Math642\_HW10\_FyonaSun

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## Problem 1

Using the R code posted as an example, create a neural network that learns how to multiply 2 numbers from 1 to 10 together. Try different numbers of nodes per layer and number of hidden layers. Plot the best neural network and describe the model. Describe how accurate the results are in each case.

library(neuralnet)  
#Generate 50 random numbers uniformly distributed between 0 and 10  
#And store them as a dataframe  
set.seed(1)  
traininginput <- data.frame(x1=runif(50, min=0, max=10), x2=runif(50, min=0, max=10))  
trainingoutput <- traininginput$x1\*traininginput$x2  
  
#Column bind the data into one variable  
trainingdata <- cbind(traininginput,trainingoutput)  
head(trainingdata)

## x1 x2 trainingoutput  
## 1 2.655087 4.7761962 12.681215  
## 2 3.721239 8.6120948 32.047663  
## 3 5.728534 4.3809711 25.096540  
## 4 9.082078 2.4479728 22.232679  
## 5 2.016819 0.7067905 1.425469  
## 6 8.983897 0.9946616 8.935937

net.multi <- neuralnet(trainingoutput~x1+x2,data=trainingdata, hidden=c(10,10), threshold=0.01,stepmax = 1e16)  
print(net.multi)

## $call  
## neuralnet(formula = trainingoutput ~ x1 + x2, data = trainingdata,   
## hidden = c(10, 10), threshold = 0.01, stepmax = 1e+16)  
##   
## $response  
## trainingoutput  
## 1 12.681215  
## 2 32.047663  
## 3 25.096540  
## 4 22.232679  
## 5 1.425469  
## 6 8.935937  
## 7 29.877406  
## 8 34.271238  
## 9 41.647669  
## 10 2.513652  
## 11 18.802923  
## 12 5.183766  
## 13 31.538864  
## 14 12.767403  
## 15 50.106704  
## 16 12.841476  
## 17 34.341293  
## 18 76.010822  
## 19 3.201679  
## 20 68.051439  
## 21 31.693325  
## 22 17.808099  
## 23 22.592454  
## 24 4.190714  
## 25 12.729090  
## 26 34.449035  
## 27 1.157379  
## 28 14.912730  
## 29 67.602870  
## 30 32.694537  
## 31 20.954069  
## 32 42.719945  
## 33 19.741374  
## 34 6.058630  
## 35 62.639371  
## 36 13.549303  
## 37 56.480082  
## 38 1.313587  
## 39 17.766272  
## 40 5.893743  
## 41 19.672288  
## 42 3.813409  
## 43 50.286852  
## 44 48.460869  
## 45 41.260636  
## 46 62.936069  
## 47 1.062210  
## 48 19.570445  
## 49 59.381142  
## 50 41.905638  
##   
## $covariate  
## x1 x2  
## [1,] 2.6550866 4.7761962  
## [2,] 3.7212390 8.6120948  
## [3,] 5.7285336 4.3809711  
## [4,] 9.0820779 2.4479728  
## [5,] 2.0168193 0.7067905  
## [6,] 8.9838968 0.9946616  
## [7,] 9.4467527 3.1627171  
## [8,] 6.6079779 5.1863426  
## [9,] 6.2911404 6.6200508  
## [10,] 0.6178627 4.0683019  
## [11,] 2.0597457 9.1287592  
## [12,] 1.7655675 2.9360337  
## [13,] 6.8702285 4.5906573  
## [14,] 3.8410372 3.3239467  
## [15,] 7.6984142 6.5087047  
## [16,] 4.9769924 2.5801678  
## [17,] 7.1761851 4.7854525  
## [18,] 9.9190609 7.6631067  
## [19,] 3.8003518 0.8424691  
## [20,] 7.7744522 8.7532133  
## [21,] 9.3470523 3.3907294  
## [22,] 2.1214252 8.3944035  
## [23,] 6.5167377 3.4668349  
## [24,] 1.2555510 3.3377493  
## [25,] 2.6722067 4.7635125  
## [26,] 3.8611409 8.9219834  
## [27,] 0.1339033 8.6433947  
## [28,] 3.8238796 3.8998954  
## [29,] 8.6969085 7.7732070  
## [30,] 3.4034900 9.6061800  
## [31,] 4.8208012 4.3465948  
## [32,] 5.9956583 7.1251468  
## [33,] 4.9354131 3.9999437  
## [34,] 1.8621760 3.2535215  
## [35,] 8.2737332 7.5708715  
## [36,] 6.6846674 2.0269226  
## [37,] 7.9423986 7.1112122  
## [38,] 1.0794363 1.2169192  
## [39,] 7.2371095 2.4548851  
## [40,] 4.1127443 1.4330438  
## [41,] 8.2094629 2.3962942  
## [42,] 6.4706019 0.5893438  
## [43,] 7.8293276 6.4228826  
## [44,] 5.5303631 8.7626921  
## [45,] 5.2971958 7.7891468  
## [46,] 7.8935623 7.9730883  
## [47,] 0.2333120 4.5527445  
## [48,] 4.7723007 4.1008408  
## [49,] 7.3231374 8.1087024  
## [50,] 6.9273156 6.0493329  
##   
## $model.list  
## $model.list$response  
## [1] "trainingoutput"  
##   
## $model.list$variables  
## [1] "x1" "x2"  
##   
##   
## $err.fct  
## function (x, y)   
## {  
## 1/2 \* (y - x)^2  
## }  
## <bytecode: 0x7f87234874c8>  
## <environment: 0x7f8723488968>  
## attr(,"type")  
## [1] "sse"  
##   
## $act.fct  
## function (x)   
## {  
## 1/(1 + exp(-x))  
## }  
## <bytecode: 0x7f87262f1d48>  
## <environment: 0x7f87262f44f0>  
## attr(,"type")  
## [1] "logistic"  
##   
## $linear.output  
## [1] TRUE  
##   
## $data  
## x1 x2 trainingoutput  
## 1 2.6550866 4.7761962 12.681215  
## 2 3.7212390 8.6120948 32.047663  
## 3 5.7285336 4.3809711 25.096540  
## 4 9.0820779 2.4479728 22.232679  
## 5 2.0168193 0.7067905 1.425469  
## 6 8.9838968 0.9946616 8.935937  
## 7 9.4467527 3.1627171 29.877406  
## 8 6.6079779 5.1863426 34.271238  
## 9 6.2911404 6.6200508 41.647669  
## 10 0.6178627 4.0683019 2.513652  
## 11 2.0597457 9.1287592 18.802923  
## 12 1.7655675 2.9360337 5.183766  
## 13 6.8702285 4.5906573 31.538864  
## 14 3.8410372 3.3239467 12.767403  
## 15 7.6984142 6.5087047 50.106704  
## 16 4.9769924 2.5801678 12.841476  
## 17 7.1761851 4.7854525 34.341293  
## 18 9.9190609 7.6631067 76.010822  
## 19 3.8003518 0.8424691 3.201679  
## 20 7.7744522 8.7532133 68.051439  
## 21 9.3470523 3.3907294 31.693325  
## 22 2.1214252 8.3944035 17.808099  
## 23 6.5167377 3.4668349 22.592454  
## 24 1.2555510 3.3377493 4.190714  
## 25 2.6722067 4.7635125 12.729090  
## 26 3.8611409 8.9219834 34.449035  
## 27 0.1339033 8.6433947 1.157379  
## 28 3.8238796 3.8998954 14.912730  
## 29 8.6969085 7.7732070 67.602870  
## 30 3.4034900 9.6061800 32.694537  
## 31 4.8208012 4.3465948 20.954069  
## 32 5.9956583 7.1251468 42.719945  
## 33 4.9354131 3.9999437 19.741374  
## 34 1.8621760 3.2535215 6.058630  
## 35 8.2737332 7.5708715 62.639371  
## 36 6.6846674 2.0269226 13.549303  
## 37 7.9423986 7.1112122 56.480082  
## 38 1.0794363 1.2169192 1.313587  
## 39 7.2371095 2.4548851 17.766272  
## 40 4.1127443 1.4330438 5.893743  
## 41 8.2094629 2.3962942 19.672288  
## 42 6.4706019 0.5893438 3.813409  
## 43 7.8293276 6.4228826 50.286852  
## 44 5.5303631 8.7626921 48.460869  
## 45 5.2971958 7.7891468 41.260636  
## 46 7.8935623 7.9730883 62.936069  
## 47 0.2333120 4.5527445 1.062210  
## 48 4.7723007 4.1008408 19.570445  
## 49 7.3231374 8.1087024 59.381142  
## 50 6.9273156 6.0493329 41.905638  
##   
## $exclude  
## NULL  
##   
## $net.result  
## $net.result[[1]]  
## [,1]  
## [1,] 12.677509  
## [2,] 32.041960  
## [3,] 25.105071  
## [4,] 22.234862  
## [5,] 1.437681  
## [6,] 8.935643  
## [7,] 29.873445  
## [8,] 34.272699  
## [9,] 41.661421  
## [10,] 2.507614  
## [11,] 18.800990  
## [12,] 5.202638  
## [13,] 31.533856  
## [14,] 12.746552  
## [15,] 50.091394  
## [16,] 12.846744  
## [17,] 34.343091  
## [18,] 76.010455  
## [19,] 3.191216  
## [20,] 68.049453  
## [21,] 31.696108  
## [22,] 17.811130  
## [23,] 22.592204  
## [24,] 4.201577  
## [25,] 12.729411  
## [26,] 34.452338  
## [27,] 1.157485  
## [28,] 14.939017  
## [29,] 67.609544  
## [30,] 32.695650  
## [31,] 20.942900  
## [32,] 42.705261  
## [33,] 19.746188  
## [34,] 6.036272  
## [35,] 62.617290  
## [36,] 13.545628  
## [37,] 56.494479  
## [38,] 1.301114  
## [39,] 17.768024  
## [40,] 5.900384  
## [41,] 19.671112  
## [42,] 3.815189  
## [43,] 50.296796  
## [44,] 48.460632  
## [45,] 41.265970  
## [46,] 62.946675  
## [47,] 1.065884  
## [48,] 19.562849  
## [49,] 59.379147  
## [50,] 41.901874  
##   
##   
## $weights  
## $weights[[1]]  
## $weights[[1]][[1]]  
## [,1] [,2] [,3] [,4] [,5] [,6]  
## [1,] 3.7058464 -3.8726087 -0.7094619 2.1328045 3.90475826 -2.3981718  
## [2,] -0.8121451 0.2974382 -0.1036156 1.7664235 -0.06502322 -0.6968875  
## [3,] 0.1880711 0.4147811 0.4283282 -0.4471493 -0.48832626 1.2441251  
## [,7] [,8] [,9] [,10]  
## [1,] -2.4635835 -1.6013873 -0.8668011 1.11003980  
## [2,] 0.2006309 1.1989368 0.2693704 0.07978545  
## [3,] 0.4713748 -0.2940514 -1.0492305 -0.56572061  
##   
## $weights[[1]][[2]]  
## [,1] [,2] [,3] [,4] [,5] [,6]  
## [1,] -0.9615342 0.6924705 -1.53893359 -0.121441587 0.0605988 -1.1863790  
## [2,] -2.6176280 -5.3065824 -2.00689382 -2.219810056 -3.5193987 -4.4407817  
## [3,] 3.1038306 2.9953922 -0.03595046 0.001099838 1.3209328 2.2686169  
## [4,] -1.2855918 1.7988671 1.29024627 0.208235397 0.3141163 0.5587601  
## [5,] 2.2403647 0.9147854 5.07818141 1.259452608 0.6678002 1.6734567  
## [6,] -1.7889529 -6.2378807 -1.30477203 -2.763166458 -7.5932956 -9.1315092  
## [7,] 1.7652559 -1.4261132 -1.68477629 -1.693317703 0.2956615 0.8085698  
## [8,] -0.6970380 -1.7373463 0.60212889 0.021676841 -0.4413481 -1.3148893  
## [9,] 1.4053151 0.3772688 1.61893759 3.093305160 3.4882757 1.2670231  
## [10,] -2.5058745 -30.4377830 -4.11509946 -2.659488998 -101.5853507 13.6249820  
## [11,] -3.3100273 -1.1829249 -2.92140425 -3.384839519 -1.6378489 -6.8158828  
## [,7] [,8] [,9] [,10]  
## [1,] 2.8311663 -1.4117078 -0.96579070 1.1390548  
## [2,] -2.3957809 -4.2850710 -3.09471167 -12.8710567  
## [3,] -1.3796190 3.6834309 5.22673545 2.1464851  
## [4,] -0.8967128 0.5614032 0.01928677 0.1761856  
## [5,] 3.8140983 2.7944794 1.24609093 -0.9495265  
## [6,] -4.6217867 0.1249645 -3.60997112 -2.5790619  
## [7,] 0.4044224 0.9789358 0.04605120 -2.9094045  
## [8,] -0.3404017 -1.4099237 -0.62890351 1.3959018  
## [9,] 0.8516823 2.2356151 1.22884940 -0.4354296  
## [10,] -26.1422991 -6.9695635 1.16004431 1.5755883  
## [11,] -2.8453588 -2.8683555 -3.37986531 -0.5912580  
##   
## $weights[[1]][[3]]  
## [,1]  
## [1,] -1.133436  
## [2,] 9.831442  
## [3,] 9.242852  
## [4,] 9.948868  
## [5,] 6.281922  
## [6,] 12.894776  
## [7,] 19.134317  
## [8,] 5.841806  
## [9,] 7.587927  
## [10,] 7.939912  
## [11,] 15.394572  
##   
##   
##   
## $generalized.weights  
## $generalized.weights[[1]]  
## [,1] [,2]  
## [1,] -0.033780294 -0.017855079  
## [2,] -0.008724807 -0.003805083  
## [3,] -0.007324742 -0.009204953  
## [4,] -0.004813561 -0.020775188  
## [5,] -1.378174574 -3.479256374  
## [6,] -0.023812760 -0.068813668  
## [7,] -0.003401838 -0.010692140  
## [8,] -0.004505276 -0.005835930  
## [9,] -0.004034328 -0.003743663  
## [10,] -1.105211121 -0.122143070  
## [11,] -0.033578090 -0.006147455  
## [12,] -0.137499091 -0.073195536  
## [13,] -0.004784229 -0.007091517  
## [14,] -0.021449717 -0.025875894  
## [15,] -0.002715219 -0.003189579  
## [16,] -0.018249325 -0.032641218  
## [17,] -0.004292984 -0.006164744  
## [18,] -0.001163719 -0.001325312  
## [19,] -0.099740590 -0.540071680  
## [20,] -0.001913142 -0.001596568  
## [21,] -0.003205386 -0.009738885  
## [22,] -0.031017704 -0.007698044  
## [23,] -0.006471406 -0.013533344  
## [24,] -0.240215528 -0.095384645  
## [25,] -0.033444450 -0.017834804  
## [26,] -0.007812031 -0.003279045  
## [27,] -11.700489063 -2.972126416  
## [28,] -0.018285799 -0.018980094  
## [29,] -0.001756904 -0.001852796  
## [30,] -0.008602935 -0.003052098  
## [31,] -0.010302109 -0.011536608  
## [32,] -0.004140975 -0.003438236  
## [33,] -0.011014443 -0.013151612  
## [34,] -0.108039074 -0.057285502  
## [35,] -0.001999466 -0.002111304  
## [36,] -0.010607618 -0.043083530  
## [37,] -0.002313522 -0.002477089  
## [38,] -3.428352169 -3.342608594  
## [39,] -0.007827604 -0.023765125  
## [40,] -0.042752866 -0.147324978  
## [41,] -0.006676239 -0.023204818  
## [42,] -0.068160800 -0.395512968  
## [43,] -0.002753102 -0.003205784  
## [44,] -0.003625349 -0.002259598  
## [45,] -0.004719782 -0.003344009  
## [46,] -0.002038431 -0.002073268  
## [47,] -50.173393646 -0.228539513  
## [48,] -0.011343003 -0.013090232  
## [49,] -0.002368566 -0.002096193  
## [50,] -0.003418203 -0.004086458  
##   
##   
## $startweights  
## $startweights[[1]]  
## $startweights[[1]][[1]]  
## [,1] [,2] [,3] [,4] [,5] [,6]  
## [1,] 0.3981059 -1.129363 -0.3672215 -0.1350546 0.68973936 0.1887923  
## [2,] -0.6120264 1.433024 -1.0441346 2.4016178 0.02800216 -1.8049586  
## [3,] 0.3411197 1.980400 0.5697196 -0.0392400 -0.74327321 1.4655549  
## [,7] [,8] [,9] [,10]  
## [1,] 0.1532533 -0.7099464 -1.2536334 0.001105352  
## [2,] 2.1726117 0.6107264 0.2914462 0.074341324  
## [3,] 0.4755095 -0.9340976 -0.4432919 -0.589520946  
##   
## $startweights[[1]][[2]]  
## [,1] [,2] [,3] [,4] [,5] [,6]  
## [1,] -0.5686687 1.20786781 -0.9109216 -0.6506964 -0.10019074 -1.53644982  
## [2,] -0.1351786 1.16040262 0.1580288 -0.2073807 0.71266631 -0.30097613  
## [3,] 1.1780870 0.70021365 -0.6545846 -0.3928079 -0.07356440 -0.52827990  
## [4,] -1.5235668 1.58683345 1.7672873 -0.3199929 -0.03763417 -0.65209478  
## [5,] 0.5939462 0.55848643 0.7167075 -0.2791133 -0.68166048 -0.05689678  
## [6,] 0.3329504 -1.27659221 0.9101742 0.4941883 -0.32427027 -1.91435943  
## [7,] 1.0630998 -0.57326541 0.3841854 -0.1773305 0.06016044 1.17658331  
## [8,] -0.3041839 -1.22461261 1.6821761 -0.5059575 -0.58889449 -1.66497244  
## [9,] 0.3700188 -0.47340064 -0.6357365 1.3430388 0.53149619 -0.46353040  
## [10,] 0.2670988 -0.62036668 -0.4616447 -0.2145794 -1.51839408 -1.11592011  
## [11,] -0.5425200 0.04211587 1.4322822 -0.1795565 0.30655786 -0.75081900  
## [,7] [,8] [,9] [,10]  
## [1,] 2.08716655 -0.6212667 -0.14439960 1.2079084  
## [2,] 0.01739562 -1.3844268 0.20753834 -1.2313234  
## [3,] -1.28630053 1.8692906 2.30797840 0.9838956  
## [4,] -1.64060553 0.4251004 0.10580237 0.2199248  
## [5,] 0.45018710 -0.2386471 0.45699881 -1.4672500  
## [6,] -0.01855983 1.0584830 -0.07715294 0.5210227  
## [7,] -0.31806837 0.8864227 -0.33400084 -0.1587546  
## [8,] -0.92936215 -0.6192430 -0.03472603 1.4645873  
## [9,] -1.48746031 2.2061025 0.78763961 -0.7660820  
## [10,] -1.07519230 -0.2550270 2.07524501 -0.4302118  
## [11,] 1.00002880 -1.4244947 1.02739244 -0.9261095  
##   
## $startweights[[1]][[3]]  
## [,1]  
## [1,] -0.1771040  
## [2,] 0.4020118  
## [3,] -0.7317482  
## [4,] 0.8303732  
## [5,] -1.2080828  
## [6,] -1.0479844  
## [7,] 1.4411577  
## [8,] -1.0158475  
## [9,] 0.4119747  
## [10,] -0.3810761  
## [11,] 0.4094018  
##   
##   
##   
## $result.matrix  
## [,1]  
## error 2.353088e-03  
## reached.threshold 9.762037e-03  
## steps 1.452060e+05  
## Intercept.to.1layhid1 3.705846e+00  
## x1.to.1layhid1 -8.121451e-01  
## x2.to.1layhid1 1.880711e-01  
## Intercept.to.1layhid2 -3.872609e+00  
## x1.to.1layhid2 2.974382e-01  
## x2.to.1layhid2 4.147811e-01  
## Intercept.to.1layhid3 -7.094619e-01  
## x1.to.1layhid3 -1.036156e-01  
## x2.to.1layhid3 4.283282e-01  
## Intercept.to.1layhid4 2.132804e+00  
## x1.to.1layhid4 1.766423e+00  
## x2.to.1layhid4 -4.471493e-01  
## Intercept.to.1layhid5 3.904758e+00  
## x1.to.1layhid5 -6.502322e-02  
## x2.to.1layhid5 -4.883263e-01  
## Intercept.to.1layhid6 -2.398172e+00  
## x1.to.1layhid6 -6.968875e-01  
## x2.to.1layhid6 1.244125e+00  
## Intercept.to.1layhid7 -2.463583e+00  
## x1.to.1layhid7 2.006309e-01  
## x2.to.1layhid7 4.713748e-01  
## Intercept.to.1layhid8 -1.601387e+00  
## x1.to.1layhid8 1.198937e+00  
## x2.to.1layhid8 -2.940514e-01  
## Intercept.to.1layhid9 -8.668011e-01  
## x1.to.1layhid9 2.693704e-01  
## x2.to.1layhid9 -1.049230e+00  
## Intercept.to.1layhid10 1.110040e+00  
## x1.to.1layhid10 7.978545e-02  
## x2.to.1layhid10 -5.657206e-01  
## Intercept.to.2layhid1 -9.615342e-01  
## 1layhid1.to.2layhid1 -2.617628e+00  
## 1layhid2.to.2layhid1 3.103831e+00  
## 1layhid3.to.2layhid1 -1.285592e+00  
## 1layhid4.to.2layhid1 2.240365e+00  
## 1layhid5.to.2layhid1 -1.788953e+00  
## 1layhid6.to.2layhid1 1.765256e+00  
## 1layhid7.to.2layhid1 -6.970380e-01  
## 1layhid8.to.2layhid1 1.405315e+00  
## 1layhid9.to.2layhid1 -2.505875e+00  
## 1layhid10.to.2layhid1 -3.310027e+00  
## Intercept.to.2layhid2 6.924705e-01  
## 1layhid1.to.2layhid2 -5.306582e+00  
## 1layhid2.to.2layhid2 2.995392e+00  
## 1layhid3.to.2layhid2 1.798867e+00  
## 1layhid4.to.2layhid2 9.147854e-01  
## 1layhid5.to.2layhid2 -6.237881e+00  
## 1layhid6.to.2layhid2 -1.426113e+00  
## 1layhid7.to.2layhid2 -1.737346e+00  
## 1layhid8.to.2layhid2 3.772688e-01  
## 1layhid9.to.2layhid2 -3.043778e+01  
## 1layhid10.to.2layhid2 -1.182925e+00  
## Intercept.to.2layhid3 -1.538934e+00  
## 1layhid1.to.2layhid3 -2.006894e+00  
## 1layhid2.to.2layhid3 -3.595046e-02  
## 1layhid3.to.2layhid3 1.290246e+00  
## 1layhid4.to.2layhid3 5.078181e+00  
## 1layhid5.to.2layhid3 -1.304772e+00  
## 1layhid6.to.2layhid3 -1.684776e+00  
## 1layhid7.to.2layhid3 6.021289e-01  
## 1layhid8.to.2layhid3 1.618938e+00  
## 1layhid9.to.2layhid3 -4.115099e+00  
## 1layhid10.to.2layhid3 -2.921404e+00  
## Intercept.to.2layhid4 -1.214416e-01  
## 1layhid1.to.2layhid4 -2.219810e+00  
## 1layhid2.to.2layhid4 1.099838e-03  
## 1layhid3.to.2layhid4 2.082354e-01  
## 1layhid4.to.2layhid4 1.259453e+00  
## 1layhid5.to.2layhid4 -2.763166e+00  
## 1layhid6.to.2layhid4 -1.693318e+00  
## 1layhid7.to.2layhid4 2.167684e-02  
## 1layhid8.to.2layhid4 3.093305e+00  
## 1layhid9.to.2layhid4 -2.659489e+00  
## 1layhid10.to.2layhid4 -3.384840e+00  
## Intercept.to.2layhid5 6.059880e-02  
## 1layhid1.to.2layhid5 -3.519399e+00  
## 1layhid2.to.2layhid5 1.320933e+00  
## 1layhid3.to.2layhid5 3.141163e-01  
## 1layhid4.to.2layhid5 6.678002e-01  
## 1layhid5.to.2layhid5 -7.593296e+00  
## 1layhid6.to.2layhid5 2.956615e-01  
## 1layhid7.to.2layhid5 -4.413481e-01  
## 1layhid8.to.2layhid5 3.488276e+00  
## 1layhid9.to.2layhid5 -1.015854e+02  
## 1layhid10.to.2layhid5 -1.637849e+00  
## Intercept.to.2layhid6 -1.186379e+00  
## 1layhid1.to.2layhid6 -4.440782e+00  
## 1layhid2.to.2layhid6 2.268617e+00  
## 1layhid3.to.2layhid6 5.587601e-01  
## 1layhid4.to.2layhid6 1.673457e+00  
## 1layhid5.to.2layhid6 -9.131509e+00  
## 1layhid6.to.2layhid6 8.085698e-01  
## 1layhid7.to.2layhid6 -1.314889e+00  
## 1layhid8.to.2layhid6 1.267023e+00  
## 1layhid9.to.2layhid6 1.362498e+01  
## 1layhid10.to.2layhid6 -6.815883e+00  
## Intercept.to.2layhid7 2.831166e+00  
## 1layhid1.to.2layhid7 -2.395781e+00  
## 1layhid2.to.2layhid7 -1.379619e+00  
## 1layhid3.to.2layhid7 -8.967128e-01  
## 1layhid4.to.2layhid7 3.814098e+00  
## 1layhid5.to.2layhid7 -4.621787e+00  
## 1layhid6.to.2layhid7 4.044224e-01  
## 1layhid7.to.2layhid7 -3.404017e-01  
## 1layhid8.to.2layhid7 8.516823e-01  
## 1layhid9.to.2layhid7 -2.614230e+01  
## 1layhid10.to.2layhid7 -2.845359e+00  
## Intercept.to.2layhid8 -1.411708e+00  
## 1layhid1.to.2layhid8 -4.285071e+00  
## 1layhid2.to.2layhid8 3.683431e+00  
## 1layhid3.to.2layhid8 5.614032e-01  
## 1layhid4.to.2layhid8 2.794479e+00  
## 1layhid5.to.2layhid8 1.249645e-01  
## 1layhid6.to.2layhid8 9.789358e-01  
## 1layhid7.to.2layhid8 -1.409924e+00  
## 1layhid8.to.2layhid8 2.235615e+00  
## 1layhid9.to.2layhid8 -6.969564e+00  
## 1layhid10.to.2layhid8 -2.868356e+00  
## Intercept.to.2layhid9 -9.657907e-01  
## 1layhid1.to.2layhid9 -3.094712e+00  
## 1layhid2.to.2layhid9 5.226735e+00  
## 1layhid3.to.2layhid9 1.928677e-02  
## 1layhid4.to.2layhid9 1.246091e+00  
## 1layhid5.to.2layhid9 -3.609971e+00  
## 1layhid6.to.2layhid9 4.605120e-02  
## 1layhid7.to.2layhid9 -6.289035e-01  
## 1layhid8.to.2layhid9 1.228849e+00  
## 1layhid9.to.2layhid9 1.160044e+00  
## 1layhid10.to.2layhid9 -3.379865e+00  
## Intercept.to.2layhid10 1.139055e+00  
## 1layhid1.to.2layhid10 -1.287106e+01  
## 1layhid2.to.2layhid10 2.146485e+00  
## 1layhid3.to.2layhid10 1.761856e-01  
## 1layhid4.to.2layhid10 -9.495265e-01  
## 1layhid5.to.2layhid10 -2.579062e+00  
## 1layhid6.to.2layhid10 -2.909404e+00  
## 1layhid7.to.2layhid10 1.395902e+00  
## 1layhid8.to.2layhid10 -4.354296e-01  
## 1layhid9.to.2layhid10 1.575588e+00  
## 1layhid10.to.2layhid10 -5.912580e-01  
## Intercept.to.trainingoutput -1.133436e+00  
## 2layhid1.to.trainingoutput 9.831442e+00  
## 2layhid2.to.trainingoutput 9.242852e+00  
## 2layhid3.to.trainingoutput 9.948868e+00  
## 2layhid4.to.trainingoutput 6.281922e+00  
## 2layhid5.to.trainingoutput 1.289478e+01  
## 2layhid6.to.trainingoutput 1.913432e+01  
## 2layhid7.to.trainingoutput 5.841806e+00  
## 2layhid8.to.trainingoutput 7.587927e+00  
## 2layhid9.to.trainingoutput 7.939912e+00  
## 2layhid10.to.trainingoutput 1.539457e+01  
##   
## attr(,"class")  
## [1] "nn"

