

Gradient-Boosting-for-Classification.R

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```
# Extreme Gradient Boosting (xgb or xgboost)

# classification of flowers using lenght of sepal, width of sepal, lenght of petal, and width of petal
# xgboost requires the target variable classes to be in an integer format starting with 0
library(xgboost)

## Warning: package 'xgboost' was built under R version 4.0.2

data("iris")
attach(iris)
str(iris)

## 'data.frame':   150 obs. of  5 variables:
##  $ Sepal.Length: num   5.1 4.9 4.7 4.6 5 5.4 4.6 5 4.4 4.9 ...
##  $ Sepal.Width : num   3.5 3 3.2 3.1 3.6 3.9 3.4 3.4 2.9 3.1 ...
##  $ Petal.Length: num   1.4 1.4 1.3 1.5 1.4 1.7 1.4 1.5 1.4 1.5 ...
##  $ Petal.Width : num   0.2 0.2 0.2 0.2 0.2 0.4 0.3 0.2 0.2 0.1 ...
##  $ Species      : Factor w/ 3 levels "setosa","versicolor",...: 1 1 1 1 1 1 1 1 1 1 ...

head(iris)

##      Sepal.Length Sepal.Width Petal.Length Petal.Width Species
## 1           5.1           3.5           1.4           0.2  setosa
## 2           4.9           3.0           1.4           0.2  setosa
## 3           4.7           3.2           1.3           0.2  setosa
## 4           4.6           3.1           1.5           0.2  setosa
## 5           5.0           3.6           1.4           0.2  setosa
## 6           5.4           3.9           1.7           0.4  setosa

species <- iris$Species
#converting target variable "species" to integer format
label <- as.integer(iris$Species)
label

##      [1] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
##     [38] 1 1 1 1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
##     [75] 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 3 3 3 3 3 3 3 3 3
##    [112] 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3
##    [149] 3 3

#converting first class to 0 , 2nd to 1, 3rd to 2
label <- as.integer(iris$Species) -1
label

##      [1] 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
##     [38] 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
```

```
## [75] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2 2 2
## [112] 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
## [149] 2 2
```

```
#removing Species variable
```

```
iris$Species <- NULL
```

```
# * training data should not contain the target variable (label)
```

```
#SPLIT TRAIN/TEST
```

```
indx <- sample(2, nrow(iris), replace=TRUE, prob=c(0.75, 0.25))
```

```
train_data <- iris[indx==1, ]
```

```
train_labels <- label[indx==1]
```

```
test_data <- iris[indx==2, ]
```

```
test_labels <- label[indx==2]
```

```
#if we had categorical variables, we would need to convert them to numerical using dummy variables
```

```
#transform data into "xgb.DMatrix" format
```

```
#but the inputs to xgb.DMatrix have to be matrices themselves
```

```
train_data <- as.matrix(iris[indx==1, ])
```

```
test_data <- as.matrix(iris[indx==2, ])
```

```
# xgboost requires this input format
```

```
xgb.train <- xgb.DMatrix(data = train_data, label=train_labels)
```

```
xgb.test <- xgb.DMatrix(data = test_data, label=test_labels)
```

```
# 2 functions to train model: xgb.train & xgboost
```

```
params = list(booster="gbtree", max_depth = 5,
              eta = .001, objective= "multi:softprob",
              eval_metric= "mlogloss", num_class = length(levels(species)))
```

```
# nrounds = max num of iterations required in Grad Boosting Model
```

```
 #(remember we are adding weak learners to improve model)
```

```
# early_stopping_rounds = performance of model in a validation data and
```

```
#stops training once the performance on the validation data has not improved
```

```
#after a certain number of iterations
```

```
 #early_stopping_rounds = 10 --> (prevent overfitting)
```

```
 #if performance does not improve after 10 iterations, we stop.
```

```
#booster="gbtree" or "gblinear"
```

```
#eta -- learning rate in gradient boosting
```

```
 #F_M = F_(M-1) + eta Delta_M
```

```
# objective= "multi:softprob" - multiclass classification probs
```

```
 #reg:linear - for linear regression probs
```

```
 #binary:logistic - binary classification
```

```
 #multi:softmax - predict classes
```

```
 #multi:softprob - predict probabilities
```

```
#eval_metric= mae, auc, error, logloss (for binary classification), mlogloss (multiclass)
```

```
xgb.fit <- xgb.train(data = xgb.train, params = params, nrounds=1000,
```

```
                watchlist = list(val1 = xgb.train, val2 = xgb.test), early_stopping_rounds= 10)
```

```
## [1] val1-mlogloss:1.097249 val2-mlogloss:1.097269
```

```
## Multiple eval metrics are present. Will use val2_mlogloss for early stopping.
```

```

## Will train until val2_mlogloss hasn't improved in 10 rounds.
##
## [2] val1-mlogloss:1.095887 val2-mlogloss:1.095929
## [3] val1-mlogloss:1.094527 val2-mlogloss:1.094590
## [4] val1-mlogloss:1.093170 val2-mlogloss:1.093255
## [5] val1-mlogloss:1.091815 val2-mlogloss:1.091921
## [6] val1-mlogloss:1.090462 val2-mlogloss:1.090590
## [7] val1-mlogloss:1.089114 val2-mlogloss:1.089262
## [8] val1-mlogloss:1.087765 val2-mlogloss:1.087936
## [9] val1-mlogloss:1.086419 val2-mlogloss:1.086612
## [10] val1-mlogloss:1.085076 val2-mlogloss:1.085290
## [11] val1-mlogloss:1.083734 val2-mlogloss:1.083971
## [12] val1-mlogloss:1.082397 val2-mlogloss:1.082654
## [13] val1-mlogloss:1.081061 val2-mlogloss:1.081340
## [14] val1-mlogloss:1.079728 val2-mlogloss:1.080027
## [15] val1-mlogloss:1.078396 val2-mlogloss:1.078718
## [16] val1-mlogloss:1.077066 val2-mlogloss:1.077410
## [17] val1-mlogloss:1.075739 val2-mlogloss:1.076105
## [18] val1-mlogloss:1.074414 val2-mlogloss:1.074803
## [19] val1-mlogloss:1.073091 val2-mlogloss:1.073502
## [20] val1-mlogloss:1.071771 val2-mlogloss:1.072204
## [21] val1-mlogloss:1.070453 val2-mlogloss:1.070908
## [22] val1-mlogloss:1.069138 val2-mlogloss:1.069614
## [23] val1-mlogloss:1.067824 val2-mlogloss:1.068323
## [24] val1-mlogloss:1.066512 val2-mlogloss:1.067034
## [25] val1-mlogloss:1.065202 val2-mlogloss:1.065747
## [26] val1-mlogloss:1.063897 val2-mlogloss:1.064463
## [27] val1-mlogloss:1.062591 val2-mlogloss:1.063180
## [28] val1-mlogloss:1.061290 val2-mlogloss:1.061901
## [29] val1-mlogloss:1.059988 val2-mlogloss:1.060623
## [30] val1-mlogloss:1.058691 val2-mlogloss:1.059347
## [31] val1-mlogloss:1.057395 val2-mlogloss:1.058074
## [32] val1-mlogloss:1.056101 val2-mlogloss:1.056803
## [33] val1-mlogloss:1.054810 val2-mlogloss:1.055534
## [34] val1-mlogloss:1.053521 val2-mlogloss:1.054267
## [35] val1-mlogloss:1.052234 val2-mlogloss:1.053003
## [36] val1-mlogloss:1.050949 val2-mlogloss:1.051741
## [37] val1-mlogloss:1.049666 val2-mlogloss:1.050481
## [38] val1-mlogloss:1.048385 val2-mlogloss:1.049224
## [39] val1-mlogloss:1.047106 val2-mlogloss:1.047968
## [40] val1-mlogloss:1.045830 val2-mlogloss:1.046715
## [41] val1-mlogloss:1.044555 val2-mlogloss:1.045463
## [42] val1-mlogloss:1.043284 val2-mlogloss:1.044214
## [43] val1-mlogloss:1.042015 val2-mlogloss:1.042968
## [44] val1-mlogloss:1.040747 val2-mlogloss:1.041723
## [45] val1-mlogloss:1.039481 val2-mlogloss:1.040480
## [46] val1-mlogloss:1.038216 val2-mlogloss:1.039241
## [47] val1-mlogloss:1.036955 val2-mlogloss:1.038002
## [48] val1-mlogloss:1.035697 val2-mlogloss:1.036766
## [49] val1-mlogloss:1.034438 val2-mlogloss:1.035533
## [50] val1-mlogloss:1.033184 val2-mlogloss:1.034301
## [51] val1-mlogloss:1.031932 val2-mlogloss:1.033071
## [52] val1-mlogloss:1.030680 val2-mlogloss:1.031844
## [53] val1-mlogloss:1.029431 val2-mlogloss:1.030618

```

```

## [54] val1-mlogloss:1.028185 val2-mlogloss:1.029395
## [55] val1-mlogloss:1.026939 val2-mlogloss:1.028174
## [56] val1-mlogloss:1.025697 val2-mlogloss:1.026955
## [57] val1-mlogloss:1.024457 val2-mlogloss:1.025738
## [58] val1-mlogloss:1.023218 val2-mlogloss:1.024523
## [59] val1-mlogloss:1.021981 val2-mlogloss:1.023310
## [60] val1-mlogloss:1.020747 val2-mlogloss:1.022099
## [61] val1-mlogloss:1.019513 val2-mlogloss:1.020891
## [62] val1-mlogloss:1.018283 val2-mlogloss:1.019685
## [63] val1-mlogloss:1.017055 val2-mlogloss:1.018480
## [64] val1-mlogloss:1.015829 val2-mlogloss:1.017278
## [65] val1-mlogloss:1.014604 val2-mlogloss:1.016077
## [66] val1-mlogloss:1.013381 val2-mlogloss:1.014879
## [67] val1-mlogloss:1.012161 val2-mlogloss:1.013683
## [68] val1-mlogloss:1.010943 val2-mlogloss:1.012488
## [69] val1-mlogloss:1.009726 val2-mlogloss:1.011297
## [70] val1-mlogloss:1.008513 val2-mlogloss:1.010106
## [71] val1-mlogloss:1.007301 val2-mlogloss:1.008918
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## [73] val1-mlogloss:1.004882 val2-mlogloss:1.006548
## [74] val1-mlogloss:1.003676 val2-mlogloss:1.005366
## [75] val1-mlogloss:1.002469 val2-mlogloss:1.004186
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## [77] val1-mlogloss:1.000067 val2-mlogloss:1.001832
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## [79] val1-mlogloss:0.997673 val2-mlogloss:0.999486
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## [81] val1-mlogloss:0.995284 val2-mlogloss:0.997148
## [82] val1-mlogloss:0.994093 val2-mlogloss:0.995982
## [83] val1-mlogloss:0.992905 val2-mlogloss:0.994818
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## [98] val1-mlogloss:0.975337 val2-mlogloss:0.977591
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## [100] val1-mlogloss:0.973025 val2-mlogloss:0.975327
## [101] val1-mlogloss:0.971873 val2-mlogloss:0.974198
## [102] val1-mlogloss:0.970723 val2-mlogloss:0.973070
## [103] val1-mlogloss:0.969574 val2-mlogloss:0.971945
## [104] val1-mlogloss:0.968427 val2-mlogloss:0.970821
## [105] val1-mlogloss:0.967281 val2-mlogloss:0.969699
## [106] val1-mlogloss:0.966137 val2-mlogloss:0.968579
## [107] val1-mlogloss:0.964995 val2-mlogloss:0.967461

```

## [108]	val1-mlogloss:0.963857	val2-mlogloss:0.966345
## [109]	val1-mlogloss:0.962720	val2-mlogloss:0.965230
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## [190]	val1-mlogloss:0.876210	val2-mlogloss:0.880747
## [191]	val1-mlogloss:0.875208	val2-mlogloss:0.879771
## [192]	val1-mlogloss:0.874208	val2-mlogloss:0.878797
## [193]	val1-mlogloss:0.873209	val2-mlogloss:0.877824
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## [196]	val1-mlogloss:0.870220	val2-mlogloss:0.874915
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## [200]	val1-mlogloss:0.866256	val2-mlogloss:0.871057
## [201]	val1-mlogloss:0.865268	val2-mlogloss:0.870097
## [202]	val1-mlogloss:0.864283	val2-mlogloss:0.869137
## [203]	val1-mlogloss:0.863299	val2-mlogloss:0.868180
## [204]	val1-mlogloss:0.862316	val2-mlogloss:0.867224
## [205]	val1-mlogloss:0.861334	val2-mlogloss:0.866269
## [206]	val1-mlogloss:0.860356	val2-mlogloss:0.865316
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## [982]    val1-mlogloss:0.390019    val2-mlogloss:0.421350
## [983]    val1-mlogloss:0.389658    val2-mlogloss:0.421030
## [984]    val1-mlogloss:0.389297    val2-mlogloss:0.420710
## [985]    val1-mlogloss:0.388939    val2-mlogloss:0.420385
## [986]    val1-mlogloss:0.388579    val2-mlogloss:0.420066
## [987]    val1-mlogloss:0.388220    val2-mlogloss:0.419748
## [988]    val1-mlogloss:0.387862    val2-mlogloss:0.419430
## [989]    val1-mlogloss:0.387504    val2-mlogloss:0.419107
## [990]    val1-mlogloss:0.387146    val2-mlogloss:0.418790
## [991]    val1-mlogloss:0.386789    val2-mlogloss:0.418473
## [992]    val1-mlogloss:0.386432    val2-mlogloss:0.418151
## [993]    val1-mlogloss:0.386075    val2-mlogloss:0.417835
## [994]    val1-mlogloss:0.385720    val2-mlogloss:0.417520
## [995]    val1-mlogloss:0.385364    val2-mlogloss:0.417198
## [996]    val1-mlogloss:0.385009    val2-mlogloss:0.416884
## [997]    val1-mlogloss:0.384654    val2-mlogloss:0.416570
## [998]    val1-mlogloss:0.384300    val2-mlogloss:0.416250
## [999]    val1-mlogloss:0.383946    val2-mlogloss:0.415936
## [1000]   val1-mlogloss:0.383592    val2-mlogloss:0.415623
```

```
xgb.pred <- predict(xgb.fit , test_data, reshape=T)
head(xgb.pred) #we get predicted probabilities of each class
```

```
##           [,1]      [,2]      [,3]
## [1,] 0.7009067 0.15102 0.1480733
## [2,] 0.7009067 0.15102 0.1480733
## [3,] 0.7009067 0.15102 0.1480733
## [4,] 0.7009067 0.15102 0.1480733
## [5,] 0.7009067 0.15102 0.1480733
## [6,] 0.7009067 0.15102 0.1480733
```

```
#formatting results
xgb.pred<- as.data.frame(xgb.pred)
colnames(xgb.pred) = levels(species)
head(xgb.pred)
```

```
##      setosa versicolor virginica
## 1 0.7009067    0.15102 0.1480733
## 2 0.7009067    0.15102 0.1480733
## 3 0.7009067    0.15102 0.1480733
## 4 0.7009067    0.15102 0.1480733
## 5 0.7009067    0.15102 0.1480733
## 6 0.7009067    0.15102 0.1480733
```