Assignment 7

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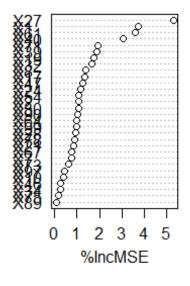
```
# Load necessary libraries
library(randomForest)
## Warning: package 'randomForest' was built under R version 4.4.3
## randomForest 4.7-1.2
## Type rfNews() to see new features/changes/bug fixes.
library(xgboost)
## Warning: package 'xgboost' was built under R version 4.4.3
library(glmnet)
## Warning: package 'glmnet' was built under R version 4.4.3
## Loading required package: Matrix
## Loaded glmnet 4.1-8
# Set seed for reproducibility
set.seed(123)
# Simulate 100 predictor variables from standard normal distributions
n <- 100
p <- 100
X <- matrix(rnorm(n * p), nrow = n, ncol = p)</pre>
colnames(X) <- paste0("X", 1:p)</pre>
# Calculate the mean parameter μi
mu \leftarrow 1 + 2 * X[,1] + X[,2] + 0.5 * X[,5] + 1.5 * X[,10]
# Generate count response Yi from Poisson(μi)
Y <- rpois(n, lambda = exp(mu))
# Convert to dataframe for modeling
dt <- data.frame(Y, X)</pre>
   1. Fitting Random Forest and the varaible importance
# Fit a random forest model
rf_model <- randomForest(Y ~ ., data = dt, importance = TRUE)</pre>
rf importance <- importance(rf model)</pre>
rf importance(order(-rf importance[,1]),]
```

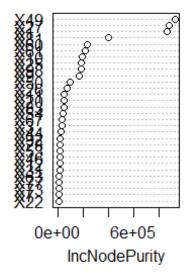
```
# Print Random Forest Variable Importance
cat("\n\033[1mRandom Forest Variable Importance:\033[0m\n")
##
## [1mRandom Forest Variable Importance: [0m
print(rf_importance)
##
            %IncMSE IncNodePurity
## X27
         5.30759733
                      881090.47536
## X1
         3.72026306
                      866634.25820
## X61
         3.58617249
                      216184.67246
## X40
         3.04738808
                        1784.44152
## X71
         1.90855364
                         298.54509
## X39
         1.88671055
                         538.12181
## X19
         1.74727366
                          75.05095
## X32
                         282.04309
         1.65732124
## X8
                        4801.79653
         1.38918159
## X17
         1.35316337
                         229.89701
## X47
         1.23845849
                        4674.18936
## X24
                          64.10196
         1.13916152
## X54
         1.08018517
                       35812.50891
## X2
         1.06783692
                         180.96380
## X30
         1.05219825
                         107.97832
## X90
                        1375.87574
         1.01598700
## X64
                        6719.50642
         1.00171077
## X99
         0.97273009
                        2358.02669
## X28
         0.95506592
                       14151.84096
## X78
         0.90706266
                         154.19700
## X21
         0.86484247
                         509.20778
## X67
         0.75500657
                       28691.42995
## X7
                        9034.79896
         0.74095355
         0.59612828
## X73
                        9533.38687
## X97
         0.43783949
                         100.08881
## X10
                      191972.20040
         0.37576905
## X46
         0.25584864
                       12819.61119
## X34
         0.23455841
                         151.79743
## X75
         0.17565372
                         977.57718
## X89
         0.08030552
                         253.60311
## X4
         0.06628237
                         193.08934
## X82
        -0.03448401
                         381.13683
## X83
        -0.07962143
                       43184.93561
## X81
        -0.08994891
                      397062.40274
## X29
        -0.09289687
                         843.31797
## X66
        -0.10266363
                        3766.18101
## X70
        -0.18490572
                         623.81001
## X13
        -0.18795050
                          92.86620
## X58
        -0.28265185
                         394.28933
## X98
        -0.32646605
                      181375.59050
## X100 -0.36769468
                         237.91234
```

```
## X56
        -0.37161208
                         1522.43257
## X6
        -0.38369347
                          212.86839
## X9
        -0.38637822
                      171211.50349
## X84
                         3168.50160
        -0.46637875
## X26
        -0.49389634
