P8106 HW3

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3/22/2022

Load packages

```
library(tidyverse)
library(AppliedPredictiveModeling)
library(pROC)
library(caret)
library(klaR)
library(MASS)
```

Import and tidy data

```
data = read_csv("auto.csv") %>%
  mutate(
    year = factor(year),
    origin = factor(origin),
    mpg_cat = factor(mpg_cat),
    mpg_cat = fct_relevel(mpg_cat, c("low", "high"))
  )
```

Partition the data for model training

```
set.seed(2022)

# partition data into training and testing sets into randomized 4:1 splits
train_index = createDataPartition(y = data$mpg_cat, p = 0.7, list = FALSE)
train_data = data[train_index, ]
test_data = data[-train_index, ]

# matrices of predictors
train_pred = model.matrix(mpg_cat ~ ., train_data)[ ,-1]
train_cont_pred = model.matrix(mpg_cat ~ ., train_data)[ , 2:6]
test_pred = model.matrix(mpg_cat ~ ., test_data)[ ,-1]
test_cont_pred = model.matrix(mpg_cat ~ ., train_data)[ , 2:6]

# vectors of response
train_resp = train_data$mpg_cat
test_resp = test_data$mpg_cat
```

Calculate descriptive statistics: quantile data for the continuous variables and count data for the categorical variables. Number of cylinders is arguably an ordinal categorical variable but is treated as a continuous variable here. Most cars have an American origin (category 1), and the number of high and low mileage car samples are the same.

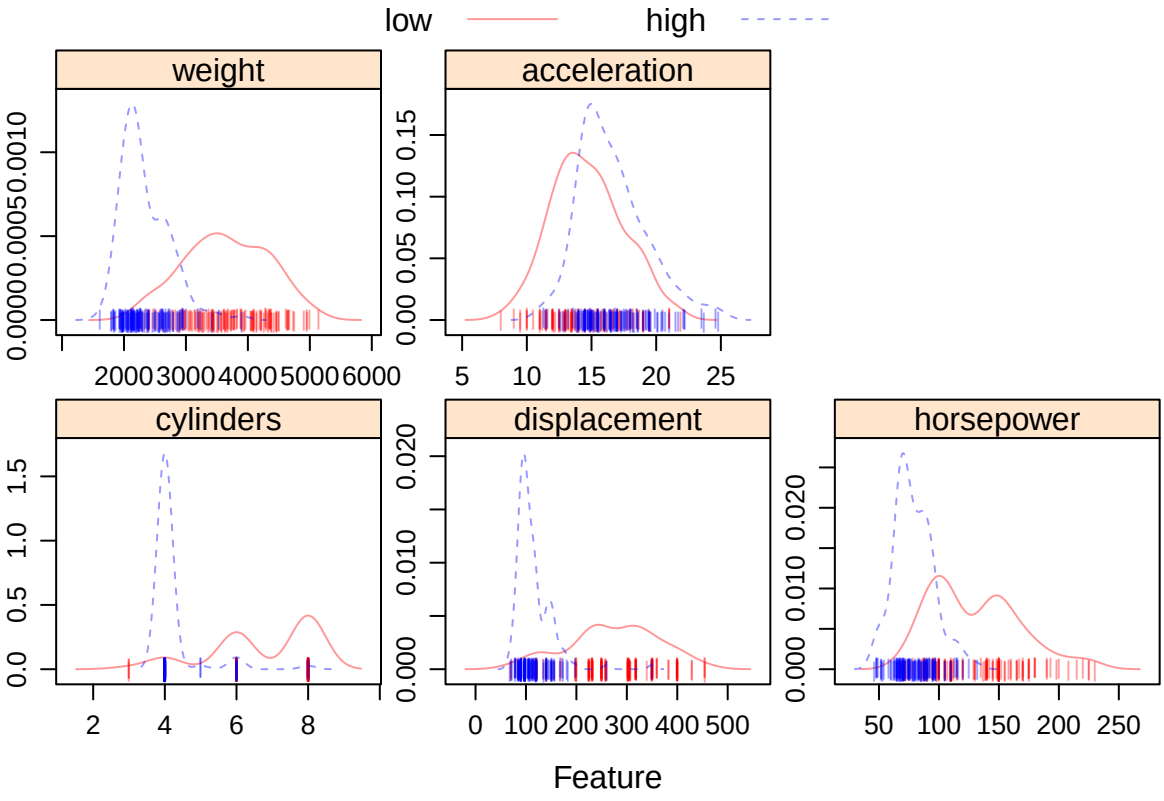
```
summary(train_data)
```

```
##    cylinders      displacement     horsepower        weight      acceleration
##  Min.   :3.00   Min.   : 68.0   Min.   : 46.0   Min.   :1613   Min.   : 8.00
##  1st Qu.:4.00   1st Qu.:100.2   1st Qu.: 75.0   1st Qu.:2222   1st Qu.:13.90
##  Median :4.00   Median :151.0   Median : 95.0   Median :2798   Median :15.50
##  Mean   :5.46   Mean   :194.3   Mean   :104.5   Mean   :2991   Mean   :15.66
##  3rd Qu.:8.00   3rd Qu.:302.0   3rd Qu.:129.2   3rd Qu.:3635   3rd Qu.:17.32
##  Max.   :8.00   Max.   :455.0   Max.   :230.0   Max.   :5140   Max.   :24.80
##
##       year     origin  mpg_cat
##  78     : 28   1:175   low :138
##  73     : 27   2: 47   high:138
##  72     : 22   3: 54
##  75     : 22
##  76     : 22
##  79     : 22
##  (Other):133
```

