

Importing Packages

```
In [1]:  
import numpy as np  
import matplotlib.pyplot as plt
```

Hyper Parameters

```
In [2]:  
msg_total = 8  
channel = 4  
epochs = 1000  
batch_size = 1024  
x=np.random.randint(0,8,10000)
```

Supervised Learning

```
In [3]:  
from keras.models import Sequential  
from keras.layers import Dense, GaussianNoise  
from keras.wrappers.scikit_learn import KerasClassifier  
  
def func():  
    model = Sequential()  
    model.add(Dense(msg_total,input_dim=1,activation='relu'))  
    model.add(Dense(2*channel, activation = 'linear'))  
    model.add(GaussianNoise(1))  
    model.add(Dense(msg_total, activation = 'softmax'))  
    model.compile(loss='categorical_crossentropy', optimizer='adam',metrics=['acc'])  
    return model  
  
estimator=KerasClassifier(build_fn=func,epochs=epochs,batch_size=batch_size,verbose=1)  
  
Using TensorFlow backend.
```

```
In [4]:  
history=estimator.fit(x,x)  
loss_supervised=history.history['loss']  
acc=history.history['acc']
```

```
Epoch 1/1000
10000/10000 [=====] - 2s 159us/step - loss: 3.0989 - acc: 0.0958
Epoch 2/1000
10000/10000 [=====] - 0s 9us/step - loss: 2.9755 - acc: 0.1041
Epoch 3/1000
10000/10000 [=====] - 0s 10us/step - loss: 2.8776 - acc: 0.1152
Epoch 4/1000
10000/10000 [=====] - 0s 10us/step - loss: 2.7888 - acc: 0.1206
Epoch 5/1000
10000/10000 [=====] - 0s 10us/step - loss: 2.6900 - acc: 0.1286
Epoch 6/1000
10000/10000 [=====] - 0s 10us/step - loss: 2.6362 - acc: 0.1328
Epoch 7/1000
10000/10000 [=====] - 0s 9us/step - loss: 2.5812 - acc: 0.1336
Epoch 8/1000
10000/10000 [=====] - 0s 13us/step - loss: 2.5285 - acc: 0.1399
Epoch 9/1000
10000/10000 [=====] - 0s 8us/step - loss: 2.4977 - acc: 0.1470
Epoch 10/1000
10000/10000 [=====] - 0s 11us/step - loss: 2.4391 - acc: 0.1488
Epoch 11/1000
10000/10000 [=====] - 0s 7us/step - loss: 2.4125 - acc: 0.1484
Epoch 12/1000
10000/10000 [=====] - 0s 6us/step - loss: 2.3789 - acc: 0.1550
Epoch 13/1000
10000/10000 [=====] - 0s 6us/step - loss: 2.3289 - acc: 0.1578
Epoch 14/1000
10000/10000 [=====] - 0s 6us/step - loss: 2.3275 - acc: 0.1558
Epoch 15/1000
10000/10000 [=====] - 0s 6us/step - loss: 2.2984 - acc: 0.1611
Epoch 16/1000
10000/10000 [=====] - 0s 7us/step - loss: 2.2669 - acc: 0.1692
Epoch 17/1000
10000/10000 [=====] - 0s 6us/step - loss: 2.2378 - acc: 0.1720
Epoch 18/1000
10000/10000 [=====] - 0s 6us/step - loss: 2.2274 - acc: 0.1743
Epoch 19/1000
10000/10000 [=====] - 0s 7us/step - loss: 2.2024 - acc: 0.1774
Epoch 20/1000
10000/10000 [=====] - 0s 8us/step - loss: 2.1759 - acc: 0.1799
Epoch 21/1000
10000/10000 [=====] - 0s 7us/step - loss: 2.1642 - acc: 0.1880
Epoch 22/1000
10000/10000 [=====] - 0s 7us/step - loss: 2.1533 - acc: 0.1846
Epoch 23/1000
10000/10000 [=====] - 0s 6us/step - loss: 2.1237 - acc: 0.1902
Epoch 24/1000
10000/10000 [=====] - 0s 7us/step - loss: 2.1018 - acc: 0.1953
Epoch 25/1000
10000/10000 [=====] - 0s 7us/step - loss: 2.0786 - acc: 0.1993
Epoch 26/1000
10000/10000 [=====] - 0s 6us/step - loss: 2.0619 - acc: 0.1967
Epoch 27/1000
10000/10000 [=====] - 0s 6us/step - loss: 2.0517 - acc: 0.1988
Epoch 28/1000
10000/10000 [=====] - 0s 7us/step - loss: 2.0333 - acc: 0.2081
Epoch 29/1000
10000/10000 [=====] - 0s 6us/step - loss: 2.0161 - acc: 0.2088
Epoch 30/1000
10000/10000 [=====] - 0s 6us/step - loss: 1.9915 - acc: 0.2106
Epoch 31/1000
10000/10000 [=====] - 0s 6us/step - loss: 1.9811 - acc: 0.2179
Epoch 32/1000
10000/10000 [=====] - 0s 7us/step - loss: 1.9530 - acc: 0.2280
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Epoch 33/1000
10000/10000 [=====] - 0s 8us/step - loss: 1.9489 - acc: 0.2262
Epoch 34/1000
10000/10000 [=====] - 0s 6us/step - loss: 1.9277 - acc: 0.2320
Epoch 35/1000
10000/10000 [=====] - 0s 6us/step - loss: 1.9123 - acc: 0.2257
Epoch 36/1000
10000/10000 [=====] - 0s 7us/step - loss: 1.8918 - acc: 0.2341
Epoch 37/1000
10000/10000 [=====] - 0s 7us/step - loss: 1.8785 - acc: 0.2373
Epoch 38/1000
10000/10000 [=====] - 0s 7us/step - loss: 1.8532 - acc: 0.2442
Epoch 39/1000
10000/10000 [=====] - 0s 7us/step - loss: 1.8485 - acc: 0.2373
Epoch 40/1000
10000/10000 [=====] - 0s 10us/step - loss: 1.8216 - acc: 0.2508
Epoch 41/1000
10000/10000 [=====] - 0s 8us/step - loss: 1.8177 - acc: 0.2517
Epoch 42/1000
10000/10000 [=====] - 0s 6us/step - loss: 1.7970 - acc: 0.2527
Epoch 43/1000
10000/10000 [=====] - 0s 8us/step - loss: 1.7828 - acc: 0.2633
Epoch 44/1000
10000/10000 [=====] - 0s 7us/step - loss: 1.7699 - acc: 0.2632
Epoch 45/1000
10000/10000 [=====] - 0s 6us/step - loss: 1.7558 - acc: 0.2597
Epoch 46/1000
10000/10000 [=====] - 0s 8us/step - loss: 1.7480 - acc: 0.2629
Epoch 47/1000
10000/10000 [=====] - 0s 6us/step - loss: 1.7353 - acc: 0.2628
Epoch 48/1000
10000/10000 [=====] - 0s 7us/step - loss: 1.7142 - acc: 0.2763
Epoch 49/1000
10000/10000 [=====] - 0s 6us/step - loss: 1.6949 - acc: 0.2831
Epoch 50/1000
10000/10000 [=====] - 0s 6us/step - loss: 1.6919 - acc: 0.2743
Epoch 51/1000
10000/10000 [=====] - 0s 8us/step - loss: 1.6732 - acc: 0.2831
Epoch 52/1000
10000/10000 [=====] - 0s 7us/step - loss: 1.6604 - acc: 0.2914
Epoch 53/1000
10000/10000 [=====] - 0s 6us/step - loss: 1.6475 - acc: 0.2946
Epoch 54/1000
10000/10000 [=====] - 0s 7us/step - loss: 1.6371 - acc: 0.2975
Epoch 55/1000
10000/10000 [=====] - 0s 7us/step - loss: 1.6297 - acc: 0.2900
Epoch 56/1000
10000/10000 [=====] - 0s 6us/step - loss: 1.6178 - acc: 0.2980
Epoch 57/1000
10000/10000 [=====] - 0s 6us/step - loss: 1.5904 - acc: 0.3142
Epoch 58/1000
10000/10000 [=====] - 0s 8us/step - loss: 1.5901 - acc: 0.3080
Epoch 59/1000
10000/10000 [=====] - 0s 8us/step - loss: 1.5869 - acc: 0.3079
Epoch 60/1000
10000/10000 [=====] - 0s 7us/step - loss: 1.5741 - acc: 0.3152
Epoch 61/1000
10000/10000 [=====] - 0s 11us/step - loss: 1.5594 - acc: 0.3196
Epoch 62/1000
10000/10000 [=====] - 0s 12us/step - loss: 1.5451 - acc: 0.3236
Epoch 63/1000
10000/10000 [=====] - 0s 9us/step - loss: 1.5428 - acc: 0.3215
Epoch 64/1000
10000/10000 [=====] - 0s 6us/step - loss: 1.5327 - acc: 0.3275
Epoch 65/1000
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10000/10000 [=====] - 0s 6us/step - loss: 1.5264 - acc: 0.3346
Epoch 66/1000
10000/10000 [=====] - 0s 6us/step - loss: 1.5129 - acc: 0.3340
Epoch 67/1000
10000/10000 [=====] - 0s 6us/step - loss: 1.5058 - acc: 0.3308
Epoch 68/1000
10000/10000 [=====] - 0s 7us/step - loss: 1.4913 - acc: 0.3405
Epoch 69/1000
10000/10000 [=====] - 0s 6us/step - loss: 1.4865 - acc: 0.3447
Epoch 70/1000
10000/10000 [=====] - 0s 6us/step - loss: 1.4783 - acc: 0.3426
Epoch 71/1000
10000/10000 [=====] - 0s 6us/step - loss: 1.4726 - acc: 0.3442
Epoch 72/1000
10000/10000 [=====] - 0s 7us/step - loss: 1.4610 - acc: 0.3555
Epoch 73/1000
10000/10000 [=====] - 0s 7us/step - loss: 1.4519 - acc: 0.3525
Epoch 74/1000
10000/10000 [=====] - 0s 6us/step - loss: 1.4496 - acc: 0.3576
Epoch 75/1000
10000/10000 [=====] - 0s 6us/step - loss: 1.4378 - acc: 0.3636
Epoch 76/1000
10000/10000 [=====] - 0s 7us/step - loss: 1.4298 - acc: 0.3602
Epoch 77/1000
10000/10000 [=====] - 0s 6us/step - loss: 1.4233 - acc: 0.3714
Epoch 78/1000
10000/10000 [=====] - 0s 6us/step - loss: 1.4086 - acc: 0.3772
Epoch 79/1000
10000/10000 [=====] - 0s 6us/step - loss: 1.4005 - acc: 0.3782
Epoch 80/1000
10000/10000 [=====] - 0s 7us/step - loss: 1.4012 - acc: 0.3773
Epoch 81/1000
10000/10000 [=====] - 0s 7us/step - loss: 1.3888 - acc: 0.3806
Epoch 82/1000
10000/10000 [=====] - 0s 8us/step - loss: 1.3820 - acc: 0.3844
Epoch 83/1000
10000/10000 [=====] - 0s 7us/step - loss: 1.3776 - acc: 0.3876
Epoch 84/1000
10000/10000 [=====] - 0s 6us/step - loss: 1.3726 - acc: 0.3835
Epoch 85/1000
10000/10000 [=====] - 0s 7us/step - loss: 1.3673 - acc: 0.3901
Epoch 86/1000
10000/10000 [=====] - 0s 6us/step - loss: 1.3534 - acc: 0.4013
Epoch 87/1000
10000/10000 [=====] - 0s 6us/step - loss: 1.3464 - acc: 0.4038
Epoch 88/1000
10000/10000 [=====] - 0s 8us/step - loss: 1.3496 - acc: 0.4003
Epoch 89/1000
10000/10000 [=====] - 0s 7us/step - loss: 1.3373 - acc: 0.4089
Epoch 90/1000
10000/10000 [=====] - 0s 6us/step - loss: 1.3305 - acc: 0.4036
Epoch 91/1000
10000/10000 [=====] - 0s 6us/step - loss: 1.3252 - acc: 0.4108
Epoch 92/1000
10000/10000 [=====] - 0s 7us/step - loss: 1.3137 - acc: 0.4198
Epoch 93/1000
10000/10000 [=====] - 0s 6us/step - loss: 1.3135 - acc: 0.4130
Epoch 94/1000
10000/10000 [=====] - 0s 7us/step - loss: 1.3049 - acc: 0.4207
Epoch 95/1000
10000/10000 [=====] - 0s 6us/step - loss: 1.2964 - acc: 0.4236
Epoch 96/1000
10000/10000 [=====] - 0s 8us/step - loss: 1.2912 - acc: 0.4270
Epoch 97/1000
10000/10000 [=====] - 0s 6us/step - loss: 1.2888 - acc: 0.4298
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Epoch 98/1000
10000/10000 [=====] - 0s 6us/step - loss: 1.2835 - acc: 0.4232
Epoch 99/1000
10000/10000 [=====] - 0s 7us/step - loss: 1.2764 - acc: 0.4319
Epoch 100/1000
10000/10000 [=====] - 0s 6us/step - loss: 1.2689 - acc: 0.4437
Epoch 101/1000
10000/10000 [=====] - 0s 6us/step - loss: 1.2661 - acc: 0.4429
Epoch 102/1000
10000/10000 [=====] - 0s 6us/step - loss: 1.2634 - acc: 0.4440
Epoch 103/1000
10000/10000 [=====] - 0s 8us/step - loss: 1.2540 - acc: 0.4451
Epoch 104/1000
10000/10000 [=====] - 0s 7us/step - loss: 1.2490 - acc: 0.4474
Epoch 105/1000
10000/10000 [=====] - 0s 7us/step - loss: 1.2391 - acc: 0.4536
Epoch 106/1000
10000/10000 [=====] - 0s 6us/step - loss: 1.2361 - acc: 0.4516
Epoch 107/1000
10000/10000 [=====] - 0s 6us/step - loss: 1.2330 - acc: 0.4546
Epoch 108/1000
10000/10000 [=====] - 0s 6us/step - loss: 1.2257 - acc: 0.4572
Epoch 109/1000
10000/10000 [=====] - 0s 7us/step - loss: 1.2198 - acc: 0.4623
Epoch 110/1000
10000/10000 [=====] - 0s 6us/step - loss: 1.2138 - acc: 0.4626
Epoch 111/1000
10000/10000 [=====] - 0s 6us/step - loss: 1.2085 - acc: 0.4695
Epoch 112/1000
10000/10000 [=====] - 0s 6us/step - loss: 1.2064 - acc: 0.4747
Epoch 113/1000
10000/10000 [=====] - 0s 6us/step - loss: 1.2036 - acc: 0.4666
Epoch 114/1000
10000/10000 [=====] - 0s 7us/step - loss: 1.1985 - acc: 0.4807
Epoch 115/1000
10000/10000 [=====] - 0s 6us/step - loss: 1.1907 - acc: 0.4775
Epoch 116/1000
10000/10000 [=====] - 0s 6us/step - loss: 1.1876 - acc: 0.4743
Epoch 117/1000
10000/10000 [=====] - 0s 6us/step - loss: 1.1842 - acc: 0.4807
Epoch 118/1000
10000/10000 [=====] - 0s 8us/step - loss: 1.1815 - acc: 0.4857
Epoch 119/1000
10000/10000 [=====] - 0s 6us/step - loss: 1.1706 - acc: 0.4843
Epoch 120/1000
10000/10000 [=====] - 0s 6us/step - loss: 1.1695 - acc: 0.4807
Epoch 121/1000
10000/10000 [=====] - 0s 7us/step - loss: 1.1568 - acc: 0.4962
Epoch 122/1000
10000/10000 [=====] - 0s 6us/step - loss: 1.1598 - acc: 0.4936
Epoch 123/1000
10000/10000 [=====] - 0s 6us/step - loss: 1.1484 - acc: 0.4969
Epoch 124/1000
10000/10000 [=====] - 0s 8us/step - loss: 1.1443 - acc: 0.5040
Epoch 125/1000
10000/10000 [=====] - 0s 7us/step - loss: 1.1429 - acc: 0.5084
Epoch 126/1000
10000/10000 [=====] - 0s 6us/step - loss: 1.1425 - acc: 0.5074
Epoch 127/1000
10000/10000 [=====] - 0s 6us/step - loss: 1.1347 - acc: 0.5158
Epoch 128/1000
10000/10000 [=====] - 0s 6us/step - loss: 1.1291 - acc: 0.5175
Epoch 129/1000
10000/10000 [=====] - 0s 6us/step - loss: 1.1242 - acc: 0.5065
Epoch 130/1000
```

