STAT4520 HW6

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Problem 1

```
library(faraway)
library(lme4)
```

```
## Loading required package: Matrix
```

```
library(caret)
```

```
## Loading required package: ggplot2

## Loading required package: lattice

##
## Attaching package: 'lattice'

## The following object is masked from 'package:faraway':
##
##     melanoma
```

```
library(nnet)
library(ggplot2)
library(NeuralNetTools)

set.seed(123)

data<-ratdrink

model <- lmer(wt ~ weeks * treat + (weeks | subject), data = ratdrink)
sumary(model, digits = 3)
```

```
## Fixed Effects:
##                          coef.est coef.se
## (Intercept)              52.880    2.094
## weeks                    26.480    1.266
## treatthiouracil           4.780    2.961
## treatthyroxine           -0.794    3.263
## weeks:treatthiouracil -9.370    1.790
```

```
## weeks:treatthyroxine   0.663    1.973
##
## Random Effects:
##  Groups   Name        Std.Dev. Corr
##  subject  (Intercept) 5.700
##           weeks       3.760    -0.133
##  Residual             4.348
## ---
## number of obs: 135, groups: subject, 27
## AIC = 898.7, DIC = 912.7
## deviance = 895.7
```

```
coef(model)$subject
```

```
##    (Intercept)    weeks treatthiouracil treatthyroxine weeks:treatthiouracil
## 1     56.26985 28.44095            4.78     -0.7942857                  -9.37
## 2     60.43983 29.19996            4.78     -0.7942857                  -9.37
## 3     49.48953 32.28684            4.78     -0.7942857                  -9.37
## 4     46.02999 28.26936            4.78     -0.7942857                  -9.37
## 5     55.23620 23.57695            4.78     -0.7942857                  -9.37
## 6     47.32027 26.86454            4.78     -0.7942857                  -9.37
## 7     49.75071 22.06261            4.78     -0.7942857                  -9.37
## 8     62.12312 23.42741            4.78     -0.7942857                  -9.37
## 9     47.26982 22.54424            4.78     -0.7942857                  -9.37
## 10    54.87069 28.12713            4.78     -0.7942857                  -9.37
## 11    57.39132 29.93034            4.78     -0.7942857                  -9.37
## 12    51.31906 20.53800            4.78     -0.7942857                  -9.37
## 13    50.27982 32.57573            4.78     -0.7942857                  -9.37
## 14    57.15640 29.36841            4.78     -0.7942857                  -9.37
## 15    53.35421 22.08151            4.78     -0.7942857                  -9.37
## 16    51.94129 21.67647            4.78     -0.7942857                  -9.37
## 17    48.71791 29.18954            4.78     -0.7942857                  -9.37
## 18    59.98224 27.06134            4.78     -0.7942857                  -9.37
## 19    56.90775 25.59810            4.78     -0.7942857                  -9.37
## 20    52.44331 27.86768            4.78     -0.7942857                  -9.37
## 21    59.08383 25.08727            4.78     -0.7942857                  -9.37
## 22    49.93150 31.13342            4.78     -0.7942857                  -9.37
## 23    50.86651 25.37911            4.78     -0.7942857                  -9.37
## 24    55.76068 22.97087            4.78     -0.7942857                  -9.37
## 25    49.87763 29.77968            4.78     -0.7942857                  -9.37
## 26    43.87071 23.81001            4.78     -0.7942857                  -9.37
## 27    50.07584 26.11253            4.78     -0.7942857                  -9.37
##    weeks:treatthyroxine
## 1             0.6628571
## 2             0.6628571
## 3             0.6628571
## 4             0.6628571
## 5             0.6628571
## 6             0.6628571
## 7             0.6628571
## 8             0.6628571
## 9             0.6628571
## 10            0.6628571
## 11            0.6628571
```

```
## 12            0.6628571
## 13            0.6628571
## 14            0.6628571
## 15            0.6628571
## 16            0.6628571
## 17            0.6628571
## 18            0.6628571
## 19            0.6628571
## 20            0.6628571
## 21            0.6628571
## 22            0.6628571
## 23            0.6628571
## 24            0.6628571
## 25            0.6628571
## 26            0.6628571
## 27            0.6628571
```

According to the summary, the rat's weight increase about 26.48 for each week of study. We can see that if the rat has the treatment thiouracil, it increases the weight by 4.78, and if the has the treatment thyroxine, it decreases the weight by 0.7943. We also fits the interaction term to the model. If the rat has the treatment thiouracil, it decreases 9.37 weight each week. Lastly, if the rat has the treatment thyoxine increases the weight by 0.6629 weight each week.

The standard deviation deviation for the intercept is 5.7 and the standard deviation for the slope is 3.76. We can see that the variation in increase weight is smaller than the variation in overall weight between individual rats. This model has the correlation of -0.133. Lastly, the variation has a standard deviation of 4.348.

