TRABALHO DE IAA005 – Estatística Aplicada II

Equipe 03:

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1 Regressões Ridge, Lasso e ElasticNet

Instalando e carregando os pacotes necessários.

```
## Loading required package: plyr
```

```
## Loading required package: readr
```

```
## Loading required package: dplyr
```

```
##
## Attaching package: 'dplyr'
```

```
## The following objects are masked from 'package:plyr':
##
##     arrange, count, desc, failwith, id, mutate, rename, summarise,
##     summarize
```

```
## The following objects are masked from 'package:stats':
##
##     filter, lag
```

```
## The following objects are masked from 'package:base':
##
##     intersect, setdiff, setequal, union
```

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

```
## Loading required package: ggplot2
```

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

```
## Loading required package: repr
```

```
## Loading required package: glmnet
```

```
## Loading required package: Matrix
```

```
## Loaded glmnet 4.1-8
```

```
##    plyr   readr   dplyr   caret ggplot2    repr  glmnet
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
```

Carregando a base de dados.

```
load("trabalhosalarios.RData")

glimpse(trabalhosalarios)
```

```
## Rows: 2,574
## Columns: 17
## $ husage   <dbl> 56, 31, 33, 34, 42, 45, 33, 31, 31, 44, 45, 22, 66, 43, 26, 3~
## $ husunion <dbl> 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0~
## $ husearns <dbl> 1500, 800, 950, 1000, 730, 1154, 1350, 769, 340, 750, 1200, 2~
## $ huseduc  <dbl> 14, 17, 13, 14, 14, 16, 16, 18, 12, 12, 12, 12, 16, 12, 14, 1~
## $ husblck  <dbl> 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0~
## $ hushisp  <dbl> 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0~
## $ hushrs   <dbl> 40, 40, 60, 50, 40, 38, 40, 55, 40, 40, 50, 40, 40, 50, 36, 5~
## $ kidge6   <dbl> 1, 0, 0, 1, 1, 1, 0, 0, 0, 1, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0~
## $ earns    <dbl> 100, 480, 455, 102, 300, 425, 770, 125, 245, 539, 300, 299, 5~
## $ age      <dbl> 49, 29, 30, 31, 41, 45, 32, 27, 30, 42, 42, 23, 55, 31, 27, 3~
## $ black    <dbl> 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0~
## $ educ     <dbl> 12, 14, 12, 12, 12, 18, 12, 14, 15, 12, 12, 13, 12, 12, 14, 1~
## $ hispanic <dbl> 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0~
## $ union    <dbl> 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 0~
## $ exper    <dbl> 31, 9, 12, 13, 23, 21, 14, 7, 9, 24, 24, 4, 37, 13, 7, 12, 31~
## $ kidlt6   <dbl> 0, 0, 1, 0, 0, 0, 0, 1, 1, 0, 0, 0, 0, 0, 0, 1, 0, 1, 1, 0, 1~
## $ lwage    <dbl> 1.897120, 2.484907, 2.431418, 1.629241, 2.302585, 2.496741, 2~
```

Visualizando estatisticas do DF.

```
summary(trabalhosalarios)
```

```
##      husage         husunion         husearns         huseduc
##  Min.   :19.00   Min.   :0.0000   Min.   :  27.0   Min.   : 0.00
##  1st Qu.:32.00   1st Qu.:0.0000   1st Qu.: 380.0   1st Qu.:12.00
##  Median :39.00   Median :0.0000   Median : 538.0   Median :13.00
##  Mean   :40.22   Mean   :0.2218   Mean   : 605.6   Mean   :13.49
##  3rd Qu.:47.00   3rd Qu.:0.0000   3rd Qu.: 750.0   3rd Qu.:16.00
##  Max.   :69.00   Max.   :1.0000   Max.   :1923.0   Max.   :18.00
##     husblck           hushisp            hushrs          kidge6
##  Min.   :0.00000   Min.   :0.00000   Min.   : 0.00   Min.   :0.0000
##  1st Qu.:0.00000   1st Qu.:0.00000   1st Qu.:40.00   1st Qu.:0.0000
##  Median :0.00000   Median :0.00000   Median :40.00   Median :0.0000
##  Mean   :0.06566   Mean   :0.05167   Mean   :42.44   Mean   :0.3481
##  3rd Qu.:0.00000   3rd Qu.:0.00000   3rd Qu.:50.00   3rd Qu.:1.0000
##  Max.   :1.00000   Max.   :1.00000   Max.   :99.00   Max.   :1.0000
```

```
##      earns             age            black              educ
##  Min.   :   1.0   Min.   :18.00   Min.   :0.00000   Min.   : 0.00
##  1st Qu.: 204.0   1st Qu.:31.00   1st Qu.:0.00000   1st Qu.:12.00
##  Median : 325.0   Median :37.00   Median :0.00000   Median :13.00
##  Mean   : 371.0   Mean   :37.96   Mean   :0.06371   Mean   :13.46
##  3rd Qu.: 485.8   3rd Qu.:44.00   3rd Qu.:0.00000   3rd Qu.:16.00
##  Max.   :2884.5   Max.   :59.00   Max.   :1.00000   Max.   :18.00
##     hispanic           union            exper          kidlt6
##  Min.   :0.00000   Min.   :0.0000   Min.   : 0.0   Min.   :0.0000
##  1st Qu.:0.00000   1st Qu.:0.0000   1st Qu.:11.0   1st Qu.:0.0000
##  Median :0.00000   Median :0.0000   Median :18.0   Median :0.0000
##  Mean   :0.05556   Mean   :0.1461   Mean   :18.5   Mean   :0.2545
##  3rd Qu.:0.00000   3rd Qu.:0.0000   3rd Qu.:25.0   3rd Qu.:1.0000
##  Max.   :1.00000   Max.   :1.0000   Max.   :44.0   Max.   :1.0000
##      lwage
##  Min.   :-3.401
##  1st Qu.: 1.851
##  Median : 2.169
##  Mean   : 2.197
##  3rd Qu.: 2.526
##  Max.   : 4.278
```

