# Predicting-Automobile-Prices-using-NN-and-LReg.R

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```
#Predicting Automobile Prices using Neural Networks

#We want to predict an accurate manufacturer's suggested retail price (MSRP)
by using data collected for a previous batch of cars.
#This data contains 27 independent variables such as price, age, fuel type,
horse power, etc, and 1 dependent variable (price of each car)

library(readxl)

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

data <- read_excel("~/Downloads/Car_Data.xlsx")
str(data)

## tibble [31 × 28] (S3: tbl_df/tbl/data.frame)
##  $ Price  : num [1:31] 21000 20000 19650 21550 22550 ...
##  $ Age    : num [1:31] 26 23 26 32 33 29 31 25 25 31 ...
##  $ KM     : num [1:31] 31463 43612 32191 23002 34133 ...
##  $ Fuel   : chr [1:31] "Petrol" "Petrol" "Petrol" "Petrol" ...
##  $ HP     : num [1:31] 195 195 195 195 195 195 195 113 113 113 ...
##  $ MC     : num [1:31] 0 0 0 1 1 0 1 1 0 1 ...
##  $ Colour : chr [1:31] "silver" "red" "red" "black" ...
##  $ Auto   : num [1:31] 0 0 0 0 0 0 0 0 0 0 ...
##  $ CC     : num [1:31] 1800 1800 1800 1800 1800 1800 1800 1600 1600 1600
...
##  $ Drs    : num [1:31] 3 3 3 3 3 3 3 3 3 3 ...
##  $ Cyl    : num [1:31] 3 3 3 3 3 3 3 3 3 3 ...
##  $ Grs    : num [1:31] 6 6 6 6 6 6 5 5 5 5 ...
##  $ Wght   : num [1:31] 1189 1189 1189 1189 1189 ...
##  $ G_P    : num [1:31] 10 4 4 4 4 4 4 20 4 4 ...
##  $ Mfr_G  : num [1:31] 1 1 1 1 1 1 1 0 0 1 ...
##  $ ABS    : num [1:31] 1 1 1 1 1 1 1 1 1 1 ...
##  $ Abag_1 : num [1:31] 1 1 1 1 1 1 1 1 1 1 ...
##  $ Abag_2 : num [1:31] 1 1 1 1 1 1 1 0 1 1 ...
##  $ AC     : num [1:31] 1 1 1 1 1 1 1 0 1 0 ...
##  $ Comp   : num [1:31] 0 1 1 1 1 1 1 0 1 1 ...
##  $ CD     : num [1:31] 1 0 0 1 1 0 1 0 1 1 ...
##  $ Clock  : num [1:31] 1 1 1 1 1 1 1 1 1 1 ...
##  $ Pw     : num [1:31] 1 1 1 1 1 1 1 1 1 1 ...
##  $ PStr   : num [1:31] 1 1 1 1 1 1 1 1 1 1 ...
##  $ Radio  : num [1:31] 0 0 0 0 0 0 0 1 0 0 ...
##  $ SpM    : num [1:31] 0 1 1 1 1 1 0 0 0 1 ...
```

```
##  $ M_Rim  : num [1:31] 1 1 1 1 1 1 1 0 0 0 ...
##  $ Tow_Bar: num [1:31] 0 0 0 0 0 0 0 1 0 0 ...

#Data  Preprocessing
data$Fuel <- as.factor(data$Fuel)
data$MC <- as.factor(data$MC)
data$Colour <- as.factor(data$Colour)
data$Auto <- as.factor(data$Auto)
data$Mfr_G <- as.factor(data$Mfr_G)
data$ABS <- as.factor(data$ABS)
data$Abag_1 <- as.factor(data$Abag_1)
data$Abag_2 <- as.factor(data$Abag_2)
data$AC <- as.factor(data$AC)
data$Comp <- as.factor(data$Comp)
data$CD <- as.factor(data$CD)
data$Clock <- as.factor(data$Clock)
data$Pw <- as.factor(data$Pw)
data$PStr <- as.factor(data$PStr)
data$Radio <- as.factor(data$Radio)
data$SpM <- as.factor(data$SpM)
data$M_Rim <- as.factor(data$M_Rim)
data$Tow_Bar <- as.factor(data$Tow_Bar)
str(data)

## tibble [31 × 28] (S3: tbl_df/tbl/data.frame)
##  $ Price  : num [1:31] 21000 20000 19650 21550 22550 ...
##  $ Age    : num [1:31] 26 23 26 32 33 29 31 25 25 31 ...
##  $ KM     : num [1:31] 31463 43612 32191 23002 34133 ...
##  $ Fuel   : Factor w/ 1 level "Petrol": 1 1 1 1 1 1 1 1 1 1 ...
##  $ HP     : num [1:31] 195 195 195 195 195 195 195 113 113 113 ...
##  $ MC     : Factor w/ 2 levels "0","1": 1 1 1 2 2 1 2 2 1 2 ...
##  $ Colour : Factor w/ 6 levels "black","blue",..: 6 5 5 1 4 4 4 2 4 4 ...
##  $ Auto   : Factor w/ 2 levels "0","1": 1 1 1 1 1 1 1 1 1 1 ...
##  $ CC     : num [1:31] 1800 1800 1800 1800 1800 1800 1800 1600 1600 1600
...
##  $ Drs    : num [1:31] 3 3 3 3 3 3 3 3 3 3 ...
##  $ Cyl    : num [1:31] 3 3 3 3 3 3 3 3 3 3 ...
##  $ Grs    : num [1:31] 6 6 6 6 6 6 5 5 5 5 ...
##  $ Wght   : num [1:31] 1189 1189 1189 1189 1189 ...
##  $ G_P    : num [1:31] 10 4 4 4 4 4 4 20 4 4 ...
##  $ Mfr_G  : Factor w/ 2 levels "0","1": 2 2 2 2 2 2 2 1 1 2 ...
##  $ ABS    : Factor w/ 1 level "1": 1 1 1 1 1 1 1 1 1 1 ...
##  $ Abag_1 : Factor w/ 1 level "1": 1 1 1 1 1 1 1 1 1 1 ...
##  $ Abag_2 : Factor w/ 2 levels "0","1": 2 2 2 2 2 2 2 1 2 2 ...
##  $ AC     : Factor w/ 2 levels "0","1": 2 2 2 2 2 2 2 1 2 1 ...
##  $ Comp   : Factor w/ 2 levels "0","1": 1 2 2 2 2 2 2 1 2 2 ...
##  $ CD     : Factor w/ 2 levels "0","1": 2 1 1 2 2 1 2 1 2 2 ...
##  $ Clock  : Factor w/ 2 levels "0","1": 2 2 2 2 2 2 2 2 2 2 ...
##  $ Pw     : Factor w/ 2 levels "0","1": 2 2 2 2 2 2 2 2 2 2 ...
##  $ PStr   : Factor w/ 1 level "1": 1 1 1 1 1 1 1 1 1 1 ...
```

