MovieLens Recommender System Capstone Project - Report

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Contents

1 Executive Summary

The purpose for this project is creating a recommender system using MovieLens dataset.

The version of movielens dataset used for this final assignment contains approximately 10 Milions of movies ratings, divided in 9 Milions for training and one Milion for validation. It is a small subset of a much larger (and famous) dataset with several millions of ratings. Into the training dataset there are approximately **70.000 users** and **11.000 different movies** divided in 20 genres such as Action, Adventure, Horror, Drama, Thriller and more.

After a initial data exploration, the recommender systems builted on this dataset are evaluated and choosen based on the RMSE - Root Mean Squared Error that should be at least lower than**0.87750**.

$$\text{RMSE} = \sqrt{\frac{1}{n}\sum_{t=1} e_t^2}$$

For accomplishing this goal, the **Regularized Movie+User+Genre Model** is capable to reach a RMSE of **0.8628**, that is really good.

2 Exploratory Data Analysis

2.1 Inital data Exploration

The 10 Millions dataset is divided into two dataset: `edx` for training purpose and `validation` for the validation phase.

The `edx` dataset contains approximately 9 Millions of rows with 70.000 different users and 11.000 movies with rating score between 0.5 and 5. There is no missing values (0 or NA).

edx dataset

Users	Movies
69878	10677

Missing Values per Column

	x
userId	0
movieId	0
rating	0
timestamp	0
title	0
genres	0

The features/variables/columns in both datasets are six:

- **userId** `<integer>` that contains the unique identification number for each user.
- **movieId** `<numeric>` that contains the unique identification number for each movie.
- **rating** `<numeric>` that contains the rating of one movie by one user. Ratings are made on a 5-Star scale with half-star increments.
- **timestamp** `<integer>` that contains the timestamp for one specific rating provided by one user.
- **title** `<character>` that contains the title of each movie including the year of the release.
- **genres** `<character>` that contains a list of pipe-separated of genre of each movie.

First 6 Rows of edx dataset

userId	movieId	rating	timestamp	title	genres
1	122	5	838985046	Boomerang (1992)	Comedy|Romance
1	185	5	838983525	Net, The (1995)	Action|Crime|Thriller
1	231	5	838983392	Dumb & Dumber (1994)	Comedy
1	292	5	838983421	Outbreak (1995)	Action|Drama|Sci-Fi|Thriller
1	316	5	838983392	Stargate (1994)	Action|Adventure|Sci-Fi
1	329	5	838983392	Star Trek: Generations (1994)	Action|Adventure|Drama|Sci-Fi

2.2 Dataset Pre-Processing and Feature Engineering

After a initial data exploration, we notice that the `genres` are pipe-separated values. It's necessary to extract them for more consisten, robust and precise estimate. We also observe that the `title` contains the year where the movie war released and this it could be necessary to predic the movie rating. Finally, we can extract the year and the month for each rating.

The pre-processing phase is composed by this steps:

1.Convert `timestamp` to a human readable date format;
2.Extract the month and the year from the date; 3.Extract the release year for each movie from the title;
4.Separate each genre from the pipe-separated value. It increases the size of both datasets.

After preprocessing the data, `edx` dataset looks like this:

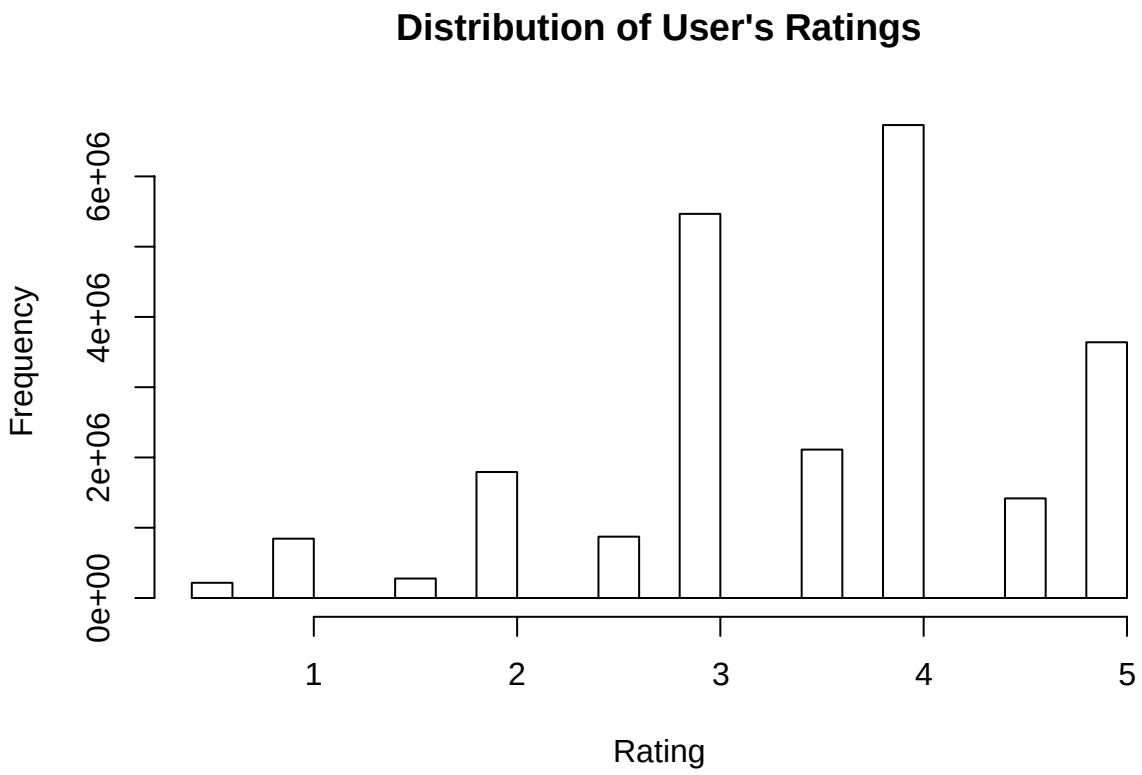
Processed edx datadaset

userId	movieId	rating	title	genre	release	yearOfRate	monthOfRate
1	122	5	Boomerang	Comedy	1992	1996	8
1	122	5	Boomerang	Romance	1992	1996	8
1	185	5	Net, The	Action	1995	1996	8
1	185	5	Net, The	Crime	1995	1996	8
1	185	5	Net, The	Thriller	1995	1996	8
1	231	5	Dumb & Dumber	Comedy	1994	1996	8

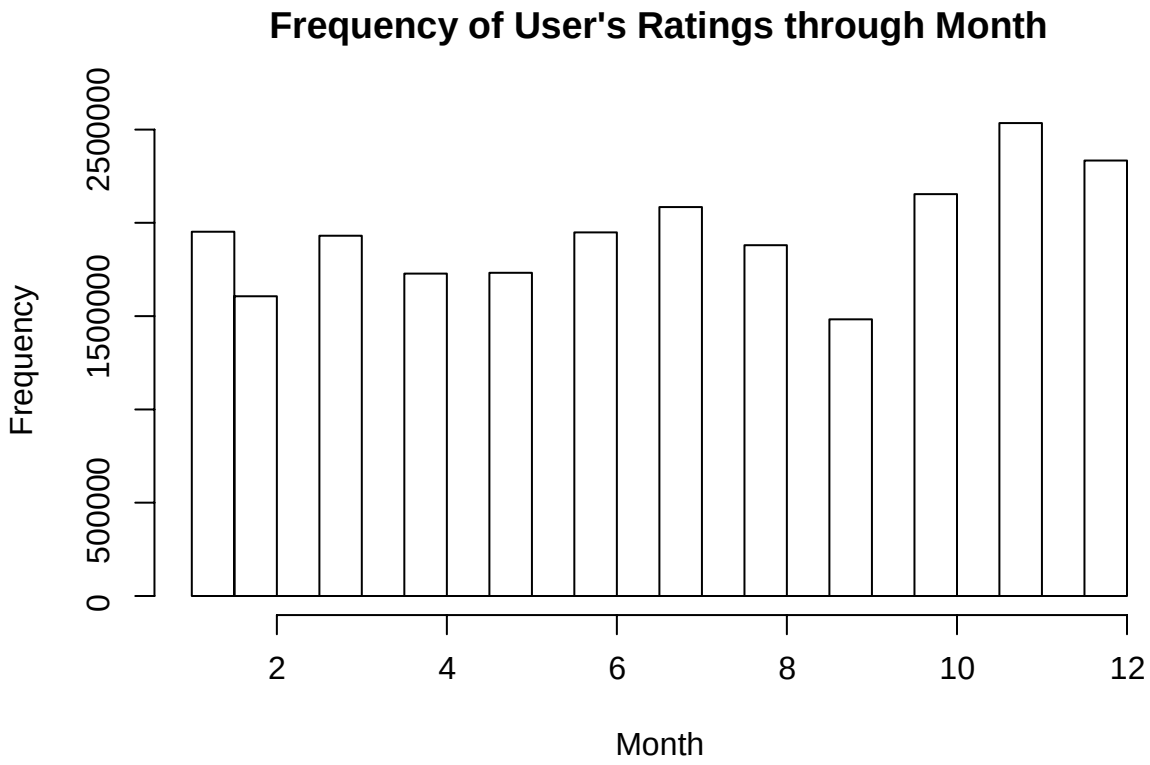
2.3 Rating Distribution

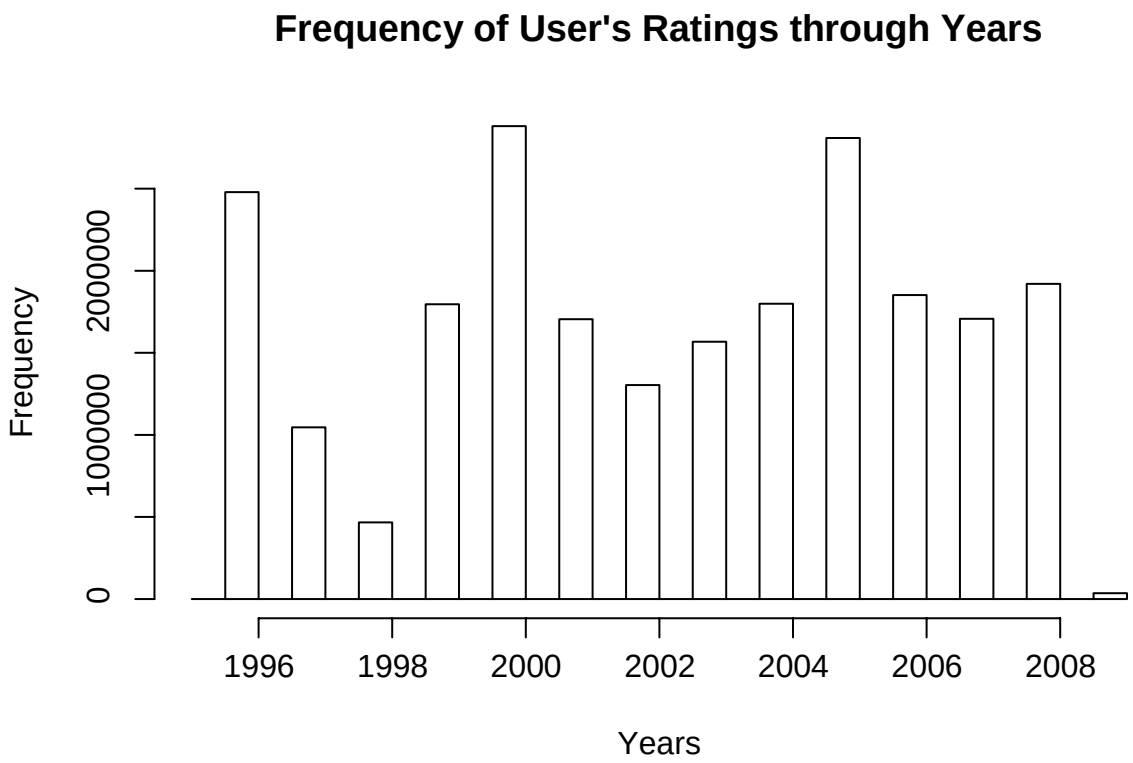
Overview of Rating Distribution

According to the histogram below, it shows that there are a small amount of negative votes (below 3). Maybe, the user tends to give a vote if he liked the movie. Half-Star votes are less common than "Full-Star" votes.