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10000/10000 [=====] - 0s 9us/step - loss: 1.1171 - acc: 0.5309
Epoch 131/1000
10000/10000 [=====] - 0s 6us/step - loss: 1.1170 - acc: 0.5146
Epoch 132/1000
10000/10000 [=====] - 0s 6us/step - loss: 1.1114 - acc: 0.5220
Epoch 133/1000
10000/10000 [=====] - 0s 6us/step - loss: 1.1042 - acc: 0.5312
Epoch 134/1000
10000/10000 [=====] - 0s 6us/step - loss: 1.1001 - acc: 0.5233
Epoch 135/1000
10000/10000 [=====] - 0s 8us/step - loss: 1.0962 - acc: 0.5286
Epoch 136/1000
10000/10000 [=====] - 0s 7us/step - loss: 1.0942 - acc: 0.5306
Epoch 137/1000
10000/10000 [=====] - 0s 7us/step - loss: 1.0910 - acc: 0.5297
Epoch 138/1000
10000/10000 [=====] - 0s 6us/step - loss: 1.0858 - acc: 0.5292
Epoch 139/1000
10000/10000 [=====] - 0s 7us/step - loss: 1.0770 - acc: 0.5408
Epoch 140/1000
10000/10000 [=====] - 0s 7us/step - loss: 1.0784 - acc: 0.5378
Epoch 141/1000
10000/10000 [=====] - 0s 7us/step - loss: 1.0698 - acc: 0.5443
Epoch 142/1000
10000/10000 [=====] - 0s 6us/step - loss: 1.0674 - acc: 0.5423
Epoch 143/1000
10000/10000 [=====] - 0s 6us/step - loss: 1.0652 - acc: 0.5500
Epoch 144/1000
10000/10000 [=====] - 0s 6us/step - loss: 1.0592 - acc: 0.5495
Epoch 145/1000
10000/10000 [=====] - 0s 7us/step - loss: 1.0498 - acc: 0.5567
Epoch 146/1000
10000/10000 [=====] - 0s 6us/step - loss: 1.0504 - acc: 0.5610
Epoch 147/1000
10000/10000 [=====] - 0s 6us/step - loss: 1.0447 - acc: 0.5587
Epoch 148/1000
10000/10000 [=====] - 0s 6us/step - loss: 1.0408 - acc: 0.5608
Epoch 149/1000
10000/10000 [=====] - 0s 6us/step - loss: 1.0366 - acc: 0.5657
Epoch 150/1000
10000/10000 [=====] - 0s 9us/step - loss: 1.0354 - acc: 0.5635
Epoch 151/1000
10000/10000 [=====] - 0s 8us/step - loss: 1.0345 - acc: 0.5600
Epoch 152/1000
10000/10000 [=====] - 0s 7us/step - loss: 1.0273 - acc: 0.5735
Epoch 153/1000
10000/10000 [=====] - 0s 6us/step - loss: 1.0204 - acc: 0.5831
Epoch 154/1000
10000/10000 [=====] - 0s 6us/step - loss: 1.0174 - acc: 0.5814
Epoch 155/1000
10000/10000 [=====] - 0s 9us/step - loss: 1.0187 - acc: 0.5684
Epoch 156/1000
10000/10000 [=====] - 0s 6us/step - loss: 1.0118 - acc: 0.5686
Epoch 157/1000
10000/10000 [=====] - 0s 7us/step - loss: 1.0085 - acc: 0.5855
Epoch 158/1000
10000/10000 [=====] - 0s 8us/step - loss: 1.0025 - acc: 0.5846
Epoch 159/1000
10000/10000 [=====] - 0s 6us/step - loss: 1.0010 - acc: 0.5784
Epoch 160/1000
10000/10000 [=====] - 0s 8us/step - loss: 0.9987 - acc: 0.5920
Epoch 161/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.9908 - acc: 0.5864
Epoch 162/1000
10000/10000 [=====] - 0s 9us/step - loss: 0.9858 - acc: 0.5921
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Epoch 163/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.9806 - acc: 0.5932
Epoch 164/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.9814 - acc: 0.5901
Epoch 165/1000
10000/10000 [=====] - 0s 8us/step - loss: 0.9777 - acc: 0.5907
Epoch 166/1000
10000/10000 [=====] - 0s 9us/step - loss: 0.9766 - acc: 0.5959
Epoch 167/1000
10000/10000 [=====] - 0s 8us/step - loss: 0.9712 - acc: 0.5957
Epoch 168/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.9639 - acc: 0.5975
Epoch 169/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.9609 - acc: 0.6008
Epoch 170/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.9583 - acc: 0.6124
Epoch 171/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.9571 - acc: 0.5974
Epoch 172/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.9526 - acc: 0.6037
Epoch 173/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.9499 - acc: 0.5998
Epoch 174/1000
10000/10000 [=====] - 0s 10us/step - loss: 0.9412 - acc: 0.6157
Epoch 175/1000
10000/10000 [=====] - 0s 11us/step - loss: 0.9373 - acc: 0.6137
Epoch 176/1000
10000/10000 [=====] - 0s 9us/step - loss: 0.9337 - acc: 0.6148
Epoch 177/1000
10000/10000 [=====] - 0s 10us/step - loss: 0.9325 - acc: 0.6204
Epoch 178/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.9305 - acc: 0.6122
Epoch 179/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.9278 - acc: 0.6136
Epoch 180/1000
10000/10000 [=====] - 0s 8us/step - loss: 0.9209 - acc: 0.6215
Epoch 181/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.9142 - acc: 0.6241
Epoch 182/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.9167 - acc: 0.6133
Epoch 183/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.9114 - acc: 0.6265
Epoch 184/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.9045 - acc: 0.6305
Epoch 185/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.9040 - acc: 0.6210
Epoch 186/1000
10000/10000 [=====] - 0s 8us/step - loss: 0.9020 - acc: 0.6258
Epoch 187/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.8962 - acc: 0.6340
Epoch 188/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.8930 - acc: 0.6318
Epoch 189/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.8935 - acc: 0.6369
Epoch 190/1000
10000/10000 [=====] - 0s 8us/step - loss: 0.8865 - acc: 0.6346
Epoch 191/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.8853 - acc: 0.6379
Epoch 192/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.8805 - acc: 0.6339
Epoch 193/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.8757 - acc: 0.6395
Epoch 194/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.8719 - acc: 0.6427
Epoch 195/1000
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10000/10000 [=====] - 0s 6us/step - loss: 0.8738 - acc: 0.6355
Epoch 196/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.8682 - acc: 0.6401
Epoch 197/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.8625 - acc: 0.6491
Epoch 198/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.8653 - acc: 0.6460
Epoch 199/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.8613 - acc: 0.6443
Epoch 200/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.8564 - acc: 0.6437
Epoch 201/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.8517 - acc: 0.6537
Epoch 202/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.8486 - acc: 0.6396
Epoch 203/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.8423 - acc: 0.6635
Epoch 204/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.8433 - acc: 0.6489
Epoch 205/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.8381 - acc: 0.6586
Epoch 206/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.8354 - acc: 0.6540
Epoch 207/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.8347 - acc: 0.6530
Epoch 208/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.8296 - acc: 0.6570
Epoch 209/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.8240 - acc: 0.6667
Epoch 210/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.8253 - acc: 0.6627
Epoch 211/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.8224 - acc: 0.6632
Epoch 212/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.8164 - acc: 0.6626
Epoch 213/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.8176 - acc: 0.6646
Epoch 214/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.8128 - acc: 0.6704
Epoch 215/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.8088 - acc: 0.6719
Epoch 216/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.8084 - acc: 0.6612
Epoch 217/1000
10000/10000 [=====] - 0s 8us/step - loss: 0.8005 - acc: 0.6797
Epoch 218/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.7987 - acc: 0.6750
Epoch 219/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.7950 - acc: 0.6758
Epoch 220/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.7933 - acc: 0.6739
Epoch 221/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.7901 - acc: 0.6766
Epoch 222/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.7883 - acc: 0.6684
Epoch 223/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.7804 - acc: 0.6831
Epoch 224/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.7837 - acc: 0.6741
Epoch 225/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.7775 - acc: 0.6868
Epoch 226/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.7746 - acc: 0.6849
Epoch 227/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.7698 - acc: 0.6798
```

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Epoch 228/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.7656 - acc: 0.6866
Epoch 229/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.7655 - acc: 0.6810
Epoch 230/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.7623 - acc: 0.6889
Epoch 231/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.7605 - acc: 0.6812
Epoch 232/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.7549 - acc: 0.6897
Epoch 233/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.7525 - acc: 0.6941
Epoch 234/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.7535 - acc: 0.6837
Epoch 235/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.7471 - acc: 0.6947
Epoch 236/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.7488 - acc: 0.6890
Epoch 237/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.7428 - acc: 0.6887
Epoch 238/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.7425 - acc: 0.6889
Epoch 239/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.7389 - acc: 0.6971
Epoch 240/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.7369 - acc: 0.6968
Epoch 241/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.7314 - acc: 0.6936
Epoch 242/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.7283 - acc: 0.7023
Epoch 243/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.7239 - acc: 0.7066
Epoch 244/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.7240 - acc: 0.7008
Epoch 245/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.7182 - acc: 0.7076
Epoch 246/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.7161 - acc: 0.7056
Epoch 247/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.7122 - acc: 0.7100
Epoch 248/1000
10000/10000 [=====] - 0s 8us/step - loss: 0.7073 - acc: 0.7129
Epoch 249/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.7050 - acc: 0.7205
Epoch 250/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.7024 - acc: 0.7234
Epoch 251/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.6997 - acc: 0.7188
Epoch 252/1000
10000/10000 [=====] - 0s 8us/step - loss: 0.6966 - acc: 0.7309
Epoch 253/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.6956 - acc: 0.7225
Epoch 254/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.6919 - acc: 0.7250
Epoch 255/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.6867 - acc: 0.7361
Epoch 256/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.6845 - acc: 0.7350
Epoch 257/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.6806 - acc: 0.7423
Epoch 258/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.6793 - acc: 0.7403
Epoch 259/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.6716 - acc: 0.7509
Epoch 260/1000
```

