R Markdown_Neural Networks Part 2

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Background: * Neural Network Examples and Pitfalls

Goal: * Performing a classification problem. * Using the 'iris' data set, one can identify the iris flower species (setosa, versicolor, andvirginica) based on four measurements (sepal length, sepal width, petal length, and petal width). The response variable is 'species,' which is categorical and nominal. * The response variable is 'species,' which is categorical and nominal.

```
data(iris)
dim(iris)
```

```
## [1] 150   5
```

```
head(iris)
```

```
##   Sepal.Length Sepal.Width Petal.Length Petal.Width Species
## 1          5.1         3.5          1.4         0.2  setosa
## 2          4.9         3.0          1.4         0.2  setosa
## 3          4.7         3.2          1.3         0.2  setosa
## 4          4.6         3.1          1.5         0.2  setosa
## 5          5.0         3.6          1.4         0.2  setosa
## 6          5.4         3.9          1.7         0.4  setosa
```

Comments: * There are 150 flowers in the data with 50 flowers in each of the species. * need to build a neural network model for the data. To do this, activate the neuralnet package.

```
library (neuralnet)
NNModel <- neuralnet(Species ~ Sepal.Length + Sepal.Width + Petal.Length + Petal.Width, data = iris, hidden = 10)
```

```
## Warning: Algorithm did not converge in 1 of 1 repetition(s) within the stepmax.
```

Comments: * am error message * Neural network models cannot work with categorical variables. It needs numbers. The algorithm thrives on optimization and calculus. The error function 0.5(target value – network value)2 needs numbers for calculations

```
table(iris$Species)
```

```
##
##     setosa versicolor  virginica
##         50         50         50
```

Comments: * need to convert the categories into numbers. * Create a new column ‘Species1.’

```
iris$Species1 <- ifelse(iris$Species == "setosa", 0, ifelse(iris$Species == "versicolor", 1, 2))
head(iris)
```

```
##   Sepal.Length Sepal.Width Petal.Length Petal.Width Species Species1
## 1          5.1         3.5          1.4         0.2  setosa        0
## 2          4.9         3.0          1.4         0.2  setosa        0
## 3          4.7         3.2          1.3         0.2  setosa        0
## 4          4.6         3.1          1.5         0.2  setosa        0
## 5          5.0         3.6          1.4         0.2  setosa        0
## 6          5.4         3.9          1.7         0.4  setosa        0
```

Comments: * find the neural network model

```
NNModel <- neuralnet(Species1 ~ Sepal.Length + Sepal.Width + Petal.Length + Petal.Width, data = iris, hidden = 5)
NNModel
```

```
## $call
## neuralnet(formula = Species1 ~ Sepal.Length + Sepal.Width + Petal.Length +
##     Petal.Width, data = iris, hidden = 5)
##
## $response
##     Species1
## 1          0
## 2          0
## 3          0
## 4          0
## 5          0
## 6          0
## 7          0
## 8          0
## 9          0
## 10         0
## 11         0
## 12         0
## 13         0
## 14         0
## 15         0
## 16         0
## 17         0
## 18         0
## 19         0
## 20         0
## 21         0
## 22         0
## 23         0
## 24         0
## 25         0
## 26         0
## 27         0
## 28         0
## 29         0
## 30         0
## 31         0
## 32         0
## 33         0
```

```
## 34         0
## 35         0
## 36         0
## 37         0
## 38         0
## 39         0
## 40         0
## 41         0
## 42         0
## 43         0
## 44         0
## 45         0
## 46         0
## 47         0
## 48         0
## 49         0
## 50         0
## 51         1
## 52         1
## 53         1
## 54         1
## 55         1
## 56         1
## 57         1
## 58         1
## 59         1
## 60         1
## 61         1
## 62         1
## 63         1
## 64         1
## 65         1
## 66         1
## 67         1
## 68         1
## 69         1
## 70         1
## 71         1
## 72         1
```

```
## 73          1
## 74          1
## 75          1
## 76          1
## 77          1
## 78          1
## 79          1
## 80          1
## 81          1
## 82          1
## 83          1
## 84          1
## 85          1
## 86          1
## 87          1
## 88          1
## 89          1
## 90          1
## 91          1
## 92          1
## 93          1
## 94          1
## 95          1
## 96          1
## 97          1
## 98          1
## 99          1
## 100         1
## 101         2
## 102         2
## 103         2
## 104         2
## 105         2
## 106         2
## 107         2
## 108         2
## 109         2
## 110         2
## 111         2
```

```
## 112        2
## 113        2
## 114        2
## 115        2
## 116        2
## 117        2
## 118        2
## 119        2
## 120        2
## 121        2
## 122        2
## 123        2
## 124        2
## 125        2
## 126        2
## 127        2
## 128        2
## 129        2
## 130        2
## 131        2
## 132        2
## 133        2
## 134        2
## 135        2
## 136        2
## 137        2
## 138        2
## 139        2
## 140        2
## 141        2
## 142        2
## 143        2
## 144        2
## 145        2
## 146        2
## 147        2
## 148        2
## 149        2
## 150        2
```

```
##
## $covariate
##        Sepal.Length Sepal.Width Petal.Length Petal.Width
##   [1,]          5.1         3.5          1.4         0.2
##   [2,]          4.9         3.0          1.4         0.2
##   [3,]          4.7         3.2          1.3         0.2
##   [4,]          4.6         3.1          1.5         0.2
##   [5,]          5.0         3.6          1.4         0.2
##   [6,]          5.4         3.9          1.7         0.4
##   [7,]          4.6         3.4          1.4         0.3
##   [8,]          5.0         3.4          1.5         0.2
##   [9,]          4.4         2.9          1.4         0.2
##  [10,]          4.9         3.1          1.5         0.1
##  [11,]          5.4         3.7          1.5         0.2
##  [12,]          4.8         3.4          1.6         0.2
##  [13,]          4.8         3.0          1.4         0.1
##  [14,]          4.3         3.0          1.1         0.1
##  [15,]          5.8         4.0          1.2         0.2
##  [16,]          5.7         4.4          1.5         0.4
##  [17,]          5.4         3.9          1.3         0.4
##  [18,]          5.1         3.5          1.4         0.3
##  [19,]          5.7         3.8          1.7         0.3
##  [20,]          5.1         3.8          1.5         0.3
##  [21,]          5.4         3.4          1.7         0.2
##  [22,]          5.1         3.7          1.5         0.4
##  [23,]          4.6         3.6          1.0         0.2
##  [24,]          5.1         3.3          1.7         0.5
##  [25,]          4.8         3.4          1.9         0.2
##  [26,]          5.0         3.0          1.6         0.2
##  [27,]          5.0         3.4          1.6         0.4
##  [28,]          5.2         3.5          1.5         0.2
##  [29,]          5.2         3.4          1.4         0.2
##  [30,]          4.7         3.2          1.6         0.2
##  [31,]          4.8         3.1          1.6         0.2
##  [32,]          5.4         3.4          1.5         0.4
##  [33,]          5.2         4.1          1.5         0.1
##  [34,]          5.5         4.2          1.4         0.2
##  [35,]          4.9         3.1          1.5         0.2
##  [36,]          5.0         3.2          1.2         0.2
```

