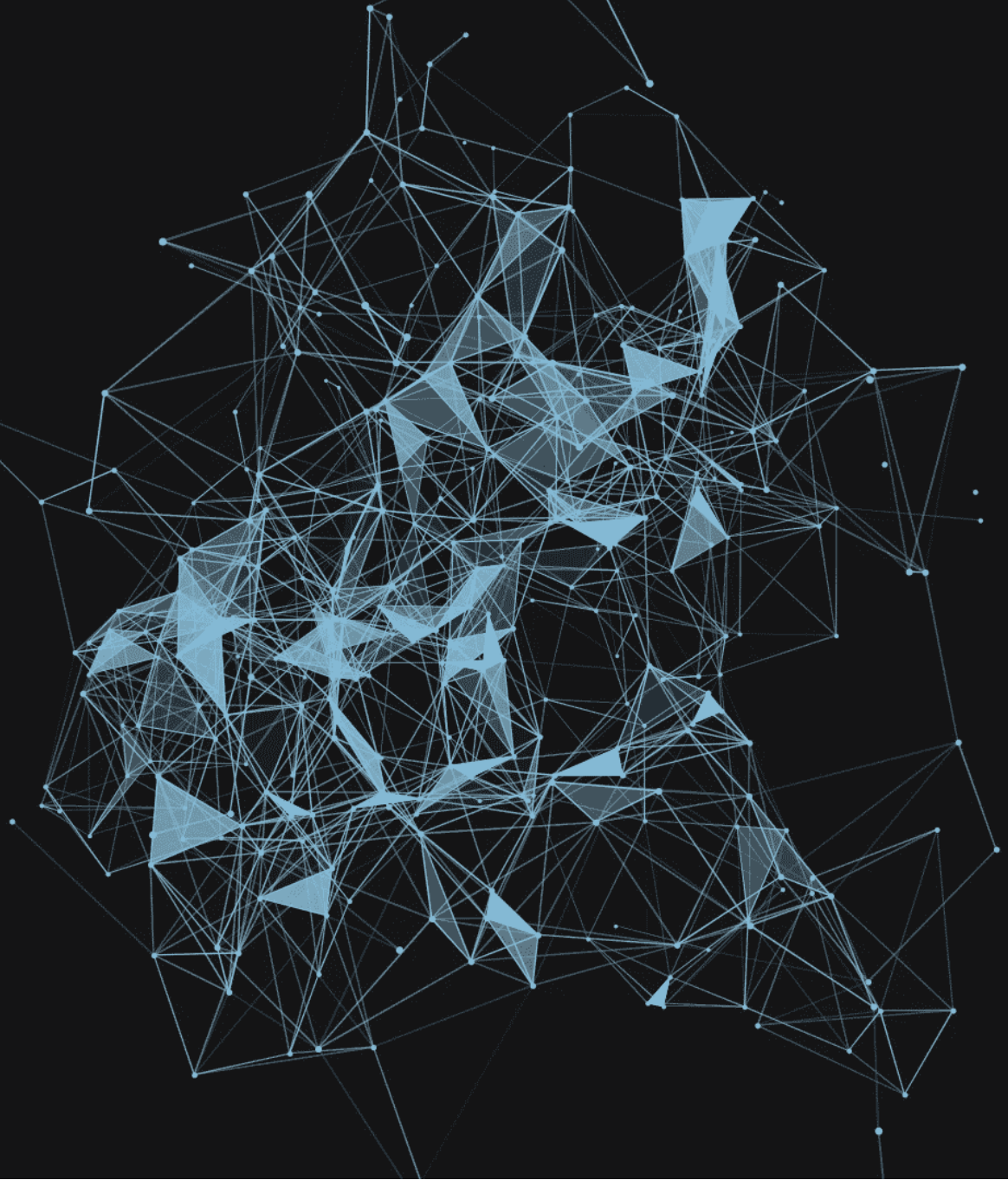
R + Analytics + Cloud

Analytics/Big Data Training



Thiago Pires | 22 and 23 Apr 2021

github.com/th1460/r-analytics

Analytics

> *Fact-based decisions have become our competitive strength. Using or not using analytics is no longer an option*

Analytics

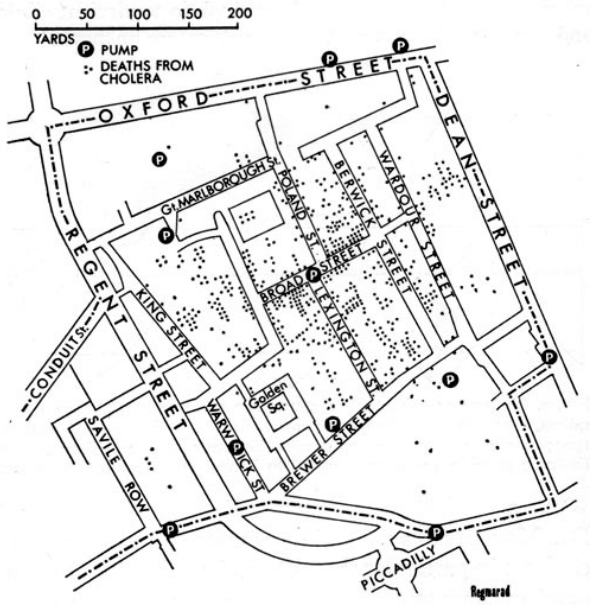
> *Analytics is a comprehensive and multidimensional field that uses mathematical techniques, statistics, predictive modeling and machine learning to find meaningful patterns and knowledge in data.*

Florence Nightingale recording and analyzing mortality data in the 1850s. She presented data on wounded soldiers with death counts per month. He ended up realizing that the main **death rate was due to hospital infection and not battle injuries**, as many imagined.

Analytics

A concrete example of spatial analysis carried out in 1854 in the city of London, where the population was **suffering a serious cholera epidemic**, disease about which at the time the form of contamination was not known. In a situation where more than 500 deaths had already occurred, the **Dr. John Snow had an idea: put on the city map the location of the cholera patients and the water wells** (at that time, the main source of water for the city's inhabitants). The obtained map is shown in the figure below.

Dr. Snow realized that most cases were concentrated around the "Broad Street" well



Analytics

Data analysis can reveal correlations and patterns. There is less need to rely on assumptions or intuition. And it can help answer questions like:

- What happened?
- How or why it happened?
- What is happening now?
- What will likely happen next?

R

Linguagem R

Developed by **Ross Ihaka** and **Robert Gentleman** in the Statistics department at the University of Auckland, New Zealand in 1993.

