# NeuralNetwork-Project

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```
library(neuralnet)
```

```
## Loading required package: grid
```

```
## Loading required package: MASS
```

```
set.seed(13)
cs = read.csv(file="C:/Users/jzhanggn/Documents/Creditset.csv",header=TRUE, stringsAsFactors = F
ALSE)
head(cs)
```

```
##   clientid   income      age      loan         LTI default10yr
## 1        1 66155.93 59.01702 8106.5321 0.122536751           0
## 2        2 34415.15 48.11715 6564.7450 0.190751581           0
## 3        3 57317.17 63.10805 8020.9533 0.139939800           0
## 4        4 42709.53 45.75197 6103.6423 0.142910532           0
## 5        5 66952.69 18.58434 8770.0992 0.130989500           1
## 6        6 24904.06 57.47161   15.4986 0.000622332           0
```

```
summary(cs)
```

```
##     clientid          income           age             loan         
##  Min.   :   1.0   Min.   :20014   Min.   :18.06   Min.   :    1.378  
##  1st Qu.: 500.8   1st Qu.:32796   1st Qu.:29.06   1st Qu.: 1939.709  
##  Median :1000.5   Median :45789   Median :41.38   Median : 3974.719  
##  Mean   :1000.5   Mean   :45332   Mean   :40.93   Mean   : 4444.370  
##  3rd Qu.:1500.2   3rd Qu.:57791   3rd Qu.:52.60   3rd Qu.: 6432.411  
##  Max.   :2000.0   Max.   :69996   Max.   :63.97   Max.   :13766.051  
##       LTI              default10yr    
##  Min.   :0.0000491   Min.   :0.0000  
##  1st Qu.:0.0479035   1st Qu.:0.0000  
##  Median :0.0994365   Median :0.0000  
##  Mean   :0.0984028   Mean   :0.1415  
##  3rd Qu.:0.1475846   3rd Qu.:0.0000  
##  Max.   :0.1999377   Max.   :1.0000  
```

```
dim(cs)
```

```
## [1] 2000    6
```

```
names(cs)
```

```
## [1] "clientid"    "income"      "age"         "loan"        "LTI"
## [6] "default10yr"
```

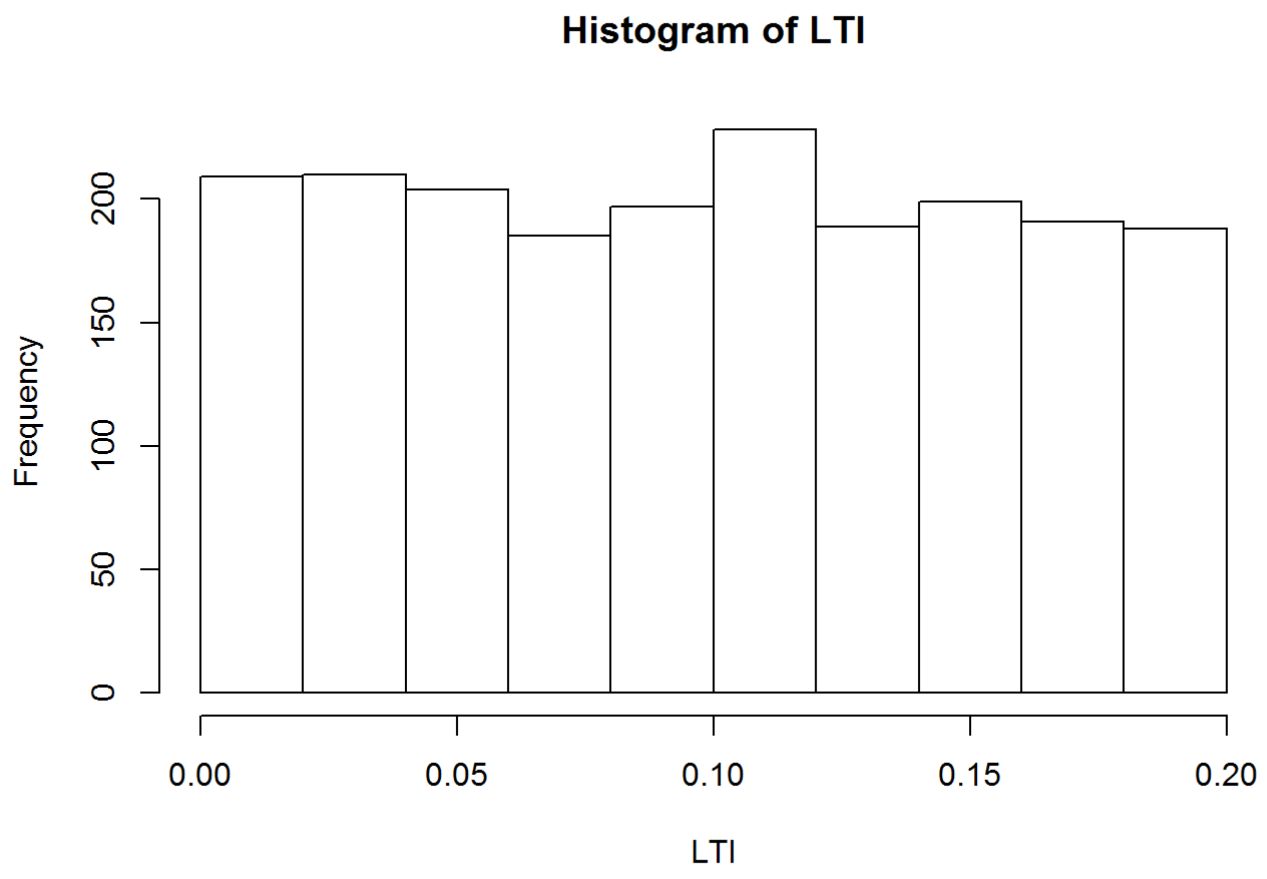
```
attach(cs)
trainset<- cs[1:800, ]
mean(default10yr)
```