10000/10000 [=====] - 0s 7us/step - loss: 0.6706 - acc: 0.7471
Epoch 261/1000
10000/10000 [=====] - 0s 8us/step - loss: 0.6663 - acc: 0.7557
Epoch 262/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.6659 - acc: 0.7504
Epoch 263/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.6623 - acc: 0.7579
Epoch 264/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.6566 - acc: 0.7572
Epoch 265/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.6534 - acc: 0.7631
Epoch 266/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.6531 - acc: 0.7643
Epoch 267/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.6398 - acc: 0.7800
Epoch 268/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.6406 - acc: 0.7799
Epoch 269/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.6315 - acc: 0.7876
Epoch 270/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.6303 - acc: 0.7840
Epoch 271/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.6242 - acc: 0.7904
Epoch 272/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.6181 - acc: 0.7941
Epoch 273/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.6107 - acc: 0.7971
Epoch 274/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.6076 - acc: 0.8005
Epoch 275/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.6038 - acc: 0.8052
Epoch 276/1000
10000/10000 [=====] - ETA: 0s - loss: 0.5942 - acc: 0.814 - 0s 7us/s
tep - loss: 0.5938 - acc: 0.8142
Epoch 277/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.5884 - acc: 0.8170
Epoch 278/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.5838 - acc: 0.8249
Epoch 279/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.5779 - acc: 0.8232
Epoch 280/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.5649 - acc: 0.8395
Epoch 281/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.5585 - acc: 0.8432
Epoch 282/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.5512 - acc: 0.8447
Epoch 283/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.5496 - acc: 0.8449
Epoch 284/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.5357 - acc: 0.8555
Epoch 285/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.5317 - acc: 0.8556
Epoch 286/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.5240 - acc: 0.8531
Epoch 287/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.5177 - acc: 0.8616
Epoch 288/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.5112 - acc: 0.8643
Epoch 289/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.5066 - acc: 0.8666
Epoch 290/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.5023 - acc: 0.8675
Epoch 291/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.4921 - acc: 0.8741
Epoch 292/1000

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10000/10000 [=====] - 0s 6us/step - loss: 0.4902 - acc: 0.8708
Epoch 293/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.4863 - acc: 0.8744
Epoch 294/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.4790 - acc: 0.8808
Epoch 295/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.4711 - acc: 0.8826
Epoch 296/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.4700 - acc: 0.8827
Epoch 297/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.4596 - acc: 0.8884
Epoch 298/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.4601 - acc: 0.8862
Epoch 299/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.4502 - acc: 0.8930
Epoch 300/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.4475 - acc: 0.8927
Epoch 301/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.4455 - acc: 0.8937
Epoch 302/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.4383 - acc: 0.8974
Epoch 303/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.4311 - acc: 0.9005
Epoch 304/1000
10000/10000 [=====] - 0s 8us/step - loss: 0.4300 - acc: 0.8989
Epoch 305/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.4238 - acc: 0.9027
Epoch 306/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.4217 - acc: 0.9042
Epoch 307/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.4150 - acc: 0.9030
Epoch 308/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.4132 - acc: 0.9045
Epoch 309/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.4058 - acc: 0.9098
Epoch 310/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.4049 - acc: 0.9100
Epoch 311/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.4022 - acc: 0.9063
Epoch 312/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.3946 - acc: 0.9099
Epoch 313/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.3930 - acc: 0.9135
Epoch 314/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.3911 - acc: 0.9119
Epoch 315/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.3860 - acc: 0.9140
Epoch 316/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.3850 - acc: 0.9127
Epoch 317/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.3763 - acc: 0.9206
Epoch 318/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.3798 - acc: 0.9131
Epoch 319/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.3747 - acc: 0.9197
Epoch 320/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.3676 - acc: 0.9188
Epoch 321/1000
10000/10000 [=====] - 0s 8us/step - loss: 0.3669 - acc: 0.9197
Epoch 322/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.3609 - acc: 0.9246
Epoch 323/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.3613 - acc: 0.9191
Epoch 324/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.3549 - acc: 0.9275
```

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Epoch 325/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.3532 - acc: 0.9251
Epoch 326/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.3499 - acc: 0.9252
Epoch 327/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.3460 - acc: 0.9248
Epoch 328/1000
10000/10000 [=====] - 0s 8us/step - loss: 0.3449 - acc: 0.9265
Epoch 329/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.3428 - acc: 0.9247
Epoch 330/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.3379 - acc: 0.9292
Epoch 331/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.3345 - acc: 0.9321
Epoch 332/1000
10000/10000 [=====] - 0s 11us/step - loss: 0.3326 - acc: 0.9292
Epoch 333/1000
10000/10000 [=====] - 0s 8us/step - loss: 0.3294 - acc: 0.9370
Epoch 334/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.3257 - acc: 0.9345
Epoch 335/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.3243 - acc: 0.9343
Epoch 336/1000
10000/10000 [=====] - 0s 8us/step - loss: 0.3185 - acc: 0.9381
Epoch 337/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.3179 - acc: 0.9393
Epoch 338/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.3133 - acc: 0.9393
Epoch 339/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.3113 - acc: 0.9433
Epoch 340/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.3109 - acc: 0.9392
Epoch 341/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.3074 - acc: 0.9418
Epoch 342/1000
10000/10000 [=====] - 0s 8us/step - loss: 0.3021 - acc: 0.9435
Epoch 343/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.3024 - acc: 0.9368
Epoch 344/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.3006 - acc: 0.9443
Epoch 345/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.2937 - acc: 0.9468
Epoch 346/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.2915 - acc: 0.9476
Epoch 347/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.2905 - acc: 0.9439
Epoch 348/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.2892 - acc: 0.9437
Epoch 349/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.2843 - acc: 0.9476
Epoch 350/1000
10000/10000 [=====] - 0s 8us/step - loss: 0.2834 - acc: 0.9480
Epoch 351/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.2816 - acc: 0.9491
Epoch 352/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.2776 - acc: 0.9470
Epoch 353/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.2770 - acc: 0.9488
Epoch 354/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.2773 - acc: 0.9488
Epoch 355/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.2732 - acc: 0.9495
Epoch 356/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.2697 - acc: 0.9515
Epoch 357/1000
```