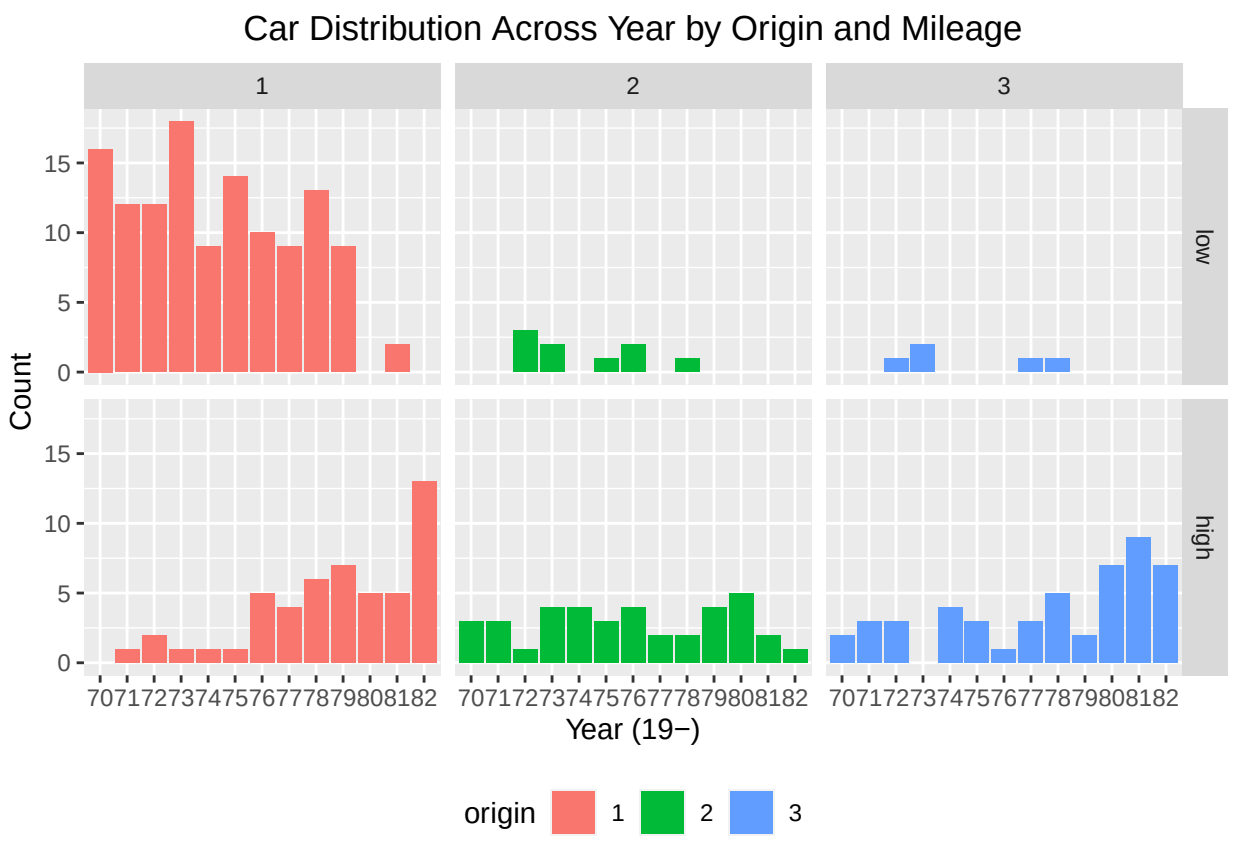
Visualize data distribution. In general, cars with high mileage have lower weights, cylinder count, engine displacement in inches, and horsepower. Note the unequal distribution of car count when conditioned on their origin and mileage.

```
trellis.par.set(transparentTheme(trans = .4))

featurePlot(train_pred[, 1:5], train_resp,
            scales = list(x = list(relation = "free"),
                          y = list(relation = "free")),
            plot = "density", pch = "|",
            auto.key = list(columns = 2))
```



```
train_data %>%
  count(year, origin, mpg_cat) %>%
  ggplot(aes(x = year, y = n, fill = origin)) +
  geom_col() +
  facet_grid(cols = vars(origin), rows = vars(mpg_cat)) +
  labs(
    title = "Car Distribution Across Year by Origin and Mileage",
    x = "Year (19-)",
    y = "Count"
  ) +
  theme(
    plot.title = element_text(hjust = 0.5),
    legend.position = "bottom"
  )
```




```
logit_fit = glm(mpg_cat ~ .,
            data = train_data,
            family = binomial(link = "logit"))
summary(logit_fit)
```

```
##
## Call:
## glm(formula = mpg_cat ~ ., family = binomial(link = "logit"),
##     data = train_data)
##
## Deviance Residuals:
##      Min        1Q    Median        3Q       Max
## -2.11900  -0.07509  -0.00004   0.07578   2.85467
```

```
##
## Coefficients:
##                Estimate Std. Error z value Pr(>|z|)
## (Intercept)   1.657e+01  5.458e+00   3.036   0.0024 **
## cylinders     2.827e-01  6.146e-01   0.460   0.6455
## displacement  1.306e-02  1.746e-02   0.748   0.4544
## horsepower   -2.206e-02  3.178e-02  -0.694   0.4877
## weight       -7.571e-03  1.919e-03  -3.946 7.96e-05 ***
## acceleration  5.695e-02  1.793e-01   0.318   0.7507
## year71       -1.327e+00  1.670e+00  -0.795   0.4267
## year72       -1.125e+00  1.490e+00  -0.755   0.4502
## year73       -1.740e+00  1.513e+00  -1.150   0.2502
## year74        1.077e+00  1.798e+00   0.599   0.5490
## year75        1.324e+00  1.629e+00   0.813   0.4164
## year76        2.209e+00  1.814e+00   1.218   0.2233
## year77        2.333e+00  2.057e+00   1.134   0.2568
## year78        1.763e+00  1.579e+00   1.116   0.2642
## year79        4.374e+00  1.738e+00   2.517   0.0118 *
## year80        2.102e+01  2.099e+03   0.010   0.9920
## year81        4.028e+00  1.774e+00   2.270   0.0232 *
## year82        2.089e+01  2.004e+03   0.010   0.9917
## origin2       2.509e+00  1.101e+00   2.279   0.0226 *
## origin3       1.213e+00  1.000e+00   1.213   0.2253
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 382.617  on 275  degrees of freedom
## Residual deviance:  81.557  on 256  degrees of freedom
## AIC: 121.56
##
## Number of Fisher Scoring iterations: 18
```

```
logit_pred_prob = predict(logit_fit, newdata = test_data,
                          type = "response")
logit_pred = rep("low", length(logit_pred_prob))
logit_pred[logit_pred_prob > 0.5] = "high"

confusionMatrix(data = factor(logit_pred, levels = c("low", "high")),
                reference = test_resp,
                positive = "high")
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction low high
##       low   49    5
##       high   9   53
##
##                Accuracy : 0.8793
##                  95% CI : (0.8058, 0.9324)
##     No Information Rate : 0.5
##     P-Value [Acc > NIR] : <2e-16
##
```