#Plot the neural network  
plot(net.multi)

A close up of a map

Description automatically generated

#Test the neural network on some training data  
set.seed(1)  
testdata <- data.frame(x1=runif(20, min=0, max=10), x2=runif(20, min=0, max=10))  
net.results <- predict(net.multi, testdata) #Run them through the neural network  
  
#Lets see the results  
print(net.results)

## [,1]  
## [1,] 25.306635  
## [2,] 7.983956  
## [3,] 37.197326  
## [4,] 10.634707  
## [5,] 5.489751  
## [6,] 35.124971  
## [7,] 8.947969  
## [8,] 25.277294  
## [9,] 54.444994  
## [10,] 2.141611  
## [11,] 9.889186  
## [12,] 10.520162  
## [13,] 33.889668  
## [14,] 7.239040  
## [15,] 63.747313  
## [16,] 33.061690  
## [17,] 57.003164  
## [18,] 11.052891  
## [19,] 27.404187  
## [20,] 32.181841

#Lets display a better version of the results  
cleanoutput <- cbind(testdata,testdata$x1\*testdata$x2,  
 as.data.frame(net.results))  
colnames(cleanoutput) <- c("Input-x1","Input-x2","ExpectedOutput","NeuralNetOutput")  
print(cleanoutput)

## Input-x1 Input-x2 ExpectedOutput NeuralNetOutput  
## 1 2.6550866 9.3470523 24.817234 25.306635  
## 2 3.7212390 2.1214252 7.894330 7.983956  
## 3 5.7285336 6.5167377 37.331351 37.197326  
## 4 9.0820779 1.2555510 11.403012 10.634707  
## 5 2.0168193 2.6722067 5.389358 5.489751  
## 6 8.9838968 3.8611409 34.688092 35.124971  
## 7 9.4467527 0.1339033 1.264952 8.947969  
## 8 6.6079779 3.8238796 25.268112 25.277294  
## 9 6.2911404 8.6969085 54.713472 54.444994  
## 10 0.6178627 3.4034900 2.102890 2.141611  
## 11 2.0597457 4.8208012 9.929625 9.889186  
## 12 1.7655675 5.9956583 10.585740 10.520162  
## 13 6.8702285 4.9354131 33.907415 33.889668  
## 14 3.8410372 1.8621760 7.152687 7.239040  
## 15 7.6984142 8.2737332 63.694625 63.747313  
## 16 4.9769924 6.6846674 33.269539 33.061690  
## 17 7.1761851 7.9423986 56.996122 57.003164  
## 18 9.9190609 1.0794363 10.706994 11.052891  
## 19 3.8003518 7.2371095 27.503562 27.404187  
## 20 7.7744522 4.1127443 31.974334 32.181841

(sum((cleanoutput$NeuralNetOutput - cleanoutput$ExpectedOutput)^2) / nrow(cleanoutput)) ^ 0.5

## [1] 1.737692

net.multi <- neuralnet(trainingoutput~x1+x2,data=trainingdata, hidden=c(5,10), threshold=0.01,stepmax = 1e16)  
print(net.multi)