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10000/10000 [=====] - 0s 7us/step - loss: 0.2677 - acc: 0.9503
Epoch 358/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.2668 - acc: 0.9504
Epoch 359/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.2649 - acc: 0.9533
Epoch 360/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.2620 - acc: 0.9522
Epoch 361/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.2542 - acc: 0.9578
Epoch 362/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.2557 - acc: 0.9539
Epoch 363/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.2536 - acc: 0.9552
Epoch 364/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.2517 - acc: 0.9584
Epoch 365/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.2467 - acc: 0.9603
Epoch 366/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.2469 - acc: 0.9588
Epoch 367/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.2456 - acc: 0.9572
Epoch 368/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.2438 - acc: 0.9554
Epoch 369/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.2405 - acc: 0.9595
Epoch 370/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.2374 - acc: 0.9607
Epoch 371/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.2371 - acc: 0.9579
Epoch 372/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.2321 - acc: 0.9619
Epoch 373/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.2329 - acc: 0.9587
Epoch 374/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.2287 - acc: 0.9634
Epoch 375/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.2285 - acc: 0.9611
Epoch 376/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.2258 - acc: 0.9631
Epoch 377/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.2256 - acc: 0.9642
Epoch 378/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.2237 - acc: 0.9622
Epoch 379/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.2225 - acc: 0.9599
Epoch 380/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.2224 - acc: 0.9625
Epoch 381/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.2146 - acc: 0.9645
Epoch 382/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.2145 - acc: 0.9662
Epoch 383/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.2143 - acc: 0.9655
Epoch 384/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.2091 - acc: 0.9675
Epoch 385/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.2110 - acc: 0.9649
Epoch 386/1000
10000/10000 [=====] - 0s 8us/step - loss: 0.2090 - acc: 0.9673
Epoch 387/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.2062 - acc: 0.9666
Epoch 388/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.2054 - acc: 0.9672
Epoch 389/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.1998 - acc: 0.9708
```

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Epoch 390/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.1983 - acc: 0.9695
Epoch 391/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.1996 - acc: 0.9666
Epoch 392/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.2003 - acc: 0.9652
Epoch 393/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.1952 - acc: 0.9698
Epoch 394/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.1941 - acc: 0.9688
Epoch 395/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.1942 - acc: 0.9699
Epoch 396/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.1909 - acc: 0.9700
Epoch 397/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.1895 - acc: 0.9707
Epoch 398/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.1870 - acc: 0.9730
Epoch 399/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.1868 - acc: 0.9692
Epoch 400/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.1873 - acc: 0.9710
Epoch 401/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.1845 - acc: 0.9697
Epoch 402/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.1805 - acc: 0.9722
Epoch 403/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.1787 - acc: 0.9731
Epoch 404/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.1770 - acc: 0.9724
Epoch 405/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.1785 - acc: 0.9705
Epoch 406/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.1745 - acc: 0.9731
Epoch 407/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.1735 - acc: 0.9732
Epoch 408/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.1735 - acc: 0.9742
Epoch 409/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.1723 - acc: 0.9746
Epoch 410/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.1679 - acc: 0.9726
Epoch 411/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.1676 - acc: 0.9762
Epoch 412/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.1652 - acc: 0.9758
Epoch 413/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.1646 - acc: 0.9752
Epoch 414/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.1644 - acc: 0.9761
Epoch 415/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.1590 - acc: 0.9781
Epoch 416/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.1595 - acc: 0.9779
Epoch 417/1000
10000/10000 [=====] - 0s 8us/step - loss: 0.1610 - acc: 0.9752
Epoch 418/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.1585 - acc: 0.9777
Epoch 419/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.1554 - acc: 0.9781
Epoch 420/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.1567 - acc: 0.9750
Epoch 421/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.1533 - acc: 0.9787
Epoch 422/1000
```

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10000/10000 [=====] - 0s 7us/step - loss: 0.1531 - acc: 0.9764
Epoch 423/1000
10000/10000 [=====] - 0s 5us/step - loss: 0.1520 - acc: 0.9775
Epoch 424/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.1493 - acc: 0.9811
Epoch 425/1000
10000/10000 [=====] - 0s 9us/step - loss: 0.1479 - acc: 0.9808
Epoch 426/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.1488 - acc: 0.9778
Epoch 427/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.1434 - acc: 0.9821
Epoch 428/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.1446 - acc: 0.9803
Epoch 429/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.1443 - acc: 0.9798
Epoch 430/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.1412 - acc: 0.9816
Epoch 431/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.1395 - acc: 0.9809
Epoch 432/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.1418 - acc: 0.9786
Epoch 433/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.1403 - acc: 0.9801
Epoch 434/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.1385 - acc: 0.9799
Epoch 435/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.1359 - acc: 0.9818
Epoch 436/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.1379 - acc: 0.9772
Epoch 437/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.1352 - acc: 0.9802
Epoch 438/1000
10000/10000 [=====] - 0s 8us/step - loss: 0.1336 - acc: 0.9830
Epoch 439/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.1298 - acc: 0.9831
Epoch 440/1000
10000/10000 [=====] - 0s 8us/step - loss: 0.1332 - acc: 0.9819
Epoch 441/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.1311 - acc: 0.9829
Epoch 442/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.1299 - acc: 0.9816
Epoch 443/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.1302 - acc: 0.9806
Epoch 444/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.1284 - acc: 0.9821
Epoch 445/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.1287 - acc: 0.9800
Epoch 446/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.1266 - acc: 0.9824
Epoch 447/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.1230 - acc: 0.9837
Epoch 448/1000
10000/10000 [=====] - 0s 8us/step - loss: 0.1234 - acc: 0.9836
Epoch 449/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.1227 - acc: 0.9823
Epoch 450/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.1246 - acc: 0.9805
Epoch 451/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.1207 - acc: 0.9842
Epoch 452/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.1179 - acc: 0.9865
Epoch 453/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.1177 - acc: 0.9837
Epoch 454/1000
10000/10000 [=====] - 0s 8us/step - loss: 0.1183 - acc: 0.9841
```


Epoch 455/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.1175 - acc: 0.9842
Epoch 456/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.1178 - acc: 0.9845
Epoch 457/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.1143 - acc: 0.9859
Epoch 458/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.1117 - acc: 0.9871
Epoch 459/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.1137 - acc: 0.9858
Epoch 460/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.1127 - acc: 0.9842
Epoch 461/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.1108 - acc: 0.9856
Epoch 462/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.1117 - acc: 0.9849
Epoch 463/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.1094 - acc: 0.9842
Epoch 464/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.1069 - acc: 0.9864
Epoch 465/1000
10000/10000 [=====] - 0s 8us/step - loss: 0.1061 - acc: 0.9867
Epoch 466/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.1059 - acc: 0.9869
Epoch 467/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.1061 - acc: 0.9858
Epoch 468/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.1047 - acc: 0.9865
Epoch 469/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.1026 - acc: 0.9884
Epoch 470/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.1016 - acc: 0.9889
Epoch 471/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.1027 - acc: 0.9873
Epoch 472/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.1004 - acc: 0.9864
Epoch 473/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.1005 - acc: 0.9852
Epoch 474/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.1005 - acc: 0.9870
Epoch 475/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0977 - acc: 0.9883
Epoch 476/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0984 - acc: 0.9865
Epoch 477/1000
10000/10000 [=====] - 0s 8us/step - loss: 0.0990 - acc: 0.9850
Epoch 478/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0957 - acc: 0.9895
Epoch 479/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0965 - acc: 0.9876
Epoch 480/1000
10000/10000 [=====] - 0s 8us/step - loss: 0.0947 - acc: 0.9891
Epoch 481/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0936 - acc: 0.9878
Epoch 482/1000
10000/10000 [=====] - 0s 8us/step - loss: 0.0933 - acc: 0.9888
Epoch 483/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0925 - acc: 0.9888
Epoch 484/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0939 - acc: 0.9876
Epoch 485/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0901 - acc: 0.9900
Epoch 486/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0912 - acc: 0.9895
Epoch 487/1000

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10000/10000 [=====] - 0s 6us/step - loss: 0.0901 - acc: 0.9893
Epoch 488/1000
10000/10000 [=====] - 0s 10us/step - loss: 0.0904 - acc: 0.9878
Epoch 489/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0885 - acc: 0.9888
Epoch 490/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0910 - acc: 0.9890
Epoch 491/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0862 - acc: 0.9891
Epoch 492/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0848 - acc: 0.9898
Epoch 493/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0833 - acc: 0.9913
Epoch 494/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0851 - acc: 0.9911
Epoch 495/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0851 - acc: 0.9898
Epoch 496/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0848 - acc: 0.9896
Epoch 497/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0827 - acc: 0.9898
Epoch 498/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0826 - acc: 0.9904
Epoch 499/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0818 - acc: 0.9905
Epoch 500/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0801 - acc: 0.9903
Epoch 501/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0801 - acc: 0.9910
Epoch 502/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0795 - acc: 0.9910
Epoch 503/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0807 - acc: 0.9897
Epoch 504/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0776 - acc: 0.9909
Epoch 505/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0796 - acc: 0.9897
Epoch 506/1000
10000/10000 [=====] - 0s 9us/step - loss: 0.0774 - acc: 0.9901
Epoch 507/1000
10000/10000 [=====] - 0s 10us/step - loss: 0.0777 - acc: 0.9904
Epoch 508/1000
10000/10000 [=====] - 0s 13us/step - loss: 0.0772 - acc: 0.9902
Epoch 509/1000
10000/10000 [=====] - 0s 9us/step - loss: 0.0762 - acc: 0.9909
Epoch 510/1000
10000/10000 [=====] - 0s 10us/step - loss: 0.0762 - acc: 0.9898
Epoch 511/1000
10000/10000 [=====] - 0s 9us/step - loss: 0.0736 - acc: 0.9917
Epoch 512/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0754 - acc: 0.9911
Epoch 513/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0721 - acc: 0.9928
Epoch 514/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0720 - acc: 0.9921
Epoch 515/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0739 - acc: 0.9919
Epoch 516/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0718 - acc: 0.9918
Epoch 517/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0718 - acc: 0.9900
Epoch 518/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0693 - acc: 0.9930
Epoch 519/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0713 - acc: 0.9916
```