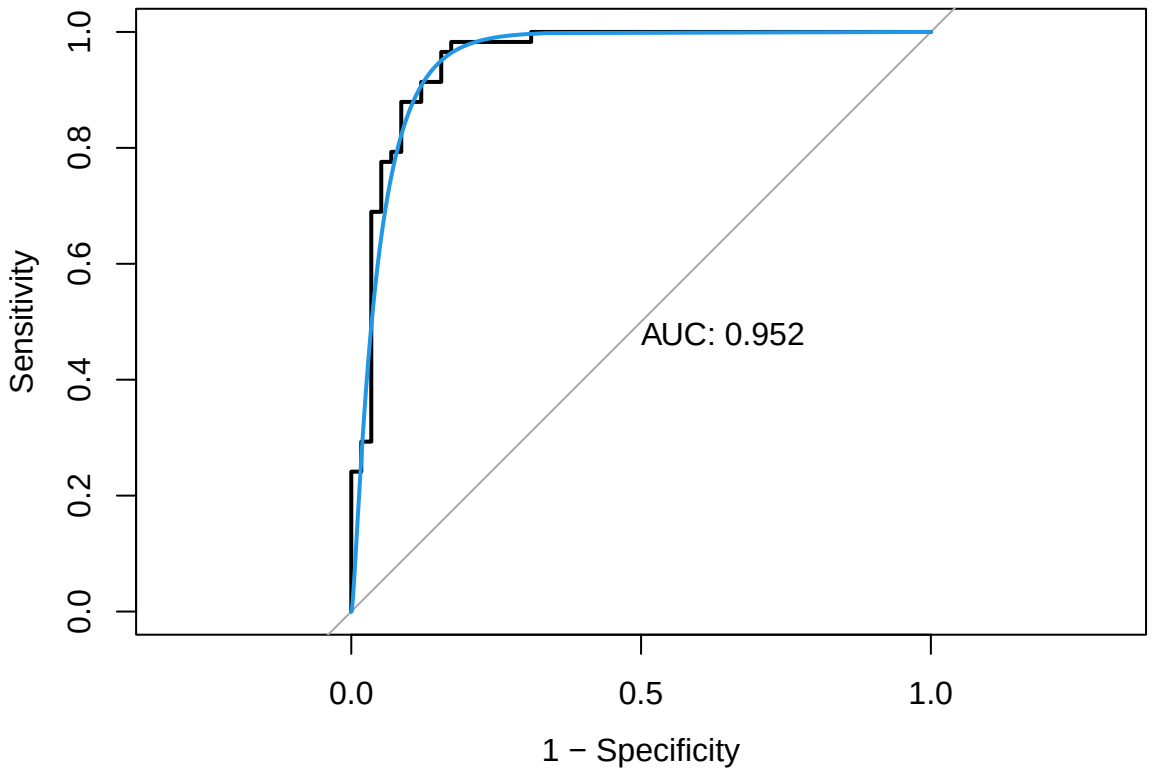
```
##                  Kappa : 0.7586
##
##  Mcnemar's Test P-Value : 0.4227
##
##             Sensitivity : 0.9138
##             Specificity : 0.8448
##          Pos Pred Value : 0.8548
##          Neg Pred Value : 0.9074
##              Prevalence : 0.5000
##          Detection Rate : 0.4569
##    Detection Prevalence : 0.5345
##       Balanced Accuracy : 0.8793
##
##        'Positive' Class : high
##
```

```
logit_roc = roc(test_resp, logit_pred_prob)
```

```
## Setting levels: control = low, case = high
```

```
## Setting direction: controls < cases
```

```
plot(logit_roc, legacy.axes = TRUE, print.auc = TRUE)
plot(smooth(logit_roc), col = 4, add = TRUE)
```




```
ctrl = trainControl(method = "repeatedcv", repeats = 5, number = 10,
                    summaryFunction = twoClassSummary,
                    classProbs = TRUE)
```

```
set.seed(2022)
```

```r
mars_grid = expand.grid(degree = 1:3, nprune = 2:20)
mars_fit = train(x = train_pred,
                 y = train_resp,
                 method = "earth",
                 tuneGrid = mars_grid,
                 metric = "ROC",
                 trControl = ctrl)
```

```
## Loading required package: earth

## Loading required package: Formula

## Loading required package: plotmo

## Loading required package: plotrix

## Loading required package: TeachingDemos

##
## Attaching package: 'TeachingDemos'

## The following object is masked from 'package:klaR':
##
##     triplot

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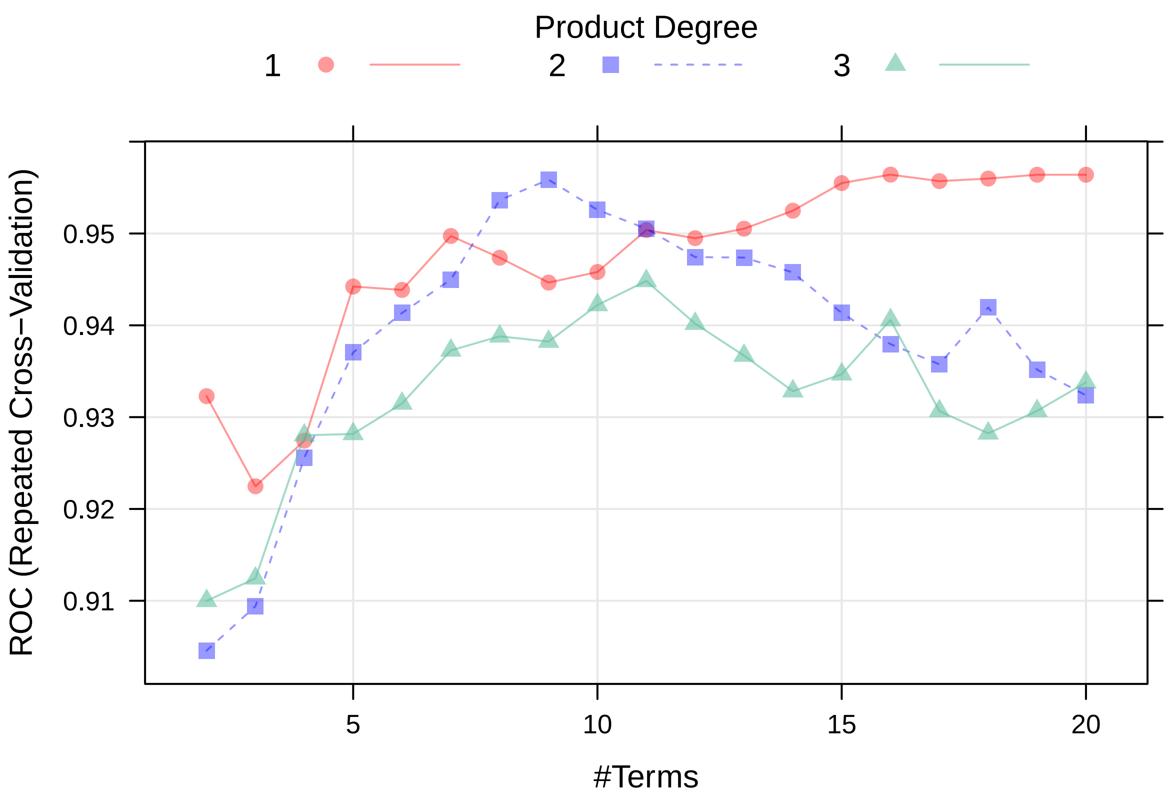
```
plot(mars_fit)
```



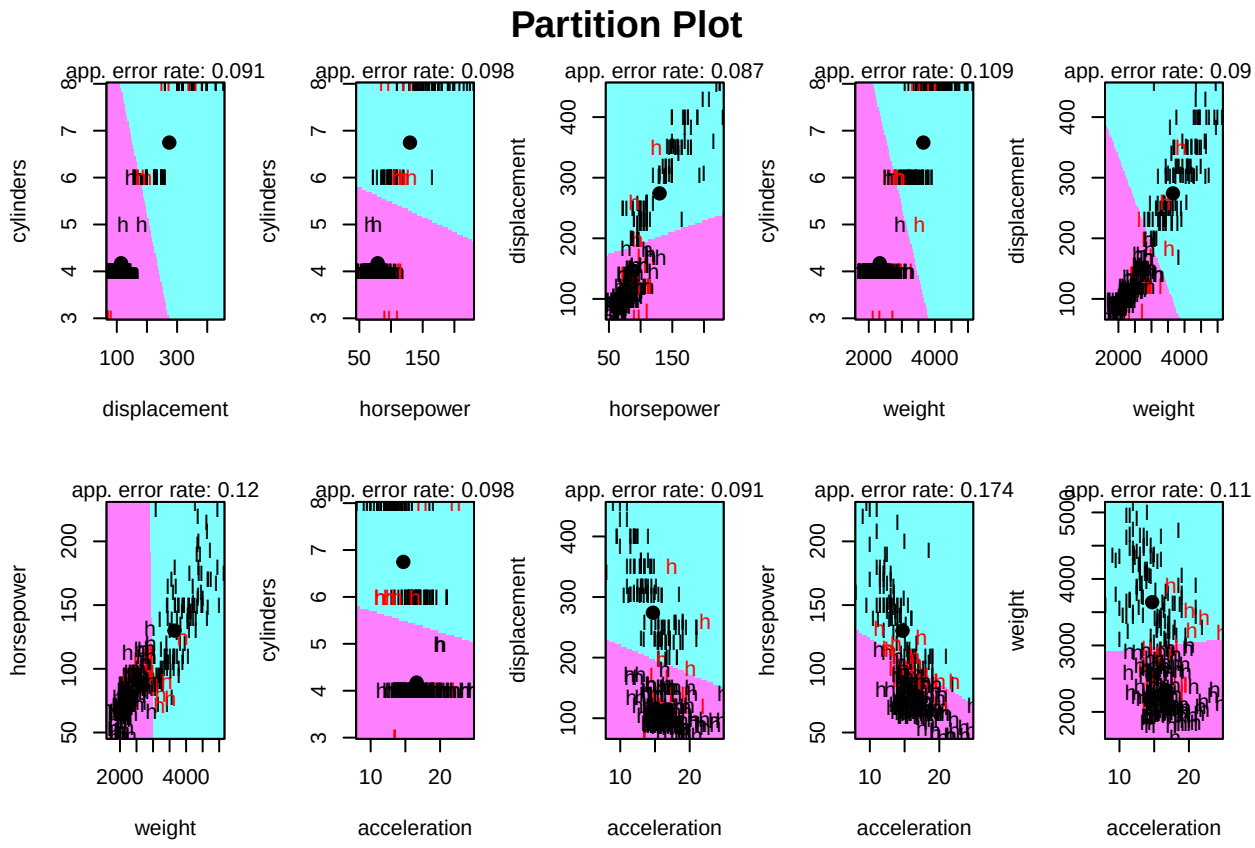
```
mars_fit$bestTune
```