```
##  $ Radio  : Factor w/ 2 levels "0","1": 1 1 1 1 1 1 1 2 1 1 ...
##  $ SpM    : Factor w/ 2 levels "0","1": 1 2 2 2 2 2 1 1 1 2 ...
##  $ M_Rim  : Factor w/ 2 levels "0","1": 2 2 2 2 2 2 2 1 1 1 ...
##  $ Tow_Bar: Factor w/ 2 levels "0","1": 1 1 1 1 1 1 1 2 1 1 ...
```

```
#normalize numerical variables
#x'= x - min / max -min
num_cols <- unlist(lapply(data, is.numeric))
num_cols
```

```
##   Price     Age      KM    Fuel      HP      MC  Colour    Auto      CC
Drs
##    TRUE    TRUE    TRUE   FALSE    TRUE   FALSE   FALSE   FALSE    TRUE
TRUE
##     Cyl     Grs    Wght     G_P   Mfr_G     ABS  Abag_1  Abag_2      AC
Comp
##    TRUE    TRUE    TRUE    TRUE   FALSE   FALSE   FALSE   FALSE   FALSE
FALSE
##      CD   Clock      Pw    PStr   Radio     SpM   M_Rim Tow_Bar
##   FALSE   FALSE   FALSE   FALSE   FALSE   FALSE   FALSE   FALSE
```

```
dataNum <- data[,num_cols]  #only numerical variables
#min & max of all columns
mins<- apply(dataNum, 2, min) #1-rows, 2 -columns
maxs<- apply(dataNum, 2, max)

scaled.data<-as.data.frame(scale(dataNum, center = mins, scale= maxs - mins))
summary(scaled.data) #we can see now min is 0 and max is 1.
```

```
##      Price             Age               KM               HP
##  Min.   :0.0000   Min.   :0.0000   Min.   :0.0000   Min.   :0.0000
##  1st Qu.:0.2857   1st Qu.:0.3000   1st Qu.:0.2710   1st Qu.:0.0000
##  Median :0.3367   Median :0.5000   Median :0.3880   Median :0.1368
##  Mean   :0.4338   Mean   :0.4935   Mean   :0.4128   Mean   :0.2832
##  3rd Qu.:0.5102   3rd Qu.:0.7000   3rd Qu.:0.5605   3rd Qu.:0.1368
##  Max.   :1.0000   Max.   :1.0000   Max.   :1.0000   Max.   :1.0000
##
##        CC              Drs           Cyl           Grs              Wght
##  Min.   :0.0000   Min.   : NA   Min.   : NA   Min.   :0.0000   Min.
:0.0000
##  1st Qu.:0.0000   1st Qu.: NA   1st Qu.: NA   1st Qu.:0.0000   1st
Qu.:0.2917
##  Median :0.5000   Median : NA   Median : NA   Median :0.0000   Median
:0.4583
##  Mean   :0.4355   Mean   :NaN   Mean   :NaN   Mean   :0.1935   Mean
:0.5081
##  3rd Qu.:0.5000   3rd Qu.: NA   3rd Qu.: NA   3rd Qu.:0.0000   3rd
Qu.:0.6667
##  Max.   :1.0000   Max.   : NA   Max.   : NA   Max.   :1.0000   Max.
:1.0000
##                   NA's   :31    NA's   :31
```

```
##       G_P        
##  Min.   :0.00000  
##  1st Qu.:0.00000  
##  Median :0.00000  
##  Mean   :0.05645  
##  3rd Qu.:0.00000  
##  Max.   :1.00000  
##
```

```
#add to scaled df the variables that were factors (categorical)
data <- data.frame(scaled.data, data[!num_cols] )
str(data)
```