Epoch 520/1000
10000/10000 [=====] - 0s 8us/step - loss: 0.0694 - acc: 0.9924
Epoch 521/1000
10000/10000 [=====] - 0s 10us/step - loss: 0.0670 - acc: 0.9935
Epoch 522/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0707 - acc: 0.9915
Epoch 523/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0699 - acc: 0.9916
Epoch 524/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0677 - acc: 0.9924
Epoch 525/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0676 - acc: 0.9923
Epoch 526/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0662 - acc: 0.9932
Epoch 527/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0655 - acc: 0.9930
Epoch 528/1000
10000/10000 [=====] - ETA: 0s - loss: 0.0658 - acc: 0.993 - 0s 7us/s
tep - loss: 0.0654 - acc: 0.9933
Epoch 529/1000
10000/10000 [=====] - 0s 8us/step - loss: 0.0639 - acc: 0.9931
Epoch 530/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0670 - acc: 0.9923
Epoch 531/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0644 - acc: 0.9919
Epoch 532/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0627 - acc: 0.9930
Epoch 533/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0615 - acc: 0.9937
Epoch 534/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0627 - acc: 0.9917
Epoch 535/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0611 - acc: 0.9938
Epoch 536/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0609 - acc: 0.9931
Epoch 537/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0609 - acc: 0.9947
Epoch 538/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0595 - acc: 0.9940
Epoch 539/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0591 - acc: 0.9950
Epoch 540/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0597 - acc: 0.9925
Epoch 541/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0581 - acc: 0.9935
Epoch 542/1000
10000/10000 [=====] - 0s 13us/step - loss: 0.0590 - acc: 0.9943
Epoch 543/1000
10000/10000 [=====] - 0s 9us/step - loss: 0.0574 - acc: 0.9942
Epoch 544/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0573 - acc: 0.9937
Epoch 545/1000
10000/10000 [=====] - 0s 9us/step - loss: 0.0566 - acc: 0.9938
Epoch 546/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0546 - acc: 0.9948
Epoch 547/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0569 - acc: 0.9934
Epoch 548/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0571 - acc: 0.9921
Epoch 549/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0557 - acc: 0.9940
Epoch 550/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0527 - acc: 0.9955
Epoch 551/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0536 - acc: 0.9948

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Epoch 552/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0525 - acc: 0.9952
Epoch 553/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0514 - acc: 0.9947
Epoch 554/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0524 - acc: 0.9946
Epoch 555/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0509 - acc: 0.9958
Epoch 556/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0503 - acc: 0.9950
Epoch 557/1000
10000/10000 [=====] - 0s 9us/step - loss: 0.0500 - acc: 0.9947
Epoch 558/1000
10000/10000 [=====] - 0s 8us/step - loss: 0.0503 - acc: 0.9955
Epoch 559/1000
10000/10000 [=====] - 0s 8us/step - loss: 0.0511 - acc: 0.9933
Epoch 560/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0475 - acc: 0.9960
Epoch 561/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0469 - acc: 0.9957
Epoch 562/1000
10000/10000 [=====] - 0s 5us/step - loss: 0.0483 - acc: 0.9949
Epoch 563/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0466 - acc: 0.9964
Epoch 564/1000
10000/10000 [=====] - 0s 5us/step - loss: 0.0488 - acc: 0.9938
Epoch 565/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0468 - acc: 0.9956
Epoch 566/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0455 - acc: 0.9962
Epoch 567/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0460 - acc: 0.9953
Epoch 568/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0448 - acc: 0.9960
Epoch 569/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0456 - acc: 0.9954
Epoch 570/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0447 - acc: 0.9960
Epoch 571/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0440 - acc: 0.9954
Epoch 572/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0430 - acc: 0.9959
Epoch 573/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0419 - acc: 0.9962
Epoch 574/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0417 - acc: 0.9966
Epoch 575/1000
10000/10000 [=====] - 0s 8us/step - loss: 0.0416 - acc: 0.9968
Epoch 576/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0433 - acc: 0.9954
Epoch 577/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0410 - acc: 0.9966
Epoch 578/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0409 - acc: 0.9964
Epoch 579/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0421 - acc: 0.9964
Epoch 580/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0403 - acc: 0.9967
Epoch 581/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0411 - acc: 0.9956
Epoch 582/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0397 - acc: 0.9964
Epoch 583/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0409 - acc: 0.9952
Epoch 584/1000
```

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10000/10000 [=====] - 0s 6us/step - loss: 0.0394 - acc: 0.9957
Epoch 585/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0384 - acc: 0.9969
Epoch 586/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0389 - acc: 0.9968
Epoch 587/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0363 - acc: 0.9974
Epoch 588/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0371 - acc: 0.9970
Epoch 589/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0373 - acc: 0.9969
Epoch 590/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0360 - acc: 0.9977
Epoch 591/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0376 - acc: 0.9961
Epoch 592/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0366 - acc: 0.9970
Epoch 593/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0374 - acc: 0.9963
Epoch 594/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0345 - acc: 0.9980
Epoch 595/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0353 - acc: 0.9979
Epoch 596/1000
10000/10000 [=====] - 0s 8us/step - loss: 0.0363 - acc: 0.9962
Epoch 597/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0354 - acc: 0.9970
Epoch 598/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0347 - acc: 0.9971
Epoch 599/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0336 - acc: 0.9978
Epoch 600/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0350 - acc: 0.9974
Epoch 601/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0334 - acc: 0.9968
Epoch 602/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0348 - acc: 0.9967
Epoch 603/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0327 - acc: 0.9969
Epoch 604/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0338 - acc: 0.9971
Epoch 605/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0343 - acc: 0.9967
Epoch 606/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0327 - acc: 0.9976
Epoch 607/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0320 - acc: 0.9974
Epoch 608/1000
10000/10000 [=====] - 0s 8us/step - loss: 0.0310 - acc: 0.9977
Epoch 609/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0318 - acc: 0.9973
Epoch 610/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0308 - acc: 0.9977
Epoch 611/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0316 - acc: 0.9977
Epoch 612/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0302 - acc: 0.9977
Epoch 613/1000
10000/10000 [=====] - 0s 8us/step - loss: 0.0301 - acc: 0.9980
Epoch 614/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0301 - acc: 0.9980
Epoch 615/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0294 - acc: 0.9982
Epoch 616/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0304 - acc: 0.9971
```