## $call  
## neuralnet(formula = trainingoutput ~ x1 + x2, data = trainingdata,   
## hidden = c(5, 10), threshold = 0.01, stepmax = 1e+16)  
##   
## $response  
## trainingoutput  
## 1 12.681215  
## 2 32.047663  
## 3 25.096540  
## 4 22.232679  
## 5 1.425469  
## 6 8.935937  
## 7 29.877406  
## 8 34.271238  
## 9 41.647669  
## 10 2.513652  
## 11 18.802923  
## 12 5.183766  
## 13 31.538864  
## 14 12.767403  
## 15 50.106704  
## 16 12.841476  
## 17 34.341293  
## 18 76.010822  
## 19 3.201679  
## 20 68.051439  
## 21 31.693325  
## 22 17.808099  
## 23 22.592454  
## 24 4.190714  
## 25 12.729090  
## 26 34.449035  
## 27 1.157379  
## 28 14.912730  
## 29 67.602870  
## 30 32.694537  
## 31 20.954069  
## 32 42.719945  
## 33 19.741374  
## 34 6.058630  
## 35 62.639371  
## 36 13.549303  
## 37 56.480082  
## 38 1.313587  
## 39 17.766272  
## 40 5.893743  
## 41 19.672288  
## 42 3.813409  
## 43 50.286852  
## 44 48.460869  
## 45 41.260636  
## 46 62.936069  
## 47 1.062210  
## 48 19.570445  
## 49 59.381142  
## 50 41.905638  
##   
## $covariate  
## x1 x2  
## [1,] 2.6550866 4.7761962  
## [2,] 3.7212390 8.6120948  
## [3,] 5.7285336 4.3809711  
## [4,] 9.0820779 2.4479728  
## [5,] 2.0168193 0.7067905  
## [6,] 8.9838968 0.9946616  
## [7,] 9.4467527 3.1627171  
## [8,] 6.6079779 5.1863426  
## [9,] 6.2911404 6.6200508  
## [10,] 0.6178627 4.0683019  
## [11,] 2.0597457 9.1287592  
## [12,] 1.7655675 2.9360337  
## [13,] 6.8702285 4.5906573  
## [14,] 3.8410372 3.3239467  
## [15,] 7.6984142 6.5087047  
## [16,] 4.9769924 2.5801678  
## [17,] 7.1761851 4.7854525  
## [18,] 9.9190609 7.6631067  
## [19,] 3.8003518 0.8424691  
## [20,] 7.7744522 8.7532133  
## [21,] 9.3470523 3.3907294  
## [22,] 2.1214252 8.3944035  
## [23,] 6.5167377 3.4668349  
## [24,] 1.2555510 3.3377493  
## [25,] 2.6722067 4.7635125  
## [26,] 3.8611409 8.9219834  
## [27,] 0.1339033 8.6433947  
## [28,] 3.8238796 3.8998954  
## [29,] 8.6969085 7.7732070  
## [30,] 3.4034900 9.6061800  
## [31,] 4.8208012 4.3465948  
## [32,] 5.9956583 7.1251468  
## [33,] 4.9354131 3.9999437  
## [34,] 1.8621760 3.2535215  
## [35,] 8.2737332 7.5708715  
## [36,] 6.6846674 2.0269226  
## [37,] 7.9423986 7.1112122  
## [38,] 1.0794363 1.2169192  
## [39,] 7.2371095 2.4548851  
## [40,] 4.1127443 1.4330438  
## [41,] 8.2094629 2.3962942  
## [42,] 6.4706019 0.5893438  
## [43,] 7.8293276 6.4228826  
## [44,] 5.5303631 8.7626921  
## [45,] 5.2971958 7.7891468  
## [46,] 7.8935623 7.9730883  
## [47,] 0.2333120 4.5527445  
## [48,] 4.7723007 4.1008408  
## [49,] 7.3231374 8.1087024  
## [50,] 6.9273156 6.0493329  
##   
## $model.list  
## $model.list$response  
## [1] "trainingoutput"  
##   
## $model.list$variables  
## [1] "x1" "x2"  
##   
##   
## $err.fct  
## function (x, y)   
## {  
## 1/2 \* (y - x)^2  
## }  
## <bytecode: 0x7f87234874c8>  
## <environment: 0x7f872768ca10>  
## attr(,"type")  
## [1] "sse"  
##   
## $act.fct  
## function (x)   
## {  
## 1/(1 + exp(-x))  
## }  
## <bytecode: 0x7f87262f1d48>  
## <environment: 0x7f872768c578>  
## attr(,"type")  
## [1] "logistic"  
##   
## $linear.output  
## [1] TRUE  
##   
## $data  
## x1 x2 trainingoutput  
## 1 2.6550866 4.7761962 12.681215  
## 2 3.7212390 8.6120948 32.047663  
## 3 5.7285336 4.3809711 25.096540  
## 4 9.0820779 2.4479728 22.232679  
## 5 2.0168193 0.7067905 1.425469  
## 6 8.9838968 0.9946616 8.935937  
## 7 9.4467527 3.1627171 29.877406  
## 8 6.6079779 5.1863426 34.271238  
## 9 6.2911404 6.6200508 41.647669  
## 10 0.6178627 4.0683019 2.513652  
## 11 2.0597457 9.1287592 18.802923  
## 12 1.7655675 2.9360337 5.183766  
## 13 6.8702285 4.5906573 31.538864  
## 14 3.8410372 3.3239467 12.767403  
## 15 7.6984142 6.5087047 50.106704  
## 16 4.9769924 2.5801678 12.841476  
## 17 7.1761851 4.7854525 34.341293  
## 18 9.9190609 7.6631067 76.010822  
## 19 3.8003518 0.8424691 3.201679  
## 20 7.7744522 8.7532133 68.051439  
## 21 9.3470523 3.3907294 31.693325  
## 22 2.1214252 8.3944035 17.808099  
## 23 6.5167377 3.4668349 22.592454  
## 24 1.2555510 3.3377493 4.190714  
## 25 2.6722067 4.7635125 12.729090  
## 26 3.8611409 8.9219834 34.449035  
## 27 0.1339033 8.6433947 1.157379  
## 28 3.8238796 3.8998954 14.912730  
## 29 8.6969085 7.7732070 67.602870  
## 30 3.4034900 9.6061800 32.694537  
## 31 4.8208012 4.3465948 20.954069  
## 32 5.9956583 7.1251468 42.719945  
## 33 4.9354131 3.9999437 19.741374  
## 34 1.8621760 3.2535215 6.058630  
## 35 8.2737332 7.5708715 62.639371  
## 36 6.6846674 2.0269226 13.549303  
## 37 7.9423986 7.1112122 56.480082  
## 38 1.0794363 1.2169192 1.313587  
## 39 7.2371095 2.4548851 17.766272  
## 40 4.1127443 1.4330438 5.893743  
## 41 8.2094629 2.3962942 19.672288  
## 42 6.4706019 0.5893438 3.813409  
## 43 7.8293276 6.4228826 50.286852  
## 44 5.5303631 8.7626921 48.460869  
## 45 5.2971958 7.7891468 41.260636  
## 46 7.8935623 7.9730883 62.936069  
## 47 0.2333120 4.5527445 1.062210  
## 48 4.7723007 4.1008408 19.570445  
## 49 7.3231374 8.1087024 59.381142  
## 50 6.9273156 6.0493329 41.905638  
##   
## $exclude  
## NULL  
##   
## $net.result  
## $net.result[[1]]  
## [,1]  
## [1,] 12.686287  
## [2,] 32.065525  
## [3,] 25.084766  
## [4,] 22.240260  
## [5,] 1.409380  
## [6,] 8.935376  
## [7,] 29.876789  
## [8,] 34.261128  
## [9,] 41.639447  
## [10,] 2.477577  
## [11,] 18.810054  
## [12,] 5.216648  
## [13,] 31.551060  
## [14,] 12.748226  
## [15,] 50.121339  
## [16,] 12.846365  
## [17,] 34.336871  
## [18,] 76.009174  
## [19,] 3.221296  
## [20,] 68.050588  
## [21,] 31.691904  
## [22,] 17.797652  
## [23,] 22.594596  
## [24,] 4.200781  
## [25,] 12.735174  
## [26,] 34.430910  
## [27,] 1.157772  
## [28,] 14.908533  
## [29,] 67.614475  
## [30,] 32.693877  
## [31,] 20.959841  
## [32,] 42.700720  
## [33,] 19.743169  
## [34,] 6.042092  
## [35,] 62.619676  
## [36,] 13.553142  
## [37,] 56.508483  
## [38,] 1.316765  
## [39,] 17.776273  
## [40,] 5.879254  
## [41,] 19.655496  
## [42,] 3.812604  
## [43,] 50.252157  
## [44,] 48.471857  
## [45,] 41.267033  
## [46,] 62.941656  
## [47,] 1.081730  
## [48,] 19.574201  
## [49,] 59.366393  
## [50,] 41.935848  
##   
##   
## $weights  
## $weights[[1]]  
## $weights[[1]][[1]]  
## [,1] [,2] [,3] [,4] [,5]  
## [1,] 5.3069854 -4.7438254 3.4937482 2.1011582 -1.9125571  
## [2,] 0.3165482 0.3623006 -0.3077353 0.4667796 0.3315504  
## [3,] -0.6603752 0.3422437 -0.2800632 -0.2745539 -0.9914733  
##   
## $weights[[1]][[2]]  
## [,1] [,2] [,3] [,4] [,5] [,6]  
## [1,] -0.3552167 -0.4221027 0.2475597 -1.672978 -1.3370053 -0.2247352  
## [2,] 1.0443770 2.0902610 1.6513336 0.887525 3.3250467 -1.0973877  
## [3,] 4.4788689 3.0588821 1.5886920 4.541940 2.5920818 3.6851648  
## [4,] -5.2357096 -10.8977263 -5.5531356 -16.667975 -3.2702856 -7.2705825  
## [5,] 3.6748218 -1.0595832 -0.4137183 -1.732491 -0.5604287 1.8483244  
## [6,] -4.3185629 -181.7862310 -127.8871385 -284.874134 -6.2336951 -0.1366297  
## [,7] [,8] [,9] [,10]  
## [1,] -0.3035726 -0.3521843 -1.5223237 -0.88287571  
## [2,] 1.8858590 1.3781835 1.9186154 -0.03701397  
## [3,] 1.5041994 3.1110069 3.6679984 12.32191368  
## [4,] -5.5349722 -4.3638728 -2.7553186 -4.95893995  
## [5,] 1.1795108 1.0565827 -0.2898827 5.84569537  
## [6,] -6.4242755 -35.0639327 -3.3943725 1.18384849  
##   
## $weights[[1]][[3]]  
## [,1]  
## [1,] -8.654180  
## [2,] 15.151625  
## [3,] 14.826133  
## [4,] 7.702594  
## [5,] 66.637047  
## [6,] 6.731100  
## [7,] 9.002911  
## [8,] 8.670619  
## [9,] 6.430165  
## [10,] 6.599582  
## [11,] 8.685164  
##   
##   
##   
## $generalized.weights  
## $generalized.weights[[1]]  
## [,1] [,2]  
## [1,] -0.033218159 -0.018705020  
## [2,] -0.008619457 -0.003570914  
## [3,] -0.007253447 -0.009440249  
## [4,] -0.005415317 -0.019393477  
## [5,] -1.432932397 -3.873916651  
## [6,] -0.022758986 -0.116748553  
## [7,] -0.003907888 -0.010725918  
## [8,] -0.004555857 -0.005815026  
## [9,] -0.003963918 -0.003723018  
## [10,] -1.028683064 -0.102007028  
## [11,] -0.027429232 -0.006846006  
## [12,] -0.130351091 -0.074040819  
## [13,] -0.004806207 -0.007025962  
## [14,] -0.022364315 -0.025683239  
## [15,] -0.002551614 -0.003179654  
## [16,] -0.017105679 -0.032760710  
## [17,] -0.004165462 -0.006162177  
## [18,] -0.001353777 -0.002401711  
## [19,] -0.109908854 -0.515460443  
## [20,] -0.002057623 -0.001754877  
## [21,] -0.003524887 -0.009960595  
## [22,] -0.029159838 -0.006795874  
## [23,] -0.007067910 -0.013541168  
## [24,] -0.240850718 -0.079986887  
## [25,] -0.032841445 -0.018670859  
## [26,] -0.007791127 -0.003289482  
## [27,] -39.084548848 -5.906254617  
## [28,] -0.018904414 -0.018684249  
## [29,] -0.001746191 -0.002076249  
## [30,] -0.009230159 -0.003507291  
## [31,] -0.010316801 -0.011562163  
## [32,] -0.004036201 -0.003390179  
## [33,] -0.010787676 -0.013322500  
## [34,] -0.105409866 -0.056661712  
## [35,] -0.001914265 -0.002169666  
## [36,] -0.011863202 -0.040630780  
## [37,] -0.002193083 -0.002556821  
## [38,] -3.246268446 -3.321698691  
## [39,] -0.008117273 -0.023771954  
## [40,] -0.047587463 -0.144401671  
## [41,] -0.006465672 -0.022136029  
## [42,] -0.052784325 -0.463885053  
## [43,] -0.002458681 -0.003229827  
## [44,] -0.003759454 -0.002340948  
## [45,] -0.004679365 -0.003226317  
## [46,] -0.002050683 -0.002004052  
## [47,] -44.050615165 0.160274760  
## [48,] -0.011240378 -0.013150411  
## [49,] -0.002331754 -0.002047000  
## [50,] -0.003543788 -0.004063574  
##   
##   
## $startweights  
## $startweights[[1]]  
## $startweights[[1]][[1]]  
## [,1] [,2] [,3] [,4] [,5]  
## [1,] 0.91897737 -1.98935170 -0.1557955 0.4179416 0.38767161  
## [2,] 0.78213630 0.61982575 -1.4707524 1.3586796 -0.05380504  
## [3,] 0.07456498 -0.05612874 -0.4781501 -0.1027877 -1.37705956  
##   
## $startweights[[1]][[2]]  
## [,1] [,2] [,3] [,4] [,5] [,6]  
## [1,] -0.4149946 -0.2533617 0.7685329 -1.1293631 -0.13505460 0.1887923  
## [2,] -0.3942900 0.6969634 -0.1123462 1.4330237 2.40161776 -1.8049586  
## [3,] -0.0593134 0.5566632 0.8811077 1.9803999 -0.03924000 1.4655549  
## [4,] 1.1000254 -0.6887557 0.3981059 -0.3672215 0.68973936 0.1532533  
## [5,] 0.7631757 -0.7074952 -0.6120264 -1.0441346 0.02800216 2.1726117  
## [6,] -0.1645236 0.3645820 0.3411197 0.5697196 -0.74327321 0.4755095  
## [,7] [,8] [,9] [,10]  
## [1,] -0.7099464 0.001105352 -1.5235668 0.2670988  
## [2,] 0.6107264 0.074341324 0.5939462 -0.5425200  
## [3,] -0.9340976 -0.589520946 0.3329504 1.2078678  
## [4,] -1.2536334 -0.568668733 1.0630998 1.1604026  
## [5,] 0.2914462 -0.135178615 -0.3041839 0.7002136  
## [6,] -0.4432919 1.178086997 0.3700188 1.5868335  
##   
## $startweights[[1]][[3]]  
## [,1]  
## [1,] 0.55848643  
## [2,] -1.27659221  
## [3,] -0.57326541  
## [4,] -1.22461261  
## [5,] -0.47340064  
## [6,] -0.62036668  
## [7,] 0.04211587  
## [8,] -0.91092165  
## [9,] 0.15802877  
## [10,] -0.65458464  
## [11,] 1.76728727  
##   
##   
##   
## $result.matrix  
## [,1]  
## error 5.357529e-03  
## reached.threshold 9.485465e-03  
## steps 3.872330e+05  
## Intercept.to.1layhid1 5.306985e+00  
## x1.to.1layhid1 3.165482e-01  
## x2.to.1layhid1 -6.603752e-01  
## Intercept.to.1layhid2 -4.743825e+00  
## x1.to.1layhid2 3.623006e-01  
## x2.to.1layhid2 3.422437e-01  
## Intercept.to.1layhid3 3.493748e+00  
## x1.to.1layhid3 -3.077353e-01  
## x2.to.1layhid3 -2.800632e-01  
## Intercept.to.1layhid4 2.101158e+00  
## x1.to.1layhid4 4.667796e-01  
## x2.to.1layhid4 -2.745539e-01  
## Intercept.to.1layhid5 -1.912557e+00  
## x1.to.1layhid5 3.315504e-01  
## x2.to.1layhid5 -9.914733e-01  
## Intercept.to.2layhid1 -3.552167e-01  
## 1layhid1.to.2layhid1 1.044377e+00  
## 1layhid2.to.2layhid1 4.478869e+00  
## 1layhid3.to.2layhid1 -5.235710e+00  
## 1layhid4.to.2layhid1 3.674822e+00  
## 1layhid5.to.2layhid1 -4.318563e+00  
## Intercept.to.2layhid2 -4.221027e-01  
## 1layhid1.to.2layhid2 2.090261e+00  
## 1layhid2.to.2layhid2 3.058882e+00  
## 1layhid3.to.2layhid2 -1.089773e+01  
## 1layhid4.to.2layhid2 -1.059583e+00  
## 1layhid5.to.2layhid2 -1.817862e+02  
## Intercept.to.2layhid3 2.475597e-01  
## 1layhid1.to.2layhid3 1.651334e+00  
## 1layhid2.to.2layhid3 1.588692e+00  
## 1layhid3.to.2layhid3 -5.553136e+00  
## 1layhid4.to.2layhid3 -4.137183e-01  
## 1layhid5.to.2layhid3 -1.278871e+02  
## Intercept.to.2layhid4 -1.672978e+00  
## 1layhid1.to.2layhid4 8.875250e-01  
## 1layhid2.to.2layhid4 4.541940e+00  
## 1layhid3.to.2layhid4 -1.666798e+01  
## 1layhid4.to.2layhid4 -1.732491e+00  
## 1layhid5.to.2layhid4 -2.848741e+02  
## Intercept.to.2layhid5 -1.337005e+00  
## 1layhid1.to.2layhid5 3.325047e+00  
## 1layhid2.to.2layhid5 2.592082e+00  
## 1layhid3.to.2layhid5 -3.270286e+00  
## 1layhid4.to.2layhid5 -5.604287e-01  
## 1layhid5.to.2layhid5 -6.233695e+00  
## Intercept.to.2layhid6 -2.247352e-01  
## 1layhid1.to.2layhid6 -1.097388e+00  
## 1layhid2.to.2layhid6 3.685165e+00  
## 1layhid3.to.2layhid6 -7.270583e+00  
## 1layhid4.to.2layhid6 1.848324e+00  
## 1layhid5.to.2layhid6 -1.366297e-01  
## Intercept.to.2layhid7 -3.035726e-01  
## 1layhid1.to.2layhid7 1.885859e+00  
## 1layhid2.to.2layhid7 1.504199e+00  
## 1layhid3.to.2layhid7 -5.534972e+00  
## 1layhid4.to.2layhid7 1.179511e+00  
## 1layhid5.to.2layhid7 -6.424275e+00  
## Intercept.to.2layhid8 -3.521843e-01  
## 1layhid1.to.2layhid8 1.378183e+00  
## 1layhid2.to.2layhid8 3.111007e+00  
## 1layhid3.to.2layhid8 -4.363873e+00  
## 1layhid4.to.2layhid8 1.056583e+00  
## 1layhid5.to.2layhid8 -3.506393e+01  
## Intercept.to.2layhid9 -1.522324e+00  
## 1layhid1.to.2layhid9 1.918615e+00  
## 1layhid2.to.2layhid9 3.667998e+00  
## 1layhid3.to.2layhid9 -2.755319e+00  
## 1layhid4.to.2layhid9 -2.898827e-01  
## 1layhid5.to.2layhid9 -3.394372e+00  
## Intercept.to.2layhid10 -8.828757e-01  
## 1layhid1.to.2layhid10 -3.701397e-02  
## 1layhid2.to.2layhid10 1.232191e+01  
## 1layhid3.to.2layhid10 -4.958940e+00  
## 1layhid4.to.2layhid10 5.845695e+00  
## 1layhid5.to.2layhid10 1.183848e+00  
## Intercept.to.trainingoutput -8.654180e+00  
## 2layhid1.to.trainingoutput 1.515162e+01  
## 2layhid2.to.trainingoutput 1.482613e+01  
## 2layhid3.to.trainingoutput 7.702594e+00  
## 2layhid4.to.trainingoutput 6.663705e+01  
## 2layhid5.to.trainingoutput 6.731100e+00  
## 2layhid6.to.trainingoutput 9.002911e+00  
## 2layhid7.to.trainingoutput 8.670619e+00  
## 2layhid8.to.trainingoutput 6.430165e+00  
## 2layhid9.to.trainingoutput 6.599582e+00  
## 2layhid10.to.trainingoutput 8.685164e+00  
##   
## attr(,"class")  
## [1] "nn"

