Intro and descriptive statistics

The ASTA team

Contents

1 Software

1.1 Rstudio

- Make a folder on your computer where you want to keep files to use in **Rstudio**. **Do NOT use Danish characters æ, ø, å** in the folder name (or anywhere in the path to the folder).
- Set the working directory to this folder: `Session -> Set Working Directory -> Choose Directory` (shortcut: Ctrl+Shift+H).
- Make the change permanent by setting the default directory in: `Tools -> Global Options -> Choose Directory`.

1.2 R extensions

- The functionality of **R** can be extended through libraries or packages (much like plugins in browsers etc.). Some are installed by default in **R** and you just need to load them.
- To install a new package in **Rstudio** use the menu: `Tools -> Install Packages`
- You need to know the name of the package you want to install. You can also do it through a command:

```
install.packages("mosaic")
```

- When it is installed you can load it through the `library` command:

```
library(mosaic)
```

- This loads the `mosaic` package which has a lot of convenient functions for this course (we will get back to that later). It also prints a lot of info about functions that have been changed by the `mosaic` package, but you can safely ignore that.

1.3 R help

- You get help via `?<command>`:

```
?sum
```

- Use `tab` to make **Rstudio** guess what you have started typing.
- Search for help:

```
help.search("plot")
```

- You can find a cheat sheet with the **R** functions we use for this course here.

2 Data

2.1 Data example

We use data about pengiuns from the R package palmerpenguins

```
pingviner <- palmerpenguins::penguins
pingviner
```

```
## # A tibble: 344 x 8
##    species island    bill_length_mm bill_depth_mm flipp~ body~ sex    year
##    <fctr>  <fctr>             <dbl>         <dbl>  <int> <int> <fct> <int>
##  1 Adelie  Torgersen           39.1          18.7    181  3750 male   2007
##  2 Adelie  Torgersen           39.5          17.4    186  3800 fema~  2007
##  3 Adelie  Torgersen           40.3          18.0    195  3250 fema~  2007
##  4 Adelie  Torgersen          NA            NA        NA    NA <NA>   2007
##  5 Adelie  Torgersen           36.7          19.3    193  3450 fema~  2007
##  6 Adelie  Torgersen           39.3          20.6    190  3650 male   2007
##  7 Adelie  Torgersen           38.9          17.8    181  3625 fema~  2007
##  8 Adelie  Torgersen           39.2          19.6    195  4675 male   2007
##  9 Adelie  Torgersen           34.1          18.1    193  3475 <NA>   2007
## 10 Adelie  Torgersen           42.0          20.2    190  4250 <NA>   2007
## # ... with 334 more rows
```

- What is fundamentally different about the the variables (columns) `species` and `body_mass_g`?

2.2 Data types

2.2.1 Quantitative variables

- The measurements have numerical values.
- Quantative data often comes about in one of the following ways:
  - **Continuous variables**: measurements of time, length, size, age, mass, etc.
  - **Discrete variables**: counts of e.g. words in a text, hits on a webpage, number of arrivals to a queue in one hour, etc.
- Measurements like this have a well-defined scale and in **R** they are stored as the type **numeric**.
- It is important to be able to distinguish between discrete count variables and continuous variables, since this often determines how we describe the uncertainty of a measurement.
- Are any of the measurements in our data set quantitative?

