Data Visualization with R
Ggplot2 tutorial

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University of Washington - Fall 2023

What is ggplot2?

Ggplot2 is the graphics package from the tidyverse, a collection of R packages designed for data science.

There is a base graphics package in R, which is present in the default version of R.

However, ggplot2 gives users a lot more flexibility and control over their visualizations.

Main concepts of ggplot2

Ggplot2 is based on layers:

- A first layer to describe the dataset.
- Layers describing the objects representing the data (dots, lines, bars, etc.).
- Additional objects describing the graphic itself (coordinates, scales, fonts, etc.)

Example: Histograms

Built-in R graphics package:

```
hist(airquality$Temp)
```

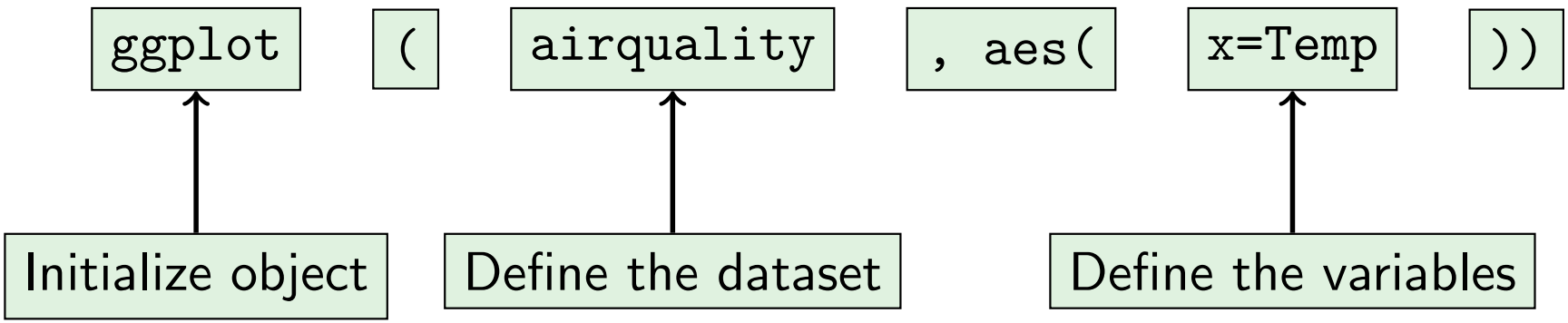
Quick plot using ggplot2:

```
qplot(airquality$Temp)
```

Ggplot2 command structure

```
ggplot(airquality, aes(x=Temp))
```

This command does not plot anything.



Ggplot2 command structure

We need to add a command to explain the kind of object that we want to plot:

```
ggplot(airquality, aes(x=Temp)) +
geom_histogram()
```

Bar plots

We can use bar plots to visualize one categorical variable:

```
ggplot(df_desc, aes(x=Vancouver)) +
geom_bar()
```

The height of the bar is proportional to the number of cases in each group.

Bar plots

Or a combination of a categorical variable and a continuous variable:

```
ggplot(RetailSales, aes(x=Month, y=Sales)) +
geom_bar(stat="identity")
```

Using `stat = "identity"` tells ggplot2 to sum the values for each group (Month) and plot bars proportional to the sums.

Box plots

For each layer that we want to add on our plot, we add the corresponding object:

```
ggplot(df_hum, aes(x=month, y=Vancouver)) +
geom_boxplot()
```

Scatter plots and line plots

The relationship between two continuous variables can be visualize with a scatter plot or a line plot:

```
ggplot(df, aes(x=time, y=distance)) +
geom_point()
```

```
ggplot(df, aes(x=time, y=distance)) +
geom_line()
```

Changing histogram defaults

Modify the number of bins:

```
ggplot(df_hum, aes(x=Vancouver)) +
geom_histogram(bins=15)
```

Modify the filling and the color:

```
ggplot(df_hum, aes(x=Vancouver)) +
geom_histogram(bins=15, fill="white", color=1)
```