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Epoch 617/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0284 - acc: 0.9977
Epoch 618/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0296 - acc: 0.9974
Epoch 619/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0299 - acc: 0.9975
Epoch 620/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0295 - acc: 0.9979
Epoch 621/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0273 - acc: 0.9985
Epoch 622/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0285 - acc: 0.9978
Epoch 623/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0289 - acc: 0.9980
Epoch 624/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0284 - acc: 0.9980
Epoch 625/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0274 - acc: 0.9981
Epoch 626/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0261 - acc: 0.9986
Epoch 627/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0280 - acc: 0.9976
Epoch 628/1000
10000/10000 [=====] - 0s 9us/step - loss: 0.0277 - acc: 0.9979
Epoch 629/1000
10000/10000 [=====] - 0s 8us/step - loss: 0.0276 - acc: 0.9980
Epoch 630/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0268 - acc: 0.9985
Epoch 631/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0271 - acc: 0.9976
Epoch 632/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0255 - acc: 0.9986
Epoch 633/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0258 - acc: 0.9983
Epoch 634/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0251 - acc: 0.9982
Epoch 635/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0265 - acc: 0.9978
Epoch 636/1000
10000/10000 [=====] - 0s 8us/step - loss: 0.0260 - acc: 0.9979
Epoch 637/1000
10000/10000 [=====] - 0s 8us/step - loss: 0.0257 - acc: 0.9978
Epoch 638/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0258 - acc: 0.9973
Epoch 639/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0259 - acc: 0.9978
Epoch 640/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0253 - acc: 0.9980
Epoch 641/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0254 - acc: 0.9976
Epoch 642/1000
10000/10000 [=====] - 0s 9us/step - loss: 0.0234 - acc: 0.9987
Epoch 643/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0237 - acc: 0.9986
Epoch 644/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0237 - acc: 0.9988
Epoch 645/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0241 - acc: 0.9977
Epoch 646/1000
10000/10000 [=====] - 0s 8us/step - loss: 0.0234 - acc: 0.9988
Epoch 647/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0247 - acc: 0.9982
Epoch 648/1000
10000/10000 [=====] - 0s 8us/step - loss: 0.0228 - acc: 0.9984
Epoch 649/1000
```

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10000/10000 [=====] - 0s 7us/step - loss: 0.0228 - acc: 0.9984
Epoch 650/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0230 - acc: 0.9986
Epoch 651/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0225 - acc: 0.9986
Epoch 652/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0234 - acc: 0.9983
Epoch 653/1000
10000/10000 [=====] - 0s 10us/step - loss: 0.0219 - acc: 0.9990
Epoch 654/1000
10000/10000 [=====] - 0s 10us/step - loss: 0.0236 - acc: 0.9980
Epoch 655/1000
10000/10000 [=====] - 0s 9us/step - loss: 0.0209 - acc: 0.9989
Epoch 656/1000
10000/10000 [=====] - 0s 10us/step - loss: 0.0222 - acc: 0.9984
Epoch 657/1000
10000/10000 [=====] - 0s 10us/step - loss: 0.0213 - acc: 0.9987
Epoch 658/1000
10000/10000 [=====] - 0s 9us/step - loss: 0.0211 - acc: 0.9985
Epoch 659/1000
10000/10000 [=====] - 0s 10us/step - loss: 0.0219 - acc: 0.9978
Epoch 660/1000
10000/10000 [=====] - 0s 11us/step - loss: 0.0220 - acc: 0.9982
Epoch 661/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0205 - acc: 0.9990
Epoch 662/1000
10000/10000 [=====] - 0s 9us/step - loss: 0.0213 - acc: 0.9984
Epoch 663/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0203 - acc: 0.9988
Epoch 664/1000
10000/10000 [=====] - 0s 8us/step - loss: 0.0209 - acc: 0.9987
Epoch 665/1000
10000/10000 [=====] - 0s 9us/step - loss: 0.0203 - acc: 0.9986
Epoch 666/1000
10000/10000 [=====] - 0s 10us/step - loss: 0.0209 - acc: 0.9988
Epoch 667/1000
10000/10000 [=====] - 0s 11us/step - loss: 0.0210 - acc: 0.9977
Epoch 668/1000
10000/10000 [=====] - 0s 12us/step - loss: 0.0197 - acc: 0.9991
Epoch 669/1000
10000/10000 [=====] - 0s 12us/step - loss: 0.0193 - acc: 0.9989
Epoch 670/1000
10000/10000 [=====] - 0s 9us/step - loss: 0.0205 - acc: 0.9985
Epoch 671/1000
10000/10000 [=====] - 0s 11us/step - loss: 0.0198 - acc: 0.9989
Epoch 672/1000
10000/10000 [=====] - 0s 9us/step - loss: 0.0192 - acc: 0.9986
Epoch 673/1000
10000/10000 [=====] - 0s 11us/step - loss: 0.0207 - acc: 0.9982
Epoch 674/1000
10000/10000 [=====] - 0s 10us/step - loss: 0.0197 - acc: 0.9987
Epoch 675/1000
10000/10000 [=====] - 0s 10us/step - loss: 0.0191 - acc: 0.9987
Epoch 676/1000
10000/10000 [=====] - 0s 10us/step - loss: 0.0187 - acc: 0.9992
Epoch 677/1000
10000/10000 [=====] - 0s 10us/step - loss: 0.0190 - acc: 0.9987
Epoch 678/1000
10000/10000 [=====] - 0s 11us/step - loss: 0.0195 - acc: 0.9986
Epoch 679/1000
10000/10000 [=====] - 0s 10us/step - loss: 0.0185 - acc: 0.9990
Epoch 680/1000
10000/10000 [=====] - 0s 10us/step - loss: 0.0189 - acc: 0.9982
Epoch 681/1000
10000/10000 [=====] - 0s 9us/step - loss: 0.0186 - acc: 0.9989
```

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Epoch 682/1000
10000/10000 [=====] - 0s 11us/step - loss: 0.0185 - acc: 0.9986
Epoch 683/1000
10000/10000 [=====] - 0s 10us/step - loss: 0.0170 - acc: 0.9992
Epoch 684/1000
10000/10000 [=====] - 0s 11us/step - loss: 0.0178 - acc: 0.9990
Epoch 685/1000
10000/10000 [=====] - 0s 9us/step - loss: 0.0180 - acc: 0.9984
Epoch 686/1000
10000/10000 [=====] - 0s 11us/step - loss: 0.0182 - acc: 0.9991
Epoch 687/1000
10000/10000 [=====] - 0s 10us/step - loss: 0.0182 - acc: 0.9991
Epoch 688/1000
10000/10000 [=====] - 0s 11us/step - loss: 0.0181 - acc: 0.9990
Epoch 689/1000
10000/10000 [=====] - 0s 10us/step - loss: 0.0173 - acc: 0.9991
Epoch 690/1000
10000/10000 [=====] - 0s 11us/step - loss: 0.0168 - acc: 0.9987
Epoch 691/1000
10000/10000 [=====] - 0s 9us/step - loss: 0.0171 - acc: 0.9994
Epoch 692/1000
10000/10000 [=====] - 0s 9us/step - loss: 0.0168 - acc: 0.9991
Epoch 693/1000
10000/10000 [=====] - 0s 10us/step - loss: 0.0167 - acc: 0.9988
Epoch 694/1000
10000/10000 [=====] - 0s 10us/step - loss: 0.0168 - acc: 0.9993
Epoch 695/1000
10000/10000 [=====] - 0s 11us/step - loss: 0.0169 - acc: 0.9989
Epoch 696/1000
10000/10000 [=====] - 0s 10us/step - loss: 0.0160 - acc: 0.9992
Epoch 697/1000
10000/10000 [=====] - 0s 11us/step - loss: 0.0173 - acc: 0.9981
Epoch 698/1000
10000/10000 [=====] - 0s 10us/step - loss: 0.0170 - acc: 0.9988
Epoch 699/1000
10000/10000 [=====] - 0s 10us/step - loss: 0.0165 - acc: 0.9989
Epoch 700/1000
10000/10000 [=====] - 0s 9us/step - loss: 0.0166 - acc: 0.9989
Epoch 701/1000
10000/10000 [=====] - 0s 8us/step - loss: 0.0158 - acc: 0.9987
Epoch 702/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0164 - acc: 0.9987
Epoch 703/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0155 - acc: 0.9989
Epoch 704/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0152 - acc: 0.9994
Epoch 705/1000
10000/10000 [=====] - 0s 9us/step - loss: 0.0154 - acc: 0.9992
Epoch 706/1000
10000/10000 [=====] - 0s 8us/step - loss: 0.0160 - acc: 0.9989
Epoch 707/1000
10000/10000 [=====] - 0s 8us/step - loss: 0.0156 - acc: 0.9991
Epoch 708/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0154 - acc: 0.9992
Epoch 709/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0153 - acc: 0.9989
Epoch 710/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0151 - acc: 0.9990
Epoch 711/1000
10000/10000 [=====] - 0s 8us/step - loss: 0.0151 - acc: 0.9995
Epoch 712/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0150 - acc: 0.9993
Epoch 713/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0149 - acc: 0.9988
Epoch 714/1000
```



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10000/10000 [=====] - 0s 7us/step - loss: 0.0146 - acc: 0.9994
Epoch 715/1000
10000/10000 [=====] - 0s 8us/step - loss: 0.0151 - acc: 0.9995
Epoch 716/1000
10000/10000 [=====] - 0s 8us/step - loss: 0.0144 - acc: 0.9991
Epoch 717/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0147 - acc: 0.9985
Epoch 718/1000
10000/10000 [=====] - 0s 11us/step - loss: 0.0142 - acc: 0.9990
Epoch 719/1000
10000/10000 [=====] - 0s 9us/step - loss: 0.0138 - acc: 0.9995
Epoch 720/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0143 - acc: 0.9991
Epoch 721/1000
10000/10000 [=====] - 0s 9us/step - loss: 0.0138 - acc: 0.9990
Epoch 722/1000
10000/10000 [=====] - 0s 9us/step - loss: 0.0136 - acc: 0.9994
Epoch 723/1000
10000/10000 [=====] - 0s 9us/step - loss: 0.0134 - acc: 0.9990
Epoch 724/1000
10000/10000 [=====] - 0s 9us/step - loss: 0.0145 - acc: 0.9991A: 0s
- loss: 0.0144 - acc: 0.999
Epoch 725/1000
10000/10000 [=====] - 0s 9us/step - loss: 0.0133 - acc: 0.9995
Epoch 726/1000
10000/10000 [=====] - 0s 8us/step - loss: 0.0139 - acc: 0.9991
Epoch 727/1000
10000/10000 [=====] - 0s 8us/step - loss: 0.0135 - acc: 0.9993
Epoch 728/1000
10000/10000 [=====] - 0s 8us/step - loss: 0.0132 - acc: 0.9991
Epoch 729/1000
10000/10000 [=====] - 0s 8us/step - loss: 0.0127 - acc: 0.9994
Epoch 730/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0132 - acc: 0.9992
Epoch 731/1000
10000/10000 [=====] - 0s 8us/step - loss: 0.0130 - acc: 0.9995
Epoch 732/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0131 - acc: 0.9995
Epoch 733/1000
10000/10000 [=====] - 0s 5us/step - loss: 0.0132 - acc: 0.9989
Epoch 734/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0125 - acc: 0.9995
Epoch 735/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0127 - acc: 0.9995
Epoch 736/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0130 - acc: 0.9988
Epoch 737/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0128 - acc: 0.9992
Epoch 738/1000
10000/10000 [=====] - 0s 8us/step - loss: 0.0126 - acc: 0.9992
Epoch 739/1000
10000/10000 [=====] - 0s 9us/step - loss: 0.0117 - acc: 0.9994
Epoch 740/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0121 - acc: 0.9993
Epoch 741/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0117 - acc: 0.9995
Epoch 742/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0121 - acc: 0.9995A: 0s
- loss: 0.0122 - acc: 0.999
Epoch 743/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0120 - acc: 0.9991
Epoch 744/1000
10000/10000 [=====] - 0s 8us/step - loss: 0.0117 - acc: 0.9993
Epoch 745/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0118 - acc: 0.9994
```

