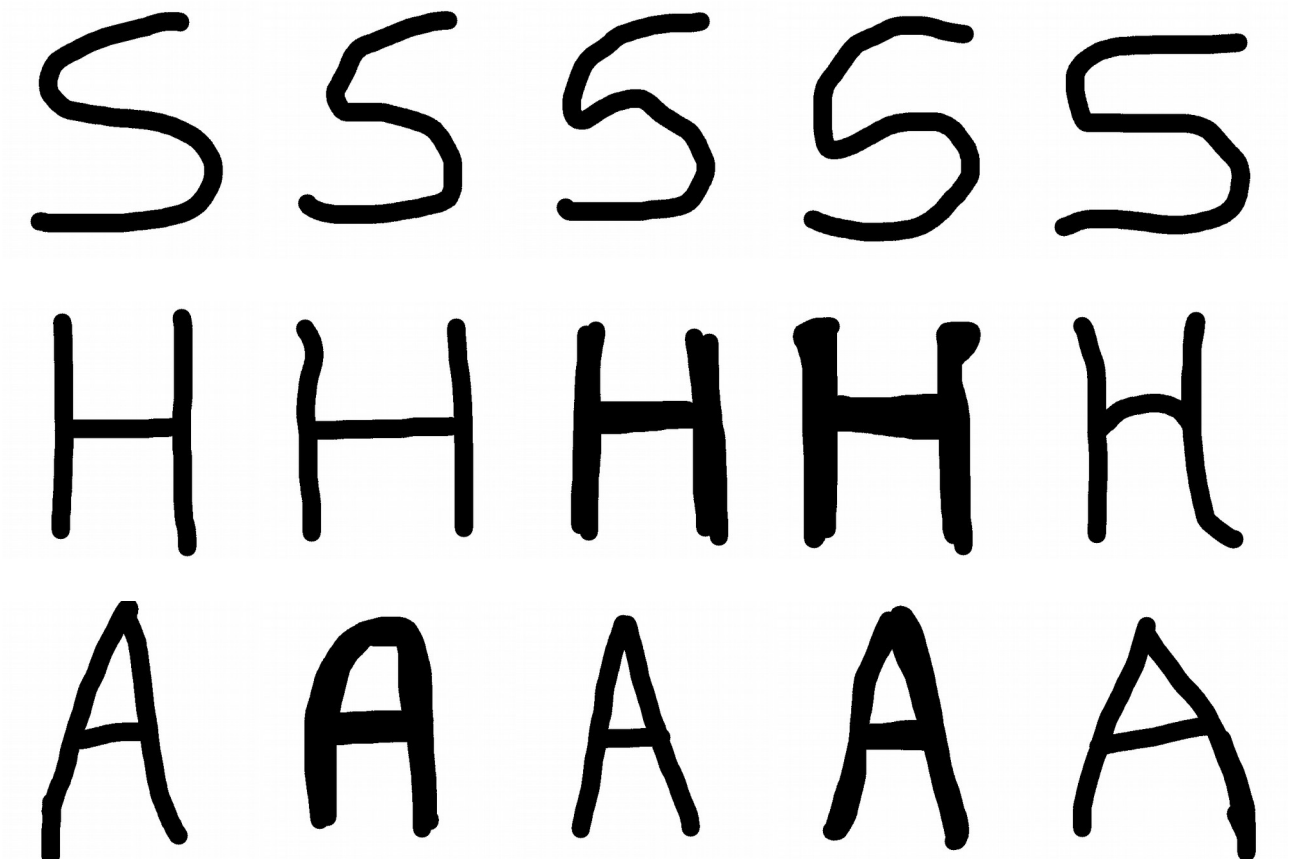
NFT ASSIGNMENT-1

Name- Suruchi Shrey
Roll no- BT18CSE014

1. Training Vectors

Letters used – S, H, A



2. Input Feature Vectors

Dataset[0,1,2,3,4]= S1, S2, S3, S4, S5
Dataset[5,6,7,8,9]=H1, H2, H3, H4, H5
Dataset[10,11,12,13,14]=A1, A2, A3, A4, A5

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dataset= [[1, 1, 1, 1, 1, 1, 0, 1, 1, 1,
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3. Architecture of Neural Network

