Movielens

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```
################################
# Create edx set, validation set
################################

# Note: this process could take a couple of minutes

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

```
## Loading required package: tidyverse
```

```
## -- Attaching packages ---------------------------------------------- tidyverse 1.3.0 --
```

```
## v ggplot2 3.3.0     v purrr   0.3.4
## v tibble  3.0.1     v dplyr   0.8.5
## v tidyr   1.0.2     v stringr 1.4.0
## v readr   1.3.1     v forcats 0.5.0
```

```
## -- Conflicts ------------------------------------------------- tidyverse_conflicts() --
## x dplyr::filter() masks stats::filter()
## x dplyr::lag()    masks stats::lag()
```

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

```
## Loading required package: caret
```

```
## Loading required package: lattice
```

```
##
## Attaching package: 'caret'
```

```
## The following object is masked from 'package:purrr':
##
##     lift
```

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

```
## Loading required package: data.table
```

```
##
## Attaching package: 'data.table'
```

```
## The following objects are masked from 'package:dplyr':
##
##     between, first, last
```

```
## The following object is masked from 'package:purrr':
##
##     transpose
```

```
# 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 <- fread(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% of MovieLens data
set.seed(1, sample.kind="Rounding")
```

```
## Warning in set.seed(1, sample.kind = "Rounding"): non-uniform 'Rounding' sampler
## used
```

```
# if using R 3.5 or earlier, use `set.seed(1)` instead
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") %>%
  semi_join(edx, by = "genres")

# Add rows removed from validation set back into edx set
removed <- anti_join(temp, validation)
```

```
## Joining, by = c("userId", "movieId", "rating", "timestamp", "title", "genres")
```

```
edx <- rbind(edx, removed)
dim(edx)
```

```
## [1] 9000055       6
```

```
head(edx)
```

```
##   userId movieId rating timestamp                         title
## 1      1     122      5 838985046              Boomerang (1992)
## 2      1     185      5 838983525               Net, The (1995)
## 4      1     292      5 838983421               Outbreak (1995)
## 5      1     316      5 838983392               Stargate (1994)
## 6      1     329      5 838983392 Star Trek: Generations (1994)
## 7      1     355      5 838984474       Flintstones, The (1994)
##                          genres
## 1                Comedy|Romance
```