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Epoch 746/1000
10000/10000 [=====] - 0s 8us/step - loss: 0.0121 - acc: 0.9996
Epoch 747/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0114 - acc: 0.9997
Epoch 748/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0112 - acc: 0.9998
Epoch 749/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0113 - acc: 0.9997
Epoch 750/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0109 - acc: 0.9998
Epoch 751/1000
10000/10000 [=====] - 0s 8us/step - loss: 0.0124 - acc: 0.9990
Epoch 752/1000
10000/10000 [=====] - 0s 11us/step - loss: 0.0108 - acc: 0.9995
Epoch 753/1000
10000/10000 [=====] - 0s 10us/step - loss: 0.0113 - acc: 0.9990
Epoch 754/1000
10000/10000 [=====] - 0s 10us/step - loss: 0.0111 - acc: 0.9993
Epoch 755/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0116 - acc: 0.9995
Epoch 756/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0108 - acc: 0.9992
Epoch 757/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0111 - acc: 0.9993
Epoch 758/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0101 - acc: 1.0000
Epoch 759/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0114 - acc: 0.9993
Epoch 760/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0104 - acc: 0.9995
Epoch 761/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0108 - acc: 0.9991
Epoch 762/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0112 - acc: 0.9993
Epoch 763/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0106 - acc: 0.9998
Epoch 764/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0099 - acc: 0.9998
Epoch 765/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0104 - acc: 0.9990
Epoch 766/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0105 - acc: 0.9993
Epoch 767/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0103 - acc: 0.9996
Epoch 768/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0105 - acc: 0.9990
Epoch 769/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0101 - acc: 0.9995
Epoch 770/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0097 - acc: 0.9997
Epoch 771/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0103 - acc: 0.9992
Epoch 772/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0097 - acc: 0.9995
Epoch 773/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0100 - acc: 0.9995
Epoch 774/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0100 - acc: 0.9996
Epoch 775/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0096 - acc: 0.9995
Epoch 776/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0097 - acc: 0.9995
Epoch 777/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0101 - acc: 0.9994
Epoch 778/1000
```

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10000/10000 [=====] - 0s 7us/step - loss: 0.0103 - acc: 0.9993
Epoch 779/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0098 - acc: 0.9995
Epoch 780/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0095 - acc: 0.9992
Epoch 781/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0090 - acc: 0.9994
Epoch 782/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0101 - acc: 0.9996
Epoch 783/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0090 - acc: 0.9997
Epoch 784/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0090 - acc: 0.9997
Epoch 785/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0091 - acc: 0.9997
Epoch 786/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0089 - acc: 0.9996
Epoch 787/1000
10000/10000 [=====] - 0s 8us/step - loss: 0.0095 - acc: 0.9997
Epoch 788/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0088 - acc: 0.9998
Epoch 789/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0088 - acc: 0.9997
Epoch 790/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0093 - acc: 0.9996
Epoch 791/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0094 - acc: 0.9992
Epoch 792/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0084 - acc: 1.0000
Epoch 793/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0086 - acc: 0.9998
Epoch 794/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0093 - acc: 0.9994
Epoch 795/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0090 - acc: 0.9994
Epoch 796/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0086 - acc: 0.9994
Epoch 797/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0087 - acc: 0.9996
Epoch 798/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0084 - acc: 0.9997
Epoch 799/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0094 - acc: 0.9987
Epoch 800/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0078 - acc: 0.9997
Epoch 801/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0082 - acc: 0.9998
Epoch 802/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0080 - acc: 0.9997
Epoch 803/1000
10000/10000 [=====] - 0s 8us/step - loss: 0.0082 - acc: 0.9994
Epoch 804/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0080 - acc: 0.9995
Epoch 805/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0077 - acc: 0.9996
Epoch 806/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0079 - acc: 0.9998
Epoch 807/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0074 - acc: 0.9999
Epoch 808/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0079 - acc: 0.9996
Epoch 809/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0075 - acc: 0.9998
Epoch 810/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0081 - acc: 0.9997
```

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Epoch 811/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0077 - acc: 0.9998
Epoch 812/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0075 - acc: 0.9997
Epoch 813/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0087 - acc: 0.9992
Epoch 814/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0077 - acc: 0.9996
Epoch 815/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0082 - acc: 0.9994
Epoch 816/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0076 - acc: 0.9997
Epoch 817/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0077 - acc: 0.9996
Epoch 818/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0082 - acc: 0.9992
Epoch 819/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0076 - acc: 0.9997
Epoch 820/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0077 - acc: 0.9996
Epoch 821/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0071 - acc: 0.9997
Epoch 822/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0071 - acc: 0.9999
Epoch 823/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0081 - acc: 0.9993
Epoch 824/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0072 - acc: 0.9996
Epoch 825/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0072 - acc: 0.9996
Epoch 826/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0070 - acc: 0.9998
Epoch 827/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0068 - acc: 0.9999
Epoch 828/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0070 - acc: 0.9996
Epoch 829/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0070 - acc: 0.9999
Epoch 830/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0068 - acc: 0.9997
Epoch 831/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0074 - acc: 0.9993
Epoch 832/1000
10000/10000 [=====] - 0s 12us/step - loss: 0.0071 - acc: 0.9998
Epoch 833/1000
10000/10000 [=====] - 0s 9us/step - loss: 0.0066 - acc: 0.9996
Epoch 834/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0068 - acc: 0.9996
Epoch 835/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0062 - acc: 0.9998
Epoch 836/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0064 - acc: 1.0000
Epoch 837/1000
10000/10000 [=====] - 0s 8us/step - loss: 0.0068 - acc: 0.9996
Epoch 838/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0067 - acc: 0.9997
Epoch 839/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0066 - acc: 0.9998
Epoch 840/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0072 - acc: 0.9995
Epoch 841/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0074 - acc: 0.9992
Epoch 842/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0071 - acc: 0.9994
Epoch 843/1000
```

```
10000/10000 [=====] - 0s 8us/step - loss: 0.0064 - acc: 1.0000
Epoch 844/1000
10000/10000 [=====] - 0s 8us/step - loss: 0.0073 - acc: 0.9996
Epoch 845/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0058 - acc: 0.9999
Epoch 846/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0064 - acc: 0.9998
Epoch 847/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0064 - acc: 0.9996
Epoch 848/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0063 - acc: 0.9997
Epoch 849/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0066 - acc: 0.9997
Epoch 850/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0060 - acc: 1.0000
Epoch 851/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0063 - acc: 0.9997
Epoch 852/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0063 - acc: 0.9996
Epoch 853/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0063 - acc: 0.9996
Epoch 854/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0060 - acc: 0.9997
Epoch 855/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0059 - acc: 0.9999
Epoch 856/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0062 - acc: 0.9997
Epoch 857/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0063 - acc: 0.9999
Epoch 858/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0063 - acc: 0.9998
Epoch 859/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0058 - acc: 0.9999
Epoch 860/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0056 - acc: 1.0000
Epoch 861/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0055 - acc: 0.9999
Epoch 862/1000
10000/10000 [=====] - 0s 8us/step - loss: 0.0061 - acc: 0.9995
Epoch 863/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0053 - acc: 1.0000
Epoch 864/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0060 - acc: 0.9996
Epoch 865/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0060 - acc: 0.9997
Epoch 866/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0056 - acc: 0.9996
Epoch 867/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0056 - acc: 0.9997
Epoch 868/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0053 - acc: 0.9998
Epoch 869/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0054 - acc: 0.9999
Epoch 870/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0050 - acc: 0.9999
Epoch 871/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0052 - acc: 1.0000
Epoch 872/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0055 - acc: 0.9998
Epoch 873/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0056 - acc: 0.9996
Epoch 874/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0048 - acc: 0.9998
Epoch 875/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0052 - acc: 0.9998
```

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Epoch 876/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0058 - acc: 0.9997
Epoch 877/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0052 - acc: 0.9998
Epoch 878/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0048 - acc: 1.0000
Epoch 879/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0052 - acc: 0.9999
Epoch 880/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0052 - acc: 0.9998
Epoch 881/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0056 - acc: 0.9995
Epoch 882/1000
10000/10000 [=====] - 0s 10us/step - loss: 0.0050 - acc: 0.9999
Epoch 883/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0052 - acc: 0.9998
Epoch 884/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0052 - acc: 0.9998
Epoch 885/1000
10000/10000 [=====] - 0s 8us/step - loss: 0.0049 - acc: 0.9998
Epoch 886/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0052 - acc: 0.9997
Epoch 887/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0051 - acc: 0.9996
Epoch 888/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0046 - acc: 0.9998
Epoch 889/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0052 - acc: 0.9997
Epoch 890/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0052 - acc: 0.9998
Epoch 891/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0051 - acc: 0.9996
Epoch 892/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0048 - acc: 0.9999
Epoch 893/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0051 - acc: 0.9998
Epoch 894/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0050 - acc: 0.9999
Epoch 895/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0049 - acc: 0.9997
Epoch 896/1000
10000/10000 [=====] - 0s 8us/step - loss: 0.0051 - acc: 0.9997
Epoch 897/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0047 - acc: 0.9999
Epoch 898/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0048 - acc: 0.9997
Epoch 899/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0049 - acc: 0.9998
Epoch 900/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0057 - acc: 0.9994
Epoch 901/1000
10000/10000 [=====] - 0s 8us/step - loss: 0.0048 - acc: 0.9997
Epoch 902/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0046 - acc: 0.9999
Epoch 903/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0047 - acc: 0.9996
Epoch 904/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0044 - acc: 0.9999
Epoch 905/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0048 - acc: 0.9996
Epoch 906/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0049 - acc: 0.9996
Epoch 907/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0047 - acc: 0.9999
Epoch 908/1000
```

```
10000/10000 [=====] - 0s 6us/step - loss: 0.0046 - acc: 0.9999
Epoch 909/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0041 - acc: 1.0000
Epoch 910/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0043 - acc: 1.0000
Epoch 911/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0042 - acc: 1.0000
Epoch 912/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0045 - acc: 0.9998
Epoch 913/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0045 - acc: 0.9999
Epoch 914/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0045 - acc: 0.9998
Epoch 915/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0041 - acc: 0.9998
Epoch 916/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0043 - acc: 0.9999
Epoch 917/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0045 - acc: 0.9998
Epoch 918/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0040 - acc: 1.0000
Epoch 919/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0048 - acc: 0.9992
Epoch 920/1000
10000/10000 [=====] - 0s 8us/step - loss: 0.0043 - acc: 0.9997
Epoch 921/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0039 - acc: 0.9999
Epoch 922/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0040 - acc: 1.0000
Epoch 923/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0043 - acc: 0.9999
Epoch 924/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0038 - acc: 1.0000
Epoch 925/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0038 - acc: 1.0000
Epoch 926/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0037 - acc: 0.9999
Epoch 927/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0041 - acc: 0.9998
Epoch 928/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0041 - acc: 0.9999
Epoch 929/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0042 - acc: 0.9998
Epoch 930/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0036 - acc: 1.0000
Epoch 931/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0037 - acc: 0.9997
Epoch 932/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0041 - acc: 0.9999
Epoch 933/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0040 - acc: 0.9998
Epoch 934/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0039 - acc: 0.9998
Epoch 935/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0038 - acc: 0.9999
Epoch 936/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0037 - acc: 0.9999
Epoch 937/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0037 - acc: 0.9999
Epoch 938/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0038 - acc: 0.9999
Epoch 939/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0044 - acc: 0.9995
Epoch 940/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0038 - acc: 0.9998
```

```
Epoch 941/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0038 - acc: 1.0000
Epoch 942/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0038 - acc: 0.9998
Epoch 943/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0040 - acc: 0.9998
Epoch 944/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0038 - acc: 1.0000
Epoch 945/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0036 - acc: 0.9999
Epoch 946/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0039 - acc: 0.9999
Epoch 947/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0035 - acc: 0.9998
Epoch 948/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0039 - acc: 0.9996
Epoch 949/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0035 - acc: 1.0000
Epoch 950/1000
10000/10000 [=====] - 0s 8us/step - loss: 0.0032 - acc: 0.9998
Epoch 951/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0034 - acc: 0.9998
Epoch 952/1000
10000/10000 [=====] - 0s 8us/step - loss: 0.0036 - acc: 0.9999
Epoch 953/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0036 - acc: 0.9997
Epoch 954/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0031 - acc: 0.9999
Epoch 955/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0036 - acc: 0.9998
Epoch 956/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0038 - acc: 0.9997
Epoch 957/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0035 - acc: 0.9997
Epoch 958/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0036 - acc: 0.9998
Epoch 959/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0036 - acc: 0.9997
Epoch 960/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0034 - acc: 1.0000
Epoch 961/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0032 - acc: 0.9999
Epoch 962/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0035 - acc: 0.9997
Epoch 963/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0033 - acc: 0.9999
Epoch 964/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0031 - acc: 1.0000
Epoch 965/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0033 - acc: 1.0000
Epoch 966/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0033 - acc: 0.9998
Epoch 967/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0030 - acc: 1.0000
Epoch 968/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0030 - acc: 1.0000
Epoch 969/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0030 - acc: 0.9998
Epoch 970/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0034 - acc: 0.9998
Epoch 971/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0034 - acc: 0.9998
Epoch 972/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0029 - acc: 1.0000
Epoch 973/1000
```



```
10000/10000 [=====] - 0s 7us/step - loss: 0.0031 - acc: 0.9997
Epoch 974/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0029 - acc: 1.0000
Epoch 975/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0030 - acc: 0.9999
Epoch 976/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0030 - acc: 1.0000
Epoch 977/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0032 - acc: 0.9999
Epoch 978/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0033 - acc: 0.9996
Epoch 979/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0033 - acc: 0.9997
Epoch 980/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0028 - acc: 0.9999
Epoch 981/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0032 - acc: 1.0000
Epoch 982/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0032 - acc: 0.9999
Epoch 983/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0028 - acc: 0.9999
Epoch 984/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0027 - acc: 0.9999
Epoch 985/1000
10000/10000 [=====] - 0s 8us/step - loss: 0.0031 - acc: 0.9997
Epoch 986/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0032 - acc: 0.9997
Epoch 987/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0032 - acc: 0.9998
Epoch 988/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0027 - acc: 1.0000
Epoch 989/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0028 - acc: 1.0000
Epoch 990/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0027 - acc: 1.0000
Epoch 991/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0029 - acc: 0.9999
Epoch 992/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0029 - acc: 0.9998
Epoch 993/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0027 - acc: 0.9999
Epoch 994/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0028 - acc: 0.9999
Epoch 995/1000
10000/10000 [=====] - 0s 7us/step - loss: 0.0029 - acc: 1.0000
Epoch 996/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0030 - acc: 0.9999
Epoch 997/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0030 - acc: 0.9998
Epoch 998/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0027 - acc: 0.9999
Epoch 999/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0027 - acc: 0.9997
Epoch 1000/1000
10000/10000 [=====] - 0s 6us/step - loss: 0.0026 - acc: 1.0000
```

```
In [5]:  
x_test=np.random.randint(0,8,10)  
print(x_test)  
y_test=estimator.predict(x_test)  
print(y_test)  
  
[0 3 5 3 3 7 3 0 3 2]  
10/10 [=====] - 0s 7ms/step  
[0 3 5 3 3 7 3 0 3 2]
```

