Data Transformation and Exploration

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Using the `dplyr` package

Motivation

Common tasks

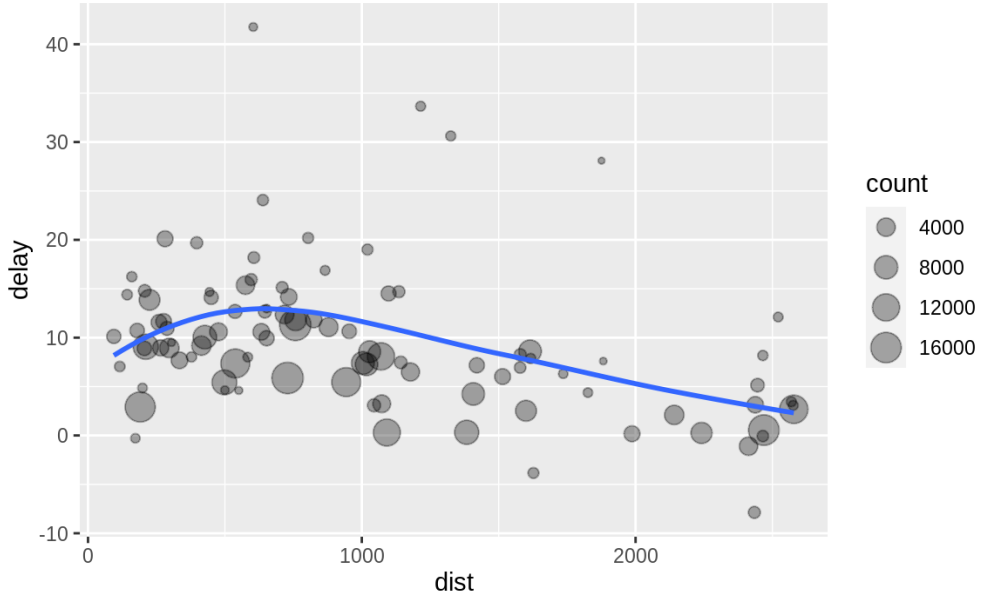
- Often you will need to create some *new variables* or *summaries*, or maybe you just want to *rename* the variables or *reorder* the observations to make the data a little easier to work with.
- We will focus on how to use the `dplyr` package, another core member of the `tidyverse`.

Prerequisites: Install the `nycflights13` and `tidyverse` packages

```
library(tidyverse)
library(nycflights13)
```

Data from `nycflights13`

This dataset contains flights departing New York City (NYC) in 2013. It contains all 336,776 flights that departed from NYC in 2013.



The data comes from the US Bureau of Transportation Statistics, and is documented in `?flights`

Introducing

`dplyr`

The `tidyverse`

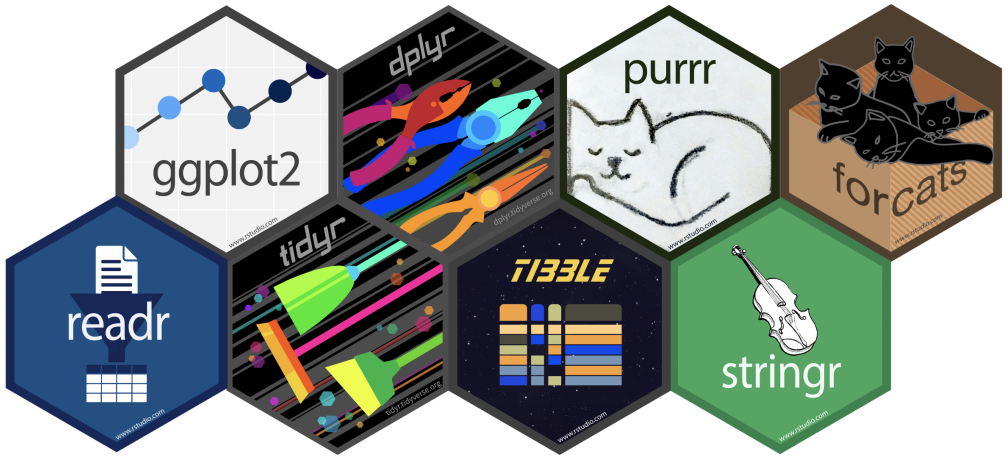
The `tidyverse` is an opinionated collection of R packages designed for data science. All packages share an underlying design philosophy, grammar, and data structures.