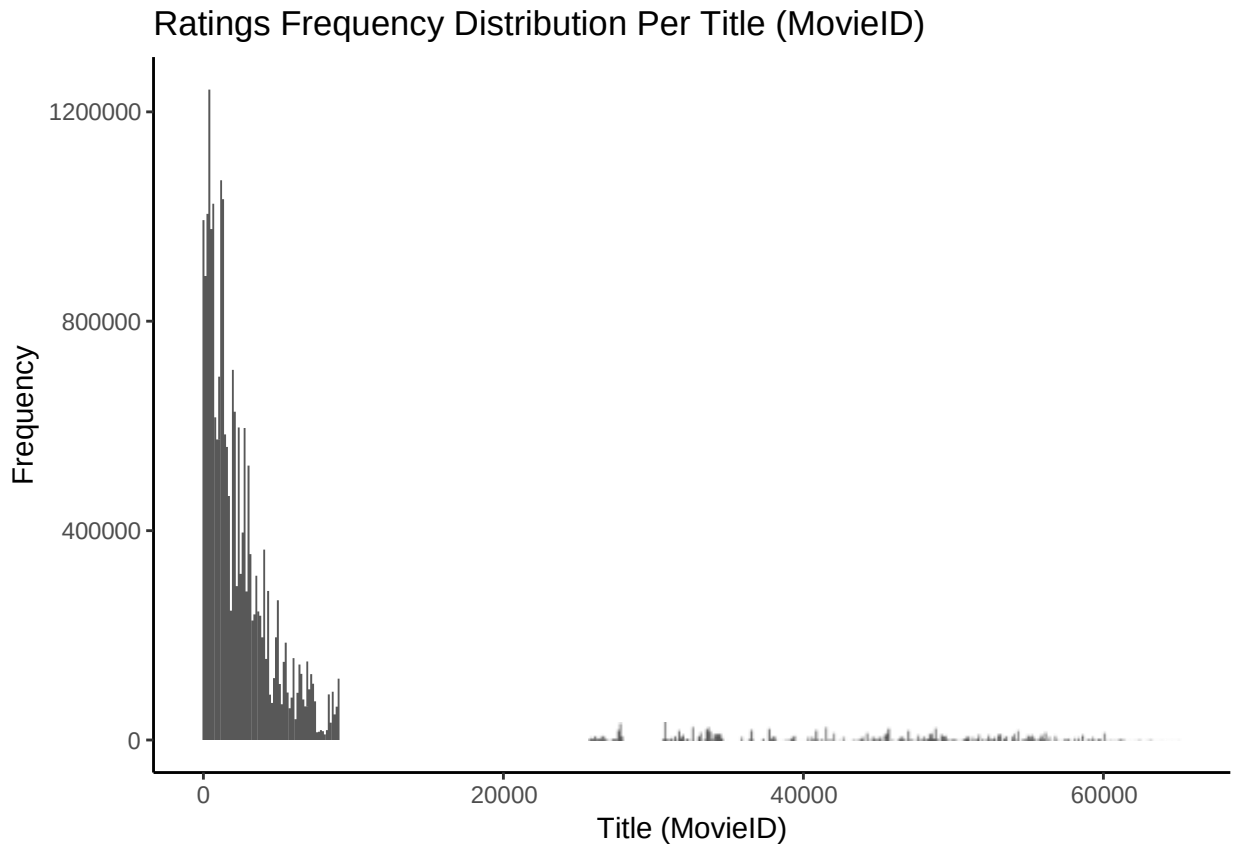


Overview of Rating Frequency through Months and Years

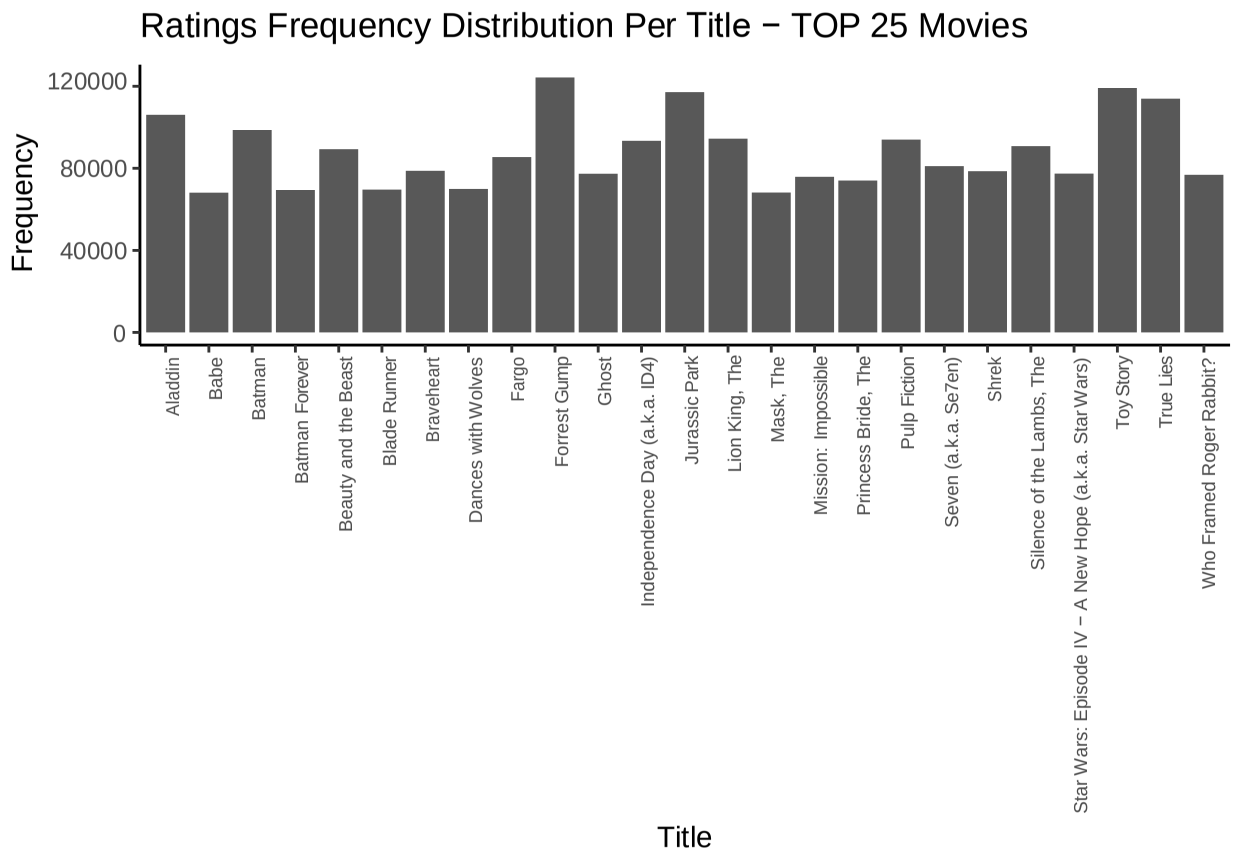

Frequency of User's Ratings through Month
Frequency
0
500000
1500000
2500000
2
4
6
8
10
12
Month


Frequency of User's Ratings through Years
Frequency
0
1000000
2000000
1996
1998
2000
2002
2004
2006
2008
Years

2.3.1 Numbers of Ratings per Movie

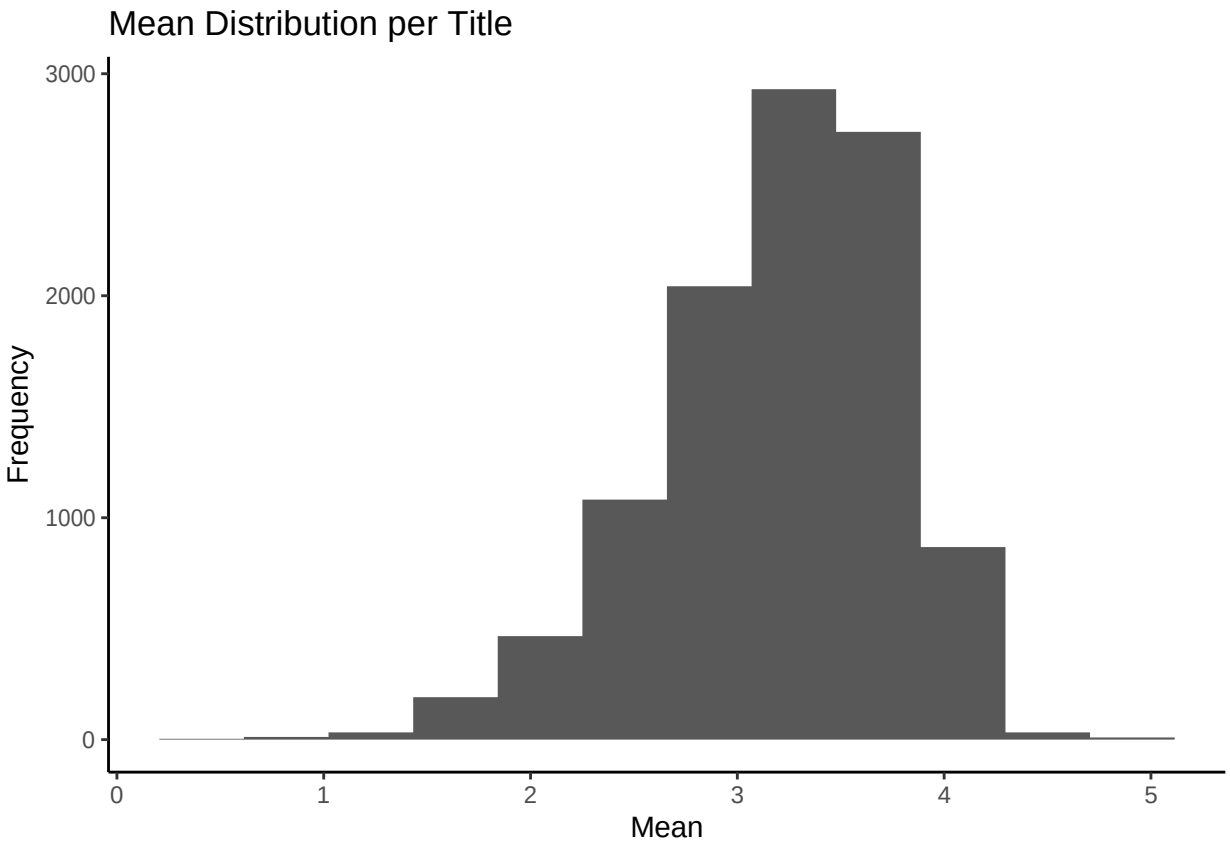


2.3.2 Top Rated Movies



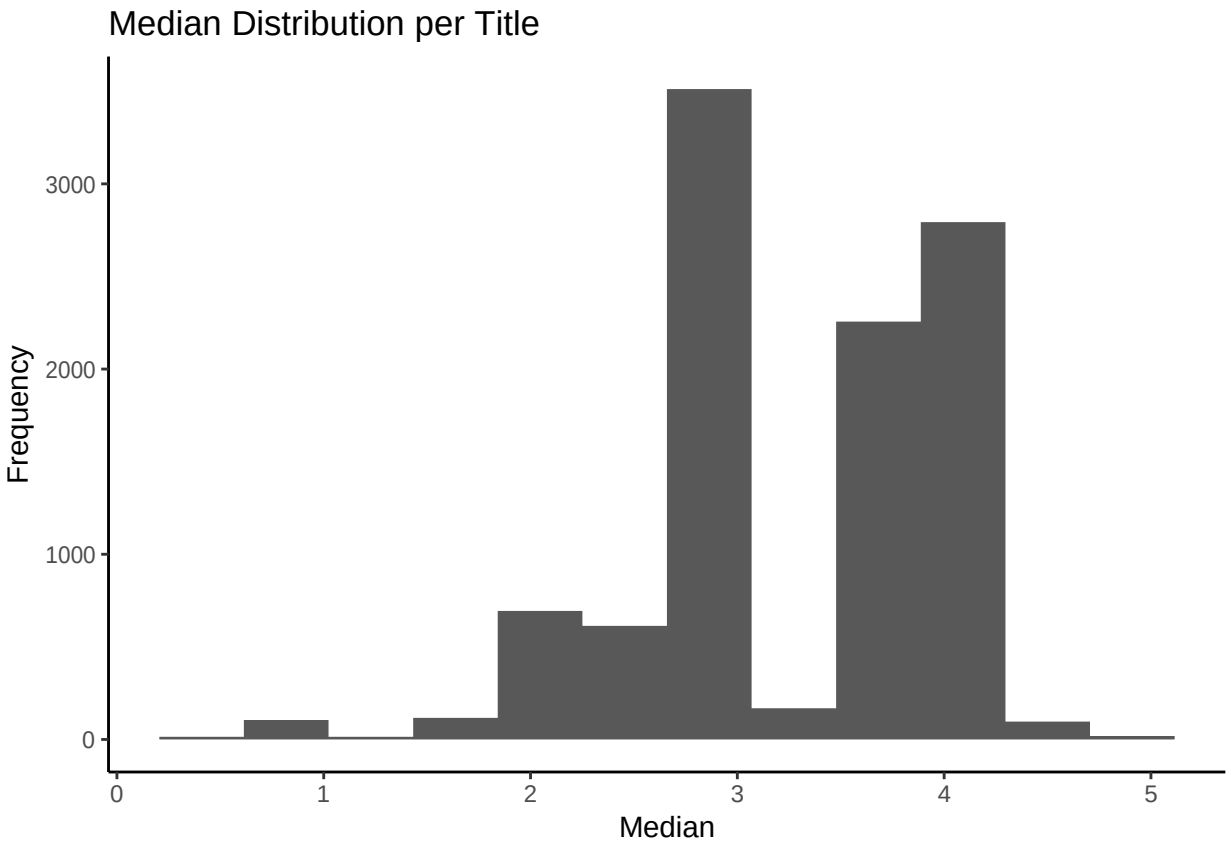
title	count
Forrest Gump	124304
Toy Story	119130
Jurassic Park	117164
True Lies	113930
Aladdin	106070
Batman	98656
Lion King, The	94435
Pulp Fiction	94008
Independence Day (a.k.a. ID4)	93440
Silence of the Lambs, The	90840
Beauty and the Beast	89315
Fargo	85480
Seven (a.k.a. Se7en)	81084
Braveheart	78774
Shrek	78564
Star Wars: Episode IV - A New Hope (a.k.a. Star Wars)	77427
Ghost	77335
Who Framed Roger Rabbit?	76825
Mission: Impossible	75876
Princess Bride, The	74045
Dances with Wolves	69936
Blade Runner	69615
Batman Forever	69432
Mask, The	68200
Babe	68140

2.3.3 Mean Distribution per Title (Movie ID)



title	mean
Blue Light, The (Das Blaue Licht)	5.000000
Constantine’s Sword	5.000000
Fighting Elegy (Kenka erejii)	5.000000
Hellhounds on My Trail	5.000000
Satan’s Tango (SÃ¡tÃ¡ntangÃ³)	5.000000
Shadows of Forgotten Ancestors	5.000000
Sun Alley (Sonnenallee)	5.000000
Human Condition II, The (Ningen no joken II)	4.833333
Human Condition III, The (Ningen no joken III)	4.750000
Who’s Singin’ Over There? (a.k.a. Who Sings Over There) (Ko to tamo peva)	4.750000
Class, The (Entre les Murs)	4.666667
I’m Starting From Three (Ricomincio da Tre)	4.666667
Man Who Planted Trees, The (Homme qui plantait des arbres, L’)	4.571429
Bad Blood (Mauvais sang)	4.500000
CaÃ³tica Ana	4.500000
Demon Lover Diary	4.500000
End of Summer, The (Kohayagawa-ke no aki)	4.500000
Fires on the Plain (Nobi)	4.500000
Ladrones	4.500000
Life of Oharu, The (Saikaku ichidai onna)	4.500000
Man Named Pearl, A	4.500000
Mickey	4.500000
Please Vote for Me	4.500000
Power of Nightmares: The Rise of the Politics of Fear, The	4.500000
Testament of Orpheus, The (Testament d’OrphÃ©e)	4.500000

2.3.4 Median Distribution per Title (Movie ID)

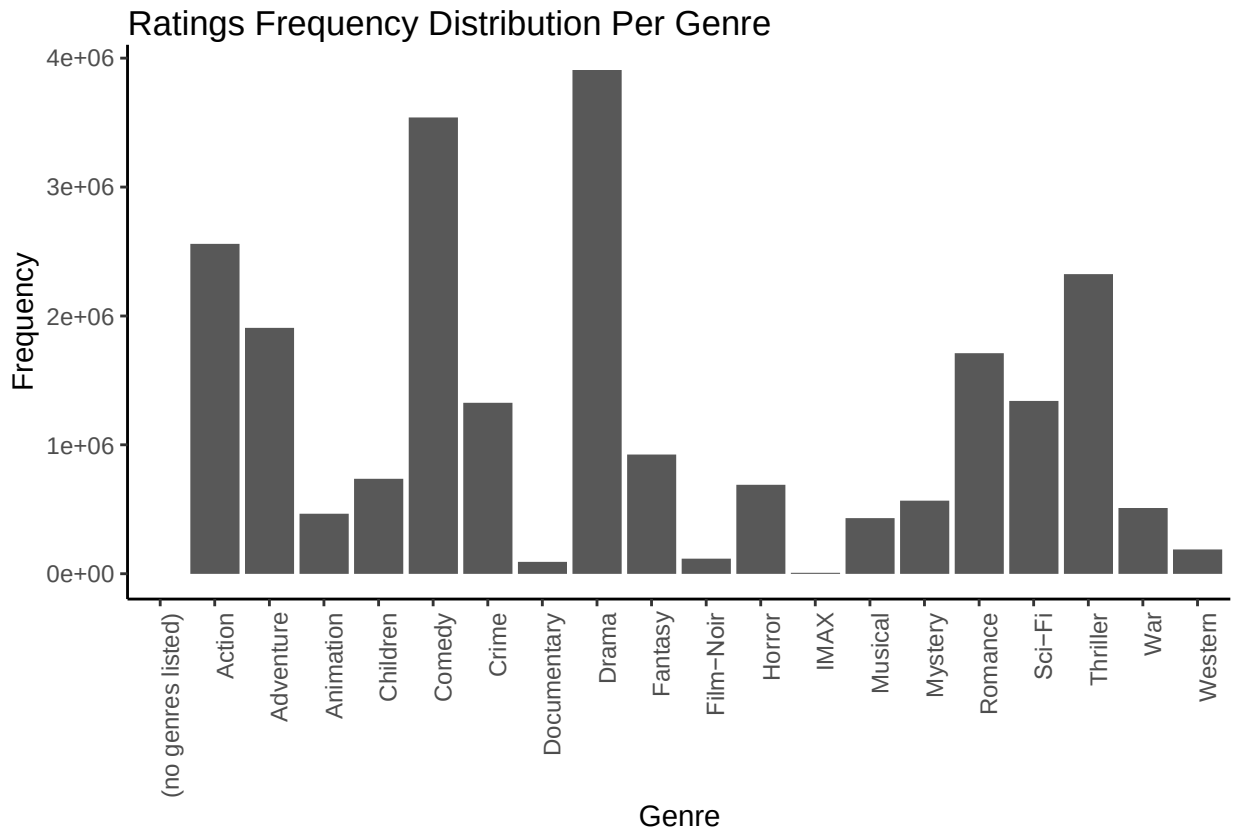


title	median
Aerial, The (La Antena)	5.00
Blue Light, The (Das Blaue Licht)	5.00
Class, The (Entre les Murs)	5.00
Constantine’s Sword	5.00
Fighting Elegy (Kenka erejii)	5.00
Godfather, The	5.00
Hellhounds on My Trail	5.00
Human Condition II, The (Ningen no joken II)	5.00
Jesus	5.00
Kids of Survival	5.00
Man Who Planted Trees, The (Homme qui plantait des arbres, L’)	5.00
Parallel Sons	5.00
Satan’s Tango (SÃ¡tÃ¡ntangÃ³)	5.00
Shadows of Forgotten Ancestors	5.00
Shawshank Redemption, The	5.00
Sun Alley (Sonnenallee)	5.00
Who’s Singin’ Over There? (a.k.a. Who Sings Over There) (Ko to tamo peva)	5.00
World of Apu, The (Apur Sansar)	5.00
Human Condition III, The (Ningen no joken III)	4.75
400 Blows, The (Les Quatre cents coups)	4.50
49 Up	4.50
Amelie (Fabuleux destin d’AmÃ©lie Poulain, Le)	4.50
American Beauty	4.50
Andrei Rublev (Andrey Rublyov)	4.50
Bad Blood (Mauvais sang)	4.50

2.4 Genre Analysis

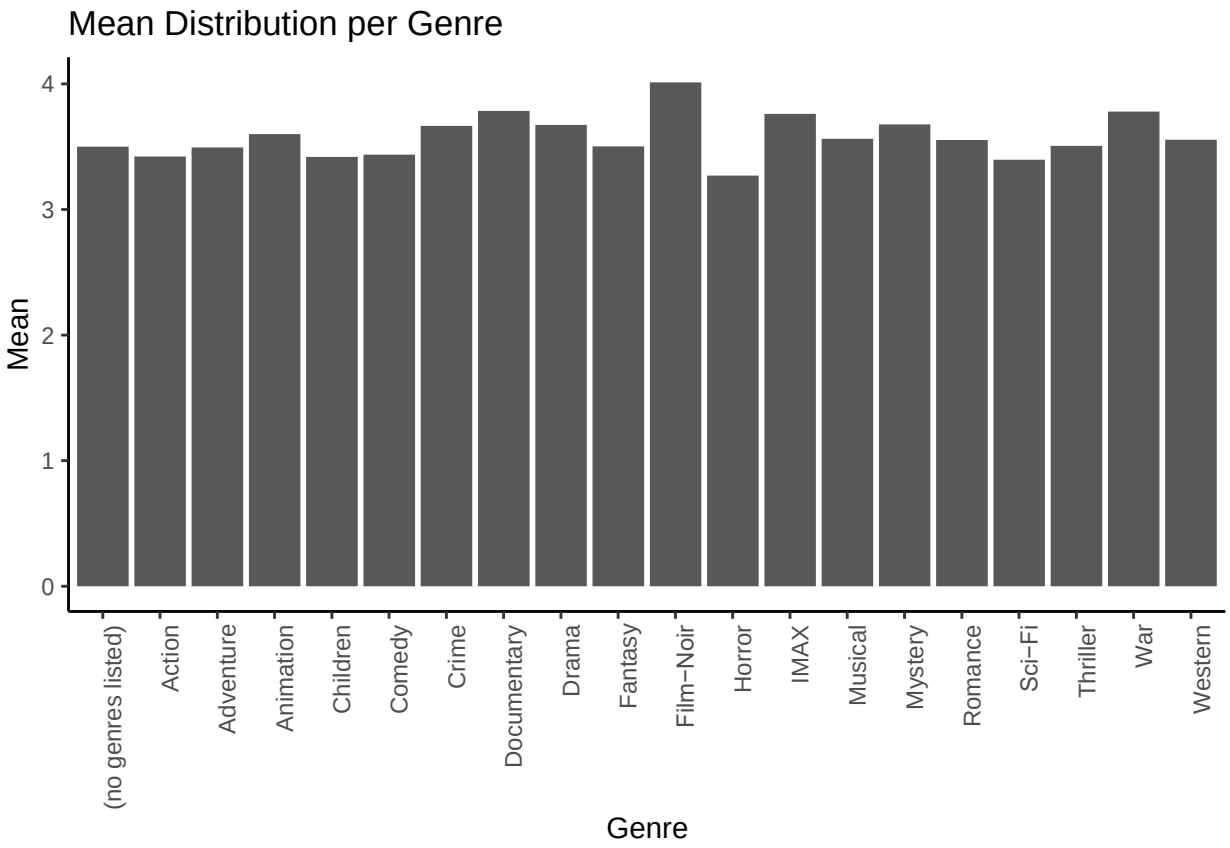
2.4.1 Rating Distribution per Genre Overview of

Rating distribution overGenre



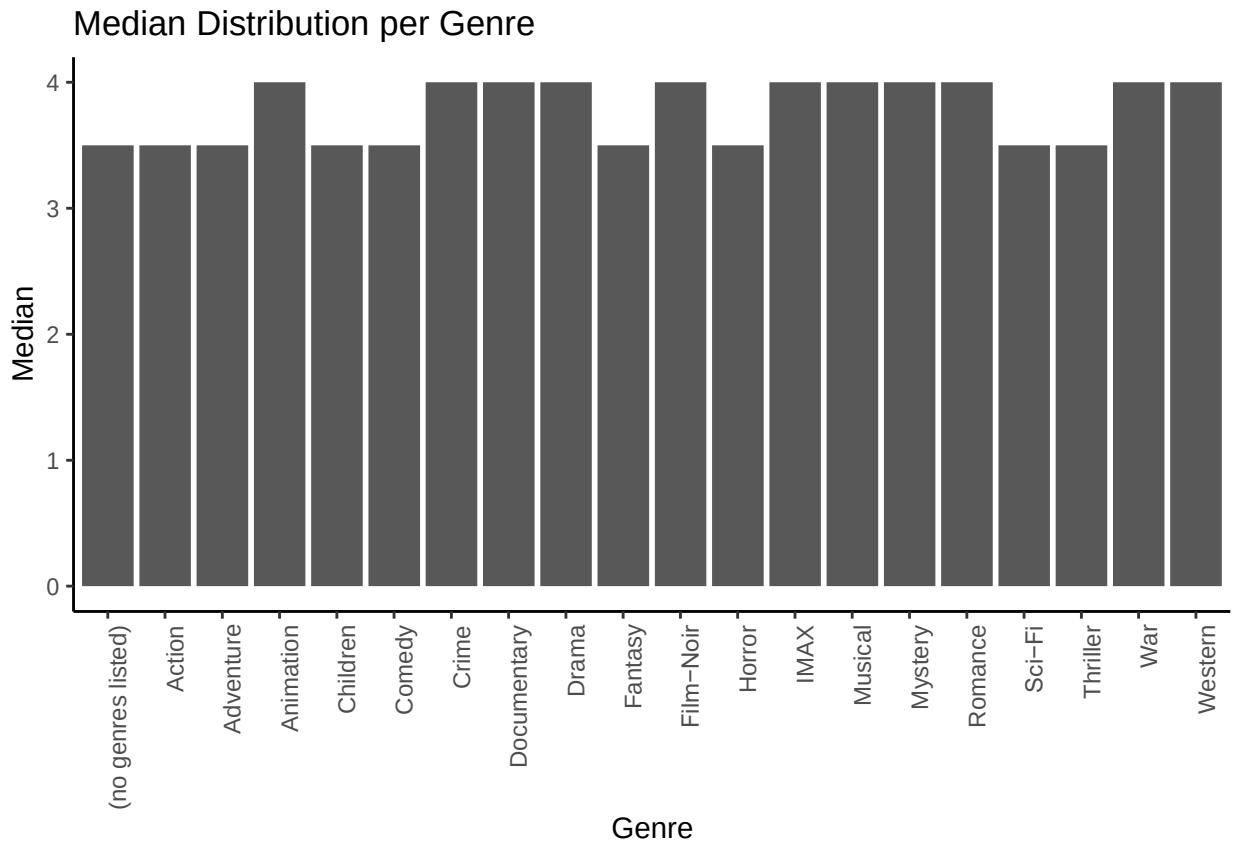
genre	count
Drama	3909401
Comedy	3541284
Action	2560649
Thriller	2325349
Adventure	1908692
Romance	1712232
Sci-Fi	1341750
Crime	1326917
Fantasy	925624
Children	737851
Horror	691407
Mystery	567865
War	511330
Animation	467220
Musical	432960
Western	189234
Film-Noir	118394
Documentary	93252
IMAX	8190
(no genres listed)	6

2.4.2 Mean Distribution per Genre



genre	mean
Film-Noir	4.011732
Documentary	3.784385
War	3.779457
IMAX	3.761844
Mystery	3.677412
Drama	3.673047
Crime	3.666151
Animation	3.599588
Musical	3.562761
Western	3.555122
Romance	3.553594
Thriller	3.506879
Fantasy	3.502419
(no genres listed)	3.500000
Adventure	3.494076
Comedy	3.437040
Action	3.421589
Children	3.418673
Sci-Fi	3.396756
Horror	3.269523

2.4.3 Median Distribution per Genre



genre	median
Animation	4.0
Crime	4.0
Documentary	4.0
Drama	4.0
Film-Noir	4.0
IMAX	4.0
Musical	4.0
Mystery	4.0
Romance	4.0
War	4.0
Western	4.0
(no genres listed)	3.5
Action	3.5
Adventure	3.5
Children	3.5
Comedy	3.5
Fantasy	3.5
Horror	3.5
Sci-Fi	3.5
Thriller	3.5

3 Analysis - Model Building and Evaluation

3.1 Naive Baseline Model

The simplest model that someone can build, is a Naive Model that predict ALWAYS the mean. In this case, the mean is approximately 3.5.

```
## [1] "The mean is: 3.52700364195256"
```

3.1.1 Naive Mean-Baseline Model

The formula used is:

$$Y_{u,i} = \hat{\mu} + \varepsilon_{u,i}$$

With $\hat{\mu}$ is the mean and $\varepsilon_{i,u}$ is the independent errors sampled from the same distribution centered at 0.

The RMSE on the `validation` dataset is **1.05**. It is very far for the target RMSE (below 0.87) and that indicates poor performance for the model.

3.2 Movie-Based Model, a Content-based Approach

The first Non-Naive Model takes into account the content. In this case the movies that are rated higher or lower resperct to each other.

The formula used is:

$$Y_{u,i} = \hat{\mu} + b_i + s_{u,i}$$

With $\hat{\mu}$ is the mean and $\varepsilon_{i,u}$ is the independent errors sampled from the same distribution centered at 0. The b_i is a measure for the popularity of movie i, i.e. the bias of movie i.

The RMSE on the `validation` dataset is **0.94**. It better than the Naive Mean-Baseline Model, but it is also very far from the target RMSE (below 0.87) and that indicates poor performance for themodel.

3.3 Movie + User Model, a User-based approach

The second Non-Naive Model consider that the users have different tastes and rate differently. The formula used is:

$$Y_{u,i} = \hat{\mu} + b_i + b_u + s_{u,i}$$

With $\hat{\mu}$ is the mean and $\varepsilon_{i,u}$ is the independent errors sampled from the same distribution centered at 0. The b_i is a measure for the popularity of movie i, i.e. the bias of movie i. The b_u is a measure for the mildness of user u, i.e. the bias of user u.

The RMSE on the `validation` dataset is **0.8635** and this is very good. The Movie+User Based Model reaches the desidered performance but applying the regularization techniques, can improve the performance just a little.

3.4 Movie + User + Genre Model, the Genre Popularity

The formula used is:

$$Y_{u,i} = \hat{\mu} + b_i + b_u + b_{u,g} + s_{u,i}$$

With $\hat{\mu}$ is the mean and $\varepsilon_{i,u}$ is the independent errors sampled from the same distribution centered at 0. The b_i is a measure for the popularity of movie i, i.e. the bias of movie i. The b_u is a measure for the mildness of user u, i.e. the bias of user u. The $b_{u,g}$ is a measure for how much a user u likes the genre g.

The RMSE on the `validation` dataset is **0.8634** and this is very good. The Movie+User+Genre Based Model reaches the desidered performance but adding the `genre` predictor, doesn't improve significantly the model's performance. Applying the regularization techniques, can improve the performance just a little.

3.5 Regularization

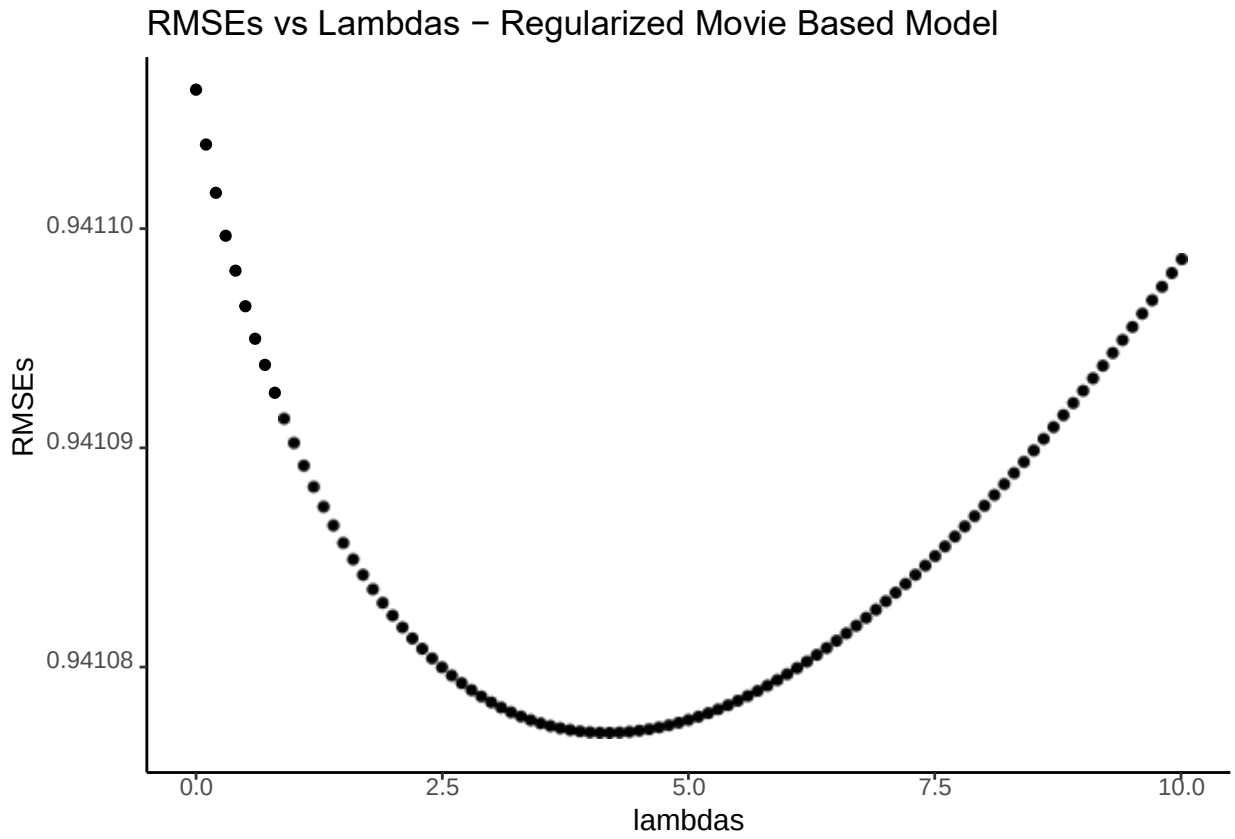
The regularization method allows us to add a penalty λ (lambda) to penalizes movies with large estimates from a small sample size. In order to optimize b_i, it necessary to use this equation:

$$\frac{1}{N}\sum_{u,i}(y_{u,i} - \mu - b_i)^2 + \lambda \sum_i b_i^2$$

reduced to this equation:

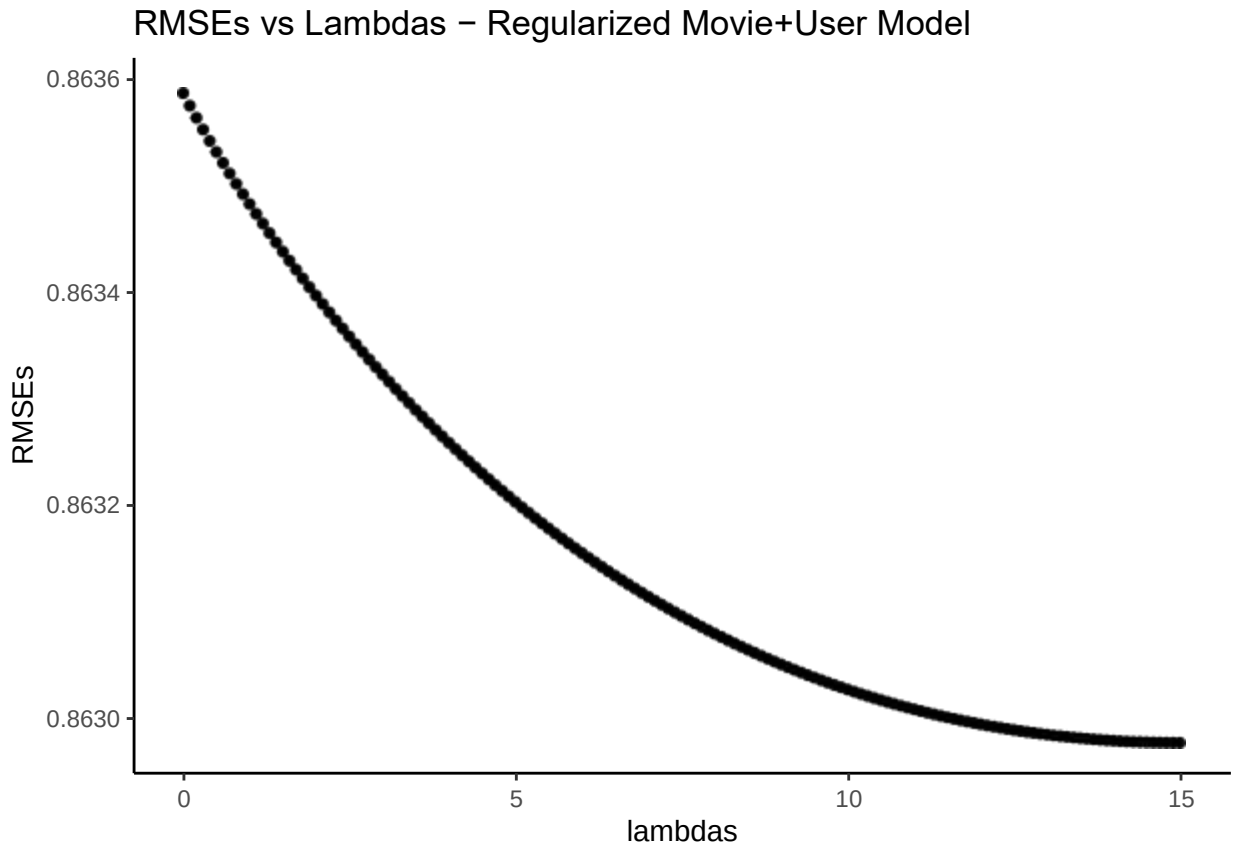
$$\hat{b}_i(\lambda) = \frac{1}{\lambda + n_i}\sum_{u=1}^{n_i}(Y_{u,i} - \hat{\mu})$$

3.5.1 Regularized Movie-Based Model



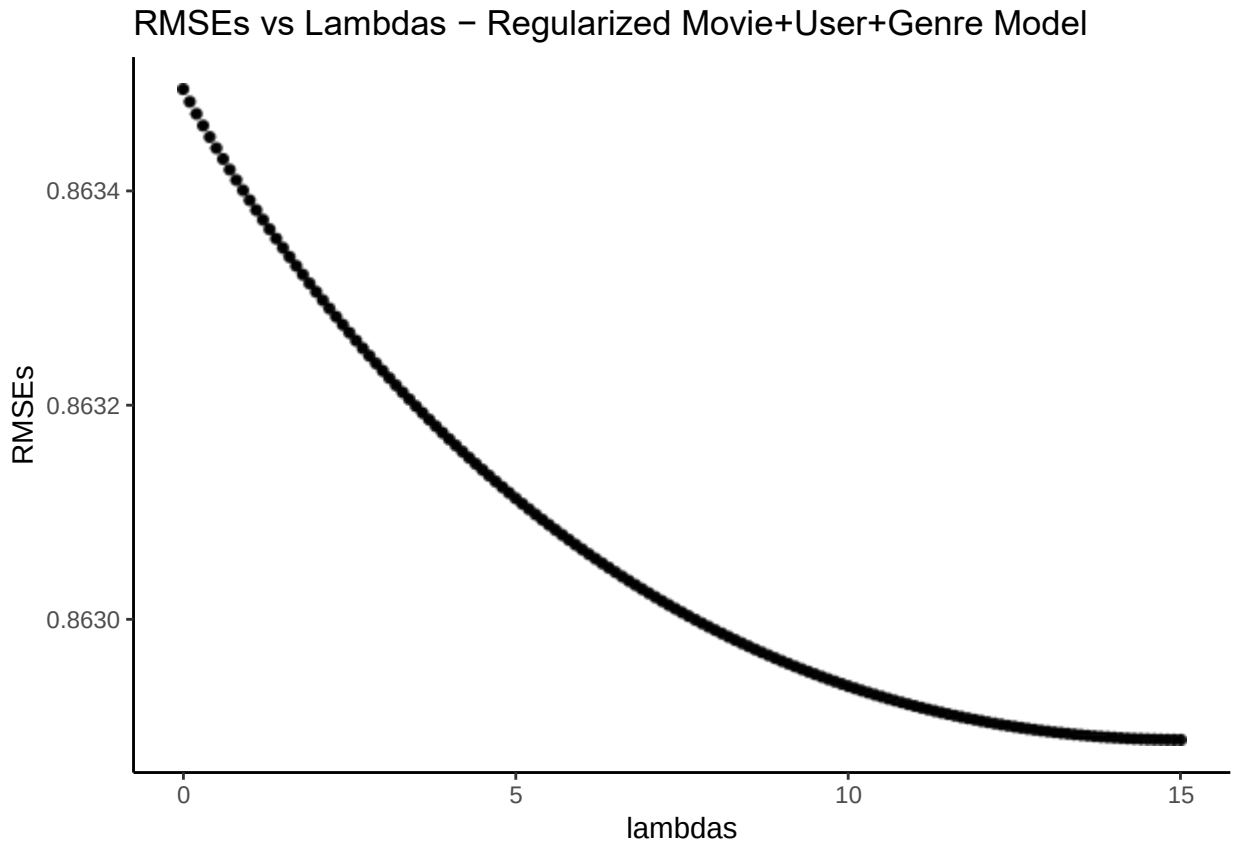
The RMSE on the `validation` dataset is **0.8635** and this is very good. The Movie+User Based Model reaches the desidered performance but applying the regularization techniques, can improve the performance just a little.

3.5.2 Regularized Movie+User Model



The RMSE on the `validation` dataset is **0.8629**. The Regularized Movie+User Based Model improves just a little the result of the Non-Regularized Model.

3.5.3 Regularized Movie+User+Genre Model



The RMSE on the `validation` dataset is **0.8628** and this is the best result of the builted models. The Regularized Movie+User+Genre Based Model improves just a little the result of the Non-Regularized Model. As the Non-Regularized Model, the `genre` predictor doesn't improve significantly the model's performance.

4 Results

This is the summary results for all the model builted, trained on `edx` dataset and validated on the `validation` dataset.

model	RMSE
Naive Mean-Baseline Model	1.0524433
Movie-Based Model	0.9411063
Movie+User Based Model	0.8635899
Movie+User+Genre Based Model	0.8634946
Regularized Movie-Based Model	0.9410767
Regularized Movie+User Based Model	0.8629791
Regularized Movie+User+Genre Based Model	0.8628874

5 Conclusion

After training different models, it's very clear that `movieId` and `userId` contribute more than the `genre` predictor. Without regularization, the model can archieves and overtakes the desidered peformance, but the

best is the enemy of the good and applying regularization and adding the genre predictor, it make possible to reach a RSME of **0.8628** that is the best result for the trained models.

6 Appendix

6.1 1a - Initial Code privided by edX

```
##########################################################
# Create edx set, validation set, and submission file
##########################################################

# Note: this process could take a couple of minutes

if(!require(tidyverse)) install.packages("tidyverse", repos ="http://cran.us.r-project.org")
if(!require(caret)) install.packages("caret", repos = "http://cran.us.r-project.org")

# MovieLens 10M dataset:
# https://grouplens.org/datasets/movielens/10m/
# http://files.grouplens.org/datasets/movielens/ml-10m.zip

dl <- tempfile() download.file("http://files.grouplens.org/datasets/movielens/ml-
10m.zip", dl)

ratings <- read.table(text = gsub("::", "¥t", readLines(unzip(dl,"ml-10M100K/ratings.dat"))),
                      col.names = c("userId", "movieId", "rating", "timestamp"))

movies <- str_split_fixed(readLines(unzip(dl, "ml-10M100K/movies.dat")), "¥¥::", 3)
colnames(movies) <- c("movieId", "title", "genres")
movies <- as.data.frame(movies)  %>% mutate(movieId = as.numeric(levels(movieId))[movieId],
                                            title = as.character(title),
                                            genres = as.character(genres))

movielens <- left_join(ratings, movies, by = "movieId") #

Validation set will be 10・ 0f MovieLens data set.seed(1)
test_index <- createDataPartition(y = movielens$rating, times = 1, p = 0.1, list = FALSE) edx
<- movielens[-test_index,]
temp <- movielens[test_index,]

# Make sure userId and movieId in validation set are also in edx set

validation <- temp  %>%
  semi_join(edx, by = "movieId")  %>%
  semi_join(edx, by = "userId")

# Add rows removed from validation set back into edx set

removed <- anti_join(temp, validation)
edx <- rbind(edx, removed)

rm(dl, ratings, movies, test_index, temp, movielens, removed) write.csv(edx,
"edx.csv")
```

6.2 1b - Code used in this report - MovieLens Project.R

```
# Install all needed libraries if it is not present

if(!require(tidyverse)) install.packages("tidyverse")
if(!require(kableExtra)) install.packages("kableExtra")
if(!require(tidyr)) install.packages("tidyr")
if(!require(tidyverse)) install.packages("tidyverse")
if(!require(stringr)) install.packages("stringr")
if(!require(forcats)) install.packages("forcats")
if(!require(ggplot2)) install.packages("ggplot2")

# Loading all needed libraries

library(dplyr)
library(tidyverse)
library(kableExtra)
library(tidyr)
library(stringr)
library(forcats)
library(ggplot2)

# The RMSE function that will be used in this project is:
RMSE <- function(true_ratings = NULL, predicted_ratings = NULL) {
    sqrt(mean((true_ratings - predicted_ratings)^2))
}

# Convert timestamp to a human readable date

edx$date <- as.POSIXct(edx$timestamp, origin="1970-01-01") validation$date
<- as.POSIXct(validation$timestamp, origin="1970-01-01")

# Extract the year and month of rate in both dataset

edx$yearOfRate <- format(edx$date," Y")
edx$monthOfRate <- format(edx$date," m")

validation$yearOfRate <- format(validation$date," Y") validation$monthOfRate
<- format(validation$date," m")                    %

# Extract the year of release for each movie in both dataset #
edx dataset

edx <- edx  %>%
   mutate(title = str_trim(title))   %>%
   extract(title,
           c("titleTemp", "release"),
           regex = "^(.*) ¥¥(([0-9 ¥¥-]*)¥¥)$",
           remove = F)  %>%
   mutate(release = if_else(str_length(release) > 4,
                            as.integer(str_split(release, "-",
                                                 simplify = T)[1]),
                            as.integer(release))
   ) %>%
```

```
   mutate(title = if_else(is.na(titleTemp),
                          title,
                          titleTemp)
          ) %>%
  select(-titleTemp)

# validation dataset

validation <- validation  %>%
   mutate(title = str_trim(title))   %>%
   extract(title,
           c("titleTemp", "release"),
           regex = "^(.*) ¥¥(([0-9 ¥¥-]*)¥¥)$",
           remove = F)  %>%
   mutate(release = if_else(str_length(release) > 4,
                                as.integer(str_split(release, "-",
                                                     simplify = T)[1]),
                                as.integer(release))
   ) %>%
   mutate(title = if_else(is.na(titleTemp),
                          title,
                          titleTemp)
          ) %>%
  select(-titleTemp)

# Extract the genre in edx datasets

edx <- edx  %>%
   mutate(genre = fct_explicit_na(genres,
                                  na_level = "(no genres listed)")
          ) %>%
   separate_rows(genre,
                 sep = "¥¥|")

# Extract the genre in validation datasets

validation <- validation  %>%
   mutate(genre = fct_explicit_na(genres,
                                  na_level = "(no genres listed)")
          ) %>%
   separate_rows(genre,
                 sep = "¥¥|")

# remove unnecessary columns on edx and validation dataset

edx <- edx  %>%  select(userId, movieId, rating, title, genre, release, yearOfRate, monthOfRate) validation

<- validation             %>%  select(userId, movieId, rating, title, genre, release, yearOfRate, monthOf #

Convert the columns into the desidered data type

edx$yearOfRate <- as.numeric(edx$yearOfRate)
edx$monthOfRate <- as.numeric(edx$monthOfRate) edx$release
<- as.numeric(edx$release)
```

```
validation$yearOfRate <- as.numeric(validation$yearOfRate) validation$monthOfRate
<- as.numeric(validation$monthOfRate) validation$release <-
as.numeric(validation$release)

# Calculate the average of all movies

mu_hat <- mean(edx$rating)

# Predict the RMSE on the validation set rmse_mean_model_result

<- RMSE(validation$rating, mu_hat)

# Creating a results dataframe that contains all RMSE results

results <- data.frame(model="Naive Mean-Baseline Model", RMSE=rmse_mean_model_result) #

Calculate the average by movie

movie_avgs <- edx  %>%
   group_by(movieId)  %>%
   summarize(b_i = mean(rating - mu_hat))

# Compute the predicted ratings on validation dataset

rmse_movie_model <- validation  %>%
   left_join(movie_avgs, by='movieId')  %>%
   mutate(pred = mu_hat + b_i)  %>%
   pull(pred)

rmse_movie_model_result <- RMSE(validation$rating, rmse_movie_model) #

Adding the results to the results dataset

results <- results  %>%  add_row(model="Movie-Based Model", RMSE=rmse_movie_model_result) #

Calculate the average by user

user_avgs <- edx  %>%
   left_join(movie_avgs, by='movieId')  %>%
   group_by(userId)  %>%
   summarize(b_u = mean(rating - mu_hat - b_i))

# Compute the predicted ratings on validation dataset

rmse_movie_user_model <- validation  %>%
   left_join(movie_avgs, by='movieId')  >% %
   left_join(user_avgs, by='userId')  %>%
   mutate(pred = mu_hat + b_i + b_u)  %>%
   pull(pred)

rmse_movie_user_model_result <- RMSE(validation$rating, rmse_movie_user_model) #

Adding the results to the results dataset
```

```
results <- results  %>%  add_row(model="Movie+User Based Model", RMSE=rmse_movie_user_model_result)

genre_pop <- edx  %>%
   left_join(movie_avgs, by='movieId')  >% %
   left_join(user_avgs, by='userId')   %>%
   group_by(genre)  %>%
   summarize(b_u_g = mean(rating - mu_hat - b_i - b_u))

# Compute the predicted ratings on validation dataset

rmse_movie_user_genre_model <- validation   %>%
   left_join(movie_avgs, by='movieId') > % %
   left_join(user_avgs, by='userId')   %>%
   left_join(genre_pop, by='genre')   %>%
   mutate(pred = mu_hat + b_i + b_u + b_u_g)    %>%
   pull(pred)

rmse_movie_user_genre_model_result <- RMSE(validation$rating, rmse_movie_user_genre_model) #

Adding the results to the results dataset

results <- results  %>%  add_row(model="Movie+User+Genre Based Model", RMSE=rmse_movie_user_genre_model_r

lambdas <- seq(0, 10, 0.1)

# Compute the predicted ratings on validation dataset using different values of lambda rmses

<- sapply(lambdas, function(lambda) {

  # Calculate the average by user

   b_i <- edx  %>%
      group_by(movieId)  %>%
      summarize(b_i = sum(rating - mu_hat) / (n() + lambda))

   # Compute the predicted ratings on validation dataset

   predicted_ratings <- validation  %>%
      left_join(b_i, by='movieId')  %>%
      mutate(pred = mu_hat + b_i)  %>%
      pull(pred)

   # Predict the RMSE on the validation set

   return(RMSE(validation$rating, predicted_ratings))
})


# Get the lambda value that minimize the RMSE
min_lambda <- lambdas[which.min(rmses)]

# Predict the RMSE on the validation set
```

```
rmse_regularized_movie_model <- min(rmses) #

Adding the results to the results dataset

results <- results  %>%  add_row(model="Regularized Movie-Based Model", RMSE=rmse_regularized_movie_model

rmses <- sapply(lambdas, function(lambda) {

   # Calculate the average by user

   b_i <- edx  %>%
      group_by(movieId)  %>%
      summarize(b_i = sum(rating - mu_hat) / (n() + lambda))

   # Calculate the average by user

   b_u <- edx  %>%
      left_join(b_i, by='movieId')  %>%
      group_by(userId)  %>%
      summarize(b_u = sum(rating - b_i - mu_hat) / (n() + lambda))

   # Compute the predicted ratings on validation dataset

   predicted_ratings <- validation  %>%
      left_join(b_i, by='movieId')  %>%
      left_join(b_u, by='userId')  %>%
      mutate(pred = mu_hat + b_i + b_u)  %>%
      pull(pred)

   # Predict the RMSE on the validation set

   return(RMSE(validation$rating, predicted_ratings))
})

# Get the lambda value that minimize the RMSE

min_lambda <- lambdas[which.min(rmses)]

# Predict the RMSE on the validation set

rmse_regularized_movie_user_model <- min(rmses) #

Adding the results to the results dataset

results <- results  %>%  add_row(model="Regularized Movie+User Based Model", RMSE=rmse_regularized_movie_

lambdas <- seq(0, 15, 0.1)

# Compute the predicted ratings on validation dataset using different values of lambda rmses

<- sapply(lambdas, function(lambda) {

   # Calculate the average by user
```

```
   b_i <- edx %>%
      group_by(movieId) %>%
      summarize(b_i = sum(rating - mu_hat) / (n() + lambda))

   # Calculate the average by user

   b_u <- edx %>%
      left_join(b_i, by='movieId') %>%
      group_by(userId) %>%
      summarize(b_u = sum(rating - b_i - mu_hat) / (n() + lambda))

    b_u_g <- edx %>%
      left_join(b_i, by='movieId') %>%
      left_join(b_u, by='userId') %>%
      group_by(genre) %>%
      summarize(b_u_g = sum(rating - b_i - mu_hat - b_u) / (n() + lambda))

   # Compute the predicted ratings on validation dataset

   predicted_ratings <- validation %>%
      left_join(b_i, by='movieId') %>%
      left_join(b_u, by='userId') %>%
      left_join(b_u_g, by='genre') %>%
      mutate(pred = mu_hat + b_i + b_u + b_u_g)   %>%
      pull(pred)

   # Predict the RMSE on the validation set

   return(RMSE(validation$rating, predicted_ratings))
})

# Get the lambda value that minimize the RMSE

min_lambda <- lambdas[which.min(rmses)]

# Predict the RMSE on the validation set

rmse_regularized_movie_user_genre_model <- min(rmses) #

Adding the results to the results dataset

results <- results %>% add_row(model="Regularized Movie+User+Genre Based Model", RMSE=rmse_regularized_
```

6.3 1c - Enviroment

```
print("Operating System:")
```

```
## [1] "Operating System:"
```

```
version
```

```
##                _
## platform       x86_64-w64-mingw32
## arch           x86_64
## os             mingw32
## system         x86_64, mingw32
```

```
## status
## major          3
## minor          6.0
## year           2019
## month          04
## day            26
## svn rev        76424
## language       R
## version.string R version 3.6.0 (2019-04-26)
## nickname       Planting of a Tree
```

```
print("All  installed  packages")
```

```
## [1] "All  installed packages"
```

```
installed.packages()
```

```
##              Package
## askpass      "askpass"
## assertthat   "assertthat"
## backports    "backports"
## base64enc    "base64enc"
## BH           "BH"
## bitops       "bitops"
## broom        "broom"
## callr        "callr"
## caret        "caret"
## caTools      "caTools"
## cellranger   "cellranger"
## cli          "cli"
## clipr        "clipr"
## colorspace   "colorspace"
## crayon       "crayon"
## curl         "curl"
## data.table   "data.table"
## DBI          "DBI"
## dbplyr       "dbplyr"
## digest       "digest"
## dplyr        "dplyr"
## dslabs       "dslabs"
## ellipsis     "ellipsis"
## evaluate     "evaluate"
## fansi        "fansi"
## forcats      "forcats"
## foreach      "foreach"
## fs           "fs"
## generics     "generics"
## ggplot2      "ggplot2"
## glue         "glue"
## gower        "gower"
## gtable       "gtable"
## haven        "haven"
## highr        "highr"
## hms          "hms"
## htmltools    "htmltools"
## httr         "httr"
```

```
## ipred         "ipred"
## iterators     "iterators"
## jsonlite      "jsonlite"
## kableExtra    "kableExtra"
## knitr         "knitr"
## labeling      "labeling"
## lava          "lava"
## lazyeval      "lazyeval"
## lubridate     "lubridate"
## magrittr      "magrittr"
## markdown      "markdown"
## mime          "mime"
## ModelMetrics "ModelMetrics"
## modelr        "modelr"
## munsell       "munsell"
## numDeriv      "numDeriv"
## openssl       "openssl"
## pillar        "pillar"
## pkgconfig     "pkgconfig"
## plogr         "plogr"
## plyr          "plyr"
## prettyunits   "prettyunits"
## processx      "processx"
## prodlim       "prodlim"
## progress      "progress"
## ps            "ps"
## purrr         "purrr"
## R6            "R6"
## RColorBrewer "RColorBrewer"
## Rcpp          "Rcpp"
## RcppRoll      "RcppRoll"
## readr         "readr"
## readxl        "readxl"
## recipes       "recipes"
## rematch       "rematch"
## reprex        "reprex"
## reshape2      "reshape2"
## rlang         "rlang"
## rmarkdown     "rmarkdown"
## rprojroot     "rprojroot"
## rstudioapi    "rstudioapi"
## rvest         "rvest"
## scales        "scales"
## selectr       "selectr"
## SQUAREM       "SQUAREM"
## stringi       "stringi"
## stringr       "stringr"
## sys           "sys"
## tibble        "tibble"
## tidyr         "tidyr"
## tidyselect    "tidyselect"
## tidyverse     "tidyverse"
## timeDate      "timeDate"
## tinytex       "tinytex"
```

```
## utf8          "utf8"
## viridisLite   "viridisLite"
## webshot       "webshot"
## whisker       "whisker"
## withr         "withr"
## xfun          "xfun"
## xml2          "xml2"
## yaml          "yaml"
## base          "base"
## boot          "boot"
## class         "class"
## cluster       "cluster"
## codetools     "codetools"
## compiler      "compiler"
## datasets      "datasets"
## foreign       "foreign"
## graphics      "graphics"
## grDevices     "grDevices"
## grid          "grid"
## KernSmooth    "KernSmooth"
## lattice       "lattice"
## MASS          "MASS"
## Matrix        "Matrix"
## methods       "methods"
## mgcv          "mgcv"
## nlme          "nlme"
## nnet          "nnet"
## parallel      "parallel"
## rpart         "rpart"
## spatial       "spatial"
## splines       "splines"
## stats         "stats"
## stats4        "stats4"
## survival      "survival"
## tcltk         "tcltk"
## tools         "tools"
## translations "translations"
## utils         "utils"
##               LibPath
##  askpass     "C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"  ##
assertthat    "C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"    ##
backports     "C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"       ##
base64enc   "C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"  ##  BH
                  "C:/Users/aless/OneDrive/Documenti/R/win-library/3.6" ##
bitops   "C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"  ##  broom
"C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"      ##      callr
"C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"      ##      caret
"C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"     ##     caTools
"C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"    ##    cellranger
"C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"       ##       cli
"C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"      ##      clipr
"C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"    ##    colorspace
"C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"     ##     crayon
"C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"
```

```
## curl         "C:/Users/aless/OneDrive/Documenti/R/win-library/3.6" ##
data.table "C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"  ## DBI
"C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"      ##      dbplyr
"C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"      ##      digest
"C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"       ##       dplyr
"C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"      ##      dslabs
"C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"     ##     ellipsis
"C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"     ##     evaluate
"C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"       ##       fansi
 "C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"     ##     forcats
 "C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"     ##     foreach
"C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"         ##         fs
                   "C:/Users/aless/OneDrive/Documenti/R/win-library/3.6" ##
generics       "C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"       ##
ggplot2    "C:/Users/aless/OneDrive/Documenti/R/win-library/3.6" ## glue
"C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"       ##       gower
"C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"      ##      gtable
"C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"       ##       haven
"C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"       ##       highr
"C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"        ##        hms
"C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"    ##    htmltools
"C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"       ##       httr
"C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"       ##       ipred
"C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"    ##    iterators
 "C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"     ##     jsonlite
"C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"    ##   kableExtra
"C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"       ##       knitr
"C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"     ##     labeling
"C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"        ##        lava
   "C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"     ##  lazyeval
     "C:/Users/aless/OneDrive/Documenti/R/win-library/3.6" ##  lubridate
      "C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"  ## magrittr
      "C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"  ## markdown
          "C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"  ## mime
  "C:/Users/aless/OneDrive/Documenti/R/win-library/3.6" ## ModelMetrics
        "C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"  ## modelr
       "C:/Users/aless/OneDrive/Documenti/R/win-library/3.6" ##  munsell
      "C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"  ## numDeriv
       "C:/Users/aless/OneDrive/Documenti/R/win-library/3.6" ##  openssl
        "C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"  ## pillar
     "C:/Users/aless/OneDrive/Documenti/R/win-library/3.6" ##  pkgconfig
          "C:/Users/aless/OneDrive/Documenti/R/win-library/3.6" ## plogr
          "C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"  ## plyr
    "C:/Users/aless/OneDrive/Documenti/R/win-library/3.6" ## prettyunits
      "C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"  ## processx
       "C:/Users/aless/OneDrive/Documenti/R/win-library/3.6" ##  prodlim
      "C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"  ## progress
            "C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"  ## ps
                  "C:/Users/aless/OneDrive/Documenti/R/win-library/3.6" ##
purrr        "C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"  ## R6
                  "C:/Users/aless/OneDrive/Documenti/R/win-library/3.6" ##
RColorBrewer   "C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"   ##
Rcpp           "C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"  ##
RcppRoll  "C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"
```

```
##   readr      "C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"   ##
readxl      "C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"      ##
recipes     "C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"      ##
rematch    "C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"       ##
reprex     "C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"       ##
reshape2  "C:/Users/aless/OneDrive/Documenti/R/win-library/3.6" ## rlang
"C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"    ##    rmarkdown
"C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"    ##    rprojroot
"C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"    ##   rstudioapi
"C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"      ##      rvest
"C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"     ##     scales
"C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"     ##     selectr
"C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"     ##     SQUAREM
"C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"     ##     stringi
"C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"     ##     stringr
"C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"       ##       sys
"C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"     ##     tibble
"C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"      ##      tidyr
"C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"   ##   tidyselect
"C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"    ##    tidyverse
"C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"    ##    timeDate
"C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"     ##     tinytex
"C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"      ##       utf8
"C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"   ##   viridisLite
"C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"     ##     webshot
"C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"     ##     whisker
"C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"      ##      withr
"C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"      ##       xfun
"C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"      ##       xml2
"C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"      ##       yaml
"C:/Users/aless/OneDrive/Documenti/R/win-library/3.6"      ##       base
"C:/Program Files/R/R-3.6.0/library"
## boot         "C:/Program Files/R/R-3.6.0/library"
## class       "C:/Program Files/R/R-3.6.0/library" ##
cluster      "C:/Program  Files/R/R-3.6.0/library"   ##
codetools   "C:/Program   Files/R/R-3.6.0/library"   ##
compiler     "C:/Program  Files/R/R-3.6.0/library"   ##
datasets     "C:/Program  Files/R/R-3.6.0/library"   ##
foreign      "C:/Program  Files/R/R-3.6.0/library"   ##
graphics     "C:/Program  Files/R/R-3.6.0/library"   ##
grDevices "C:/Program Files/R/R-3.6.0/library" ## grid
"C:/Program  Files/R/R-3.6.0/library"   ##  KernSmooth
"C:/Program   Files/R/R-3.6.0/library"    ##    lattice
"C:/Program    Files/R/R-3.6.0/library"     ##     MASS
"C:/Program    Files/R/R-3.6.0/library"    ##    Matrix
"C:/Program Files/R/R-3.6.0/library" ## methods
"C:/Program Files/R/R-3.6.0/library" ## mgcv
"C:/Program Files/R/R-3.6.0/library" ## nlme
"C:/Program Files/R/R-3.6.0/library" ## nnet
"C:/Program Files/R/R-3.6.0/library" ## parallel
"C:/Program Files/R/R-3.6.0/library" ## rpart
"C:/Program Files/R/R-3.6.0/library" ## spatial
"C:/Program Files/R/R-3.6.0/library" ## splines
"C:/Program Files/R/R-3.6.0/library"
```

```
##   stats   "C:/Program   Files/R/R-3.6.0/library"   ##
stats4    "C:/Program    Files/R/R-3.6.0/library"    ##
survival   "C:/Program  Files/R/R-3.6.0/library"    ##
tcltk        "C:/Program  Files/R/R-3.6.0/library"  ##
tools    "C:/Program    Files/R/R-3.6.0/library"    ##
translations  "C:/Program  Files/R/R-3.6.0/library"  ##
utils "C:/Program Files/R/R-3.6.0/library" ##
               Version Priority
## askpass      "1.1"         NA
## assertthat   "0.2.1"       NA
## backports    "1.1.4"       NA
## base64enc    "0.1-3"       NA
## BH           "1.69.0-1"    NA
## bitops       "1.0-6"       NA
## broom        "0.5.2"       NA
## callr        "3.2.0"       NA
## caret        "6.0-84"      NA
## caTools      "1.17.1.2"    NA
## cellranger   "1.1.0"       NA
## cli          "1.1.0"       NA
## clipr        "0.6.0"       NA
## colorspace   "1.4-1"       NA
## crayon       "1.3.4"       NA
## curl         "3.3"         NA
## data.table   "1.12.2"      NA
## DBI          "1.0.0"       NA
## dbplyr       "1.4.0"       NA
## digest       "0.6.18"      NA
## dplyr        "0.8.0.1"     NA
## dslabs       "0.5.2"       NA
## ellipsis     "0.1.0"       NA
## evaluate     "0.13"        NA
## fansi        "0.4.0"       NA
## forcats      "0.4.0"       NA
## foreach      "1.4.4"       NA
## fs           "1.3.0"       NA
## generics     "0.0.2"       NA
## ggplot2      "3.1.1"       NA
## glue         "1.3.1"       NA
## gower        "0.2.0"       NA
## gtable       "0.3.0"       NA
## haven        "2.1.0"       NA
## highr        "0.8"         NA
## hms          "0.4.2"       NA
## htmltools    "0.3.6"       NA
## httr         "1.4.0"       NA
## ipred        "0.9-9"       NA
## iterators    "1.0.10"      NA
## jsonlite     "1.6"         NA
## kableExtra   "1.1.0"       NA
## knitr        "1.22"        NA
## labeling     "0.3"         NA
## lava         "1.6.5"       NA
## lazyeval     "0.2.2"       NA
```

```
## lubridate     "1.7.4"    NA ##
magrittr      "1.5"        NA
## markdown      "0.9"        NA
## mime         "0.6"        NA ##
ModelMetrics  "1.2.2"      NA ##
modelr        "0.1.4"        NA ##
munsell        "0.5.0"      NA ##
numDeriv     "2016.8-1"    NA ##
openssl         "1.3"        NA ##
pillar        "1.3.1"        NA ##
pkgconfig       "2.0.2"      NA ##
plogr          "0.2.0"      NA
## plyr           "1.8.4"      NA
##  prettyunits  "1.0.2"  NA  ##
processx      "3.3.0"       NA  ##
prodlim    "2018.04.18"   NA   ##
progress     "1.2.0"      NA ## ps
                  "1.3.0"      NA
## purrr          "0.3.2"      NA
## R6             "2.4.0"      NA
## RColorBrewer "1.1-2"     NA ##
Rcpp          "1.0.1"      NA
## RcppRoll     "0.3.0"      NA ##
readr          "1.3.1"      NA
## readxl       "1.3.1"      NA ##
recipes        "0.1.5"      NA ##
rematch        "1.0.1"      NA ##
reprex        "0.2.1"        NA ##
reshape2       "1.4.3"      NA ##
rlang         "0.3.4"        NA ##
rmarkdown       "1.12"      NA ##
rprojroot       "1.3-2"     NA ##
rstudioapi     "0.10"        NA ##
rvest          "0.3.3"      NA
## scales       "1.0.0"      NA ##
selectr        "0.4-1"      NA ##
SQUAREM        "2017.10-1"  NA
## stringi       "1.4.3"     NA ##
stringr        "1.4.0"      NA ##
sys           "3.2"         NA
## tibble         "2.1.1"      NA
## tidyr         "0.8.3"      NA ##
tidyselect     "0.2.5"      NA ##
tidyverse       "1.2.1"     NA ##
timeDate     "3043.102"     NA ##
tinytex        "0.12"       NA ##
utf8          "1.1.4"       NA
## viridisLite  "0.3.0"     NA ##
webshot        "0.5.1"      NA ##
whisker        "0.3-2"      NA ##
withr         "2.1.2"       NA
## xfun            "0.6"         NA
## xml2            "1.2.0"       NA
## yaml            "2.2.0"       NA
```

```
## base           "3.6.0"       "base"
## boot          "1.3-22"       "recommended"
## class         "7.3-15"       "recommended"
## cluster        "2.0.8"       "recommended"
## codetools     "0.2-16"       "recommended"
## compiler "3.6.0" "base"
## datasets       "3.6.0"       "base"
## foreign        "0.8-71"      "recommended"
## graphics       "3.6.0"       "base"
## grDevices      "3.6.0"       "base"
## grid           "3.6.0"       "base"
## KernSmooth     "2.23-15"     "recommended"
## lattice      "0.20-38"       "recommended"
## MASS          "7.3-51.4"     "recommended"
## Matrix       "1.2-17"        "recommended"
## methods "3.6.0" "base"
## mgcv            "1.8-28"     "recommended"
## nlme            "3.1-139"    "recommended"
## nnet          "7.3-12"       "recommended"
## parallel "3.6.0" "base"
## rpart        "4.1-15"        "recommended"
## spatial       "7.3-11"       "recommended"
## splines "3.6.0" "base"
## stats           "3.6.0"      "base"
## stats4          "3.6.0"      "base"
## survival       "2.44-1.1"    "recommended"
## tcltk           "3.6.0"      "base"
## tools           "3.6.0"      "base"
## translations  "3.6.0"        NA
## utils           "3.6.0"      "base"
##                Depends
## askpass        NA
## assertthat     NA
## backports   "R (>= 3.0.0)" ##
base64enc   "R (>= 2.9.0)" ## BH
                NA
## bitops         NA
## broom          "R (>= 3.1)"
## callr          NA
## caret          "R (>= 3.2.0), lattice (>= 0.20), ggplot2"
## caTools        "R (>= 2.2.0)"
## cellranger     "R (>= 3.0.0)"
## cli            "R (>= 2.10)"
## clipr          NA
## colorspace     "R (>= 3.0.0), methods"
## crayon         NA
## curl           "R (>= 3.0.0)"
## data.table     "R (>= 3.1.0)"
## DBI            "R (>= 3.0.0), methods"
## dbplyr         "R (>= 3.1)"
## digest         "R (>= 3.1.0)"
## dplyr          "R (>= 3.1.2)"
## dslabs         "R (>= 3.1.2)"
## ellipsis       "R (>= 3.1)"
```

```
## evaluate      "R (>= 3.0.2)"
## fansi         "R (>= 3.1.0)"
## forcats       "R (>= 3.1)"
## foreach       "R (>= 2.5.0)"
## fs            "R (>= 3.1)"
## generics      "R (>= 3.1)"
## ggplot2       "R (>= 3.1)"
## glue          "R (>= 3.1)"
## gower         NA
## gtable        "R (>= 3.0)"
## haven         "R (>= 3.1)"
## highr         "R (>= 3.2.3)"
## hms           NA
## htmltools     "R (>= 2.14.1)"
## httr          "R (>= 3.1)"
## ipred         "R (>= 2.10)"
## iterators     "R (>= 2.5.0), utils"
## jsonlite      "methods"
## kableExtra    "R (>= 3.1.0)"
## knitr         "R (>= 3.1.0)"
## labeling      NA
## lava          "R (>= 3.0)"
## lazyeval      "R (>= 3.1.0)"
## lubridate     "methods, R (>= 3.0.0)"
## magrittr      NA
## markdown      "R (>= 2.11.1)"
## mime          NA
## ModelMetrics  "R (>= 3.2.2)"
## modelr        "R (>= 3.1)"
## munsell       NA
## numDeriv      "R (>= 2.11.1)"
## openssl       NA
## pillar        NA
## pkgconfig     NA
## plogr         NA
## plyr          "R (>= 3.1.0)"
## prettyunits   NA
## processx      NA
## prodlim       "R (>= 2.9.0)"
## progress      NA
## ps            "R (>= 3.1)"
## purrr         "R (>= 3.1)"
## R6            "R (>= 3.0)"
## RColorBrewer  "R (>= 2.0.0)"
## Rcpp          "R (>= 3.0.0)"
## RcppRoll      "R (>= 2.15.1)"
## readr         "R (>= 3.1)"
## readxl        NA
## recipes       "R (>= 3.1), dplyr"
## rematch       NA
## reprex        "R (>= 3.1)"
## reshape2      "R (>= 3.1)"
## rlang         "R (>= 3.1.0)"
## rmarkdown     "R (>= 3.0)"
```

```
## rprojroot     "R (>= 3.0.0)"
## rstudioapi    NA
## rvest         "R (>= 3.1), xml2"
## scales        "R (>= 3.1)"
## selectr       "R (>= 3.0)"
## SQUAREM       "R (>= 3.0)"
## stringi       "R (>= 2.14)"
## stringr       "R (>= 3.1)"
## sys           NA
## tibble        "R (>= 3.1.0)"
## tidyr         "R (>= 3.1)"
## tidyselect    "R (>= 3.1)"
## tidyverse     NA
## timeDate      "R (>= 2.15.1), graphics, utils, stats, methods"
## tinytex       NA
## utf8          "R (>= 2.10)"
## viridisLite   "R (>= 2.10)"
## webshot       "R (>= 3.0)"
## whisker       NA
## withr         "R (>= 3.0.2)"
## xfun          NA
## xml2          "R (>= 3.1.0)"
## yaml          NA
## base          NA
## boot          "R (>= 3.0.0), graphics, stats"
## class         "R (>= 3.0.0), stats, utils"
## cluster       "R (>= 3.3.0)"
## codetools     "R (>= 2.1)"
## compiler      NA
## datasets      NA
## foreign       "R (>= 3.0.0)"
## graphics      NA
## grDevices     NA
## grid          NA
## KernSmooth    "R (>= 2.5.0), stats"
## lattice       "R (>= 3.0.0)"
## MASS          "R (>= 3.1.0), grDevices, graphics, stats, utils"
## Matrix        "R (>= 3.2.0)"
## methods       NA
## mgcv          "R (>= 2.14.0), nlme (>= 3.1-64)"
## nlme          "R (>= 3.4.0)"
## nnet          "R (>= 2.14.0), stats, utils"
## parallel      NA
## rpart         "R (>= 2.15.0), graphics, stats, grDevices"
## spatial       "R (>= 3.0.0), graphics, stats, utils"
## splines       NA
## stats         NA
## stats4       NA
## survival   "R (>= 2.13.0)"  ##
tcltk  NA
## tools      NA ##
translations  NA ##
utils        NA
##               Imports
```

```
## askpass       "sys (>= 2.1)"
## assertthat    "tools"
## backports     "utils"
## base64enc     NA
## BH            NA
## bitops        NA
## broom         "backports, dplyr, generics (>= 0.0.2), methods, nlme, purrr,¥nreshape2, stringr, tibbl##
callr           "processx (>= 3.3.0), R6, utils"
## caret         "foreach, methods, plyr, ModelMetrics (>= 1.1.0), nlme,¥nreshape2, stats, stats4, utils##
caTools         "bitops"
## cellranger    "rematch, tibble"
## cli           "assertthat, crayon (>= 1.3.4), methods, utils"
## clipr         "utils"
## colorspace    "graphics, grDevices, stats"
## crayon        "grDevices, methods, utils"
## curl          NA
## data.table    "methods"
## DBI           NA
## dbplyr        "assertthat (>= 0.2.0), DBI (>= 1.0.0), dplyr (>= 0.8.0), glue¥n(>= 1.2.0), methods, pu##
digest          NA
## dplyr         "assertthat (>= 0.2.0), glue (>= 1.1.1), magrittr (>= 1.5),¥nmethods, pkgconfig (>= 2.0##
dslabs          "ggplot2"
## ellipsis      NA
## evaluate      "methods"
## fansi         NA
## forcats       "ellipsis, magrittr, rlang, tibble"
## foreach       "codetools, utils, iterators"
## fs            "methods, Rcpp"
## generics      "methods"
## ggplot2       "digest, grid, gtable (>= 0.1.1), lazyeval, MASS, mgcv, plyr¥n(>= 1.7.1), reshape2, rla##
glue            "methods"
## gower         NA
## gtable        "grid"
## haven         "forcats (>= 0.2.0), hms, Rcpp (>= 0.11.4), readr (>= 0.1.0),¥ntibble"##
highr           NA
## hms           "methods, pkgconfig, rlang"
## htmltools     "utils, digest, Rcpp"
## httr          "curl (>= 0.9.1), jsonlite, mime, openssl (>= 0.8), R6" ##
ipred           "rpart (>= 3.1-8), MASS, survival, nnet, class, prodlim"
## iterators     NA
## jsonlite      NA
## kableExtra "knitr (>= 1.16), magrittr, stringr (>= 1.0), xml2 (>= 1.1.1),¥nrvest, rmarkdown (>= 1. ##
knitr    "evaluate (>= 0.10), highr, markdown, stringr (>= 0.6), yaml¥n(>= 2.1.19), methods, xfu ##
labeling NA
## lava          "grDevices, graphics, methods, numDeriv, stats, survival,¥nSQUAREM, utils"##
lazyeval        NA
## lubridate     "stringr, Rcpp (>= 0.12.13),"
## magrittr      NA
## markdown      "utils, mime (>= 0.3)"
## mime          "tools"
## ModelMetrics "Rcpp, data.table"
## modelr        "broom, dplyr, magrittr, purrr (>= 0.2.2), rlang (>= 0.2.0),¥ntibble, tidyr (>= 0.8.0)"##
munsell         "colorspace, methods"
## numDeriv      NA
```

```
## openssl       "askpass"
## pillar        "cli (>= 1.0.0), crayon (>= 1.3.4), fansi (>= 0.4.0), methods,¥nrlang (>= 0.3.0.1), utf##
pkgconfig       "utils"
## plogr         NA
## plyr          "Rcpp (>= 0.11.0)"
## prettyunits   "magrittr, assertthat, methods"
## processx      "ps (>= 1.2.0), R6, utils"
## prodlim       "Rcpp (>= 0.11.5), stats, graphics, survival, KernSmooth, lava"##
progress        "hms, prettyunits, R6, crayon"
## ps            "utils"
## purrr         "magrittr (>= 1.5), rlang (>= 0.3.1)"
## R6            NA
## RColorBrewer NA
## Rcpp          "methods, utils"
## RcppRoll      "Rcpp"
## readr         "Rcpp (>= 0.12.0.5), tibble, hms (>= 0.4.1), R6, clipr, crayon,¥nmethods"##
readxl          "cellranger, Rcpp (>= 0.12.18), tibble (>= 1.3.1), utils"
## recipes       "generics, glue, gower, ipred, lubridate, magrittr, Matrix,¥npurrr (>= 0.2.3),RcppRoll ##
rematch         NA
## reprex        "callr (>= 2.0.0), clipr (>= 0.4.0), fs, rlang, rmarkdown,¥ntools, utils, whisker, with##
reshape2        "plyr (>= 1.8.1), Rcpp, stringr"
## rlang         NA
## rmarkdown     "tools, utils, knitr (>= 1.22), yaml (>= 2.1.19), htmltools (>=¥n0.3.5), evaluate (>= 0##
rprojroot       "backports"
## rstudioapi    NA
## rvest         "httr (>= 0.5), magrittr, selectr"
## scales        "labeling, munsell (>= 0.5), R6, RColorBrewer, Rcpp,¥nviridisLite"##
selectr         "methods, stringr, R6"
## SQUAREM       NA
## stringi "tools, utils, stats"
## stringr    "glue (>= 1.2.0), magrittr, stringi (>= 1.1.7)" ##
sys  NA
## tibble   "cli (>= 1.0.1), crayon (>= 1.3.4), fansi (>= 0.4.0), methods,¥npillar (>= 1.3.1), pkgc ##
tidyr  "dplyr (>= 0.7.0), glue, magrittr, purrr, Rcpp, rlang, stringi,¥ntibble, tidyselect (>= ##
tidyselect "glue (>= 1.3.0), purrr, rlang (>= 0.2.2), Rcpp (>= 0.12.0)"
## tidyverse "broom (>= 0.4.2), cli (>= 1.0.0), crayon (>= 1.3.4), dplyr (>=¥n0.7.4), dbplyr (>= 1.1 ##
timeDate NA
## tinytex       "xfun (>= 0.5)"
## utf8          NA
## viridisLite   NA
## webshot       "magrittr, jsonlite, callr"
## whisker       NA
## withr         "stats, graphics, grDevices"
## xfun          "tools"
## xml2          "Rcpp"
## yaml          NA
## base          NA
## boot          NA
## class         "MASS"
## cluster       "graphics, grDevices, stats, utils"
## codetools     NA
## compiler      NA
## datasets      NA
## foreign       "methods, utils, stats"
```

```
## graphics      "grDevices"
## grDevices     NA
## grid          "grDevices, utils"
## KernSmooth    NA
## lattice       "grid, grDevices, graphics, stats, utils"
## MASS          "methods"
## Matrix        "methods, graphics, grid, stats, utils, lattice"
## methods       "utils, stats"
## mgcv          "methods, stats, graphics, Matrix, splines, utils"
## nlme          "graphics, stats, utils, lattice"
## nnet          NA
## parallel      "tools, compiler"
## rpart         NA
## spatial       NA
## splines       "graphics, stats"
## stats         "utils, grDevices, graphics"
## stats4        "graphics, methods, stats"
## survival      "graphics, Matrix, methods, splines, stats, utils"
## tcltk         "utils"
##   tools   NA   ##
translations  NA  ##
utils  NA
##               LinkingTo
## askpass       NA
## assertthat    NA
## backports     NA
## base64enc     NA
## BH            NA
## bitops        NA
## broom         NA
## callr         NA
## caret         NA
##  caTools      NA
##   cellranger  NA
## cli           NA
##  clipr        NA
##   colorspace  NA
## crayon        NA
## curl          NA
##   data.table  NA
## DBI           NA
## dbplyr        NA
## digest        NA
## dplyr         "BH (>= 1.58.0-1), plogr (>= 0.1.10), Rcpp (>= 1.0.0)"
## dslabs        NA
## ellipsis      NA
## evaluate      NA
## fansi         NA
## forcats       NA
## foreach       NA
## fs            "Rcpp"
## generics      NA
## ggplot2       NA
## glue          NA
```

```
## gower         NA
## gtable        NA
## haven         "Rcpp"
## highr         NA
## hms           NA
## htmltools     "Rcpp"
## httr          NA
## ipred         NA
##  iterators    NA
##  jsonlite  NA  ##
kableExtra   NA   ##
knitr  NA
## labeling      NA
## lava          NA
## lazyeval      NA
## lubridate     "Rcpp,"
## magrittr      NA
## markdown      NA
## mime          NA
## ModelMetrics "Rcpp"
## modelr        NA
## munsell       NA
## numDeriv      NA
## openssl       NA
## pillar        NA
## pkgconfig     NA
## plogr         NA
## plyr          "Rcpp"
## prettyunits   NA
## processx      NA
## prodlim       "Rcpp"
## progress      NA
## ps            NA
## purrr         NA
## R6            NA
## RColorBrewer NA
## Rcpp          NA
## RcppRoll      "Rcpp"
## readr         "Rcpp, BH"
## readxl        "progress, Rcpp"
## recipes       NA
## rematch       NA
## reprex        NA
## reshape2      "Rcpp"
## rlang         NA
##  rmarkdown    NA
## rprojroot  NA  ##
rstudioapi   NA   ##
rvest  NA
##  scales  "Rcpp"
## selectr      NA
## SQUAREM       NA
## stringi      NA
## stringr      NA
```

```
## sys           NA
## tibble        NA
## tidyr         "Rcpp"
## tidyselect    "Rcpp (>= 0.12.0),"
## tidyverse     NA
## timeDate      NA
##  tinytex      NA
##   utf8   NA   ##
viridisLite  NA  ##
webshot  NA
## whisker       NA
## withr         NA
## xfun          NA
## xml2          "Rcpp (>= 0.12.12)"
## yaml          NA
## base          NA
## boot          NA
## class         NA
## cluster       NA
## codetools     NA
## compiler      NA
## datasets      NA
## foreign       NA
## graphics      NA
##  grDevices    NA
##   grid   NA   ##
KernSmooth   NA  ##
lattice  NA
## MASS  NA
## Matrix        NA
## methods       NA
## mgcv          NA
## nlme          NA
## nnet          NA
## parallel      NA
## rpart         NA
## spatial       NA
## splines       NA
## stats         NA
## stats4        NA
## survival      NA
## tcltk         NA
##   tools   NA   ##
translations  NA  ##
utils  NA
##               Suggests
## askpass       "testthat"
## assertthat    "testthat, covr"
## backports     NA
## base64enc     NA
## BH            NA
## bitops        NA
## broom         "AER, akima, AUC, bbmle, betareg, biglm, binGroup, boot, brms,¥nbtergm, car, caret, cod##
callr           "cliapp, covr, crayon, pingr, ps, testthat, withr"
```

```
## caret         "BradleyTerry2, e1071, earth (>= 2.2-3), fastICA, gam (>=¥n1.15), ipred, kernlab, knitr##
caTools         "MASS, rpart"
## cellranger    "covr, testthat (>= 1.0.0), knitr, rmarkdown"
## cli           "covr, fansi, mockery, testthat, webshot, withr"
## clipr         "covr, knitr, rmarkdown, rstudioapi (>= 0.5), testthat (>=¥n2.0.0)"
## colorspace "datasets, utils, KernSmooth, MASS, kernlab, mvtnorm, vcd,¥ntcltk, shiny, shinyjs, ggpl ##
crayon          "mockery, rstudioapi, testthat, withr"
## curl "spelling, testthat (>= 1.0.0), knitr, jsonlite, rmarkdown,¥nmagrittr, httpuv (>= 1.4.4 ##
data.table "bit64, curl, R.utils, knitr, xts, nanotime, zoo"
## DBI           "blob, covr, hms, knitr, magrittr, rprojroot, rmarkdown,¥nRSQLite (>= 1.1-2), testthat, ##
dbplyr          "bit64, covr, knitr, Lahman, nycflights13, RMariaDB (>=¥n1.0.2), rmarkdown, RMySQL (>= ##
digest          "knitr, rmarkdown"
## dplyr  "bit64 (>= 0.9.7), callr (>= 3.1.1), covr (>= 3.0.1), DBI (>=¥n0.7.14), dbplyr (>= 1.2. ##
dslabs          NA
## ellipsis "covr, testthat"
## evaluate      "testthat, lattice, ggplot2"
## fansi         "unitizer, knitr, rmarkdown"
## forcats       "covr, ggplot2, testthat, readr, knitr, rmarkdown, dplyr" ##
foreach         "randomForest"
## fs            "testthat, covr, pillar (>= 1.0.0), crayon, rmarkdown, knitr,¥nwithr, spelling"##
generics        "covr, pkgload, testthat, tibble"
## ggplot2       "covr, dplyr, ggplot2movies, hexbin, Hmisc, lattice, mapproj,¥nmaps, maptools,multcomp ##
glue            "testthat, covr, magrittr, crayon, knitr, rmarkdown, DBI,¥nRSQLite, R.utils, forcats, ##
gower           "testthat,"
## gtable        "covr, testthat, knitr, rmarkdown, ggplot2, profvis"
## haven         "covr, fs, knitr, rmarkdown, testthat, pillar (>= 1.1.1), cli,¥ncrayon"##
highr           "knitr, testit"
## hms           "crayon, lubridate, pillar (>= 1.1.0), testthat"
## htmltools     "markdown, testthat"
## httr          "covr, httpuv, jpeg, knitr, png, readr, rmarkdown, testthat¥n(>= 0.8.0), xml2"##
ipred           "mvtnorm, mlbench, TH.data"
## iterators     "RUnit, foreach"
## jsonlite      "httr, curl, plyr, testthat, knitr, rmarkdown, R.rsp, sp"##
kableExtra      "testthat, magick, formattable, dplyr"
## knitr         "formatR, testit, digest, rgl (>= 0.95.1201), codetools,¥nrmarkdown, htmlwidgets (>= 0.##
labeling        NA
## lava          "KernSmooth, Matrix, Rgraphviz, data.table, ellipse, fields,¥nforeach, geepack, gof (>=##
lazyeval        "knitr, rmarkdown (>= 0.2.65), testthat, covr"
## lubridate     "testthat, knitr, covr"
## magrittr      "testthat, knitr"
## markdown      "knitr, RCurl"
## mime          NA
## ModelMetrics "testthat"
## modelr        "compiler, covr, ggplot2, testthat"
## munsell       "ggplot2, testthat"
## numDeriv      NA
## openssl       "testthat, digest, knitr, rmarkdown, jsonlite, jose"
## pillar        "knitr (>= 1.19), lubridate (>= 1.7.4), testthat (>= 2.0.0),¥nwithr (>= 2.1.2)"##
pkgconfig       "covr, testthat, disposables (>= 1.0.3)"
## plogr         "Rcpp"
## plyr          "abind, testthat, tcltk, foreach, doParallel, itertools,¥niterators, covr"##
prettyunits     "testthat"
## processx      "callr, covr, crayon, debugme, parallel, testthat, withr"##
prodlim         NA
```

```
## progress      "Rcpp, testthat, withr"
## ps            "callr, covr, curl, pingr, processx (>= 3.1.0), R6, rlang,¥ntestthat, tibble"
## purrr         "covr, crayon, dplyr (>= 0.7.8), knitr, rmarkdown, testthat,¥ntibble, tidyselect"##
R6              "knitr, microbenchmark, pryr, testthat, ggplot2, scales"
## RColorBrewer NA
## Rcpp          "RUnit, inline, rbenchmark, knitr, rmarkdown, pinp, pkgKitten¥n(>= 0.1.2)"##
RcppRoll        "zoo, testthat"
## readr         "curl, testthat, knitr, rmarkdown, stringi, covr, spelling"##
readxl          "covr, knitr, rmarkdown, rprojroot (>= 1.1), testthat"
## recipes       "covr, ddalpha, dimRed (>= 0.2.2), fastICA, ggplot2, igraph,¥nkernlab, knitr, NMF, pls,##
rematch         "covr, testthat"
## reprex        "covr, devtools, fortunes, knitr, miniUI, rprojroot,¥nrstudioapi, shiny, styler (>= 1.0##
reshape2        "covr, lattice, testthat (>= 0.8.0)"
## rlang         "covr, crayon, magrittr, methods, pillar, rmarkdown, testthat¥n(>= 2.0.0)"
## rmarkdown     "shiny (>= 0.11), tufte, testthat, digest, dygraphs, tibble,¥nfs, callr (>= 2.0.0)"##
rprojroot       "testthat, mockr, knitr, withr, rmarkdown"
## rstudioapi    "testthat, knitr, rmarkdown"
## rvest         "covr, knitr, png, rmarkdown, spelling, stringi (>= 0.3.1),¥ntestthat"##
scales          "dichromat, bit64, covr, hms, testthat (>= 2.0)"
## selectr       "testthat, XML, xml2"
## SQUAREM       "setRNG"
## stringi       NA
## stringr       "covr, htmltools, htmlwidgets, knitr, rmarkdown, testthat"##
sys             "unix (>= 1.4), spelling, testthat"
## tibble        "bench (>= 1.0.1), covr (>= 3.2.1), dplyr (>= 0.7.8),¥nhtmltools (>= 0.3.6), import (>=##
tidyr           "covr, gapminder, knitr, rmarkdown, testthat"
## tidyselect    "covr, dplyr, testthat"
## tidyverse     "feather (>= 0.3.1), knitr (>= 1.17), rmarkdown (>= 1.7.4)"##
timeDate        "date, RUnit"
## tinytex       "testit, rstudioapi"
## utf8          "knitr, rmarkdown, testthat"
## viridisLite   "hexbin (>= 1.27.0), ggplot2 (>= 1.0.1), testthat, covr"##
webshot         "httpuv, knitr, rmarkdown, shiny"
## whisker       "markdown"
## withr         "testthat, covr, lattice, DBI, RSQLite, methods, knitr,¥nrmarkdown"
## xfun          "testit, parallel, rstudioapi, tinytex, mime, markdown, knitr,¥nhtmltools, base64enc,##
xml2            "testthat, curl, covr, knitr, rmarkdown, magrittr, httr"
## yaml          "RUnit"
## base          "methods"
## boot          "MASS, survival"
## class         NA
## cluster       "MASS, Matrix"
## codetools     NA
## compiler      NA
## datasets      NA
## foreign       NA
## graphics      NA
## grDevices     "KernSmooth"
## grid          "lattice"
## KernSmooth    "MASS"
## lattice       "KernSmooth, MASS, latticeExtra"
## MASS          "lattice, nlme, nnet, survival"
## Matrix        "expm, MASS"
## methods       "codetools"
```

```
## mgcv          "parallel, survival, MASS"
## nlme          "Hmisc, MASS"
## nnet          "MASS"
## parallel      "methods"
## rpart         "survival"
## spatial       "MASS"
## splines       "Matrix, methods"
## stats         "MASS, Matrix, SuppDists, methods, stats4"
## stats4        NA
## survival      NA
## tcltk         NA
## tools         "codetools, methods, xml2, curl, commonmark"
## translations NA
## utils         "methods, xml2, commonmark"
##               Enhances
## askpass       NA
##assertthat     NA
## backports     NA
## base64enc     "png"
## BH            NA
## bitops        NA
## broom         NA
## callr         NA
## caret         NA
##  caTools      NA
##   cellranger  NA
## cli           NA
##  clipr        NA
##   colorspace  NA
## crayon        NA
## curl          NA
##   data.table  NA
## DBI           NA
## dbplyr        NA
## digest        NA
## dplyr         NA
## dslabs        NA
## ellipsis      NA
## evaluate      NA
## fansi         NA
## forcats       NA
## foreach       "compiler,          doMC, RUnit, doParallel"
## fs            NA
## generics      NA
## ggplot2       "sp"
## glue          NA
## gower         NA
## gtable        NA
## haven         NA
## highr         NA
## hms           NA
## htmltools     "knitr"
## httr          NA
## ipred         NA
```

```
## iterators    NA
## jsonlite   NA ##
kableExtra   NA  ##
knitr        NA
## labeling      NA
## lava          NA
## lazyeval      NA
## lubridate     "chron, fts, timeSeries, timeDate, tis, tseries, xts, zoo" ##
magrittr         NA
##  markdown     NA
##   mime   NA   ##
ModelMetrics  NA  ##
modelr  NA
## munsell       NA
## numDeriv      NA
## openssl       NA
## pillar        NA
## pkgconfig     NA
## plogr         NA
##   plyr   NA   ##
prettyunits  NA  ##
processx  NA
## prodlim      NA
## progress     NA
## ps            NA
## purrr         NA
## R6            NA
## RColorBrewer NA
## Rcpp          NA
## RcppRoll      NA
## readr         NA
## readxl        NA
## recipes       NA
## rematch       NA
## reprex        NA
## reshape2      NA
## rlang         NA
##  rmarkdown    NA
## rprojroot  NA ##
rstudioapi   NA  ##
rvest  NA
## scales       NA
## selectr      NA
## SQUAREM       NA
## stringi       NA
## stringr       NA
## sys           NA
## tibble        NA
##   tidyr   NA   ##
tidyselect   NA  ##
tidyverse  NA
## timeDate      NA
## tinytex       NA
## utf8          NA
```

```
## viridisLite   NA
## webshot       NA
## whisker       NA
## withr         NA
## xfun          NA
## xml2          NA
## yaml          NA
## base          NA
## boot          NA
## class         NA
## cluster       NA
## codetools     NA
## compiler      NA
## datasets      NA
## foreign       NA
## graphics      NA
## grDevices     NA
## grid          NA
## KernSmooth    NA
## lattice       "chron"
## MASS          NA
## Matrix        "MatrixModels, graph, SparseM, sfsmisc"
## methods       NA
## mgcv          NA
## nlme          NA
## nnet          NA
## parallel      "snow, nws, Rmpi"
## rpart         NA
## spatial       NA
## splines       NA
## stats         NA
## stats4        NA
## survival      NA
## tcltk         NA
## tools      NA ##
translations  NA ##
utils        NA
##               License                                 License_is_FOSS
## askpass       "MIT + file  LICENSE"                    NA
## assertthat    "GPL-3"                                  NA
## backports     "GPL-2"                                  NA
## base64enc     "GPL-2 | GPL-3"                          NA
## BH            "BSL-1.0"                                NA
## bitops        "GPL (>= 2)"                             NA
## broom         "MIT + file LICENSE"                     NA
## callr         "MIT + file LICENSE"                     NA
## caret         "GPL (>= 2)"                             NA
## caTools       "GPL-3"                                  NA
## cellranger    "MIT + file LICENSE"                     NA
## cli           "MIT + file LICENSE"                     NA
## clipr         "GPL-3"                                  NA
## colorspace    "BSD_3_clause + file  LICENSE"           NA
## crayon        "MIT + file LICENSE"                     NA
## curl          "MIT + file LICENSE"                     NA
```

```
## data.table    "MPL-2.0 | file LICENSE" "LGPL            NA
## DBI           (>= 2)"                                   NA
## dbplyr        "MIT + file LICENSE"                       NA
## digest        "GPL (>= 2)"                               NA
## dplyr         "MIT + file LICENSE"                       NA
## dslabs        "Artistic-2.0"                             NA
## ellipsis      "GPL-3"                                    NA
## evaluate      "MIT + file LICENSE"                       NA
## fansi         "GPL (>= 2)"                               NA
## forcats       "GPL-3"                                    NA
## foreach       "Apache License (== 2.0)"                  NA
## fs            "GPL-3"                                    NA
## generics      "GPL-2"                                    NA
## ggplot2       "GPL-2 | file LICENSE"                     NA
## glue          "MIT + file LICENSE"                       NA
## gower         "GPL-3"                                    NA
## gtable        "GPL-2"                                    NA
## haven         "MIT + file LICENSE"                       NA
## highr         "GPL"                                      NA
## hms           "GPL-3"                                    NA
## htmltools     "GPL (>= 2)"                               NA
## httr          "MIT + file LICENSE"                       NA
## ipred         "GPL (>= 2)"                               NA
## iterators     "Apache License (== 2.0)"                  NA
## jsonlite      "MIT + file LICENSE"                       NA
## kableExtra    "MIT + file LICENSE"                       NA
## knitr         "GPL"                                      NA
## labeling      "MIT + file LICENSE | Unlimited"           NA
## lava          "GPL-3"                                    NA
## lazyeval      "GPL-3"                                    NA
## lubridate     "GPL (>= 2)"                               NA
## magrittr      "MIT + file  LICENSE"                      NA
## markdown      "GPL-2"                                    NA
## mime          "GPL"                                      NA
## ModelMetrics  "GPL (>= 2)"                               NA
## modelr        "GPL-3"                                    NA
## munsell       "MIT + file  LICENSE"                      NA
## numDeriv      "GPL-2"                                    NA
## openssl       "MIT + file  LICENSE"                      NA
## pillar        "GPL-3"                                    NA
## pkgconfig     "MIT + file LICENSE"                       NA
## plogr         "MIT + file LICENSE"                       NA
## plyr          "MIT + file LICENSE"                       NA
## prettyunits   "MIT + file LICENSE"                       NA
## processx      "MIT + file LICENSE"                       NA
## prodlim       "GPL (>= 2)"                               NA
## progress      "MIT + file LICENSE"                       NA
## ps            "BSD_3_clause + file LICENSE"              NA
## purrr         "GPL-3 | file LICENSE"                     NA
## R6            "MIT + file LICENSE"                       NA
## RColorBrewer  "Apache License 2.0"                       NA
## Rcpp          "GPL (>= 2)"                               NA
## RcppRoll      "GPL (>= 2)"                               NA
## readr         "GPL (>= 2) | file LICENSE"                NA
```

```
## readxl       "GPL-3"                                      NA
## recipes      "GPL-2"                                      NA
## rematch      "MIT + file LICENSE"                         NA
## reprex       "MIT + file LICENSE"                         NA
## reshape2     "MIT + file LICENSE"                         NA
## rlang        "GPL-3"                                      NA
## rmarkdown    "GPL-3"                                      NA
## rprojroot    "GPL-3"                                      NA
## rstudioapi   "MIT + file LICENSE"                         NA
## rvest        "GPL-3"                                      NA
## scales       "MIT + file LICENSE"                         NA
## selectr      "BSD_3_clause + file  LICENCE"               NA
## SQUAREM      "GPL (>= 2)"                                 NA
## stringi      "file LICENSE"                               "yes"
## stringr      "GPL-2 | file LICENSE"                       NA
## sys          "MIT + file LICENSE"                         NA
## tibble       "MIT + file LICENSE"                         NA
## tidyr        "MIT + file LICENSE"                         NA
## tidyselect   "GPL-3"                                      NA
## tidyverse    "GPL-3 | file LICENSE"                       NA
## timeDate     "GPL (>= 2)"                                 NA
## tinytex      "MIT + file  LICENSE"                        NA
## utf8         "Apache License (== 2.0) | file  LICENSE"    NA
## viridisLite  "MIT + file LICENSE"                         NA
## webshot      "GPL-2"                                      NA
## whisker      "GPL-3"                                      NA
## withr        "GPL (>= 2)"                                 NA
## xfun         "MIT + file LICENSE"                         NA
## xml2         "GPL (>= 2)"                                 NA
## yaml         "BSD_3_clause + file LICENSE"                NA
## base         "Part of R 3.6.0"                            NA
## boot         "Unlimited"                                  NA
## class        "GPL-2 | GPL-3"                              NA
## cluster      "GPL (>= 2)"                                 NA
## codetools    "GPL"                                        NA
## compiler     "Part of R 3.6.0"                            NA
## datasets     "Part of R 3.6.0"                            NA
## foreign      "GPL (>= 2)"                                 NA
## graphics     "Part of R 3.6.0"                            NA
## grDevices    "Part of R 3.6.0"                            NA
## grid         "Part of R 3.6.0"                            NA
## KernSmooth   "Unlimited"                                  NA
## lattice      "GPL (>= 2)"                                 NA
## MASS         "GPL-2 | GPL-3"                              NA
## Matrix       "GPL (>= 2) | file LICENCE"                  NA
## methods      "Part of R 3.6.0"                            NA
## mgcv         "GPL (>= 2)"                                 NA
## nlme         "GPL (>= 2) | file LICENCE"                  NA
## nnet         "GPL-2 | GPL-3"                              NA
## parallel     "Part of R 3.6.0"                            NA
## rpart        "GPL-2 | GPL-3"                              NA
## spatial      "GPL-2 | GPL-3"                              NA
## splines      "Part of R 3.6.0"                            NA
## stats        "Part of R 3.6.0"                            NA
```

```
## stats4        "Part of R 3.6.0"                        NA
## survival      "LGPL (>= 2)"                            NA
## tcltk         "Part of R 3.6.0"                        NA
## tools         "Part of R 3.6.0"                        NA
## translations "Part of R 3.6.0"                         NA
## utils         "Part of R 3.6.0"                        NA
##               License_restricts_use OS_type MD5sum NeedsCompilation Built
## askpass       NA                    NA      NA     "yes"            "3.6.0"
## assertthat    NA                    NA      NA     "no"             "3.6.0"
## backports     NA                    NA      NA     "yes"            "3.6.0"
## base64enc     NA                    NA      NA     "yes"            "3.6.0"
## BH            NA                    NA      NA     "no"             "3.6.0"
## bitops        NA                    NA      NA     "yes"            "3.6.0"
## broom         NA                    NA      NA     "no"             "3.6.0"
## callr         NA                    NA      NA     "no"             "3.6.0"
## caret         NA                    NA      NA     "yes"            "3.6.0"
## caTools       NA                    NA      NA     "yes"            "3.6.0"
## cellranger    NA                    NA      NA     "no"             "3.6.0"
## cli           NA                    NA      NA     "no"             "3.6.0"
## clipr         NA                    NA      NA     "no"             "3.6.0"
## colorspace    NA                    NA      NA     "yes"            "3.6.0"
## crayon        NA                    NA      NA     "no"             "3.6.0"
## curl          NA                    NA      NA     "yes"            "3.6.0"
## data.table    NA                    NA      NA     "yes"            "3.6.0"
## DBI           NA                    NA      NA     "no"             "3.6.0"
## dbplyr        NA                    NA      NA     "no"             "3.6.0"
## digest        NA                    NA      NA     "yes"            "3.6.0"
## dplyr         NA                    NA      NA     "yes"            "3.6.0"
## dslabs        NA                    NA      NA     "no"             "3.6.0"
## ellipsis      NA                    NA      NA     "yes"            "3.6.0"
## evaluate      NA                    NA      NA     "no"             "3.6.0"
## fansi         NA                    NA      NA     "yes"            "3.6.0"
## forcats       NA                    NA      NA     "no"             "3.6.0"
## foreach       NA                    NA      NA     "no"             "3.6.0"
## fs            NA                    NA      NA     "yes"            "3.6.0"
## generics      NA                    NA      NA     "no"             "3.6.0"
## ggplot2       NA                    NA      NA     "no"             "3.6.0"
## glue          NA                    NA      NA     "yes"            "3.6.0"
## gower         NA                    NA      NA     "yes"            "3.6.0"
## gtable        NA                    NA      NA     "no"             "3.6.0"
## haven         NA                    NA      NA     "yes"            "3.6.0"
## highr         NA                    NA      NA     "no"             "3.6.0"
## hms           NA                    NA      NA     "no"             "3.6.0"
## htmltools     NA                    NA      NA     "yes"            "3.6.0"
## httr          NA                    NA      NA     "no"             "3.6.0"
## ipred         NA                    NA      NA     "yes"            "3.6.0"
## iterators     NA                    NA      NA     "no"             "3.6.0"
## jsonlite      NA                    NA      NA     "yes"            "3.6.0"
## kableExtra    NA                    NA      NA     "no"             "3.6.0"
## knitr         NA                    NA      NA     "no"             "3.6.0"
## labeling      NA                    NA      NA     "no"             "3.6.0"
## lava          NA                    NA      NA     "no"             "3.6.0"
## lazyeval      NA                    NA      NA     "yes"            "3.6.0"
## lubridate     NA                    NA      NA     "yes"            "3.6.0"
```

```
## magrittr      NA                    NA       NA       "no"              "3.6.0"
## markdown      NA                    NA       NA       "yes"             "3.6.0"
## mime          NA                    NA       NA       "yes"             "3.6.0"
## ModelMetrics  NA                    NA       NA       "yes"             "3.6.0"
## modelr        NA                    NA       NA       "no"              "3.6.0"
## munsell       NA                    NA       NA       "no"              "3.6.0"
## numDeriv      NA                    NA       NA       "no"              "3.6.0"
## openssl       NA                    NA       NA       "yes"             "3.6.0"
## pillar        NA                    NA       NA       "no"              "3.6.0"
## pkgconfig     NA                    NA       NA       "no"              "3.6.0"
## plogr         NA                    NA       NA       "no"              "3.6.0"
## plyr          NA                    NA       NA       "yes"             "3.6.0"
## prettyunits   NA                    NA       NA       "no"              "3.6.0"
## processx      NA                    NA       NA       "yes"             "3.6.0"
## prodlim       NA                    NA       NA       "yes"             "3.6.0"
## progress      NA                    NA       NA       "no"              "3.6.0"
## ps            NA                    NA       NA       "yes"             "3.6.0"
## purrr         NA                    NA       NA       "yes"             "3.6.0"
## R6            NA                    NA       NA       "no"              "3.6.0"
## RColorBrewer  NA                    NA       NA       "no"              "3.6.0"
## Rcpp          NA                    NA       NA       "yes"             "3.6.0"
## RcppRoll      NA                    NA       NA       "yes"             "3.6.0"
## readr         NA                    NA       NA       "yes"             "3.6.0"
## readxl        NA                    NA       NA       "yes"             "3.6.0"
## recipes       NA                    NA       NA       "no"              "3.6.0"
## rematch       NA                    NA       NA       "no"              "3.6.0"
## reprex        NA                    NA       NA       "no"              "3.6.0"
## reshape2      NA                    NA       NA       "yes"             "3.6.0"
## rlang         NA                    NA       NA       "yes"             "3.6.0"
## rmarkdown     NA                    NA       NA       "no"              "3.6.0"
## rprojroot     NA                    NA       NA       "no"              "3.6.0"
## rstudioapi    NA                    NA       NA       "no"              "3.6.0"
## rvest         NA                    NA       NA       "no"              "3.6.0"
## scales        NA                    NA       NA       "yes"             "3.6.0"
## selectr       NA                    NA       NA       "no"              "3.6.0"
## SQUAREM       NA                    NA       NA       "no"              "3.6.0"
## stringi       NA                    NA       NA       "yes"             "3.6.0"
## stringr       NA                    NA       NA       "no"              "3.6.0"
## sys           NA                    NA       NA       "yes"             "3.6.0"
## tibble        NA                    NA       NA       "yes"             "3.6.0"
## tidyr         NA                    NA       NA       "yes"             "3.6.0"
## tidyselect    NA                    NA       NA       "yes"             "3.6.0"
## tidyverse     NA                    NA       NA       "no"              "3.6.0"
## timeDate      NA                    NA       NA       "no"              "3.6.0"
## tinytex       NA                    NA       NA       "no"              "3.6.0"
## utf8          NA                    NA       NA       "yes"             "3.6.0"
## viridisLite   NA                    NA       NA       "no"              "3.6.0"
## webshot       NA                    NA       NA       "no"              "3.6.0"
## whisker       NA                    NA       NA       "no"              "3.6.0"
## withr         NA                    NA       NA       "no"              "3.6.0"
## xfun          NA                    NA       NA       "no"              "3.6.0"
## xml2          NA                    NA       NA       "yes"             "3.6.0"
## yaml          NA                    NA       NA       "yes"             "3.6.0"
## base          NA                    NA       NA       NA                "3.6.0"
```

```
## boot          NA                  NA       NA      "no"            "3.6.0"
## class         NA                  NA       NA      "yes"           "3.6.0"
## cluster       NA                  NA       NA      "yes"           "3.6.0"
## codetools     NA                  NA       NA      "no"            "3.6.0"
## compiler      NA                  NA       NA      NA              "3.6.0"
## datasets      NA                  NA       NA      NA              "3.6.0"
## foreign       NA                  NA       NA      "yes"           "3.6.0"
## graphics      NA                  NA       NA      "yes"           "3.6.0"
## grDevices     NA                  NA       NA      "yes"           "3.6.0"
## grid          NA                  NA       NA      "yes"           "3.6.0"
## KernSmooth    NA                  NA       NA      "yes"           "3.6.0"
## lattice       NA                  NA       NA      "yes"           "3.6.0"
## MASS          NA                  NA       NA      "yes"           "3.6.0"
## Matrix        NA                  NA       NA      "yes"           "3.6.0"
## methods       NA                  NA       NA      "yes"           "3.6.0"
## mgcv          NA                  NA       NA      "yes"           "3.6.0"
## nlme          NA                  NA       NA      "yes"           "3.6.0"
## nnet          NA                  NA       NA      "yes"           "3.6.0"
## parallel      NA                  NA       NA      "yes"           "3.6.0"
## rpart         NA                  NA       NA      "yes"           "3.6.0"
## spatial       NA                  NA       NA      "yes"           "3.6.0"
## splines       NA                  NA       NA      "yes"           "3.6.0"
## stats         NA                  NA       NA      "yes"           "3.6.0"
## stats4        NA                  NA       NA      NA              "3.6.0"
## survival      NA                  NA       NA      "yes"           "3.6.0"
## tcltk         NA                  NA       NA      "yes"           "3.6.0"
## tools         NA                  NA       NA      "yes"           "3.6.0"
## translations  NA                  NA       NA      NA              "3.6.0"
## utils         NA                  NA       NA      "yes"           "3.6.0"
```