```
## 'data.frame':    31 obs. of  28 variables:
##  $ Price  : num  0.816 0.714 0.679 0.872 0.974 ...
##  $ Age    : num  0.3 0 0.3 0.9 1 0.6 0.8 0.2 0.2 0.8 ...
##  $ KM     : num  0.375 0.585 0.387 0.229 0.421 ...
##  $ HP     : num  1 1 1 1 1 ...
##  $ CC     : num  1 1 1 1 1 1 1 0.5 0.5 0.5 ...
##  $ Drs    : num  NaN NaN NaN NaN NaN NaN NaN NaN NaN NaN ...
##  $ Cyl    : num  NaN NaN NaN NaN NaN NaN NaN NaN NaN NaN ...
##  $ Grs    : num  1 1 1 1 1 1 0 0 0 0 ...
##  $ Wght   : num  1 1 1 1 1 ...
##  $ G_P    : num  0.375 0 0 0 0 0 0 1 0 0 ...
##  $ Fuel   : Factor w/ 1 level "Petrol": 1 1 1 1 1 1 1 1 1 1 ...
##  $ MC     : Factor w/ 2 levels "0","1": 1 1 1 2 2 1 2 2 1 2 ...
##  $ Colour : Factor w/ 6 levels "black","blue",..: 6 5 5 1 4 4 4 2 4 4 ...
##  $ Auto   : Factor w/ 2 levels "0","1": 1 1 1 1 1 1 1 1 1 1 ...
##  $ Mfr_G  : Factor w/ 2 levels "0","1": 2 2 2 2 2 2 2 1 1 2 ...
##  $ ABS    : Factor w/ 1 level "1": 1 1 1 1 1 1 1 1 1 1 ...
##  $ Abag_1 : Factor w/ 1 level "1": 1 1 1 1 1 1 1 1 1 1 ...
##  $ Abag_2 : Factor w/ 2 levels "0","1": 2 2 2 2 2 2 2 1 2 2 ...
##  $ AC     : Factor w/ 2 levels "0","1": 2 2 2 2 2 2 2 1 2 1 ...
##  $ Comp   : Factor w/ 2 levels "0","1": 1 2 2 2 2 2 2 1 2 2 ...
##  $ CD     : Factor w/ 2 levels "0","1": 2 1 1 2 2 1 2 1 2 2 ...
##  $ Clock  : Factor w/ 2 levels "0","1": 2 2 2 2 2 2 2 2 2 2 ...
##  $ Pw     : Factor w/ 2 levels "0","1": 2 2 2 2 2 2 2 2 2 2 ...
##  $ PStr   : Factor w/ 1 level "1": 1 1 1 1 1 1 1 1 1 1 ...
##  $ Radio  : Factor w/ 2 levels "0","1": 1 1 1 1 1 1 1 2 1 1 ...
##  $ SpM    : Factor w/ 2 levels "0","1": 1 2 2 2 2 2 1 1 1 2 ...
##  $ M_Rim  : Factor w/ 2 levels "0","1": 2 2 2 2 2 2 2 1 1 1 ...
##  $ Tow_Bar: Factor w/ 2 levels "0","1": 1 1 1 1 1 1 1 2 1 1 ...
```

```
#we leave only categorical variables with more than 1 factor level and remove
num variables that have the same value for all instances
data<- data[,-6] #remove drs
data<- data[,-6] #remove cyl
data<- data[,-9] #remove fuel
data<- data[,-13] #remove abs
data<- data[,-13] #remove abag_1
```

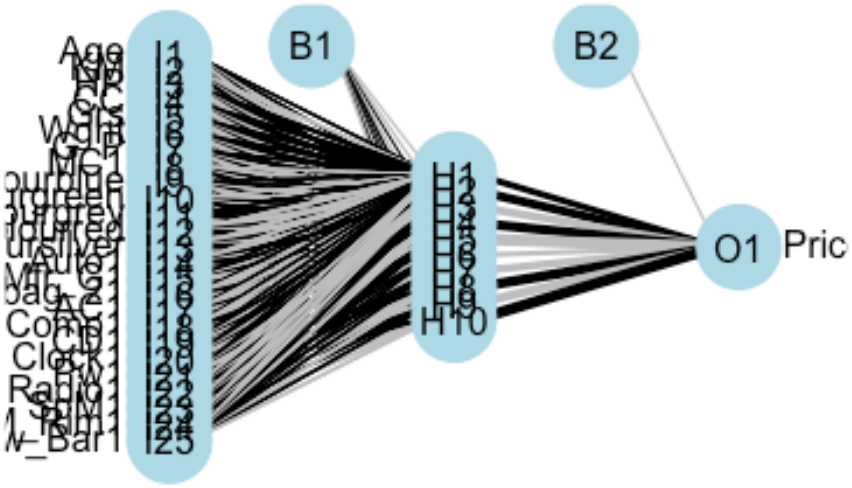
```r
data<- data[,-19] #remove PStr
str(data)
```

```
## 'data.frame':    31 obs. of  22 variables:
##  $ Price  : num  0.816 0.714 0.679 0.872 0.974 ...
##  $ Age    : num  0.3 0 0.3 0.9 1 0.6 0.8 0.2 0.2 0.8 ...
##  $ KM     : num  0.375 0.585 0.387 0.229 0.421 ...
##  $ HP     : num  1 1 1 1 1 ...
##  $ CC     : num  1 1 1 1 1 1 1 0.5 0.5 0.5 ...
##  $ Grs    : num  1 1 1 1 1 1 0 0 0 0 ...
##  $ Wght   : num  1 1 1 1 1 ...
##  $ G_P    : num  0.375 0 0 0 0 0 0 1 0 0 ...
##  $ MC     : Factor w/ 2 levels "0","1": 1 1 1 2 2 1 2 2 1 2 ...
##  $ Colour : Factor w/ 6 levels "black","blue",..: 6 5 5 1 4 4 4 2 4 4 ...
##  $ Auto   : Factor w/ 2 levels "0","1": 1 1 1 1 1 1 1 1 1 1 ...
##  $ Mfr_G  : Factor w/ 2 levels "0","1": 2 2 2 2 2 2 2 1 1 2 ...
##  $ Abag_2 : Factor w/ 2 levels "0","1": 2 2 2 2 2 2 2 1 2 2 ...
##  $ AC     : Factor w/ 2 levels "0","1": 2 2 2 2 2 2 2 1 2 1 ...
##  $ Comp   : Factor w/ 2 levels "0","1": 1 2 2 2 2 2 2 1 2 2 ...
##  $ CD     : Factor w/ 2 levels "0","1": 2 1 1 2 2 1 2 1 2 2 ...
##  $ Clock  : Factor w/ 2 levels "0","1": 2 2 2 2 2 2 2 2 2 2 ...
##  $ Pw     : Factor w/ 2 levels "0","1": 2 2 2 2 2 2 2 2 2 2 ...
##  $ Radio  : Factor w/ 2 levels "0","1": 1 1 1 1 1 1 1 2 1 1 ...
##  $ SpM    : Factor w/ 2 levels "0","1": 1 2 2 2 2 2 1 1 1 2 ...
##  $ M_Rim  : Factor w/ 2 levels "0","1": 2 2 2 2 2 2 2 1 1 1 ...
##  $ Tow_Bar: Factor w/ 2 levels "0","1": 1 1 1 1 1 1 1 2 1 1 ...
```

