Data visualization

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M1 MIDS/MFA/LOGOS
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Course Homepage
Moodle

> **Objectives**
>
> This workbook introduces visualization according to the *Grammar of Graphics* framework.
> Using `ggplot2`, we reproduce Rosling's `gapminder` talk.
> This is an opportunity to develop the layered construction of graphical objects.

Grammar of Graphics

We will use the *Grammar of Graphics* approach to visualization

The expression *Grammar of Graphics* was coined by Leiland Wilkinson to describe a principled approach to visualization in Data Analysis (EDA)

A plot is organized around tabular data (a table with rows (observations) and columns (variables))

A *plot* is a *graphical object* that can be built *layer* by *layer*

Building a graphical object consists in *chaining* elementary operations

The acclaimed TED presentation by Hans Rosling illustrates the Grammar of Graphics approach

Visit https://www.youtube.com/embed/jbkSRLYSojo

We will reproduce the animated demonstration using

- `ggplot2`: an implementation of *grammar of graphics* in 'R
- `plotly`: a bridge between `R` and the javascript library `D3.js`
- Using `plotly`, opting for `html` ouput, brings the possibility of interactivity and animation

Setup

We will use the following packages. If needed, we install them.

```
stopifnot(
  require(tidyverse),
```

```
  require(patchwork),
  require(glue),
  require(ggforce),
  require(plotly),
  require(ggthemes),
  require(gapminder),
  require(ggrepel)
)
```

The data we will use can be obtained by loading package `gapminder`

Tip

If the packages have not yet been installed on your hard drive, install them.
You can do that using base `R` `install.packages()` function:

```
install.packages("tidyverse")
```

It is often faster to use functions from package `pak`

```
install.packages("pak")
pak::pkg_install("tidyverse")
```

You need to understand the difference between *installing* and *loading* a package

Question

- How do we get the list of *installed* packages?
- How do we get the list of *loaded* packages?
- Which objects are made available by a package?

Have a look at `gapminder` dataset

The `gapminder` table can be found at `gapminder::gapminder`

- A table has a *schema*: a list of named *columns*, each with a given type
- A table has a *content*: *rows*. Each row is a collection of items, corresponding to the columns

Question

Explore `gapminder::gapminder`, using `glimpse()` and `head()`

- `glimpse()` allows to see the schema and the first rows
- `head()` allows to see the first rows
- Use the pipe `|>` to chain operations

Get a feeling of the dataset

Question

Pick two random rows for each continent using `slice_sample()`

Question

What makes a table *tidy*?

Tip

Have a look at Data tidying in R for Data Science (2nd ed.)

Question

Is the `gapminder` table redundant?

Gapminder tibble (extract)

Question

Extract/filter a subset of rows using `dplyr::filter(...)`

- All rows concerning a given country
- All rows concerning a year
- All rows concerning a given continnent and a year

Filtering (selection σ from database theory) : Picking one year of data

There is simple way to filter rows satisfying some condition. It consists in mimicking indexation in a matrix, leaving the colum index empty, replacing the row index by a condition statement (a logical expression) also called a mask.

```
# q: in gapminder table extract all raws concerning year 2002

gapminder_2002 <- gapminder |>
  filter(year==2002)  #

gapminder_2002 <- gapminder[gapminder$year==2002,]
```

Have a look at

```
gapminder$year==2002
```

What is the type/class of this expression?

This is possible in base `R` and very often convenient.

Nevertheless, this way of performing row filtering does not emphasize the connection between the dataframe and the condition. Any logical vector with the right length could be used as a mask. Moreover, this way of performing filtering is not very functional.

In the parlance of Relational Algebra, `filter` performs a *selection* of rows. Relational expression

$$\sigma_{\text{condition}}(\text{Table})$$

translates to

```
filter(Table, condition)
```

where condition is a boolean expression that can be evaluated on each row of Table. In `SQL`, the relational expression would translate into

```
SELECT
  *
FROM
  Table
WHERE
  condition
```

Check Package `dplyr` docs
The `posit` cheatsheet on `dplyr` is an unvaluable resource for table manipulation.