```
## [1] 0.1415
```

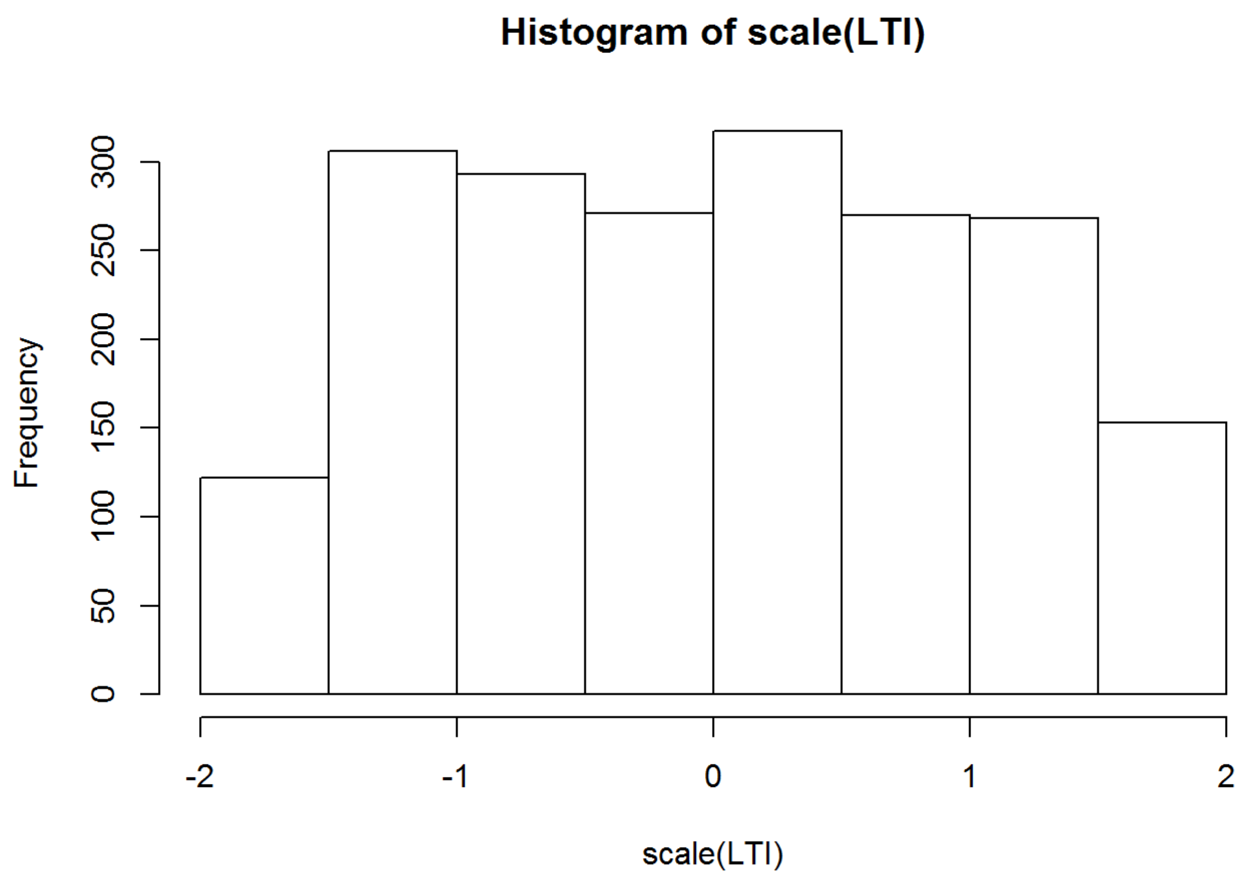
```
## [1] 0.1415
mean(trainset$default10yr)
```