```r
#************** Neural Net with 10 hidden neurons
set.seed(154)
indx<- sample(2, nrow(data), replace=T, prob=c(0.8,0.2))
train <- data[indx==1, ]
test <- data[indx==2, ]

library(nnet)
nn <- nnet(Price ~ . , data= train, linout= T , size= 10, decay=0.01)
```

```
## # weights:  271
## initial  value 2.996035
## iter  10 value 0.485863
## iter  20 value 0.120596
## iter  30 value 0.066076
## iter  40 value 0.060760
## iter  50 value 0.059755
## iter  60 value 0.058940
## iter  70 value 0.058455
## iter  80 value 0.058269
## iter  90 value 0.058058
## iter 100 value 0.057949
## final  value 0.057949
## stopped after 100 iterations
```

```
library(devtools)

source_url('https://gist.githubusercontent.com/fawda123/7471137/raw/466c1474d
0a505ff044412703516c34f1a4684a5/nnet_plot_update.r')

plot.nnet(nn)
```




```
#TEST
nn.preds<- predict(nn, test)
nn.preds   #predicted values on test data

##         [,1]
## 5  0.8656114
## 7  0.7372649
## 15 0.4151589
## 22 0.1756761
## 25 0.2325943
## 26 0.2841179
## 28 0.3165041
## 30 0.1392859

#EVALUATE
#MEAN SQUARED ERROR
mse <- mean((nn.preds - test$Price)^2)
mse

## [1] 0.01431462

#************** 10-Fold CV with 10 hidden neurons
k <- 10
nmethod <- 1
folds <- cut(seq(1,nrow(data)),breaks=k,labels=FALSE)
model.meansquarederror <- matrix(-1, k, nmethod, dimnames=list(paste0("Fold",
1:k), c("NNet")))
```

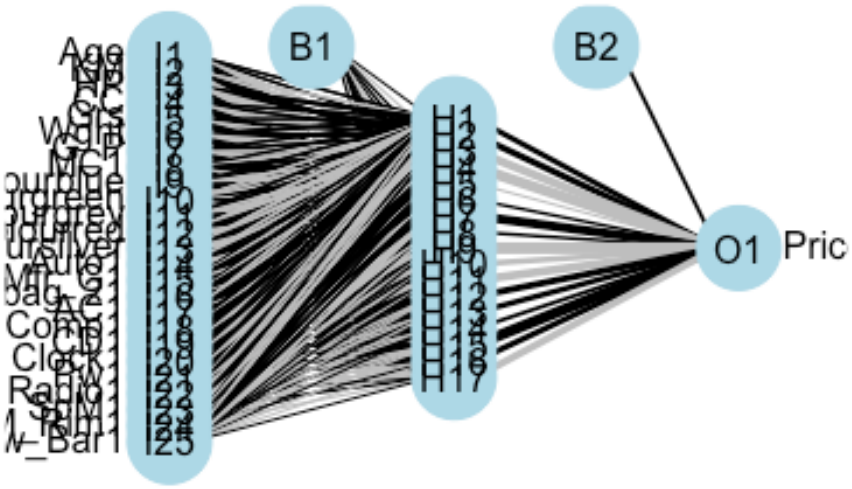
```r
for(i in 1:k)
{
  testindexes <- which(folds == i, arr.ind=TRUE)
  test <- data[testindexes, ]
  train <- data[-testindexes, ]

  nnModel<- nnet(Price ~ . , data= train, linout= T, size= 10, decay=0.01)
  predicted <- predict(nnModel, test)
  model.meansquarederror[i] <- mean((test$Price - predicted)^2)
}
```

```
## # weights:  271
## initial  value 13.458846
## iter  10 value 0.574049
## iter  20 value 0.167997
## iter  30 value 0.092745
## iter  40 value 0.085800
## iter  50 value 0.084339
## iter  60 value 0.083849
## iter  70 value 0.083671
## iter  80 value 0.083519
## iter  90 value 0.083439
## iter 100 value 0.083359
## final  value 0.083359
## stopped after 100 iterations
## # weights:  271
## initial  value 6.216472
## iter  10 value 0.400509
## iter  20 value 0.124637
## iter  30 value 0.078163
## iter  40 value 0.074726
## iter  50 value 0.074036
## iter  60 value 0.073751
## iter  70 value 0.073616
## iter  80 value 0.073504
## iter  90 value 0.073409
## iter 100 value 0.073363
## final  value 0.073363
## stopped after 100 iterations
## # weights:  271
## initial  value 38.442358
## iter  10 value 0.475361
## iter  20 value 0.140956
## iter  30 value 0.097887
## iter  40 value 0.089481
## iter  50 value 0.087374
## iter  60 value 0.086873
## iter  70 value 0.086678
## iter  80 value 0.086421
## iter  90 value 0.086129
```