```
##  [37,]          5.5         3.5          1.3         0.2
##  [38,]          4.9         3.6          1.4         0.1
##  [39,]          4.4         3.0          1.3         0.2
##  [40,]          5.1         3.4          1.5         0.2
##  [41,]          5.0         3.5          1.3         0.3
##  [42,]          4.5         2.3          1.3         0.3
##  [43,]          4.4         3.2          1.3         0.2
##  [44,]          5.0         3.5          1.6         0.6
##  [45,]          5.1         3.8          1.9         0.4
##  [46,]          4.8         3.0          1.4         0.3
##  [47,]          5.1         3.8          1.6         0.2
##  [48,]          4.6         3.2          1.4         0.2
##  [49,]          5.3         3.7          1.5         0.2
##  [50,]          5.0         3.3          1.4         0.2
##  [51,]          7.0         3.2          4.7         1.4
##  [52,]          6.4         3.2          4.5         1.5
##  [53,]          6.9         3.1          4.9         1.5
##  [54,]          5.5         2.3          4.0         1.3
##  [55,]          6.5         2.8          4.6         1.5
##  [56,]          5.7         2.8          4.5         1.3
##  [57,]          6.3         3.3          4.7         1.6
##  [58,]          4.9         2.4          3.3         1.0
##  [59,]          6.6         2.9          4.6         1.3
##  [60,]          5.2         2.7          3.9         1.4
##  [61,]          5.0         2.0          3.5         1.0
##  [62,]          5.9         3.0          4.2         1.5
##  [63,]          6.0         2.2          4.0         1.0
##  [64,]          6.1         2.9          4.7         1.4
##  [65,]          5.6         2.9          3.6         1.3
##  [66,]          6.7         3.1          4.4         1.4
##  [67,]          5.6         3.0          4.5         1.5
##  [68,]          5.8         2.7          4.1         1.0
##  [69,]          6.2         2.2          4.5         1.5
##  [70,]          5.6         2.5          3.9         1.1
##  [71,]          5.9         3.2          4.8         1.8
##  [72,]          6.1         2.8          4.0         1.3
##  [73,]          6.3         2.5          4.9         1.5
##  [74,]          6.1         2.8          4.7         1.2
##  [75,]          6.4         2.9          4.3         1.3
```

```
##  [76,]         6.6         3.0         4.4         1.4
##  [77,]         6.8         2.8         4.8         1.4
##  [78,]         6.7         3.0         5.0         1.7
##  [79,]         6.0         2.9         4.5         1.5
##  [80,]         5.7         2.6         3.5         1.0
##  [81,]         5.5         2.4         3.8         1.1
##  [82,]         5.5         2.4         3.7         1.0
##  [83,]         5.8         2.7         3.9         1.2
##  [84,]         6.0         2.7         5.1         1.6
##  [85,]         5.4         3.0         4.5         1.5
##  [86,]         6.0         3.4         4.5         1.6
##  [87,]         6.7         3.1         4.7         1.5
##  [88,]         6.3         2.3         4.4         1.3
##  [89,]         5.6         3.0         4.1         1.3
##  [90,]         5.5         2.5         4.0         1.3
##  [91,]         5.5         2.6         4.4         1.2
##  [92,]         6.1         3.0         4.6         1.4
##  [93,]         5.8         2.6         4.0         1.2
##  [94,]         5.0         2.3         3.3         1.0
##  [95,]         5.6         2.7         4.2         1.3
##  [96,]         5.7         3.0         4.2         1.2
##  [97,]         5.7         2.9         4.2         1.3
##  [98,]         6.2         2.9         4.3         1.3
##  [99,]         5.1         2.5         3.0         1.1
## [100,]         5.7         2.8         4.1         1.3
## [101,]         6.3         3.3         6.0         2.5
## [102,]         5.8         2.7         5.1         1.9
## [103,]         7.1         3.0         5.9         2.1
## [104,]         6.3         2.9         5.6         1.8
## [105,]         6.5         3.0         5.8         2.2
## [106,]         7.6         3.0         6.6         2.1
## [107,]         4.9         2.5         4.5         1.7
## [108,]         7.3         2.9         6.3         1.8
## [109,]         6.7         2.5         5.8         1.8
## [110,]         7.2         3.6         6.1         2.5
## [111,]         6.5         3.2         5.1         2.0
## [112,]         6.4         2.7         5.3         1.9
## [113,]         6.8         3.0         5.5         2.1
## [114,]         5.7         2.5         5.0         2.0
```

```
## [115,]          5.8         2.8          5.1         2.4
## [116,]          6.4         3.2          5.3         2.3
## [117,]          6.5         3.0          5.5         1.8
## [118,]          7.7         3.8          6.7         2.2
## [119,]          7.7         2.6          6.9         2.3
## [120,]          6.0         2.2          5.0         1.5
## [121,]          6.9         3.2          5.7         2.3
## [122,]          5.6         2.8          4.9         2.0
## [123,]          7.7         2.8          6.7         2.0
## [124,]          6.3         2.7          4.9         1.8
## [125,]          6.7         3.3          5.7         2.1
## [126,]          7.2         3.2          6.0         1.8
## [127,]          6.2         2.8          4.8         1.8
## [128,]          6.1         3.0          4.9         1.8
## [129,]          6.4         2.8          5.6         2.1
## [130,]          7.2         3.0          5.8         1.6
## [131,]          7.4         2.8          6.1         1.9
## [132,]          7.9         3.8          6.4         2.0
## [133,]          6.4         2.8          5.6         2.2
## [134,]          6.3         2.8          5.1         1.5
## [135,]          6.1         2.6          5.6         1.4
## [136,]          7.7         3.0          6.1         2.3
## [137,]          6.3         3.4          5.6         2.4
## [138,]          6.4         3.1          5.5         1.8
## [139,]          6.0         3.0          4.8         1.8
## [140,]          6.9         3.1          5.4         2.1
## [141,]          6.7         3.1          5.6         2.4
## [142,]          6.9         3.1          5.1         2.3
## [143,]          5.8         2.7          5.1         1.9
## [144,]          6.8         3.2          5.9         2.3
## [145,]          6.7         3.3          5.7         2.5
## [146,]          6.7         3.0          5.2         2.3
## [147,]          6.3         2.5          5.0         1.9
## [148,]          6.5         3.0          5.2         2.0
## [149,]          6.2         3.4          5.4         2.3
## [150,]          5.9         3.0          5.1         1.8
##
## $model.list
## $model.list$response
```