```
## 2         Action|Crime|Thriller
## 4  Action|Drama|Sci-Fi|Thriller
## 5       Action|Adventure|Sci-Fi
## 6 Action|Adventure|Drama|Sci-Fi
## 7       Children|Comedy|Fantasy
```

```
#Define train and test sets
# Test set will be 10% of edx data
set.seed(1, sample.kind="Rounding")
```

```
## Warning in set.seed(1, sample.kind = "Rounding"): non-uniform 'Rounding' sampler
## used
```

```
# if using R 3.5 or earlier, use `set.seed(1)` instead
test_index <- createDataPartition(y = edx$rating, times = 1, p = 0.1, list = FALSE)
train <- movielens[-test_index,]
temp <- movielens[test_index,]

# Make sure userId, movieId and genres in test set are also in train set
test <- temp %>%
  semi_join(train, by = "movieId") %>%
  semi_join(train, by = "userId") %>%
  semi_join(train, by = "genres")

# Add rows removed from validation set back into edx set
removed <- anti_join(temp, test)
```

```
## Joining, by = c("userId", "movieId", "rating", "timestamp", "title", "genres")
```

```
train <- rbind(train, removed)
```

```
#define RMSE function
RMSE <- function(true_ratings, predicted_ratings){
  sqrt(mean((true_ratings - predicted_ratings)^2))
}
```

```
#define mean rating
mu_hat <- mean(train$rating)
mu_hat
```

```
## [1] 3.512178
```

```
#rmse using mean rating
naive_rmse <- RMSE(test$rating, mu_hat)
naive_rmse
```

```
## [1] 1.060232
```

```
#evaluating movie effect
mu <- mean(train$rating)
movie_avgs <- train %>%
  group_by(movieId) %>%
  summarize(b_i = mean(rating - mu))

predicted_ratings <- mu + test %>%
  left_join(movie_avgs, by='movieId') %>%
  pull(b_i)
#rmse movie effect
```

```
movie_effect_rmse<-RMSE(predicted_ratings, test$rating)
#evaluating users effect
user_avgs <- train %>%
  group_by(userId) %>%
  summarize(b_u = mean(rating - mu))

predicted_ratings <- test %>%
  left_join(user_avgs, by='userId') %>%
  mutate(pred = mu + b_u) %>%
  pull(pred)
#rmse users effect
users_effect_rmse<-RMSE(predicted_ratings, test$rating)
#evaluating genre effect
genre_avgs <- train %>%
  group_by(genres) %>%
  summarize(b_g = mean(rating - mu))

predicted_ratings <- test %>%
  left_join(genre_avgs, by='genres') %>%
  mutate(pred = mu + b_g) %>%
  pull(pred)
#rmse genre effect
genre_effect_rmse<-RMSE(predicted_ratings, test$rating)