```
## [1] 0.14875
```

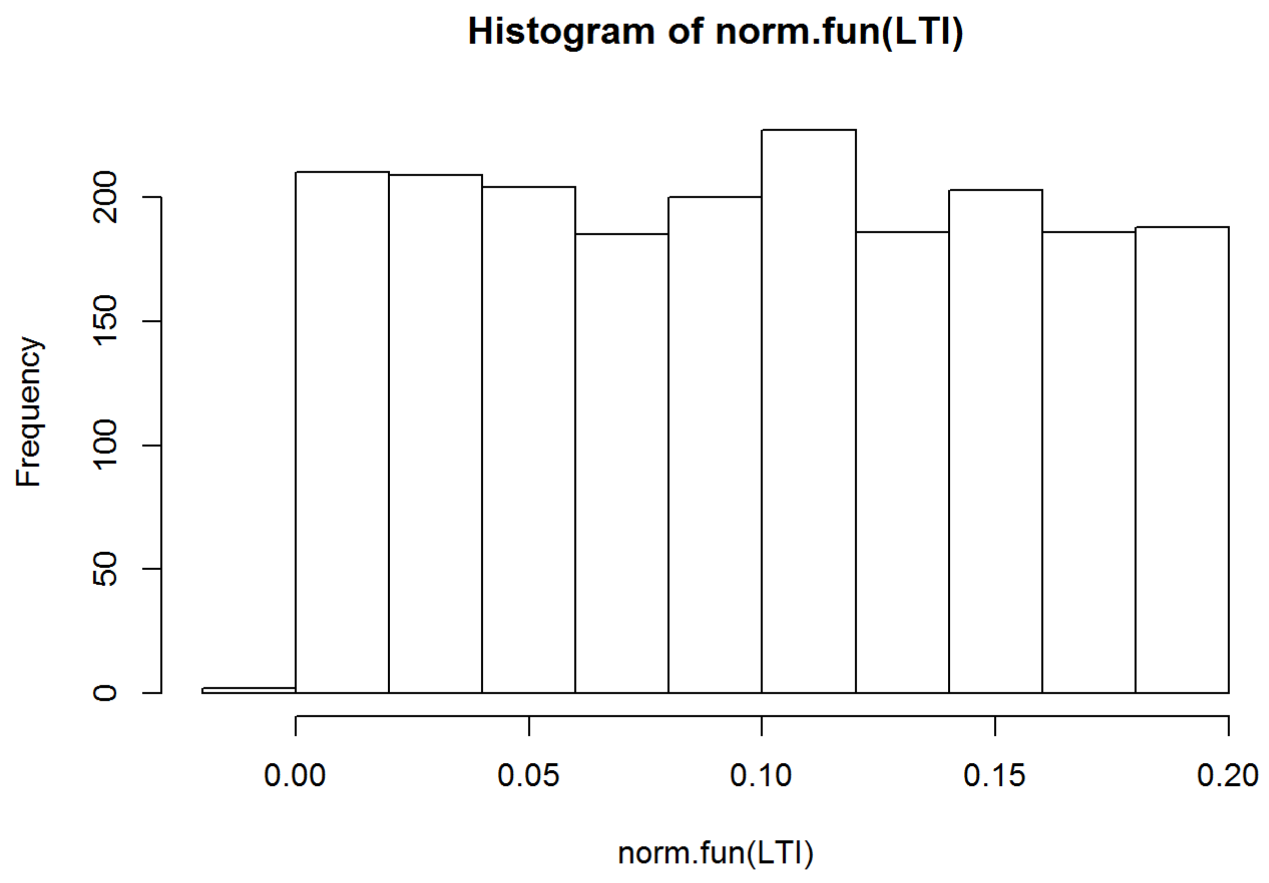
```
#[1] 0.14875
testset <- cs[801:2000, ]
hist(LTI)
```



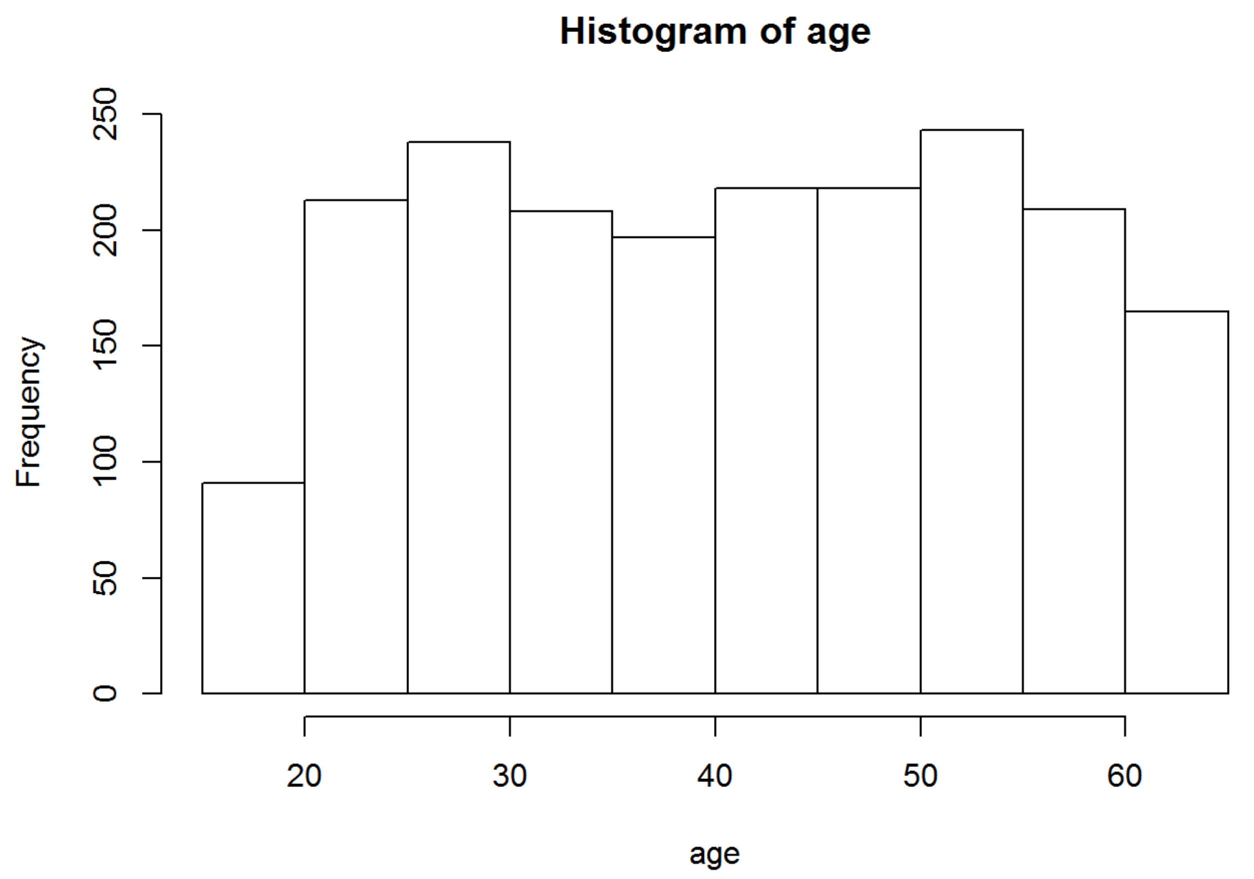
```
hist(scale(LTI))
```