```
## [1] "Species1"
##
## $model.list$variables
## [1] "Sepal.Length" "Sepal.Width"  "Petal.Length" "Petal.Width"
##
##
## $err.fct
## function (x, y)
## {
##     1/2 * (y - x)^2
## }
## <bytecode: 0x000000001311f7a8>
## <environment: 0x0000000015ba22f8>
## attr(,"type")
## [1] "sse"
##
## $act.fct
## function (x)
## {
##     1/(1 + exp(-x))
## }
## <bytecode: 0x000000001311afc8>
## <environment: 0x0000000015ba1e60>
## attr(,"type")
## [1] "logistic"
##
## $linear.output
## [1] TRUE
##
## $data
##     Sepal.Length Sepal.Width Petal.Length Petal.Width    Species Species1
## 1            5.1         3.5          1.4         0.2     setosa        0
## 2            4.9         3.0          1.4         0.2     setosa        0
## 3            4.7         3.2          1.3         0.2     setosa        0
## 4            4.6         3.1          1.5         0.2     setosa        0
## 5            5.0         3.6          1.4         0.2     setosa        0
## 6            5.4         3.9          1.7         0.4     setosa        0
## 7            4.6         3.4          1.4         0.3     setosa        0
## 8            5.0         3.4          1.5         0.2     setosa        0
```

```
## 9          4.4         2.9          1.4         0.2     setosa        0
## 10         4.9         3.1          1.5         0.1     setosa        0
## 11         5.4         3.7          1.5         0.2     setosa        0
## 12         4.8         3.4          1.6         0.2     setosa        0
## 13         4.8         3.0          1.4         0.1     setosa        0
## 14         4.3         3.0          1.1         0.1     setosa        0
## 15         5.8         4.0          1.2         0.2     setosa        0
## 16         5.7         4.4          1.5         0.4     setosa        0
## 17         5.4         3.9          1.3         0.4     setosa        0
## 18         5.1         3.5          1.4         0.3     setosa        0
## 19         5.7         3.8          1.7         0.3     setosa        0
## 20         5.1         3.8          1.5         0.3     setosa        0
## 21         5.4         3.4          1.7         0.2     setosa        0
## 22         5.1         3.7          1.5         0.4     setosa        0
## 23         4.6         3.6          1.0         0.2     setosa        0
## 24         5.1         3.3          1.7         0.5     setosa        0
## 25         4.8         3.4          1.9         0.2     setosa        0
## 26         5.0         3.0          1.6         0.2     setosa        0
## 27         5.0         3.4          1.6         0.4     setosa        0
## 28         5.2         3.5          1.5         0.2     setosa        0
## 29         5.2         3.4          1.4         0.2     setosa        0
## 30         4.7         3.2          1.6         0.2     setosa        0
## 31         4.8         3.1          1.6         0.2     setosa        0
## 32         5.4         3.4          1.5         0.4     setosa        0
## 33         5.2         4.1          1.5         0.1     setosa        0
## 34         5.5         4.2          1.4         0.2     setosa        0
## 35         4.9         3.1          1.5         0.2     setosa        0
## 36         5.0         3.2          1.2         0.2     setosa        0
## 37         5.5         3.5          1.3         0.2     setosa        0
## 38         4.9         3.6          1.4         0.1     setosa        0
## 39         4.4         3.0          1.3         0.2     setosa        0
## 40         5.1         3.4          1.5         0.2     setosa        0
## 41         5.0         3.5          1.3         0.3     setosa        0
## 42         4.5         2.3          1.3         0.3     setosa        0
## 43         4.4         3.2          1.3         0.2     setosa        0
## 44         5.0         3.5          1.6         0.6     setosa        0
## 45         5.1         3.8          1.9         0.4     setosa        0
## 46         4.8         3.0          1.4         0.3     setosa        0
## 47         5.1         3.8          1.6         0.2     setosa        0
```

```
## 48          4.6         3.2          1.4         0.2     setosa        0
## 49          5.3         3.7          1.5         0.2     setosa        0
## 50          5.0         3.3          1.4         0.2     setosa        0
## 51          7.0         3.2          4.7         1.4 versicolor        1
## 52          6.4         3.2          4.5         1.5 versicolor        1
## 53          6.9         3.1          4.9         1.5 versicolor        1
## 54          5.5         2.3          4.0         1.3 versicolor        1
## 55          6.5         2.8          4.6         1.5 versicolor        1
## 56          5.7         2.8          4.5         1.3 versicolor        1
## 57          6.3         3.3          4.7         1.6 versicolor        1
## 58          4.9         2.4          3.3         1.0 versicolor        1
## 59          6.6         2.9          4.6         1.3 versicolor        1
## 60          5.2         2.7          3.9         1.4 versicolor        1
## 61          5.0         2.0          3.5         1.0 versicolor        1
## 62          5.9         3.0          4.2         1.5 versicolor        1
## 63          6.0         2.2          4.0         1.0 versicolor        1
## 64          6.1         2.9          4.7         1.4 versicolor        1
## 65          5.6         2.9          3.6         1.3 versicolor        1
## 66          6.7         3.1          4.4         1.4 versicolor        1
## 67          5.6         3.0          4.5         1.5 versicolor        1
## 68          5.8         2.7          4.1         1.0 versicolor        1
## 69          6.2         2.2          4.5         1.5 versicolor        1
## 70          5.6         2.5          3.9         1.1 versicolor        1
## 71          5.9         3.2          4.8         1.8 versicolor        1
## 72          6.1         2.8          4.0         1.3 versicolor        1
## 73          6.3         2.5          4.9         1.5 versicolor        1
## 74          6.1         2.8          4.7         1.2 versicolor        1
## 75          6.4         2.9          4.3         1.3 versicolor        1
## 76          6.6         3.0          4.4         1.4 versicolor        1
## 77          6.8         2.8          4.8         1.4 versicolor        1
## 78          6.7         3.0          5.0         1.7 versicolor        1
## 79          6.0         2.9          4.5         1.5 versicolor        1
## 80          5.7         2.6          3.5         1.0 versicolor        1
## 81          5.5         2.4          3.8         1.1 versicolor        1
## 82          5.5         2.4          3.7         1.0 versicolor        1
## 83          5.8         2.7          3.9         1.2 versicolor        1
## 84          6.0         2.7          5.1         1.6 versicolor        1
## 85          5.4         3.0          4.5         1.5 versicolor        1
## 86          6.0         3.4          4.5         1.6 versicolor        1
```

```