```
##    nprune degree
## 15     16      1
```

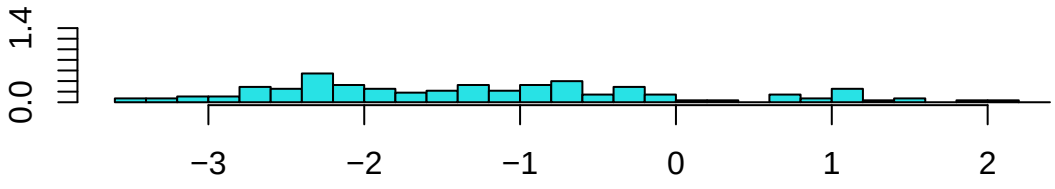
```
coef(mars_fit$finalModel)
```

```
##           (Intercept)  h(250-displacement)  h(displacement-151)
##           44.67312980           0.09253074          -0.47155857
##       h(weight-3060)                 year73                 year72
##            0.01289500          -3.40267187          -3.15233593
## h(acceleration-19.5)       h(cylinders-6)       h(6-cylinders)
##          144.79607867          30.27427393         -26.64043004
##       h(cylinders-4)  h(displacement-140)       h(weight-2735)
##          -26.80949121           0.47014901          -0.01491321
## h(acceleration-20.1)   h(acceleration-21) h(acceleration-17.5)
##         -242.24771530         106.41886067          -1.35134097
```

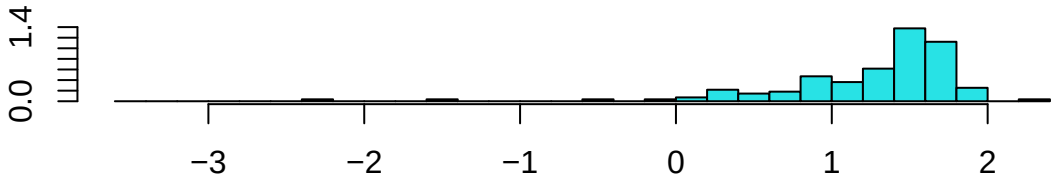
```
partimat(mpg_cat ~ cylinders + displacement + horsepower + weight + acceleration,
         method = "lda", data = train_data, nplots.vert = 2)
```




