

APPLICATIONS



OF DATA SCIENCE

Tidy Data Wrangling - Part B

Applications of Data Science - Class 3

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APPLICATIONS



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Joining Tables

APPLICATIONS



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Detour: The Starwars Dataset(s)

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The Starwars Dataset(s)

planets		characters		films	
planet_id	int	character_id	int	film_id	int
name	varchar	name	varchar	episode_id	int
diameter	double	gender	varchar	title	varchar
climate	varchar	height	varchar	release_date	date
gravity	varchar	eye_color	varchar	director	varchar
population	double	film_id	int	producer	varchar
		homeworld_id	int	opening_crawl	varchar

```
sw_tables <- read_rds("../data/sw_tables.rds")
characters <- sw_tables$characters
planets <- sw_tables$planets
films <- sw_tables$films
```



What are the advantages/disadvantages of storing data in such a way?

```
glimpse(characters)
```

```
## Rows: 173
## Columns: 14
## $ character_id <int> 1, 1, 1, 1, 1, 2, 2, 2, 2, 2, 3, 3, 3, 3, 3, 3, 3,
## $ name <chr> "Luke Skywalker", "Luke Skywalker", "Luke Skywalker"
## $ gender <chr> "male", "male", "male", "male", NA, NA, NA,
## $ homeworld_id <dbl> 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 8, 8, 8, 8, 8, 8,
## $ height <dbl> 172, 172, 172, 172, 172, 167, 167, 167, 167, 167, 167, 167, 167, 167, 167, 167, 167
## $ mass <dbl> 77, 77, 77, 77, 77, 75, 75, 75, 75, 75, 75, 75, 75, 32, 32,
## $ hair_color <chr> "blond", "blond", "blond", "blond", "blond", NA, NA
## $ skin_color <chr> "fair", "fair", "fair", "fair", "fair", "gold", "go
## $ eye_color <chr> "blue", "blue", "blue", "blue", "blue", "yellow", "
## $ birth_year <dbl> 19.0, 19.0, 19.0, 19.0, 19.0, 112.0, 112.0, 112.0,
## $ film_id <dbl> 1, 2, 3, 6, 7, 1, 2, 3, 4, 5, 6, 1, 2, 3, 4, 5, 6,
## $ species <list> "http://swapi.co/api/species/1/", "http://swapi.co
## $ vehicles <list> <"http://swapi.co/api/vehicles/14/", "http://swapi
## $ starships <list> <"http://swapi.co/api/starships/12/", "http://swap
```

```
glimpse(planets)
```

```
## Rows: 61
## Columns: 10
## $ planet_id      <dbl> 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15
## $ name           <chr> "Tatooine", "Alderaan", "Yavin IV", "Hoth", "Dagobah"
## $ rotation_period <dbl> 23, 24, 24, 23, 23, 12, 18, 26, 24, 27, 30, 27, 16
## $ orbital_period   <dbl> 304, 364, 4818, 549, 341, 5110, 402, 312, 368, 490, 355, 55
## $ diameter        <dbl> 10465, 12500, 10200, 7200, 8900, 118000, 4900, 12900, 5000, 10000, 10000, 10000
## $ climate          <chr> "arid", "temperate", "temperate, tropical", "frozen", "temperate", "arid", "temperate", "temperate", "temperate", "temperate", "temperate", "temperate"
## $ gravity          <chr> "1 standard", "1 standard", "1 standard", "1.1 standard", "1 standard", "0.9 standard", "0.8 standard", "0.9 standard", "0.8 standard", "0.7 standard", "0.6 standard", "0.5 standard"
## $ terrain           <chr> "desert", "grasslands, mountains", "jungle, rainforest", "desert", "desert", "desert", "desert", "desert", "desert", "desert", "desert", "desert"
## $ surface_water     <dbl> 1.0, 40.0, 8.0, 100.0, 8.0, 0.0, 8.0, 12.0, NA, 0.0, 0.0, 0.0
## $ population        <dbl> 2.0e+05, 2.0e+09, 1.0e+03, NA, NA, 6.0e+06, 3.0e+09, 1.0e+03, 1.0e+03, 1.0e+03, 1.0e+03, 1.0e+03
```

```
glimpse(films)
```

```
## Rows: 7
## Columns: 7
## $ film_id        <dbl> 1, 2, 3, 4, 5, 6, 7
## $ title           <chr> "A New Hope", "The Empire Strikes Back", "Return of the Jedi", "The Force Awakens", "Star Wars: Episode V - The Empire Strikes Back", "Star Wars: Episode VI - Return of the Jedi", "Star Wars: Episode I - The Phantom Menace"
## $ episode_id       <int> 4, 5, 6, 1, 2, 3, 7
## $ opening_crawl    <chr> "It is a period of civil war.\r\nRebel spaceships, with their enormous starships, have won their first major victory against the Galactic Empire, and are势不可挡。", "A new希望", "帝国反击战", "绝地归来", "帝国大反攻", "绝地归来", "星球大战：前传I - 幽灵的威胁"
## $ director         <chr> "George Lucas", "Irvin Kershner", "Richard Marquand", "J. J. Abrams", "Kirk Hammett", "Karen H. Gómez", "Rian Johnson"
## $ producer         <chr> "Gary Kurtz, Rick McCallum", "Gary Kutz, Rick McCallum", "Gary Kutz, Rick McCallum", "J. J. Abrams", "Kirk Hammett", "Karen H. Gómez", "Rian Johnson"
## $ release_date     <chr> "1977-05-25", "1980-05-17", "1983-05-25", "1999-05-19", "2015-12-18", "2016-05-20", "2017-05-25"
```

End of Detour

APPLICATIONS



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Q: Which characters appear in SW films directed by George Lucas?

```
unique(
  characters$name[
    characters$film_id %in%
      films$film_id[films$director == "George Lucas"]
  ]
)

# or dplyr approach:
characters %>%
  filter(film_id %in% (films %>%
    filter(director=="George Lucas") %>%
    pull(film_id))) %>%
  pull(name) %>%
  unique()
```

First problem with this approach: code gets messier and messier, prone to bugs and hard to debug.