## 87          6.7         3.1          4.7         1.5 versicolor        1
## 88          6.3         2.3          4.4         1.3 versicolor        1
## 89          5.6         3.0          4.1         1.3 versicolor        1
## 90          5.5         2.5          4.0         1.3 versicolor        1
## 91          5.5         2.6          4.4         1.2 versicolor        1
## 92          6.1         3.0          4.6         1.4 versicolor        1
## 93          5.8         2.6          4.0         1.2 versicolor        1
## 94          5.0         2.3          3.3         1.0 versicolor        1
## 95          5.6         2.7          4.2         1.3 versicolor        1
## 96          5.7         3.0          4.2         1.2 versicolor        1
## 97          5.7         2.9          4.2         1.3 versicolor        1
## 98          6.2         2.9          4.3         1.3 versicolor        1
## 99          5.1         2.5          3.0         1.1 versicolor        1
## 100         5.7         2.8          4.1         1.3 versicolor        1
## 101         6.3         3.3          6.0         2.5  virginica        2
## 102         5.8         2.7          5.1         1.9  virginica        2
## 103         7.1         3.0          5.9         2.1  virginica        2
## 104         6.3         2.9          5.6         1.8  virginica        2
## 105         6.5         3.0          5.8         2.2  virginica        2
## 106         7.6         3.0          6.6         2.1  virginica        2
## 107         4.9         2.5          4.5         1.7  virginica        2
## 108         7.3         2.9          6.3         1.8  virginica        2
## 109         6.7         2.5          5.8         1.8  virginica        2
## 110         7.2         3.6          6.1         2.5  virginica        2
## 111         6.5         3.2          5.1         2.0  virginica        2
## 112         6.4         2.7          5.3         1.9  virginica        2
## 113         6.8         3.0          5.5         2.1  virginica        2
## 114         5.7         2.5          5.0         2.0  virginica        2
## 115         5.8         2.8          5.1         2.4  virginica        2
## 116         6.4         3.2          5.3         2.3  virginica        2
## 117         6.5         3.0          5.5         1.8  virginica        2
## 118         7.7         3.8          6.7         2.2  virginica        2
## 119         7.7         2.6          6.9         2.3  virginica        2
## 120         6.0         2.2          5.0         1.5  virginica        2
## 121         6.9         3.2          5.7         2.3  virginica        2
## 122         5.6         2.8          4.9         2.0  virginica        2
## 123         7.7         2.8          6.7         2.0  virginica        2
## 124         6.3         2.7          4.9         1.8  virginica        2
## 125         6.7         3.3          5.7         2.1  virginica        2
```

```
## 126          7.2         3.2          6.0         1.8  virginica        2
## 127          6.2         2.8          4.8         1.8  virginica        2
## 128          6.1         3.0          4.9         1.8  virginica        2
## 129          6.4         2.8          5.6         2.1  virginica        2
## 130          7.2         3.0          5.8         1.6  virginica        2
## 131          7.4         2.8          6.1         1.9  virginica        2
## 132          7.9         3.8          6.4         2.0  virginica        2
## 133          6.4         2.8          5.6         2.2  virginica        2
## 134          6.3         2.8          5.1         1.5  virginica        2
## 135          6.1         2.6          5.6         1.4  virginica        2
## 136          7.7         3.0          6.1         2.3  virginica        2
## 137          6.3         3.4          5.6         2.4  virginica        2
## 138          6.4         3.1          5.5         1.8  virginica        2
## 139          6.0         3.0          4.8         1.8  virginica        2
## 140          6.9         3.1          5.4         2.1  virginica        2
## 141          6.7         3.1          5.6         2.4  virginica        2
## 142          6.9         3.1          5.1         2.3  virginica        2
## 143          5.8         2.7          5.1         1.9  virginica        2
## 144          6.8         3.2          5.9         2.3  virginica        2
## 145          6.7         3.3          5.7         2.5  virginica        2
## 146          6.7         3.0          5.2         2.3  virginica        2
## 147          6.3         2.5          5.0         1.9  virginica        2
## 148          6.5         3.0          5.2         2.0  virginica        2
## 149          6.2         3.4          5.4         2.3  virginica        2
## 150          5.9         3.0          5.1         1.8  virginica        2
##
## $exclude
## NULL
##
## $net.result
## $net.result[[1]]
##                [,1]
##   [1,] -0.0002981083
##   [2,] -0.0003000635
##   [3,] -0.0002990770
##   [4,] -0.0002999512
##   [5,] -0.0002979684
##   [6,] -0.0002987766
##   [7,] -0.0002998701
```

```
##   [8,] -0.0002984321
##   [9,] -0.0003015555
##  [10,] -0.0002984397
##  [11,] -0.0002977802
##  [12,] -0.0002986116
##  [13,] -0.0002986993
##  [14,] -0.0002987101
##  [15,] -0.0002974633
##  [16,] -0.0002976599
##  [17,] -0.0002984366
##  [18,] -0.0002989676
##  [19,] -0.0002980967
##  [20,] -0.0002981933
##  [21,] -0.0002983959
##  [22,] -0.0002996160
##  [23,] -0.0002979052
##  [24,] -0.0003072328
##  [25,] -0.0002988955
##  [26,] -0.0003003136
##  [27,] -0.0003024016
##  [28,] -0.0002981286
##  [29,] -0.0002982771
##  [30,] -0.0002994611
##  [31,] -0.0002999077
##  [32,] -0.0003013637
##  [33,] -0.0002973943
##  [34,] -0.0002974312
##  [35,] -0.0002996465
##  [36,] -0.0002987731
##  [37,] -0.0002979422
##  [38,] -0.0002976347
##  [39,] -0.0003004736
##  [40,] -0.0002983868
##  [41,] -0.0002989271
##  [42,] -0.0001370568
##  [43,] -0.0002993078
##  [44,] -0.0003132797
##  [45,] -0.0002996905
##  [46,] -0.0003031919
```

```
##  [47,] -0.0002977602
##  [48,] -0.0002992757
##  [49,] -0.0002978005
##  [50,] -0.0002986344
##  [51,]  0.9915977758
##  [52,]  0.9746376790
##  [53,]  0.9836585829
##  [54,]  1.0526138511
##  [55,]  1.1271740701
##  [56,]  0.9843894953
##  [57,]  1.0197286754
##  [58,]  1.0110161895
##  [59,]  0.9909874503
##  [60,]  1.0073661408
##  [61,]  0.9963946643
##  [62,]  0.9945489911
##  [63,]  1.0051529968
##  [64,]  0.9916817368
##  [65,]  0.9959793676
##  [66,]  0.9877276969
##  [67,]  1.0729014953
##  [68,]  1.0154724971
##  [69,]  1.0211088903
##  [70,]  1.0029465574
##  [71,]  1.1069435991
##  [72,]  0.9896972364
##  [73,]  1.0341836196
##  [74,]  0.9966090447
##  [75,]  0.9932947773
##  [76,]  0.9815530468
##  [77,]  0.9881268863
##  [78,]  0.9549129582
##  [79,]  1.0895842895
##  [80,]  1.0162135671
##  [81,]  0.9994106389
##  [82,]  1.0108421543
##  [83,]  0.9994239927
##  [84,]  1.2310605419
##  [85,]  1.0979483365
```

```