Use `dplyr::filter()` to perform row filtering

Static plotting: First attempt

Question

Define a plot with respect to `gapminder_2002` along the lines suggested by Rosling's presentation.

You should define a `ggplot` object with data layer `gapminder_2022` and call this object `p` for further reuse.

Question

Map variables `gdpPercap` and `lifeExp` to axes `x` and `y`. Define the axes. In `ggplot2` parlance, this is called *aesthetic mapping*. Use `aes()`.

Use `ggplot` object `p` and add a global aesthetic mapping `gdpPercap` and `lifeExp` to axes `x` and `y` (using `+` from `ggplot2`) .

Question

For each row, draw a point at coordinates defined by the mapping. You need to add a `geom_` layer to your `ggplot` object, in this case `geom_point()` will do.

What's up?

We are building a graphical object (a `ggplot` object) around a data frame (`gapminder`)
We supply *aesthetic mappings* (`aes()`) that can be either global or specifically bound to some *geometries* (`geom_point()`) or *statistics*
The global aesthetic mapping defines which columns (variables) are

- mapped to position (which columns are mapped to axes),
- possibly mapped to colours, linetypes, shapes, ...

Geometries and Statistics describe the building blocks of graphics

What's missing here?

when comparing to the Gapminder demonstration, we can spot that

- colors are missing
- bubble sizes are all the same. They should reflect the population size of the country
- titles and legends are missing. This means the graphic object is useless.

We will add other layers to the graphical object to complete the plot

Second attempt: display more information

Question

- Map `continent` to color (use `aes()`)
- Map `pop` to bubble size (use `aes()`)
- Make point transparent by tuning `alpha` (inside `geom_point()` avoid *overplotting*)

Scaling

To pay tribute to Hans Rosling, we need to take care of two *scaling* issues:

- the gdp per capita axis should be *logarithmic* `scale_x_log10()`
- the *area* of the point should be proportional to the population `scale_size_area()`

Complete the graphical object accordingly

Question

Motivate the proposed scalings.

- Why is it important to use logarithmic scaling for gdp per capita?
- When is it important to use logarithmic scaling on some axis (in other contexts)?
- Why is it important to specify `scale_size_area()` ?

In perspective

> **Question**
>
> Using copilots completions, we can summarize the construcion of the graphical object in a series of questions.
>
> ```
> # q: Define a plot with respect to table gapminder_2002 along the lines suggested by P
> # q: Map variables gdpPercap and lifeExp to axes x and y. Define the axes.
> # q: For each row, draw a point at coordinates defined by the mapping.
> # q: Map continent to color
> # q: Map pop to bubble size
> # q: Make point transparent by tuning alpha (inside geom_point() avoid overplotting)
> # q: Add a plot title
> # q: Make axes titles explicit and readable
> # q: Use labs(...)
> # q: Use scale_x_log10() and scale_size_area()
> # q: Fine tune the guides: replace pop by Population and titlecase continent
> # q: Use theme_minimal()
> # q: Use scale_color_manual(...) to fine tune the color aesthetic mapping.
> # q: Use facet_zoom() from package ggforce
> # q: Add labels to points. This can be done by aesthetic mapping. Use aes(label=..)
> ```

> **Question**
>
> What should be the respective purposes of Title, Subtitle, Caption, … ?

Theming using `ggthemes` (or not)