Definition of **tidy data**: (see paper by Hadley Wickham)

- Each variable is a column
- Each observation is a row
- Each type of observational unit is a table

Core `tidyverse` packages

`ggplot2`	data visualization
`dplyr`	data manipulation
`tidyr`	tidy up data
`readr`	data import
`purrr`	functional programming
`tibble`	dataframes reimagined



`stringr`	working with strings
`forcats`	working with factors

`dplyr` basics

1. **Pick observations** by their values: `filter()`
2. **Reorder** the rows: `arrange()`
3. **Pick variables** by their names: `select()`
4. **Create new variables** with functions of existing variables: `mutate()`
5. **Collapse** many values down to a single summary: `summarize()`
6. Operate on a **group-by-group** basis: `group_by()`

Filtering *rows*

`filter()` allows you to subset observations based on their values. For example, we can select all flights on January 1st with:

```
filter(flights, month == 1, day == 1)
```

Below is the `dep_time` and `sched_dep_time` for the first 100 rows

	dep_time	sched_dep_time
1	727	730
2	559	559
3	627	630
4	558	600
5	723	725

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Comparisons

`dplyr` functions never modify their inputs, so if you want to save the result, you will need to use the assignment operator, `<-`

```
jan1 <- filter(flights, month == 1, day == 1)
```

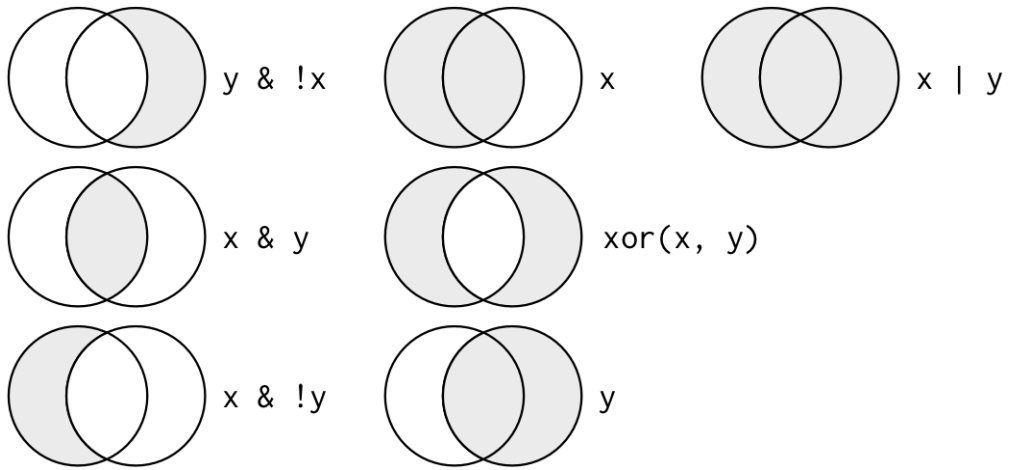
To use filtering effectively, you have to know how to select the observations that you want using comparison operators:

`>`, `>=`, `<`, `<=`,

`!=` (not equal), and

`==` (equal).

Logical operators



Flights in November *OR* December

The following code finds all flights that departed in November OR December:

```
filter(flights, month == 11 | month == 12)
```

A useful short-hand is `x %in% y`. This will select every row where `x` is one of the values in `y`. We could use it to rewrite the code above:

```
nov_dec <- filter(flights, month %in% c(11, 12))
```

Arrange rows with `arrange()`

`arrange()` works similarly to `filter()` except that instead of selecting rows, it **changes their order**.

It takes a data frame and a set of column names to order by.

```
arrange(flights, year, month, day)
```

Use `desc()` to re-order by a column in descending order:

```
arrange(flights, desc(arr_delay))
```

Select columns with `select()`

`select()` allows you to rapidly zoom in on a useful subset using the names of the **variables**.

```
# Select columns by name
select(flights, year, month, day)
```

There are a number of helper functions you can use within `select()`:

`starts_with("abc")`: matches names that begin with `"abc"`.

`ends_with("xyz")`: matches names that end with `"xyz"`.

`contains("ijk")`: matches names that contain `"ijk"`.