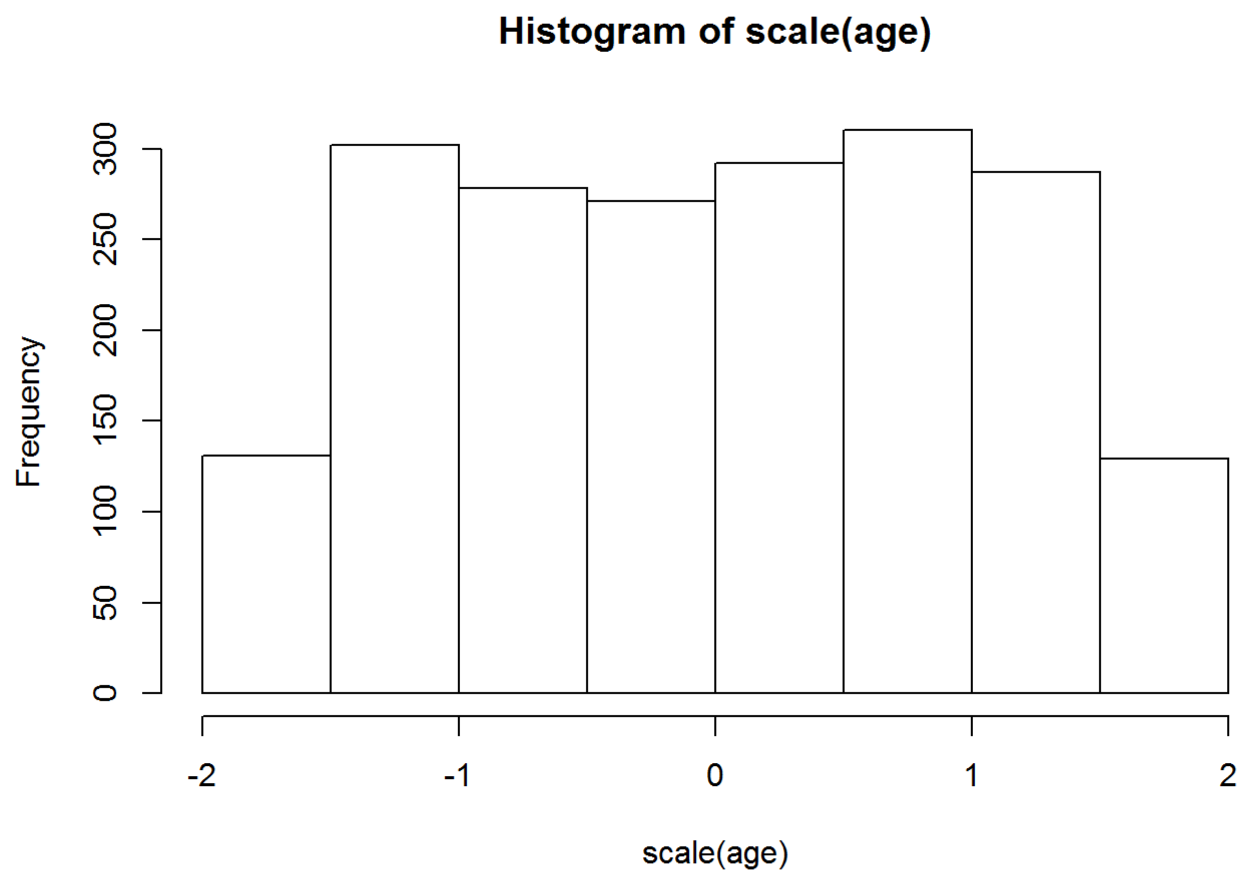
```
norm.fun = function(ds) {
(ds-min(ds)/(max(ds)-min(ds)))
}
hist(norm.fun(LTI))
```


Histogram of norm.fun(LTI)
Frequency
0
50
100
150
200
0.00
0.05
0.10
0.15
0.20
norm.fun(LTI)

