Getting started with ggplot2

STAT 133

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ggplot2

Resources for "ggplot2"

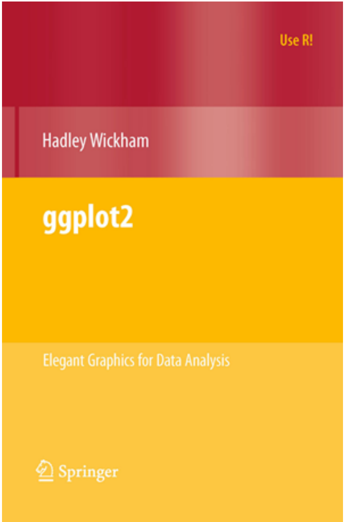
- Documentation: http://docs.ggplot2.org/
- Book: **ggplot2: Elegant Graphics for Data Analysis** (by Hadley Wickham)
- Book: **R Graphics Cookbook** (by Winston Chang)
- RStudio ggplot2 cheat sheet

  https://www.rstudio.com/wp-content/uploads/2015/03/ggplot2-cheatsheet.pdf

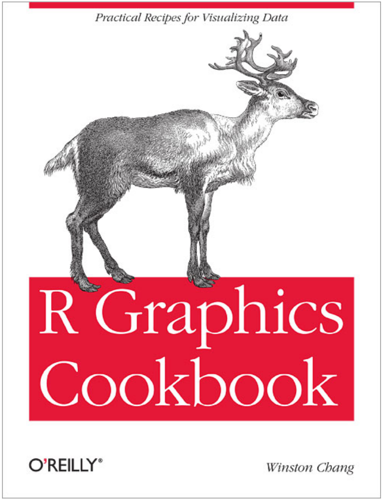
package "ggplot2"

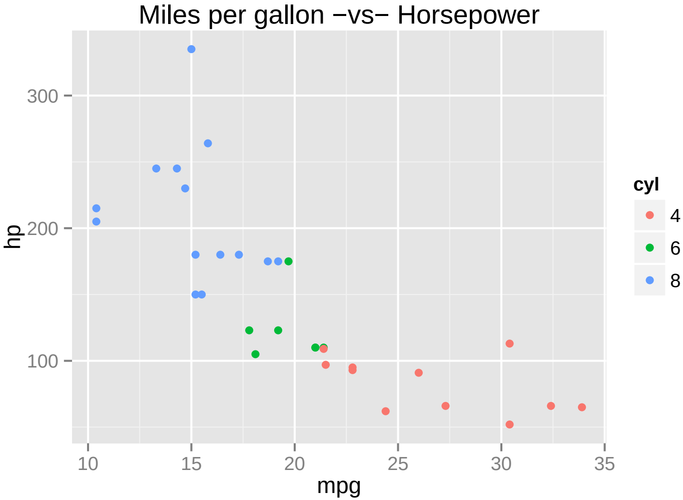
```r
# remember to install ggplot2
# (just once)
install.packages("ggplot2")


# load ggplot2
library(ggplot2)


# see basic documentation
?ggplot
```

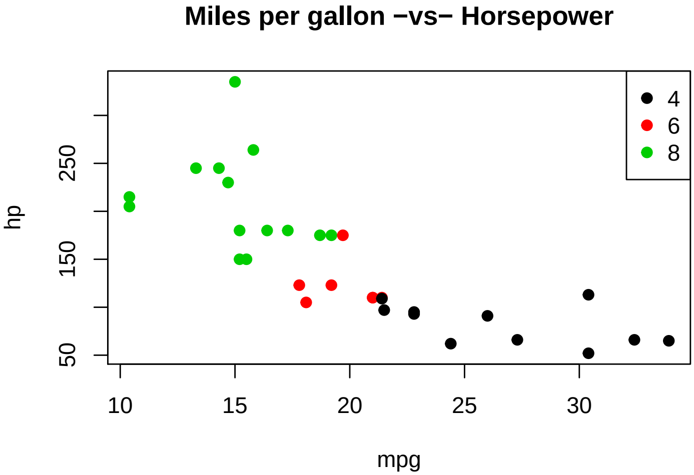
ggplot2 book



R Graphics Cookbook



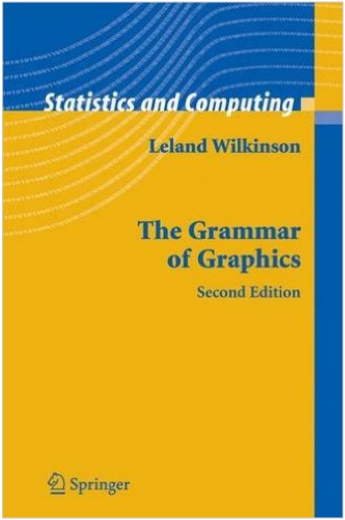

Miles per gallon −vs− Horsepower
hp
300
200
100
10
15
20
25
30
35
mpg
cyl
4
6
8


Miles per gallon −vs− Horsepower
hp
50
150
250
mpg
10
15
20
25
30
● 4
● 6
● 8

About "ggplot2"

- "ggplot2" (by Hadley Wickham) is an R package for producing statistical graphics
- It provides a framework based on Leland Wilkinson's **Grammar of Graphics**
- "ggplot2" provides beautiful plots while taking care of fiddly details like legends, axes, colors, etc.
- "ggplot2" is built on the R graphics package "grid"
- Underlying philosophy is to describe a wide range of graphics with a compact syntax and independent components

The Grammar of Graphics



Statistics and Computing

Leland Wilkinson

The Grammar of Graphics

Second Edition

Springer

About the Grammar of Graphics

- *The Grammar of Graphics* is Wilkinson's attempt to define a theoretical framework for graphics
- **Grammar**: Formal system of rules for generating graphics
  - Some rules are mathematic
  - Some rules are aesthetic

About the Grammar of Graphics

3 Stages of Graphic Creation

- **Specification**: link data to graphic objects
- **Assembly**: put everything together
- **Display**: render of a graphic

About the Grammar of Graphics

Specification

Link data to graphic objects

- Data
- Transformation of variables (e.g. aggregation)
- Scale transformations (e.g. log)
- Coordinate system (e.g. cartesian)
- Graphic Elements (e.g. points, lines)
- Guides (e.g. labels, legends)

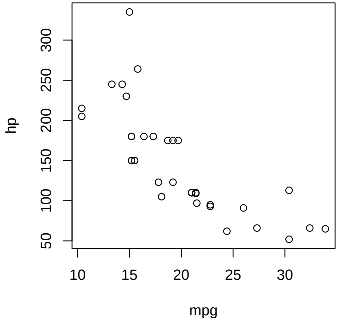
R package "ggplot2"

About "ggplot2"

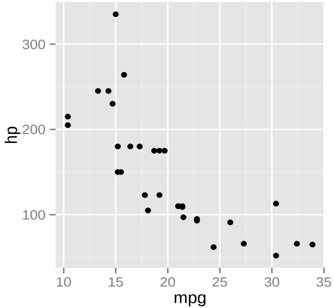
- Default appearance of plots carefully chosen
- Designed with visual perception in mind
- Inclusion of some components, like legends, are automated
- Great flexibility for annotating, editing, and embedding output

Base graphics -vs- "ggplot2"

base graphics



ggplot2



About "ggplot2"

- "ggplot2" is the name of the package
- The gg in "ggplot2" stands for *Grammar of Graphics*
- Inspired in the **Grammar of Graphics** by Lee Wilkinson
- "ggplot" is the class of objects (plots)
- ggplot() is the main function in "ggplot2"

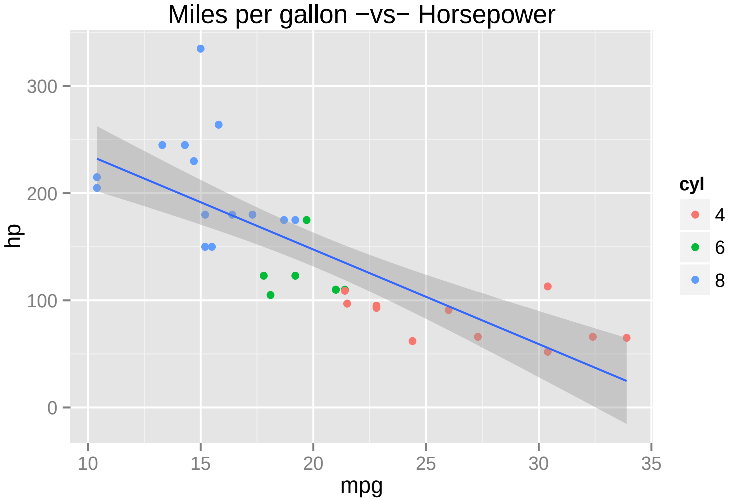
What is a Statistical Graphic?

Some Data set

```
mtcars
```

```
##                    mpg  hp  cyl
## Mazda RX4         21.0 110    6
## Mazda RX4 Wag     21.0 110    6
## Datsun 710        22.8  93    4
## Hornet 4 Drive    21.4 110    6
## Hornet Sportabout 18.7 175    8
## Valiant           18.1 105    6
## Duster 360        14.3 245    8
## Merc 240D         24.4  62    4
## Merc 230          22.8  95    4
## Merc 280          19.2 123    6
```

What is a statistical graphic?



What is a statistical graphic?

Elements to draw the chart “manually”

What is a statistical graphic?

Elements to draw the chart “manually”

- coordinate system
- x and y axis (intervals)
- axis tick marks
- axis labels, and title
- points (with colors)
- regression line (and ribbon)
- legend

What is a statistical graphic?

Simply put, a statistical graphic is:

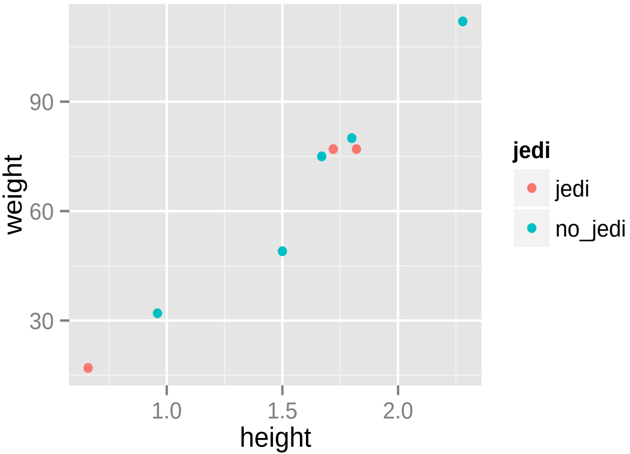
- A mapping from data to aesthetic attributes (color, shape, size) of geometric objects (points, lines, bars)
- A plot may also contain statistical transformations of the data
- A plot is drawn on a specific coordinate system
- Sometimes faceting can be used to get the same plot for different subsets of the dataset

Starting with "ggplot2"

starwarstoy.csv

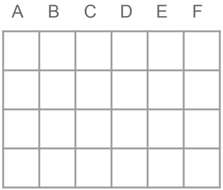
```
##               name gender height weight    jedi species     weapon
## 1 Luke Skywalker   male   1.72     77    jedi   human lightsaber
## 2 Leia Skywalker female   1.50     49 no_jedi   human    blaster
## 3 Obi-Wan Kenobi   male   1.82     77    jedi   human lightsaber
## 4       Han Solo   male   1.80     80 no_jedi   human    blaster
## 5          R2-D2   male   0.96     32 no_jedi   droid    unarmed
## 6          C-3PO   male   1.67     75 no_jedi   droid    unarmed
## 7           Yoda   male   0.66     17    jedi    yoda lightsaber
## 8      Chewbacca   male   2.28    112 no_jedi wookiee  bowcaster
```

Scatterplot

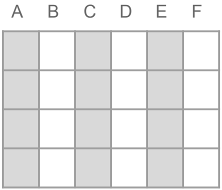


Main steps in creating ggplot graphics

1 Dataset

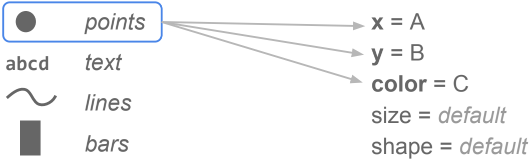


2 Which variables



3 Geometric objects

4 Aesthetics



- ● *points*
- abcd *text*
- *lines*
- *bars*

x = A

y = B

color = C

size = *default*

shape = *default*

Building a scatterplot

User specifications

- Dataset: `starwars`
- Variables: `height, weight, jedi`
- Geoms: points
- Aesthetics (attributes):
  - **x**: `height`
  - **y**: `weight`
  - **color**: `jedi`

Scatterplot with "ggplot2"

```
ggplot(data = starwars) +
  geom_point(aes(x = height, y = weight, color = jedi))
```

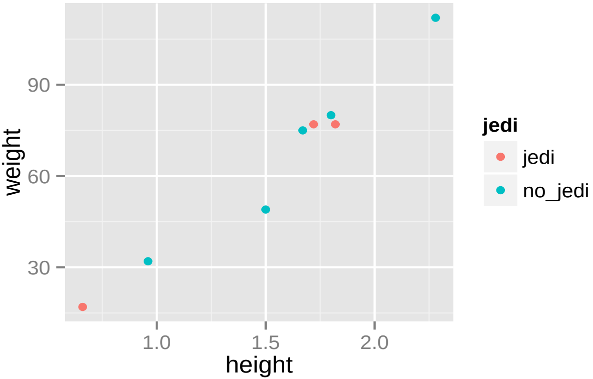
Scatterplot with "ggplot2"

```
ggplot(data = starwars) +
  geom_point(aes(x = height, y = weight, color = jedi))
```

- `ggplot()` initializes a "ggplot" object
- specify the dataset with `data`
- type of geometric object: `geom_point()`
- mapping aesthetic attributes to variables with `aes()`
  - x-position: `height`
  - y-position: `weight`
  - color: `jedi`

Scatterplot with "ggplot2"

```
ggplot(data = starwars) +
  geom_point(aes(x = height, y = weight, color = jedi))
```



Scatterplot with "ggplot2"

Automated things in "ggplot2"

- Axis labels
- Legends (position, labels, symbols)
- Choose of colors for points
- Background color (e.g. gray)
- Grid lines (major and minor)
- Axis tick marks

you can always change the automated elements

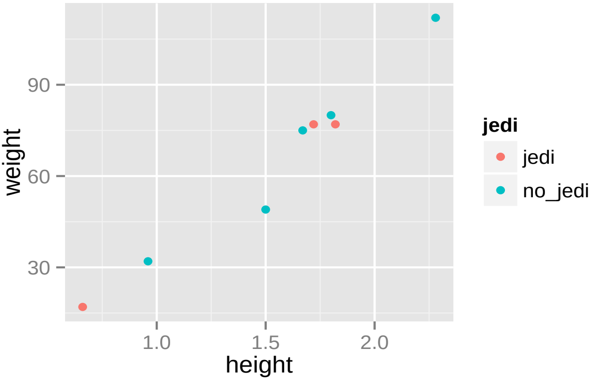
"ggplot2" graphics

Philosophy of "ggplot2"

A graphic is a **mapping** from **data** to **aesthetic attributes** (color, shape, size) of **geometric objects** (points, lines, bars)

Scatterplot with "ggplot2"

```
ggplot(data = starwars) +
  geom_point(aes(x = height, y = weight, color = jedi))
```



Mapping

data values

height	weight	jedi
1.72	77	jedi
1.50	49	no_jedi
1.82	77	jedi
1.80	80	no_jedi
0.96	32	no_jedi
1.67	75	no_jedi
0.66	17	jedi
2.28	112	no_jedi

mapping

aesthetic attributes

x	y	color
x_1	y_1	#F8766D
x_2	y_2	#00BFC4
x_3	y_3	#F8766D
x_4	y_4	#00BFC4
x_5	y_5	#00BFC4
x_6	y_6	#00BFC4
x_7	y_7	#F8766D
x_8	y_8	#00BFC4

"ggplot2" graphics

Philosophy of "ggplot2"

A graphic is a **mapping** from **data** to **aesthetic attributes** (color, shape, size) of **geometric objects** (points, lines, bars)

- `ggplot(data, ...)`
- `aes()`
- `geom_objects()`

Scatterplot with "ggplot2"

How does "ggplot2" work?

- plots are created piece-by-piece
- plot components added with + operator
- aesthetic attributes mapped to data values
- computation of scales for aesthetic attributes

How does it work?

Usually, we specify the data and variables inside the function `ggplot()`

```
ggplot(data = mtcars, aes(x = mpg, y = hp))
```

Note the use of the internal function `aes()` to *map* `x` to `mpg`, and `y` to `hp`.

Then we **add a layer** of geometric objects: points in this case

```
+ geom_point()
```

Some alternative options

```r
# option A
ggplot(data = starwars,
       aes(x = height, y = weight, color = jedi)) +
  geom_point()
```

Some alternative options

```r
# option A
ggplot(data = starwars,
       aes(x = height, y = weight, color = jedi)) +
  geom_point()
```

```r
# option B
ggplot(data = starwars) +
  geom_point(aes(x = height, y = weight, color = jedi))
```

Some alternative options

```r
# option A
ggplot(data = starwars,
       aes(x = height, y = weight, color = jedi)) +
  geom_point()
```

```r
# option B
ggplot(data = starwars) +
  geom_point(aes(x = height, y = weight, color = jedi))
```

```r
# option C
ggplot() +
  geom_point(data = starwars,
             aes(x = height, y = weight, color = jedi))
```

Main inquiries

Always ask yourself ...

- What is the **data** set of interest?
- What **variables** will be used to make the plot?
- What **graphics shapes** will be used to display?
- What **features** of the shapes will be used to represent the data values?

"ggplot2" basics

- The data must be in a `data.frame`
- Variables are mapped to aesthetic attributes
- Aesthetic attributes belong to geometric objects **geoms** (points, lines, polygons)

Basic Terminology

- **ggplot()** - The main function where you specify the dataset and variables to plot
- **geoms** - geometric objetcs
  - `geom_point()`, `geom_bar()`, `geom_line()`, `geom_density()`
- **aes** - aesthetics (i.e. attributes)
  - shape, color, fill, linetype

Warning

`"ggplot2"` comes with the function `qplot()` (i.e. *quick plot*). Avoid using it!

As Karthik Ram says: "you'll end up unlearning and relearning a good bit"