                       68024.78966
## X33
        -0.52786698
                          200.86270
## X5
        -0.56655594
                         1619.07682
## X55
        -0.60195018
                         431.33324
## X20
        -0.60607102
                       44574.74780
## X65
                          564.76879
        -0.64938898
## X57
        -0.67075844
                        4734.12403
## X86
        -0.68028220
                         1862.28872
## X69
        -0.70366309
                         187.40884
## X88
        -0.71795101
                         129.97169
## X50
        -0.76756537
                       93419.90356
## X14
        -0.77310824
                           96.80784
## X92
        -0.77845956
                       16824.65706
## X16
        -0.82016732
                         4893.17641
## X93
        -0.83071027
                          321.09511
## X76
                         1870.81023
        -0.84121499
## X43
                         1496.09877
        -0.87150390
## X18
        -0.87868221
                          304.59342
## X52
        -0.88764040
                         439.52405
## X42
        -0.90219070
                          221.95097
## X94
        -0.93735546
                         2150.81223
## X37
        -0.94317895
                          380.32834
        -0.97451433
## X31
                       11964.55288
## X11
        -0.99142939
                       46976.61239
## X68
        -1.00138737
                         5728.23119
        -1.00495449
## X51
                        7231.78785
## X12
        -1.00772380
                       12565.78768
## X38
        -1.00877485
                         1148.87695
## X87
        -1.01112206
                         3571.15054
## X35
        -1.01581803
                          202.83144
## X95
        -1.01890650
                         219.96381
## X49
                      927406.53038
        -1.02334090
## X80
        -1.03386931
                          505.24169
## X77
        -1.05202040
                       10271.99878
## X44
        -1.07231658
                       20996.17705
## X72
        -1.15694458
                         3583.75737
## X3
        -1.18029939
                       27422.58860
## X45
        -1.20420465
                         2442.61084
## X62
        -1.23237674
                         224.30732
## X91
        -1.24887041
                         612.30146
## X15
        -1.27414855
                         104.60445
## X48
        -1.29238385
                          368.73963
## X41
        -1.29960979
                         6202.91579
## X22
        -1.40247297
                         7908.34988
## X63
        -1.44447956
                       10778.10417
## X74
        -1.45842055
                        1630.75028
```

```
## X25 -1.47709932 186624.52347
## X59 -1.49937631
                     1127.27596
                   14067.55301
## X53 -1.51864541
## X96 -1.53344086
                      2522.28707
## X23 -1.77088423
                       281.81191
## X85
       -1.85139539
                       238.31573
## X79 -1.97343978
                      2026.04687
## X60 -2.22489485 231596.98706
## X36 -2.56410807
                        98.70026
# Plot Random Forest Variable Importance
varImpPlot(rf_model, main = "Random Forest Variable Importance")
```

Random Forest Variable Importance





2. XGBoost Model and the variable importance

```
# Fit an XGBoost model
dtrain <- xgb.DMatrix(data = as.matrix(X), label = Y)
params <- list(objective = "count:poisson", eval_metric = "rmse")

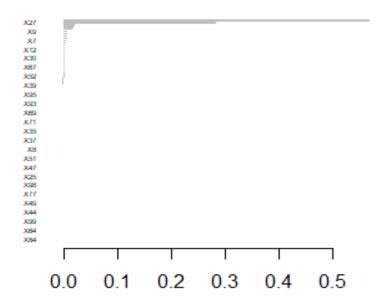
xgb_model <- xgb.train(params = params, data = dtrain, nrounds = 100)
xgb_importance <- xgb.importance(model = xgb_model)

# Print XGBoost Variable Importance
cat("\n\033[1mXGBoost Variable Importance:\033[0m\n"))
##
## [1mXGBoost Variable Importance:[0m</pre>
```

```
print(xgb importance)
##
       Feature
                       Gain
                                    Cover
                                             Frequency
##
        <char>
                      <num>
                                    <num>
                                                 <num>
##
    1:
           X27 5.692578e-01 6.621867e-02 0.0224150398