##  [86,]  0.9850248773
##  [87,]  0.9798552774
##  [88,]  1.0546313595
##  [89,]  0.9942789358
##  [90,]  0.9926788127
##  [91,]  0.9884200601
##  [92,]  0.9804235732
##  [93,]  0.9936857256
##  [94,]  1.0088820143
##  [95,]  0.9831465947
##  [96,]  1.0069166361
##  [97,]  0.9889670988
##  [98,]  0.9916336493
##  [99,]  1.0084145595
## [100,]  0.9855717171
## [101,]  1.9819824981
## [102,]  1.9772847982
## [103,]  2.0040069133
## [104,]  2.0896641900
## [105,]  2.0061715552
## [106,]  2.0021430454
## [107,]  2.0948251126
## [108,]  2.0931779822
## [109,]  1.9865683746
## [110,]  1.9976002257
## [111,]  2.0409724361
## [112,]  1.9917550983
## [113,]  2.0052685009
## [114,]  2.0019990605
## [115,]  1.9816997215
## [116,]  2.0119491667
## [117,]  2.0240274552
## [118,]  1.9920848294
## [119,]  1.9802512987
## [120,]  1.8637305432
## [121,]  2.0109403485
## [122,]  1.9821403248
## [123,]  1.9898225894
## [124,]  2.0735079544
```

```
## [125,]  1.9885458934
## [126,]  1.8445720402
## [127,]  2.0324909931
## [128,]  1.8280910443
## [129,]  2.0064295081
## [130,]  2.1713198346
## [131,]  2.0009603104
## [132,]  2.0499999973
## [133,]  2.0017227608
## [134,]  1.5141207205
## [135,]  1.9955143035
## [136,]  2.0036826341
## [137,]  2.0009349769
## [138,]  1.9223135660
## [139,]  1.7959728190
## [140,]  2.0046989206
## [141,]  1.9917098361
## [142,]  2.0193207899
## [143,]  1.9772847982
## [144,]  2.0057757078
## [145,]  1.9866328507
## [146,]  2.0082777476
## [147,]  1.9898447178
## [148,]  2.0036973014
## [149,]  2.0126997517
## [150,]  2.0096833804
##
##
## $weights
## $weights[[1]]
## $weights[[1]][[1]]
##            [,1]        [,2]       [,3]       [,4]       [,5]
## [1,]  12.967055  17.8124820  18.111926 -6.8620062  -4.212033
## [2,]   1.168055   0.4769610   3.132773 -0.4049684   1.917957
## [3,]   5.820569   4.3161773  12.900001 -2.2806297 -15.153753
## [4,]  -1.879965  -0.8748163  -2.417733  0.6494946   9.733660
## [5,] -16.902345 -14.2377132 -39.033990  7.1804287  30.655574
##
## $weights[[1]][[2]]
```

```
##            [,1]
## [1,]  2.6775145
## [2,] -5.7973604
## [3,] -0.4101476
## [4,]  3.5296962
## [5,] -1.7294631
## [6,]  1.0225217
##
##
##
## $generalized.weights
## $generalized.weights[[1]]
##                 [,1]          [,2]          [,3]          [,4]
##   [1,] -1.110943e-03 -6.256332e-03  1.781708e-03  1.969775e-02
##   [2,] -3.751341e-03 -2.101748e-02  5.962829e-03  6.624370e-02
##   [3,] -2.418689e-03 -1.361979e-02  3.878463e-03  4.288201e-02
##   [4,] -3.594674e-03 -2.020829e-02  5.747644e-03  6.364799e-02
##   [5,] -9.213721e-04 -5.188807e-03  1.477704e-03  1.633666e-02
##   [6,] -2.014279e-03 -1.134076e-02  3.229101e-03  3.570763e-02
##   [7,] -3.483237e-03 -1.961323e-02  5.584962e-03  6.175310e-02
##   [8,] -1.549087e-03 -8.723059e-03  2.484047e-03  2.746458e-02
##   [9,] -5.743013e-03 -3.215387e-02  9.117644e-03  1.013585e-01
##  [10,] -1.559530e-03 -8.779725e-03  2.499737e-03  2.764440e-02
##  [11,] -6.660710e-04 -3.751043e-03  1.068246e-03  1.180995e-02
##  [12,] -1.791457e-03 -1.008734e-02  2.872440e-03  3.176037e-02
##  [13,] -1.910084e-03 -1.075267e-02  3.061349e-03  3.385692e-02
##  [14,] -1.924348e-03 -1.083712e-02  3.086257e-03  3.412009e-02
##  [15,] -2.354351e-04 -1.325882e-03  3.775945e-04  4.174461e-03
##  [16,] -5.026797e-04 -2.830903e-03  8.062054e-04  8.912931e-03
##  [17,] -1.555037e-03 -8.757325e-03  2.493963e-03  2.757196e-02
##  [18,] -2.271462e-03 -1.279026e-02  3.642139e-03  4.027055e-02
##  [19,] -1.095311e-03 -6.167283e-03  1.756136e-03  1.941805e-02
##  [20,] -1.225961e-03 -6.904103e-03  1.966191e-03  2.173720e-02
##  [21,] -1.501202e-03 -8.441886e-03  2.401571e-03  2.658688e-02
##  [22,] -3.143000e-03 -1.769539e-02  5.038421e-03  5.571606e-02
##  [23,] -8.356956e-04 -4.706324e-03  1.340302e-03  1.481758e-02
##  [24,] -4.014922e-02  7.611342e-02 -8.476389e-02 -4.104918e-02
##  [25,] -2.176661e-03 -1.223087e-02  3.477505e-03  3.852608e-02
##  [26,] -4.158069e-03 -2.249520e-02  6.213989e-03  7.143033e-02
```

```
##  [27,] -6.930658e-03 -3.804977e-02  1.063129e-02  1.204421e-01
##  [28,] -1.138379e-03 -6.410662e-03  1.825621e-03  2.018376e-02
##  [29,] -1.339409e-03 -7.542597e-03  2.147942e-03  2.374772e-02
##  [30,] -2.936974e-03 -1.651484e-02  4.697980e-03  5.201250e-02
##  [31,] -3.545597e-03 -1.982932e-02  5.618300e-03  6.252223e-02
##  [32,] -5.543788e-03 -3.041948e-02  8.495865e-03  9.630032e-02
##  [33,] -1.416544e-04 -7.977446e-04  2.271876e-04  2.511652e-03
##  [34,] -1.918678e-04 -1.080527e-03  3.077205e-04  3.401976e-03
##  [35,] -3.189029e-03 -1.789613e-02  5.083380e-03  5.638649e-02
##  [36,] -2.009318e-03 -1.131481e-02  3.222126e-03  3.562462e-02
##  [37,] -8.858836e-04 -4.988897e-03  1.420761e-03  1.570729e-02
##  [38,] -4.684541e-04 -2.638157e-03  7.513139e-04  8.306084e-03
##  [39,] -4.290524e-03 -2.414691e-02  6.873455e-03  7.603546e-02
##  [40,] -1.487848e-03 -8.378014e-03  2.385746e-03  2.637833e-02
##  [41,] -2.216807e-03 -1.248367e-02  3.555079e-03  3.930448e-02
##  [42,] -2.765749e+00  2.061532e+01 -1.342580e+01 -4.112486e+01
##  [43,] -2.728968e-03 -1.536776e-02  4.376386e-03  4.838499e-02
##  [44,] -2.922806e-02 -6.889330e-02 -3.590224e-04  2.797970e-01
##  [45,] -3.247000e-03 -1.823405e-02  5.182007e-03  5.744289e-02
##  [46,] -8.050715e-03 -4.343466e-02  1.197220e-02  1.380026e-01
##  [47,] -6.389582e-04 -3.598366e-03  1.024768e-03  1.132925e-02
##  [48,] -2.685985e-03 -1.512350e-02  4.306365e-03  4.761739e-02
##  [49,] -6.935509e-04 -3.905803e-03  1.112320e-03  1.229720e-02
##  [50,] -1.822336e-03 -1.026131e-02  2.921998e-03  3.230805e-02
##  [51,]  1.086146e+00  6.481204e+00 -1.738431e+00 -2.109335e+01
##  [52,] -1.821502e-01 -1.405777e-01  3.170246e-01 -1.271194e+00
##  [53,] -2.083973e+00 -8.881539e+00  3.419807e+00  2.244578e+01
##  [54,]  1.315844e+00  7.643492e+00 -3.776230e+00 -1.988226e+01
##  [55,]  1.409810e+00  7.204316e+00 -2.735638e+00 -2.000197e+01
##  [56,] -2.193261e-01 -9.757990e-02  3.791769e-01 -1.880898e+00
##  [57,]  4.877280e+00  2.323585e+01 -8.489861e+00 -6.344818e+01
##  [58,] -3.765441e-01 -2.148389e+00  6.036341e-01  6.816578e+00
##  [59,]  9.004527e-01  5.546119e+00 -1.439283e+00 -1.835809e+01
##  [60,]  5.379810e+00  3.003218e+01 -1.581305e+01 -7.415202e+01
##  [61,]  1.704425e+00  1.072122e+01 -2.708872e+00 -3.590808e+01
##  [62,] -9.461524e+00 -4.417899e+01  1.761888e+01  1.154093e+02
##  [63,] -1.119384e+00 -6.501880e+00  1.793403e+00  2.084379e+01
##  [64,] -4.497551e+00 -1.976152e+01  7.466743e+00  5.117951e+01
##  [65,]  2.080853e+00  1.223467e+01 -3.329798e+00 -3.950073e+01
```

```