Adding aesthetics to the plot

Add title and axis labels to the histogram:

```
ggplot(df_hum, aes(x=Vancouver)) +
geom_histogram(bins=15, fill="white", color=1) +
ggtitle("Humidity for Vancouver city") +
xlab("Humidity") +
theme(axis.text.x=element_text(size=12),
axis.text.y=element_text(size=12))
```

Adding aesthetics to the boxplot

Add labels to the box plot:

```
ggplot(df_hum, aes(x=month, y=Vancouver)) +
geom_boxplot(color=1, fill=3) +
ylab("Humidity") +
theme(axis.text.x=element_text(size=15),
axis.text.y=element_text(size=15),
axis.title.x=element_text(size=15, color=2),
axis.title.y=element_text(size=15, color=2))
```

Layers

Each plot can be thought as a separate variable, and the sum of the variables will make the final plot. You can define:

```
p1 <- ggplot(df,
      aes(x=Electricity_consumption_per_capita))
p2 <- p1 + geom_histogram()
p3 <- p1 + geom_histogram(bins=15)
p4 <- p3 + xlab("Electricity consumption per capita")
```

and you can choose to plot p2, p3, or p4.

Scales

Scales `scale_x_continuous` or `scale_x_discrete` can be used to specify the axes. `name`, `limits`, `breaks`, and `labels` are the main parameters that can be adjusted.

```
p1 <- ggplot(df, aes(x=gdp_per_capita))
p2 <- p1 + geom_histogram()
p3 <- p2 + scale_x_continuous(
           name"GDP per capita),
           limits=c(0, 50000),
           breaks=seq(0, 40000, 4000),
           labels=c("0K", "4K", "8K", "12K", "16K",
           "20K",  "24K", "28K", "32K", "36K", "40K"))
```

Polar coordinates

You can define the coordinates with `coord_cartesian` or `coord_polar`:

```
t <- seq(0, 360, by=15)
r <- 2
qplot(r, t) +
coord_polar(theta="y") +
scale_y_continuous(breaks=seq(0, 360, 30))
```

Facets

A Trellis display allows creating a plot for each group of a categorical variable:

```
p <- ggplot(df,
     aes(x=gdp_per_capita,
     y=Electricity_consumption_per_capita)) +
     geom_point()
p + facet_grid(Country ~ .)
p + facet_grid(. ~ Country)
p + facet_wrap(~Country)
```

You can group subplots horizontally, vertically or wrapped together.

Shapes and colors

You can change shape and color for the entire plot:

```
ggplot(df, aes_string(x=var1, y=var2)) +
geom_point(color=2, shape=2)
```

Or assign a different shape and color for each group of a categorical variable:

```
ggplot(df, aes_string(x=var1, y=var2)) +
geom_point(aes(color=Country, shape=Country))
```

Themes

Theme is used to change the non-data elements of the plot:

Theme	Type	Arguments
axis.title.x	element_text	size, color, family, angle
axis.title.y	element_text	size, color, family, angle
plot.background	element_rect	fill, color, linewidth
panel.background	element_rect	fill, fill, color, line width
panel.grid.major	element_line	color, linetype, linewidth

Type `?theme` to show all possible types of themes, their types and their arguments.

Themes

You can add themes to the plot to customize the non-data elements:

```
p1 <- ggplot(dfn, aes(Genre, WorldGross))
p2 <- p1+ geom_bar(aes(fill=LeadStudio),
                   stat="Identity",
                   position="dodge")
p3 <- p2 + theme(axis.title.x=element_text(size=15),
                 axis.title.y=element_text(size=15),
plot.background=element_rect(fill="gray87"),
panel.background=element_rect(fill="beige"),
panel.grid.major=element_line(color="Gray",
                              linetype=1))
```