##
    2:
            X1 2.836419e-01 1.456162e-01 0.2516268980
##
    3:
           X20 2.131615e-02 1.184277e-02 0.0151843818
           X10 1.796197e-02 9.652739e-02 0.0535068691
##
    4:
            X9 1.654552e-02 2.747674e-02 0.0216919740
##
    5:
##
           X96 6.752969e-03 2.319880e-03 0.0057845264
    6:
    7:
           X81 6.540440e-03 1.005066e-02 0.0079537238
##
##
    8:
           X15 6.395241e-03 4.850265e-03 0.0093998554
    9:
           X7 5.942486e-03 7.426706e-03 0.0072306580
##
## 10:
           X70 4.947148e-03 7.125978e-04 0.0043383948
## 11:
            X2 4.269116e-03 1.800890e-02 0.0592913955
            X4 3.182346e-03 2.738187e-02 0.0325379610
## 12:
## 13:
           X12 3.024917e-03 8.721397e-04 0.0050614606
           X56 2.740804e-03 9.631405e-04 0.0043383948
## 14:
## 15:
           X76 2.640107e-03 5.098548e-04 0.0043383948
           X75 2.604847e-03 4.598309e-04 0.0036153290
## 16:
## 17:
           X30 2.602553e-03 9.266481e-03 0.0093998554
           X66 2.581811e-03 4.317957e-02 0.0195227766
## 18:
## 19:
           X78 2.271119e-03 1.072769e-02 0.0079537238
## 20:
          X100 2.215905e-03 7.488980e-03 0.0079537238
## 21:
           X67 2.109257e-03 1.283218e-03 0.0028922632
## 22:
           X94 2.047465e-03 2.609350e-03 0.0108459870
## 23:
           X74 1.884844e-03 6.554736e-03 0.0079537238
## 24:
           X22 1.645139e-03 2.842221e-02 0.0159074476
## 25:
           X52 1.494873e-03 5.000613e-04 0.0021691974
## 26:
           X45 1.362410e-03 5.170042e-04 0.0021691974
## 27:
           X79 1.258441e-03 1.103129e-02 0.0086767896
## 28:
           X16 1.185332e-03 1.377472e-03 0.0065075922
## 29:
           X39 1.161146e-03 2.059545e-03 0.0093998554
           X83 1.078189e-03 8.591070e-05 0.0028922632
## 30:
           X55 9.890685e-04 2.579437e-03 0.0036153290
## 31:
## 32:
           X13 9.818007e-04 2.136237e-03 0.0108459870
## 33:
           X95 8.632194e-04 5.680942e-03 0.0050614606
## 34:
           X33 8.246365e-04 2.461783e-02 0.0115690528
## 35:
           X61 7.137879e-04 3.288040e-02 0.0115690528
## 36:
           X62 7.104149e-04 3.994010e-03 0.0036153290
           X93 6.955822e-04 3.992919e-04 0.0021691974
## 37:
## 38:
           X18 6.714233e-04 2.725579e-03 0.0130151844
## 39:
            X3 6.660532e-04 1.202367e-02 0.0289226320
## 40:
           X88 6.353700e-04 6.454782e-03 0.0072306580
           X69 6.225559e-04 1.028818e-03 0.0036153290
## 41:
## 42:
           X34 5.920321e-04 2.397567e-03 0.0079537238
## 43:
           X21 5.860887e-04 1.274359e-03 0.0057845264
## 44:
           X65 5.633568e-04 6.749032e-04 0.0028922632
## 45:
           X71 5.413478e-04 3.926602e-02 0.0130151844
## 46:
           X31 5.245129e-04 1.358709e-03 0.0057845264
```

```
## 47:
           X36 5.146123e-04 2.125161e-02 0.0079537238
## 48:
           X32 5.037984e-04 1.763553e-02 0.0086767896
## 49:
           X35 4.879140e-04 1.321706e-02 0.0079537238
           X24 4.001082e-04 7.082961e-03 0.0043383948
## 50:
## 51:
            X5 3.949750e-04 2.338163e-02 0.0238611714
## 52:
           X54 3.833944e-04 3.348807e-02 0.0130151844
## 53:
           X37 3.609419e-04 1.890173e-02 0.0137382502
## 54:
           X41 3.494368e-04 6.935531e-03 0.0057845264
## 55:
           X73 3.199906e-04 5.973822e-02 0.0202458424
## 56:
           X53 3.140084e-04 1.449216e-03 0.0036153290
## 57:
            X8 2.891729e-04 2.264581e-04 0.0043383948
           X23 2.638934e-04 3.402781e-02 0.0115690528
## 58:
## 59:
           X92 2.029522e-04 1.584540e-03 0.0028922632
## 60:
           X97 1.566786e-04 1.376301e-03 0.0043383948
           X51 1.140807e-04 1.278157e-03 0.0050614606
## 61:
## 62:
           X19 1.073618e-04 1.399819e-03 0.0028922632
## 63:
           X40 9.361749e-05 8.299692e-04 0.0043383948
           X17 8.681726e-05 8.881332e-04 0.0021691974
## 64:
           X47 8.183355e-05 2.948777e-04 0.0021691974
## 65:
## 66:
            X6 7.961564e-05 3.793751e-04 0.0144613160
## 67:
           X14 7.862251e-05 9.827116e-03 0.0065075922
## 68:
           X29 7.677699e-05 6.322071e-03 0.0115690528
## 69:
           X25 6.431273e-05 2.323078e-03 0.0065075922
## 70:
           X82 4.934686e-05 1.167511e-04 0.0021691974
## 71:
           X57 4.903361e-05 3.113228e-03 0.0021691974
