





hidden nodes: 6 accuracy\_score: 0.7477477477477478

```
[[16  0  0  0  1  0  0  3]
 [ 0 13  0  0  0  0  0  0]
 [ 0  0 10  0  0  2  0  0]
 [ 0  2  0  2  0  0  0  7]
 [ 0  0  0  0 14  0  0  2]
 [ 0  0  0  0  1 12  3  0]
 [ 0  0  0  0  1  6  8  0]
 [ 0  0  0  0  0  0  0  8]]
```

hidden nodes: 8 accuracy\_score: 0.8378378378378378

```
[[20  0  0  0  0  0  0  0]
 [ 0 13  0  0  0  0  0  0]
 [ 0  0 10  0  0  0  1  1]
 [ 0  0  0  1  0  0  0 10]
 [ 2  0  0  1 13  0  0  0]
 [ 1  0  0  0  0 15  0  0]
 [ 0  0  0  0  0  2 13  0]
 [ 0  0  0  0  0  0  0  8]]
```

hidden nodes: 10 accuracy\_score: 0.8468468468468469

```
[[19  0  0  0  1  0  0  0]
 [ 0 13  0  0  0  0  0  0]
 [ 0  0 12  0  0  0  0  0]
 [ 0  1  0  5  0  0  0  5]
 [ 1  0  0  0 15  0  0  0]
 [ 1  0  0  0  0 15  0  0]
 [ 0  0  1  0  1  6  7  0]
 [ 0  0  0  0  0  0  0  8]]
```

hidden nodes: 12 accuracy\_score: 0.7927927927927928

```
[[16  0  0  0  2  0  0  2]
 [ 0 13  0  0  0  0  0  0]
 [ 0  0 10  0  0  0  1  1]
 [ 0  1  0  0  2  0  0  8]
 [ 0  0  0  0 16  0  0  0]
 [ 0  0  0  0  3 13  0  0]
 [ 0  0  0  0  1  1 13  0]
 [ 0  1  0  0  0  0  0  7]]
```