Q: Which characters, whose homeworld is Alderaan, appear in SW films directed by George Lucas?

```
unique(  
  characters$name[  
    characters$film_id %in%  
      films$film_id[films$director == "George Lucas"] &  
    characters$homeworld_id ==  
      planets$planet_id[planets$name == "Alderaan"]  
  ]  
)  
  
# or dplyr approach:  
characters %>%  
  filter(film_id %in% (films %>%  
    filter(director=="George Lucas") %>%  
    pull(film_id)),  
  homeworld_id == (planets %>%  
    filter(name == "Alderaan") %>%  
    pull(planet_id))) %>%  
  pull(name) %>%  
  unique()  
  
# [1] "Leia Organa"          "Bail Prestor Organa" "Raymus Antilles"
```

Now imagine these two tables

lines: each film, each scene, each minute, each character, the line

```
lines <- tibble::tribble(
  ~film_id, ~scene_id, ~minute_id, ~character_id,
  1, 1, 1, 23,
  1, 1, 2, 15, "somet
  1, 1, 2, 23, "something somet
  1, 1, 3, 15,
  1, 1, 3, 23,
  1, 1, 4, 8, "wha
)
```

locations: for each film, each scene, each minute, its location

```
locations <- tibble::tribble(
  ~film_id, ~scene_id, ~minute_id, ~location,
  1, 1, 1, "spaceship",
  1, 1, 2, "Alderaan, outdoors",
  1, 1, 3, "spaceship",
  1, 1, 4, "bar"
)
```

Q: Which characters say "something" in a bar?

- filter only lines which contain "something"
- filter only "bar" locations and then...
- if the two filtered tables match on film, scene and minute...
- we take the unique characters
- but how do we match? `for` loop*

→ Clearly, second problem with this approach: it doesn't generalize well to more complex scenarios, where we need to match on multiple criteria

And third problem: speed (but only in a complex scenario!)

* There *is* a way without using a for loop, without joining, still not recommended.

inner_join()

(Inner) Joining two tables:

```
characters %>%
  inner_join(films) %>%
  select(character_id, name, film_id, title, director) %>%
  head(7)

## Joining with `by = join_by(film_id)`

## # A tibble: 7 × 5
##   character_id name      film_id title                director
##       <int> <chr>     <dbl> <chr>                <chr>
## 1           1 Luke Skywalker     1 A New Hope        George Lucas
## 2           1 Luke Skywalker     2 The Empire Strikes Back Irvin Kershner
## 3           1 Luke Skywalker     3 Return of the Jedi Richard Marquand
## 4           1 Luke Skywalker     6 Revenge of the Sith George Lucas
## 5           1 Luke Skywalker     7 The Force Awakens J. J. Abrams
## 6           2 C-3PO             1 A New Hope        George Lucas
## 7           2 C-3PO             2 The Empire Strikes Back Irvin Kershner
```

(Inner) Joining multiple tables:

```
characters %>%
  inner_join(films) %>%
  inner_join(planets, by = c("homeworld_id" = "planet_id")) %>%
  select(character_id, name.x, film_id, title, director, name.y, c

## Joining with `by = join_by(film_id)` 

## # A tibble: 7 × 7
##   character_id name.x      film_id title          director name.y
##       <int> <chr>      <dbl> <chr>          <chr>    <chr>
## 1             1 Luke Skywalker     1 A New Hope George ... Tatoo...
## 2             1 Luke Skywalker     2 The Empire Strike... Irvin K... Tatoo...
## 3             1 Luke Skywalker     3 Return of the Jedi Richard... Tatoo...
## 4             1 Luke Skywalker     6 Revenge of the Si... George ... Tatoo...
## 5             1 Luke Skywalker     7 The Force Awakens J. J. A... Tatoo...
## 6             2 C-3PO              1 A New Hope George ... Tatoo...
## 7             2 C-3PO              2 The Empire Strike... Irvin K... Tatoo...
```

(Inner) Joining on multiple keys:

```
lines %>%
  inner_join(locations, by = c("film_id", "scene_id", "minute_id"))
```

```
## # A tibble: 6 × 6
##   film_id scene_id minute_id character_id line
##       <dbl>     <dbl>      <dbl>        <dbl> <chr>
## 1         1         1          1            1  blah blah blah
## 2         1         1          1            2  something something
## 3         1         1          1            2  something something to you to
## 4         1         1          1            3        <NA>
## 5         1         1          1            3        <NA>
## 6         1         1          1            4  whatever whatever
```



The base R function for joining is `merge()` which tends to be slower.

What would `inner_join()` do?

Q: Which characters appear in SW films directed by George Lucas?

```
# naive
characters %>%
  inner_join(films, by = "film_id") %>%
  filter(director == "George Lucas") %>%
  pull(name) %>%
  unique()

# smarter
characters %>%
  inner_join(films %>% filter(director == "George Lucas"),
             by = "film_id") %>%
  pull(name) %>%
  unique()
```



What else could you do to make `inner_join`'s life easier?

What would `inner_join()` do?

Q: Which characters, whose homeworld is Alderaan, appear in SW films directed by George Lucas?