```
hist(age)
```



```
hist(scale(age))
```



Now we ll build a neural network with 4 hidden nodes

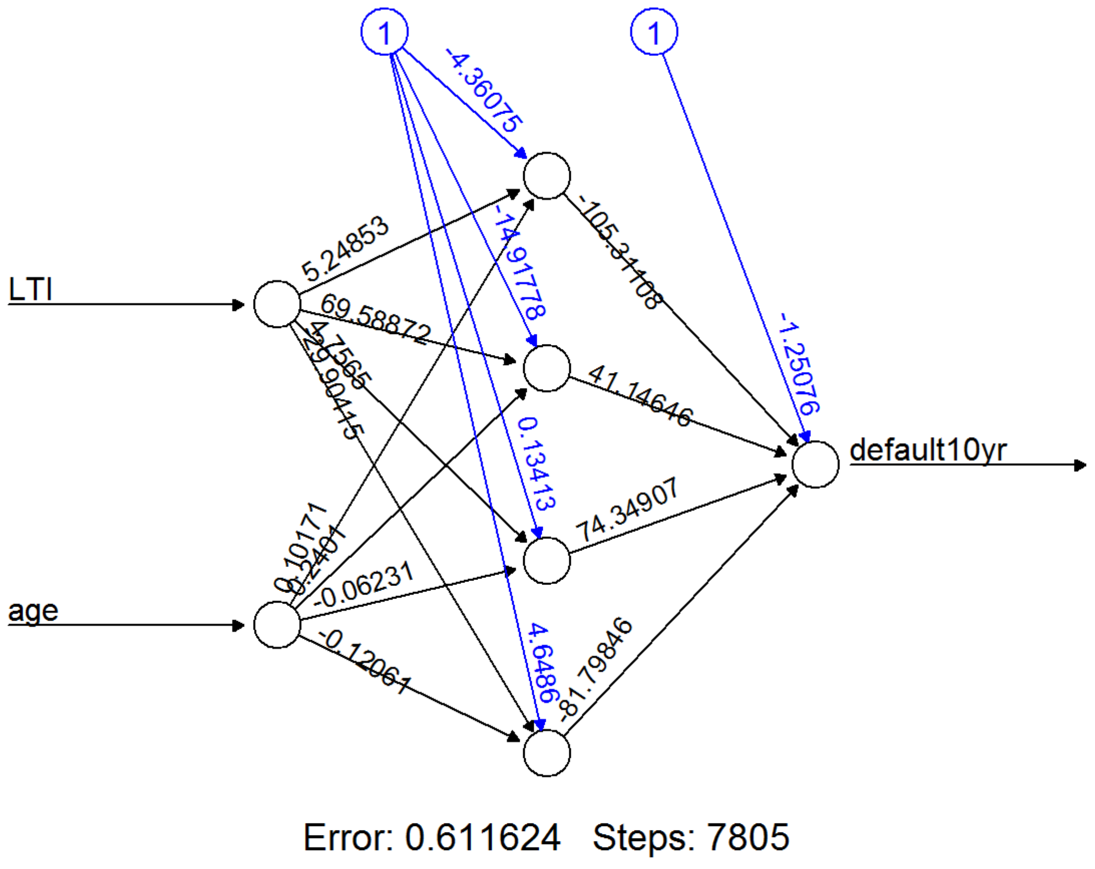
```
creditnet1 <- neuralnet(default10yr ~ LTI + age, trainset, hidden = 4, lifesign = "full", linea
r.output = FALSE, threshold = 0.1)
```