Exemplo

```
1 + 2 + (3 * 4)
```

```
[1] 15
```

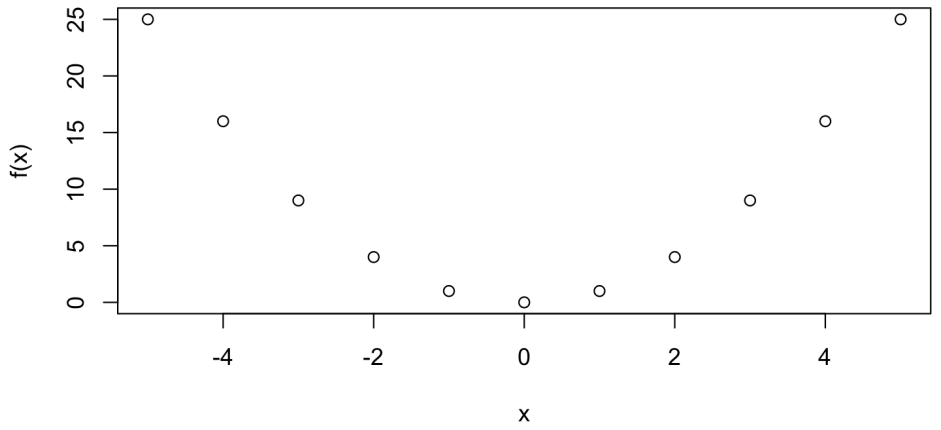
```
f <- function(x) {x^2}
x <- seq(-5, 5, 1); f(x)
```

```
 [1] 25 16  9  4  1  0  1  4  9 16 25
```

```
paste("If x = 2, then f(2) =", f(2))
```

```
[1] "If x = 2, then f(2) = 4"
```

```
plot(x, f(x))
```



Base language × Tidyverse

Base language

```
# sum elements in a vector
sum(c(10, 5, 8, 12, 2, 0))
```

```
[1] 37
```

```
# data.frame
df <- data.frame(x = 1:3, y = letters[1:3])
df$z <- df$x^2

# filter and select
df[df$y == "b", c("x", "z")]
```

```
  x z
2 2 4
```

Tidyverse

```
require(dplyr)
# sum elements in a vector
c(10, 5, 8, 12, 2, 0) %>% sum
```

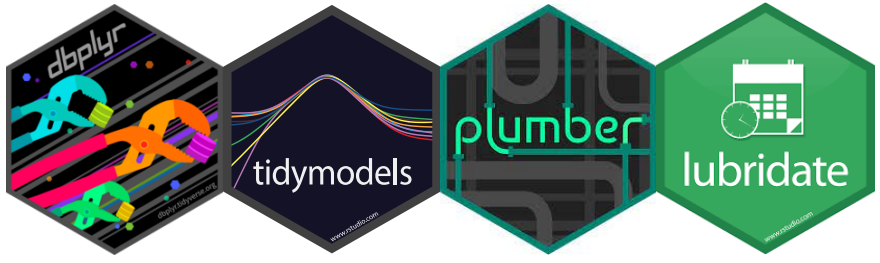
```
[1] 37
```

```
# tibble
df <- tibble(x = 1:3, y = letters[1:3], z = x^2)

# filter and select
df %>% filter(y == "b") %>% select(x, z)
```

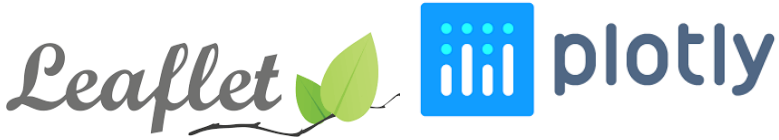
```
# A tibble: 1 x 2
      x     z
  <int> <dbl>
1     2     4
```

Packages


dplyr
ggplot2
forcats
tibble
readr
stringr
tidyr
purrr


dbplyr
tidymodels
plumber
lubridate


Shiny
rmarkdown
xaringan
renv

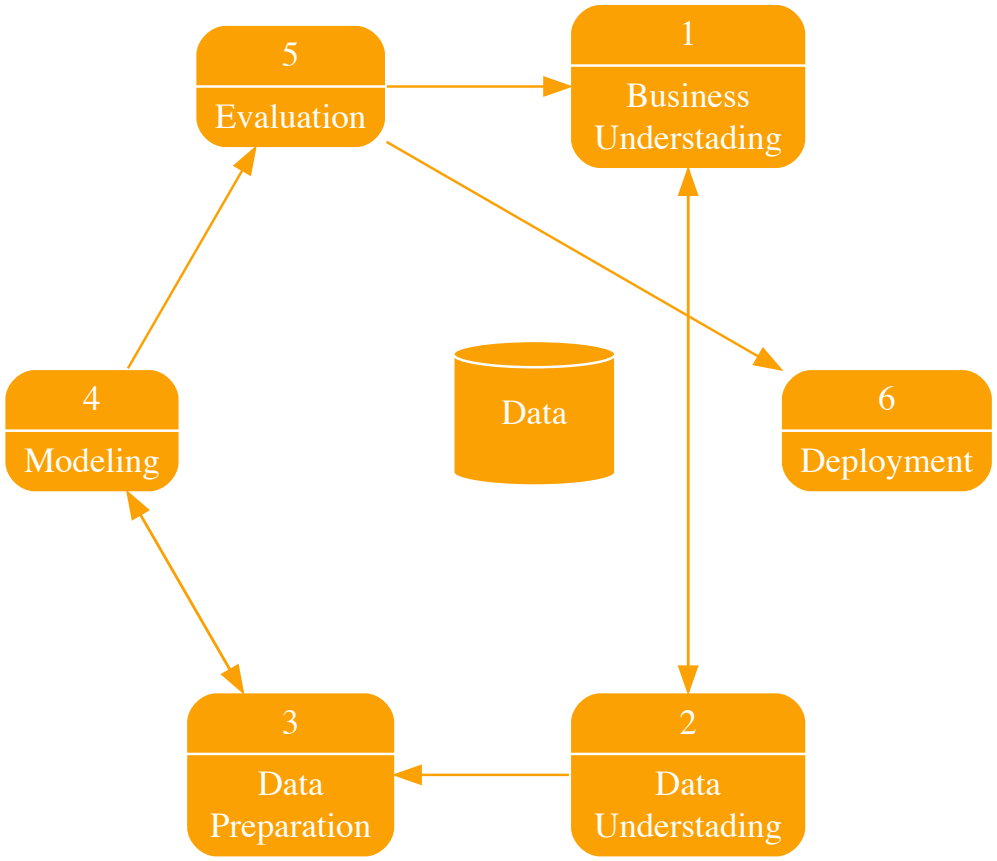

Leaflet
plotly

CRISP-DM

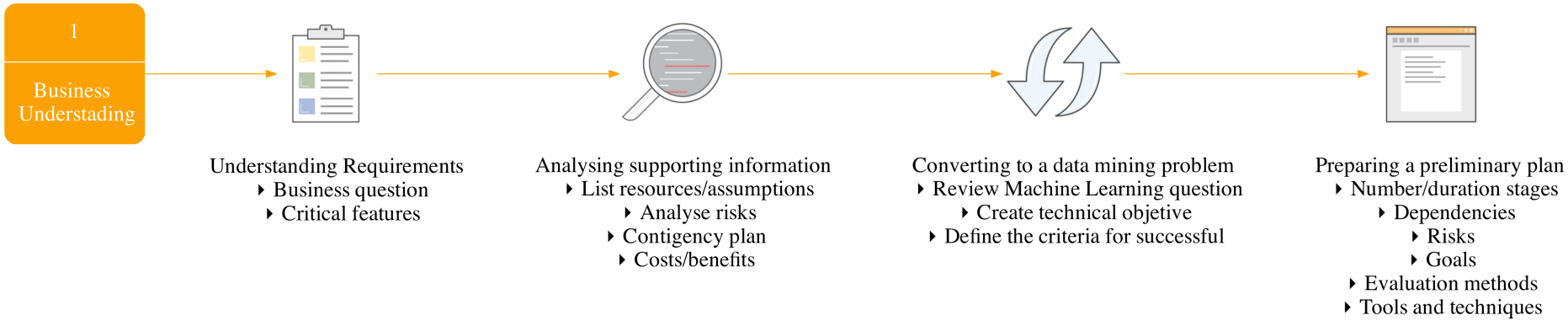
> *Cross Industry Standard Process for Data Mining*