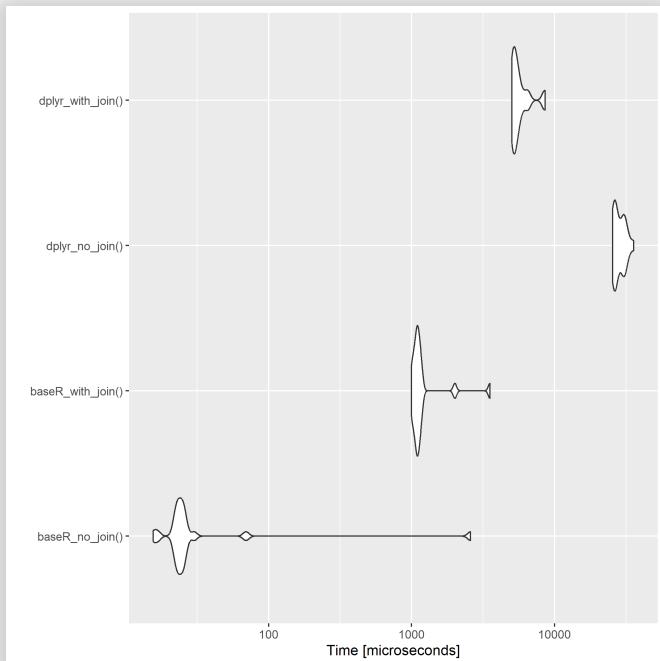
```
characters %>%
  inner_join(films %>% filter(director == "George Lucas"),
             by = "film_id") %>%
  inner_join(planets %>% filter(name == "Alderaan"),
             by = c("homeworld_id" = "planet_id"),
             suffix = c("_char", "_planet")) %>%
  pull(name_char) %>%
  unique()
```

```
## [1] "Leia Organa"          "Bail Prestor Organa" "Raymus Antilles"
```

Note of caution: Join is not always faster!

```
baseR_no_join <- function() {  
  unique(characters$name[characters$film_id %in% films$film_id[fi]  
}  
  
baseR_with_join <- function() {  
  unique(merge(characters, films[films$director == "George Lucas",  
}  
  
dplyr_no_join <- function() {  
  characters %>%  
    filter(film_id %in% (films %>%  
      filter(director=="George Lucas") %>%  
      pull(film_id))) %>%  
    pull(name) %>%  
    unique()  
}  
  
dplyr_with_join <- function() {  
  characters %>%  
    inner_join(films %>% filter(director=="George Lucas"), by = "f  
    pull(name) %>%  
    unique()  
}
```

```
library(microbenchmark)
res <- microbenchmark(baseR_no_join(), baseR_with_join(),
                      dplyr_no_join(), dplyr_with_join(), times =
autoplot(res)
```



So when does it shine?

- See [this](#) StackOverflow question and answer for a good example*
- But in general: when data gets bigger, when multiple keys are involved

* Yes, I know, I answered my own question, 🤦

Other types of Joins?

Definitely, read [here](#), [here](#) and [here](#) about:

- `left_join()`
- `right_join()`
- `full_join()`
- `anti_join()`
- `semi_join()`

All Joins

A	B	C	
a	t	1	
b	u	2	
c	v	3	



A	B	D	
b	u	3	
c	v	2	
d	w	1	



A	B	C	D
b	u	2	3
c	v	3	2

inner_join()

A	B	C	
a	t	1	
b	u	2	
c	v	3	



A	B	D	
b	u	3	
c	v	2	
d	w	1	



A	B	C	D
a	t	1	NA
b	u	2	3
c	v	3	2

left_join()

A	B	C	
a	t	1	
b	u	2	
c	v	3	



A	B	D	
b	u	3	
c	v	2	
d	w	1	



A	B	C	D
b	u	2	3
c	v	3	2
d	w	NA	1

right_join()

All Joins



A	B	C	
a	t	1	
b	u	2	
c	v	3	



A	B	D	
b	u	3	
c	v	2	
d	w	1	

full_join()



A	B	C	
a	t	1	
b	u	2	
c	v	3	

semi_join()



A	B	C	
a	t	1	
b	u	2	
c	v	3	

anti_join()

Tidying Tables

APPLICATIONS



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Detour: The Migration Dataset

APPLICATIONS



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The Migration Dataset

- Straight from the [UN, Dept. of Economic and Social Affairs, Population Division](#)
- "Monitoring global population trends"
- For each country, how many (men, women and total) migrated to each country
- In 1990, 1995, 2000, 2005, 2010, 2015, 2019
- How would *you* give access to these data?

What's untidy about the migration Excel file?

- It's an Excel file 😠
- Multiple sheets
- Color coded, font coded (bold), space coded!
- Logo, free text in header lines
- Merged cells
- French letters (anything but [A-Za-z] can break code)
- Spaces, parentheses in column names
- Different NA values: "..", "-"
- Variable "country_dest" contains sub-total and totals for categories, continents...
- Variable "country_orig" violates Tidy rule no. 1: not in its own column

"Today Only, The Landlord Went Nuts!"

- ~~It's an Excel file~~ 😠
- ~~Multiple sheets~~
- ~~Color coded, font coded (bold), space coded!~~
- ~~Logo, free text in header lines~~
- ~~Merged cells~~
- ~~French letters (anything but [A-Z a-z] can break code)~~
- ~~Spaces, parentheses in column names~~
- ~~Different NA values: "", ""~~
- ~~Variable "country_dest" contains sub-total and totals for categories, continents...~~
- Variable "country_orig" violates Tidy rule no. 1: not in its own column