```
## hidden: 4    thresh: 0.1    rep: 1/1    steps:    1000   min thresh: 1.238609061
##                                                   2000   min thresh: 1.238609061
##                                                   3000   min thresh: 1.238609061
##                                                   4000   min thresh: 1.238609061
##                                                   5000   min thresh: 1.238609061
##                                                   6000   min thresh: 1.238609061
##                                                   7000   min thresh: 0.3830583742
##                                                   8000   min thresh: 0.382573307
##                                                   9000   min thresh: 0.382573307
##                                                  10000   min thresh: 0.382573307
##                                                  11000   min thresh: 0.382573307
##                                                  12000   min thresh: 0.382573307
##                                                  13000   min thresh: 0.3398207953
##                                                  14000   min thresh: 0.3398207953
##                                                  15000   min thresh: 0.3398207953
##                                                  16000   min thresh: 0.2763080856
##                                                  17000   min thresh: 0.2763080856
##                                                  18000   min thresh: 0.2763080856
##                                                  19000   min thresh: 0.2763080856
##                                                  20000   min thresh: 0.2763080856
##                                                  21000   min thresh: 0.2763080856
##                                                  22000   min thresh: 0.2763080856
##                                                  23000   min thresh: 0.2763080856
##                                                  24000   min thresh: 0.2763080856
##                                                  25000   min thresh: 0.2763080856
##                                                  26000   min thresh: 0.2763080856
##                                                  27000   min thresh: 0.2763080856
##                                                  28000   min thresh: 0.2763080856
##                                                  29000   min thresh: 0.2763080856
##                                                  30000   min thresh: 0.2763080856
##                                                  31000   min thresh: 0.2763080856
##                                                  32000   min thresh: 0.2763080856
##                                                  33000   min thresh: 0.2763080856
##                                                  34000   min thresh: 0.2763080856
##                                                  35000   min thresh: 0.2763080856
##                                                  36000   min thresh: 0.2763080856
##                                                  37000   min thresh: 0.2763080856
##                                                  38000   min thresh: 0.2763080856
##                                                  39000   min thresh: 0.2763080856
##                                                  40000   min thresh: 0.2763080856
##                                                  41000   min thresh: 0.2763080856
##                                                  42000   min thresh: 0.2763080856
##                                                  43000   min thresh: 0.2763080856
##                                                  44000   min thresh: 0.2763080856
##                                                  45000   min thresh: 0.2763080856
##                                                  46000   min thresh: 0.2763080856
##                                                  47000   min thresh: 0.2763080856
##                                                  48000   min thresh: 0.2763080856
##                                                  49000   min thresh: 0.2763080856
##                                                  50000   min thresh: 0.2763080856
##                                                  51000   min thresh: 0.2763080856
##                                                  52000   min thresh: 0.2763080856
##                                                  53000   min thresh: 0.2763080856
##                                                   54000   min thresh: 0.1951336724
##                                                   55000   min thresh: 0.1951336724
##                                                   56000   min thresh: 0.1951336724
##                                                   57000   min thresh: 0.1951336724
##                                                   58000   min thresh: 0.1748810787
##                                                   59000   min thresh: 0.1748810787
##                                                   60000   min thresh: 0.1748810787
##                                                   61000   min thresh: 0.1748810787
##                                                   62000   min thresh: 0.1748810787
##                                                   63000   min thresh: 0.1748810787
##                                                   64000   min thresh: 0.1748810787
##                                                   65000   min thresh: 0.1748810787
##                                                   66000   min thresh: 0.1748810787
##                                                   67000   min thresh: 0.1748810787
##                                                   68000   min thresh: 0.1748810787
##                                                   69000   min thresh: 0.1748810787
##                                                   69619   error: 0.01624  time: 42.2 secs
```

```
creditnet1 <- neuralnet(default10yr ~ LTI + age, trainset, hidden = 4, stepmax = 10000,rep = 10,
 linear.output = FALSE, threshold =.3)
```

```
## Warning: algorithm did not converge in 2 of 10 repetition(s) within the
## stepmax
```

```
plot(creditnet1, rep = "best")
```



```
test1 <- subset(testset, select = c("LTI", "age"))
# compute is the nn version of predict
creditnet1.results <- compute(creditnet1, test1)
names(creditnet1.results)
```

```
## [1] "neurons"    "net.result"
```

```
# [1] "neurons"    "net.result"

results1 <- data.frame(actual = testset$default10yr, prediction = creditnet1.results$net.result)
head(results1)
```

```
##     actual            prediction
## 801      0 0.0000000000195746385
## 802      0 0.0008848836875043884
## 803      0 0.00350313571425949107
## 804      0 0.0000000789041340787
## 805      0 0.0000164536878972939
## 806      0 0.0000103552067631609
```

```
results1$prediction <- round(results1$prediction)
head(results1)
```

```
##     actual prediction
## 801      0          0
## 802      0          0
## 803      0          0
## 804      0          0
## 805      0          0
## 806      0          0
```

```
resultsneg = subset(results1,results1[,1]==0) #take data has no default(0) called negative


resultspos = subset(results1, results1[,1] == 1)# has default
View(resultspos)

falseneg = sum((resultsneg[,1]-resultsneg[,2])^2)#RSS on all false negtive
falsepos = sum((resultspos[,1]-resultspos[,2])^2)# RSS on all false positive
allfalse = sum((results1[,1]-results1[,2])^2) # RSS-actually minus predication
```

Create a function to keep track of false positive

```
misses = function(results) {

     resultsneg = subset(results,results[,1]==0)
     resultspos = subset(results, results[,1] == 1)
     falseneg = sum((resultsneg[,1]-resultsneg[,2])^2)
     falsepos = sum((resultspos[,1]-resultspos[,2])^2)
     allfalse = sum((results[,1]-results[,2])^2) # sanity check
     miss= matrix(c(falseneg,falsepos,allfalse),1,3)
     colnames(miss ) = c('F neg', 'F pos', 'all errors')
return(miss)
}

misses(results1)
```

```
##      F neg F pos all errors
## [1,]     2     3          5
```

```
# Add income variable
creditnet2 <- neuralnet(default10yr ~ LTI + age+income, trainset, hidden = 4, rep = 10 , lifesig
n = "full", linear.output = FALSE, threshold = 0.1, stepmax=10000)
```

```
## hidden: 4    thresh: 0.1    rep:  1/10    steps:      25 error: 50.64953 time: 0.01 secs
## hidden: 4    thresh: 0.1    rep:  2/10    steps:      20 error: 50.64958 time: 0.01 secs
## hidden: 4    thresh: 0.1    rep:  3/10    steps:      10 error: 50.64961 time: 0.01 secs
## hidden: 4    thresh: 0.1    rep:  4/10    steps:       6 error: 50.64945 time: 0 secs
## hidden: 4    thresh: 0.1    rep:  5/10    steps:      29 error: 50.64938 time: 0.02 secs
## hidden: 4    thresh: 0.1    rep:  6/10    steps:      19 error: 50.64938 time: 0.01 secs
## hidden: 4    thresh: 0.1    rep:  7/10    steps:      21 error: 50.64949 time: 0.01 secs
## hidden: 4    thresh: 0.1    rep:  8/10    steps:      25 error: 50.64938 time: 0.01 secs
## hidden: 4    thresh: 0.1    rep:  9/10    steps:      11 error: 50.64977 time: 0 secs
## hidden: 4    thresh: 0.1    rep: 10/10    steps:      17 error: 50.64966 time: 0.01 secs
```

```
test2 <- subset(testset, select = c("LTI", "age","income"))
creditnet2.results <- compute(creditnet2, test2)
```

```
results2 <- data.frame(actual = testset$default10yr, prediction = creditnet2.results$net.result)
results2$prediction <- round(results2$prediction)
results2[100:115, ]
```

```
##     actual prediction
## 900      0          0
## 901      0          0
## 902      0          0
## 903      1          0
## 904      0          0
## 905      0          0
## 906      0          0
## 907      1          0
## 908      0          0
## 909      0          0
## 910      0          0
## 911      1          0
## 912      0          0
## 913      1          0
## 914      0          0
## 915      0          0
```

```
misses(results2)
```

```
##      F neg F pos all errors
## [1,]     0   164        164
```

```
# check if over training by adding another layer
creditnet3 <- neuralnet(default10yr ~ LTI + age+income, trainset, hidden = c(4,4), rep = 10, lif
esign = "full", linear.output = FALSE, threshold = 0.1, stepmax =10000)
```

```
## hidden: 4, 4    thresh: 0.1    rep:  1/10    steps:      18  error: 50.64941 time: 0.02 secs
## hidden: 4, 4    thresh: 0.1    rep:  2/10    steps:      20  error: 50.64944 time: 0.02 secs
## hidden: 4, 4    thresh: 0.1    rep:  3/10    steps:      18  error: 50.64965 time: 0.02 secs
## hidden: 4, 4    thresh: 0.1    rep:  4/10    steps:      18  error: 50.64961 time: 0.02 secs
## hidden: 4, 4    thresh: 0.1    rep:  5/10    steps:      21  error: 50.6495  time: 0.02 secs
## hidden: 4, 4    thresh: 0.1    rep:  6/10    steps:      12  error: 50.64939 time: 0.01 secs
## hidden: 4, 4    thresh: 0.1    rep:  7/10    steps:      13  error: 50.64972 time: 0.01 secs
## hidden: 4, 4    thresh: 0.1    rep:  8/10    steps:      13  error: 50.64938 time: 0.01 secs
## hidden: 4, 4    thresh: 0.1    rep:  9/10    steps:      22  error: 50.64938 time: 0.02 secs
## hidden: 4, 4    thresh: 0.1    rep: 10/10    steps:      13  error: 50.64959 time: 0.01 secs
```

```
creditnet3.results <- compute(creditnet3, test2)
results3 <- data.frame(actual = testset$default10yr, prediction = creditnet2.results$net.result)
results3$prediction <- round(results2$prediction)
misses(results3)
```

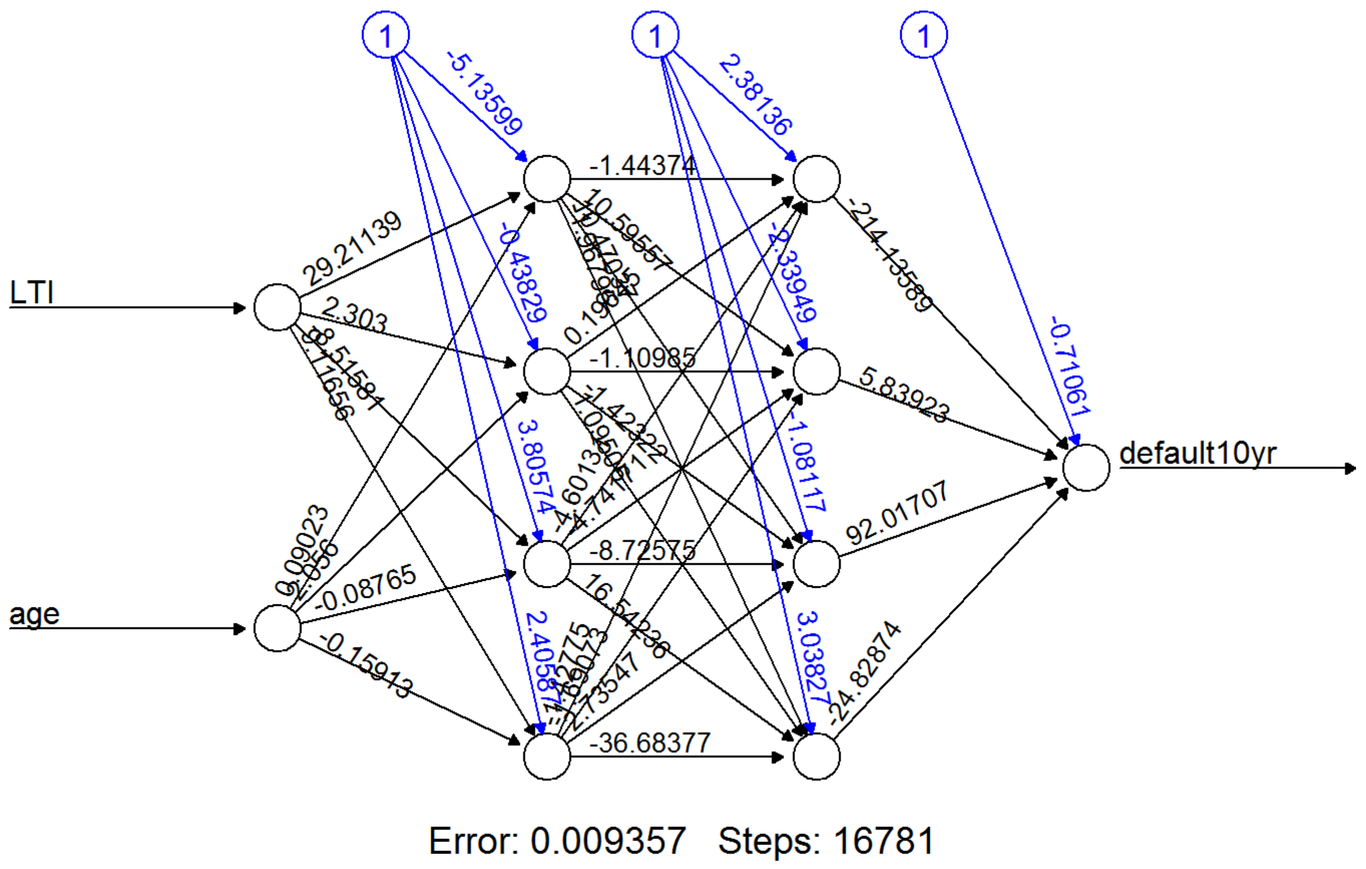
```
##      F neg F pos all errors
## [1,]     0   164        164
```