Particionamento do dataset, 80% para treinamento e 20% para teste.

```
indexes <- sample(1:nrow(trabalhosalarios), 0.8*nrow(trabalhosalarios))

train <- trabalhosalarios[indexes,]
test <- trabalhosalarios[-indexes,]
```

Padronização de variáveis, excluindo as binárias. normalização Z-score: “center”: centraliza os dados, subtraindo a média de cada variável. “scale”: normaliza os dados, dividindo pelo desvio padrão.

```
non_binary_columns = c('husage', 'husearns', 'huseduc', 'hushrs', 'earns', 'age', 'educ', 'exper', 'lwage')

# os parâmetros de padronização consideram apenas o conjuto de treinamento pois o modelo aprenderá a transformação apenas com os dados conhec
pre_process_normalization_object = caret::preProcess(train[,non_binary_columns], method=c("center", "scale"))

# aplica os parâmentos de normalização nos dados
train[, non_binary_columns] = predict(pre_process_normalization_object, train[,non_binary_columns])
test[, non_binary_columns] = predict(pre_process_normalization_object, test[,non_binary_columns])

print('Visualizando estatisticas da base de trainamento.')
```

```
## [1] "Visualizando estatisticas da base de trainamento."
```

```
summary(train)
```

```
##      husage           husunion         husearns          huseduc
##  Min.   :-2.1039   Min.   :0.0000   Min.   :-1.7145   Min.   :-5.0191
```

```
##  1st Qu.:-0.8087   1st Qu.:0.0000   1st Qu.:-0.6615   1st Qu.:-0.5568
##  Median :-0.1113   Median :0.0000   Median :-0.2166   Median :-0.1849
##  Mean   : 0.0000   Mean   :0.2205   Mean   : 0.0000   Mean   : 0.0000
##  3rd Qu.: 0.6857   3rd Qu.:0.0000   3rd Qu.: 0.4212   3rd Qu.: 0.9306
##  Max.   : 2.8775   Max.   :1.0000   Max.   : 3.9006   Max.   : 1.6744
##     husblck           hushisp            hushrs            kidge6
##  Min.   :0.00000   Min.   :0.00000   Min.   :-3.3291   Min.   :0.0000
##  1st Qu.:0.00000   1st Qu.:0.00000   1st Qu.:-0.1961   1st Qu.:0.0000
##  Median :0.00000   Median :0.00000   Median :-0.1961   Median :0.0000
##  Mean   :0.06217   Mean   :0.04905   Mean   : 0.0000   Mean   :0.3439
##  3rd Qu.:0.00000   3rd Qu.:0.00000   3rd Qu.: 0.5871   3rd Qu.:1.0000
##  Max.   :1.00000   Max.   :1.00000   Max.   : 4.4250   Max.   :1.0000
##      earns              age               black             educ
##  Min.   :-1.5221   Min.   :-2.12418   Min.   :0.00000   Min.   :-5.6264
##  1st Qu.:-0.7105   1st Qu.:-0.83944   1st Qu.:0.00000   1st Qu.:-0.6265
##  Median :-0.2110   Median :-0.09001   Median :0.00000   Median :-0.2098
##  Mean   : 0.0000   Mean   : 0.00000   Mean   :0.06022   Mean   : 0.0000
##  3rd Qu.: 0.4966   3rd Qu.: 0.65943   3rd Qu.:0.00000   3rd Qu.: 1.0401
##  Max.   :10.4631   Max.   : 2.26536   Max.   :1.00000   Max.   : 1.8734
##     hispanic           union             exper             kidlt6
##  Min.   :0.00000   Min.   :0.0000   Min.   :-1.89545   Min.   :0.0000
##  1st Qu.:0.00000   1st Qu.:0.0000   1st Qu.:-0.86181   1st Qu.:0.0000
##  Median :0.00000   Median :0.0000   Median :-0.03489   Median :0.0000
##  Mean   :0.05148   Mean   :0.1481   Mean   : 0.00000   Mean   :0.2545
##  3rd Qu.:0.00000   3rd Qu.:0.0000   3rd Qu.: 0.68866   3rd Qu.:1.0000
##  Max.   :1.00000   Max.   :1.0000   Max.   : 2.65259   Max.   :1.0000
##      lwage
##  Min.   :-4.78007
##  1st Qu.:-0.69165
##  Median :-0.05973
##  Mean   : 0.00000
##  3rd Qu.: 0.65187
##  Max.   : 4.11492
```

```
print('Visualizando estatisticas da base de test.')
```

```
## [1] "Visualizando estatisticas da base de test."
```

```
summary(test)
```

```
##      husage            husunion         husearns           huseduc
##  Min.   :-1.80501   Min.   :0.0000   Min.   :-1.72343   Min.   :-5.0191
##  1st Qu.:-0.70910   1st Qu.:0.0000   1st Qu.:-0.72231   1st Qu.:-0.5568
##  Median :-0.01171   Median :0.0000   Median :-0.20173   Median :-0.1849
##  Mean   : 0.05078   Mean   :0.2272   Mean   :-0.03584   Mean   :-0.0167
##  3rd Qu.: 0.68568   3rd Qu.:0.0000   3rd Qu.: 0.42118   3rd Qu.: 0.9306
##  Max.   : 2.47898   Max.   :1.0000   Max.   : 3.90062   Max.   : 1.6744
##     husblck           hushisp            hushrs            kidge6
```

```
##  Min.   :0.00000   Min.   :0.00000   Min.   :-3.32913   Min.   :0.000
##  1st Qu.:0.00000   1st Qu.:0.00000   1st Qu.:-0.19614   1st Qu.:0.000
##  Median :0.00000   Median :0.00000   Median :-0.19614   Median :0.000
##  Mean   :0.07961   Mean   :0.06214   Mean   :-0.02625   Mean   :0.365
##  3rd Qu.:0.00000   3rd Qu.:0.00000   3rd Qu.: 0.46963   3rd Qu.:1.000
##  Max.   :1.00000   Max.   :1.00000   Max.   : 4.42503   Max.   :1.000
##      earns                age               black              educ
##  Min.   :-1.538766   Min.   :-1.91006   Min.   :0.00000   Min.   :-5.62636
##  1st Qu.:-0.668853   1st Qu.:-0.73238   1st Qu.:0.00000   1st Qu.:-0.62650
##  Median :-0.148570   Median : 0.01706   Median :0.00000   Median :-0.62650
##  Mean   : 0.005482   Mean   : 0.06404   Mean   :0.07767   Mean   :-0.09496
##  3rd Qu.: 0.452877   3rd Qu.: 0.76649   3rd Qu.:0.00000   3rd Qu.: 0.62347
##  Max.   : 5.949147   Max.   : 2.26536   Max.   :1.00000   Max.   : 1.87343
##     hispanic           union             exper              kidlt6
##  Min.   :0.00000   Min.   :0.0000   Min.   :-1.79209   Min.   :0.0000
##  1st Qu.:0.00000   1st Qu.:0.0000   1st Qu.:-0.65508   1st Qu.:0.0000
##  Median :0.00000   Median :0.0000   Median :-0.03489   Median :0.0000
##  Mean   :0.07184   Mean   :0.1379   Mean   : 0.08533   Mean   :0.2544
##  3rd Qu.:0.00000   3rd Qu.:0.0000   3rd Qu.: 0.74034   3rd Qu.:1.0000
##  Max.   :1.00000   Max.   :1.0000   Max.   : 2.44586   Max.   :1.0000
##      lwage
##  Min.   :-11.060110
##  1st Qu.: -0.635121
##  Median : -0.041678
##  Mean   :  0.008121
##  3rd Qu.:  0.651875
##  Max.   :  4.027740
```