The much nicer migration table

```
migration <- read_rds("../data/migration.rds")  
  
migration  
  
## # A tibble: 3,248 × 236  
##   gender year  code country_dest afghanistan albania algeria american_...  
##   <chr>   <dbl> <dbl> <chr>          <dbl>    <dbl>    <dbl>  
## 1 men     1990   108 burundi          0        0        0  
## 2 men     1990   174 comoros          0        0        0  
## 3 men     1990   262 djibouti         0        0        0  
## 4 men     1990   232 eritrea          0        0        0  
## 5 men     1990   231 ethiopia         0        0        0  
## 6 men     1990   404 kenya            0        0        0  
## 7 men     1990   450 madagascar       0        0        0  
## 8 men     1990   454 malawi           0        0        0  
## 9 men     1990   480 mauritius        0        0        0  
## 10 men    1990   175 mayotte          0        0        0  
## # ... with 3,238 more rows, and 228 more variables: andorra <dbl>, angola ...  
## # anguilla <dbl>, antigua_and_barbuda <dbl>, argentina <dbl>, armenia ...  
## # aruba <dbl>, australia <dbl>, austria <dbl>, azerbaijan <dbl>, ...  
## # bahamas <dbl>, bahrain <dbl>, bangladesh <dbl>, barbados <dbl>, ...  
## # belarus <dbl>, belgium <dbl>, belize <dbl>, benin <dbl>, bermuda <db...  
## # bhutan <dbl>, bolivia_plurinational_state_of <dbl>, ...  
## # ... with 228 more variables:
```

It's not right, but it's Ok:

- How many men immigrated from Russia to Israel in 1990?

```
migration %>%
  filter(country_dest == "israel", year == 1990, gender == "men")
  pull(russian_federation)
```

```
## [1] 80450
```

- How many men immigrated from Israel to Russia in 1990?

```
migration %>%
  filter(country_dest == "russian_federation", year == 1990, gender == "men")
  pull(israel)
```

```
## [1] 1395
```

It would have been much nicer to have:

```
migration %>%
  filter(country_orig == "israel", country_dest == "russian_fedrat"
        year == 1990, gender == "men") %>%
  pull(n_migrants)
```

Then we could put it in a (simpler) function and call the opposite:

```
get_1way_migration <- function(orig, dest, gen, .year) {
  migration %>%
    filter(country_orig == orig, country_dest == dest,
          year == .year, gender == gen) %>%
    pull(n_migrants)
}

get_1way_migration("russian_federation", "israel")
```

End of Detour

APPLICATIONS



OF DATA SCIENCE

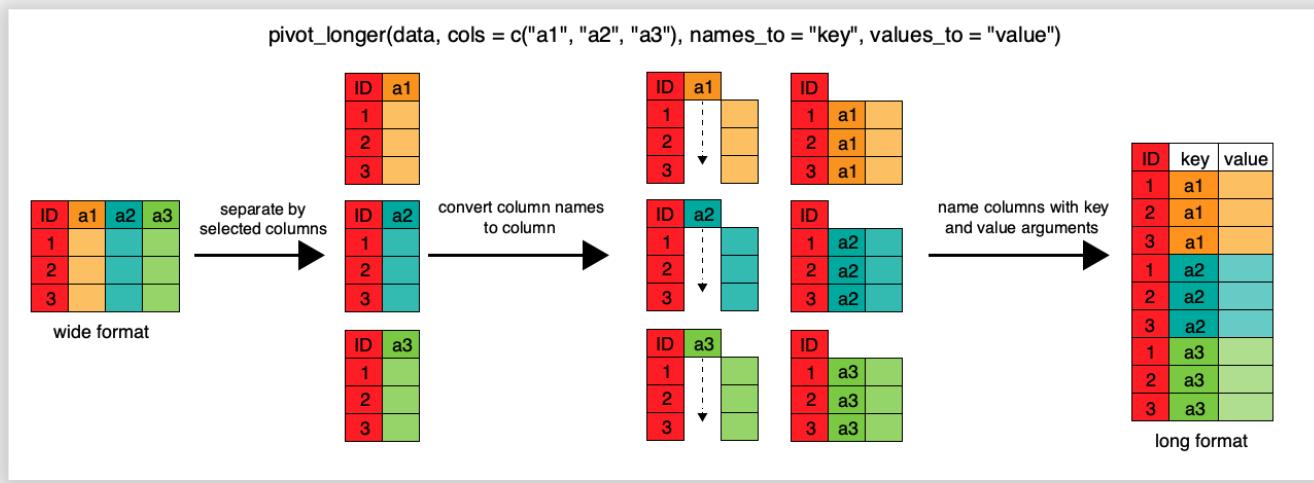
pivot_longer()

```
migration_long <- migration %>%
  pivot_longer(cols = -c(1:4),
               names_to = "country_orig",
               values_to = "n_migrants")
```

```
migration_long
```

```
## # A tibble: 753,536 × 6
##   gender year code country_dest country_orig      n_migrants
##   <chr>   <dbl> <dbl> <chr>          <chr>            <dbl>
## 1 men     1990    108 burundi      afghanistan        0
## 2 men     1990    108 burundi      albania           0
## 3 men     1990    108 burundi      algeria           0
## 4 men     1990    108 burundi      american_samoa    0
## 5 men     1990    108 burundi      andorra          0
## 6 men     1990    108 burundi      angola            0
## 7 men     1990    108 burundi      anguilla          0
## 8 men     1990    108 burundi      antigua_and_barbuda 0
## 9 men     1990    108 burundi      argentina         0
## 10 men    1990    108 burundi     armenia           0
## # ... with 753,526 more rows
```

What sorcery is this?



Source: [The Carpentries](#)

pivot_wider()

```
migration_wide <- migration_long %>%
  pivot_wider(id_cols = 1:4,
              names_from = country_orig,
              values_from = n_migrants)

migration_wide
```

