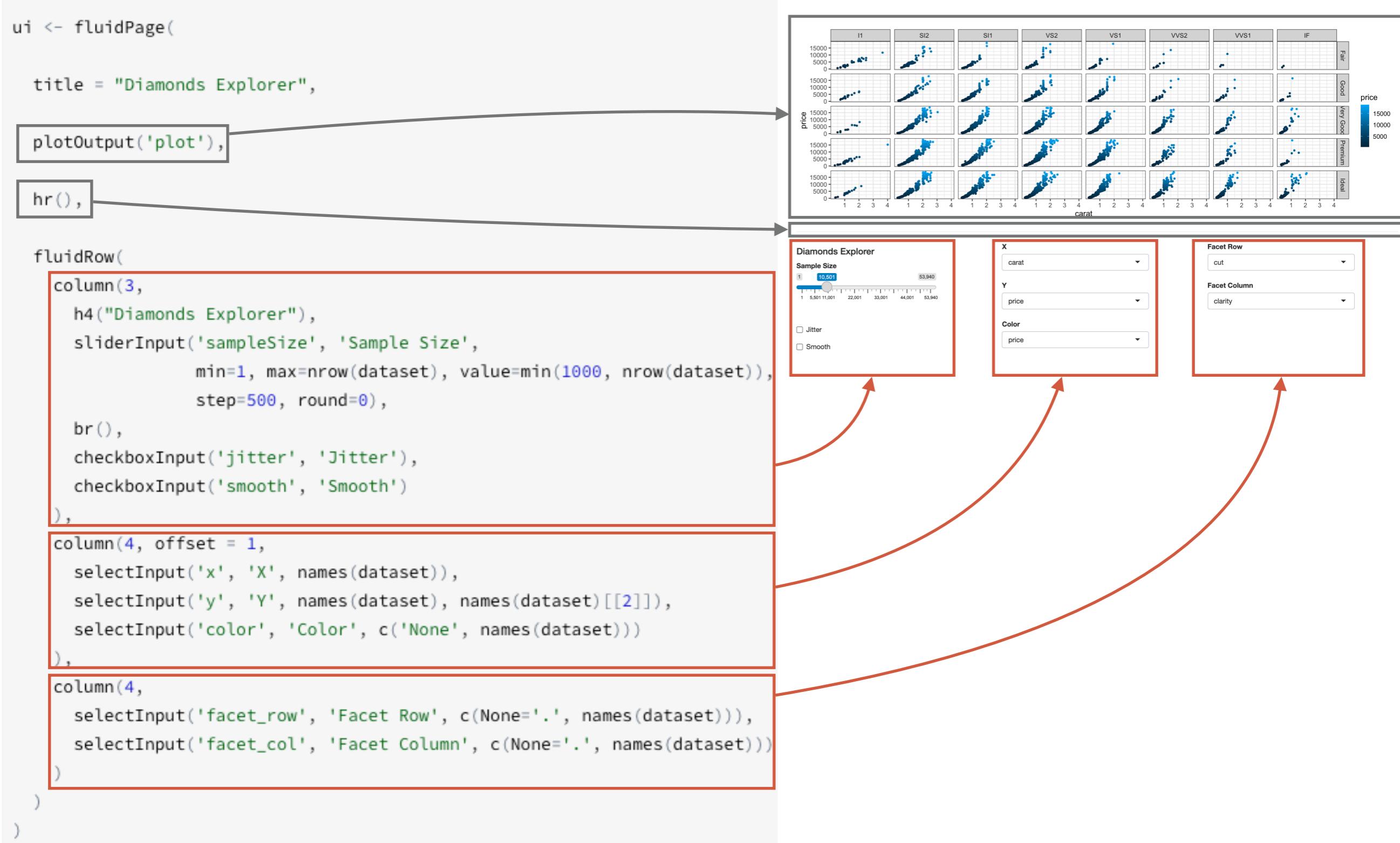
reactiveValues({}) : handling data

```
3 ui <- fluidPage(  
4   # input field  
5  textInput("user_text", label = "Enter some text:", placeholder = "Please enter some text."),  
6   actionButton("submit", label = "Submit"),  
7  
8   # display text output  
9   textOutput("text")  
10 )  
11  
12 server <- function(input, output) {  
13  
14   # observe event for updating the reactiveValues  
15   observeEvent(input$submit,  
16     {  
17       text_reactive$text <- input$user_text  
18     })  
19  
20   # reactiveValues  
21   text_reactive <- reactiveValues(  
22     text = "No text has been submitted yet."  
23   )  
24  
25   # text output  
26   output$text <- renderText({  
27     text_reactive$text  
28   })  
29 }
```

Note that reactiveValues outputs a list callable anywhere in server

LAYOUT INPUT OUTPUT REACTIVITY

Grid Layout



Layout & design

Improving layout

For custom layout

<https://shiny.rstudio.com/articles/layout-guide.html>

Rely on shiny extensions

<https://rstudio.github.io/flexdashboard/articles/examples.html> [**flexdashboard**]

<https://rstudio.github.io/shinydashboard/examples.html> [**shinydashboard**]

<https://rinterface.github.io/shinydashboardPlus/index.html> [**shinydashboardPlus**]

Improve rendering

Customize theme

<https://shiny.rstudio.com/articles/themes.html>

Customizing UI with html and css

Deployment

Where ? Local/Cloud servers with R env running, shinyapp.io

Authentication process : **shinymanager**, **Shinyauthr**, <https://shiny.rstudio.com/gallery/authentication-and-database.html>

Deployment

Where to deploy the app, and how ?

Local machine with R env running

Server with R env running - access and setup requires IT expertise if internal, if external quite easy to do (see this auto on using AWS's servers to deploy an app <https://www.charlesbordet.com/en/guide-shiny-aws/#>)

For open access : shinyapp.io

Authentication management in the app

Packages: [shinymanager](#), [Shinyauthr](#)

Studio resource: <https://shiny.rstudio.com/gallery/authentication-and-database.html>

Response time

R profiling is a great tool to look at the amount of time each piece of your code takes, in order to prioritize dev efforts

Recommended reading