Single hidden layer-

Number of neurons in input layer: 100
Number of neurons in hidden layer: 75
Number of neurons in output layer: 3
Activation function: sigmoid

Two hidden layers-

Number of neurons in input layer: 100
Number of neurons in hidden layer 1: 70
Number of neurons in hidden layer 2: 30
Number of neurons in output layer: 3
Activation function: sigmoid

4. Training Results

[1,0,0] is mapped to the letter S
[0,1,0] is mapped to the letter H
[0,0,1] is mapped to the letter A

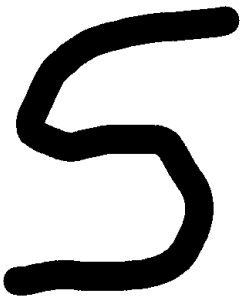
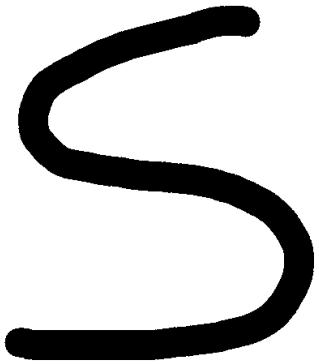
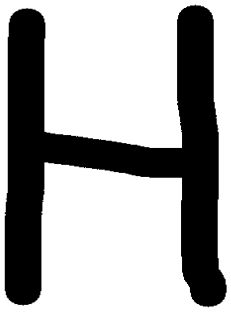
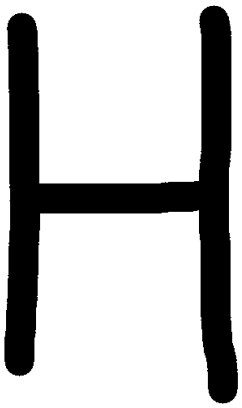
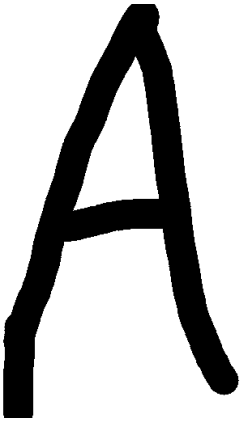
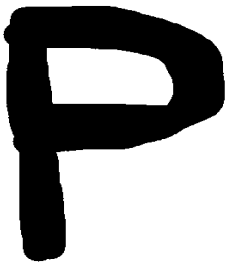
Single hidden layer-

Learning rate	0.8	0.4	0.2	0.1	0.05	0.01
Epochs	1500	2600	3500	6000	11200	20000
Error Threshold	0.05	0.05	0.05	0.05	0.05	0.05

Two hidden layers-

Learning rate	0.8	0.4	0.2	0.1	0.05	0.01
Epochs	2000	5000	7000	12000	22000	>30000
Error Threshold	0.05	0.05	0.05	0.05	0.05	0.05