```
creditnet4 <- neuralnet(default10yr ~ LTI + age, trainset, hidden = c(4,4), rep = 10, stepmax =
20000,lifesign = "full", linear.output = FALSE, threshold =0.1)
```

```
## hidden: 4, 4    thresh: 0.1    rep:  1/10    steps:    1000  min thresh: 0.8149877644
##                                                        2000  min thresh: 0.8149877644
##                                                        3000  min thresh: 0.8149877644
##                                                        4000  min thresh: 0.8149877644
##                                                        5000  min thresh: 0.8149877644
##                                                        6000  min thresh: 0.8149877644
##                                                        7000  min thresh: 0.2398928434
##                                                        8000  min thresh: 0.1468522037
##                                                        9000  min thresh: 0.1468522037
##                                                       10000  min thresh: 0.1468522037
##                                                       11000  min thresh: 0.1441812789
##                                                       12000  min thresh: 0.1441812789
##                                                       13000  min thresh: 0.1441812789
##                                                       14000  min thresh: 0.1441812789
##                                                       15000  min thresh: 0.1441812789
##                                                       16000  min thresh: 0.1441812789
##                                                       17000  min thresh: 0.1441812789
##                                                       18000  min thresh: 0.1441812789
##                                                       19000  min thresh: 0.1441812789
##                                                     stepmax  min thresh: 0.1441812789
## hidden: 4, 4    thresh: 0.1    rep:  2/10    steps:    1000  min thresh: 1.073313979
##                                                        2000  min thresh: 1.073313979
##                                                        3000  min thresh: 0.7391243062
##                                                        4000  min thresh: 0.7391243062
##                                                        5000  min thresh: 0.7391243062
##                                                        6000  min thresh: 0.7391243062
##                                                        7000  min thresh: 0.7391243062
##                                                        8000  min thresh: 0.7391243062
##                                                        9000  min thresh: 0.7391243062
##                                                       10000  min thresh: 0.7391243062
##                                                       11000  min thresh: 0.7391243062
##                                                       12000  min thresh: 0.7391243062
##                                                       13000  min thresh: 0.7391243062
##                                                       14000  min thresh: 0.7391243062
##                                                       15000  min thresh: 0.7391243062
##                                                       16000  min thresh: 0.7391243062
##                                                       17000  min thresh: 0.7391243062
##                                                       18000  min thresh: 0.7391243062
##                                                       19000  min thresh: 0.7391243062
##                                                     stepmax  min thresh: 0.7391243062
## hidden: 4, 4    thresh: 0.1    rep:  3/10    steps:    1000  min thresh: 0.3632684021
##                                                        2000  min thresh: 0.3632684021
##                                                        3000  min thresh: 0.3632684021
##                                                        4000  min thresh: 0.3632684021
##                                                        5000  min thresh: 0.3632684021
##                                                        6000  min thresh: 0.3632684021
##                                                        7000  min thresh: 0.3632684021
##                                                        8000  min thresh: 0.3632684021
##                                                        9000  min thresh: 0.3632684021
##                                                       10000  min thresh: 0.3632684021
##                                                       11000  min thresh: 0.3632684021
##                                                       12000  min thresh: 0.3632684021
##                                                       13000  min thresh: 0.3632684021
##                                                   14000  min thresh: 0.2873478519
##                                                   15000  min thresh: 0.2873478519
##                                                   16000  min thresh: 0.2873478519
##                                                   17000  min thresh: 0.2158299548
##                                                   18000  min thresh: 0.2158299548
##                                                   19000  min thresh: 0.2158299548
##                                                 stepmax  min thresh: 0.2090410405
## hidden: 4, 4    thresh: 0.1    rep:  4/10    steps:    1000  min thresh: 2.255716317
##                                                    2000  min thresh: 1.834371055
##                                                    3000  min thresh: 1.601586385
##                                                    4000  min thresh: 0.7883240387
##                                                    5000  min thresh: 0.7883240387
##                                                    6000  min thresh: 0.6705291733
##                                                    6317  error: 0.98135  time: 7.01 secs
## hidden: 4, 4    thresh: 0.1    rep:  5/10    steps:    1000  min thresh: 0.8993122945
##                                                    2000  min thresh: 0.3132300685
##                                                    3000  min thresh: 0.3132300685
##                                                    4000  min thresh: 0.3132300685
##                                                    5000  min thresh: 0.1638914077
##                                                    5339  error: 0.00948  time: 5.68 secs
## hidden: 4, 4    thresh: 0.1    rep:  6/10    steps:    1000  min thresh: 0.4847285798
##                                                    2000  min thresh: 0.4847285798
##                                                    3000  min thresh: 0.4847285798
##                                                    4000  min thresh: 0.4847285798
##                                                    5000  min thresh: 0.4847285798
##                                                    6000  min thresh: 0.4847285798
##                                                    7000  min thresh: 0.4205196526
##                                                    8000  min thresh: 0.4205196526
##                                                    9000  min thresh: 0.4205196526
##                                                   10000  min thresh: 0.4205196526
##                                                   11000  min thresh: 0.4205196526
##                                                   12000  min thresh: 0.4205196526
##                                                   13000  min thresh: 0.4205196526
##                                                   14000  min thresh: 0.4205196526
##                                                   15000  min thresh: 0.4205196526
##                                                   16000  min thresh: 0.2627324275
##                                                   17000  min thresh: 0.2627324275
##                                                   18000  min thresh: 0.2627324275
##                                                   19000  min thresh: 0.2627324275
##                                                 stepmax  min thresh: 0.2627324275
## hidden: 4, 4    thresh: 0.1    rep:  7/10    steps:    1000  min thresh: 0.3751338821
##                                                    2000  min thresh: 0.3751338821
##                                                    3000  min thresh: 0.3751338821
##                                                    4000  min thresh: 0.3751338821
##                                                    5000  min thresh: 0.3751338821
##                                                    6000  min thresh: 0.3582934939
##                                                    7000  min thresh: 0.3328801888
##                                                    8000  min thresh: 0.2251012527
##                                                    9000  min thresh: 0.2236856184
##                                                   10000  min thresh: 0.1762179227
##                                                   11000  min thresh: 0.134600152
##                                                   12000  min thresh: 0.1148038163
##                                                   12936  error: 0.01283  time: 13.84 secs
## hidden: 4, 4    thresh: 0.1    rep:  8/10    steps:    1000  min thresh: 0.902748817
##                                                   2000  min thresh: 0.485867249
##                                                   3000  min thresh: 0.485867249
##                                                   4000  min thresh: 0.485867249
##                                                   5000  min thresh: 0.485867249
##                                                   6000  min thresh: 0.485867249
##                                                   7000  min thresh: 0.4706854402
##                                                   8000  min thresh: 0.4706854402
##                                                   9000  min thresh: 0.4706854402
##                                                  10000  min thresh: 0.1698200029
##                                                  11000  min thresh: 0.1435650855
##                                                  12000  min thresh: 0.1084264832
##                                                  13000  min thresh: 0.1084264832
##                                                  14000  min thresh: 0.1084264832
##                                                  15000  min thresh: 0.1084264832
##                                                  16000  min thresh: 0.1084264832
##                                                  17000  min thresh: 0.1084264832
##                                                  18000  min thresh: 0.1084264832
##                                                  19000  min thresh: 0.1084264832
##                                                stepmax  min thresh: 0.1084264832
## hidden: 4, 4    thresh: 0.1    rep:  9/10    steps:    1000  min thresh: 1.09718985
##                                                   2000  min thresh: 0.3923669746
##                                                   3000  min thresh: 0.3923669746
##                                                   4000  min thresh: 0.3923669746
##                                                   5000  min thresh: 0.3923669746
##                                                   6000  min thresh: 0.3923669746
##                                                   7000  min thresh: 0.3744291952
##                                                   8000  min thresh: 0.3744291952
##                                                   9000  min thresh: 0.3744291952
##                                                  10000  min thresh: 0.3744291952
##                                                  11000  min thresh: 0.3744291952
##                                                  12000  min thresh: 0.3744291952
##                                                  13000  min thresh: 0.3744291952
##                                                  14000  min thresh: 0.2144503022
##                                                  15000  min thresh: 0.1160257414
##                                                  16000  min thresh: 0.1021022113
##                                                  16781  error: 0.00936  time: 18.05 secs
## hidden: 4, 4    thresh: 0.1    rep: 10/10    steps:    1000  min thresh: 0.777769739
##                                                   2000  min thresh: 0.777769739
##                                                   3000  min thresh: 0.5446419654
##                                                   4000  min thresh: 0.5446419654
##                                                   5000  min thresh: 0.4383825487
##                                                   6000  min thresh: 0.427774916
##                                                   7000  min thresh: 0.1966255901
##                                                   8000  min thresh: 0.1966255901
##                                                   9000  min thresh: 0.1966255901
##                                                  10000  min thresh: 0.1896347109
##                                                  11000  min thresh: 0.1896347109
##                                                  12000  min thresh: 0.158156904
##                                                  13000  min thresh: 0.158156904
##                                                  14000  min thresh: 0.158156904
##                                                  15000  min thresh: 0.1503340721
##                                                  16000  min thresh: 0.1503340721
##                                                  17000  min thresh: 0.1478620633
##                                                  18000  min thresh: 0.1416955154
##                                                         19000  min thresh: 0.1335492201
##                                                         19561  error: 0.01389  time: 20.9 secs
```

```
## Warning: algorithm did not converge in 5 of 10 repetition(s) within the
## stepmax
```

```
plot(creditnet4, rep = "best")
```



```
creditnet4.results <- compute(creditnet1, test1)
# create a data frame to check
results4 <- data.frame(actual = testset$default10yr, prediction = creditnet4.results$net.result)
results4$prediction <- round(results4$prediction)
misses(results4)
```

```
##       F neg F pos all errors
## [1,]     2     3          5
```

Compare with traditional logistic regression model on this data set with the same 2 and three variables.

```
credit.log = glm(default10yr ~ LTI + age,family = binomial ,data = cs[1:800,])
credit.logpred = predict(credit.log, newdata = cs[801:2000,], type = 'response')
logcomp = cbind(cs$default10yr[801:2000],round(credit.logpred))
misses(logcomp)
```

```
##      F neg F pos all errors
## [1,]    37    27         64
```

```
#three variables
credit.log1 = glm(default10yr ~ LTI + age +income,family = binomial ,data = cs[1:800,])
credit.logpred1 = predict(credit.log1, newdata = cs[801:2000,], type = 'response')
logcomp1 = cbind(cs$default10yr[801:2000],round(credit.logpred1))
misses(logcomp1)
```

```
##      F neg F pos all errors
## [1,]    37    26         63
```

Based on this analysis. we see that NeuralNet work out performs logistic Regression model