Regressão Ridge

Realizando o one-hot encoding das variáveis categoricas, para este caso já estão no formato one-hot.

Criando as matrizes de treinamento, e test e vetores da variáveis dependente de treinamento e teste.

```
cols_reg <- c('husage', 'husearns', 'huseduc', 'hushrs', 'earns', 'age', 'educ', 'exper','lwage',
              'husunion', 'husblck', 'hushisp', 'kidge6', 'black', 'hispanic',
              'union', 'kidlt6')

one_hot_encoding <- dummyVars(lwage~husage+husearns+huseduc+hushrs+
                        earns+age+educ+exper+husunion+husblck+hushisp+
                        kidge6+black+hispanic+union+kidlt6,
                      data = trabalhosalarios[,cols_reg])
train_encoded = predict(one_hot_encoding, newdata = train[,cols_reg])
test_encoded = predict(one_hot_encoding, newdata = test[,cols_reg])

x_train = as.matrix(train_encoded)
y_train = train$lwage
```

```r
x_test = as.matrix(test_encoded)
y_test = test$lwage
```

Calculando o melhor lambda

```r
lambdas <- 10^seq(2, -3, by = -.1)

# Calculando o lambda:
ridge_lamb <- cv.glmnet(x_train, y_train, alpha = 0, lambda = lambdas)

best_lambda_ridge <- ridge_lamb$lambda.min
cat('Melhor parâmetro lambda para o modelo Ridge: ', best_lambda_ridge, '\n\n')
```

```
## Melhor parâmetro lambda para o modelo Ridge:  0.01258925
```

Treinando o modelo Ridge

```r
ridge_reg = glmnet(x_train, y_train, nlambda = 25, alpha = 0,
                   family = 'gaussian',
                   lambda = best_lambda_ridge)
```

Parâmetros do modelo treinado

```r
ridge_reg[["beta"]]
```

```
## 16 x 1 sparse Matrix of class "dgCMatrix"
##                    s0
## husage    0.016897671
## husearns  0.077988172
## huseduc   0.017610106
## hushrs   -0.021516851
## earns     0.739945837
## age       0.019953989
## educ      0.104154253
## exper    -0.005149851
## husunion  0.056497871
## husblck   0.183482999
## hushisp  -0.022770546
## kidge6    0.006206444
## black    -0.247993955
## hispanic -0.100458809
## union     0.092112223
## kidlt6    0.123228163
```

```r
eval_results <- function(true, predicted, df, modelName, phase) {
  SSE <- sum((predicted - true)^2)
  SST <- sum((true - mean(true))^2)
  R_square <- 1 - SSE / SST
  RMSE = sqrt(SSE/nrow(df))
```

```
  # As metricas de performace do modelo:
  data.frame(
    ModelName = modelName,
    Phase = phase,
    RMSE = RMSE,
    Rsquare = R_square
  )
}
```

Estatisticas do modelo Ridge na base de treinamento e teste.

```
models_stats <- data.frame(
  ModelName = character(),
  Phase = character(),
  RMSE = numeric(),
  Rsquare = numeric(),
  stringsAsFactors = FALSE
)

predictions_train <- predict(ridge_reg,
                             s = best_lambda_ridge,
                             newx = x_train)

ridge_train_eval_results <- eval_results(y_train, predictions_train, train, 'Ridge', 'train')
models_stats <- rbind(models_stats, ridge_train_eval_results)

predictions_test <- predict(ridge_reg,
                            s = best_lambda_ridge,
                            newx = x_test)

ridge_test_eval_results = eval_results(y_test, predictions_test, test, 'Ridge', 'test')
models_stats <- rbind(models_stats, ridge_test_eval_results)

models_stats
```

```
##   ModelName Phase      RMSE   Rsquare
## 1     Ridge train 0.5346936 0.7139639
## 2     Ridge  test 0.7113684 0.6169343
```