Themes

You can use predefined themes:

```
p2 + theme_bw() + ggtitle("theme_bw()")
p2 + theme_classic() + ggtitle("theme_classic()")
p2 + theme_classic() + ggtitle("theme_gray()")
p2 + theme_minimal() + ggtitle("theme_minimal()")
```

Themes

You can also use define your own theme:

```
mytheme <- theme(legend.title=element_blank(),
legend.position="bottom",
text=element_text(color="Blue"),
axis.text=element_text(size=12, color="Red"),
axis.title=element_text(size=rel(1.5)))
```

and use it for a single plot:

```
p2 + mytheme + ggtitle("Changed Plot with my theme")
```

or for all the plots by placing it at the beginning of your code:

```
theme_set(my_theme)
```

Themes

You can change the color palette.

Type `?scale_fill_brewer` to see all the color palettes available.

```
p4 <- p2 + theme_bw() + ggtitle("theme_bw()")
p4 + scale_fill_brewer(palette="Spectral")
```

Bubble charts

You can make the size of each marker proportional to a variable:

```
ggplot(dfs, aes(x=Year,
                y=Electricity_consumption_per_capita))
+ geom_point(aes(size=population, color=Country))
+ scale_size(breaks=c(0, 1e+8, 0.3e+9, 0.5e+9,
                      1e+9, 1.5e+9), range=c(1, 5))
```

Density plots

Instead of plotting an histogram, ggplot2 will estimate the density before plotting it:

```
ggplot(df, aes(x=loan_amnt)) +
geom_density() +
facet_wrap(~grade)
```

It is also possible to superimpose the density plots:

```
ggplot(df, aes(x=loan_amnt)) +
geom_density(aes(fill=grade), alpha=1/2) +
scale_fill_brewer(palette="Dark2")
```

Time series plots

Use `geom_line` to make time series plots:

```
df_fb$Date <- as.Date(df_fb$Date)
ggplot(df_fb, aes(x=Date, y=Close, group=1)) +
geom_line(color="black", na.rm=TRUE) +
scale_x_date(date_breaks='3 month')
```

We use `group=1` one there is only one line to be show.

Use `group=MyCategory` to plot a line per value of a categorical variable.

Statistical summaries

You can add statistical summaries of the data (e.g. mean, median, quantiles) to the plot:

```
ggplot(df_fb, aes(Month, Close)) +
geom_point(color="red", alpha=1/2,
           position=position_jitter(h=0.0, w=0.0)) +
stat_summary(geom="line", fun="quantile",
             fun.args=list(probs=.1), linetype=2,
             color="green", size=1) +
stat_summary(geom="line", fun="quantile",
             fun.args=list(probs=.9), linetype=2,
             color="green", size=1)
```

Linear regression

Ggplot can also fit a linear regression to the data and add it to the plot. It may be done for all the data:

```
ggplot(dfs, aes(gdp_per_capita,
                Electricity_consumption_per_capita)) +
geom_point(aes(color=Country)) +
stat_smooth(method=lm)
```

Linear regression

Or you can fit a linear regression to each category:

```
ggplot(dfs, aes(gdp_per_capita,
                Electricity_consumption_per_capita,
                color=Country)) +
geom_point() +
stat_smooth(method=lm)
```

Correlations

You can also plot correlations between different variables:

```
M <- cor(df)
corrplot(M, method="number")
corrplot(M, method="pie")
corrplot(M, method="ellipse")
```

Maps

You can use maps from the `maps` and `map_data` packages to plot maps:

```
world_map <- map_data("world")
states_map <- map_data("state")
```

You can select only some polygons from the map using:

```
europe <- map_data("world",
region=c("Germany", "Spain", "Italy",
         "France", "UK", "Ireland"))
```

Maps

To plot the data, we may use geom_polygom or geom_path.

The projection is defined with coord_map.

```
ggplot(states_map, aes(x=long, y=lat, group=group)) +
geom_polygon(fill="white", color="black")
```

```
ggplot(states_map, aes(x=long, y=lat, group=group)) +
geom_path() +
coord_map("mercator")
```