```
## iter 100 value 0.085943
## final  value 0.085943
## stopped after 100 iterations
## # weights:  271
## initial  value 15.597217
## iter  10 value 0.491837
## iter  20 value 0.153532
## iter  30 value 0.090084
## iter  40 value 0.083377
## iter  50 value 0.081137
## iter  60 value 0.080187
## iter  70 value 0.079883
## iter  80 value 0.079657
## iter  90 value 0.079299
## iter 100 value 0.079056
## final  value 0.079056
## stopped after 100 iterations
## # weights:  271
## initial  value 11.568156
## iter  10 value 0.417691
## iter  20 value 0.114930
## iter  30 value 0.086278
## iter  40 value 0.082506
## iter  50 value 0.081203
## iter  60 value 0.080155
## iter  70 value 0.079673
## iter  80 value 0.079475
## iter  90 value 0.079357
## iter 100 value 0.079280
## final  value 0.079280
## stopped after 100 iterations
## # weights:  271
## initial  value 21.964462
## iter  10 value 1.680096
## iter  20 value 0.472929
## iter  30 value 0.141074
## iter  40 value 0.083813
## iter  50 value 0.078038
## iter  60 value 0.076696
## iter  70 value 0.076228
## iter  80 value 0.075903
## iter  90 value 0.075422
## iter 100 value 0.074965
## final  value 0.074965
## stopped after 100 iterations
## # weights:  271
## initial  value 3.642738
## iter  10 value 0.426174
## iter  20 value 0.124242
## iter  30 value 0.077795
```

```
## iter  40 value 0.071089
## iter  50 value 0.069574
## iter  60 value 0.068963
## iter  70 value 0.068720
## iter  80 value 0.068606
## iter  90 value 0.068539
## iter 100 value 0.068503
## final  value 0.068503
## stopped after 100 iterations
## # weights:  271
## initial  value 13.158712
## iter  10 value 0.451571
## iter  20 value 0.129317
## iter  30 value 0.089076
## iter  40 value 0.084959
## iter  50 value 0.083409
## iter  60 value 0.082615
## iter  70 value 0.082283
## iter  80 value 0.082116
## iter  90 value 0.082025
## iter 100 value 0.081913
## final  value 0.081913
## stopped after 100 iterations
## # weights:  271
## initial  value 12.645853
## iter  10 value 0.485891
## iter  20 value 0.134423
## iter  30 value 0.097173
## iter  40 value 0.089889
## iter  50 value 0.088113
## iter  60 value 0.087044
## iter  70 value 0.086461
## iter  80 value 0.085734
## iter  90 value 0.085132
## iter 100 value 0.084945
## final  value 0.084945
## stopped after 100 iterations
## # weights:  271
## initial  value 15.736014
## iter  10 value 0.428039
## iter  20 value 0.144336
## iter  30 value 0.101542
## iter  40 value 0.094214
## iter  50 value 0.092471
## iter  60 value 0.091719
## iter  70 value 0.091272
## iter  80 value 0.091089
## iter  90 value 0.091015
## iter 100 value 0.090978
```

```
## final  value 0.090978
## stopped after 100 iterations

model.meansquarederror

##                NNet
## Fold1  0.023161749
## Fold2  0.043680538
## Fold3  0.020307371
## Fold4  0.023811570
## Fold5  0.007866919
## Fold6  0.027924399
## Fold7  0.036602239
## Fold8  0.005888398
## Fold9  0.005277719
## Fold10 0.001916918

mean(model.meansquarederror)

## [1] 0.01964378

############## Neural Net with 17 hidden neurons
nn2 <- nnet(Price ~ . , data= train, linout= T , size= 17, decay=0.01)

## # weights:  460
## initial  value 77.051114
## iter  10 value 0.995366
## iter  20 value 0.294480
## iter  30 value 0.141737
## iter  40 value 0.109988
## iter  50 value 0.098667
## iter  60 value 0.094532
## iter  70 value 0.092805
## iter  80 value 0.091967
## iter  90 value 0.091502
## iter 100 value 0.091075
## final  value 0.091075
## stopped after 100 iterations

library(devtools)
source_url('https://gist.githubusercontent.com/fawda123/7471137/raw/466c1474d
0a505ff044412703516c34f1a4684a5/nnet_plot_update.r')

plot.nnet(nn2)
```




```
#TEST
nn.preds2<- predict(nn2, test)
nn.preds2   #predicted values on test data

##          [,1]
## 29 0.30966331
## 30 0.09928087
## 31 0.03916540

#EVALUATE
#MEAN SQUARED ERROR
mse2 <- mean((nn.preds2 - test$Price)^2)
mse2

## [1] 0.003882995

#************* 10-Fold CV with 17 hidden neurons
k <- 10
nmethod <- 1
folds <- cut(seq(1,nrow(data)),breaks=k,labels=FALSE)
model.meansquarederror <- matrix(-1, k, nmethod, dimnames=list(paste0("Fold",
1:k), c("NNet")))

for(i in 1:k)
{
  testindexes <- which(folds == i, arr.ind=TRUE)
  test <- data[testindexes, ]
  train <- data[-testindexes, ]

  nnModel<- nnet(Price ~ . , data= train, linout= T, size= 17, decay=0.01)
  predicted <- predict(nnModel, test)
```