Criando o dataframe de predição para e realizando a normalização.

```
predicao_df <- trabalhosalarios[0, ]

predicao_df <- data.frame(
  husage=40,
  husunion=0,
  husearns=600,
```

```
  huseduc=13,
  husblck=1,
  hushisp=0,
  hushrs=40,
  kidge6=1,
  earns=600,
  age=38,
  black=0,
  educ=13,
  hispanic=1,
  union=0,
  exper=18,
  kidlt6=1,
  lwage=0
)

predicao_df[, non_binary_columns] = predict(pre_process_normalization_object, predicao_df[,non_binary_columns])

summary(predicao_df)
```

```
##      husage            husunion    husearns           huseduc
##  Min.   :-0.01171   Min.   :0   Min.   :-0.02376   Min.   :-0.1849
##  1st Qu.:-0.01171   1st Qu.:0   1st Qu.:-0.02376   1st Qu.:-0.1849
##  Median :-0.01171   Median :0   Median :-0.02376   Median :-0.1849
##  Mean   :-0.01171   Mean   :0   Mean   :-0.02376   Mean   :-0.1849
##  3rd Qu.:-0.01171   3rd Qu.:0   3rd Qu.:-0.02376   3rd Qu.:-0.1849
##  Max.   :-0.01171   Max.   :0   Max.   :-0.02376   Max.   :-0.1849
##     husblck     hushisp      hushrs            kidge6      earns
##  Min.   :1   Min.   :0   Min.   :-0.1961   Min.   :1   Min.   :0.9544
##  1st Qu.:1   1st Qu.:0   1st Qu.:-0.1961   1st Qu.:1   1st Qu.:0.9544
##  Median :1   Median :0   Median :-0.1961   Median :1   Median :0.9544
##  Mean   :1   Mean   :0   Mean   :-0.1961   Mean   :1   Mean   :0.9544
##  3rd Qu.:1   3rd Qu.:0   3rd Qu.:-0.1961   3rd Qu.:1   3rd Qu.:0.9544
##  Max.   :1   Max.   :0   Max.   :-0.1961   Max.   :1   Max.   :0.9544
##       age              black        educ            hispanic     union
##  Min.   :0.01706   Min.   :0   Min.   :-0.2098   Min.   :1   Min.   :0
##  1st Qu.:0.01706   1st Qu.:0   1st Qu.:-0.2098   1st Qu.:1   1st Qu.:0
##  Median :0.01706   Median :0   Median :-0.2098   Median :1   Median :0
##  Mean   :0.01706   Mean   :0   Mean   :-0.2098   Mean   :1   Mean   :0
##  3rd Qu.:0.01706   3rd Qu.:0   3rd Qu.:-0.2098   3rd Qu.:1   3rd Qu.:0
##  Max.   :0.01706   Max.   :0   Max.   :-0.2098   Max.   :1   Max.   :0
##      exper              kidlt6      lwage
##  Min.   :-0.03489   Min.   :1   Min.   :-4.339
##  1st Qu.:-0.03489   1st Qu.:1   1st Qu.:-4.339
##  Median :-0.03489   Median :1   Median :-4.339
##  Mean   :-0.03489   Mean   :1   Mean   :-4.339
```

```
##  3rd Qu.:-0.03489   3rd Qu.:1   3rd Qu.:-4.339
##  Max.   :-0.03489   Max.   :1   Max.   :-4.339
```

Realização da predição no modelo ridge

```
pred_matrix <- as.matrix(predicao_df[,!(names(predicao_df) %in% "lwage")])

pred_ridge <- predict(ridge_reg, s=best_lambda_ridge, newx = pred_matrix)

cat("Predição Ridge padronizada:", pred_ridge, "\n")
```

```
## Predição Ridge padronizada: 0.5957217
```

```
lwage_pred_ridge=(pred_ridge*
                  pre_process_normalization_object[["std"]][["lwage"]])+
                  pre_process_normalization_object[["mean"]][["lwage"]]

cat("Predição Ridge valor nominal porém ainda em logaritmo:", lwage_pred_ridge, "\n")
```

```
## Predição Ridge valor nominal porém ainda em logaritmo: 2.497312
```

```
#antilog
cat("Predição Ridge valor em dólares:", exp(lwage_pred_ridge), "\n")
```

```
## Predição Ridge valor em dólares: 12.14979
```

Calculando os intervalos de confiança

```
calculate_intervals <- function(pred, modelName){
  n <- nrow(train)
  m <- pred
  s <- pre_process_normalization_object[["std"]][["lwage"]]
  dam <- s / sqrt(n)
  z <- qnorm(0.025)
  cilwr <- m + z * dam
  ciupper <- m - z * dam

  cat("Para o modelo", modelName, "o intervalo de confiança inferior é de: USD", exp(cilwr),"\n" )
  cat("Para o modelo", modelName, "o intervalo de confiança superior é de: USD", exp(ciupper),"\n" )
}
```

```
calculate_intervals(lwage_pred_ridge, 'Ridge')
```

```
## Para o modelo Ridge o intervalo de confiança inferior é de: USD 11.8871
## Para o modelo Ridge o intervalo de confiança superior é de: USD 12.41829
```

Interpretação: O salário hora da a esposa é em média USD 12.15 e pode variar entre USD 11.88 a USD 12.42 com 95% de confiança. O modelo Ridge, mantendo todas as variáveis, apresentou uma boa capacidade de generalização e foi consistente entre treinamento e teste. A penalização L2 contribuiu para evitar overfitting.

Regressão Lasso

```
# Calculando o lambda:
lasso_lamb <- cv.glmnet(x_train, y_train, alpha = 1, lambda = lambdas, standardize = TRUE, nfolds = 5)

best_lambda_lasso <- lasso_lamb$lambda.min
cat('Melhor parâmetro lambda para o modelo Lasso: ', best_lambda_lasso, '\n\n')
```

```
## Melhor parâmetro lambda para o modelo Lasso:  0.001584893
```

```
lasso_reg <- glmnet(x_train, y_train, alpha = 1,
                    lambda = best_lambda_lasso,
                    standardize = TRUE)

lasso_reg[["beta"]]
```

```
## 16 x 1 sparse Matrix of class "dgCMatrix"
##                    s0
## husage     0.01518725
## husearns   0.07578203
## huseduc    0.01524764
## hushrs    -0.01932864
## earns      0.75055695
## age        0.01427042
## educ       0.10331803
## exper      .
## husunion   0.05509532
## husblck    0.11496351
## hushisp   -0.01784389
## kidge6     0.00362059
## black     -0.17793067
## hispanic  -0.10106573
## union      0.08558302
## kidlt6     0.11819250
```

```
predictions_lasso_train <- predict(lasso_reg,
                           s = best_lambda_lasso,
                           newx = x_train)


lasso_train_eval_results <- eval_results(y_train, predictions_lasso_train, train, 'Lasso', 'train')
models_stats <- rbind(models_stats, lasso_train_eval_results)

predictions_lasso_test <- predict(lasso_reg,
                          s = best_lambda_lasso,
                          newx = x_test)

lasso_test_eval_results <- eval_results(y_test, predictions_lasso_test, test, 'Lasso', 'test')
```

```r
models_stats <- rbind(models_stats, lasso_test_eval_results)

models_stats
```

```
##   ModelName Phase      RMSE   Rsquare
## 1     Ridge train 0.5346936 0.7139639
## 2     Ridge  test 0.7113684 0.6169343
## 3     Lasso train 0.5346985 0.7139586
## 4     Lasso  test 0.7101215 0.6182760
```

```r
pred_lasso <- predict(lasso_reg, s=best_lambda_lasso, newx = pred_matrix)

cat("Predição Lasso padronizada:", pred_lasso, "\n")
```

```
## Predição Lasso padronizada: 0.6778859
```

```r
lwage_pred_lasso=(pred_lasso*
                  pre_process_normalization_object[["std"]][["lwage"]])+
                  pre_process_normalization_object[["mean"]][["lwage"]]

cat("Predição Lasso valor nominal porém ainda em logaritmo:", lwage_pred_lasso, "\n")
```

```
## Predição Lasso valor nominal porém ainda em logaritmo: 2.538892
```

```r
#antilog
cat("Predição Lasso valor em dólares:", exp(lwage_pred_lasso), "\n")
```

```
## Predição Lasso valor em dólares: 12.66563
```

```r
calculate_intervals(lwage_pred_lasso, 'Lasso')
```

```
## Para o modelo Lasso o intervalo de confiança inferior é de: USD 12.39178
## Para o modelo Lasso o intervalo de confiança superior é de: USD 12.94553
```

Interpretação: O salário hora da a esposa é em média USD 12.67 e pode variar entre USD 12.40 e USD 12.95 com 95% de confiança. O modelo Lasso apresentou desempenho muito próximo ao Ridge, como pode ser visto acima o modelo Lasso fez a seleção de variáveis, a penalização L1 foi utilizada para zerar coeficientes não significativos, para este caso foi excluido a variavel 'exper'.

Comparado ao modelo Ridge teve um desempenho muito semelhante, houve uma pequena melhora no R^2 de teste, mostrando que a exclusão da váriavel 'exper' não prejudicou o ajuste do modelo.

Regressão ElasticNet

```r
elasticnet_train_control <- trainControl(method = "repeatedcv",
                           number = 10,
                           repeats = 5,
                           search = "random",
                           verboseIter = TRUE)

elastic_reg <- train(lwage~husage+husearns+huseduc+hushrs+
```

```
                      earns+age+educ+exper+husunion+husblck+hushisp+
                      kidge6+black+hispanic+union+kidlt6,
                    data = train,
                    method = "glmnet",
                    tuneLength = 10,
                    trControl = elasticnet_train_control)
```

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## - Fold10.Rep5: alpha=0.51148, lambda=0.005422
## + Fold10.Rep5: alpha=0.62836, lambda=3.578862
## - Fold10.Rep5: alpha=0.62836, lambda=3.578862
## + Fold10.Rep5: alpha=0.74298, lambda=0.012335
## - Fold10.Rep5: alpha=0.74298, lambda=0.012335
## + Fold10.Rep5: alpha=0.76859, lambda=0.264158
## - Fold10.Rep5: alpha=0.76859, lambda=0.264158
## + Fold10.Rep5: alpha=0.04725, lambda=0.804106
## - Fold10.Rep5: alpha=0.04725, lambda=0.804106
## + Fold10.Rep5: alpha=0.16550, lambda=0.017630
## - Fold10.Rep5: alpha=0.16550, lambda=0.017630
## + Fold10.Rep5: alpha=0.95704, lambda=0.330759
## - Fold10.Rep5: alpha=0.95704, lambda=0.330759
## + Fold10.Rep5: alpha=0.17116, lambda=0.010915
## - Fold10.Rep5: alpha=0.17116, lambda=0.010915

## Warning in nominalTrainWorkflow(x = x, y = y, wts = weights, info = trainInfo,
## : There were missing values in resampled performance measures.

## Aggregating results
## Selecting tuning parameters
```

```
## Fitting alpha = 0.171, lambda = 0.0109 on full training set
```

```
best_apha <- elastic_reg$bestTune
best_apha
```

```
##      alpha    lambda
## 3 0.171165 0.0109149
```

```
elastic_reg[["finalModel"]][["beta"]]
```

```
## 16 x 79 sparse Matrix of class "dgCMatrix"
##   [[ suppressing 79 column names 's0', 's1', 's2' ... ]]
##
## husage   . .          .          .          .          .          .
## husearns . .          .          .          .          .          .
## huseduc  . .          .          .          .          .          .
## hushrs   . .          .          .          .          .          .
## earns    . 0.01581185 0.03248532 0.05001478 0.06838622 0.08757664 0.1075536
## age      . .          .          .          .          .          .
## educ     . .          .          .          .          .          .
## exper    . .          .          .          .          .          .
## husunion . .          .          .          .          .          .
## husblck  . .          .          .          .          .          .
## hushisp  . .          .          .          .          .          .
## kidge6   . .          .          .          .          .          .
## black    . .          .          .          .          .          .
## hispanic . .          .          .          .          .          .
## union    . .          .          .          .          .          .
## kidlt6   . .          .          .          .          .          .
##
## husage   .         .         .           .          .          .
## husearns .         .         .           .          .          .
## huseduc  .         .         .           .          .          .
## hushrs   .         .         .           .          .          .
## earns    0.1282748 0.1496881 0.170500577 0.19152837 0.21288878 0.23450460
## age      .         .         .           .          .          .
## educ     .         .         0.008270225 0.01778762 0.02713975 0.03627165
## exper    .         .         .           .          .          .
## husunion .         .         .           .          .          .
## husblck  .         .         .           .          .          .
## hushisp  .         .         .           .          .          .
## kidge6   .         .         .           .          .          .
## black    .         .         .           .          .          .
## hispanic .         .         .           .          .          .
## union    .         .         .           .          .          .
## kidlt6   .         .         .           .          .          .
##
```

```
## husage   .           .           .           .           .           .
## husearns 0.005471892 0.01200240 0.01821545 0.023589026 0.028616411 0.033308716
## huseduc  .           .           .          0.003157797 0.006119538 0.008724556
## hushrs   .           .           .           .           .           .
## earns    0.255615816 0.27663035 0.29762313 0.318299696 0.338818928 0.359135790
## age      .           .           .           .           .           .
## educ     0.044530126 0.05229564 0.05967723 0.065790502 0.071452529 0.076700545
## exper    .           .           .           .           .           .
## husunion .           .           .           .           .           .
## husblck  .           .           .           .           .           .
## hushisp  .           .           .           .           .           .
## kidge6   .           .           .           .           .           .
## black    .           .           .           .           .           .
## hispanic .           .           .           .           .           .
## union    .           .           .           .           .           .
## kidlt6   .           .           .           .           .           .
##
## husage   .           .           .           .           .           .
## husearns 0.03767017 0.04170306 0.04541311 0.04880910 0.05190240 0.05470653
## huseduc  0.01098793 0.01292825 0.01456711 0.01592833 0.01703717 0.01791957
## hushrs   .           .           .           .           .           .
## earns    0.37917806 0.39888173 0.41818644 0.43703620 0.45538000 0.47317231
## age      .           .           .           .           .           .
## educ     0.08153371 0.08595578 0.08997482 0.09360274 0.09685477 0.09974886
## exper    .           .           .           .           .           .
## husunion .           .           .           .           .           .
## husblck  .           .           .           .           .           .
## hushisp  .           .           .           .           .           .
## kidge6   .           .           .           .           .           .
## black    .           .           .           .           .           .
## hispanic .           .           .           .           .           .
## union    .           .           .           .           .           .
## kidlt6   .           .           .           .           .           .
##
## husage   .           .           .           .           .           .
## husearns 0.05726056 0.05957358 0.06164142 0.06348775 0.06512988 0.06658483
## huseduc  0.01869848 0.01928948 0.01974907 0.02008427 0.02031501 0.02045927
## hushrs   .           .           .           .           .           .
## earns    0.49004270 0.50624425 0.52181968 0.53673502 0.55097681 0.56453728
## age      .           .           .           .           .           .
## educ     0.10207301 0.10408353 0.10579771 0.10724904 0.10846195 0.10946046
## exper    .           .           .           .           .           .
## husunion .           .           .           .           .           .
## husblck  .           .           .           .           .           .
## hushisp  .           .           .           .           .           .
## kidge6   .           .           .           .           .           .
```

```
## black    .          .          .          .          .          .
## hispanic .          .          .          .          .          .
## union    0.00815487 0.01634152 0.02390123 0.03086500 0.03726298 0.04312717
## kidlt6   .          .          .          .          .          .
##
## husage   .          .          .          .          .          .
## husearns 0.06786923 0.06899913 0.06998980 0.07085567 0.07161019 0.07226582
## huseduc  0.02053314 0.02055074 0.02052429 0.02046424 0.02037940 0.02027706
## hushrs   .          .          .          .          .          .
## earns    0.57741399 0.58960947 0.60113078 0.61198907 0.62219904 0.63177850
## age      .          .          .          .          .          .
## educ     0.11026781 0.11090624 0.11139671 0.11175881 0.11201064 0.11216872
## exper    .          .          .          .          .          .
## husunion .          .          .          .          .          .
## husblck  .          .          .          .          .          .
## hushisp  .          .          .          .          .          .
## kidge6   .          .          .          .          .          .
## black    .          .          .          .          .          .
## hispanic .          .          .          .          .          .
## union    0.04849066 0.05338694 0.05784931 0.06191042 0.06560183 0.06895376
## kidlt6   .          .          .          .          .          .
##
## husage   .            .            .           0.000599507  0.001742397
## husearns 0.072917094  0.073487902  0.073949725  0.074507694  0.074950270
## huseduc  0.020136048  0.019921610  0.019561118  0.019309506  0.019063683
## hushrs   .            .           -0.001017168 -0.002714457 -0.004248915
## earns    0.640815760  0.649444707  0.657424731  0.664807738  0.671665106
## age      .            0.001052731  0.003287689  0.004826801  0.005791642
## educ     0.112189134  0.111941402  0.111710678  0.111400551  0.111091212
## exper    .            .            .            .            .
## husunion .            0.003928296  0.008233682  0.012142544  0.015757875
## husblck  .            .            .            .            .
## hushisp  .            .            .            .            .
## kidge6   .            .            .            .            .
## black    .            .            .            .            .
## hispanic .           -0.005401474 -0.013910554 -0.021867473 -0.029278850
## union    0.072033863  0.073961261  0.075332886  0.076588161  0.077685335
## kidlt6   0.002427007  0.009781936  0.018003529  0.025879496  0.033320857
##
## husage    0.002772029  0.003537540  0.004572694  0.005434660  0.006209856
## husearns  0.075341715  0.075584165  0.075758457  0.075919880  0.076057379
## huseduc   0.018823424  0.018590687  0.018355472  0.018137050  0.017932481
## hushrs   -0.005661205 -0.006974627 -0.008177129 -0.009283923 -0.010299302
## earns     0.678038532  0.683934656  0.689411400  0.694471801  0.699147264
## age       0.006710169  0.007698541  0.008356906  0.009036250  0.009677497
## educ      0.110764939  0.110397592  0.110044460  0.109687570  0.109336351
```

```
## exper     .           .           .           .           .
## husunion  0.019101128  0.022324302  0.025308237  0.028055733  0.030587128
## husblck   .           .           .           .           .
## hushisp   .           .           .           .           .
## kidge6    .           .           .           .           .
## black     .          -0.006026308 -0.011724094 -0.016986101 -0.021841363
## hispanic -0.036184913 -0.042979183 -0.049306164 -0.055172418 -0.060604607
## union     0.078646485  0.079749867  0.080725033  0.081599515  0.082379892
## kidlt6    0.040255473  0.046771633  0.052884353  0.058538420  0.063771361
##
## husage    0.006921435  0.007577827  0.008183772  8.742950e-03  0.009269546
## husearns  0.076174243  0.076273397  0.076357414  7.642853e-02  0.076486780
## huseduc   0.017741441  0.017563637  0.017398614  1.724582e-02  0.017067609
## hushrs   -0.011230335 -0.012083526 -0.012864957 -1.358030e-02 -0.014237556
## earns     0.703462539  0.707441367  0.711106490  7.144796e-01  0.717593255
## age       0.010269835  0.010813535  0.011311424  1.176682e-02  0.012176009
## educ      0.108993958  0.108662702  0.108344325  1.080401e-01  0.107735033
## exper     .           .           .           .           .
## husunion  0.032917041  0.035059673  0.037028555  3.883650e-02  0.040477094
## husblck   .           .           .           .           .
## hushisp   .           .           .          -2.681101e-05 -0.001668744
## kidge6    .           .           .           .           .
## black    -0.026316849 -0.030438360 -0.034230548 -3.771801e-02 -0.040958818
## hispanic -0.065628724 -0.070269880 -0.074552476 -7.848045e-02 -0.080960280
## union     0.083076584  0.083698973  0.084255409  8.475384e-02  0.085240529
## kidlt6    0.068611012  0.073082050  0.077207965  8.101180e-02  0.084547534
##
## husage    0.009762055  0.010218654  0.010640342  0.011029066  0.011387012
## husearns  0.076536015  0.076577404  0.076612212  0.076641477  0.076666068
## huseduc   0.016900180  0.016745478  0.016603126  0.016472358  0.016352358
## hushrs   -0.014839068 -0.015389086 -0.015891813 -0.016351170 -0.016770786
## earns     0.720449435  0.723071444  0.725477370  0.727683789  0.729706151
## age       0.012544943  0.012879329  0.013183117  0.013459324  0.013710491
## educ      0.107455379  0.107193309  0.106947586  0.106717671  0.106503063
## exper     .           .           .           .           .
## husunion  0.041983638  0.043364795  0.044630197  0.045788978  0.046849664
## husblck   .           .           .           .           .
## hushisp  -0.003439248 -0.005115816 -0.006664931 -0.008088346 -0.009394138
## kidge6    .           .           .           .           .
## black    -0.043929903 -0.046654907 -0.049153211 -0.051442538 -0.053539362
## hispanic -0.083038686 -0.084905816 -0.086608293 -0.088165093 -0.089589122
## union     0.085681385  0.086078573  0.086436187  0.086758315  0.087048668
## kidlt6    0.087805306  0.090801400  0.093554001  0.096080957  0.098399235
##
## husage    0.01175621  0.01208193  0.01236802  0.012624150  0.01277209
## husearns  0.07669305  0.07670974  0.07672363  0.076735345  0.07676610
```

```
## huseduc   0.01625568  0.01615733  0.01606469  0.015979300  0.01598632
## hushrs   -0.01715684 -0.01750654 -0.01782574 -0.018117084 -0.01836788
## earns     0.73154651  0.73324582  0.73480014  0.736221832  0.73749794
## age       0.01388999  0.01407807  0.01426105  0.014433093  0.01467033
## educ      0.10629871  0.10610984  0.10593710  0.105777807  0.10559981
## exper     .           .           .           .            .
## husunion  0.04781995  0.04870717  0.04951869  0.050260598  0.05095687
## husblck   .           .           .           0.001286127  0.01803490
## hushisp  -0.01039906 -0.01144326 -0.01244383 -0.013305503 -0.01460454
## kidge6    .           .           .           .            .
## black    -0.05545622 -0.05721400 -0.05882160 -0.061498464 -0.07857117
## hispanic -0.09101900 -0.09224992 -0.09334251 -0.094374833 -0.09478889
## union     0.08731522  0.08755062  0.08776360  0.087944531  0.08800020
## kidlt6    0.10051221  0.10246264  0.10424866  0.105883642  0.10739691
##
## husage    0.01306112  0.01334827  0.01361317  0.01385965  1.409034e-02
## husearns  0.07676850  0.07676881  0.07677141  0.07677026  7.676719e-02
## huseduc   0.01601915  0.01605245  0.01607844  0.01610925  1.614143e-02
## hushrs   -0.01860023 -0.01881192 -0.01900525 -0.01918107 -1.934108e-02
## earns     0.73866720  0.73973608  0.74071352  0.74160533  7.424193e-01
## age       0.01474097  0.01478532  0.01482376  0.01485416  1.487659e-02
## educ      0.10541138  0.10523593  0.10507719  0.10492737  1.047875e-01
## exper     .           .           .           .           .
## husunion  0.05161780  0.05222316  0.05277145  0.05327761  5.374258e-02
## husblck   0.03368493  0.04839622  0.06123029  0.07390275  8.601090e-02
## hushisp  -0.01524100 -0.01581779 -0.01635249 -0.01683695 -1.727350e-02
## kidge6    .           .           .           .           3.746123e-05
## black    -0.09456008 -0.10958951 -0.12277242 -0.13573441 -1.480982e-01
## hispanic -0.09558469 -0.09631404 -0.09697966 -0.09758456 -9.813816e-02
## union     0.08804556  0.08808401  0.08812354  0.08815288  8.817457e-02
## kidlt6    0.10877741  0.11004316  0.11120127  0.11226033  1.132459e-01
##
## husage    0.0143281629  0.014539778  0.014736175  0.014918625  0.015085473
## husearns  0.0767466745  0.076726422  0.076706194  0.076686615  0.076671390
## huseduc   0.0161393668  0.016143983  0.016151614  0.016160765  0.016164006
## hushrs   -0.0195047315 -0.019652897 -0.019787758 -0.019910569 -0.020022834
## earns     0.7432230240  0.743952345  0.744617747  0.745224879  0.745780401
## age       0.0149159289  0.014954318  0.014986308  0.015012584  0.015036217
## educ      0.1046602283  0.104540976  0.104429682  0.104326456  0.104234613
## exper     .             .            .            .            .
## husunion  0.0541028340  0.054439057  0.054748341  0.055032001  0.055285498
## husblck   0.0963586558  0.106616888  0.116442103  0.125704536  0.133352746
## hushisp  -0.0177752194 -0.018242289 -0.018663714 -0.019045637 -0.019384112
## kidge6    0.0009400438  0.001755095  0.002499613  0.003179684  0.003800733
## black    -0.1587641467 -0.169283067 -0.179334858 -0.188799652 -0.196680285
## hispanic -0.0986551795 -0.099111083 -0.099528287 -0.099909535 -0.100270559
```

```
## union     0.0881614307  0.088144697  0.088126095  0.088107013  0.088094960
## kidlt6    0.1146009974  0.115832338  0.116957920  0.117986713  0.118925979
##
## husage    0.01523768  0.015379086  0.015508121  0.015625873  0.015734978
## husearns  0.07665553  0.076639696  0.076627882  0.076615401  0.076602746
## huseduc   0.01617064  0.016179471  0.016183054  0.016188819  0.016196688
## hushrs   -0.02012500 -0.020217940 -0.020302881 -0.020380227 -0.020450546
## earns     0.74628613  0.746747181  0.747169073  0.747553031  0.747902799
## age       0.01505802  0.015075480  0.015090456  0.015105165  0.015116897
## educ      0.10414873  0.104068571  0.103997589  0.103931466  0.103869576
## exper     .           .            .            .            .
## husunion  0.05552030  0.055736577  0.055928882  0.056107199  0.056271907
## husblck   0.14095662  0.148265726  0.154118678  0.160010984  0.165740191
## hushisp  -0.01970763 -0.019999674 -0.020244393 -0.020490191 -0.020713735
## kidge6    0.00436829  0.004886192  0.005356957  0.005788973  0.006182914
## black    -0.20447249 -0.211941545 -0.217984038 -0.224027077 -0.229880594
## hispanic -0.10058524 -0.100872390 -0.101155314 -0.101393952 -0.101609778
## union     0.08807984  0.088063450  0.088053946  0.088041584  0.088027903
## kidlt6    0.11978472  0.120568970  0.121282384  0.121936397  0.122533329
##
## husage    0.015836522  0.015927297
## husearns  0.076590341  0.076581875
## huseduc   0.016205632  0.016209374
## hushrs   -0.020514512 -0.020572915
## earns     0.748221572  0.748513095
## age       0.015125679  0.015132755
## educ      0.103812003  0.103762019
## exper     .            .
## husunion  0.056423438  0.056556828
## husblck   0.171198998  0.175283484
## hushisp  -0.020915260 -0.021065982
## kidge6    0.006542193  0.006864291
## black    -0.235444987 -0.239669106
## hispanic -0.101806924 -0.102015144
## union     0.088013822  0.088007103
## kidlt6    0.123078165  0.123568826
```

```r
predictions_elasticnet_train <- predict(elastic_reg, x_train)
elastic_train_eval_results <- eval_results(y_train, predictions_elasticnet_train, train, 'Elasticnet', 'train')
models_stats <- rbind(models_stats, elastic_train_eval_results)

predictions_elasticnet_test <- predict(elastic_reg, x_test)
elastic_test_eval_results <- eval_results(y_test, predictions_elasticnet_test, test, 'Elasticnet', 'test')
models_stats <- rbind(models_stats, elastic_test_eval_results)

models_stats
```

```
##    ModelName Phase      RMSE   Rsquare
## 1      Ridge train 0.5346936 0.7139639
## 2      Ridge  test 0.7113684 0.6169343
## 3      Lasso train 0.5346985 0.7139586
## 4      Lasso  test 0.7101215 0.6182760
## 5 Elasticnet train 0.5348464 0.7138003
## 6 Elasticnet  test 0.7105757 0.6177875
```

```
pred_elastic <- predict(elastic_reg, pred_matrix)

cat("Predição Elasticnet padronizada:", pred_elastic, "\n")
```

```
## Predição Elasticnet padronizada: 0.7363465
```

```
lwage_pred_elastic=(pred_elastic*
                  pre_process_normalization_object[["std"]][["lwage"]])+
                  pre_process_normalization_object[["mean"]][["lwage"]]

cat("Predição Elasticnet valor nominal porém ainda em logaritmo:", lwage_pred_elastic, "\n")
```

```
## Predição Elasticnet valor nominal porém ainda em logaritmo: 2.568476
```

```
#antilog
cat("Predição Elasticnet valor em dólares:", exp(lwage_pred_elastic), "\n")
```

```
## Predição Elasticnet valor em dólares: 13.04593
```

```
calculate_intervals(lwage_pred_elastic, 'Elasticnet')
```

```
## Para o modelo Elasticnet o intervalo de confiança inferior é de: USD 12.76386
## Para o modelo Elasticnet o intervalo de confiança superior é de: USD 13.33423
```

Interpretação: O salário hora da a esposa é em média USD 13.05 e pode variar entre USD 12.76 a USD 13.33 com 95% de confiança. Com combinação das penalizações L1 e L2 o modelo Elasticnet beneficia-se da seleção de variáveis do Lasso e da estabilidade do Ridge, ainda sim as estatisticas do modelo são muito semelhates a dos modelos Ridge e Lasso.

Estatísticas dos modelos

Estatísticas dos modelos Ridge, Lasso e Elasticnet nas fases de treinamento e teste.

```
models_stats
```

```
##    ModelName Phase      RMSE   Rsquare
## 1      Ridge train 0.5346936 0.7139639
## 2      Ridge  test 0.7113684 0.6169343
## 3      Lasso train 0.5346985 0.7139586
## 4      Lasso  test 0.7101215 0.6182760
## 5 Elasticnet train 0.5348464 0.7138003
## 6 Elasticnet  test 0.7105757 0.6177875
```

Conclusão

Definição: RMSE - Quanto MENOR, MELHOR (menos erro). R2 - Quanto MAIOR, MELHOR (mais explicação).

Os três modelos apresentaram desempenho praticamente idênticos em termos de erro(RMSE) e explicação(Rsquare). O modelo Elasticnet se destaca pois apresentou um melhor poder de generalização para novos dados, apresentando o menor RMSE e maior explicação R^2 nos testes, indicando uma ligeira vantangem estatistica, além disso combinar as penalizações L1 e L2 o modelo geralmente produz um melhor balanço entre viés e variancia (tradeoff).