CRISP-DM

> *Cross-industry standard process for data mining, known as CRISP-DM is an open standard process model that describes common approaches used by data mining experts. It is the most widely-used analytics model*



Business Understanding



Case Titanic dataset challenge

This is a *part* (train data) from the dataset used in Kaggle Titanic challenge

Business question:

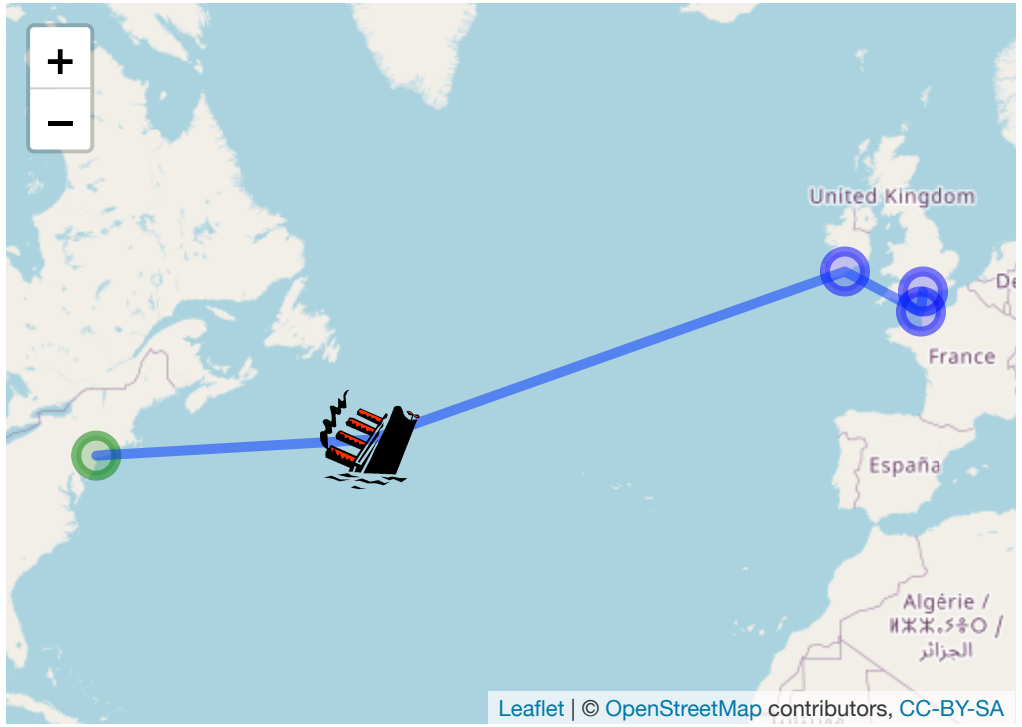
> *What factors was associated with a person survive in the Titanic disaster?*

Features:

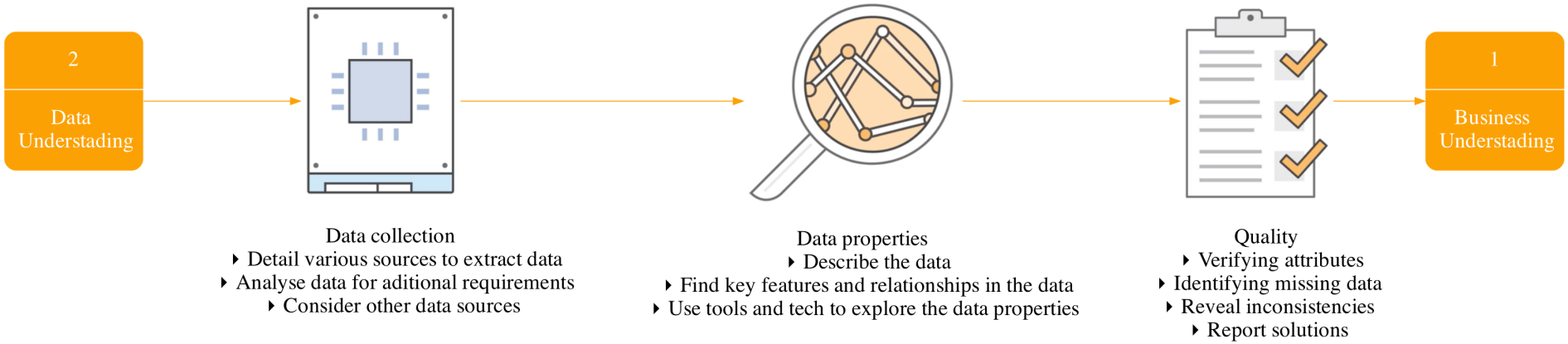
- How to analyze the data? (e.g. R, Python, etc)
- How prepare the data? (e.g. Pandas, dplyr, etc)
- What were the passager types (e.g. Ages, Gender, Class, etc)

Titanic disaster

```
require(leaflet)

events <- bind_rows(
  tibble(location = "Southampton (10-04-1912)",
         lng = -1.4191, lat = 50.7894),
  tibble(location = "Cherbourg (10-04-1912)",
         lng = -1.6109, lat = 49.6445),
  tibble(location = "Queenstown (11-04-1912)",
         lng = -8.3211, lat = 51.8535),
  tibble(location = "Naufrágio (14-04-1912)",
         lng = -49.9408, lat = 41.7258),
  tibble(location = "New York",
         lng = -73.9655, lat = 40.6832))

leaflet() %>%  addTiles() %>%
  addCircleMarkers(data = events %>% slice(1:3, 5),
                   label = ~location,
                   color = c(rep("blue", 3), "green")) 
  addMarkers(data = events %>% slice(4),
             icon = list(
               iconUrl = "resources/images/sinking-shi
               iconSize = c(50, 50)),
             label = ~location) %>%
  addPolylines(data = events, ~lng, ~lat)
```



Data Understanding



Titanic case

```
# Read data from Github
dataset <- "https://gist.githubusercontent.com/michhar/2dfd2de0d4f8727f873422c5d959fff5/raw/fa71405126017e6a37bea592
```

Data Understanding (Titanic case)

Study the data dictionary and

Inspect the dataset

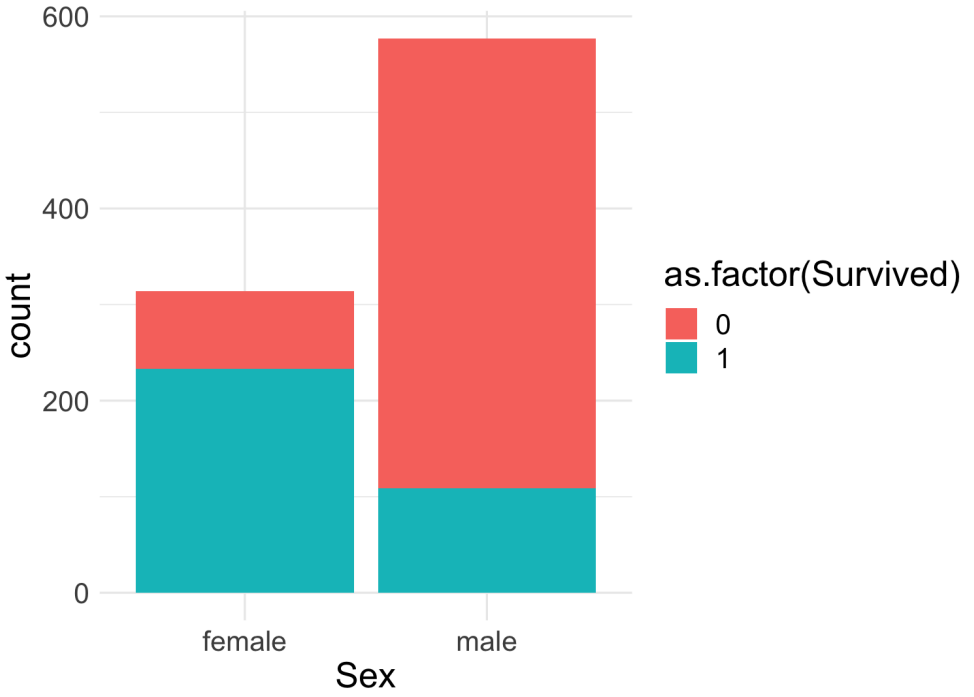
```
titanic <- readr::read_csv(dataset)
titanic %>% glimpse()
```

```
Rows: 891
Columns: 12
$ PassengerId <dbl> 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17,…
$ Survived    <dbl> 0, 1, 1, 1, 0, 0, 0, 0, 1, 1, 1, 1, 0, 0, 0, 1, 0, 1, 0, 1…
$ Pclass      <dbl> 3, 1, 3, 1, 3, 3, 1, 3, 3, 2, 3, 1, 3, 3, 3, 2, 3, 2, 3, 3…
$ Name        <chr> "Braund, Mr. Owen Harris", "Cumings, Mrs. John Bradley (Fl…
$ Sex         <chr> "male", "female", "female", "female", "male", "male", "mal…
$ Age         <dbl> 22, 38, 26, 35, 35, NA, 54, 2, 27, 14, 4, 58, 20, 39, 14, …
$ SibSp       <dbl> 1, 1, 0, 1, 0, 0, 0, 3, 0, 1, 1, 0, 0, 1, 0, 0, 4, 0, 1, 0…
$ Parch       <dbl> 0, 0, 0, 0, 0, 0, 0, 1, 2, 0, 1, 0, 0, 5, 0, 0, 1, 0, 0, 0…
$ Ticket      <chr> "A/5 21171", "PC 17599", "STON/O2. 3101282", "113803", "37…
$ Fare        <dbl> 7.2500, 71.2833, 7.9250, 53.1000, 8.0500, 8.4583, 51.8625,…
$ Cabin       <chr> NA, "C85", NA, "C123", NA, NA, "E46", NA, NA, NA, "G6", "C…
$ Embarked    <chr> "S", "C", "S", "S", "S", "Q", "S", "S", "S", "C", "S", "S"…
```

Data Understanding (Titanic case)

Detect key associations

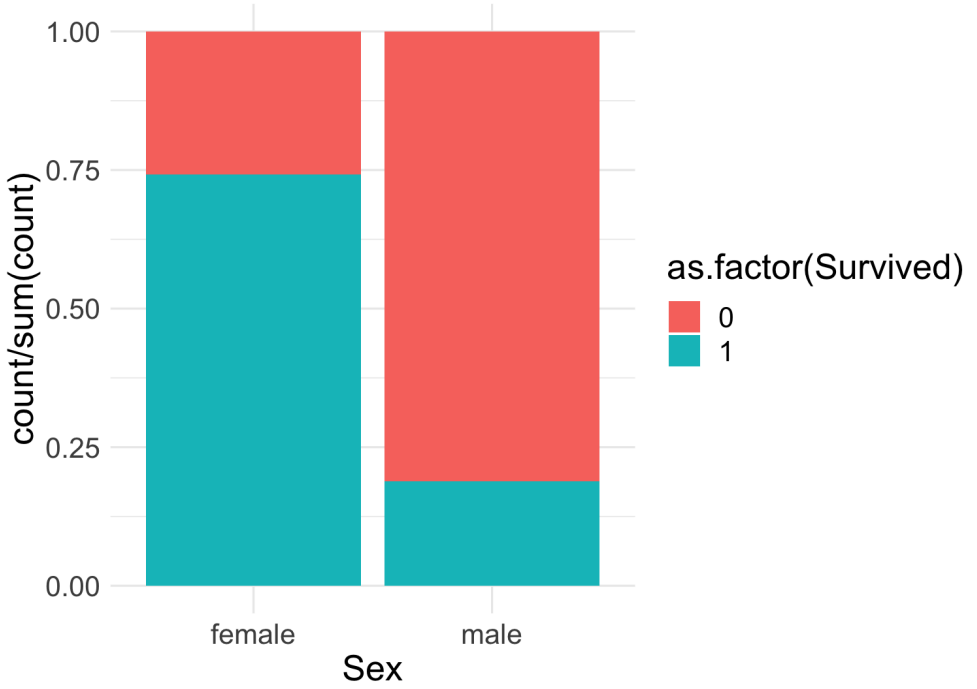
```
require(ggplot2)
theme_set(
  theme_minimal() +
    theme(text = element_text(size = 18))
)

titanic %>%
  ggplot(aes(Sex, ..count..,
             group = Survived,
             fill = as.factor(Survived))) +
  geom_bar()
```



Data Understanding (Titanic case)

Detect key associations

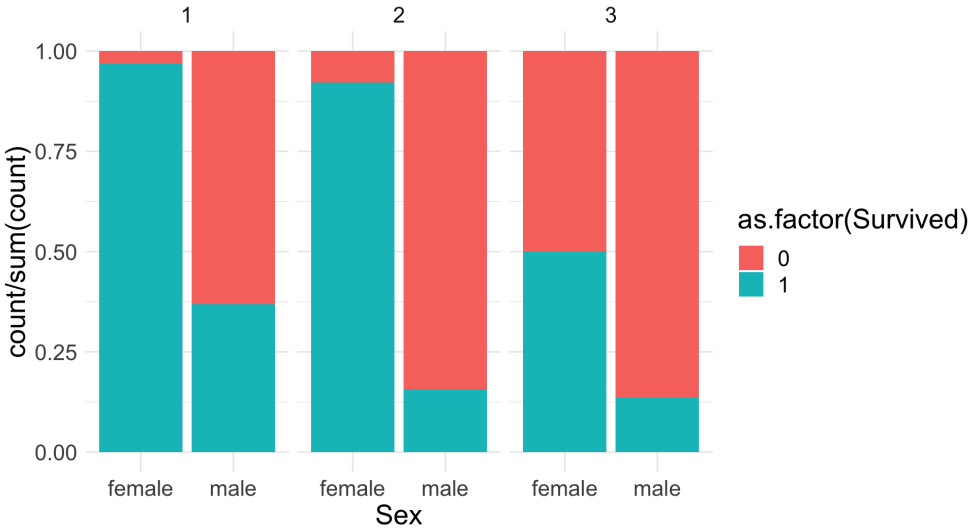
```
titanic %>%
  ggplot(aes(Sex, ..count../sum(..count..),
             group = Survived,
             fill = as.factor(Survived))) +
  geom_bar(position="fill")
```



Data Understanding (Titanic case)

Detect key associations

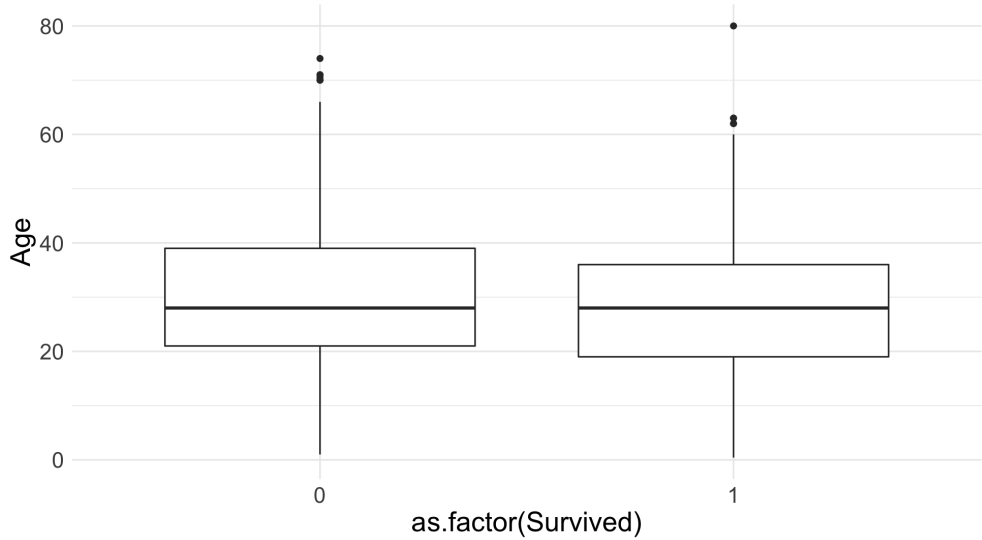
```
titanic %>%
  ggplot(aes(Sex, ..count../sum(..count..),
             group = Survived,
             fill = as.factor(Survived))) +
  geom_bar(position="fill") +
  facet_grid(~Pclass)
```



Data Understanding (Titanic case)

Detect key associations

```
titanic %>%
  ggplot(aes(as.factor(Survived), Age)) +
  geom_boxplot()
```



Data Understanding (Titanic case)

Identify missing data

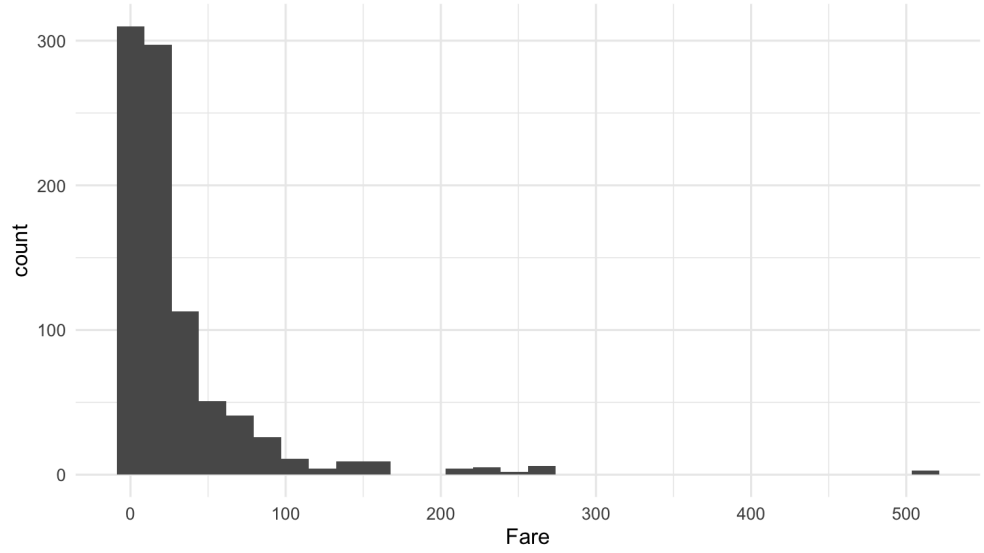
```
na_count <- function(x) sum(is.na(x))

titanic %>%
  summarise(across(everything(),
                   list(na_count),
                   .names = "{.col}")) %>%
  tidyr::pivot_longer(everything(),
                      values_to = "n_missing")
```

```
# A tibble: 12 x 2
   name        n_missing
   <chr>           <int>
 1 PassengerId         0
 2 Survived            0
 3 Pclass              0
 4 Name                0
 5 Sex                 0
 6 Age               177
 7 SibSp               0
 8 Parch               0
 9 Ticket              0
10 Fare                0
11 Cabin             687
12 Embarked            2
```

Data Understanding (Titanic case)

Analyse distribution

```
require(ggplot2)

titanic %>%
  ggplot(aes(x = Fare)) +
  geom_histogram() +
  theme_minimal()
```




```
titanic %>%
  summarise(
    min(Fare),
    max(Fare),
    mean(Fare),
    median(Fare),
    e1071::skewness(Fare)
  ) %>%
  tidyr::pivot_longer(everything(),
                      names_to = "measure") %>%
  mutate(value = value %>% round(2))
```

```
# A tibble: 5 x 2
  measure                value
  <chr>                  <dbl>
1 min(Fare)                0
2 max(Fare)              512.
3 mean(Fare)              32.2
4 median(Fare)            14.4
5 e1071::skewness(Fare)    4.77
```

Data Understanding (Titanic case)

Symetric distribution

```
set.seed(123)

dataset <- tibble(x = rnorm(100, 30, 2))
dataset %>%
  ggplot(aes(x)) +
  geom_histogram(aes(y = ..density..)) +
  geom_density(aes(x), color = "blue") +
  theme_minimal()
```

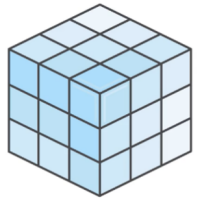
```
dataset %>%
  summarise(
    min(x),
    max(x),
    mean(x),
    median(x),
    e1071::skewness(x)
  ) %>%
  tidyr::pivot_longer(everything(),
                      names_to = "measure") %>%
  mutate(value = value %>% round(2))
```

```
# A tibble: 5 x 2
  measure            value
  <chr>              <dbl>
1 min(x)              25.4
2 max(x)              34.4
3 mean(x)             30.2
4 median(x)           30.1
5 e1071::skewness(x)  0.06
```

Data Preparation

3

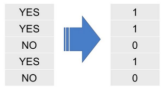
Data Preparation



Final dataset selection
- Total size
- Included and excluded columns
- Record selection
- Data type

Data preparation
- Cleaning
- Transforming
- Merging
- Formatting

Cleaning
- How is the missing data handled
- Clean attributes with corrupt data or variable noise



Transformation
- Derive additional attributes from original
- Normalization
- Attribute transformation

Merging
⚠ Revisit the Data Understanding phase

2

Data Understading

Formatting
- Rearrange attributes
- Randomly shuffle data
- Remove constraints of modeling tool
- Reshape

Data Preparation (Titanic case)

Do we drop rows? Which?

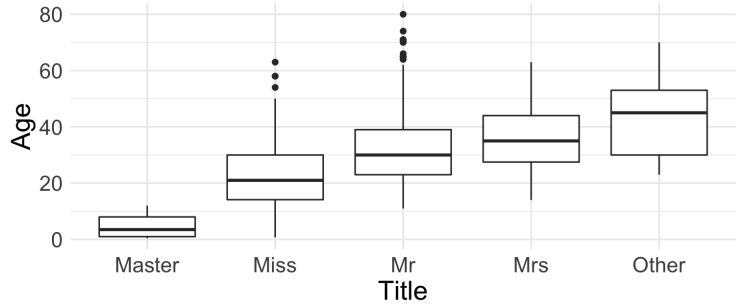
How treat empty values?

```
# A tibble: 12 x 2
   name        n_missing
   <chr>           <int>
 1 PassengerId         0
 2 Survived            0
 3 Pclass              0
 4 Name                0
 5 Sex                 0
 6 Age               177
 7 SibSp               0
 8 Parch               0
 9 Ticket              0
10 Fare                0
11 Cabin             687
12 Embarked            2
```

```
titanic$Name[4]
```

```
[1] "Futrelle, Mrs. Jacques Heath (Lily May Peel)"
```

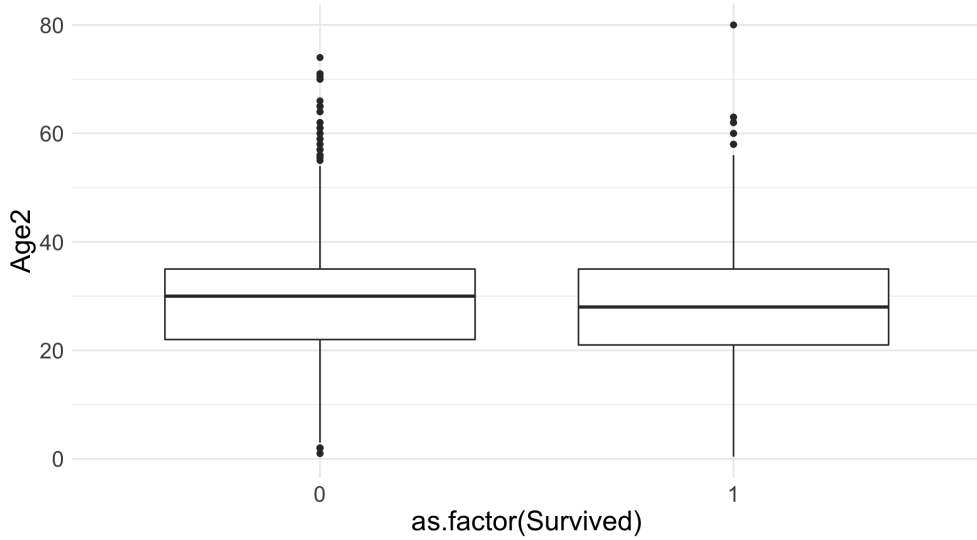
```
require(forcats)
require(ggplot2)
titanic %>%
  mutate(
    Title = Name %>%
      stringr::str_extract(
        "(?<=\\,\\s)(.*)(?=\\.)") %>%
      fct_lump(n = 4)) %>%
  ggplot(aes(Title, Age)) + geom_boxplot
```



Data Preparation (Titanic case)

After fix empty ages

```
titanic %>%
  mutate(
    Title = Name %>%
      stringr::str_extract("(?<=\\,\\s)(.*)(?=\\.)") %
      fct_lump(n = 4)) %>%
  group_by(Title) %>%
  mutate(Age2 = ifelse(is.na(Age), median(Age, na.rm =
  ggplot(aes(as.factor(Survived), Age2)) +
  geom_boxplot()
```



Data Preparation (Titanic case)

Fix types and labels

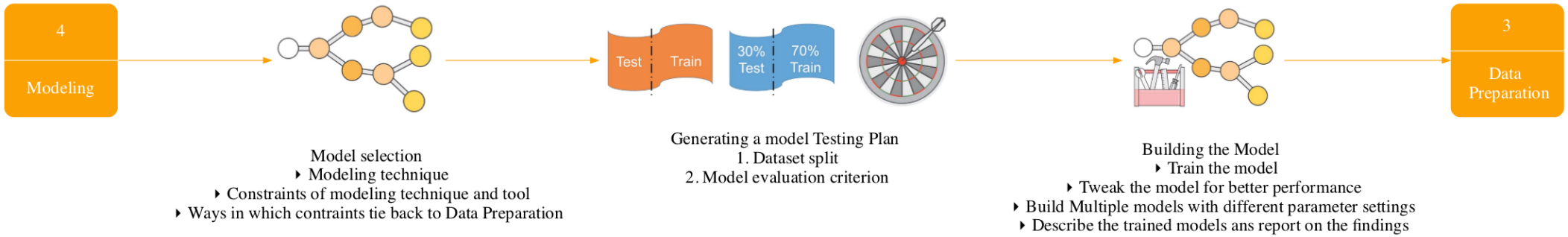
```
require(magrittr)
titanic %<>%
  mutate(Sex = as.factor(Sex),
         Pclass = factor(Pclass,
                         labels = c("1st", "2nd", "3rd
         Survived = factor(Survived,
                           labels = c("No", "Yes")),
         Embarked = fct_recode(Embarked,
                               "Cherbourg" = "C",
                               "Queenstown" = "Q",
                               "Southampton" = "S"))
titanic %>% select(Sex, Survived, Embarked) %>%
  print(n = 4)
```

```
# A tibble: 891 x 3
  Sex    Survived Embarked
  <fct>  <fct>    <fct>
1 male   No       Southampton
2 female Yes      Cherbourg
3 female Yes      Southampton
4 female Yes      Southampton
# … with 887 more rows
```

```
freq <- function(data, x) {
  table <- data %>%
    count({{x}}) %>%
    mutate(`%` = (n/sum(n) * 100) %>% round(1)) %>%
    rename(Levels = 1, N = 2)
  tibble(Variable = quo_name(quo({{x}}))) %>%
    bind_cols(table)
}

c("Sex", "Survived", "Embarked", "Pclass") %>%
  purrr::map_dfr(~ freq(titanic, !! sym(.x)))
```

```
# A tibble: 11 x 4
   Variable Levels          N   `%`
   <chr>    <fct>       <int> <dbl>
 1 Sex      female        314  35.2
 2 Sex      male          577  64.8
 3 Survived No            549  61.6
 4 Survived Yes           342  38.4
 5 Embarked Cherbourg     168  18.9
 6 Embarked Queenstown     77   8.6
 7 Embarked Southampton   644  72.3
 8 Embarked NA              2   0.2
 9 Pclass   1st           216  24.2
10 Pclass   2nd           184  20.7
11 Pclass   3rd           491  55.1
```

Modeling



Titanic case

> *What factors was associated with a person survive in the Titanic disaster?*

Model selection

- Logistic regression, Decision Tree, etc
- Features: Sex, Pclass, interaction between Sex and Pclass?
- Split strategy

Modeling (Titanic case)

Split data

```
require(tidymodels)
set.seed(555)

# Put 3/4 of the data into the training set
data_split <- initial_split(titanic, prop = 3/4)

# Create data frames for the two sets:
train_data <- training(data_split)
test_data  <- testing(data_split)
```

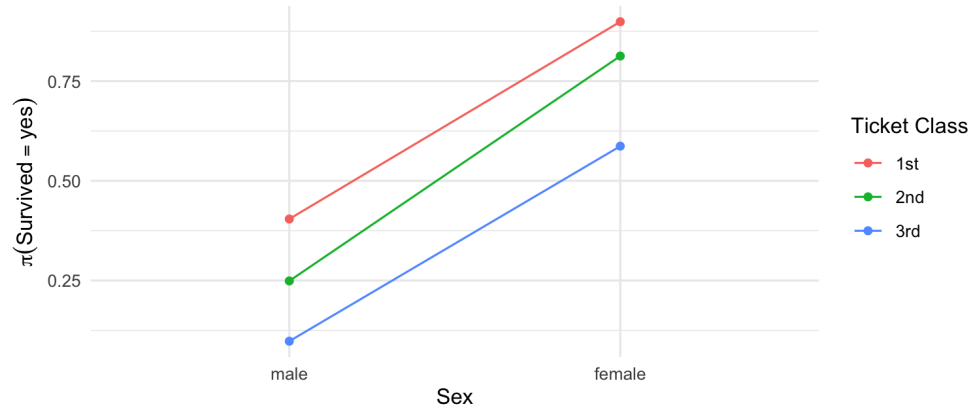
Modeling (Titanic case)

Survived ~ Sex + Pclass

```
lr_mod <-
  logistic_reg() %>%
  set_engine("glm")

lr_fit1 <-
  lr_mod %>%
  fit(Survived ~ Sex + Pclass, data = train_data)

lr_fit1 %>% tidy()
```

```
# A tibble: 4 x 5
  term        estimate std.error statistic  p.value
  <chr>          <dbl>     <dbl>     <dbl>    <dbl>
1 (Intercept)    2.18      0.249      8.77 1.76e-18
2 Sexmale       -2.57      0.208    -12.4  4.56e-35
3 Pclass2nd     -0.716     0.278     -2.58 9.97e- 3
4 Pclass3rd     -1.83      0.247     -7.44 1.03e-13
```

```
newdata <-
  expand.grid(Pclass = c("1st", "2nd", "3rd"),
              Sex = c("male", "female"))
pihat <-
  (lr_fit1 %>% predict(newdata, type = "prob")) %$%
  .pred_Yes
newdata %>% mutate(Pihat = pihat) %>%
  ggplot(aes(Sex, Pihat,
             group = Pclass, colour = Pclass)) +
  geom_line() + geom_point() +
  labs(x = "Sex", y = expression(pi(Survived == yes)),
       colour = "Ticket Class") +
  theme_minimal()
```



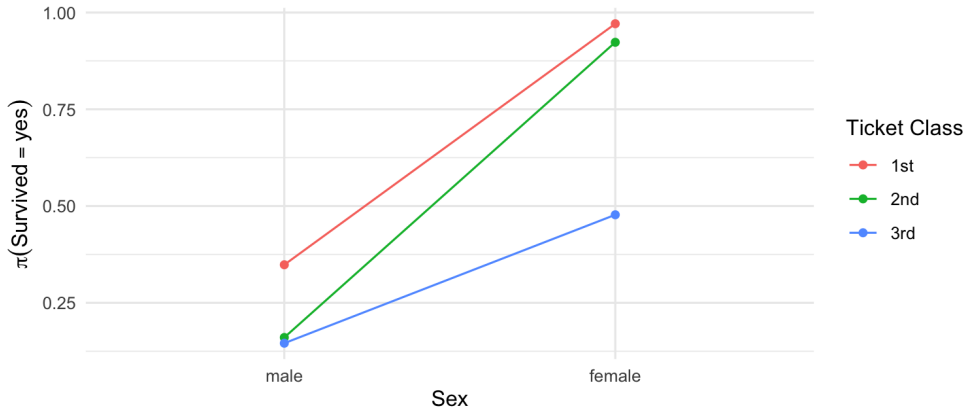
Modeling (Titanic case)

Survived ~ Sex + Pclass + Sex:Pclass

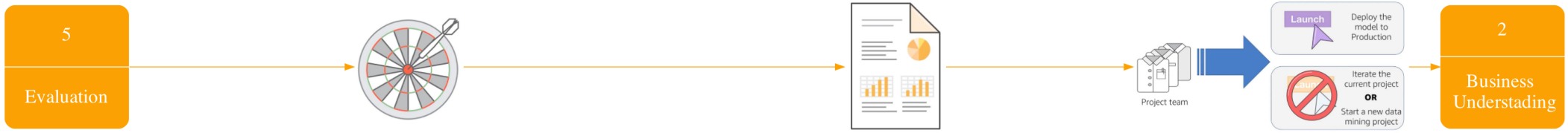
```
lr_fit2 <-
  lr_mod %>%
  fit(Survived ~ Sex * Pclass, data = train_data)

lr_fit2 %>% tidy()
```

```
# A tibble: 6 x 5
  term              estimate std.error statistic      p.value
  <chr>                <dbl>     <dbl>     <dbl>        <dbl>
1 (Intercept)         3.51        0.718   4.89     0.000000990
2 Sexmale            -4.14        0.751  -5.51     0.0000000363
3 Pclass2nd          -1.03        0.855  -1.20     0.230
4 Pclass3rd          -3.60        0.742  -4.85     0.00000122
5 Sexmale:Pclass2nd -0.00146      0.934  -0.00157  0.999
6 Sexmale:Pclass3rd  2.46        0.795   3.09     0.00198
```

```
newdata <-
  expand.grid(Pclass = c("1st", "2nd", "3rd"),
              Sex = c("male", "female"))
pihat <-
  (lr_fit2 %>% predict(newdata, type = "prob")) %$%
  .pred_Yes
newdata %>% mutate(Pihat = pihat) %>%
  ggplot(aes(Sex, Pihat,
             group = Pclass, colour = Pclass)) +
  geom_line() + geom_point() +
  labs(x = "Sex", y = expression(pi(Survived == yes)),
       colour = "Ticket Class") +
  theme_minimal()
```



Evaluation



Mensures

Predicted\Actual	Survived	No Survived
Survived	True Positive (TP)	False Positive (FP)
No Survived	False Negative (FN)	True Negative (TN)

$$\text{Accuracy} = \frac{TP + TN}{TP + TN + FP + FN}$$

$$\text{Precision} = \frac{TP}{TP + FP}$$

$$\text{Recall} = \frac{TP}{TP + FN}$$

$$F_{1-score} = \frac{2 \times \text{precision} \times \text{recall}}{\text{precision} + \text{recall}}$$

Evaluation (Titanic case)

```
measure <- function(data) {
  data %>% accuracy(truth = Survived, .pred_class) %>%
    bind_rows(data %>% f_meas(truth = Survived, .pred_class))
}
```

Survived ~ Sex + Pclass

```
predict(lr_fit1, test_data) %>%
  bind_cols(predict(lr_fit1,
                    test_data, type = "prob")) %>%
  bind_cols(test_data %>% select(Survived)) %>%
  measure()
```

```
# A tibble: 2 x 3
  .metric  .estimator .estimate
  <chr>    <chr>          <dbl>
1 accuracy binary         0.802
2 f_meas   binary         0.850
```

Survived ~ Sex + Pclass + Sex:Pclass

```
predict(lr_fit2, test_data) %>%
  bind_cols(predict(lr_fit2,
                    test_data, type = "prob")) %>%
  bind_cols(test_data %>% select(Survived)) %>%
  measure()
```

```
# A tibble: 2 x 3
  .metric  .estimator .estimate
  <chr>    <chr>          <dbl>
1 accuracy binary         0.779
2 f_meas   binary         0.850
```

Deployment

6

Deployment

Planning deployment

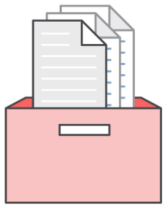
Define runtime

Maintenance and monitoring

Management

Final report

- Highlight processes used in the project
- Analyse if all the goals for the project were met
- Detail the findings of the project
- Identify and explain the model used



Project review

- Assess the outcomes of the project
- Summarise results: common pitfalls
- Summarise results: choosing the right ML solution
- Generalize the whole process to make it useful for the next generation

Deployment (Titanic case)

Save model

```
yaml::write_yaml(
  tidypredict::parse_model(lr_fit1),
  "R/my_model.yml"
)
```

Deployment (Titanic case)

IBM Cloud Functions

> IBM Cloud™ Functions service is an event-driven compute platform, also referred to as Serverless computing, or as Function as a Service (FaaS), that runs code in response to events or direct invocations.

Configure

exec

```
#!/bin/bash

# run R script
chmod +x script.R # turn executable
echo "$@" > input.json # set input
./script.R # run script
```

Dockerfile

```
FROM openwhisk/dockerskeleton
RUN apk update && apk add R R-dev R-doc build-base
RUN R -e "install.packages(c('jsonlite', 'tidypredict', 'yaml'), repos = 'http://cran.rstudio.com/')"
```

Deployment (Titanic case)

IBM Cloud Functions

Configure

script.R

```
#!/usr/bin/env Rscript

# load model
loaded_model <-
tidypredict::as_parsed_model(
yaml::read_yaml("my_model.yml"))

# input
input <- jsonlite::fromJSON("input.json", flatten = FALSE)

# compute prediction
pred <- tidypredict::tidypredict_to_column(as.data.frame(input), loaded_model)

# output
jsonlite::stream_out(pred, verbose = FALSE)
```

Deployment (Titanic case)

IBM Cloud Functions

Deploy

```
# docker
docker build th1460/titanic .
docker push th1460/titanic

# login
ibmcloud login -sso
ibmcloud target --cf

# zip
zip -r titanic.zip exec script.R my_model.yml

# deploy
ibmcloud fn action create titanic titanic.zip --docker th1460/titanic --web true
```

Deployment (Titanic case)

IBM Cloud Functions

Request

```
input <- list(Sex = "male", Pclass = "3rd")

"https://us-south.functions.appdomain.cloud/api/v1/web/thiago.pires%40ibm.com_dev/default/titanic.json" %>%
  httr::POST(., body = input, encode = "json") %>%
  httr::content() %>%
  .[c("Sex", "Pclass", "fit")] %>%
  jsonlite::toJSON(pretty = TRUE, auto_unbox = TRUE)
```

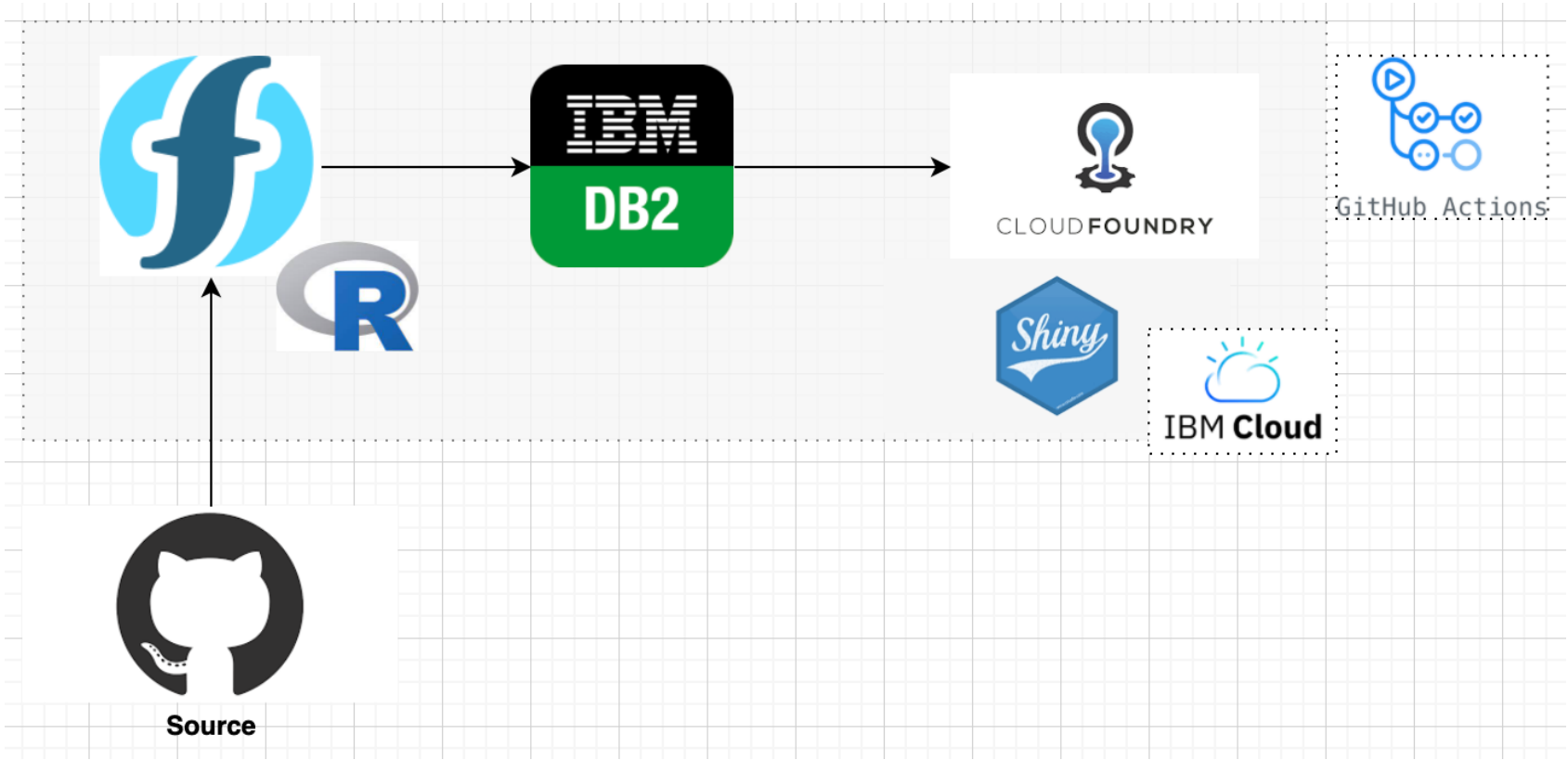

```
{
  "Sex": "male",
  "Pclass": "3rd",
  "fit": 0.0979
}
```

Deployment (Titanic case)

IBM Cloud Functions

Covid 19 Analysis

Covid 19 Analysis



Repository: github.com/th1460/covid19

Covid 19 Analysis

IBM Functions

- Dockerfile.update
- exec
- read_update_data.R
- .Renviron

```
# Docker build
docker build -t th1460/update-covid -f Dockerfile.update .

# Docker push
docker push th1460/update-covid

# Package files
zip -r update_covid.zip exec read_update_data.R .Renviron

# Create function
ibmcloud fn action create update-covid19 update_covid.zip --docker th1460/update-covid --web true
```

Covid 19 Analysis

Cloud foundry

- Dockerfile.app
- app.R
- manifest.yml

```
# Docker build
docker build -t th1460/dash-covid -f Dockerfile.app .

# Docker push
docker push th1460/dash-covid

# Deploy shiny
ibmcloud cf push dash-covid --docker-image th1460/dash-covid -k 2G
```

Covid 19 Analysis

Dashboard

References

- https://www.aws.training/Details/eLearning?id=27200
- https://the-modeling-agency.com/crisp-dm.pdf
- https://github.com/th1460/shiny-example
- https://github.com/th1460/r-actions-example

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