```r
  model.meansquarederror[i] <- mean((test$Price - predicted)^2)
}
```

```
## # weights:  460
## initial  value 13.839873
## iter  10 value 0.757658
## iter  20 value 0.187545
## iter  30 value 0.094094
## iter  40 value 0.085517
## iter  50 value 0.083944
## iter  60 value 0.083202
## iter  70 value 0.082985
## iter  80 value 0.082790
## iter  90 value 0.082637
## iter 100 value 0.082551
## final  value 0.082551
## stopped after 100 iterations
## # weights:  460
## initial  value 34.389326
## iter  10 value 0.572846
## iter  20 value 0.185774
## iter  30 value 0.093339
## iter  40 value 0.078911
## iter  50 value 0.075698
## iter  60 value 0.074767
## iter  70 value 0.073868
## iter  80 value 0.073209
## iter  90 value 0.073004
## iter 100 value 0.072913
## final  value 0.072913
## stopped after 100 iterations
## # weights:  460
## initial  value 157.216064
## iter  10 value 1.051028
## iter  20 value 0.350676
## iter  30 value 0.217346
## iter  40 value 0.174619
## iter  50 value 0.141981
## iter  60 value 0.111726
## iter  70 value 0.097444
## iter  80 value 0.092850
## iter  90 value 0.090679
## iter 100 value 0.089063
## final  value 0.089063
## stopped after 100 iterations
## # weights:  460
## initial  value 13.088746
## iter  10 value 0.735209
## iter  20 value 0.183775
## iter  30 value 0.091484
```

```
## iter  40 value 0.080885
## iter  50 value 0.079262
## iter  60 value 0.078807
## iter  70 value 0.078535
## iter  80 value 0.078324
## iter  90 value 0.078056
## iter 100 value 0.077892
## final  value 0.077892
## stopped after 100 iterations
## # weights:  460
## initial  value 6.811318
## iter  10 value 0.694724
## iter  20 value 0.171642
## iter  30 value 0.088748
## iter  40 value 0.081266
## iter  50 value 0.080034
## iter  60 value 0.079498
## iter  70 value 0.079155
## iter  80 value 0.078892
## iter  90 value 0.078687
## iter 100 value 0.078550
## final  value 0.078550
## stopped after 100 iterations
## # weights:  460
## initial  value 20.244100
## iter  10 value 0.841770
## iter  20 value 0.226039
## iter  30 value 0.091556
## iter  40 value 0.078021
## iter  50 value 0.075362
## iter  60 value 0.074265
## iter  70 value 0.073846
## iter  80 value 0.073754
## iter  90 value 0.073696
## iter 100 value 0.073606
## final  value 0.073606
## stopped after 100 iterations
## # weights:  460
## initial  value 25.317101
## iter  10 value 0.758099
## iter  20 value 0.162044
## iter  30 value 0.078272
## iter  40 value 0.070130
## iter  50 value 0.068747
## iter  60 value 0.068202
## iter  70 value 0.068022
## iter  80 value 0.067880
## iter  90 value 0.067697
## iter 100 value 0.067590
## final  value 0.067590
```

```
## stopped after 100 iterations
## # weights:  460
## initial  value 21.031273
## iter  10 value 0.766063
## iter  20 value 0.254392
## iter  30 value 0.096922
## iter  40 value 0.083629
## iter  50 value 0.081634
## iter  60 value 0.080957
## iter  70 value 0.080738
## iter  80 value 0.080572
## iter  90 value 0.080432
## iter 100 value 0.080374
## final  value 0.080374
## stopped after 100 iterations
## # weights:  460
## initial  value 6.646388
## iter  10 value 0.731647
## iter  20 value 0.220855
## iter  30 value 0.104485
## iter  40 value 0.087805
## iter  50 value 0.085421
## iter  60 value 0.084562
## iter  70 value 0.084114
## iter  80 value 0.083949
## iter  90 value 0.083802
## iter 100 value 0.083720
## final  value 0.083720
## stopped after 100 iterations
## # weights:  460
## initial  value 2.275524
## iter  10 value 0.706278
## iter  20 value 0.185608
## iter  30 value 0.101318
## iter  40 value 0.092713
## iter  50 value 0.091141
## iter  60 value 0.090468
## iter  70 value 0.090228
## iter  80 value 0.090078
## iter  90 value 0.089941
## iter 100 value 0.089857
## final  value 0.089857
## stopped after 100 iterations

model.meansquarederror

##               NNet
## Fold1  0.022535006
## Fold2  0.043663383
## Fold3  0.017654073
```

```
## Fold4  0.022701139
## Fold5  0.007850738
## Fold6  0.026145582
## Fold7  0.036080338
## Fold8  0.005980705
## Fold9  0.005108235
## Fold10 0.003425833
```

```
mean(model.meansquarederror)
```

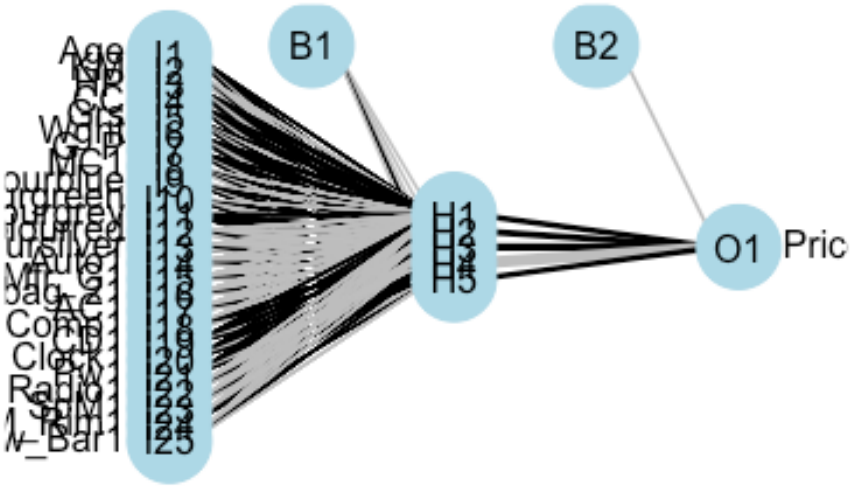
```
## [1] 0.0191145
```