5. Testing Images

S		
H		
A		
Unseen		

6. Input Feature Vectors

dataset[0]=A, dataset[1]=S, dataset[2]=H, dataset[3]=S, dataset[4]=H, dataset[5]=A, dataset[6]=P, dataset[7]=E

```
dataset=[[1, 1, 1, 1, 1, 1, 1, 1, 1, 1,
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```

7. Testing Results

a. Single Layer

The network converges for all learning rates and provides correct o/p for 5 seen images and wrong for only one(couldn’t classify S) and for unseen images it tends to classify P and E both as H ,hence accuracy for learning rates 0.8,0.4,0.2,0.1 is **62.5%**(5/8), however, as we

keep on training the network with slower and slower learning rates it starts classifying all the seen images (6/6), but the case with unseen images remains same,hence for alpha=0.05 and 0.01 its accuracy becomes **75%**(6/8).

1. Learning rate=0.8
outputs in predict
[4.401559714142141e-61, 0.07886819327399684, 0.9838447925098971]
Expected=2, Got=2
outputs in predict
[0.01615339497639617, 0.5359072263728207, 0.004379390455503661]
Expected=0, Got=1
outputs in predict
[1.0757818359024474e-09, 0.4563085233197272, 0.013967728347986229]
Expected=1, Got=1
outputs in predict
[0.9472470396087446, 0.5692669131892681, 0.0026748140641395155]
Expected=0, Got=0
outputs in predict
[0.06159865046056499, 0.5425493480977364, 0.003972262083106597]
Expected=1, Got=1
outputs in predict
[2.4317331661285918e-79, 0.036656660320589306, 0.9991603132373291]
Expected=2, Got=2
outputs in predict
[6.11844637110741e-32, 0.2380647907759028, 0.34629566590299166]
Expected=Should not classify, Got=2
outputs in predict
[3.9494560301713945e-13, 0.4187758706539255, 0.024181727437602347]
Expected=Should not classify, Got=1

2.Learning rate=0.4
outputs in predict
[3.7231837341715897e-36, 0.11672678981276055, 0.9658561000431278]
Expected=2, Got=2
outputs in predict
[0.1721356155211057, 0.5076572948281002, 0.00561453765823906]
Expected=0, Got=1
outputs in predict
[7.641372776963062e-07, 0.42783260552340696, 0.020953212581413867]
Expected=1, Got=1
outputs in predict
[0.9461130361960541, 0.5360720913532532, 0.0035082879796957274]
Expected=0, Got=0
outputs in predict
[0.06765048483981484, 0.5008995731150389, 0.006276380990940495]
Expected=1, Got=1
outputs in predict
[3.0961649241249793e-50, 0.05435711660443903, 0.9988814000966966]

Expected=2, Got=2
outputs in predict
[4.7043458128829336e-17, 0.29020066535051975, 0.2073693287936693]
Expected=Should not classify, Got=1
outputs in predict
[1.1130331439392084e-07, 0.4157687526420977, 0.02560183425428358]
Expected=Should not classify, Got=1

3. Learning rate=0.2
outputs in predict
[1.0825229499008775e-28, 0.1407108598224569, 0.9604450727809888]
Expected=2, Got=2
outputs in predict
[0.3598686629412611, 0.49394669376444145, 0.005790425950979611]
Expected=0, Got=1
outputs in predict
[6.075655099854032e-06, 0.41481429928154256, 0.025280209272714783]
Expected=1, Got=1
outputs in predict
[0.9575271538146343, 0.5197515462440011, 0.0035832486618113117]
Expected=0, Got=0
outputs in predict
[0.06878558182751263, 0.47976401689819254, 0.007534857629819226]
Expected=1, Got=1
outputs in predict
[3.324046012123221e-40, 0.07236273184702116, 0.9987104671713074]
Expected=2, Got=2
outputs in predict
[1.2360853169995176e-12, 0.31537502744210033, 0.16251433845310934]
Expected=Should not classify, Got=1
outputs in predict
[4.826942190073516e-06, 0.4132528485071945, 0.026031371966066766]
Expected=Should not classify, Got=1

4. Learning rate=0.1
outputs in predict
[1.213314443371323e-25, 0.15616291739999727, 0.9586796495897273]
Expected=2, Got=2
outputs in predict
[0.4607149946705261, 0.4869267859040813, 0.005694363427504535]
Expected=0, Got=1
outputs in predict
[1.3624633550205567e-05, 0.40904285728954737, 0.027684793063659778]
Expected=1, Got=1
outputs in predict
[0.9609299275497108, 0.5109232300082348, 0.003503784985723469]
Expected=0, Got=0
outputs in predict

[0.06872316684077173, 0.4694681430666505, 0.008106085337327004]
Expected=1, Got=1