##  [66,]  7.555505e-01  4.615974e+00 -1.207726e+00 -1.521565e+01
##  [67,]  1.624590e+00  8.485059e+00 -3.467253e+00 -2.309432e+01
##  [68,] -1.678444e-01 -9.506519e-01  2.691423e-01  3.003282e+00
##  [69,]  4.569242e+01  2.357132e+02 -8.564510e+01 -6.675519e+02
##  [70,] -2.169006e+00 -1.264810e+01  3.474250e+00  4.063882e+01
##  [71,]  8.398095e+00  4.245433e+01 -1.492223e+01 -1.205932e+02
##  [72,]  8.227684e-01  5.062694e+00 -1.313487e+00 -1.675420e+01
##  [73,] -3.331094e+01 -1.020930e+02 -1.047096e+01  3.397835e+02
##  [74,]  2.100711e+00  1.272957e+01 -3.360421e+00 -4.177260e+01
##  [75,]  1.257784e+00  7.540977e+00 -2.012383e+00 -2.460653e+01
##  [76,]  3.848356e-01  2.649975e+00 -6.102842e-01 -9.259733e+00
##  [77,] -2.925436e+00 -1.262744e+01  4.800158e+00  3.231133e+01
##  [78,]  2.202328e+01  6.160548e+01  1.313881e+01 -2.124207e+02
##  [79,]  1.539343e+00  7.987980e+00 -3.186050e+00 -2.189769e+01
##  [80,] -1.438082e-01 -8.132290e-01  2.306107e-01  2.566741e+00
##  [81,]  1.177078e+01  6.989845e+01 -1.883492e+01 -2.268975e+02
##  [82,] -3.874698e-01 -2.211880e+00  6.211528e-01  7.020137e+00
##  [83,]  1.277479e+01  7.491586e+01 -2.045590e+01 -2.414847e+02
##  [84,]  2.572378e+00  1.393288e+01 -5.555055e+00 -3.886424e+01
##  [85,]  1.103406e+00  6.298091e+00 -2.919124e+00 -1.680055e+01
##  [86,] -2.887468e+00 -1.285752e+01  5.035120e+00  3.303870e+01
##  [87,] -1.289519e+00 -5.261907e+00  2.134917e+00  1.266608e+01
##  [88,]  2.156251e+00  1.053718e+01 -3.821882e+00 -2.918662e+01
##  [89,]  1.419167e+00  8.514087e+00 -2.269568e+00 -2.779394e+01
##  [90,] -4.530841e+00 -2.038644e+01  8.293142e+00  5.181735e+01
##  [91,]  1.764600e-01  1.950968e+00 -2.654340e-01 -7.968333e+00
##  [92,] -3.642346e-01 -8.906774e-01  6.134459e-01  5.677951e-01
##  [93,]  1.206041e+00  7.378642e+00 -1.926561e+00 -2.434260e+01
##  [94,] -5.421740e-01 -3.108364e+00  8.689772e-01  9.890393e+00
##  [95,] -3.135825e-01 -5.965968e-01  5.520042e-01 -4.290352e-01
##  [96,] -7.955031e-01 -4.564927e+00  1.275048e+00  1.453254e+01
##  [97,]  6.713930e-01  4.300937e+00 -1.068901e+00 -1.452895e+01
##  [98,]  9.883408e-01  6.029364e+00 -1.579827e+00 -1.985898e+01
##  [99,] -6.030363e-01 -3.445730e+00  9.666010e-01  1.094262e+01
## [100,]  4.107137e-01  2.897765e+00 -6.463736e-01 -1.024391e+01
## [101,] -2.307133e-03 -1.194284e-02  3.629306e-03  3.718636e-02
## [102,] -2.203475e-02 -5.227371e-02  3.016438e-02  1.425166e-01
## [103,] -6.927803e-03  2.805337e-02  6.527068e-03 -1.137644e-01
## [104,] -1.003593e-03 -3.189163e-02 -6.203365e-04  1.752817e-01
```

```
## [105,] -5.992822e-03 -1.131534e-02  8.092455e-03  2.683782e-02
## [106,] -5.625432e-03  2.441097e-02  5.211086e-03 -9.857181e-02
## [107,] -1.104852e-02 -8.180905e-02  1.630821e-02  3.178403e-01
## [108,] -1.128949e-02 -7.741283e-02  1.328117e-02  3.051966e-01
## [109,] -2.881278e-02 -1.038371e-01  4.183525e-02  3.120050e-01
## [110,] -5.128475e-03 -2.375964e-02  7.878048e-03  7.280505e-02
## [111,] -1.103368e-02 -5.317293e-02  1.472681e-02  2.081093e-01
## [112,] -2.368333e-02 -6.775297e-02  3.310574e-02  1.960051e-01
## [113,] -7.969164e-03  2.725006e-02  7.824826e-03 -1.126398e-01
## [114,] -5.262331e-03  1.893251e-02  5.146655e-03 -7.853997e-02
## [115,] -2.258526e-03 -1.184569e-02  3.563265e-03  3.695045e-02
## [116,] -7.052387e-03 -2.057161e-02  1.001112e-02  5.733482e-02
## [117,]  9.564516e-02  4.417024e-01 -1.625865e-01 -1.172881e+00
## [118,] -1.960526e-02 -4.266608e-02  2.623472e-02  1.183146e-01
## [119,] -1.970259e-03 -1.030886e-02  3.106833e-03  3.214512e-02
## [120,]  3.135373e-01  1.526960e+00 -5.325882e-01 -4.276265e+00
## [121,] -6.954985e-03 -2.178018e-02  9.974762e-03  6.181096e-02
## [122,] -9.525282e-03  2.975666e-02  9.529515e-03 -1.244003e-01
## [123,] -5.833719e-03  4.002970e-02  4.394488e-03 -1.540641e-01
## [124,]  1.136203e-02  3.332465e-02 -2.035544e-02 -1.664674e-02
## [125,] -1.623456e-02 -1.364602e-02  2.045176e-02  1.864495e-02
## [126,]  8.159427e-02  6.686191e-01 -4.481314e-01 -1.606594e+00
## [127,]  7.458250e-02  3.365546e-01 -1.226235e-01 -8.786470e-01
## [128,]  3.132483e-01  1.510715e+00 -5.180099e-01 -4.230640e+00
## [129,] -5.805398e-03  6.039219e-03  6.685036e-03 -3.412306e-02
## [130,]  2.879267e-01  1.593921e+00 -6.452582e-01 -4.458702e+00
## [131,] -2.649860e-02 -9.219116e-02  3.804460e-02  2.786500e-01
## [132,] -3.058228e-01 -9.724901e-01 -8.608412e-02  3.274805e+00
## [133,] -5.595506e-03 -1.980542e-02  8.182368e-03  5.775491e-02
## [134,]  4.413108e-01  2.637724e+00 -1.207721e+00 -7.202533e+00
## [135,]  2.432715e-01  1.496790e+00 -6.984830e-01 -4.093823e+00
## [136,] -6.096421e-03 -2.615978e-02  9.223725e-03  7.916968e-02
## [137,] -5.570288e-03 -2.257568e-02  8.338202e-03  6.763525e-02
## [138,]  1.980229e-01  9.562808e-01 -3.430257e-01 -2.635425e+00
## [139,]  3.591573e-01  1.735194e+00 -5.917766e-01 -4.873590e+00
## [140,] -1.170053e-02  1.366508e-02  1.317234e-02 -7.018679e-02
## [141,] -4.120345e-03 -2.013510e-02  6.400630e-03  6.218888e-02
## [142,] -8.258107e-03 -2.792652e-02  1.197878e-02  8.079686e-02
## [143,] -2.203475e-02 -5.227371e-02  3.016438e-02  1.425166e-01
```

```
## [144,] -6.196465e-03 -2.052899e-02  8.964849e-03  5.901391e-02
## [145,] -3.203542e-03 -1.640868e-02  5.027477e-03  5.102007e-02
## [146,] -6.776002e-03 -2.730384e-02  1.013079e-02  8.174393e-02
## [147,] -1.493151e-02 -2.840423e-03  1.824948e-02 -1.906085e-02
## [148,] -2.182190e-02 -6.111933e-02  3.019418e-02  1.802180e-01
## [149,] -6.781406e-03 -4.689287e-03  8.598702e-03  1.819515e-03
## [150,]  1.115894e-01  5.148936e-01 -1.838036e-01 -1.385057e+00
##
##
## $startweights
## $startweights[[1]]
## $startweights[[1]][[1]]
##            [,1]       [,2]       [,3]       [,4]       [,5]
## [1,] -0.03426202 -0.5437162  0.2161049 -0.4120200 -1.3564261
## [2,]  0.46728514  0.4835025  2.3989793 -0.2499199 -1.6392550
## [3,]  0.52861412  0.5157298 -1.4533543 -1.4055687  0.6850789
## [4,] -2.27363890 -0.4856252 -1.2703597 -0.8572251  1.3416170
## [5,] -1.36413456 -1.1625365 -0.8445053  0.3238587 -0.5716257
##
## $startweights[[1]][[2]]
##           [,1]
## [1,]  1.3479124
## [2,] -0.1286965
## [3,] -0.8955171
## [4,] -0.2078448
## [5,] -1.5116665
## [6,]  0.4781358
##
##
##
## $result.matrix
##                                 [,1]
## error                   2.728713e-01
## reached.threshold       9.765263e-03
## steps                   3.971000e+04
## Intercept.to.1layhid1   1.296705e+01
## Sepal.Length.to.1layhid1  1.168055e+00
## Sepal.Width.to.1layhid1   5.820569e+00
## Petal.Length.to.1layhid1 -1.879965e+00
```

```
## Petal.Width.to.1layhid1  -1.690235e+01
## Intercept.to.1layhid2     1.781248e+01
## Sepal.Length.to.1layhid2  4.769610e-01
## Sepal.Width.to.1layhid2   4.316177e+00
## Petal.Length.to.1layhid2 -8.748163e-01
## Petal.Width.to.1layhid2  -1.423771e+01
## Intercept.to.1layhid3     1.811193e+01
## Sepal.Length.to.1layhid3  3.132773e+00
## Sepal.Width.to.1layhid3   1.290000e+01
## Petal.Length.to.1layhid3 -2.417733e+00
## Petal.Width.to.1layhid3  -3.903399e+01
## Intercept.to.1layhid4    -6.862006e+00
## Sepal.Length.to.1layhid4 -4.049684e-01
## Sepal.Width.to.1layhid4  -2.280630e+00
## Petal.Length.to.1layhid4  6.494946e-01
## Petal.Width.to.1layhid4   7.180429e+00
## Intercept.to.1layhid5    -4.212033e+00
## Sepal.Length.to.1layhid5  1.917957e+00
## Sepal.Width.to.1layhid5  -1.515375e+01
## Petal.Length.to.1layhid5  9.733660e+00
## Petal.Width.to.1layhid5   3.065557e+01
## Intercept.to.Species1     2.677515e+00
## 1layhid1.to.Species1     -5.797360e+00
## 1layhid2.to.Species1     -4.101476e-01
## 1layhid3.to.Species1      3.529696e+00
## 1layhid4.to.Species1     -1.729463e+00
## 1layhid5.to.Species1      1.022522e+00
##
## attr(,"class")
## [1] "nn"
```

Comments: * see what is in the output folder * get the predictions

- The network values are close to the corresponding target values.
- In the data, the first 50 data points are on ‘setosa,’ coded 0, the second fifty on ‘versicolor,’ coded 1, and the last fifty on ‘virginica’ coded 2.
- The network output is close to the target values.
- need to plot the network.

```
names(NNModel)
```

```
##  [1] "call"               "response"           "covariate"
##  [4] "model.list"         "err.fct"            "act.fct"
##  [7] "linear.output"      "data"               "exclude"
## [10] "net.result"         "weights"            "generalized.weights"
## [13] "startweights"       "result.matrix"
```

```
NNModel$result.matrix
```

```
##                                [,1]
## error                    2.728713e-01
## reached.threshold        9.765263e-03
## steps                    3.971000e+04
## Intercept.to.1layhid1    1.296705e+01
## Sepal.Length.to.1layhid1 1.168055e+00
## Sepal.Width.to.1layhid1  5.820569e+00
## Petal.Length.to.1layhid1 -1.879965e+00
## Petal.Width.to.1layhid1  -1.690235e+01
## Intercept.to.1layhid2    1.781248e+01
## Sepal.Length.to.1layhid2 4.769610e-01
## Sepal.Width.to.1layhid2  4.316177e+00
## Petal.Length.to.1layhid2 -8.748163e-01
## Petal.Width.to.1layhid2  -1.423771e+01
## Intercept.to.1layhid3    1.811193e+01
## Sepal.Length.to.1layhid3 3.132773e+00
## Sepal.Width.to.1layhid3  1.290000e+01
## Petal.Length.to.1layhid3 -2.417733e+00
## Petal.Width.to.1layhid3  -3.903399e+01
## Intercept.to.1layhid4    -6.862006e+00
## Sepal.Length.to.1layhid4 -4.049684e-01
## Sepal.Width.to.1layhid4  -2.280630e+00
## Petal.Length.to.1layhid4 6.494946e-01
## Petal.Width.to.1layhid4  7.180429e+00
## Intercept.to.1layhid5    -4.212033e+00
## Sepal.Length.to.1layhid5 1.917957e+00
## Sepal.Width.to.1layhid5  -1.515375e+01
## Petal.Length.to.1layhid5 9.733660e+00
## Petal.Width.to.1layhid5  3.065557e+01
## Intercept.to.Species1    2.677515e+00
## 1layhid1.to.Species1     -5.797360e+00
## 1layhid2.to.Species1     -4.101476e-01
## 1layhid3.to.Species1     3.529696e+00
## 1layhid4.to.Species1     -1.729463e+00
## 1layhid5.to.Species1     1.022522e+00
```

```
NNModel$net.result
```

```
## [[1]]
##                [,1]
##   [1,] -0.0002981083
##   [2,] -0.0003000635
##   [3,] -0.0002990770
##   [4,] -0.0002999512
##   [5,] -0.0002979684
##   [6,] -0.0002987766
##   [7,] -0.0002998701
##   [8,] -0.0002984321
##   [9,] -0.0003015555
##  [10,] -0.0002984397
##  [11,] -0.0002977802
##  [12,] -0.0002986116
##  [13,] -0.0002986993
##  [14,] -0.0002987101
##  [15,] -0.0002974633
##  [16,] -0.0002976599
##  [17,] -0.0002984366
##  [18,] -0.0002989676
##  [19,] -0.0002980967
##  [20,] -0.0002981933
##  [21,] -0.0002983959
##  [22,] -0.0002996160
##  [23,] -0.0002979052
##  [24,] -0.0003072328
##  [25,] -0.0002988955
##  [26,] -0.0003003136
##  [27,] -0.0003024016
##  [28,] -0.0002981286
##  [29,] -0.0002982771
##  [30,] -0.0002994611
##  [31,] -0.0002999077
##  [32,] -0.0003013637
##  [33,] -0.0002973943
##  [34,] -0.0002974312
##  [35,] -0.0002996465
##  [36,] -0.0002987731
##  [37,] -0.0002979422
```

```
##  [38,] -0.0002976347
##  [39,] -0.0003004736
##  [40,] -0.0002983868
##  [41,] -0.0002989271
##  [42,] -0.0001370568
##  [43,] -0.0002993078
##  [44,] -0.0003132797
##  [45,] -0.0002996905
##  [46,] -0.0003031919
##  [47,] -0.0002977602
##  [48,] -0.0002992757
##  [49,] -0.0002978005
##  [50,] -0.0002986344
##  [51,]  0.9915977758
##  [52,]  0.9746376790
##  [53,]  0.9836585829
##  [54,]  1.0526138511
##  [55,]  1.1271740701
##  [56,]  0.9843894953
##  [57,]  1.0197286754
##  [58,]  1.0110161895
##  [59,]  0.9909874503
##  [60,]  1.0073661408
##  [61,]  0.9963946643
##  [62,]  0.9945489911
##  [63,]  1.0051529968
##  [64,]  0.9916817368
##  [65,]  0.9959793676
##  [66,]  0.9877276969
##  [67,]  1.0729014953
##  [68,]  1.0154724971
##  [69,]  1.0211088903
##  [70,]  1.0029465574
##  [71,]  1.1069435991
##  [72,]  0.9896972364
##  [73,]  1.0341836196
##  [74,]  0.9966090447
##  [75,]  0.9932947773
##  [76,]  0.9815530468
```

```
##  [77,]  0.9881268863
##  [78,]  0.9549129582
##  [79,]  1.0895842895
##  [80,]  1.0162135671
##  [81,]  0.9994106389
##  [82,]  1.0108421543
##  [83,]  0.9994239927
##  [84,]  1.2310605419
##  [85,]  1.0979483365
##  [86,]  0.9850248773
##  [87,]  0.9798552774
##  [88,]  1.0546313595
##  [89,]  0.9942789358
##  [90,]  0.9926788127
##  [91,]  0.9884200601
##  [92,]  0.9804235732
##  [93,]  0.9936857256
##  [94,]  1.0088820143
##  [95,]  0.9831465947
##  [96,]  1.0069166361
##  [97,]  0.9889670988
##  [98,]  0.9916336493
##  [99,]  1.0084145595
## [100,]  0.9855717171
## [101,]  1.9819824981
## [102,]  1.9772847982
## [103,]  2.0040069133
## [104,]  2.0896641900
## [105,]  2.0061715552
## [106,]  2.0021430454
## [107,]  2.0948251126
## [108,]  2.0931779822
## [109,]  1.9865683746
## [110,]  1.9976002257
## [111,]  2.0409724361
## [112,]  1.9917550983
## [113,]  2.0052685009
## [114,]  2.0019990605
## [115,]  1.9816997215
```

```
## [116,]  2.0119491667
## [117,]  2.0240274552
## [118,]  1.9920848294
## [119,]  1.9802512987
## [120,]  1.8637305432
## [121,]  2.0109403485
## [122,]  1.9821403248
## [123,]  1.9898225894
## [124,]  2.0735079544
## [125,]  1.9885458934
## [126,]  1.8445720402
## [127,]  2.0324909931
## [128,]  1.8280910443
## [129,]  2.0064295081
## [130,]  2.1713198346
## [131,]  2.0009603104
## [132,]  2.0499999973
## [133,]  2.0017227608
## [134,]  1.5141207205
## [135,]  1.9955143035
## [136,]  2.0036826341
## [137,]  2.0009349769
## [138,]  1.9223135660
## [139,]  1.7959728190
## [140,]  2.0046989206
## [141,]  1.9917098361
## [142,]  2.0193207899
## [143,]  1.9772847982
## [144,]  2.0057757078
## [145,]  1.9866328507
## [146,]  2.0082777476
## [147,]  1.9898447178
## [148,]  2.0036973014
## [149,]  2.0126997517
## [150,]  2.0096833804
```

```
plot(NNModel)
```

Comments: * the first neural network plot: ** 20 weights and 4 biases go into the 5 nodes. 5 weights and 1 bias go into the output from the 5 nodes.