## 72:
           X38 4.747627e-05 2.680499e-03 0.0021691974
## 73:
           X98 4.174962e-05 3.728638e-05 0.0007230658
## 74:
           X42 4.125281e-05 3.007628e-04 0.0021691974
## 75:
           X28 3.546808e-05 1.158524e-05 0.0021691974
## 76:
           X90 3.421110e-05 6.035909e-06 0.0007230658
           X77 2.393617e-05 5.530957e-05 0.0014461316
## 77:
## 78:
           X68 1.970282e-05 1.374279e-04 0.0028922632
## 79:
           X63 1.705360e-05 9.821615e-04 0.0014461316
## 80:
           X11 1.108114e-05 1.104109e-04 0.0028922632
## 81:
           X49 9.258151e-06 6.348978e-04 0.0014461316
## 82:
           X60 7.893478e-06 1.066587e-03 0.0014461316
           X85 7.299216e-06 1.704340e-04 0.0036153290
## 83:
## 84:
           X86 5.062277e-06 3.629887e-04 0.0007230658
## 85:
           X44 4.531521e-06 9.386922e-04 0.0014461316
           X89 4.465056e-06 1.279921e-02 0.0043383948
## 86:
## 87:
           X46 4.432212e-06 1.002080e-03 0.0014461316
## 88:
           X87 4.168708e-06 6.282482e-03 0.0021691974
## 89:
           X99 3.950399e-06 6.450424e-04 0.0014461316
           X43 2.441770e-06 1.154893e-03 0.0014461316
## 90:
## 91:
           X80 2.302863e-06 1.351984e-04 0.0021691974
## 92:
           X91 2.189638e-06 3.584169e-04 0.0007230658
## 93:
           X64 1.844473e-06 2.197687e-03 0.0036153290
           X72 8.057995e-07 8.423507e-05 0.0014461316
## 94:
## 95:
           X26 4.337428e-07 1.090388e-02 0.0028922632
           X48 1.425777e-07 3.024509e-03 0.0007230658
## 96:
```

XGBoost Variable Importance



3. Fit LASSO Regression

```
# Fit a LASSO regression using 10-fold cross-validation
cv_lasso <- cv.glmnet(X, Y, family = "poisson", alpha = 1)  # LASSO (alpha = 1)
lasso_coef <- coef(cv_lasso, s = "lambda.min")
lasso_selected <- lasso_coef[lasso_coef != 0]  # Non-zero coefficients

# Print LASSO Selected Predictors (Non-Zero Coefficients)
cat("\n\033[lmLASSO Selected Predictors (Non-Zero Coefficients):\033[0m\n")

##
## [1mLASSO Selected Predictors (Non-Zero Coefficients):[0m

print(lasso_selected)

## [1] 1.168197068 1.881783627 0.893091753 0.414614357 0.027664054

## [6] 1.407121866 -0.038254651 -0.001225712 -0.003179737 -0.034716099</pre>
```

```
## [11] 0.008988551 -0.001036282 -0.011436205 -0.040760765 -0.003765141
## [16] 0.020775631 -0.026585092 0.006552738
```

Elastic Net Regression

```
# Fit an Elastic Net regression using 10-fold cross-validation
cv_elastic <- cv.glmnet(X, Y, family = "poisson", alpha = 0.5) # Elastic Net
(alpha = 0.5)
elastic_coef <- coef(cv_elastic, s = "lambda.min")</pre>
```

4. Compare LASSO & Elastic Net Regression

```
# Compare LASSO vs Elastic Net coefficients
coef comparison <- data.frame(</pre>
 Variable = rownames(lasso_coef),
 LASSO = as.vector(lasso_coef),
  Elastic_Net = as.vector(elastic_coef)
)
# Print LASSO vs Elastic Net Coefficients
cat("\n\033[1mLASSO vs Elastic Net Coefficients:\033[0m\n")
##
## [1mLASSO vs Elastic Net Coefficients:[0m
print(coef_comparison)
         Variable
                          LASS0
##
                                  Elastic Net
                   1.168197068 1.4581256261
## 1
       (Intercept)
## 2
               X1
                   1.881783627
                                 1.5674565504
## 3
                X2 0.893091753 0.6855059103
## 4
               X3
                   0.000000000 0.0357048659
## 5
               X4
                   0.000000000 0.0000000000
               X5
                   0.414614357
## 6
                                 0.3047929691
## 7
               X6 0.000000000 0.0000000000
## 8
               X7 0.000000000 -0.0078201093
## 9
               X8 0.027664054 0.0813012725
## 10
               X9
                   0.000000000 0.0000000000
## 11
              X10
                   1.407121866 1.1957601021
## 12
              X11
                   0.000000000 0.0066833525
## 13
              X12
                   0.000000000 0.0000000000
## 14
              X13
                   0.000000000 0.0000000000
## 15
              X14
                   0.000000000 0.0638081046
## 16
              X15
                   0.000000000 0.0000000000
## 17
              X16
                   0.00000000 0.000000000
## 18
              X17
                    0.000000000 0.0000000000