```
############## Neural Net with 10 hidden neurons
nn3 <- nnet(Price ~ . , data= train, linout= T , size= 5, decay=0.01)
```

```
## # weights:  136
## initial  value 21.711711
## iter  10 value 0.410980
## iter  20 value 0.147346
## iter  30 value 0.103705
## iter  40 value 0.098623
## iter  50 value 0.096664
## iter  60 value 0.095686
## iter  70 value 0.094906
## iter  80 value 0.094486
## iter  90 value 0.094105
## iter 100 value 0.093809
## final  value 0.093809
## stopped after 100 iterations
```

```
library(devtools)
source_url('https://gist.githubusercontent.com/fawda123/7471137/raw/466c1474d
0a505ff044412703516c34f1a4684a5/nnet_plot_update.r')
```

```
plot.nnet(nn3)
```




```
#TEST
nn.preds3<- predict(nn3, test)
nn.preds3   #predicted values on test data

##          [,1]
## 29 0.31180098
## 30 0.14114837
## 31 0.08195597

#EVALUATE
#MEAN SQUARED ERROR
mse3 <- mean((nn.preds3 - test$Price)^2)
mse3

## [1] 0.0009641003

#************10-Fold CV with 5 hidden neurons
k <- 10
nmethod <- 1
folds <- cut(seq(1,nrow(data)),breaks=k,labels=FALSE)
model.meansquarederror <- matrix(-1, k, nmethod, dimnames=list(paste0("Fold",
1:k), c("NNet")))

for(i in 1:k)
{
  testindexes <- which(folds == i, arr.ind=TRUE)
  test <- data[testindexes, ]
  train <- data[-testindexes, ]

  nnModel<- nnet(Price ~ . , data= train, linout= T, size= 5, decay=0.01)
  predicted <- predict(nnModel, test)
  model.meansquarederror[i] <- mean((test$Price - predicted)^2)
}
```

```
## # weights:  136
## initial  value 25.249575
## iter  10 value 0.330752
## iter  20 value 0.128456
## iter  30 value 0.094449
## iter  40 value 0.089451
## iter  50 value 0.086510
## iter  60 value 0.085595
## iter  70 value 0.085396
## iter  80 value 0.085328
## iter  90 value 0.085276
## iter 100 value 0.085207
## final  value 0.085207
## stopped after 100 iterations
## # weights:  136
## initial  value 3.961314
## iter  10 value 0.280435
## iter  20 value 0.108600
## iter  30 value 0.079040
## iter  40 value 0.075762
## iter  50 value 0.075047
## iter  60 value 0.074796
## iter  70 value 0.074646
## iter  80 value 0.074547
## iter  90 value 0.074510
## iter 100 value 0.074473
## final  value 0.074473
## stopped after 100 iterations
## # weights:  136
## initial  value 9.218478
## iter  10 value 0.312561
## iter  20 value 0.123678
## iter  30 value 0.092948
## iter  40 value 0.089286
## iter  50 value 0.088381
## iter  60 value 0.088027
## iter  70 value 0.087747
## iter  80 value 0.087459
## iter  90 value 0.087226
## iter 100 value 0.086993
## final  value 0.086993
## stopped after 100 iterations
## # weights:  136
## initial  value 16.907084
## iter  10 value 0.292709
## iter  20 value 0.117514
## iter  30 value 0.090917
## iter  40 value 0.084955
## iter  50 value 0.082215
## iter  60 value 0.081241
```

```
## iter  70 value 0.080847
## iter  80 value 0.080546
## iter  90 value 0.080381
## iter 100 value 0.080271
## final  value 0.080271
## stopped after 100 iterations
## # weights:  136
## initial  value 5.250299
## iter  10 value 0.298401
## iter  20 value 0.103878
## iter  30 value 0.084327
## iter  40 value 0.082037
## iter  50 value 0.081323
## iter  60 value 0.081171
## iter  70 value 0.081112
## iter  80 value 0.081060
## iter  90 value 0.080992
## iter 100 value 0.080938
## final  value 0.080938
## stopped after 100 iterations
## # weights:  136
## initial  value 4.751491
## iter  10 value 0.457566
## iter  20 value 0.139629
## iter  30 value 0.081870
## iter  40 value 0.077293
## iter  50 value 0.076028
## iter  60 value 0.075603
## iter  70 value 0.075355
## iter  80 value 0.075220
## iter  90 value 0.075059
## iter 100 value 0.074841
## final  value 0.074841
## stopped after 100 iterations
## # weights:  136
## initial  value 2.469193
## iter  10 value 0.262399
## iter  20 value 0.095556
## iter  30 value 0.075737
## iter  40 value 0.072416
## iter  50 value 0.070746
## iter  60 value 0.070268
## iter  70 value 0.069958
## iter  80 value 0.069808
## iter  90 value 0.069679
## iter 100 value 0.069545
## final  value 0.069545
## stopped after 100 iterations
## # weights:  136
## initial  value 5.617113
```