outputs in predict
[6.625646835004387e-36, 0.08609640389380648, 0.998607305903961]
Expected=2, Got=2
outputs in predict
[7.29018715216897e-11, 0.32855062884519537, 0.1422824870697124]
Expected=Should not classify, Got=1
outputs in predict
[2.2455603921474127e-05, 0.4124984015353924, 0.025797467529918666]
Expected=Should not classify, Got=1

5. Learning rate=0.05
outputs in predict
[3.340454180225746e-24, 0.16550434873795916, 0.9573736446279246]
Expected=2, Got=2
outputs in predict
[0.5091746730106624, 0.48336403278714274, 0.005576237057831902]
Expected=0, Got=0
outputs in predict
[1.9454171140860927e-05, 0.4064399561564097, 0.02890206193589373]
Expected=1, Got=1
outputs in predict
[0.9617655578278308, 0.5062162059115782, 0.0034271425682785 62]
Expected=0, Got=0
outputs in predict
[0.06855044735692163, 0.46444847043088666, 0.008343521300810917]
Expected=1, Got=1
outputs in predict
[7.035468135645407e-34, 0.0947643953494374, 0.9985411110703463]
Expected=2, Got=2
outputs in predict
[4.805450723466381e-10, 0.3356062803146107, 0.1315157362747823]
Expected=Should not classify, Got=1
outputs in predict
[4.648912473282379e-05, 0.4124809932074162, 0.025379294795453953]
Expected=Should not classify, Got=1

6.Learning rate=0.01
outputs and expected
[5.874158885968349e-13, 0.16331706697463838, 0.9907921276187973]
[0, 0, 1]
outputs in predict
[1.3993998817489702e-08, 0.24272648383135845, 0.819779441562467]
Expected=2, Got=2
outputs in predict
[0.7619147854359734, 0.4563812965536539, 0.010696700618562208]
Expected=0, Got=0

outputs in predict
[0.0005269039700555908, 0.35190085929778575, 0.1427518993713778]
Expected=1, Got=1
outputs in predict
[0.9436836430530374, 0.4769916682129653, 0.006389049174137397]
Expected=0, Got=0
outputs in predict
[0.11356410187283161, 0.41680534955284554, 0.028834706559145044]
Expected=1, Got=1
outputs in predict
[2.5645801134159608e-12, 0.17246854244812296, 0.9854548261253666]
Expected=2, Got=2
outputs in predict
[0.003291758918605668, 0.3731089720136886, 0.08559822274250188]
Expected=Should not classify, Got=1
outputs in predict
[0.030287700385784853, 0.3997498455711478, 0.04419797803278659]
Expected=Should not classify, Got=1

b. Multiple Layers

The network converges for all learning rates and provides correct o/p for 5 seen images and wrong for only one(couldn't classify S) and for unseen images it tends to classify P as H and E as A ,hence accuracy for learning rate 0.8 is **62.5%**(5/8), however, as we keep on training the network with slower and slower learning rates it starts classifying all the seen images (6/6), but the case with unseen images remains same except for alpha=0.01 it classifies P and E both as H,hence for alpha= 0.4,0.2,0.1,0.05 and 0.01 its accuracy becomes **75%**(6/8).

1. Learning rate=0.8
outputs in predict
[1.4237169626704029e-65, 0.06089230597021079, 0.9998607158616616]
Expected=2, Got=2
outputs in predict
[0.4430084617390378, 0.5490962540804597, 0.0023437239719048147]
Expected=0, Got=1
outputs in predict
[2.823791437308896e-19, 0.34554152391103043, 0.1420169904348293]
Expected=1, Got=1
outputs in predict
[0.9516916330624813, 0.5646755368406232, 0.0017004798004227949]
Expected=0, Got=0
outputs in predict
[0.05487444391541621, 0.536318841202146, 0.0030440537832415867]
Expected=1, Got=1
outputs in predict
[5.628532509697795e-68, 0.05495732973342258, 0.9999199726148421]
Expected=2, Got=2
outputs in predict

[2.1779605792017772e-54, 0.09715925880833694, 0.99816589682526]
Expected=Should not classify, Got=2
outputs in predict
[2.618470907337673e-27, 0.2684392993965, 0.5134842156821035]
Expected=Should not classify, Got=2

2. Learning rate=0.4
outputs in predict
[4.109520594779876e-43, 0.08325830448604919, 0.9996793952285223]
Expected=2, Got=2
outputs in predict
[0.839706175450674, 0.5247583289867901, 0.0024304611855472825]
Expected=0, Got=0
outputs in predict
[2.538001317490235e-13, 0.337940893709873, 0.15794499739009984]
Expected=1, Got=1
outputs in predict