Problem 2a

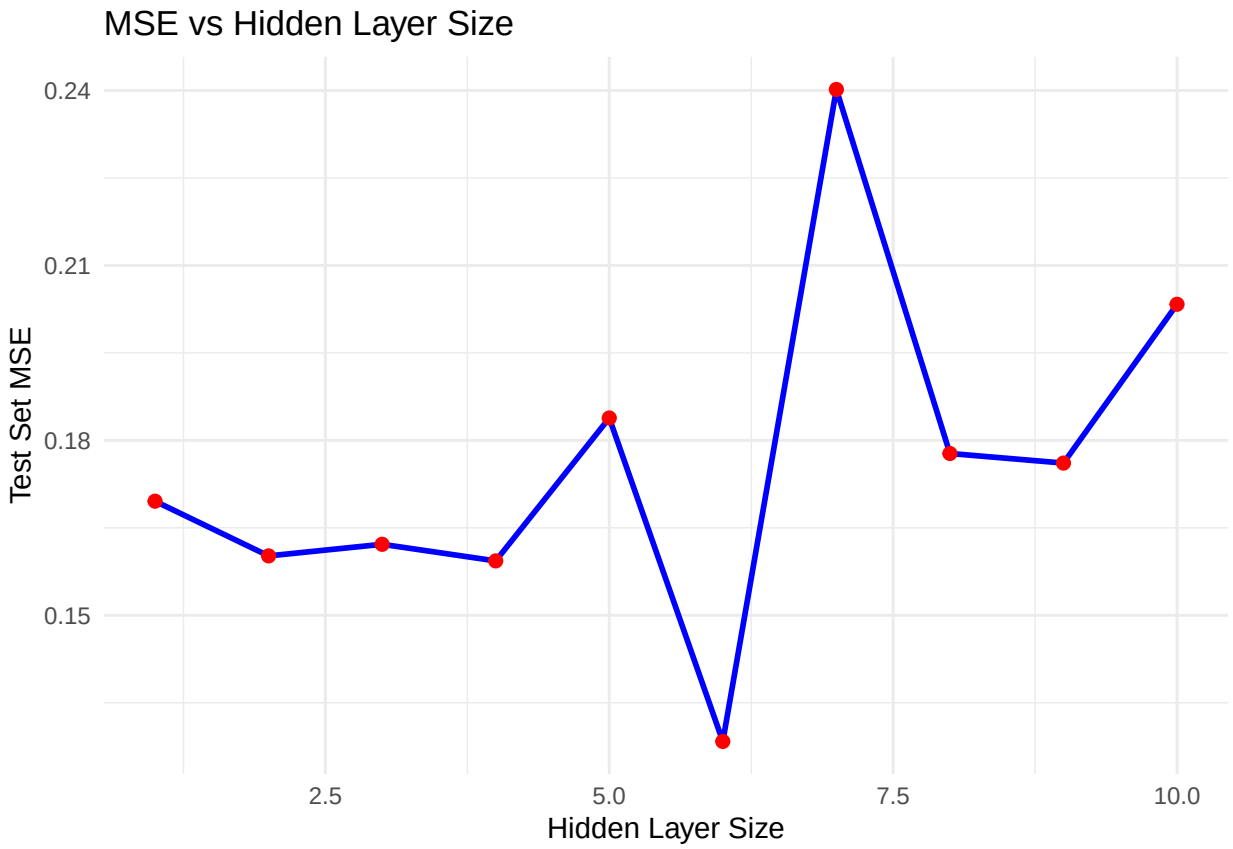
```
set.seed(123)
data<-read.csv("/Users/antonyang/Downloads/BostonScaled.csv")

train_indices<-createDataPartition(data$medv, times = 1, p = 0.8, list = FALSE)

training_set<-data[train_indices,]
test_set<-data[-train_indices,]

mse_values<-numeric(10)

for (i in 1:10){
  nn_model<-nnet(medv ~., data = training_set, size = i, linout = TRUE, trace = FALSE)
  predictions<-predict(nn_model, test_set)
  mse_values[i]<-mean((predictions - test_set$medv)^2)
}

mse_results <- data.frame(Hidden_Layer_Size = 1:10, Test_Set_MSE = mse_values)
print(mse_results)
```

```
##    Hidden_Layer_Size Test_Set_MSE
## 1                  1    0.1695626
## 2                  2    0.1601802
## 3                  3    0.1621747
```

```
## 4                  4    0.1593231
## 5                  5    0.1838311
## 6                  6    0.1283623
## 7                  7    0.2401703
## 8                  8    0.1777437
## 9                  9    0.1760977
## 10                10    0.2033299
```

```
ggplot(mse_results, aes(x = Hidden_Layer_Size, y = Test_Set_MSE)) +
  geom_line(color = "blue", size = 1) +
  geom_point(color = "red", size = 2) +
  labs(title = "MSE vs Hidden Layer Size",
       x = "Hidden Layer Size",
       y = "Test Set MSE") +
  theme_minimal()
```

```
## Warning: Using 'size' aesthetic for lines was deprecated in ggplot2 3.4.0.
## i Please use 'linewidth' instead.
## This warning is displayed once every 8 hours.
## Call 'lifecycle::last_lifecycle_warnings()' to see where this warning was
## generated.
```