```
## iter  10 value 0.264567
## iter  20 value 0.104486
## iter  30 value 0.087750
## iter  40 value 0.085591
## iter  50 value 0.084566
## iter  60 value 0.084171
## iter  70 value 0.083912
## iter  80 value 0.083538
## iter  90 value 0.083406
## iter 100 value 0.083362
## final  value 0.083362
## stopped after 100 iterations
## # weights:  136
## initial  value 23.563796
## iter  10 value 0.284763
## iter  20 value 0.119996
## iter  30 value 0.099330
## iter  40 value 0.089865
## iter  50 value 0.086816
## iter  60 value 0.086238
## iter  70 value 0.086130
## iter  80 value 0.086081
## iter  90 value 0.086058
## iter 100 value 0.086048
## final  value 0.086048
## stopped after 100 iterations
## # weights:  136
## initial  value 42.985507
## iter  10 value 2.164800
## iter  20 value 0.243599
## iter  30 value 0.119342
## iter  40 value 0.099411
## iter  50 value 0.096718
## iter  60 value 0.095949
## iter  70 value 0.095695
## iter  80 value 0.095528
## iter  90 value 0.095386
## iter 100 value 0.095223
## final  value 0.095223
## stopped after 100 iterations

model.meansquarederror

##                NNet
## Fold1  0.0235517303
## Fold2  0.0431945467
## Fold3  0.0196130912
## Fold4  0.0237192556
## Fold5  0.0079235616
## Fold6  0.0283641162
```

```
## Fold7  0.0373013344
## Fold8  0.0057985268
## Fold9  0.0054779648
## Fold10 0.0005862518

mean(model.meansquarederror)

## [1] 0.01955304

#*************

#********** LINEAR REGRESSION
set.seed(3)
indx<- sample(2, nrow(data), replace=T, prob=c(0.8,0.2))
train <- data[indx==1, ]
test <- data[indx==2, ]

lmModel <- lm(Price ~ . , data=train)
summary(lmModel)

##
## Call:
## lm(formula = Price ~ ., data = train)
##
## Residuals:
##          1          3          4          5          6          7
8
##  6.939e-18 -6.452e-18 -4.916e-02  3.693e-02  1.223e-02 -1.488e-17  6.781e-
18
##          9         10         11         12         13         14
17
## -2.184e-17  3.997e-02 -3.997e-02  5.572e-18  1.552e-02  8.941e-03  6.994e-
17
##         18         20         21         22         23         24
25
## -3.997e-02  1.552e-02 -8.305e-18  2.446e-02  6.467e-02 -7.690e-02 -1.494e-
17
##         26         27         29         30         31
##  1.220e-02 -2.442e-02  5.194e-18  3.484e-03 -3.484e-03
##
## Coefficients: (3 not defined because of singularities)
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept)   0.003361   0.243574   0.014    0.990
## Age           0.010261   0.173732   0.059    0.957
## KM           -0.186776   0.226134  -0.826    0.469
## HP            0.333139   0.651612   0.511    0.644
## CC            0.160959   0.464012   0.347    0.752
## Grs           0.031875   0.188652   0.169    0.877
## Wght          0.248436   0.504347   0.493    0.656
## G_P           0.202124   0.339409   0.596    0.593
## MC1           0.023039   0.083575   0.276    0.801
```

```
## Colourblue    0.025264   0.113759   0.222    0.839
## Colourgreen  -0.023167   0.140968  -0.164    0.880
## Colourgrey    0.050826   0.078681   0.646    0.564
## Colourred    -0.135386   0.160260  -0.845    0.460
## Coloursilver -0.220539   0.168042  -1.312    0.281
## Auto1        -0.036882   0.262313  -0.141    0.897
## Mfr_G1        0.038699   0.136976   0.283    0.796
## Abag_21       0.188468   0.331128   0.569    0.609
## AC1          -0.050802   0.188658  -0.269    0.805
## Comp1               NA         NA      NA       NA
## CD1           0.048818   0.069688   0.701    0.534
## Clock1        0.069966   0.191941   0.365    0.740
## Pw1                 NA         NA      NA       NA
## Radio1              NA         NA      NA       NA
## SpM1         -0.095945   0.155232  -0.618    0.580
## M_Rim1       -0.044906   0.096624  -0.465    0.674
## Tow_Bar1      0.014112   0.125582   0.112    0.918
##
## Residual standard error: 0.08317 on 3 degrees of freedom
## Multiple R-squared:  0.9889, Adjusted R-squared:  0.9072
## F-statistic: 12.11 on 22 and 3 DF,  p-value: 0.03119

predictions <- predict(lmModel, test)

## Warning in predict.lm(lmModel, test): prediction from a rank-deficient fit
may
## be misleading

predictions

##         2        15        16        19        28
## 0.6386574 0.4717386 0.4027741 0.3397393 0.3255323

LMmse <- mean((predictions - test$Price)^2)
LMmse

## [1] 0.01054387
```

**Results:**

| Model | MSE |
|---|---|
| Hidden Neurons=10, decay=0.01 | 0.01431462 |
| Hidden Neurons=17, decay=0.01 | 0.01433148 |
| Hidden Neurons=5, decay=0.01 | 0.01399435 |

| | |
|---|---|
| 10-fold CV, with Hidden Neurons=10, decay=0.01 | 0.01961636 |
| 10-fold CV, with Hidden Neurons=17, decay=0.01 | 0.01933614 |
| 10-fold CV, with Hidden Neurons=5, decay=0.01 | 0.01956156 |
| Linear Regression | 0.01054387 |