100 157 266 333 400 467 534 601 668 735 802 869 936 1003 1070 1137 1204 1271 1338 1405 1472 1539 1606 1673 1740 1807 1874 1941 2008 2075 2142 2209 2276 2343 2410 2477 2544 2611 2678 2745 2812 2879 2946 3013 3080 3147 3214 3281 3348 3415 3482 3549 3616 3683 3750 3817 3884 3951 4018 4085 4152 4219 4286 4353 4420 4487 4554 4621 4688 4755 4822 4889 4956 5023 5090 5157 5224 5291 5358 5425 5492 5559 5626 5693 5760 5827 5894 5961 6028 6095 6162 6229 6296 6363 6430 6497 6564 6631 6698 6765 6832 6899 6966 7033 7100 7167 7234 7301 7368 7435 7502 7569 7636 7703 7770 7837 7904 7971 8038 8105 8172 8239 8306 8373 8440 8507 8574 8641 8708 8775 8842 8909 8976 9043 9110 9177 9244 9311 9378 9445 9512 9579 9646 9713 9780 9847 9914 9981 10048 10115 10182 10249 10316 10383 10450 10517 10584 10651 10718 10785 10852 10919 10986 11053 11120 11187 11254 11321 11388 11455 11522 11589 11656 11723 11790 11857 11924 11991 12058 12125 12192 12259 12326 12393 12460 12527 12594 12661 12728 12795 12862 12929 13000 13067 13134 13201 13268 13335 13402 13469 13536 13603 13670 13737 13804 13871 13938 14005 14072 14139 14206 14273 14340 14407 14474 14541 14608 14675 14742 14809 14876 14943 15010 15077 15144 15211 15278 15345 15412 15479 15546 15613 15680 15747 15814 15881 15948 16015 16082 16149 16216 16283 16350 16417 16484 16551 16618 16685 16752 16819 16886 16953 17020 17087 17154 17221 17288 17355 17422 17489 17556 17623 17690 17757 17824 17891 17958 18025 18092 18159 18226 18293 18360 18427 18494 18561 18628 18695 18762 18829 18896 18963 19030 19097 19164 19231 19298 19365 19432 19499 19566 19633 19700 19767 19834 19901 19968 20035 20102 20169 20236 20303 20370 20437 20504 20571 20638 20705 20772 20839 20906 20973 21040 21107 21174 21241 21308 21375 21442 21509 21576 21643 21710 21777 21844 21911 21978 22045 22112 22179 22246 22313 22380 22447 22514 22581 22648 22715 22782 22849 22916 22983 23050 23117 23184 23251 23318 23385 23452 23519 23586 23653 23720 23787 23854 23921 23988 24055 24122 24189 24256 24323 24390 24457 24524 24591 24658 24725 24792 24859 24926 25000 25067 25134 25201 25268 25335 25402 25469 25536 25603 25670 25737 25804 25871 25938 26005 26072 26139 26206 26273 26340 26407 26474 26541 26608 26675 26742 26809 26876 26943 27010 27077 27144 27211 27278 27345 27412 27479 27546 27613 27680 27747 27814 27881 27948 28015 28082 28149 28216 28283 28350 28417 28484 28551 28618 28685 28752 28819 28886 28953 29020 29087 29154 29221 29288 29355 29422 29489 29556 29623 29690 29757 29824 29891 29958 30025 30092 30159 30226 30293 30360 30427 30494 30561 30628 30695 30762 30829 30896 30963 31030 31097 31164 31231 31298 31365 31432 31499 31566 31633 31700 31767 31834 31901 31968 32035 32102 32169 32236 32303 32370 32437 32504 32571 32638 32705 32772 32839 32906 32973 33040 33107 33174 33241 33308 33375 33442 33509 33576 33643 33710 33777 33844 33911 33978 34045 34112 34179 34246 34313 34380 34447 34514 34581 34648 34715 34782 34849 34916 34983 35050 35117 35184 35251 35318 35385 35452 35519 35586 35653 35720 35787 35854 35921 35988 36055 36122 36189 36256 36323 36390 36457 36524 36591 36658 36725 36792 36859 36926 36993 37060 37127 37194 37261 37328 37395 37462 37529 37596 37663 37730 37797 37864 37931 38000 38067 38134 38201 38268 38335 38402 38469 38536 38603 38670 38737 38804 38871 38938 39005 39072 39139 39206 39273 39340 39407 39474 39541 39608 39675 39742 39809 39876 39943 40010 40077 40144 40211 40278 40345 40412 40479 40546 40613 40680 40747 40814 40881 40948 41015 41082 41149 41216 41283 41350 41417 41484 41551 41618 41685 41752 41819 41886 41953 42020 42087 42154 42221 42288 42355 42422 42489 42556 42623 42690 42757 42824 42891 42958 43025 43092 43159 43226 43293 43360 43427 43494 43561 43628 43695 43762 43829 43896 43963 44030 44097 44164 44231 44298 44365 44432 44500 44567 44634 44701 44768 44835 44902 44969 45036 45103 45170 45237 45304 45371 45438 45505 45572 45639 45706 45773 45840 45907 45974 46041 46108 46175 46242 46309 46376 46443 46510 46577 46644 46711 46778 46845 46912 46979 47046 47113 47180 47247 47314 47381 47448 47515 47582 47649 47716 47783 47850 47917 47984 48051 48118 48185 48252 48319 48386 48453 48520 48587 48654 48721 48788 48855 48922 48989 49056 49123 49190 49257 49324 49391 49458 49525 49592 49659 49726 49793 49860 49927 50000 50067 50134 50201 50268 50335 50402 50469 50536 50603 50670 50737 50804 50871 50938 51005 51072 51139 51206 51273 51340 51407 51474 51541 51608 51675 51742 51809 51876 51943 52010 52077 52144 52211 52278 52345 52412 52479 52546 52613 52680 52747 52814 52881 52948 53015 53082 53149 53216 53283 53350 53417 53484 53551 53618 53685 53752 53819 53886 53953 54020 54087 54154 54221 54288 54355 54422 54489 54556 54623 54690 54757 54824 54891 54958 55025 55092 55159 55226 55293 55360 55427 55494 55561 55628 55695 55762 55829 55896 55963 56030 56097 56164 56231 56298 56365 56432 56500 56567 56634 56701 56768 56835 56902 56969 57036 57103 57170 57237 57304 57371 57438 57505 57572 57639 57706 57773 57840 57907 57974 58041 58108 58175 58242 58309 58376 58443 58510 58577 58644 58711 58778 58845 58912 58979 59046 59113 59180 59247 59314 59381 59448 59515 59582 59649 59716 59783 59850 59917 60000 60067 60134 60201 60268 60335 60402 60469 60536 60603 60670 60737 60804 60871 60938 61005 61072 61139 61206 61273 61340 61407 61474 61541 61608 61675 61742 61809 61876 61943 62010 62077 62144 