## 19
              X18
                   0.000000000 -0.0024232249
## 20
              X19
                   0.000000000 0.0000000000
## 21
              X20
                   0.00000000 0.0188758067
## 22
              X21
                    0.000000000 0.0000000000
## 23
              X22
                   0.000000000 0.0000000000
## 24
              X23 0.000000000 0.0000000000
```

```
## 25
                X24
                     0.000000000
                                   0.0225226781
## 26
                X25
                     0.000000000
                                   0.0000000000
##
   27
                X26
                     0.00000000
                                   0.0000000000
## 28
                X27
                    -0.038254651
                                  -0.1225101329
                                   0.0000000000
## 29
                X28
                     0.000000000
##
   30
                X29
                     0.000000000
                                   0.0000000000
##
   31
                X30
                     0.000000000
                                   0.0000000000
##
   32
                X31
                     0.000000000
                                   0.0000000000
##
   33
                X32
                     0.00000000
                                   0.0000000000
##
   34
                X33
                     0.000000000
                                   0.0000000000
##
   35
                X34
                    -0.001225712
                                  -0.0284727356
##
   36
                X35
                     0.000000000
                                   0.0000000000
##
   37
                X36
                     0.000000000
                                   0.0000000000
##
   38
                X37
                     0.000000000
                                   0.0000000000
##
   39
                X38
                     0.00000000
                                   0.0000000000
## 40
                X39
                     0.000000000
                                   0.0000000000
##
  41
                X40
                     0.00000000
                                   0.0000000000
## 42
                X41
                    -0.003179737
                                   0.0000000000
##
  43
                X42
                     0.000000000
                                   0.0000000000
## 44
                X43
                     0.000000000
                                   0.0000000000
##
  45
                X44
                     0.00000000
                                   0.0000000000
##
  46
                X45
                     0.00000000
                                  -0.0091477720
## 47
                X46
                    -0.034716099
                                  -0.0703284905
##
  48
                X47
                     0.000000000
                                   0.0000000000
##
  49
                X48
                     0.008988551
                                   0.0000000000
##
   50
                X49
                     0.00000000
                                   0.0000000000
##
   51
                X50
                     0.00000000
                                  -0.0109663722
##
   52
                X51
                    -0.001036282 -0.0160467518
## 53
                X52
                     0.000000000
                                   0.0000000000
## 54
                X53
                     0.000000000
                                  -0.0254609936
## 55
                X54
                     0.000000000
                                   0.0000000000
## 56
                X55
                     0.00000000
                                  -0.0334366766
##
   57
                X56
                     0.00000000
                                   0.0000000000
##
   58
                X57
                     0.000000000
                                   0.0000000000
##
   59
                X58
                     0.000000000
                                   0.0000000000
                X59
##
  60
                     0.000000000
                                   0.0000000000
##
   61