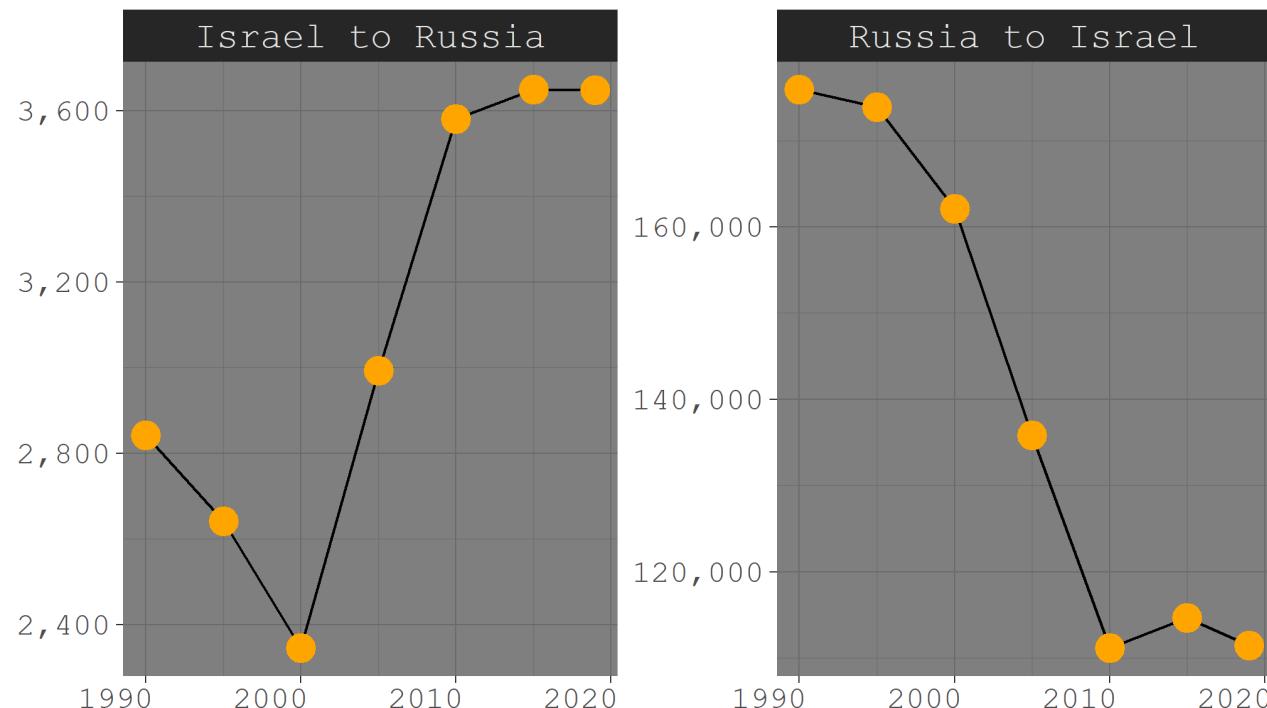
A tibble: 3,248 × 236

	gender	year	code	country_dest	afghanistan	albania	algeria	american_
	<chr>	<dbl>	<dbl>	<chr>	<dbl>	<dbl>	<dbl>	<dbl>
## 1	men	1990	108	burundi	0	0	0	
## 2	men	1990	174	comoros	0	0	0	
## 3	men	1990	262	djibouti	0	0	0	
## 4	men	1990	232	eritrea	0	0	0	
## 5	men	1990	231	ethiopia	0	0	0	
## 6	men	1990	404	kenya	0	0	0	
## 7	men	1990	450	madagascar	0	0	0	
## 8	men	1990	454	malawi	0	0	0	
## 9	men	1990	480	mauritius	0	0	0	
## 10	men	1990	175	mayotte	0	0	0	
## # ... with 3,238 more rows, and 228 more variables: andorra <dbl>, angola ·								
## # anguilla <dbl>, antigua_and_barbuda <dbl>, argentina <dbl>, armenia ·								
## # aruba <dbl>, australia <dbl>, austria <dbl>, azerbaijan <dbl>,								

Where is this going to?

```
get_1way_migration <- function(.country_dest, .country_orig) {  
  migration_long %>%  
    filter(country_dest == .country_dest, country_orig == .country_orig)  
    group_by(year) %>%  
    tally(n_migrants) %>%  
    mutate(direction = str_c(.country_orig, " to ", .country_dest))  
}  
get_2way_migration <- function(country_a, country_b) {  
  a2b <- get_1way_migration(country_b, country_a)  
  b2a <- get_1way_migration(country_a, country_b)  
  bind_rows(a2b, b2a)  
}  
  
get_2way_migration("israel", "russian_federation") %>%  
  ggplot(aes(year, n)) + geom_line() +  
  geom_point(color = "orange", size = 5) +  
  labs(x = "", y = "", title = "Israel-Russia Yearly No. of immigrants") +  
  theme_dark() +  
  facet_wrap(~direction, scales = "free", labeller = labeller(direction =  
    scale_y_continuous(labels = scales::comma_format()) +  
    theme(axis.text = element_text(size = 12, hjust=0.9, family = "mono"),  
          strip.text.x = element_text(size = 14, family = "mono"),  
          plot.title = element_text(hjust = 0.5, size = 18, family = "mono")))
```

Israel-Russia Yearly No. of immigrants



Some more useful Tidying up verbs

Remember?

```
table3 <- read_rds("../data/tidy_tables.rds")$table3  
  
table3  
  
## # A tibble: 315 × 3  
##   religion      yob pct_straight  
##   <chr>        <dbl> <chr>  
## 1 atheist      1950  26/29  
## 2 buddhist     1950  6/6  
## 3 christian    1950  28/32  
## 4 hindu        1950  0/0  
## 5 jewish       1950  21/24  
## 6 muslim        1950  0/0  
## 7 unspecified  1950  71/76  
## 8 atheist      1951  31/33  
## 9 buddhist     1951  11/11  
## 10 christian   1951  23/24  
## # ... with 305 more rows
```

separate_wider_delim()

(Superseded `separate()`)

```
table3_tidy <- table3 %>%
  separate_wider_delim(pct_straight, delim = "/",
                        names = c("straight", "total"))

table3_tidy
```



```
## # A tibble: 315 × 4
##   religion      yob straight total
##   <chr>        <dbl>  <chr>    <chr>
## 1 atheist       1950   26     29
## 2 buddhist      1950   6      6
## 3 christian     1950   28     32
## 4 hindu         1950   0      0
## 5 jewish        1950   21     24
## 6 muslim         1950   0      0
## 7 unspecified   1950   71     76
## 8 atheist        1951   31     33
## 9 buddhist       1951   11     11
## 10 christian     1951  23     24
## # ... with 305 more rows
```

unite()

(Though see a much more generalizable approach with purrrr)

```
table3_tidy %>%  
  unite(col = "pct_straight", straight, total, sep = "/")
```

```
## # A tibble: 315 × 3  
##   religion      yob pct_straight  
##   <chr>        <dbl> <chr>  
## 1 atheist      1950 26/29  
## 2 buddhist     1950 6/6  
## 3 christian    1950 28/32  
## 4 hindu        1950 0/0  
## 5 jewish       1950 21/24  
## 6 muslim        1950 0/0  
## 7 unspecified  1950 71/76  
## 8 atheist      1951 31/33  
## 9 buddhist     1951 11/11  
## 10 christian   1951 23/24  
## # ... with 305 more rows
```

Iteration without looping

APPLICATIONS



OF DATA SCIENCE

Fun fact: you're already not-looping!

- Say you want the lengths of all of these strings:

```
strings_vec <- c("I'm feeling fine", "I'm perfectly OK",
                 "Nothing is wrong!")
```

- Do you `for` loop?

```
strings_len <- numeric(length(strings_vec))
for (i in seq_along(strings_vec)) {
  strings_len[i] <- nchar(strings_vec[i])
}
strings_len
```



```
## [1] 16 16 17
```

- No, you use R's vectorized functions nature:

```
nchar(strings_vec)
```

```
## [1] 16 16 17
```

- In case you were wondering:

```
microbenchmark(nchar_loop(), nchar_vectorized())
```

```
## Unit: nanoseconds
##          expr  min    lq     mean   median    uq    max  neval
##  nchar_loop() 2300 2401 40012.99    2401 2501 3753400    100
##  nchar_vectorized()    700   701 11867.02     801   801 1088300    100
```

- So why should iterating through a `data.frame` columns or rows be any different?

The problem:

```
okcupid <- read_csv("~/okcupid.csv.zip", col_types = cols())
okcupid %>% select(essay0:essay2) %>% head(3)
```

```
## # A tibble: 3 × 3
##   essay0                           essay
##   <chr>                            <chr>
## 1 "about me:<br />\n<br />\ni would love to think that i was some..." "curr.
## 2 "i am a chef: this is what that means.<br />\n1. i am a workaho..." "dedi.
## 3 "i'm not ashamed of much, but writing public text on an online\..." "i ma.
```

- I want to apply some transformation to one or more columns (say the length of each `essay` question for each user)
- I want to apply some transformation to one or more rows (say the average length of all `essay` questions for each user)
- BTW, you can always use a `for` loop, see how it is done [here](#)

The `apply` family

- There *is* a solution in base R
 - `apply()`
 - `sapply()`
 - `lapply()`
 - `tapply()`
 - `vapply()`
 - `mapply()`
- What do you think is the issue with these? See [this](#).

I don't for, I purrr

The `purrr` package provides a set of functions to make iteration easier:

- No boilerplate code for looping --> less looping bugs
- Focus on the function, the action, not the plumbing
- Generally faster (implemented in C)
- Definitely more clear, concise and elegant code

TBH, I'm addicted 😊

You get a `map()`, you get a `map()`!

Single	Two	Multiple	Returns	Of
<code>map()</code>	<code>map2()</code>	<code>pmap()</code>	<code>list</code>	?
<code>map_lgl()</code>	<code>map2_lgl()</code>	<code>pmap_lgl()</code>	<code>vector</code>	<code>logical</code>
<code>map_chr()</code>	<code>map2_chr()</code>	<code>pmap_chr()</code>	<code>vector</code>	<code>character</code>
<code>map_int()</code>	<code>map2_int()</code>	<code>pmap_int()</code>	<code>vector</code>	<code>integer</code>
<code>map_dbl()</code>	<code>map2_dbl()</code>	<code>pmap_dbl()</code>	<code>vector</code>	<code>double</code>
<code>map_dfr()</code>	<code>map2_dfr()</code>	<code>pmap_dfr()</code>	<code>tibble</code>	?

Where "Single" means "single vector/column input", "Two" means "two vectors/columns input" etc.

(Tip of the iceberg really, I want you to survive this slide)

Example1: Vectorizing a Function

Take a clearly not-vectorized function:

```
my_func <- function(x) {  
  if (x %% 2 == 0) return("even")  
  "odd"  
}  
  
my_func(10)  
  
## [1] "even"  
  
my_func(1:5)  
  
## Error in if (x%%2 == 0) return("even"): the condition has length > 1
```



This is a silly example, do you know how to easily vectorize this function?

`map()` will always return a list:

```
map(1:3, my_func)
```

```
## [[1]]  
## [1] "odd"  
##  
## [[2]]  
## [1] "even"  
##  
## [[3]]  
## [1] "odd"
```

```
1:3 %>% map(my_func)
```

```
## [[1]]  
## [1] "odd"  
##  
## [[2]]  
## [1] "even"  
##  
## [[3]]  
## [1] "odd"
```

`map_chr()` will always return a vector of character:

```
map_chr(1:3, my_func)  
## [1] "odd"  "even" "odd"
```

```
1:3 %>% map_chr(my_func)  
## [1] "odd"  "even" "odd"
```

But here is the beautiful thing:

```
my_func_vectorized <- function(vec) map_chr(vec, my_func)  
my_func_vectorized(1:3)  
## [1] "odd"  "even" "odd"
```

Look Ma, no loops!

Example2: Complex `mutate()`

Manager: Add me a column, for each OkCupid user, whether he/she's above average height.

```
is_above_average_height <- function(sex, height_cm) {  
  if (sex == "m") height_cm > 180 else height_cm > 165  
}  
  
okcupid <- okcupid %>%  
  mutate(is_tall = map2_lgl(sex, height_cm, is_above_average_height))  
  
okcupid %>% select(sex, height_cm, is_tall) %>%  
  group_by(sex) %>% slice_sample(n = 3)  
  
## # A tibble: 6 × 3  
## # Groups:   sex [2]  
##   sex     height_cm is_tall  
##   <chr>    <dbl> <lgl>  
## 1 f        160. FALSE  
## 2 f        163. FALSE  
## 3 f        165. TRUE  
## 4 m        185. TRUE  
## 5 m        152. FALSE  
## 6 m        175. FALSE
```

Example2: You could even supply args

```
is_above_average_height <- function(sex, height_cm, men_avg, women_avg)
  if(sex == "m") height_cm > men_avg else height_cm > women_avg
}

okcupid <- okcupid %>%
  mutate(is_tall = map2_lgl(sex, height_cm, is_above_average_height,
                           men_avg = 180, women_avg = 165))

okcupid %>% select(sex, height_cm, is_tall) %>% group_by(sex) %>%

## # A tibble: 6 × 3
## # Groups:   sex [2]
##   sex    height_cm is_tall
##   <chr>     <dbl> <lgl>
## 1 f          160. FALSE
## 2 f          163. FALSE
## 3 f          183. TRUE
## 4 m          178. FALSE
## 5 m          173. FALSE
## 6 m          178. FALSE
```

Example2: Anonymous Functions

```
okcupid <- okcupid %>%
  mutate(is_tall = map2_lgl(sex, height_cm,
                            function(x, y) if(x == "m") y > 180 else
```

Heck, you can even:

```
okcupid <- okcupid %>%
  mutate(is_tall = map2_lgl(sex, height_cm,
                            ~if(.x == "m") .y > 180 else .y > 165)
```



There's a thin line between elegance and unreadable undetectable bragging.

Example 3: Remember our problem?

For each `essay` column, add a column with its length:

```
okcupid %>%
  mutate(across(essay0:essay9, list("len" = str_length))) %>%
  select(starts_with("essay")) %>%
  head(3)

## # A tibble: 3 × 20
##   essay0          essay1 essay2 essay3 essay4 essay5 essay6 essay7 essay
##   <chr>           <chr>  <chr>  <chr>  <chr>  <chr>  <chr>  <chr>
## 1 "about me:<br ... "curr... "maki... "the ... "book... "food... duali... "tryi...
## 2 "i am a chef: ... "dedi... "bein... <NA>   "i am... "deli... <NA>   "i am.
## 3 "i'm not asham... "i ma... "impr... "my l... "okay... "move... <NA>   "view... "when.
## # ... with 10 more variables: essay0_len <int>, essay1_len <int>,
## #   essay2_len <int>, essay3_len <int>, essay4_len <int>, essay5_len <int>
## #   essay6_len <int>, essay7_len <int>, essay8_len <int>, essay9_len <int>
```

`purrr` not needed, like I said, you've already been non-looping!

Example 3: Input multiple columns

~~For each user, compute the average essay length.~~

Wait, before that, for each user compute the average of the first 3 essays:

```
mean_length_3essay <- function(x, y, z) {  
  mean(str_length(c(x, y, z)), na.rm = TRUE)  
}  
  
okcupid %>%  
  mutate(essay3_avglen = pmap_dbl(  
    list(essay0, essay1, essay2),  
    mean_length_3essay)) %>%  
  select(essay0:essay2, essay3_avglen) %>%  
  head(2)  
  
## # A tibble: 2 × 4  
##   essay0                                essay1 essay2 essay3_avglen  
##   <chr>                                 <chr>  <chr>  <dbl>  
## 1 "about me:<br />\n<br />\ni would love to think t... "curr... "maki...  
## 2 "i am a chef: this is what that means.<br />\n1. ... "dedi... "bein..."
```

OK now, for each user, compute the average essay length:

```
mean_length_essay <- function(...) {  
  mean(str_length(c(...)), na.rm = TRUE)  
}  
  
okcupid %>%  
  mutate(essay_avglen = pmap_dbl(  
    across(starts_with("essay")),  
    mean_length_essay)) %>%  
  select(essay0:essay2, essay_avglen) %>%  
  head(3)
```

```
## # A tibble: 3 × 4  
##   essay0                           essay1 essay2 essa:  
##   <chr>                             <chr>  <chr>  
## 1 "about me:<br />\n<br />\ni would love to think th... "curr... "maki...  
## 2 "i am a chef: this is what that means.<br />\n1. i... "dedi... "bein...  
## 3 "i'm not ashamed of much, but writing public text ... "i ma... "impr...
```

Example4: Output multiple columns

```
essay0_features <- function(essay0) {  
  contains_love <- str_detect(essay0, "love")  
  contains_obama <- str_detect(essay0, "obama")  
  contains_rel <- str_detect(essay0, "relationship")  
  list(  
    essay0_love = contains_love,  
    essay0_obama = contains_obama,  
    essay0_rel = contains_rel  
  )  
}  
  
okcupid %>% select(essay0) %>% map_dfc(essay0_features) %>% head(4)
```

```
## # A tibble: 4 × 3  
##   essay0_love essay0_obama essay0_rel  
##   <lgl>       <lgl>       <lgl>  
## 1 TRUE        FALSE        FALSE  
## 2 TRUE        FALSE        FALSE  
## 3 TRUE        FALSE        FALSE  
## 4 FALSE       FALSE        FALSE
```

```
# or: map_dfc(okcupid$essay0, essay0_features)
```

Or if you want those features as additional columns, you could bind them with `bind_cols()`:

```
okcupid %>%
  bind_cols(
    okcupid %>% select(essay0) %>% map_dfc(essay0_features)
  ) %>%
  select(age, sex, starts_with("essay0"))

## # A tibble: 59,946 × 6
##       age   sex essay0          essay0_love essay0_obama es...
##   <dbl> <chr> <chr>           <lgl>        <lgl>      <lo...
## 1     22   m "about me:<br />\n<br />\ni ... TRUE        FALSE      FA...
## 2     35   m "i am a chef: this is what t... TRUE        FALSE      FA...
## 3     38   m "i'm not ashamed of much, bu... TRUE        FALSE      FA...
## 4     23   m "i work in a library and go ... FALSE       FALSE      FA...
## 5     29   m "hey how's it going? current... FALSE       FALSE      FA...
## 6     29   m "i'm an australian living in... TRUE        FALSE      FA...
## 7     32   f "life is about the little th... TRUE        FALSE      FA...
## 8     31   f <NA>                         NA          NA        NA
## 9     24   f <NA>                         NA          NA        NA
## 10    37   m "my names jake.<br />\ni'm a... TRUE        FALSE      FA...
## # ... with 59,936 more rows
```

```
# or: okcupid %>% mutate(as_tibble(essay0_features(essay0)))
```

rowwise() and **c_across()**

The Tidyverse dev team recently acknowledged that the purrr lingo might be a bit much for many users. Enter `rowwise()`:

Before:

```
is_above_average_height <- function(sex, height_cm) {  
  if (sex == "m") height_cm > 180 else height_cm > 165  
}  
  
okcupid %>%  
  mutate(is_tall = map2_lgl(sex, height_cm, is_above_average_height))
```

After:

```
okcupid %>%  
  rowwise() %>%  
  mutate(is_tall = is_above_average_height(sex, height_cm))
```

rowwise() and c_across()

Before:

```
mean_length_essay <- function(...) {  
  mean(str_length(c(...)), na.rm = TRUE)  
}  
  
okcupid %>%  
  mutate(essay_avglen = pmap_dbl(  
    across(starts_with("essay")),  
    mean_length_essay))
```

After:

```
okcupid %>%  
  rowwise() %>%  
  mutate(essay_avglen =  
    mean_length_essay(c_across(starts_with("essay"))))
```

Dealing with failure

```
my_func("a")
```

```
## Error in x%%2: non-numeric argument to binary operator
```

Silly example, but:

- (a) When dealing with big data expect the unexpected (input)
- (b) You don't want your app to crash

Look at: `safely()`, `quietly()` and `possibly()` which wrap your code nicely and protect you from the unexpected (crash).

My favorite: possibly()

```
my_func_safe <- possibly(my_func, otherwise = NA)  
my_func_safe("a")
```

```
## [1] NA
```

```
map_chr(list(1, 2, "3", 4), my_func_safe)
```

```
## [1] "odd"  "even" NA      "even"
```



See a more realistic example when we talk about Web Scraping



What would `map_chr(c(1, 2, "3", 4), my_func_safe)` return?

walk(), walk2(), pwalk()

You don't always need to *return* anything, you just wanna loop

```
walk(1:10, ~print("Hey Girrrl"))
```

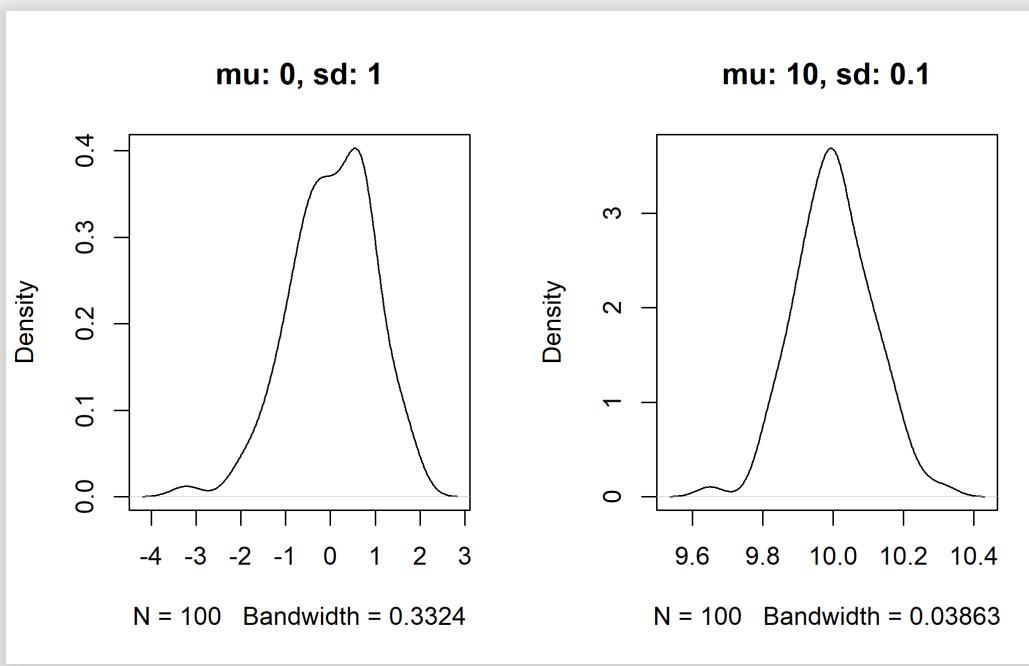
```
## [1] "Hey Girrrl"
```

```

plot_norm <- function(mu, sd) {
  plot(density(rnorm(100, mu, sd)), 
        main = str_c("mu: ", mu, ", sd: ", sd))
}

par(mfcol = c(1, 2))
walk2(c(0, 10), c(1, 0.1), plot_norm)

```



In the words of Hadley

Once you master these functions, you'll find it takes much less time to solve iteration problems.

But you should never feel bad about using a for loop instead of a map function.

The important thing is that you solve the problem that you're working on, not write the most concise and elegant code.

Some people will tell you to avoid for loops because they are slow. They're wrong!