```
lda_fit = lda(mpg_cat ~ ., data = train_data[, -6:-7])
plot(lda_fit)
```



group low



group high

```
set.seed(2022)

qda_fit = train(x = train_cont_pred,
                y = train_resp,
                method = "qda",
                metric = "ROC",
                trControl = ctrl)
```

Compare ROC. Resamples() compares caret models, so we need to recreate a logit and an LDA model using the caret package

```
set.seed(2022)

logit_fit_caret = train(x = train_pred,
                        y = train_resp,
                        method = "glm",
                        metric = "ROC",
                        trControl = ctrl)
```

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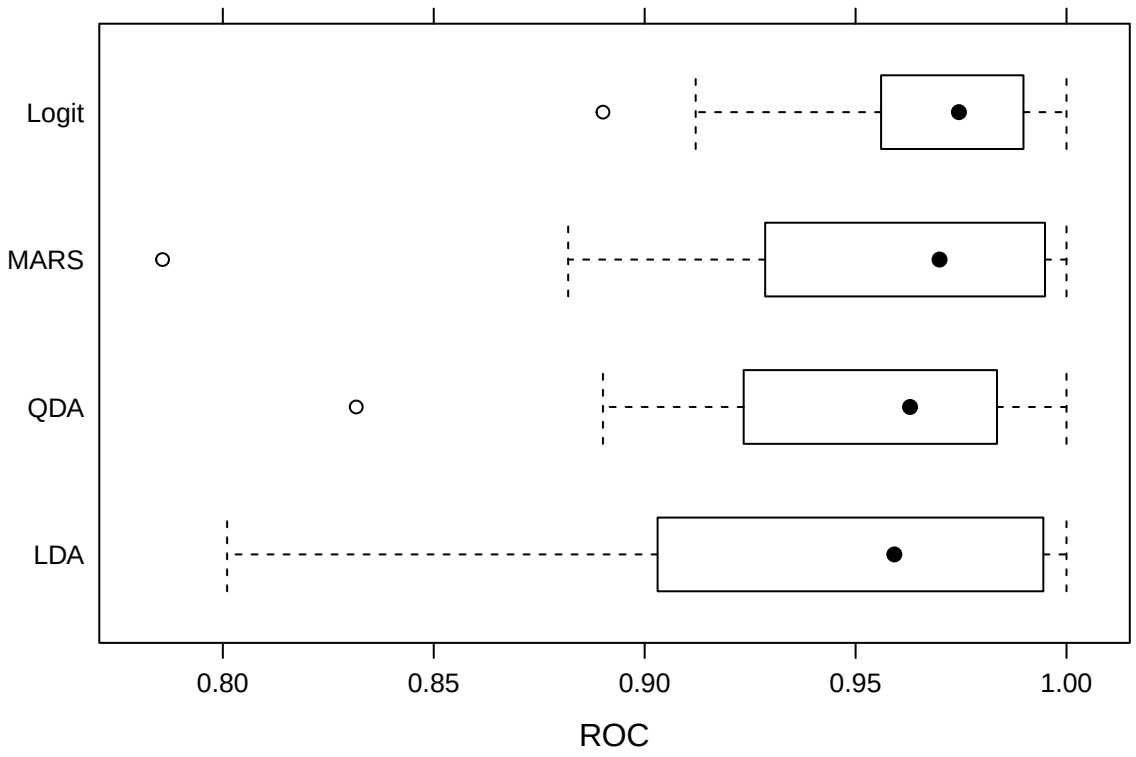
```
lda_fit_caret = train(x = train_cont_pred,
                      y = train_resp,
                      method = "lda",
                      metric = "ROC",
                      trControl = ctrl)

train_res = resamples(list(Logit = logit_fit_caret,
                           MARS = mars_fit,
```

```
                           LDA = lda_fit_caret,
                           QDA = qda_fit))
summary(train_res)
```

```
##
## Call:
## summary.resamples(object = train_res)
##
## Models: Logit, MARS, LDA, QDA
## Number of resamples: 50
##
## ROC
##            Min.   1st Qu.    Median      Mean   3rd Qu. Max. NA's
## Logit 0.8901099 0.9566779 0.9744898 0.9710657 0.9897959    1    0
## MARS  0.7857143 0.9285714 0.9699010 0.9564108 0.9936224    1    0
## LDA   0.8010204 0.9053179 0.9591837 0.9402433 0.9933281    1    0
## QDA   0.8316327 0.9234694 0.9629121 0.9516562 0.9835165    1    0
##
## Sens
##            Min.   1st Qu.    Median      Mean   3rd Qu. Max. NA's
## Logit 0.7142857 0.8571429 0.9285714 0.9092308 0.9285714    1    0
## MARS  0.7142857 0.8571429 0.9285714 0.8990110 0.9285714    1    0
## LDA   0.5714286 0.7733516 0.8571429 0.8475824 0.9285714    1    0
## QDA   0.7142857 0.8461538 0.8571429 0.8726374 0.9285714    1    0
##
## Spec
##            Min.   1st Qu.    Median      Mean   3rd Qu. Max. NA's
## Logit 0.7142857 0.8571429 0.9285714 0.9187912 1.0000000    1    0
## MARS  0.7857143 0.8571429 0.9285714 0.9245055 1.0000000    1    0
## LDA   0.8461538 0.9285714 1.0000000 0.9650549 1.0000000    1    0
## QDA   0.7692308 0.8571429 0.9285714 0.9141758 0.9285714    1    0
```

```
bwplot(train_res, metric = "ROC")
```


Logit
MARS
QDA
LDA
0.80
0.85
0.90
0.95
1.00
ROC