                X60
                    -0.011436205
                                  -0.0069661366
## 62
                X61
                    -0.040760765
                                  -0.0574961386
## 63
                X62
                     0.00000000
                                   0.0192326217
##
   64
                X63
                     0.000000000
                                   0.0000000000
##
   65
                X64
                     0.000000000
                                   0.0000000000
##
   66
                X65
                     0.000000000
                                   0.0000000000
## 67
                X66
                     0.00000000
                                   0.0171581169
##
   68
                X67
                     0.000000000
                                   0.0000000000
##
  69
                X68
                    -0.003765141
                                  -0.0091776252
## 70
                X69
                                   0.0000000000
                     0.000000000
##
  71
                X70
                     0.000000000
                                   0.0000000000
##
  72
                X71
                     0.00000000
                                   0.0000000000
##
   73
                X72
                     0.000000000
                                   0.0000000000
## 74
                X73
                     0.00000000
                                   0.0000000000
```

```
## 75
                X74
                     0.000000000 -0.0090900316
## 76
                X75
                     0.000000000 -0.0052775612
## 77
                X76
                     0.000000000
                                   0.0448153579
## 78
                X77
                     0.000000000
                                   0.0000000000
## 79
                X78
                     0.000000000
                                   0.0000000000
## 80
                X79
                     0.000000000
                                   0.0000000000
## 81
                X80
                     0.000000000
                                   0.0000000000
## 82
                X81
                     0.000000000
                                  -0.1206151301
## 83
                X82
                     0.020775631
                                   0.0148383556
## 84
                X83
                    -0.026585092 -0.0340214982
                                   0.0000000000
## 85
                X84
                     0.000000000
## 86
                X85
                     0.000000000
                                   0.0000000000
## 87
                X86
                     0.006552738
                                   0.0420503478
## 88
                X87
                     0.000000000
                                   0.0000000000
## 89
                X88
                     0.000000000
                                   0.0000000000
## 90
                X89
                     0.000000000
                                   0.0000000000
## 91
                X90
                     0.00000000
                                   0.0000000000
## 92
                X91
                     0.000000000
                                   0.0000000000
## 93
                X92
                     0.000000000
                                   0.0000000000
## 94
                X93
                     0.000000000
                                   0.0063020803
## 95
                X94
                     0.000000000
                                   0.0000000000
## 96
                X95
                     0.000000000
                                   0.0000000000
## 97
                X96
                     0.000000000
                                   0.0189567901
## 98
                X97
                     0.000000000
                                  -0.0003465524
## 99
                X98
                     0.000000000
                                   0.0381898929
## 100
                X99
                     0.00000000
                                   0.0000000000
## 101
               X100
                     0.000000000
                                   0.0000000000
```