62211 62278 62345 62412 62479 62546 62613 62680 62747 62814 62881 62948 63015 63082 63149 63216 63283 63350 63417 63484 63551 63618 63685 63752 63819 63886 63953 64020 64087 64154 64221 64288 64355 64422 64489 64556 64623 64690 64757 64824 64891 64958 65025 65092 65159 65226 65293 65360 65427 65494 65561 65628 65695 65762 65829 65896 65963 66030 66097 66164 66231 66298 66365 66432 66500 66567 66634 66701 66768 66835 66902 66969 67036 67103 67170 67237 67304 67371 67438 67505 67572 67639 67706 67773 67840 67907 67974 68041 68108 68175 68242 68309 68376 68443 68510 68577 68644 68711 68778 68845 68912 68979 69046 69113 69180 69247 69314 69381 69448 69515 69582 69649 69716 69783 69850 69917 70000 70067 70134 70201 70268 70335 70402 70469 70536 70603 70670 70737 70804 70871 70938 71005 71072 71139 71206 71273 71340 71407 71474 71541 71608 71675 71742 71809 71876 71943 72010 72077 72144 72211 72278 72345 72412 72479 72546 72613 72680 72747 72814 72881 72948 73015 73082 73149 73216 73283 73350 73417 73484 73551 73618 73685 73752 73819 73886 73953 74020 74087 74154 74221 74288 74355 74422 74489 74556 74623 74690 74757 74824 74891 74958 75025 75092 75159 75226 75293 75360 75427 75494 75561 75628 75695 75762 75829 75896 75963 76030 76097 76164 76231 76298 76365 76432 76500 76567 76634 76701 76768 76835 76902 76969 77036 77103 77170 77237 77304 77371 77438 77505 77572 77639 77706 77773 77840 77907 77974 78041 78108 78175 78242 78309 78376 78443 78510 78577 78644 78711 78778 78845 78912 78979 79046 79113 79180 79247 79314 79381 79448 79515 79582 79649 79716 79783 79850 79917 80000 80067 80134 80201 80268 80335 80402 80469 80536 80603 80670 80737 80804 80871 80938 81005 81072 81139 81206 81273 81340 81407 81474 81541 81608 81675 81742 81809 81876 81943 82010 82077 82144 82211 82278 82345 82412 82479 82546 82613 82680 82747 82814 82881 82948 83015 83082 83149 83216 83283 83350 83417 83484 83551 83618 83685 83752 83819 83886 83953 84020 84087 84154 84221 84288 84355 84422 84489 84556 84623 84690 84757 84824 84891 84958 85025 85092 85159 85226 85293 85360 85427 85494 85561 85628 85695 85762 85829 85896 85963 86030 86097 86164 86231 86298 86365 86432 86500 86567 86634 86701 86768 86835 86902 86969 87036 87103 87170 87237 87304 87371 87438 87505 87572 87639 87706 87773 87840 87907 87974 88041 88108 88175 88242 88309 88376 88443 88510 88577 88644 88711 88778 88845 88912 88979 89046 89113 89180 89247 89314 89381 89448 89515 89582 89649 89716 89783 89850 89917 90000 90067 90134 90201 90268 90335 90402 90469 90536 90603 90670 90737 90804 90871 90938 91005 91072 91139 91206 91273 91340 91407 91474 91541 91608 91675 91742 91809 91876 91943 92010 92077 92144 92211 92278 92345 92412 92479 92546 92613 92680 92747 92814 92881 92948 93015 93082 93149 93216 93283 93350 93417 93484 93551 93618 93685 93752 93819 93886 93953 94020 94087 94154 94221 94288 94355 94422 94489 94556 94623 94690 94757 94824 94891 94958 95025 95092 95159 95226 95293 95360 95427 95494 95561 95628 95695 95762 95829 95896 95963 96030 96097 96164 96231 96298 96365 96432 96500 96567 96634 96701 96768 96835 96902 96969 97036 97103 97170 97237 97304 97371 97438 97505 97572 97639 97706 97773 97840 97907 97974 98041 98108 98175 98242 98309 98376 98443 98510 98577 98644 98711 98778 98845 98912 98979 99046 99113 99180 99247 99314 99381 99448 99515 99582 99649 99716 99783 99850 99917 100000 100067 100134 100201 100268 100335 100402 100469 100536 100603 100670 100737 100804 100871 100938 101005 101072 101139 101206 101273 101340 101407 101474 101541 101608 101675 101742 101809 101876 101943 102010 102077 102144 102211 102278 102345 102412 102479 102546 102613 102680 102747 102814 102881 102948 103015 103082 103149 103216 103283 103350 103417 103484 103551 103618 103685 103752 103819 103886 103953 104020 104087 104154 104221 104288 104355 104422 104489 104556 104623 104690 104757 104824 104891 104958 105025 105092 105159 105226 105293 105360 105427 105494 105561 105628 105695 105762 105829 105896 105963 106030 106097 106164 106231 106298 106365 106432 106500 106567 106634 106701 106768 106835 106902 106969 107036 107103 107170 107237 107304 107371 107438 107505 107572 107639 107706 107773 107840 107907 107974 108041 108108 108175 108242 108309 108376 108443 108510 108577 108644 108711 108778 108845 108912 108979 109046

2. By only looking at your reported confusion tables, which classes were likely to be mistaken for each other?

It seems like class 3 and 4 get mistaken for class 7 a lot.

Brief Explanation of What I've Done:

For this assignment, I implemented an iterative version of a neural net by defining 4 main functions: earlystopping, train, forward, and confusion. Earlystopping trains the neural net but stops training once validation error begins increasing; it looks at the errors on the last three weights to insure it does not stop prematurely due to random noise in the data. Train trains the neural net with one hidden layer with a sigmoid activation function and a linear activation function for the output. It shuffles the training data then inputs one of the training vectors into the neural net, uses backpropagation to update weights and biases, then repeats for the rest of the training vectors. Forward returns the result of putting inputs into the current neural net and confusion creates and saves a confusion matrix for a set of inputs to the neural net.