#Plot the neural network  
plot(net.multi)  
A close up of a map

Description automatically generated#Test the neural network on some training data  
testdata <- data.frame(x1=runif(20, min=0, max=10), x2=runif(20, min=0, max=10))  
net.results <- predict(net.multi, testdata) #Run them through the neural network  
  
#Lets see the results  
print(net.results)

## [,1]  
## [1,] 28.6837155  
## [2,] 57.6084736  
## [3,] 32.1724326  
## [4,] 21.5925439  
## [5,] 44.8006998  
## [6,] 50.0122773  
## [7,] 40.9470385  
## [8,] 15.4294007  
## [9,] 8.0233810  
## [10,] 9.3448784  
## [11,] 29.2949060  
## [12,] 7.1837493  
## [13,] 38.6326382  
## [14,] 10.7750740  
## [15,] 10.9987670  
## [16,] 0.5560325  
## [17,] 19.2657840  
## [18,] 82.7270966  
## [19,] 26.6963424  
## [20,] 12.3637368

#Lets display a better version of the results  
cleanoutput <- cbind(testdata,testdata$x1\*testdata$x2,  
 as.data.frame(net.results))  
colnames(cleanoutput) <- c("Input-x1","Input-x2","ExpectedOutput","NeuralNetOutput")  
print(cleanoutput)

## Input-x1 Input-x2 ExpectedOutput NeuralNetOutput  
## 1 7.6322269 3.744869 28.5816872 28.6837155  
## 2 9.4796635 6.314202 59.8565132 57.6084736  
## 3 8.1863469 3.900789 31.9332146 32.1724326  
## 4 3.0829233 6.896278 21.2606977 21.5925439  
## 5 6.4957946 6.894134 44.7828793 44.8006998  
## 6 9.5335545 5.549006 52.9017534 50.0122773  
## 7 9.5373265 4.296244 40.9746825 40.9470385  
## 8 3.3997920 4.527201 15.3915406 15.4294007  
## 9 2.6247411 3.064433 8.0433422 8.0233810  
## 10 1.6545393 5.783539 9.5690935 9.3448784  
## 11 3.2216806 9.103703 29.3292232 29.2949060  
## 12 5.1012521 1.426041 7.2745937 7.1837493  
## 13 9.2396847 4.150476 38.3490920 38.6326382  
## 14 5.1095970 2.109258 10.7774558 10.7750740  
## 15 2.5762126 4.287504 11.0455211 10.9987670  
## 16 0.4646089 1.326900 0.6164894 0.5560325  
## 17 4.1785626 4.600964 19.2254179 19.2657840  
## 18 8.5400150 9.429571 80.5286745 82.7270966  
## 19 3.4723068 7.619739 26.4580700 26.6963424  
## 20 1.3144232 9.329098 12.2623833 12.3637368

(sum((cleanoutput$NeuralNetOutput - cleanoutput$ExpectedOutput)^2) / nrow(cleanoutput)) ^ 0.5

## [1] 0.9651712

net.multi <- neuralnet(trainingoutput~x1+x2,data=trainingdata, hidden=c(10,5), threshold=0.01,stepmax = 1e16)  
print(net.multi)