#evaluating combined movie, user and genre effects
user_avgs <- train %>%
  left_join(movie_avgs, by='movieId') %>%
  group_by(userId) %>%
  summarize(b_u = mean(rating - mu - b_i))

genre_avgs<-train %>%
  left_join(movie_avgs,by='movieId') %>%
  left_join(user_avgs,by='userId') %>%
  group_by(genres)%>%
  summarize(b_g=mean(rating-mu-b_i-b_u))

predicted_ratings <- test %>%
  left_join(movie_avgs, by='movieId') %>%
  left_join(user_avgs, by='userId') %>%
  left_join(genre_avgs,by='genres') %>%
  mutate(pred = mu + b_i + b_u + b_g) %>%
  pull(pred)
#rmse combined
movie_users_genre_effect_rmse<-RMSE(predicted_ratings, test$rating)

#table of results
rmse_results <- tibble(method = c("Just the average","Movie effect","Users effect","Genre effect","Movi

rmse_results
```

```
## # A tibble: 5 x 2
##   method                          RMSE
##   <chr>                          <dbl>
## 1 Just the average               1.06
```

```
## 2 Movie effect                  0.945
## 3 Users effect                  0.978
## 4 Genre effect                  1.02
## 5 Movie, users and genre effect 0.866
```

```
#REGULARIZATION
# define a cross-validation set for movies
set.seed(1, sample.kind="Rounding")
```

```
## Warning in set.seed(1, sample.kind = "Rounding"): non-uniform 'Rounding' sampler
## used
```

```
# if using R 3.5 or earlier, use `set.seed(1)` instead
test_index <- createDataPartition(y = train$rating, times = 1, p = 0.1, list = FALSE)
edx_1 <- train[-test_index,]
temp <- train[test_index,]

# Make sure userId and movieId in validation set are also in edx set
cross_validation <- temp %>%
  semi_join(edx_1, by = "movieId") %>%
  semi_join(edx_1, by = "userId") %>%
  semi_join(edx_1, by = "genres")

# Add rows removed from validation set back into edx set
removed <- anti_join(temp, cross_validation)
```

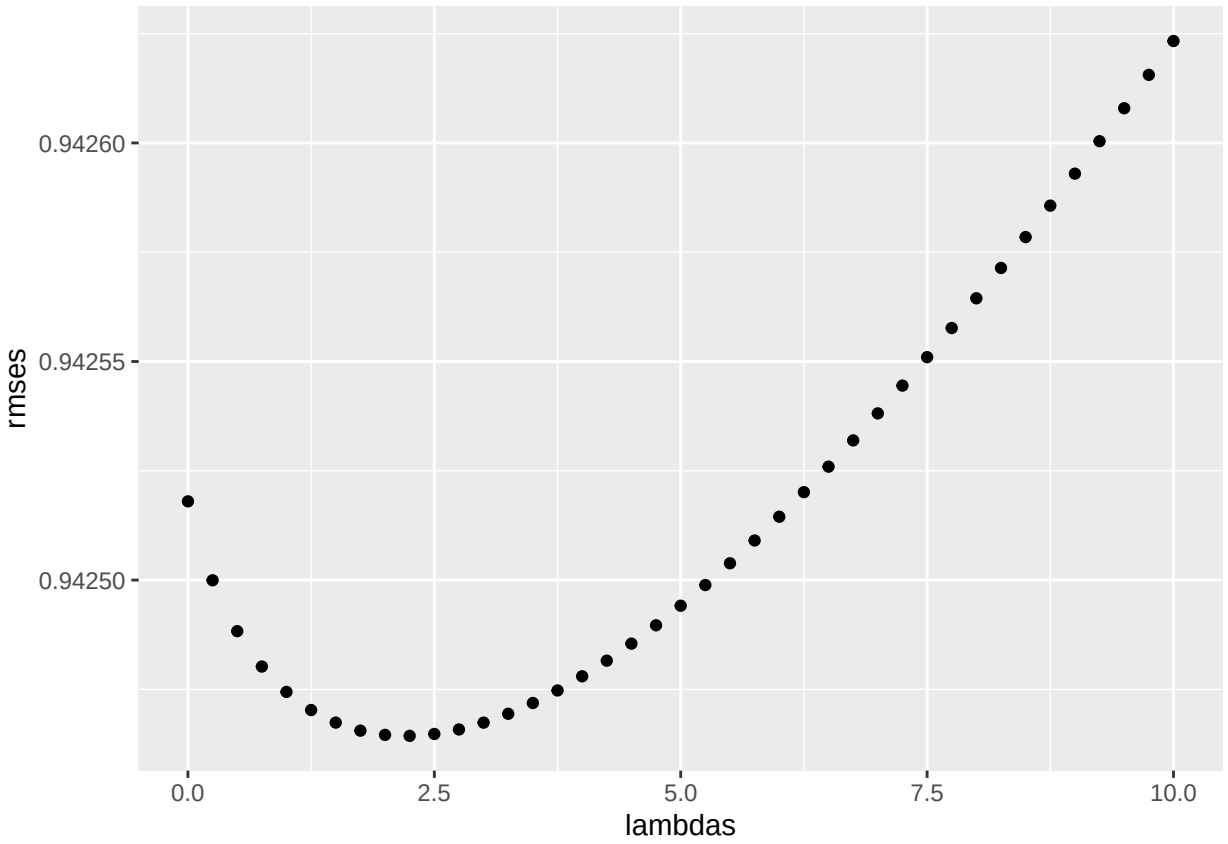
```
## Joining, by = c("userId", "movieId", "rating", "timestamp", "title", "genres")
```

```
edx_1 <- rbind(edx_1, removed)

#test values for lambda
lambdas <- seq(0, 10, 0.25)

mu <- mean(edx_1$rating)
just_the_sum <- edx_1 %>%
  group_by(movieId) %>%
  summarize(s = sum(rating - mu), n_i = n())

rmses <- sapply(lambdas, function(l){
  predicted_ratings <- cross_validation %>%
    left_join(just_the_sum, by='movieId') %>%
    mutate(b_i = s/(n_i+l)) %>%
    mutate(pred = mu + b_i) %>%
    pull(pred)
  return(RMSE(predicted_ratings, cross_validation$rating))
})
qplot(lambdas, rmses)
```




```