Alternate learning code

```

In [6]:
import tensorflow as tf
from tensorflow import keras
from tensorflow.keras.layers import *
from sklearn import preprocessing
import tensorflow.keras.backend as K
from sklearn.metrics import mean_squared_error

sigma= 1e-4

# Perturbation Sampling
def perturbation(x):
    w = K.random_normal(shape = (channel,2), mean=0.0, stddev=sigma**0.5, dtype=None)
    xp = ((1-sigma)**0.5)*x + w
    return xp

# Defining transmitter loss
def loss_tx(y_true, y_pred):
    return -y_true*y_pred

# Defining the policy
def get_policy(inp):
    xp = inp[0]
    x = inp[1]
    w = xp - x
    policy = -K.sum(w*w)
    return policy

tx_inp = Input((1,))
# Adding embedding layer
embeddings_layer = Dense(msg_total, activation = 'relu')(tx_inp)
layer_dense = Dense(2*channel, activation = 'relu')(embeddings_layer)
# real to complex
to_complex = Reshape((channel,2))(layer_dense)
# Normalising the output to unit energy
x = Lambda(lambda x: keras.backend.l2_normalize(x))(to_complex)
# Perturbation sampling
xp = Lambda(perturbation)(to_complex)
policy = Lambda(get_policy)([xp,x])

# model for policy training
model_policy = keras.models.Model(inputs=tx_inp, outputs=policy)
# model to get the perturbed output
model_tx = keras.models.Model(inputs=tx_inp, outputs=xp)
# model to get the encoded message to transmit
model_x = keras.models.Model(inputs=tx_inp, outputs=x)

model_policy.compile(loss=loss_tx, optimizer=tf.keras.optimizers.SGD(lr = 1e-5))
print(model_policy.summary())

```

```

rx_inp = Input((channel,2))
# complex to real
to_flat = Reshape((2*channel,))(rx_inp)
fc = Dense(8*2*channel, activation = 'relu')(to_flat)
softmax = Dense(msg_total, activation = 'softmax')(fc)

model_rx = keras.models.Model(inputs=rx_inp, outputs=softmax)

model_rx.compile(loss=tf.keras.losses.categorical_crossentropy, optimizer=tf.keras.optimizers.Adam())
print(model_rx.summary())

loss_tx = []
loss_rx = []
for epoch in range(epochs):
    # Transmitter Training
    raw_input = np.random.randint(0,msg_total,(batch_size))
    label = np.zeros((batch_size, msg_total))
    label[np.arange(batch_size), raw_input] = 1
    tx_input = raw_input/float(msg_total)
    xp = model_tx.predict(tx_input)
    y = xp + np.random.normal(0,0.001,(batch_size, channel,2))
    pred = model_rx.predict(y)
    loss = np.sum(np.square(label - pred), axis = 1)
    history_tx = model_policy.fit(tx_input, loss, batch_size=batch_size, epochs=1, verbose=0)
    loss_tx.append(history_tx.history['loss'][0])

    # Receiver Training
    raw_input = np.random.randint(0,msg_total,(batch_size))
    label = np.zeros((batch_size, msg_total))
    label[np.arange(batch_size), raw_input] = 1
    tx_input = raw_input/float(msg_total)
    x = model_x.predict(tx_input)
    y = x + np.random.normal(0,0.001,(batch_size, channel,2))
    history_rx = model_rx.fit(y, label, batch_size=batch_size, epochs=1, verbose=0)
    loss_rx.append(history_rx.history['loss'][0])

    if(epoch % 100 == 0):
        print('epoch: ', epoch, 'tx_loss', history_tx.history['loss'][0], 'rx_loss', history_rx.history['loss'][0])

```

Layer (type)	Output Shape	Param #	Connected to
=====			
input_1 (InputLayer)	(None, 1)	0	
dense (Dense)	(None, 8)	16	input_1[0][0]
dense_1 (Dense)	(None, 8)	72	dense[0][0]
reshape (Reshape)	(None, 4, 2)	0	dense_1[0][0]
lambda_1 (Lambda)	(None, 4, 2)	0	reshape[0][0]
lambda (Lambda)	(None, 4, 2)	0	reshape[0][0]
lambda_2 (Lambda)	()	0	lambda_1[0][0] lambda[0][0]
=====			
Total params: 88			
Trainable params: 88			
Non-trainable params: 0			

None

Layer (type)	Output Shape	Param #
=====		
input_2 (InputLayer)	(None, 4, 2)	0
reshape_1 (Reshape)	(None, 8)	0
dense_2 (Dense)	(None, 64)	576
dense_3 (Dense)	(None, 8)	520
=====		
Total params: 1,096		
Trainable params: 1,096		
Non-trainable params: 0		

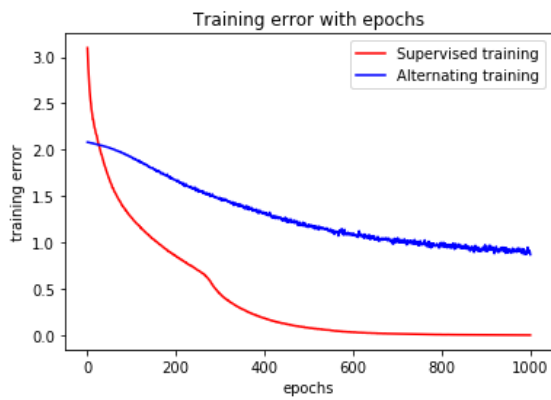
None

epoch: 0 tx_loss 71.5909652709961 rx_loss 2.0817627906799316
epoch: 100 tx_loss 1.5325736999511719 rx_loss 1.9192808866500854
epoch: 200 tx_loss 0.5519936084747314 rx_loss 1.6701114177703857
epoch: 300 tx_loss 0.23733562231063843 rx_loss 1.4618213176727295
epoch: 400 tx_loss 1.1068954467773438 rx_loss 1.3234074115753174
epoch: 500 tx_loss 1.0912060737609863 rx_loss 1.1656519174575806
epoch: 600 tx_loss 0.7089741230010986 rx_loss 1.0759291648864746
epoch: 700 tx_loss 0.6874275207519531 rx_loss 1.0501582622528076
epoch: 800 tx_loss 1.6504446268081665 rx_loss 0.9804263114929199
epoch: 900 tx_loss 0.37214022874832153 rx_loss 0.9237892031669617

Comparison

In [7]:

```
epoch_arr=range(1,epochs+1)
plt.title('Training error with epochs')
plt.plot(epoch_arr,loss_supervised,'r',label='Supervised training')
plt.plot(epoch_arr,loss_rx,'b',label='Alternating training')
plt.xlabel('epochs')
plt.ylabel('training error')
plt.legend()
plt.show()
```



In []: