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')

# 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.   :-0.2231
##  1st Qu.: 1.8458
##  Median : 2.1656
##  Mean   : 2.1958
##  3rd Qu.: 2.5257
##  Max.   : 4.2782
```

```
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.   :-3.401
##  1st Qu.: 1.874
##  Median : 2.175
##  Mean   : 2.200
##  3rd Qu.: 2.526
##  Max.   : 4.234
```

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 para o modelo Ridge

```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:  0.006309573
```

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    0.008554854
## husearns  0.039459293
## huseduc   0.008904888
## hushrs   -0.010887224
## earns     0.374509789
## age       0.010079194
## educ      0.052702032
## exper    -0.002589475
## husunion  0.028598059
## husblck   0.093006178
## hushisp  -0.011524082
## kidge6    0.003159988
## black    -0.125658077
## hispanic -0.050854237
## union     0.046594342
## kidlt6    0.062386269
```

```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 0.2705841 0.7139661
## 2     Ridge  test 0.3599891 0.6169418
```

Criando o dataframe de predição para e realizando a normalização dos dados.

```
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
)

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
##  Min.   :-0.03489   Min.   :1
##  1st Qu.:-0.03489   1st Qu.:1
##  Median :-0.03489   Median :1
##  Mean   :-0.03489   Mean   :1
##  3rd Qu.:-0.03489   3rd Qu.:1
```

```
##  Max.   :-0.03489   Max.   :1
```

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 valor nominal porém ainda em logaritmo:", pred_ridge, "\n")
```

```
## Predição Ridge valor nominal porém ainda em logaritmo: 2.497247
```

```
#antilog
cat("Predição Ridge valor em dólares (anti-log):", exp(pred_ridge), "\n")
```

```
## Predição Ridge valor em dólares (anti-log): 12.149
```

Calculando os intervalos de confiança

```
calculate_intervals <- function(pred, modelName){
  n <- nrow(train)
  m <- pred
  s <- sd(train$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(pred_ridge, 'Ridge')
```

```
## Para o modelo Ridge o intervalo de confiança inferior é de: USD 11.88632
## Para o modelo Ridge o intervalo de confiança superior é de: USD 12.41748
```

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:  0.001
```

```r
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    0.0074466451
## husearns  0.0382666355
## huseduc   0.0075899504
## hushrs   -0.0095502781
## earns     0.3797036095
## age       0.0071268316
## educ      0.0522958123
## exper     .
## husunion  0.0275210886
## husblck   0.0447439052
## hushisp  -0.0084093471
## kidge6    0.0009999533
## black    -0.0762600209
## hispanic -0.0507733699
## union     0.0430208507
## kidlt6    0.0584941904
```

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

models_stats
```

```
##   ModelName Phase      RMSE   Rsquare
## 1     Ridge train 0.2705841 0.7139661
## 2     Ridge  test 0.3599891 0.6169418
## 3     Lasso train 0.2706185 0.7138934
## 4     Lasso  test 0.3592895 0.6184291
```

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

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

```
## Predição Lasso valor nominal porém ainda em logaritmo: 2.551508
```

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

```
## Predição Lasso valor em dólares: 12.82643
```

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

```
## Para o modelo Lasso o intervalo de confiança inferior é de: USD 12.54911
## Para o modelo Lasso o intervalo de confiança superior é de: USD 13.10989
```

Interpretação: O salário hora da a esposa é em média USD 12.83 e pode variar entre USD 12.55 e USD 13.11 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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```
## 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 = 0.511, lambda = 0.00542 on full training set
```

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

```
##       alpha      lambda
## 5 0.5114764 0.005421742
```

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

```
## 16 x 76 sparse Matrix of class "dgCMatrix"
```

```
##   [[ suppressing 76 column names 's0', 's1', 's2' ... ]]
```

```
##
## husage   . .          .          .          .          .          .
## husearns . .          .          .          .          .          .
## huseduc  . .          .          .          .          .          .
## hushrs   . .          .          .          .          .          .
## earns    . 0.02164987 0.04297652 0.06389719 0.08433569 0.1042234 0.1234998
```

```
## age      . .         .         .         .         .         .
## educ     . .         .         .         .         .         .
## exper    . .         .         .         .         .         .
## husunion . .         .         .         .         .         .
## husblck  . .         .         .         .         .         .
## hushisp  . .         .         .         .         .         .
## kidge6   . .         .         .         .         .         .
## black    . .         .         .         .         .         .
## hispanic . .         .         .         .         .         .
## union    . .         .         .         .         .         .
## kidlt6   . .         .         .         .         .         .
##
## husage   .         .         .         .         .         .
## husearns .         .         .         .         .         .
## huseduc  .         .         .         .         .         .
## hushrs   .         .         .         .         .         .
## earns    0.1421133 0.1600214 0.1771903 0.1935953 0.2092201 0.2240564
## age      .         .         .         .         .         .
## educ     .         .         .         .         .         .
## exper    .         .         .         .         .         .
## husunion .         .         .         .         .         .
## husblck  .         .         .         .         .         .
## hushisp  .         .         .         .         .         .
## kidge6   .         .         .         .         .         .
## black    .         .         .         .         .         .
## hispanic .         .         .         .         .         .
## union    .         .         .         .         .         .
## kidlt6   .         .         .         .         .         .
##
## husage   .           .         .         .         .         .
## husearns .           .         .         .         .         0.001088988
## huseduc  .           .         .         .         .         .
## hushrs   .           .         .         .         .         .
## earns    0.236304048 0.24771882 0.25845031 0.26851744 0.27794430 0.286508761
## age      .           .         .         .         .         .
## educ     0.005456993 0.01087331 0.01586124 0.02044704 0.02465607 0.028324476
## exper    .           .         .         .         .         .
## husunion .           .         .         .         .         .
## husblck  .           .         .         .         .         .
## hushisp  .           .         .         .         .         .
## kidge6   .           .         .         .         .         .
## black    .           .         .         .         .         .
## hispanic .           .         .         .         .         .
## union    .           .         .         .         .         .
## kidlt6   .           .         .         .         .         .
##
```

```
## husage   .           .           .           .           .           .
## husearns 0.004420921 0.007473148 0.01027637 0.01284880 0.01520770 0.01736939
## huseduc  .           .           .           .           .           .
## hushrs   .           .           .           .           .           .
## earns    0.294005888 0.300985934 0.30747143 0.31348869 0.31906388 0.32422289
## age      .           .           .           .           .           .
## educ     0.031256619 0.033929917 0.03636418 0.03857954 0.04059479 0.04242736
## exper    .           .           .           .           .           .
## husunion .           .           .           .           .           .
## husblck  .           .           .           .           .           .
## hushisp  .           .           .           .           .           .
## kidge6   .           .           .           .           .           .
## black    .           .           .           .           .           .
## hispanic .           .           .           .           .           .
## union    .           .           .           .           .           .
## kidlt6   .           .           .           .           .           .
##
## husage   .           .           .           .           .           .
## husearns 0.01934919 0.02116145 0.02281957 0.02433603 2.572239e-02 0.0268169686
## huseduc  .           .           .           .          5.222383e-05 0.0007272521
## hushrs   .           .           .           .           .           .
## earns    0.32899109 0.33339317 0.33745303 0.34119366 3.446224e-01 0.3477609014
## age      .           .           .           .           .           .
## educ     0.04409336 0.04560764 0.04698384 0.04823444 4.934725e-02 0.0500585072
## exper    .           .           .           .           .           .
## husunion .           .           .           .           .           .
## husblck  .           .           .           .           .           .
## hushisp  .           .           .           .           .           .
## kidge6   .           .           .           .           .           .
## black    .           .           .           .           .           .
## hispanic .           .           .           .           .           .
## union    .           .           .           .           .           .
## kidlt6   .           .           .           .           .           .
##
## husage   .           .           .           .           .           .
## husearns 0.027830219 0.028781828 0.029644476 0.03043843 0.031157700 0.031930540
## huseduc  0.001457681 0.002121402 0.002731179 0.00325351 0.003765474 0.004223114
## hushrs   .           .           .           .           .           .
## earns    0.350502294 0.352928988 0.355162704 0.35719181 0.359070380 0.360916809
## age      .           .           .           .           .           .
## educ     0.050536673 0.050943251 0.051305238 0.05165615 0.051945344 0.052086901
## exper    .           .           .           .           .           .
## husunion .           .           .           .           .           .
## husblck  .           .           .           .           .           .
## hushisp  .           .           .           .           .           .
## kidge6   .           .           .           .           .           .
```

```
## black    .           .           .           .           .           .
## hispanic .           .           .           .           .           .
## union    0.003288494 0.007432062 0.011226680 0.01470485 0.017886563 0.020851657
## kidlt6   .           .           .           .           .           0.003329853
##
## husage    .            .            .             .            0.0002463027
## husearns  0.032657141  0.033312240  0.0339098706  0.034258031  0.0346742155
## huseduc   0.004588781  0.004799752  0.0050155632  0.005258965  0.0054700793
## hushrs    .            .            .             .           -0.0007073258
## earns     0.362684527  0.364326689  0.3658403887  0.367158234  0.3683121587
## age       .            .            0.0000321808  0.001407872  0.0024038137
## educ      0.052118713  0.052130162  0.0521176416  0.052176131  0.0522581859
## exper     .            .            .             .            .
## husunion  0.002390114  0.004936543  0.0072599120  0.009214838  0.0109360320
## husblck   .            .            .             .            .
## hushisp   .            .            .             .            .
## kidge6    .            .            .             .            .
## black     .            .            .             .            .
## hispanic -0.003067858 -0.007912596 -0.0123361697 -0.016321588 -0.0200320302
## union     0.023098071  0.025093997  0.0269088835  0.028293454  0.0296035713
## kidlt6    0.006821428  0.010088902  0.0131138939  0.017116297  0.0208872907
##
## husage    0.0007398123  0.001358460  0.001814779  0.002272323  0.002710385
## husearns  0.0351332669  0.035488790  0.035787851  0.036061546  0.036310639
## huseduc   0.0056856573  0.005904550  0.006063362  0.006222083  0.006367819
## hushrs   -0.0015801523 -0.002372749 -0.003102465 -0.003767414 -0.004374486
## earns     0.3693209391  0.370274822  0.371121056  0.371904377  0.372620977
## age       0.0030756668  0.003497676  0.004019359  0.004442166  0.004809481
## educ      0.0523235617  0.052345614  0.052397174  0.052428265  0.052454593
## exper     .             .            .            .            .
## husunion  0.0124796258  0.013941400  0.015307416  0.016551956  0.017687919
## husblck   .             .            .            .            .
## hushisp   .             .            .            .            .
## kidge6    .             .            .            .            .
## black     .            -0.002237809 -0.005375980 -0.008242525 -0.010861177
## hispanic -0.0234338103 -0.026671351 -0.029731241 -0.032517962 -0.035063684
## union     0.0308314584  0.032050932  0.033205681  0.034262036  0.035225990
## kidlt6    0.0244093843  0.027647624  0.030652502  0.033389238  0.035892255
##
## husage    0.003120805  0.003501130  0.003851527  0.004173321  0.0044683025
## husearns  0.036537692  0.036744665  0.036933329  0.037105298  0.0372620440
## huseduc   0.006500946  0.006622452  0.006733300  0.006834400  0.0069265936
## hushrs   -0.004928743 -0.005434696 -0.005896482 -0.006317892 -0.0067024066
## earns     0.373275722  0.373873718  0.374419736  0.374918185  0.3753731270
## age       0.005135219  0.005427383  0.005691075  0.005929887  0.0061465780
## educ      0.052477387  0.052497221  0.052514539  0.052529702  0.0525430097
```

```
## exper     .           .           .           .           .
## husunion  0.018724568 0.019670475 0.020533487 0.021320781 0.0220389266
## husblck   .           .           .           .           .
## hushisp   .           .           .           .          -0.0001800347
## kidge6    .           .           .           .           .
## black    -0.013252832 -0.015436725 -0.017430533 -0.019250488 -0.0209192871
## hispanic -0.037389099 -0.039512913 -0.041452255 -0.043222838 -0.0447029101
## union     0.036105532 0.036907918 0.037639817 0.038307348 0.0389199410
## kidlt6    0.038180481 0.040271575 0.042181948 0.043926775 0.0455227547
##
## husage    0.004742329 0.004997679 0.005233838 0.005451161 0.005650546
## husearns  0.037403388 0.037532932 0.037650910 0.037758418 0.037856392
## huseduc   0.006985887 0.007043020 0.007095227 0.007142796 0.007186147
## hushrs   -0.007054996 -0.007376451 -0.007669644 -0.007937047 -0.008180908
## earns     0.375795962 0.376177111 0.376524896 0.376842161 0.377131555
## age       0.006342366 0.006516435 0.006672278 0.006812654 0.006939585
## educ      0.052544784 0.052553838 0.052561861 0.052568987 0.052575302
## exper     .           .           .           .           .
## husunion  0.022681580 0.023271595 0.023809689 0.024300358 0.024747746
## husblck   .           .           .           .           .
## hushisp  -0.001130164 -0.002050319 -0.002902241 -0.003682783 -0.004395955
## kidge6    .           .           .           .           .
## black    -0.022454541 -0.023852224 -0.025127184 -0.026290158 -0.027350899
## hispanic -0.045495077 -0.046166014 -0.046767945 -0.047313959 -0.047810676
## union     0.039499654 0.040027174 0.040508390 0.040947213 0.041347321
## kidlt6    0.046997330 0.048343100 0.049571654 0.050692853 0.051715886
##
## husage    0.005781625 0.005918982 0.006056343 0.006316987 0.006575057
## husearns  0.037945861 0.038028097 0.038102398 0.038179880 0.038236406
## huseduc   0.007218683 0.007254520 0.007287750 0.007339997 0.007431413
## hushrs   -0.008403138 -0.008606153 -0.008791084 -0.008956491 -0.009103822
## earns     0.377387060 0.377627075 0.377846873 0.378053803 0.378225800
## age       0.007090956 0.007223003 0.007332867 0.007318184 0.007273957
## educ      0.052589763 0.052594398 0.052598150 0.052588470 0.052560114
## exper     .           .           .           .           .
## husunion  0.025158433 0.025530142 0.025869043 0.026168842 0.026476375
## husblck   .           .           .           0.002857247 0.012282171
## hushisp  -0.004933789 -0.005491946 -0.006027814 -0.006744868 -0.007234203
## kidge6    .           .           .           .           .
## black    -0.028316176 -0.029198712 -0.030003427 -0.033442893 -0.043076162
## hispanic -0.048343055 -0.048783362 -0.049164127 -0.049311352 -0.049513861
## union     0.041711131 0.042042843 0.042345542 0.042605352 0.042795886
## kidlt6    0.052631547 0.053481064 0.054257619 0.054993457 0.055655278
##
## husage    0.006748637 0.006890040 0.0070248876 0.0071506207 0.007271423
## husearns  0.038286996 0.038334696 0.0383766710 0.0384010095 0.038427432
```

```
## huseduc   0.007516111  0.007590096  0.0076606674  0.0077009817  0.007748406
## hushrs   -0.009237990 -0.009360534 -0.0094720029 -0.0095873780 -0.009687399
## earns     0.378381433  0.378523347  0.3786523723  0.3788159205  0.378947981
## age       0.007290762  0.007321894  0.0073446963  0.0073970835  0.007426533
## educ      0.052532529  0.052509245  0.0524861611  0.0524657633  0.052445859
## exper     .            .            .             .             .
## husunion  0.026758923  0.027014075  0.0272491003  0.0274149635  0.027585212
## husblck   0.021219903  0.028982160  0.0364695816  0.0429041893  0.049165603
## hushisp  -0.007570272 -0.007877039 -0.0081546183 -0.0084908959 -0.008772996
## kidge6    .            .            0.0002296395  0.0007254291  0.001120965
## black    -0.052193397 -0.060140405 -0.0677810657 -0.0743995787 -0.080803944
## hispanic -0.049782706 -0.050030586 -0.0502543750 -0.0504652713 -0.050648412
## union     0.042964551  0.043120778  0.0432524978  0.0433590101  0.043457953
## kidlt6    0.056254097  0.056799204  0.0574023016  0.0581278542  0.058748003
##
## husage    0.007384225  0.007478327  0.007570260  0.007646314  0.007722001
## husearns  0.038450835  0.038473785  0.038493551  0.038513022  0.038529565
## huseduc   0.007793042  0.007830514  0.007866952  0.007897454  0.007927463
## hushrs   -0.009778448 -0.009861671 -0.009937355 -0.010006530 -0.010069413
## earns     0.379068253  0.379178286  0.379278254  0.379369677  0.379452747
## age       0.007450850  0.007481102  0.007503018  0.007529942  0.007548833
## educ      0.052426825  0.052411238  0.052395770  0.052383143  0.052370414
## exper     .            .            .            .            .
## husunion  0.027741447  0.027881136  0.028010353  0.028125770  0.028232858
## husblck   0.055056040  0.059992490  0.064810961  0.068816849  0.072792985
## hushisp  -0.009026436 -0.009253863 -0.009466502 -0.009651675 -0.009829383
## kidge6    0.001481374  0.001810559  0.002110333  0.002383659  0.002632913
## black    -0.086818190 -0.091888362 -0.096815515 -0.100938663 -0.105007941
## hispanic -0.050816976 -0.050976391 -0.051115461 -0.051251304 -0.051366282
## union     0.043546912  0.043630757  0.043705217  0.043775513  0.043837571
## kidlt6    0.059313547  0.059828684  0.060298845  0.060726486  0.061117309
##
## husage    0.007794326  0.007862033  0.007914698  0.007967268
## husearns  0.038543973  0.038556727  0.038570056  0.038581341
## huseduc   0.007956225  0.007983239  0.008004658  0.008025621
## hushrs   -0.010126614 -0.010178681 -0.010226341 -0.010269693
## earns     0.379528315  0.379597111  0.379659978  0.379717297
## age       0.007562898  0.007574028  0.007591988  0.007604742
## educ      0.052357976  0.052346153  0.052337242  0.052328247
## exper     .            .            .            .
## husunion  0.028331547  0.028422097  0.028501993  0.028576007
## husblck   0.076598545  0.080170057  0.082972257  0.085753876
## hushisp  -0.009989989 -0.010135050 -0.010255584 -0.010377496
## kidge6    0.002859804  0.003066449  0.003254143  0.003426287
## black    -0.108890997 -0.112529159 -0.115412563 -0.118258560
## hispanic -0.051470841 -0.051566430 -0.051665093 -0.051744783
```

```
## union     0.043892958  0.043942762  0.043991036  0.044033600
## kidlt6    0.061473663  0.061798538  0.062092814  0.062362762
```

```
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 0.2705841 0.7139661
## 2      Ridge  test 0.3599891 0.6169418
## 3      Lasso train 0.2706185 0.7138934
## 4      Lasso  test 0.3592895 0.6184291
## 5 Elasticnet train 0.2708728 0.7133554
## 6 Elasticnet  test 0.3593825 0.6182316
```

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

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

```
## Predição Elasticnet valor nominal porém ainda em logaritmo: 2.526498
```

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

```
## Predição Elasticnet valor em dólares: 12.50963
```

```
calculate_intervals(pred_elastic, 'Elasticnet')
```

```
## Para o modelo Elasticnet o intervalo de confiança inferior é de: USD 12.23915
## Para o modelo Elasticnet o intervalo de confiança superior é de: USD 12.78608
```

Interpretação: O salário hora da a esposa é em média USD 12.51 e pode variar entre USD 12.24 a USD 12.79 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 0.2705841 0.7139661
## 2      Ridge  test 0.3599891 0.6169418
## 3      Lasso train 0.2706185 0.7138934
```

```
## 4      Lasso  test 0.3592895 0.6184291
## 5 Elasticnet train 0.2708728 0.7133554
## 6 Elasticnet  test 0.3593825 0.6182316
```

Conclusão

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

Obs.: A variável explicativa lwage não foi normalizada, pois foram realizados testes com e sem sua normalização, e observou-se que, ao normalizá-la, os erros aumentaram em cerca de 50%

Os três modelos apresentaram desempenho praticamente idêntico em termos de erro de predição e poder explicativo (R^2). Porém, ao considerar outros critérios como simplicidade e interpretabilidade, o modelo Lasso se destaca como a melhor escolha para este caso. O modelo Lasso se destaca pois apresentou um melhor poder de generalização para novos dados, apresentando ligeiramente menor RMSE e maior explicação R^2 nos testes, indicando uma ligeira vantangem estatistica, além disso por sua simplicidade e combinar a penalização L2 é capaz de elimiar variáveis irrelevantes e redução de overfitting.