lambdas[which.min(rmses)]
```

```
## [1] 2.25
```

```
#now repeat for users


# cross-validation set
set.seed(1, sample.kind="Rounding")
```

```
## Warning in set.seed(1, sample.kind = "Rounding"): non-uniform 'Rounding' sampler
## used
```

```
# if using R 3.5 or earlier, use `set.seed(1)` instead
test_index <- createDataPartition(y = train$rating, times = 1, p = 0.1, list = FALSE)
edx_1 <- train[-test_index,]
temp <- train[test_index,]

# Make sure userId and movieId in validation set are also in edx set
cross_validation <- temp %>%
  semi_join(edx_1, by = "movieId") %>%
  semi_join(edx_1, by = "userId") %>%
  semi_join(edx_1, by ="genres")
# Add rows removed from validation set back into edx set
removed <- anti_join(temp, cross_validation)
```

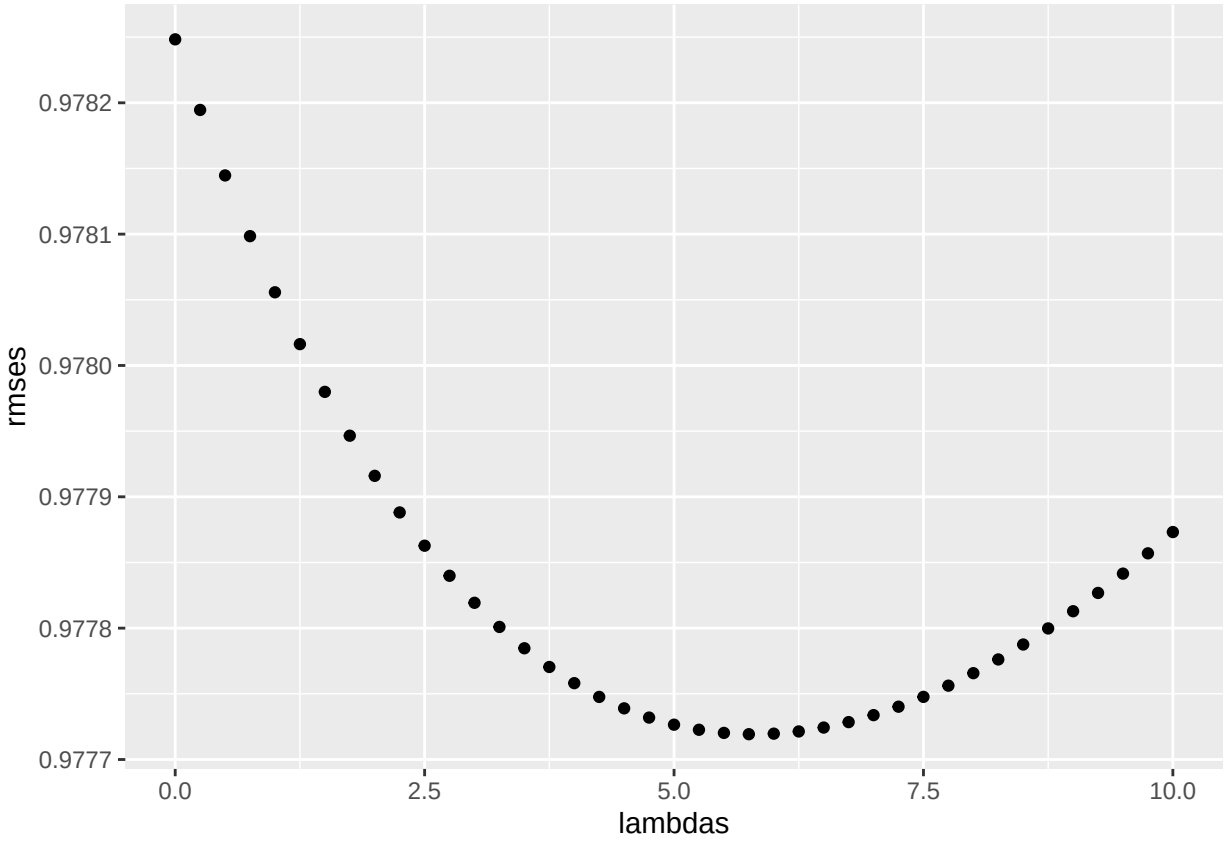
```
## Joining, by = c("userId", "movieId", "rating", "timestamp", "title", "genres")
```

```
edx_1 <- rbind(edx_1, removed)

lambdas <- seq(0, 10, 0.25)

mu <- mean(edx_1$rating)
just_the_sum <- edx_1 %>%
  group_by(userId) %>%
  summarize(s = sum(rating - mu), n_i = n())

rmses <- sapply(lambdas, function(l){
  predicted_ratings <- cross_validation %>%
    left_join(just_the_sum, by='userId') %>%
    mutate(b_u = s/(n_i+l)) %>%
    mutate(pred = mu + b_u) %>%
    pull(pred)
  return(RMSE(predicted_ratings, cross_validation$rating))
})
qplot(lambdas, rmses)
```




```
lambdas[which.min(rmses)]
```

```
## [1] 5.75
```

```
#now for genres
# cross-validation set
set.seed(1, sample.kind="Rounding")
```

```
## Warning in set.seed(1, sample.kind = "Rounding"): non-uniform 'Rounding' sampler
```

```
## used
```

```
# if using R 3.5 or earlier, use `set.seed(1)` instead
test_index <- createDataPartition(y = train$rating, times = 1, p = 0.1, list = FALSE)
edx_1 <- train[-test_index,]
temp <- train[test_index,]

# Make sure userId and movieId in validation set are also in edx set
cross_validation <- temp %>%
  semi_join(edx_1, by = "movieId") %>%
  semi_join(edx_1, by = "userId") %>%
  semi_join(edx_1, by="genres")

# Add rows removed from validation set back into edx set
removed <- anti_join(temp, cross_validation)
```

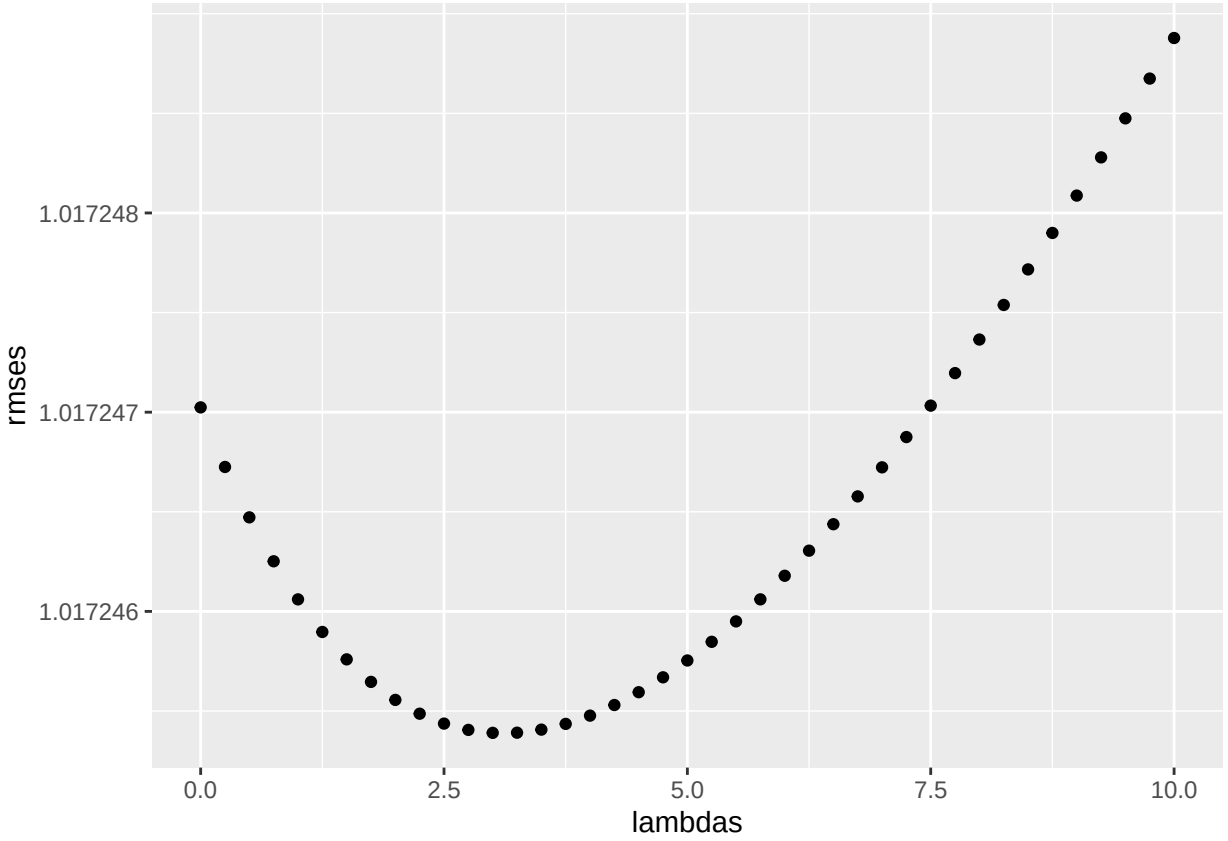
```
## Joining, by = c("userId", "movieId", "rating", "timestamp", "title", "genres")
```

```
edx_1 <- rbind(edx_1, removed)

lambdas <- seq(0, 10, 0.25)

mu <- mean(edx_1$rating)
just_the_sum <- edx_1 %>%
  group_by(genres) %>%
  summarize(s = sum(rating - mu), n_i = n())