[0.951469006962839, 0.5330342392099778, 0.0020168014366073643]
Expected=0, Got=0
outputs in predict
[0.060911778869942985, 0.4971474706171865, 0.004518472867956628]
Expected=1, Got=1
outputs in predict
[1.8010770656369326e-45, 0.07340389376624355, 0.9998514309761958]
Expected=2, Got=2
outputs in predict
[2.2462411506010896e-31, 0.15204240928494603, 0.9854544588545671]
Expected=Should not classify, Got=2
outputs in predict
[3.1161772300295355e-15, 0.31362627520753594, 0.2591832232614079 7]
Expected=Should not classify, Got=1

3. Learning rate=0.2
outputs in predict
[2.426129487140376e-35, 0.09943650015372806, 0.9994607626774152]
Expected=2, Got=2
outputs in predict
[0.8600469823645651, 0.508866291876287, 0.002557380651963679]
Expected=0, Got=0
outputs in predict
[4.238796680746772e-11, 0.3384104710444149, 0.15276865960616268]
Expected=1, Got=1
outputs in predict
[0.9481978871671763, 0.5163556579958681, 0.002135664378487245]
Expected=0, Got=0
outputs in predict
[0.0634699619088375 4, 0.4779329731026846, 0.005376739064601984]
Expected=1, Got=1

outputs in predict
[1.028669039237106e-37, 0.08678400572195726, 0.9997815950120291]
Expected=2, Got=2
outputs in predict
[4.060632793157094e-24, 0.1833667796841402, 0.9625969202443516]
Expected=Should not classify, Got=2
outputs in predict
[7.173475750964657e-12, 0.327574193389427, 0.19480997940324696]
Expected=Should not classify, Got=1

4. Learning rate=0.1
outputs in predict
[4.944514200993286e-32, 0.10923449265245105, 0.9992892274045172]
Expected=2, Got=2
outputs in predict
[0.8678428124575637, 0.5008080529484514, 0.002584719567732156]
Expected=0, Got=0
outputs in predict
[3.648214014866171e-10, 0.33899677393354577, 0.14928716155467078]
Expected=1, Got=1
outputs in predict
[0.9465418686127048, 0.5078538016313887, 0.0021661893949489405]
Expected=0, Got=0
outputs in predict
[0.06451350529343729, 0.4684827981197647, 0.00581081892781147]
Expected=1, Got=1
outputs in predict
[2.0464621780677625e-34, 0.09496102962438807, 0.9997330039072189]
Expected=2, Got=2
outputs in predict
[4.400261246559354e-21, 0.2006606902181237, 0.9397890751083657]
Expected=Should not classify, Got=2
outputs in predict
[1.7582611318253415e-10, 0.3343647960743296, 0.16660196310864145]
Expected=Should not classify, Got=1

5. Learning rate=0.05
outputs in predict
[1.699523264728458e-30, 0.11464763901581947, 0.9991780485545432]
Expected=2, Got=2
outputs in predict
[0.8714748567272983, 0.49675685322493973, 0.0025855576696756717]
Expected=0, Got=0
outputs in predict
[9.804001378614067e-10, 0.33937120067875076, 0.14725502093942966]
Expected=1, Got=1
outputs in predict
[0.9457210725726074, 0.5035579864719474, 0.002171581929503776]

Expected=0, Got=0
outputs in predict
[0.06496450908463629, 0.4638081011386304, 0.006022048972907774]
Expected=1, Got=1
outputs in predict
[6.912942095955729e-33, 0.09949900875662664, 0.9997034999794265]
Expected=2, Got=2
outputs in predict
[1.0959240817689274e-19, 0.2097156029086433, 0.9234608949354433]
Expected=Should not classify, Got=2
outputs in predict
[7.653941180094847e-10, 0.3377730328752059, 0.15311006093143933]
Expected=Should not classify, Got=1

6. Learning rate=0.01
outputs in predict
[3.257077100283362e-08, 0.22123670848176835, 0.9360287210666658]
Expected=2, Got=2
outputs in predict
[0.8671913734177046, 0.459435264886496, 0.005280626197414536]
Expected=0, Got=0
outputs in predict
[0.0007511695397459174, 0.33569590331906907, 0.18541475105635669]
Expected=1, Got=1
outputs in predict
[0.9229794445046746, 0.46809121435614337, 0.004110756060848709]
Expected=0, Got=0
outputs in predict
[0.1035524080202885, 0.4027762228941264, 0.02747931867563284]
Expected=1, Got=1
outputs in predict
[5.393272540773621e-10, 0.1833880478135316, 0.9876610226358198]
Expected=2, Got=2
outputs in predict
[0.0006634801807342081, 0.3341097401151564, 0.19331568818895173]
Expected=Should not classify, Got=1
outputs in predict
[0.014682405247128839, 0.3748860368011045, 0.06193116752466277]
Expected=Should not classify, Got=1