## $call  
## neuralnet(formula = trainingoutput ~ x1 + x2, data = trainingdata,   
## hidden = c(10, 5), threshold = 0.01, stepmax = 1e+16)  
##   
## $response  
## trainingoutput  
## 1 12.681215  
## 2 32.047663  
## 3 25.096540  
## 4 22.232679  
## 5 1.425469  
## 6 8.935937  
## 7 29.877406  
## 8 34.271238  
## 9 41.647669  
## 10 2.513652  
## 11 18.802923  
## 12 5.183766  
## 13 31.538864  
## 14 12.767403  
## 15 50.106704  
## 16 12.841476  
## 17 34.341293  
## 18 76.010822  
## 19 3.201679  
## 20 68.051439  
## 21 31.693325  
## 22 17.808099  
## 23 22.592454  
## 24 4.190714  
## 25 12.729090  
## 26 34.449035  
## 27 1.157379  
## 28 14.912730  
## 29 67.602870  
## 30 32.694537  
## 31 20.954069  
## 32 42.719945  
## 33 19.741374  
## 34 6.058630  
## 35 62.639371  
## 36 13.549303  
## 37 56.480082  
## 38 1.313587  
## 39 17.766272  
## 40 5.893743  
## 41 19.672288  
## 42 3.813409  
## 43 50.286852  
## 44 48.460869  
## 45 41.260636  
## 46 62.936069  
## 47 1.062210  
## 48 19.570445  
## 49 59.381142  
## 50 41.905638  
##   
## $covariate  
## x1 x2  
## [1,] 2.6550866 4.7761962  
## [2,] 3.7212390 8.6120948  
## [3,] 5.7285336 4.3809711  
## [4,] 9.0820779 2.4479728  
## [5,] 2.0168193 0.7067905  
## [6,] 8.9838968 0.9946616  
## [7,] 9.4467527 3.1627171  
## [8,] 6.6079779 5.1863426  
## [9,] 6.2911404 6.6200508  
## [10,] 0.6178627 4.0683019  
## [11,] 2.0597457 9.1287592  
## [12,] 1.7655675 2.9360337  
## [13,] 6.8702285 4.5906573  
## [14,] 3.8410372 3.3239467  
## [15,] 7.6984142 6.5087047  
## [16,] 4.9769924 2.5801678  
## [17,] 7.1761851 4.7854525  
## [18,] 9.9190609 7.6631067  
## [19,] 3.8003518 0.8424691  
## [20,] 7.7744522 8.7532133  
## [21,] 9.3470523 3.3907294  
## [22,] 2.1214252 8.3944035  
## [23,] 6.5167377 3.4668349  
## [24,] 1.2555510 3.3377493  
## [25,] 2.6722067 4.7635125  
## [26,] 3.8611409 8.9219834  
## [27,] 0.1339033 8.6433947  
## [28,] 3.8238796 3.8998954  
## [29,] 8.6969085 7.7732070  
## [30,] 3.4034900 9.6061800  
## [31,] 4.8208012 4.3465948  
## [32,] 5.9956583 7.1251468  
## [33,] 4.9354131 3.9999437  
## [34,] 1.8621760 3.2535215  
## [35,] 8.2737332 7.5708715  
## [36,] 6.6846674 2.0269226  
## [37,] 7.9423986 7.1112122  
## [38,] 1.0794363 1.2169192  
## [39,] 7.2371095 2.4548851  
## [40,] 4.1127443 1.4330438  
## [41,] 8.2094629 2.3962942  
## [42,] 6.4706019 0.5893438  
## [43,] 7.8293276 6.4228826  
## [44,] 5.5303631 8.7626921  
## [45,] 5.2971958 7.7891468  
## [46,] 7.8935623 7.9730883  
## [47,] 0.2333120 4.5527445  
## [48,] 4.7723007 4.1008408  
## [49,] 7.3231374 8.1087024  
## [50,] 6.9273156 6.0493329  
##   
## $model.list  
## $model.list$response  
## [1] "trainingoutput"  
##   
## $model.list$variables  
## [1] "x1" "x2"  
##   
##   
## $err.fct  
## function (x, y)   
## {  
## 1/2 \* (y - x)^2  
## }  
## <bytecode: 0x7f87234874c8>  
## <environment: 0x7f87248b46d0>  
## attr(,"type")  
## [1] "sse"  
##   
## $act.fct  
## function (x)   
## {  
## 1/(1 + exp(-x))  
## }  
## <bytecode: 0x7f87262f1d48>  
## <environment: 0x7f87248b3fd0>  
## attr(,"type")  
## [1] "logistic"  
##   
## $linear.output  
## [1] TRUE  
##   
## $data  
## x1 x2 trainingoutput  
## 1 2.6550866 4.7761962 12.681215  
## 2 3.7212390 8.6120948 32.047663  
## 3 5.7285336 4.3809711 25.096540  
## 4 9.0820779 2.4479728 22.232679  
## 5 2.0168193 0.7067905 1.425469  
## 6 8.9838968 0.9946616 8.935937  
## 7 9.4467527 3.1627171 29.877406  
## 8 6.6079779 5.1863426 34.271238  
## 9 6.2911404 6.6200508 41.647669  
## 10 0.6178627 4.0683019 2.513652  
## 11 2.0597457 9.1287592 18.802923  
## 12 1.7655675 2.9360337 5.183766  
## 13 6.8702285 4.5906573 31.538864  
## 14 3.8410372 3.3239467 12.767403  
## 15 7.6984142 6.5087047 50.106704  
## 16 4.9769924 2.5801678 12.841476  
## 17 7.1761851 4.7854525 34.341293  
## 18 9.9190609 7.6631067 76.010822  
## 19 3.8003518 0.8424691 3.201679  
## 20 7.7744522 8.7532133 68.051439  
## 21 9.3470523 3.3907294 31.693325  
## 22 2.1214252 8.3944035 17.808099  
## 23 6.5167377 3.4668349 22.592454  
## 24 1.2555510 3.3377493 4.190714  
## 25 2.6722067 4.7635125 12.729090  
## 26 3.8611409 8.9219834 34.449035  
## 27 0.1339033 8.6433947 1.157379  
## 28 3.8238796 3.8998954 14.912730  
## 29 8.6969085 7.7732070 67.602870  
## 30 3.4034900 9.6061800 32.694537  
## 31 4.8208012 4.3465948 20.954069  
## 32 5.9956583 7.1251468 42.719945  
## 33 4.9354131 3.9999437 19.741374  
## 34 1.8621760 3.2535215 6.058630  
## 35 8.2737332 7.5708715 62.639371  
## 36 6.6846674 2.0269226 13.549303  
## 37 7.9423986 7.1112122 56.480082  
## 38 1.0794363 1.2169192 1.313587  
## 39 7.2371095 2.4548851 17.766272  
## 40 4.1127443 1.4330438 5.893743  
## 41 8.2094629 2.3962942 19.672288  
## 42 6.4706019 0.5893438 3.813409  
## 43 7.8293276 6.4228826 50.286852  
## 44 5.5303631 8.7626921 48.460869  
## 45 5.2971958 7.7891468 41.260636  
## 46 7.8935623 7.9730883 62.936069  
## 47 0.2333120 4.5527445 1.062210  
## 48 4.7723007 4.1008408 19.570445  
## 49 7.3231374 8.1087024 59.381142  
## 50 6.9273156 6.0493329 41.905638  
##   
## $exclude  
## NULL  
##   
## $net.result  
## $net.result[[1]]  
## [,1]  
## [1,] 12.673759  
## [2,] 32.035390  
## [3,] 25.096213  
## [4,] 22.245438  
## [5,] 1.473321  
## [6,] 8.934203  
## [7,] 29.872594  
## [8,] 34.270888  
## [9,] 41.646933  
## [10,] 2.513399  
## [11,] 18.779142  
## [12,] 5.164633  
## [13,] 31.533408  
## [14,] 12.768903  
## [15,] 50.103698  
## [16,] 12.855362  
## [17,] 34.347619  
## [18,] 76.006658  
## [19,] 3.172000  
## [20,] 68.054435  
## [21,] 31.695210  
## [22,] 17.837519  
## [23,] 22.586564  
## [24,] 4.205031  
## [25,] 12.720730  
## [26,] 34.451060  
## [27,] 1.158756  
## [28,] 14.902423  
## [29,] 67.626860  
## [30,] 32.702748  
## [31,] 20.966807  
## [32,] 42.711427  
## [33,] 19.740239  
## [34,] 6.072580  
## [35,] 62.620474  
## [36,] 13.545587  
## [37,] 56.499234  
## [38,] 1.276660  
## [39,] 17.764045  
## [40,] 5.903563  
## [41,] 19.663311  
## [42,] 3.818786  
## [43,] 50.280633  
## [44,] 48.458217  
## [45,] 41.267471  
## [46,] 62.904148  
## [47,] 1.062390  
## [48,] 19.572699  
## [49,] 59.398275  
## [50,] 41.910615  
##   
##   
## $weights  
## $weights[[1]]  
## $weights[[1]][[1]]  
## [,1] [,2] [,3] [,4] [,5] [,6]  
## [1,] -1.3659654 -0.5287725 -3.5486671 -2.6923578 1.4755660 6.1693998  
## [2,] 1.1583527 0.1539680 -1.4635407 0.4066105 0.1762529 -0.4210939  
## [3,] -0.1214929 0.5832828 0.3532801 0.2637745 -0.9599647 -0.3170062  
## [,7] [,8] [,9] [,10]  
## [1,] 1.4669839 2.7194705 -1.4275043 1.68093708  
## [2,] -0.4109916 -0.1610761 0.2575187 -0.43961823  
## [3,] 1.2272652 -0.4390666 -0.1853609 -0.04220407  
##   
## $weights[[1]][[2]]  
## [,1] [,2] [,3] [,4] [,5]  
## [1,] 1.336118 -1.9839815 2.023526696 -7.875792e-02 0.01700331  
## [2,] 0.843029 -1.6860662 2.374793011 8.885473e-01 2.31609850  
## [3,] -1.017594 -0.4291021 0.006362132 2.722507e-01 2.39885163  
## [4,] -16.270114 -3.4753687 5.529294715 -2.616650e+03 -0.08631115  
## [5,] 1.207864 -1.0528923 1.538815869 5.126486e-01 0.48167700  
## [6,] -1.418668 12.2576180 -2.534647395 -1.445947e+01 -1.77646207  
## [7,] -1.224285 8.0642423 -5.279574277 -8.490440e+00 -3.29526109  
## [8,] 3.970987 -1.6855173 0.984107075 2.557805e+00 1.00422956  
## [9,] -3.780219 3.6657003 -4.251714877 -8.414310e+00 -3.60454873  
## [10,] 2.669028 -0.3536503 -0.116615710 1.092318e+00 1.29072057  
## [11,] -2.120577 3.7642934 -3.912978300 2.856890e+00 -2.99582838  
##   
## $weights[[1]][[3]]  
## [,1]  
## [1,] 13.51623  
## [2,] 13.33814  
## [3,] -14.29800  
## [4,] 18.20367  
## [5,] 26.11620  
## [6,] 16.61165  
##   
##   
##   
## $generalized.weights  
## $generalized.weights[[1]]  
## [,1] [,2]  
## [1,] -0.031694244 -0.017657729  
## [2,] -0.008701219 -0.003782826  
## [3,] -0.007207587 -0.009391084  
## [4,] -0.005293473 -0.019255897  
## [5,] -1.090669637 -2.513056682  
## [6,] -0.021910552 -0.102044967  
## [7,] -0.003800670 -0.011006149  
## [8,] -0.004598002 -0.005826322  
## [9,] -0.003899047 -0.003692996  
## [10,] -1.076261368 -0.130063163  
## [11,] -0.025560324 -0.005760028  
## [12,] -0.138417214 -0.086432001  
## [13,] -0.004798987 -0.007157270  
## [14,] -0.021689552 -0.025208014  
## [15,] -0.002667878 -0.003167398  
## [16,] -0.016649890 -0.031536816  
## [17,] -0.004181107 -0.006276607  
## [18,] -0.001198778 -0.001393784  
## [19,] -0.107805742 -0.526893019  
## [20,] -0.001830319 -0.001691401  
## [21,] -0.003598772 -0.009707093  
## [22,] -0.025996141 -0.006716608  
## [23,] -0.007115883 -0.013435829  
## [24,] -0.246106157 -0.098583087  
## [25,] -0.031397846 -0.017633247  
## [26,] -0.007695078 -0.003393022  
## [27,] -7.601672278 -3.997252236  
## [28,] -0.018724734 -0.018480896  
## [29,] -0.001764125 -0.001908526  
## [30,] -0.009555297 -0.003392121  
## [31,] -0.010385748 -0.011568413  
## [32,] -0.003971533 -0.003349706  
## [33,] -0.010860015 -0.013511672  
## [34,] -0.106932795 -0.063258110  
## [35,] -0.001973350 -0.002129627  
## [36,] -0.011519071 -0.040109853  
## [37,] -0.002274413 -0.002508208  
## [38,] -3.233556764 -2.926160948  
## [39,] -0.008236163 -0.024310813  
## [40,] -0.048632827 -0.150223338  
## [41,] -0.006529321 -0.022613426  
## [42,] -0.066418655 -0.430298049  
## [43,] -0.002611194 -0.003215933  
## [44,] -0.003921593 -0.002409396  
## [45,] -0.004688394 -0.003173415  
## [46,] -0.002035538 -0.002029190  
## [47,] -57.043091386 -0.118485764  
## [48,] -0.011323091 -0.013285101  
## [49,] -0.002317155 -0.002145847  
## [50,] -0.003496584 -0.004021453  
##   
##   
## $startweights  
## $startweights[[1]]  
## $startweights[[1]][[1]]  
## [,1] [,2] [,3] [,4] [,5] [,6]  
## [1,] -0.07356440 -0.32427027 0.5314962 -1.5364498 -0.65209478 1.1765833  
## [2,] -0.03763417 0.06016044 -1.5183941 -0.3009761 -0.05689678 -1.6649724  
## [3,] -0.68166048 -0.58889449 0.3065579 -0.5282799 -1.91435943 -0.4635304  
## [,7] [,8] [,9] [,10]  
## [1,] -1.115920 0.01739562 0.45018710 -0.9293621  
## [2,] -0.750819 -1.28630053 -0.01855983 -1.4874603  
## [3,] 2.087167 -1.64060553 -0.31806837 -1.0751923  
##   
## $startweights[[1]][[2]]  
## [,1] [,2] [,3] [,4] [,5]  
## [1,] 1.0000288 -1.42449465 1.0273924 -0.9261095 0.40940184  
## [2,] -0.6212667 -0.14439960 1.2079084 -0.1771040 1.68887329  
## [3,] -1.3844268 0.20753834 -1.2313234 0.4020118 1.58658843  
## [4,] 1.8692906 2.30797840 0.9838956 -0.7317482 -0.33090780  
## [5,] 0.4251004 0.10580237 0.2199248 0.8303732 -2.28523554  
## [6,] -0.2386471 0.45699881 -1.4672500 -1.2080828 2.49766159  
## [7,] 1.0584830 -0.07715294 0.5210227 -1.0479844 0.66706617  
## [8,] 0.8864227 -0.33400084 -0.1587546 1.4411577 0.54132734  
## [9,] -0.6192430 -0.03472603 1.4645873 -1.0158475 -0.01339952  
## [10,] 2.2061025 0.78763961 -0.7660820 0.4119747 0.51010842  
## [11,] -0.2550270 2.07524501 -0.4302118 -0.3810761 -0.16437583  
##   
## $startweights[[1]][[3]]  
## [,1]  
## [1,] 0.4206946  
## [2,] -0.4002467  
## [3,] -1.3702079  
## [4,] 0.9878383  
## [5,] 1.5197450  
## [6,] -0.3087406  
##   
##   
##   
## $result.matrix  
## [,1]  
## error 5.455025e-03  
## reached.threshold 9.881563e-03  
## steps 7.715600e+04  
## Intercept.to.1layhid1 -1.365965e+00  
## x1.to.1layhid1 1.158353e+00  
## x2.to.1layhid1 -1.214929e-01  
## Intercept.to.1layhid2 -5.287725e-01  
## x1.to.1layhid2 1.539680e-01  
## x2.to.1layhid2 5.832828e-01  
## Intercept.to.1layhid3 -3.548667e+00  
## x1.to.1layhid3 -1.463541e+00  
## x2.to.1layhid3 3.532801e-01  
## Intercept.to.1layhid4 -2.692358e+00  
## x1.to.1layhid4 4.066105e-01  
## x2.to.1layhid4 2.637745e-01  
## Intercept.to.1layhid5 1.475566e+00  
## x1.to.1layhid5 1.762529e-01  
## x2.to.1layhid5 -9.599647e-01  
## Intercept.to.1layhid6 6.169400e+00  
## x1.to.1layhid6 -4.210939e-01  
## x2.to.1layhid6 -3.170062e-01  
## Intercept.to.1layhid7 1.466984e+00  
## x1.to.1layhid7 -4.109916e-01  
## x2.to.1layhid7 1.227265e+00  
## Intercept.to.1layhid8 2.719470e+00  
## x1.to.1layhid8 -1.610761e-01  
## x2.to.1layhid8 -4.390666e-01  
## Intercept.to.1layhid9 -1.427504e+00  
## x1.to.1layhid9 2.575187e-01  
## x2.to.1layhid9 -1.853609e-01  
## Intercept.to.1layhid10 1.680937e+00  
## x1.to.1layhid10 -4.396182e-01  
## x2.to.1layhid10 -4.220407e-02  
## Intercept.to.2layhid1 1.336118e+00  
## 1layhid1.to.2layhid1 8.430290e-01  
## 1layhid2.to.2layhid1 -1.017594e+00  
## 1layhid3.to.2layhid1 -1.627011e+01  
## 1layhid4.to.2layhid1 1.207864e+00  
## 1layhid5.to.2layhid1 -1.418668e+00  
## 1layhid6.to.2layhid1 -1.224285e+00  
## 1layhid7.to.2layhid1 3.970987e+00  
## 1layhid8.to.2layhid1 -3.780219e+00  
## 1layhid9.to.2layhid1 2.669028e+00  
## 1layhid10.to.2layhid1 -2.120577e+00  
## Intercept.to.2layhid2 -1.983981e+00  
## 1layhid1.to.2layhid2 -1.686066e+00  
## 1layhid2.to.2layhid2 -4.291021e-01  
## 1layhid3.to.2layhid2 -3.475369e+00  
## 1layhid4.to.2layhid2 -1.052892e+00  
## 1layhid5.to.2layhid2 1.225762e+01  
## 1layhid6.to.2layhid2 8.064242e+00  
## 1layhid7.to.2layhid2 -1.685517e+00  
## 1layhid8.to.2layhid2 3.665700e+00  
## 1layhid9.to.2layhid2 -3.536503e-01  
## 1layhid10.to.2layhid2 3.764293e+00  
## Intercept.to.2layhid3 2.023527e+00  
## 1layhid1.to.2layhid3 2.374793e+00  
## 1layhid2.to.2layhid3 6.362132e-03  
## 1layhid3.to.2layhid3 5.529295e+00  
## 1layhid4.to.2layhid3 1.538816e+00  
## 1layhid5.to.2layhid3 -2.534647e+00  
## 1layhid6.to.2layhid3 -5.279574e+00  
## 1layhid7.to.2layhid3 9.841071e-01  
## 1layhid8.to.2layhid3 -4.251715e+00  
## 1layhid9.to.2layhid3 -1.166157e-01  
## 1layhid10.to.2layhid3 -3.912978e+00  
## Intercept.to.2layhid4 -7.875792e-02  
## 1layhid1.to.2layhid4 8.885473e-01  
## 1layhid2.to.2layhid4 2.722507e-01  
## 1layhid3.to.2layhid4 -2.616650e+03  
## 1layhid4.to.2layhid4 5.126486e-01  
## 1layhid5.to.2layhid4 -1.445947e+01  
## 1layhid6.to.2layhid4 -8.490440e+00  
## 1layhid7.to.2layhid4 2.557805e+00  
## 1layhid8.to.2layhid4 -8.414310e+00  
## 1layhid9.to.2layhid4 1.092318e+00  
## 1layhid10.to.2layhid4 2.856890e+00  
## Intercept.to.2layhid5 1.700331e-02  
## 1layhid1.to.2layhid5 2.316098e+00  
## 1layhid2.to.2layhid5 2.398852e+00  
## 1layhid3.to.2layhid5 -8.631115e-02  
## 1layhid4.to.2layhid5 4.816770e-01  
## 1layhid5.to.2layhid5 -1.776462e+00  
## 1layhid6.to.2layhid5 -3.295261e+00  
## 1layhid7.to.2layhid5 1.004230e+00  
## 1layhid8.to.2layhid5 -3.604549e+00  
## 1layhid9.to.2layhid5 1.290721e+00  
## 1layhid10.to.2layhid5 -2.995828e+00  
## Intercept.to.trainingoutput 1.351623e+01  
## 2layhid1.to.trainingoutput 1.333814e+01  
## 2layhid2.to.trainingoutput -1.429800e+01  
## 2layhid3.to.trainingoutput 1.820367e+01  
## 2layhid4.to.trainingoutput 2.611620e+01  
## 2layhid5.to.trainingoutput 1.661165e+01  
##   
## attr(,"class")  
## [1] "nn"