rmses <- sapply(lambdas, function(l){
  predicted_ratings <- cross_validation %>%
    left_join(just_the_sum, by='genres') %>%
    mutate(b_g = s/(n_i+l)) %>%
    mutate(pred = mu + b_g) %>%
    pull(pred)
  return(RMSE(predicted_ratings, cross_validation$rating))
})
qplot(lambdas, rmses)
```




```
lambdas[which.min(rmses)]
```

```
## [1] 3
```

```
#to select the best lambda values, perform k-fold cross-validation with k=5
#first for movie
set.seed(1, sample.kind="Rounding")
```

```
## Warning in set.seed(1, sample.kind = "Rounding"): non-uniform 'Rounding' sampler
## used
```

```
k<-5

lambda_1<-replicate(k, {
          test_index <- createDataPartition(y = train$rating, times = 1, p = 0.1, list = FALSE)
          edx_1 <- train[-test_index,]
          temp <- train[test_index,]
          cross_validation <- temp %>%
          semi_join(edx_1, by = "movieId") %>%
          semi_join(edx_1, by = "userId") %>%
          semi_join(edx_1, by="genres")
          removed <- anti_join(temp, cross_validation)
          edx_1 <- rbind(edx_1, removed)
          lambdas <- seq(0, 10, 0.25)
          mu <- mean(edx_1$rating)
          just_the_sum <- edx_1 %>%
          group_by(movieId) %>%
          summarize(s = sum(rating - mu), n_i = n())
          rmses <- sapply(lambdas, function(l){
```

```
          predicted_ratings <- cross_validation %>%
          left_join(just_the_sum, by='movieId') %>%
          mutate(b_i = s/(n_i+l)) %>%
          mutate(pred = mu + b_i) %>%
          pull(pred)
          return(RMSE(predicted_ratings, cross_validation$rating))
          })
          qplot(lambdas, rmses)
          lambdas[which.min(rmses)]
})
```

```
## Joining, by = c("userId", "movieId", "rating", "timestamp", "title", "genres")
## Joining, by = c("userId", "movieId", "rating", "timestamp", "title", "genres")
## Joining, by = c("userId", "movieId", "rating", "timestamp", "title", "genres")
## Joining, by = c("userId", "movieId", "rating", "timestamp", "title", "genres")
## Joining, by = c("userId", "movieId", "rating", "timestamp", "title", "genres")
```

```
l_1<-mean(lambda_1)
l_1
```

```
## [1] 2.3
```

```
#now for users
# cross-validation set
set.seed(1, sample.kind="Rounding")
```

```
## Warning in set.seed(1, sample.kind = "Rounding"): non-uniform 'Rounding' sampler
## used
```

```
# if using R 3.5 or earlier, use `set.seed(1)` instead

k<-5
lambda_2<-replicate(k, {
  test_index <- createDataPartition(y = train$rating, times = 1, p = 0.1, list = FALSE)
  edx_1 <- train[-test_index,]
  temp <- train[test_index,]
  cross_validation <- temp %>%
  semi_join(edx_1, by = "movieId") %>%
  semi_join(edx_1, by = "userId") %>%
  semi_join(edx_1, by="genres")
  removed <- anti_join(temp, cross_validation)
  edx_1 <- rbind(edx_1, removed)
  lambdas <- seq(0, 10, 0.25)
  mu <- mean(edx_1$rating)
  just_the_sum <- edx_1 %>%
  group_by(userId) %>%
  summarize(s = sum(rating - mu), n_i = n())
  rmses <- sapply(lambdas, function(l){
  predicted_ratings <- cross_validation %>%
    left_join(just_the_sum, by='userId') %>%
    mutate(b_u = s/(n_i+l)) %>%
    mutate(pred = mu + b_u) %>%
    pull(pred)
  return(RMSE(predicted_ratings, cross_validation$rating))
  })
  lambdas[which.min(rmses)]
```

```
})
```

```
## Joining, by = c("userId", "movieId", "rating", "timestamp", "title", "genres")
## Joining, by = c("userId", "movieId", "rating", "timestamp", "title", "genres")
## Joining, by = c("userId", "movieId", "rating", "timestamp", "title", "genres")
## Joining, by = c("userId", "movieId", "rating", "timestamp", "title", "genres")
## Joining, by = c("userId", "movieId", "rating", "timestamp", "title", "genres")
```

```
l_2<-mean(lambda_2)
l_2
```

```
## [1] 5.55
```

```
#then for genres

# cross-validation set
set.seed(1, sample.kind="Rounding")
```

```
## Warning in set.seed(1, sample.kind = "Rounding"): non-uniform 'Rounding' sampler
## used
```

```
# if using R 3.5 or earlier, use `set.seed(1)` instead

k<-5
lambda_3<-replicate(k, {
  test_index <- createDataPartition(y = train$rating, times = 1, p = 0.1, list = FALSE)
  edx_1 <- train[-test_index,]
  temp <- train[test_index,]
  cross_validation <- temp %>%
  semi_join(edx_1, by = "movieId") %>%
  semi_join(edx_1, by = "userId") %>%
  semi_join(edx_1, by="genres")
  removed <- anti_join(temp, cross_validation)
  edx_1 <- rbind(edx_1, removed)
  lambdas <- seq(0, 10, 0.25)
  mu <- mean(edx_1$rating)
  just_the_sum <- edx_1 %>%
  group_by(genres) %>%
  summarize(s = sum(rating - mu), n_i = n())
  rmses <- sapply(lambdas, function(l){
  predicted_ratings <- cross_validation %>%
    left_join(just_the_sum, by='genres') %>%
    mutate(b_g = s/(n_i+l)) %>%
    mutate(pred = mu + b_g) %>%
    pull(pred)
  return(RMSE(predicted_ratings, cross_validation$rating))
  })
  lambdas[which.min(rmses)]
})
```

```