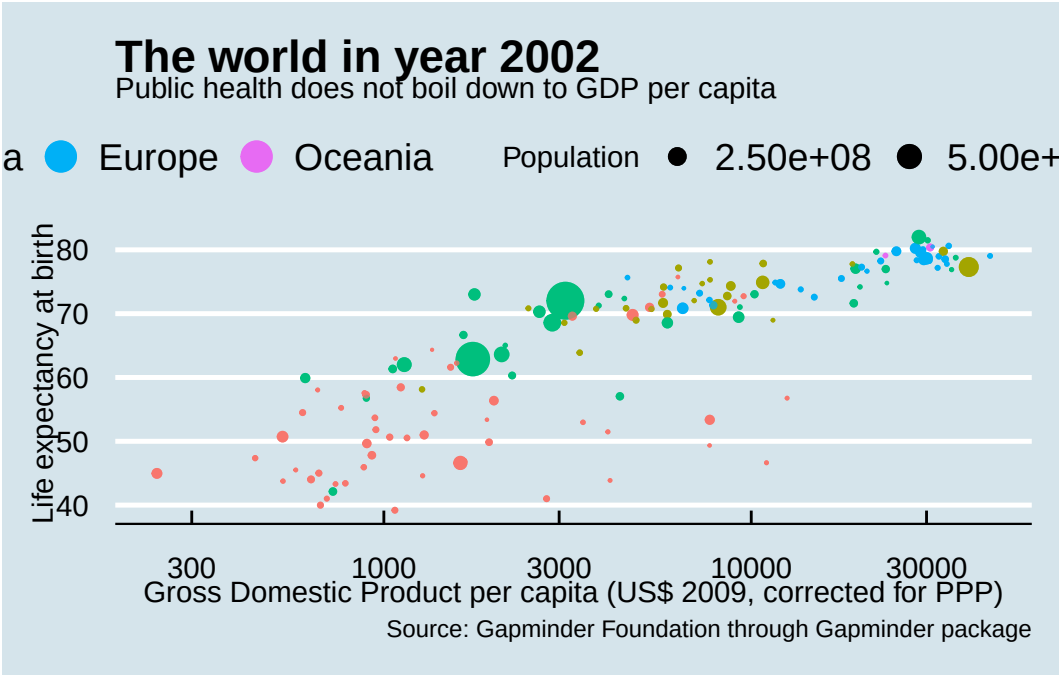
```
stopifnot(
  require("ggthemes")
)
```

A theme defines the *look and feel* of plots

Within a single document, we should use only one theme

See Getting the theme for a gallery of available themes

```
p +
  theme_economist()
```



Tuning scales

Question

Use `scale_color_manual(...)` to fine tune the color aesthetic mapping.

Tip

Choosing a color scale is a difficult task
`viridis` is often a good pick.

Zooming on a continent

```
zoom_continent <- 'Europe'  # choose another continent at your convenience
```

Use `facet_zoom()` from package `ggforce`

Adding labels

Question

Add labels to points. This can be done by aesthetic mapping. Use `aes(label=..)`
To avoid text cluttering, package `ggrepel` offers interesting tools.

Facetting

So far we have only presented one year of data (2002)

Rosling used an *animation* to display the flow of time

If we have to deliver a printable report, we cannot rely on animation, but we can rely on *facetting*

Facets are collections of small plots constructed in the same way on subsets of the data

> **Question**
>
> Add a layer to the graphical object using `facet_wrap()`

As all rows in `gapminder_2002` are all related to `year` 2002, we need to rebuild the graphical object along the same lines (using the same *graphical pipeline*) but starting from the whole `gapminder` dataset.

Should we do this using *cut and paste*?

☠ No!!!

> **Don't Repeat Yoursel (DRY)**
>
> Abide to the DRY principle using operator `%+%`: the `ggplot2` object `p` can be fed with another dataframe and all you need is proper facetting.

Animate for free with `plotly`

> **Question**
>
> Use `plotly::ggplotly()` to create a Rosling like animation.
> Use `frame` aesthetics.

Suggestions

Think about ways to visualize specific aspects of the gapminder data.

- How could you overlay the world in 1952 and 2007?
- How could you visualize the evolution of life expectancy and population across the different countries?
- Visualize the evolution of former colonies and their colonizers.
- Visualize the evolution of countries from the former Soviet Union, Warsaw Pact, and Yugoslavia.
- Visualize the evolution of countries from the former British Empire.

More material

Visit Data visualization using ggplot2 and its extensions, UseR 2021 Tutorial

Read Visualization in R for Data Science