2.2.2 Categorical/qualitative variables

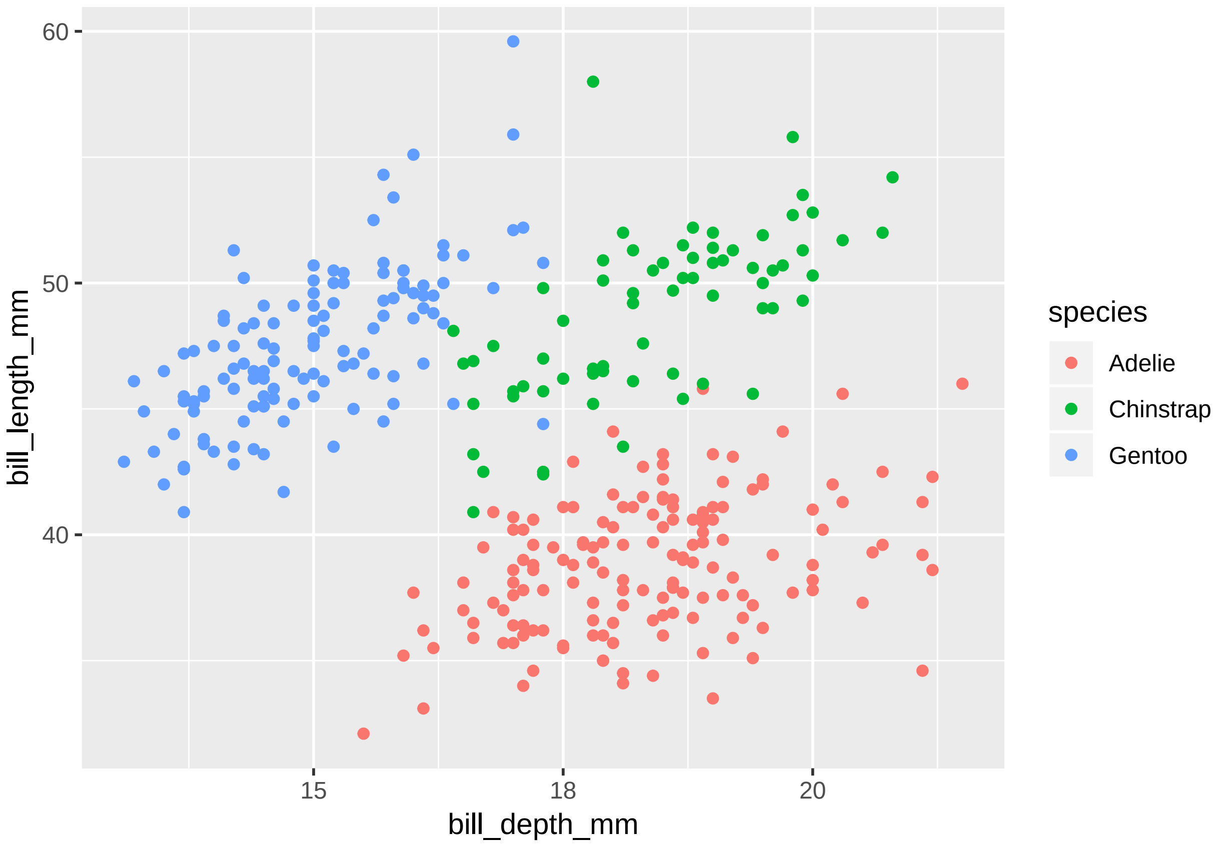
- The measurement is one of a set of given categories, e.g. sex (male/female), social status, satisfaction score (low/medium/high), etc.
- The measurement is usually stored (which is also recommended) as a **factor** in **R**. The possible categories are called **levels**. Example: the levels of the factor "sex" is male/female.
- Factors have two so-called scales:
  - **Nominal scale**: There is no natural ordering of the factor levels, e.g. sex and hair color.
  - **Ordinal scale**: There is a natural ordering of the factor levels, e.g. social status and satisfaction score. A factor in **R** can have a so-called **attribute** assigned, which tells if it is ordinal.
- Are any of the measurements in our data set categorical/qualitative?

3 Graphics for quantitative variables

3.1 Scatterplot

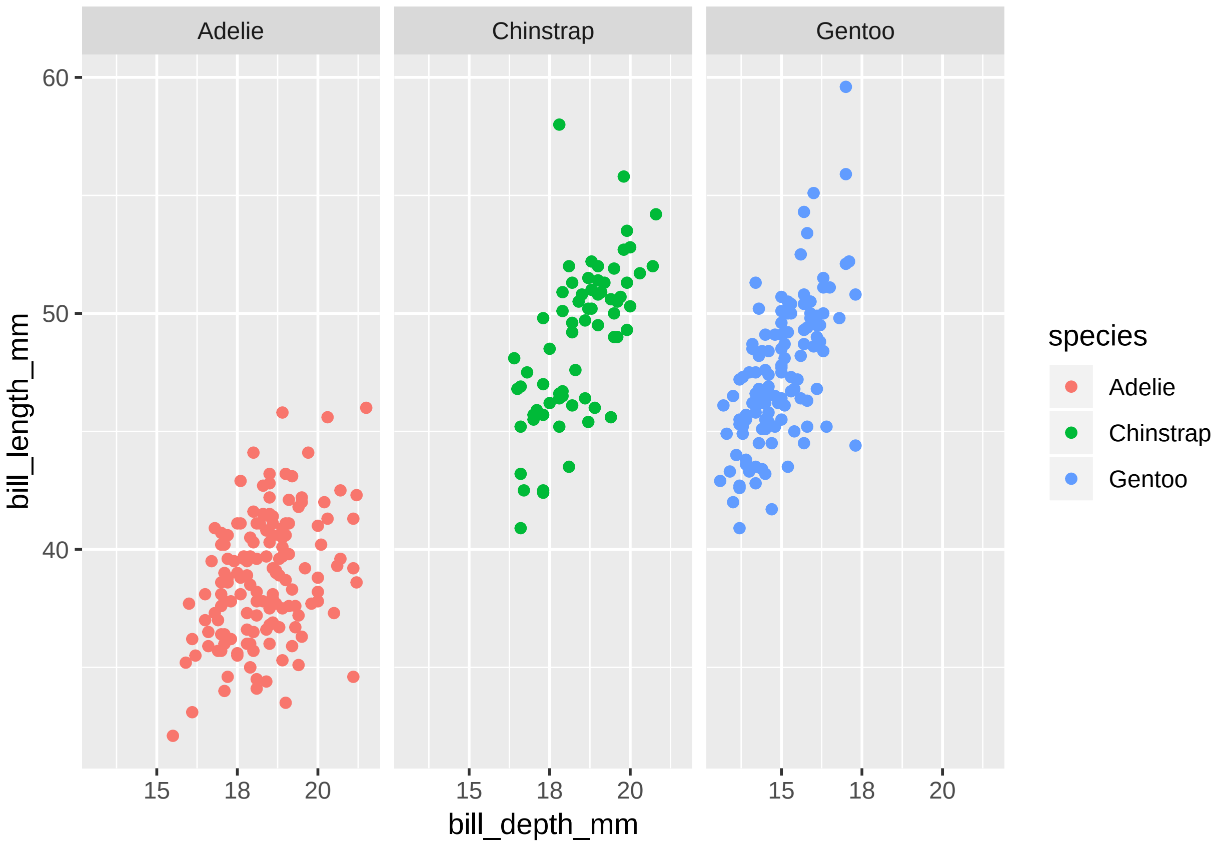
- To study the relation between two quantitative variables a scatterplot is used:

```
gf_point(bill_length_mm ~ bill_depth_mm, color = ~ species, data = pingviner)
```



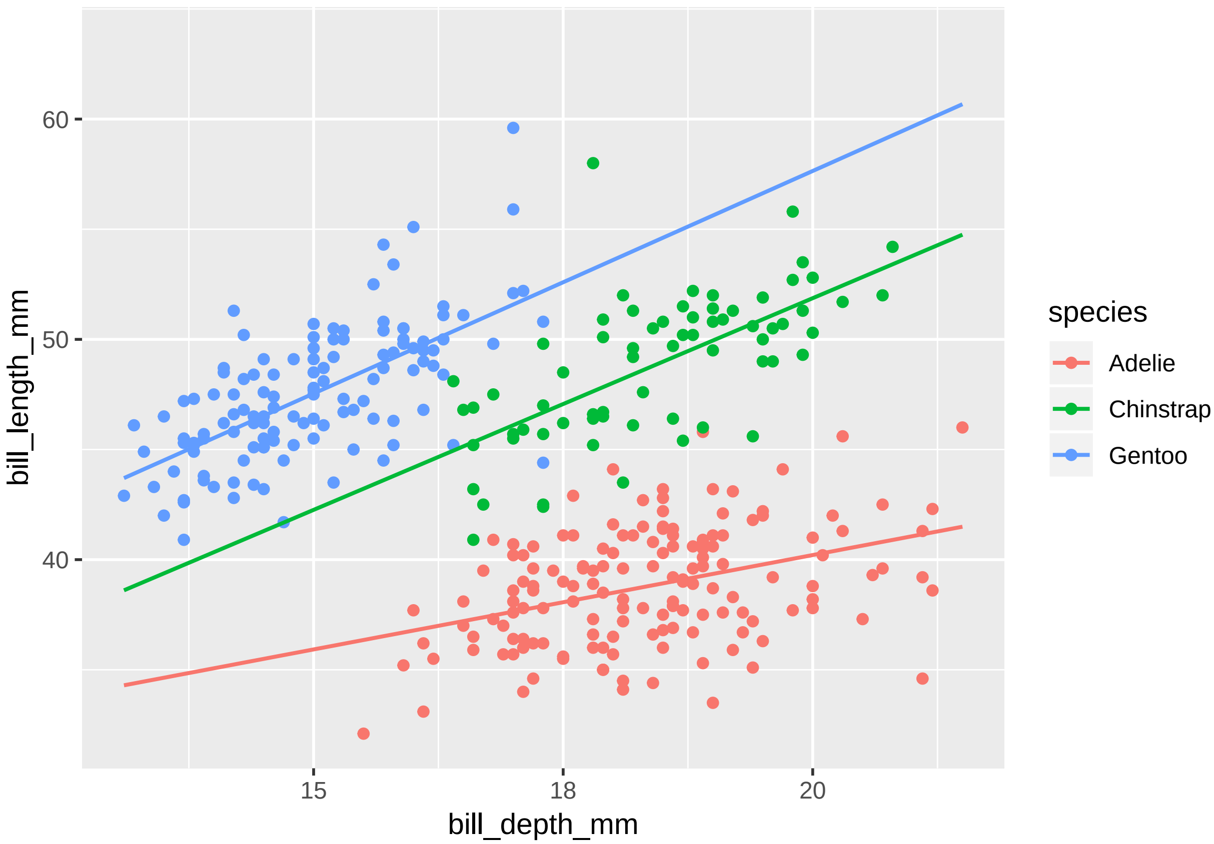
- We could also draw the graph for each species:

```
gf_point(bill_length_mm ~ bill_depth_mm | species, color = ~ species, data = pingviner)
```



- If we want a regression line along with the points we can do:

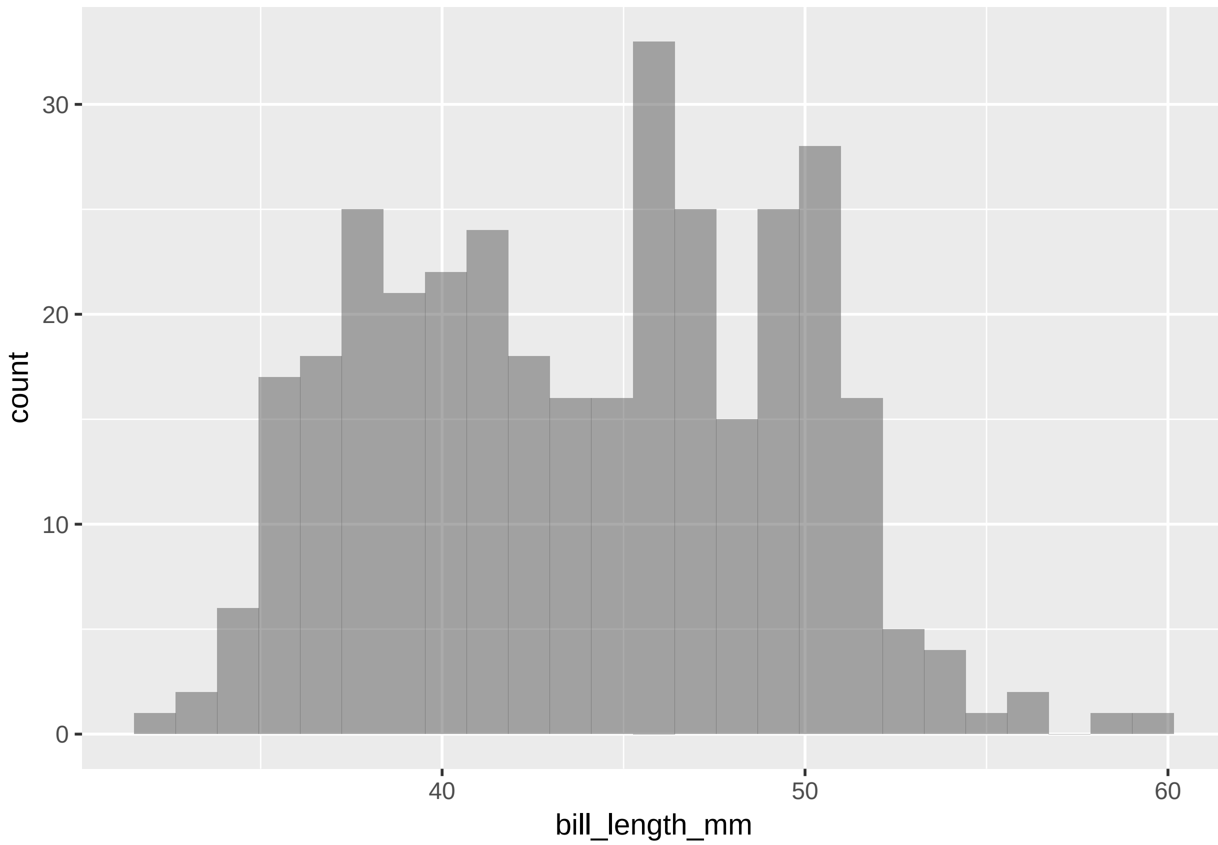
```
gf_point(bill_length_mm ~ bill_depth_mm, color = ~ species, data = pingviner) %>%
  gf_lm()
```



3.2 Histogram

- For a single quantitative variable a histogram offers more details:

```
gf_histogram( ~ bill_length_mm, data = pingviner)
```



- How to make a histogram for some variable `x`:
  - Divide the interval from the minimum value of `x` to the maximum value of `x` in an appropriate number of equal sized sub-intervals.
  - Draw a box over each sub-interval with the height being proportional to the number of observations in the sub-interval.

4 Summaries of quantitative variables

4.1 Percentiles

- **The** p**th percentile** is a value such that at least $p\%$ of the sample lies below or at this value and at least $(100 - p)\%$ of the sample lies above or at the value.

```
Q <- quantile(bill_length_mm ~ species, data = pingviner, na.rm = TRUE)
Q
```

```
##     species 0% 25% 50% 75% 100%
## 1    Adelie 32  37  39  41   46
## 2 Chinstrap 41  46  50  51   58
## 3    Gentoo 41  45  47  50   60
```

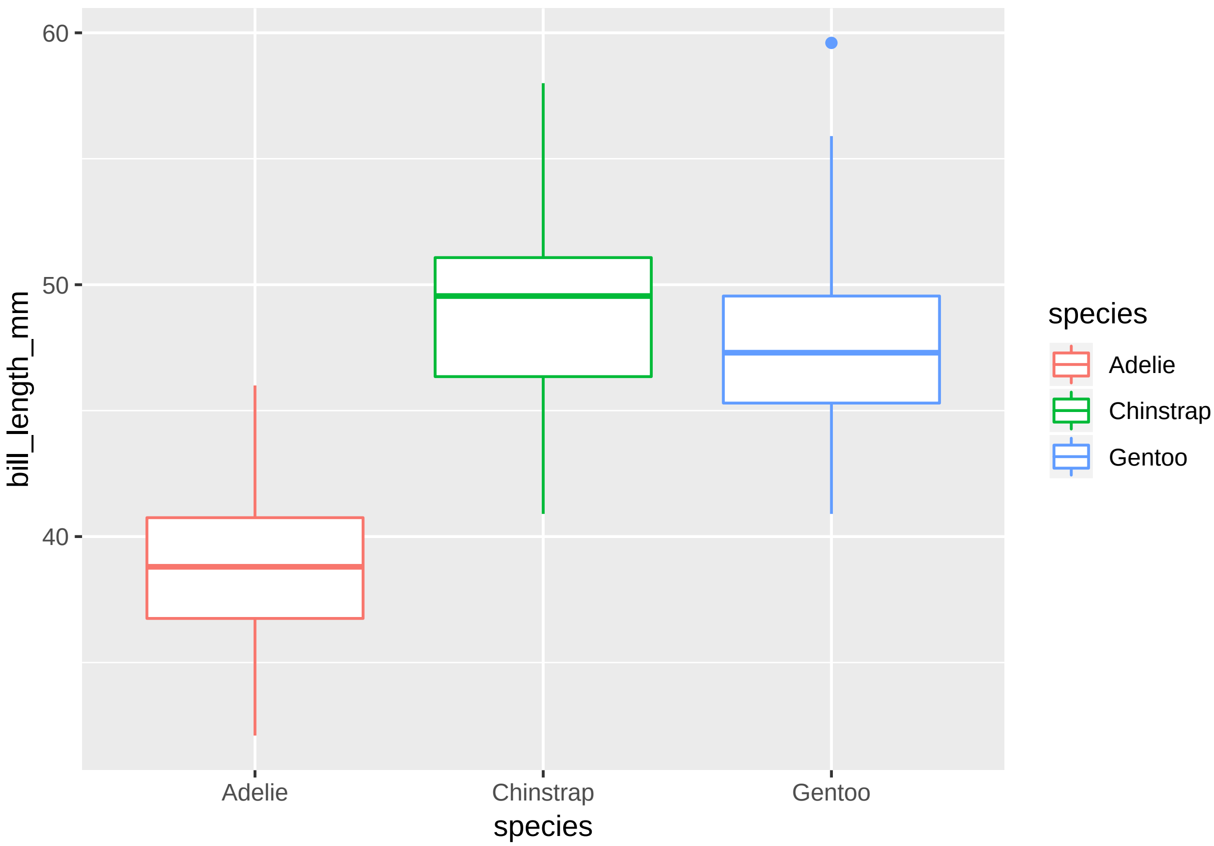
- 50-percentile is the **median** and it is a measure of the center of data as the number of data points below the median is the samme as the number above the median.

- 0-percentile is the **minimum** value.
- 25-percentile is called the **lower quartile** (Q1). Median of lower 50% of data.
- 75-percentile is called the **upper quartile** (Q3). Median of upper 50% of data.
- 100-percentil is the **maximum** value.
- **Interquartile Range (IQR)**: a measure of variability given by the difference of the upper and lower quartiles.

4.2 Boxplot

Boxplot can be good for comparing groups (notice we put the values on the y-axis here as it is more conventional for boxplots):

```
gf_boxplot(bill_length_mm ~ species, color = ~ species, data = pingviner)
```

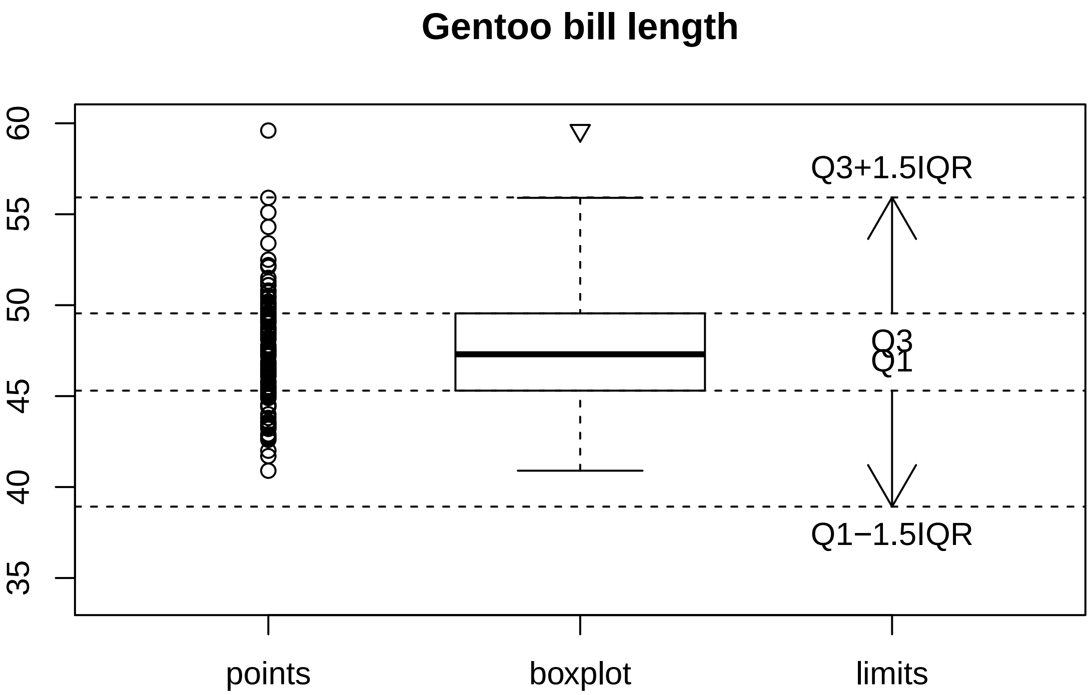


4.2.1 How to draw a box plot

- Box:
  - Calculate the median, lower and upper quartiles.
  - Plot a line by the median and draw a box between the upper and lower quartiles.
- Whiskers:
  - Calculate interquartile range and call it IQR.

  - Calculate the following values:
    * L = lower quartile - 1.5*IQR
    * U = upper quartile + 1.5*IQR
  - Draw a line from lower quartile to the smallest measurement, which is larger than L.
  - Similarly, draw a line from upper quartile to the largest measurement which is smaller than U.
- Outliers: Measurements smaller than L or larger than U are drawn as circles.

Note: Whiskers are minimum and maximum of the observations that are not deemed to be outliers.



4.3 Measures of center of data: Mean and median

- A number of numerical summaries can be retrieved using the `favstats` command:

```
favstats(bill_length_mm ~ species, data = pingviner)
```

```
##     species min Q1 median Q3 max mean  sd   n missing
## 1    Adelie  32 37     39 41  46   39 2.7 151       1
## 2 Chinstrap  41 46     50 51  58   49 3.3  68       0
## 3    Gentoo  41 45     47 50  60   48 3.1 123       1
```

- The observed values of `bill_length_mm` are $y_1 = 46.1$, $y_2 = 50, \ldots, y_n = 49.9$, where there are a total of $n = 123$ values.

As previously defined this constitutes a **sample**.

- **mean** = 48 is the **average** of the sample, which is calculated by

$$\bar{y} = \frac{1}{n} \sum_{i=1}^{n} y_i.$$

  We may also call $\bar{y}$ the **(empirical) mean** or the **sample mean**. It is calculated using `mean()` in **R**.

- **median** = 47 is calculated using `median()` in **R**.
- An important property of the **mean** and the **median** is that they have the same unit as the observations (e.g. millimeter).

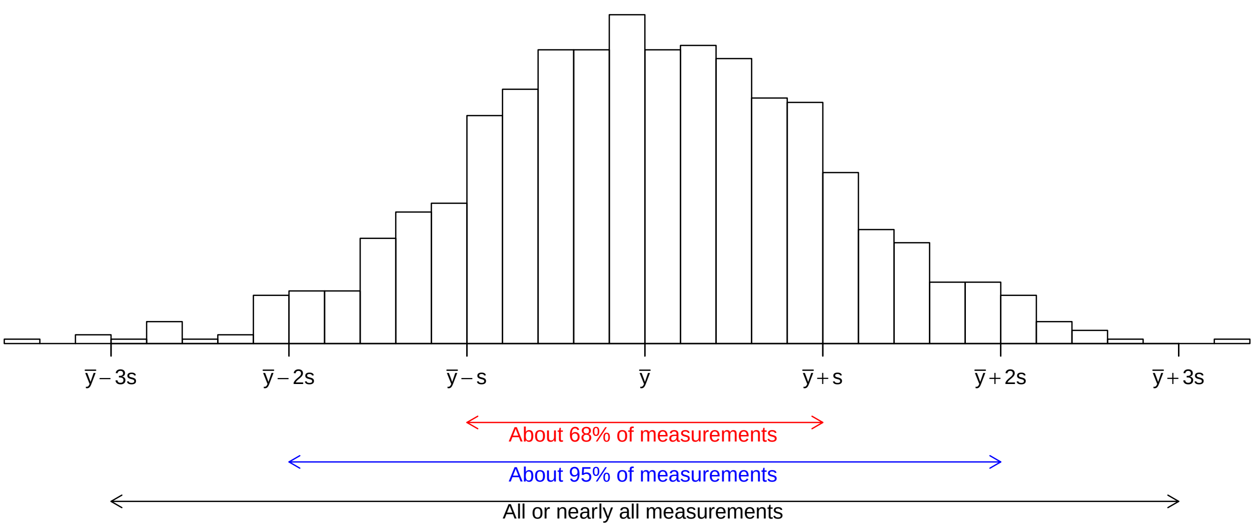
4.4 Measures of variability of data: range, standard deviation and variance

- The **range** is the difference of the largest and smallest observation (`range()` in **R**).
- The **(empirical) variance** (`var()` in **R**) is the average of the squared deviations from the mean:

$$s^2 = \frac{1}{n-1}\sum_{i=1}^{n}(y_i - \bar{y})^2.$$

- **sd** = **standard deviation** = $s = \sqrt{s^2}$ (`sd()` in **R**).
- Note: If the observations are measured in mm, the **variance** has unit mm^2 which is hard to interpret. The **standard deviation** on the other hand has the same unit as the observations.
- The standard deviation describes how much data varies around the (empirical) mean.

4.4.1 The empirical rule



If the histogram of the sample looks like a bell shaped curve, then

- about 68% of the observations lie between $\bar{y} - s$ and $\bar{y} + s$.
- about 95% of the observations lie between $\bar{y} - 2s$ and $\bar{y} + 2s$.
- All or almost all (99.7%) of the observations lie between $\bar{y} - 3s$ and $\bar{y} + 3s$.