## Joining, by = c("userId", "movieId", "rating", "timestamp", "title", "genres")
## Joining, by = c("userId", "movieId", "rating", "timestamp", "title", "genres")
## Joining, by = c("userId", "movieId", "rating", "timestamp", "title", "genres")
## Joining, by = c("userId", "movieId", "rating", "timestamp", "title", "genres")
## Joining, by = c("userId", "movieId", "rating", "timestamp", "title", "genres")
```

```
l_3<-mean(lambda_3)
l_3
```

```
## [1] 2.7
```

```
#now do regularization with the values l_1, l_2, l_3

mu <- mean(train$rating)

b_i <- train %>%
  group_by(movieId) %>%
  summarize(b_i = sum(rating - mu)/(n()+l_1))

b_u <- train %>%
  left_join(b_i, by="movieId") %>%
  group_by(userId) %>%
  summarize(b_u = sum(rating - b_i - mu)/(n()+l_2))

b_g <- train %>%
  left_join(b_u, by="userId") %>%
  left_join(b_i, by="movieId")%>%
  group_by(genres) %>%
  summarize(b_g = sum(rating - b_i - b_u - mu)/(n()+l_3))


predicted_ratings <-
  test %>%
  left_join(b_i, by = "movieId") %>%
  left_join(b_u, by = "userId") %>%
  left_join(b_g, by="genres")%>%
  mutate(pred = mu + b_i + b_u+b_g) %>%
  pull(pred)

regularized_movie_user_genre_rmse<-RMSE(predicted_ratings, test$rating)

regularized_movie_user_genre_rmse
```

```
## [1] 0.8651669
```

```
#write results

rmse_results <- tibble(method = c("Just the average","Movie effect","Users effect","Genre effect","Movi

rmse_results
```

```
## # A tibble: 6 x 2
##   method                          RMSE
##   <chr>                          <dbl>
## 1 Just the average               1.06
## 2 Movie effect                   0.945
## 3 Users effect                   0.978
## 4 Genre effect                   1.02
## 5 Movie, users and genre effect 0.866
## 6 Regularized                    0.865
```

```r
#now check the best RMSE with validation set

mu <- mean(edx$rating)

b_i <- edx %>%
  group_by(movieId) %>%
  summarize(b_i = sum(rating - mu)/(n()+l_1))

b_u <- edx %>%
  left_join(b_i, by="movieId") %>%
  group_by(userId) %>%
  summarize(b_u = sum(rating - b_i - mu)/(n()+l_2))

b_g <- edx %>%
  left_join(b_u, by="userId") %>%
  left_join(b_i, by="movieId")%>%
  group_by(genres) %>%
  summarize(b_g = sum(rating - b_i - b_u - mu)/(n()+l_3))


predicted_ratings <-
  validation %>%
  left_join(b_i, by = "movieId") %>%
  left_join(b_u, by = "userId") %>%
  left_join(b_g, by="genres")%>%
  mutate(pred = mu + b_i + b_u+b_g) %>%
  pull(pred)

regularized_movie_user_genre_rmse_check<-RMSE(predicted_ratings, validation$rating)

regularized_movie_user_genre_rmse_check
```

```
## [1] 0.8644875
```