# Predictive Modeling
# Lesson 2
# *CART*

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## Introduction

The RStudio project files and accompanying artifacts, including the tex file that created this PDF, are publicly available on GitHub
`https://github.com/zollie/PASS-PredictiveModeling-CART`

## Data Setup

I took the Excel spreadsheet and saved it as a CSV for easy import into R

```
> wine <- read.csv("~/R/PASS/PredictiveModeling/CART/Wine.csv")
> wine <- wine[1:178,1:14]
> head(wine)
```

```
  Type Alcohol Malic_Acid  Ash Ash_Alcalinity Magnesium Total_Phenols
1    A   14.23       1.71 2.43           15.6       127          2.80
2    A   13.20       1.78 2.14           11.2       100          2.65
3    A   13.16       2.36 2.67           18.6       101          2.80
4    A   14.37       1.95 2.50           16.8       113          3.85
5    A   13.24       2.59 2.87           21.0       118          2.80
6    A   14.20       1.76 2.45           15.2       112          3.27
  Flavanoids Nonflavanoid_Phenols Proanthocyanins Color_Intensity  Hue
1       3.06                0.28            2.29            5.64 1.04
2       2.76                0.26            1.28            4.38 1.05
3       3.24                0.30            2.81            5.68 1.03
4       3.49                0.24            2.18            7.80 0.86
5       2.69                0.39            1.82            4.32 1.04
6       3.39                0.34            1.97            6.75 1.05
  OD280_OD315 Proline
1        3.92    1065
2        3.40    1050
```

```
3        3.17    1185
4        3.45    1480
5        2.93     735
6        2.85    1450
```

## Partitioning

Next, partition the data into 50% Train and 50% Test sets. I set the RNG seed for reproducibility

```
> set.seed(21275)
> n <- nrow(wine)
> nt <- sort(sample(1:n, floor(n/2)))
> train <- wine[nt,]
> test <- wine[-nt,]
> head(train)

   Type Alcohol Malic_Acid  Ash Ash_Alcalinity Magnesium Total_Phenols
1     A   14.23       1.71 2.43           15.6       127          2.80
6     A   14.20       1.76 2.45           15.2       112          3.27
8     A   14.06       2.15 2.61           17.6       121          2.60
9     A   14.83       1.64 2.17           14.0        97          2.80
10    A   13.86       1.35 2.27           16.0        98          2.98
11    A   14.10       2.16 2.30           18.0       105          2.95
   Flavanoids Nonflavanoid_Phenols Proanthocyanins Color_Intensity  Hue
1        3.06                0.28            2.29            5.64 1.04
6        3.39                0.34            1.97            6.75 1.05
8        2.51                0.31            1.25            5.05 1.06
9        2.98                0.29            1.98            5.20 1.08
10       3.15                0.22            1.85            7.22 1.01
11       3.32                0.22            2.38            5.75 1.25
   OD280_OD315 Proline
1         3.92    1065
6         2.85    1450
8         3.58    1295
9         2.85    1045
10        3.55    1045
11        3.17    1510

> head(test)

   Type Alcohol Malic_Acid  Ash Ash_Alcalinity Magnesium Total_Phenols
2     A   13.20       1.78 2.14           11.2       100          2.65
3     A   13.16       2.36 2.67           18.6       101          2.80
4     A   14.37       1.95 2.50           16.8       113          3.85
5     A   13.24       2.59 2.87           21.0       118          2.80
```

```
7     A   14.39       1.87 2.45           14.6        96          2.50
12    A   14.12       1.48 2.32           16.8        95          2.20
   Flavanoids Nonflavanoid_Phenols Proanthocyanins Color_Intensity  Hue
2        2.76                0.26            1.28            4.38 1.05
3        3.24                0.30            2.81            5.68 1.03
4        3.49                0.24            2.18            7.80 0.86
5        2.69                0.39            1.82            4.32 1.04
7        2.52                0.30            1.98            5.25 1.02
12       2.43                0.26            1.57            5.00 1.17
   OD280_OD315 Proline
2         3.40    1050
3         3.17    1185
4         3.45    1480
5         2.93     735
7         3.58    1290
12        2.82    1280
```

## CART with the rpart package

First we build the decision tree with train data

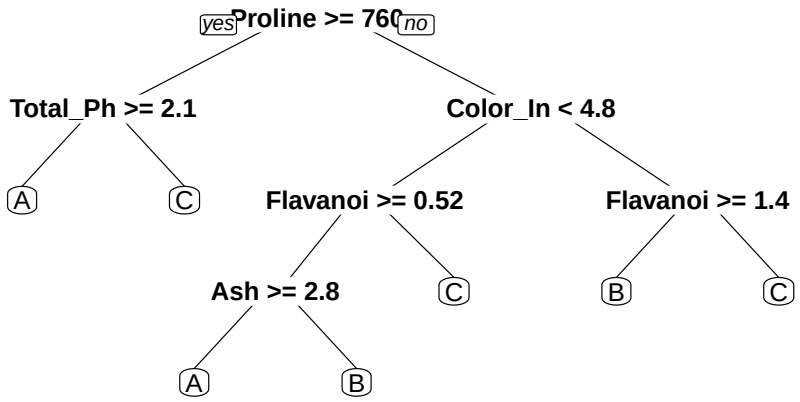
```
> library(rpart)
> fit <- rpart(Type ~ ., data=train, method="class", minbucket = 1)
```

Then make predictions using the test data

```
> pred <- predict(fit, newdata=test, type="class")
> tab <- table(pred, test[,"Type"])
```

Visually the tree looks like

```
> library(rpart.plot)
> prp(fit)
```




# Lesson 2 Question and Answer

## 1

*What is the error rate for the validation data?*

```
> printcp(fit)

Classification tree:
rpart(formula = Type ~ ., data = train, method = "class", minbucket = 1)

Variables actually used in tree construction:
[1] Flavanoids  Hue         Magnesium   OD280_OD315 Proline

Root node error: 53/89 = 0.59551

n= 89

        CP nsplit rel error  xerror     xstd
1 0.566038      0  1.000000 1.20755 0.080000
2 0.320755      1  0.433962 0.45283 0.078994
3 0.037736      2  0.113208 0.20755 0.058583
4 0.018868      4  0.037736 0.16981 0.053666
5 0.010000      5  0.018868 0.20755 0.058583
```

The error rate is

```
> 1-sum(diag(tab))/sum(tab)

[1] 0.1460674
```

## 2

*Indicate the number of misclassification*

The Classification Matrix is given below

```
> tab
```

```
pred     A  B  C
      0  0  0  0
   A  0 25  2  6
   B  0  1 31  2
   C  0  0  2 20
```

## 3

*Study the Best Pruned tree and develop a set of classification rules, using if-then statement; e.g. "if a >= b then A" and "if a < b then B"*

```
> fit
```

```
n= 89

node), split, n, loss, yval, (yprob)
      * denotes terminal node

 1) root 89 53 B (0.00000000 0.37078652 0.40449438 0.22471910)
   2) Proline>=755 34  2 A (0.00000000 0.94117647 0.05882353 0.00000000)
     4) Magnesium< 133.5 32  0 A (0.00000000 1.00000000 0.00000000 0.00000000) *
     5) Magnesium>=133.5 2  0 B (0.00000000 0.00000000 1.00000000 0.00000000) *
   3) Proline< 755 55 21 B (0.00000000 0.01818182 0.61818182 0.36363636)
     6) OD280_OD315>=2.185 32  1 B (0.00000000 0.03125000 0.96875000 0.00000000) *
     7) OD280_OD315< 2.185 23  3 C (0.00000000 0.00000000 0.13043478 0.86956522)
      14) Hue>=0.965 2  0 B (0.00000000 0.00000000 1.00000000 0.00000000) *
      15) Hue< 0.965 21  1 C (0.00000000 0.00000000 0.04761905 0.95238095)
        30) Flavanoids>=1.475 1  0 B (0.00000000 0.00000000 1.00000000 0.00000000) *
        31) Flavanoids< 1.475 20  0 C (0.00000000 0.00000000 0.00000000 1.00000000) *
```

If Proline greater than or equal to 760 and Color greater than or equal to 4.8 and Flavanoids greater than or equal to 1.4 then C

If Proline greater than or equal to 760 and Color greater than or equal to 4.8 and Flavanoids less than 1.4 then B

If Proline greater than or equal to 760 and Color less than 4.8 and Flavanoids greater than or equal to .52 then C

If Proline greater than or equal to 760 and Color less than 4.8 and Flavanoids less than .52 and Ash greater than or equal to 2.8 then B

If Proline greater than or equal to 760 and Color less than 4.8 and Flavanoids less than .52 and Ash less than 2.8 then A

If Proline less than 760 and Total Phenols greater than or equal to 2.1 then C

If Proline less than 760 and Total Phenols less than 2.1 then A