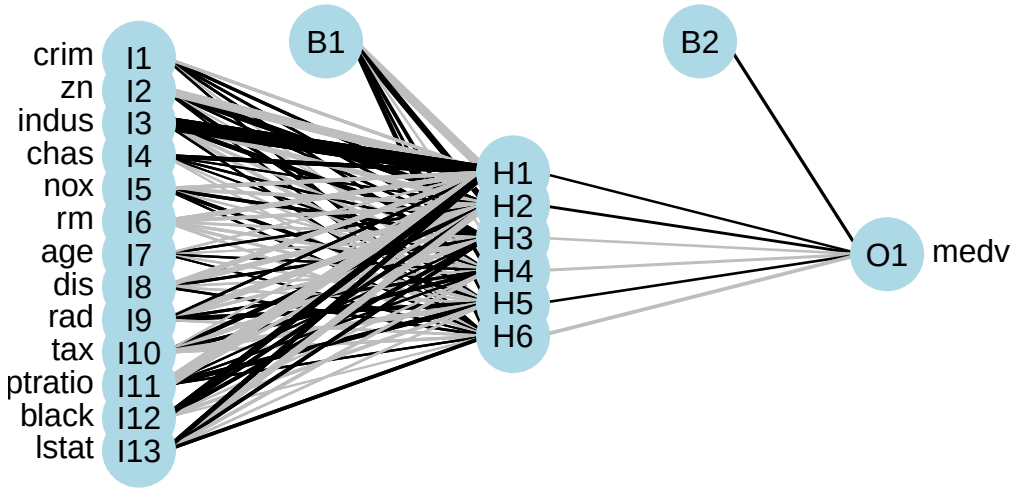



```
best_hidden_size<-which.min(mse_values)
best_nn_model<-nnet(medv~., data = training_set, size = best_hidden_size, linout = TRUE, trace = FALSE)
```

We can see that according to our simple single hidden layer neural networks model, we can see that the model with 6 hidden layers has the lowest test MSE. Therefore, our optimal model is a neural network with 6 hidden layers.

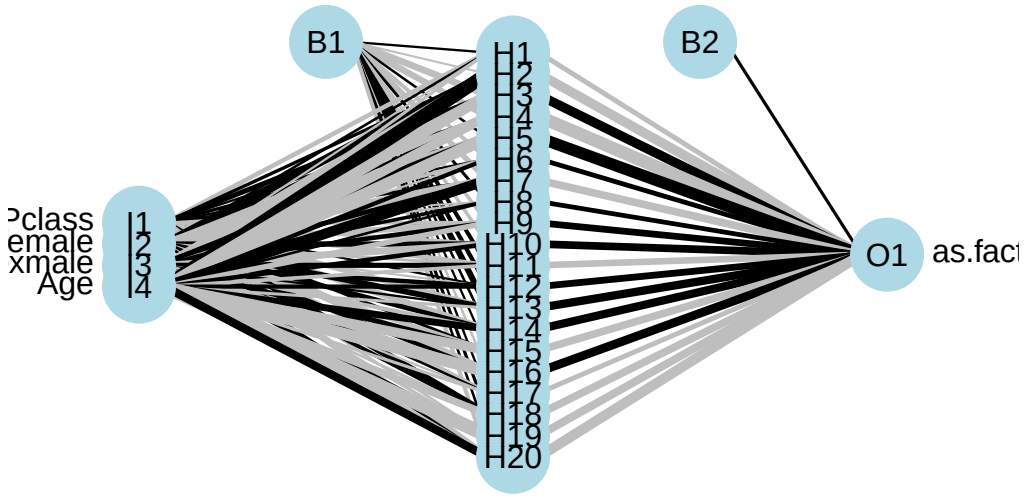
Problem 2b

```
plotnet(best_nn_model)
```



Problem 3

```
set.seed(123)
data<-read.csv("/Users/antonyang/Downloads/titanticScaled.csv")

nn_model<-nnet(as.factor(Survived) ~., data = data, size = 20, trace = FALSE, linout = FALSE, maxit = 2

plotnet(nn_model)
```



```r
best_predictions<-as.factor(predict(nn_model, data, type = "class"))

conf_matrix<-confusionMatrix(as.factor(data$Survived), best_predictions)
print(conf_matrix)
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction   0   1
##          0 390  34
##          1  74 216
##
##                Accuracy : 0.8487
##                  95% CI : (0.8203, 0.8742)
##     No Information Rate : 0.6499
##     P-Value [Acc > NIR] : < 2.2e-16
##
##                   Kappa : 0.6794
##
##  Mcnemar's Test P-Value : 0.0001749
##
##             Sensitivity : 0.8405
##             Specificity : 0.8640
##          Pos Pred Value : 0.9198
##          Neg Pred Value : 0.7448
##              Prevalence : 0.6499
##          Detection Rate : 0.5462
##    Detection Prevalence : 0.5938
##       Balanced Accuracy : 0.8523
##
##        'Positive' Class : 0
##
```

We constructed the optimal model with 20 hidden layer and weight decay of 0.01. According to our confusion matrix, this model has an accuracy of 0.8487. We can see that our model is relatively good at predicting both positive and negative with a senstivity of 0.8405 and a specificity of 0.8640.