* need to have a good enunciation of these final weights and biases.

```
NNModel$weights
```

```
## [[1]]
## [[1]][[1]]
##            [,1]        [,2]       [,3]       [,4]       [,5]
## [1,]  12.967055  17.8124820  18.111926 -6.8620062  -4.212033
## [2,]   1.168055   0.4769610   3.132773 -0.4049684   1.917957
## [3,]   5.820569   4.3161773  12.900001 -2.2806297 -15.153753
## [4,]  -1.879965  -0.8748163  -2.417733  0.6494946   9.733660
## [5,] -16.902345 -14.2377132 -39.033990  7.1804287  30.655574
##
## [[1]][[2]]
##            [,1]
## [1,]  2.6775145
## [2,] -5.7973604
## [3,] -0.4101476
## [4,]  3.5296962
## [5,] -1.7294631
## [6,]  1.0225217
```

Comments: * In the first list, the first row gives all the biases. * The second row gives the weights for sepal.length, etc. * In the second list, the first entry is the bias and the remaining entries weights coming from the nodes. * The initial weights are selected randomly. This is the reason why the final output changes from implementer to implementer.
* The neural network model here is a 31-parameter model

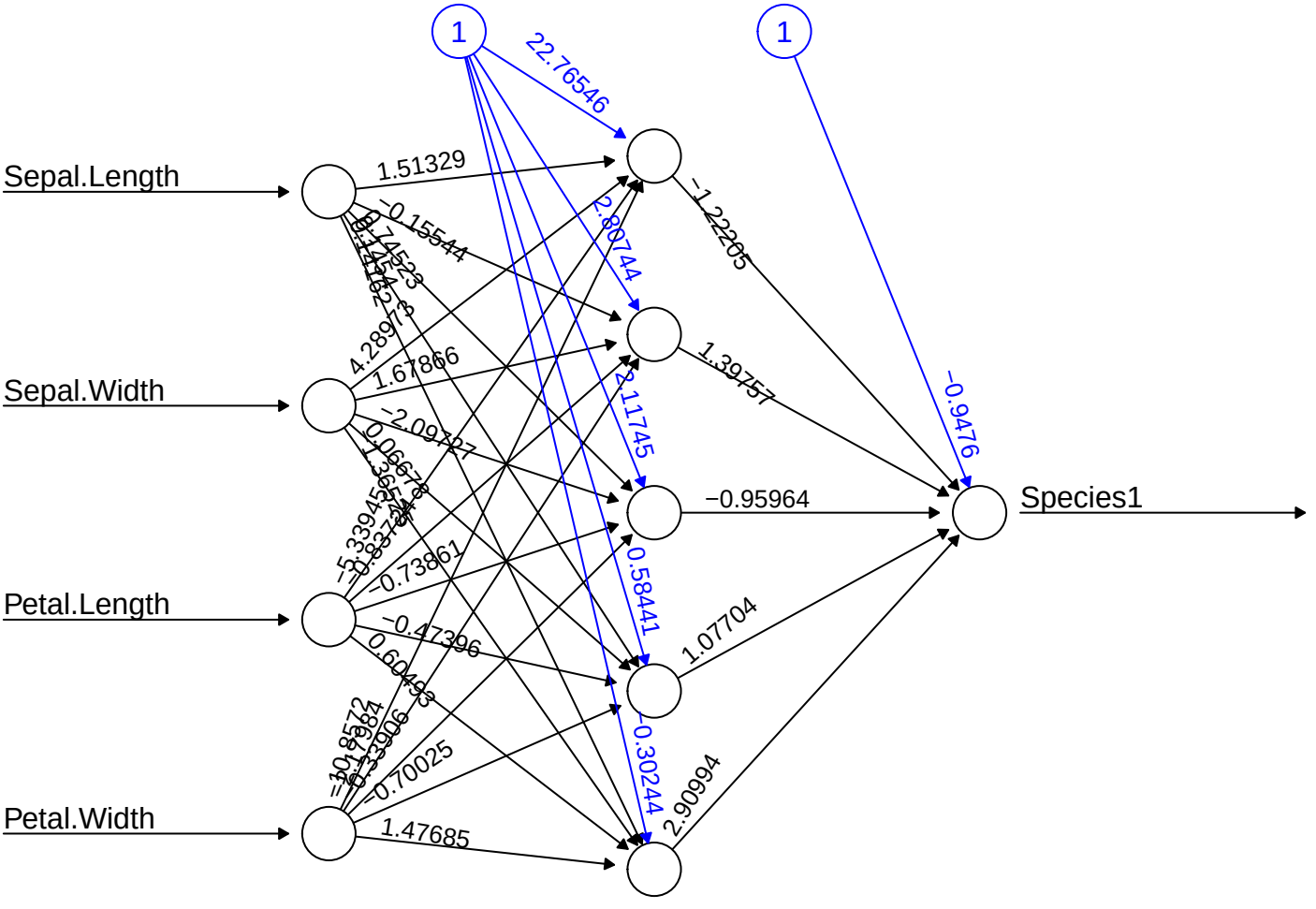
- need to create a duplicate copy of the data

```
sapply(iris, class)
```

```
## Sepal.Length  Sepal.Width Petal.Length  Petal.Width      Species     Species1
##    "numeric"    "numeric"    "numeric"    "numeric"     "factor"    "numeric"
```

```
iris1 <- iris
iris1$Species1 <- as.factor(iris1$Species1)
NNModel1<- neuralnet(Species1 ~ Sepal.Length + Sepal.Width + Petal.Length + Petal.Width, data = iris1, hidden = 5)
```

Comments: * there are no factors! ** Neural Network over fits. ** Its error estimate can be controlled by increasing the number of iterations and increasing the number of nodes in the hidden layer.



Error: 0.961669 Steps: 12526