Add new variables with `mutate()`

To *add new columns* that are functions of existing columns. That is the job of `mutate()`. `mutate()` always adds new columns at the end of your dataset.

```
# create a smaller dataset with less columns
flights_sml <- select(flights,
  year:day,
  ends_with("delay"),
  distance,
  air_time
)
```

Example: using `mutate()`

```
mutate(flights_sml,
  gain = arr_delay - dep_delay,
  speed = distance / air_time * 60
)
```

Note that you can refer to columns that you have just created:

```
mutate(flights_sml,
  gain = arr_delay - dep_delay,
  hours = air_time / 60,
  gain_per_hour = gain / hours
)
```

A random sample of 100 observations is shown below:

	year	month	day	dep_delay	arr_delay	c
1	2013	9	9	10	-9	
2	2013	12	29	-5	-8	
3	2013	10	28	-2	-13	
4	2013	5	7	-3	-22	
5	2013	5	16	-1	-4	
6	2013	11	21	0	-10	

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Grouped summaries with `summarise()`

`summarise()` *collapses* a data frame to a single row:

```
summarise(flights, delay = mean(dep_delay, na.rm = TRUE))
```

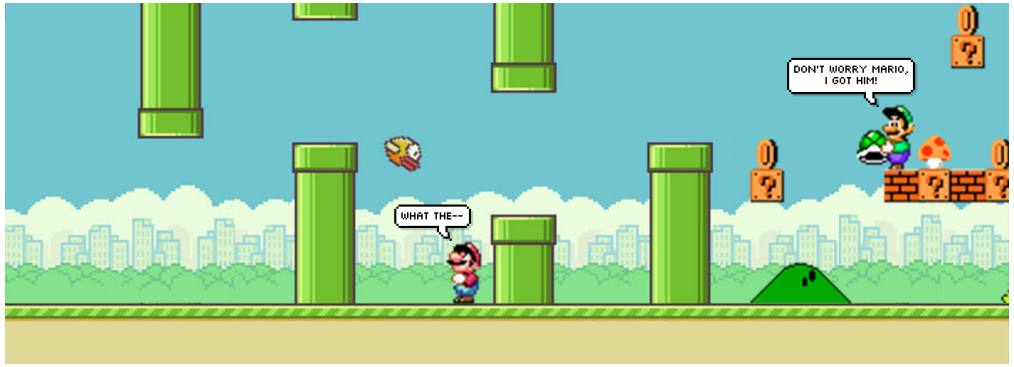
```
## # A tibble: 1 x 1
##   delay
##   <dbl>
## 1  12.6
```

The `summarise()` function is useful when we pair it with `group_by()`.

This way, the analysis can be done for individual groups.

The pipe operator

The pipe



The pipe operator is given by `%>%` (from the `magrittr` package)

Example

The pipe sends the output of the LHS function to the first argument of the RHS function.

For example:

```
# pipe example
sum(1:8) %>%
  sqrt() %>%
  log()
```

```
## [1] 1.791759
```

is equivalent to

```
# the log of the square root
# of the sum of the elements
# of the vector [1 ... 8]
log(sqrt(sum(1:8)))
```

```
## [1] 1.791759
```

Example for data exploration

Imagine that we want to explore the relationship between the distance and average delay for each location.

There are three steps to prepare this data:

1. **Group** flights by destination.
2. **Summarize** to compute distance, average delay, and number of flights.
3. **Filter** to remove noisy points and Honolulu airport, which is almost twice as far away as the next closest airport.

Power of the pipe %>% operator

```r
# create dataframe of "delays"
delays <- flights %>%
  group_by(dest) %>%
  summarize(
    count = n(),
    dist = mean(distance, na.rm = TRUE),
    delay = mean(arr_delay, na.rm = TRUE)
  ) %>%
  filter(count > 20, dest != "HNL")
```

If you use RStudio, you can type the pipe with Ctrl + Shift + M if you have a PC or Cmd + Shift + M if you have a Mac.

You can read it as a series of imperative statements: **group**, then **summarize**, then **filter**. A good way to pronounce `%>%` when reading code is "then".

The `n()` function is implemented specifically for each data source and can be used from within `summarize()`, `mutate()` and `filter()`. It returns the number of observations in the current group.

Transformations

Why `na.rm = TRUE`? Aggregation functions obey the usual rule of missing values: if there is any missing value in the input, the output will be a missing value!

```
flights %>%
  group_by(year, month, day) %>%
  summarize(mean = mean(dep_delay, na.rm = TRUE))
```

	year	month	day	mean
1	2013	1	1	11.5489260143198
2	2013	1	2	13.8588235294118
3	2013	1	3	10.9878318584071
4	2013	1	4	8.95159515951595
5	2013	1	5	5.73221757322176