#Plot the neural network  
plot(net.multi)

A close up of a map

Description automatically generated  
#Test the neural network on some training data  
testdata <- data.frame(x1=runif(20, min=0, max=10), x2=runif(20, min=0, max=10))  
net.results <- predict(net.multi, testdata) #Run them through the neural network  
  
#Lets see the results  
print(net.results)

## [,1]  
## [1,] 0.5814599  
## [2,] 52.7617099  
## [3,] 42.7278387  
## [4,] 3.1598949  
## [5,] 29.0568854  
## [6,] 7.0976135  
## [7,] 0.7532833  
## [8,] 13.9555120  
## [9,] 1.1950277  
## [10,] 26.9085013  
## [11,] 6.9210177  
## [12,] 39.6182959  
## [13,] 26.2224819  
## [14,] 15.2019665  
## [15,] 6.0200677  
## [16,] 4.1583250  
## [17,] 43.3236728  
## [18,] 42.0593237  
## [19,] 26.3655355  
## [20,] 6.8334377

#Lets display a better version of the results  
cleanoutput <- cbind(testdata,testdata$x1\*testdata$x2,  
 as.data.frame(net.results))  
colnames(cleanoutput) <- c("Input-x1","Input-x2","ExpectedOutput","NeuralNetOutput")  
print(cleanoutput)

## Input-x1 Input-x2 ExpectedOutput NeuralNetOutput  
## 1 1.0505014 0.54190429 0.56927121 0.5814599  
## 2 8.0168771 6.57828069 52.73726755 52.7617099  
## 3 7.3964175 5.78161917 42.76326894 42.7278387  
## 4 0.5214901 9.87101764 5.14763831 3.1598949  
## 5 4.8216957 6.03792401 29.11303245 29.0568854  
## 6 9.2051784 0.64949919 5.97875590 7.0976135  
## 7 0.4152843 1.62109082 0.67321355 0.7532833  
## 8 2.9399180 4.75397920 13.97630899 13.9555120  
## 9 5.0085049 0.01932835 0.09680612 1.1950277  
## 10 6.0974894 4.41459143 26.91792424 26.9085013  
## 11 2.6424905 2.60929737 6.89504351 6.9210177  
## 12 4.2309861 9.38413745 39.70415509 39.6182959  
## 13 3.6656362 7.15833284 26.23984372 26.2224819  
## 14 9.4250532 1.63085478 15.37089314 15.2019665  
## 15 1.2372357 4.76188018 5.89156793 6.0200677  
## 16 0.7003268 6.90256723 4.83405277 4.1583250  
## 17 9.6431704 4.60895180 44.44490743 43.3236728  
## 18 4.4251011 9.55146738 42.26620866 42.0593237  
## 19 3.7027238 7.12540122 26.38339272 26.3655355  
## 20 1.7024358 3.97147933 6.76118860 6.8334377

(sum((cleanoutput$NeuralNetOutput - cleanoutput$ExpectedOutput)^2) / nrow(cleanoutput)) ^ 0.5

## [1] 0.6417419

The model with 4 layers and 10 nodes in each layer has the smallest error rate with an accuracy 99.7828%. The input layer has 2 nodes, x1 and x2, the second layer and the third layer has 10 nodes and the output layer has one node.

## Problem 2

Create a neural network that predicts a hitters salary will be above the median or below using the Hitters Dataset. You will have to create a variable “above median salary” and “below median salary”.

library(ISLR)  
data("Hitters")  
Hitters <- Hitters[-which(is.na(Hitters$Salary)), ]  
sum(is.na(Hitters$Salary))

## [1] 0

Hitters$above.ms<- ifelse(Hitters$Salary>=median(Hitters$Salary),1,0)  
head(Hitters)

## AtBat Hits HmRun Runs RBI Walks Years CAtBat CHits CHmRun  
## -Alan Ashby 315 81 7 24 38 39 14 3449 835 69  
## -Alvin Davis 479 130 18 66 72 76 3 1624 457 63  
## -Andre Dawson 496 141 20 65 78 37 11 5628 1575 225  
## -Andres Galarraga 321 87 10 39 42 30 2 396 101 12  
## -Alfredo Griffin 594 169 4 74 51 35 11 4408 1133 19  
## -Al Newman 185 37 1 23 8 21 2 214 42 1  
## CRuns CRBI CWalks League Division PutOuts Assists Errors  
## -Alan Ashby 321 414 375 N W 632 43 10  
## -Alvin Davis 224 266 263 A W 880 82 14  
## -Andre Dawson 828 838 354 N E 200 11 3  
## -Andres Galarraga 48 46 33 N E 805 40 4  
## -Alfredo Griffin 501 336 194 A W 282 421 25  
## -Al Newman 30 9 24 N E 76 127 7  
## Salary NewLeague above.ms  
## -Alan Ashby 475.0 N 1  
## -Alvin Davis 480.0 A 1  
## -Andre Dawson 500.0 N 1  
## -Andres Galarraga 91.5 N 0  
## -Alfredo Griffin 750.0 A 1  
## -Al Newman 70.0 A 0

# Random sampling  
samplesize = 0.60 \* nrow(Hitters)  
set.seed(80)  
index = sample( seq\_len ( nrow ( Hitters ) ), size = samplesize )  
  
# Create training and test set  
datatrain = Hitters[ index, ]  
datatest = Hitters[ -index, ]

## Fit neural network   
library(neuralnet)  
  
# fit neural network  
set.seed(1)  
NN = neuralnet(above.ms ~AtBat+Hits+HmRun +Runs+ RBI+ Walks+ Years+ CAtBat+ CHits+ CHmRun+ CRuns+ CRBI+ CWalks+ PutOuts+ Assists+ Errors, data= datatrain, hidden = 3 , linear.output = F,stepmax = 1e16)  
  
# plot neural network  
plot(NN)  
A close up of a map

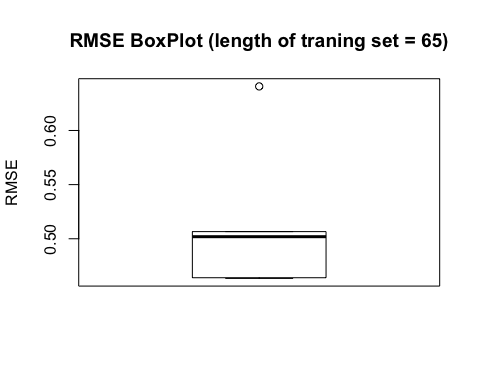
Description automatically generated

# Prediction using neural network  
  
predict\_testNN = compute(NN, datatest[,-c(14,15,10,20,21)])  
predict\_testNN = (predict\_testNN$net.result \* (max(Hitters$above.ms) - min(Hitters$above.ms))) + min(Hitters$above.ms)  
  
# Calculate Root Mean Square Error (RMSE)  
RMSE.NN = (sum((datatest$above.ms - predict\_testNN)^2) / nrow(datatest)) ^ 0.5  
RMSE.NN

## [1] 0.436304

## Cross validation of neural network model  
library(boot)  
library(plyr)  
  
# Initialize variables  
set.seed(50)  
k = 5  
RMSE.NN = NULL  
  
List = list( )  
  
# Fit neural network model within nested for loop  
for(j in 10:210){  
 for (i in 1:k) {  
 index = sample(1:nrow(Hitters),j )  
   
 trainNN = Hitters[index,]  
 testNN = Hitters[-index,]  
   
 NN = neuralnet(above.ms ~AtBat+Hits+HmRun +Runs+ RBI+ Walks+ Years+ CAtBat+ CHits+ CHmRun+ CRuns+ CRBI+ CWalks+ PutOuts+ Assists+ Errors, trainNN, hidden = 3, linear.output= F)  
 predict\_testNN = compute(NN,testNN[,-c(14,15,10,20,21)])  
 predict\_testNN = (predict\_testNN$net.result\*(max(Hitters$above.ms) - min(Hitters$above.ms))) + min(Hitters$above.ms)  
   
 RMSE.NN [i]<- (sum((testNN$above.ms - predict\_testNN)^2)/nrow(testNN))^0.5  
 }  
 List[[j]] = RMSE.NN  
}  
  
Matrix.RMSE = do.call(cbind, List)

## Prepare boxplot  
boxplot(Matrix.RMSE[,56], ylab = "RMSE", main = "RMSE BoxPlot (length of traning set = 65)")



library(matrixStats)

##   
## Attaching package: 'matrixStats'

## The following object is masked from 'package:plyr':  
##   
## count

med = colMedians(Matrix.RMSE)  
  
X = seq(10,210)  
  
plot (med~X, type = "l", xlab = "length of training set", ylab = "median RMSE", main = "Variation of RMSE with length of training set")

