```
# mlp for the blobs problem with batch gradient descent
from sklearn.datasets.samples_generator import make_blobs
from tensorflow.keras.layers import Dense
from tensorflow.keras.models import Sequential
from tensorflow.keras.optimizers import SGD
from tensorflow.keras.utils import to_categorical
from matplotlib import pyplot
# generate 2d classification dataset
X, y = make_blobs(n_samples=1000, centers=3, n_features=2, cluster_std=2, rand
# one hot encode output variable
y = to_categorical(y)
# split into train and test
n_train = 500
trainX, testX = X[:n_train, :], X[n_train:, :]
trainy, testy = y[:n_train], y[n_train:]
# define model
model = Sequential()
model.add(Dense(50, input_dim=2, activation='relu', kernel_initializer='he_uni
model.add(Dense(3, activation='softmax'))
# compile model
opt = SGD(lr=0.01, momentum=0.9)
model.compile(loss='categorical_crossentropy', optimizer=opt, metrics=['accura
# fit model
history = model.fit(trainX, trainy, validation_data=(testX, testy), epochs=200,
batch_size=len(trainX))
# evaluate the model
_, train_acc = model.evaluate(trainX, trainy, verbose=0)
_, test_acc = model.evaluate(testX, testy, verbose=0)
print('Train: %.3f, Test: %.3f' % (train_acc, test_acc))
# plot loss learning curves
pyplot.subplot(211)
pyplot.title('Cross-Entropy Loss', pad=-40)
pyplot.plot(history.history['loss'], label='train')
pyplot.plot(history.history['val_loss'], label='test')

pyplot.legend()
# plot accuracy learning curves
pyplot.subplot(212)
pyplot.title('Accuracy', pad=-40)
pyplot.plot(history.history['accuracy'], label='train')
pyplot.plot(history.history['val_accuracy'], label='test')
pyplot.legend()
pyplot.show()
```

```
Epoch 1/200
1/1 [==============================] - 0s 111ms/step - loss: 6.8224 - accuracy
Epoch 2/200
1/1 [==============================] - 0s 32ms/step - loss: 4.6731 - accuracy:
Epoch 3/200
1/1 [==============================] - 0s 29ms/step - loss: 3.3681 - accuracy:
Epoch 4/200
1/1 [==============================] - 0s 30ms/step - loss: 1.8133 - accuracy:
Epoch 5/200
1/1 [==============================] - 0s 30ms/step - loss: 3.1606 - accuracy:
Epoch 6/200
1/1 [==============================] - 0s 33ms/step - loss: 4.2873 - accuracy:
Epoch 7/200
1/1 [==============================] - 0s 29ms/step - loss: 4.2839 - accuracy:
Epoch 8/200
1/1 [==============================] - 0s 29ms/step - loss: 3.2920 - accuracy:
Epoch 9/200
1/1 [==============================] - 0s 31ms/step - loss: 2.0549 - accuracy:
Epoch 10/200
1/1 [==============================] - 0s 45ms/step - loss: 1.8573 - accuracy:
Epoch 11/200
1/1 [==============================] - 0s 32ms/step - loss: 2.6235 - accuracy:
Epoch 12/200
1/1 [==============================] - 0s 37ms/step - loss: 2.5689 - accuracy:
Epoch 13/200
1/1 [==============================] - 0s 31ms/step - loss: 2.9437 - accuracy:
Epoch 14/200
1/1 [==============================] - 0s 32ms/step - loss: 2.7853 - accuracy:
Epoch 15/200
1/1 [==============================] - 0s 31ms/step - loss: 2.2758 - accuracy:
Epoch 16/200
1/1 [==============================] - 0s 29ms/step - loss: 2.3825 - accuracy:
Epoch 17/200
1/1 [==============================] - 0s 29ms/step - loss: 1.6995 - accuracy:
Epoch 18/200
1/1 [==============================] - 0s 29ms/step - loss: 1.6310 - accuracy:
Epoch 19/200
1/1 [==============================] - 0s 28ms/step - loss: 1.0811 - accuracy:
Epoch 20/200
1/1 [==============================] - 0s 30ms/step - loss: 1.8575 - accuracy:
Epoch 21/200
1/1 [==============================] - 0s 29ms/step - loss: 2.1692 - accuracy:
Epoch 22/200
1/1 [==============================] - 0s 36ms/step - loss: 2.9409 - accuracy:
Epoch 23/200
1/1 [==============================] - 0s 30ms/step - loss: 2.7484 - accuracy:
Epoch 24/200
1/1 [==============================] - 0s 30ms/step - loss: 1.7644 - accuracy:
Epoch 25/200
1/1 [==============================] - 0s 26ms/step - loss: 2.0829 - accuracy:
Epoch 26/200
1/1 [==============================] - 0s 26ms/step - loss: 0.9480 - accuracy:
Epoch 27/200
1/1 [==============================] - 0s 29ms/step - loss: 1.2683 - accuracy:
Epoch 28/200
1/1 [==============================] - 0s 29ms/step - loss: 1.0557 - accuracy:
Epoch 29/200
1/1 [==============================] - 0s 29ms/step - loss: 1.4205 - accuracy:
Epoch 30/200
1/1 [==============================] - 0s 27ms/step - loss: 1.1404 - accuracy:
Epoch 31/200
```

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1/1 [==============================] - 0s 27ms/step - loss: 1.3081 - accuracy:
Epoch 32/200
1/1 [==============================] - 0s 34ms/step - loss: 0.9876 - accuracy:
Epoch 33/200
1/1 [==============================] - 0s 26ms/step - loss: 0.9786 - accuracy:
Epoch 34/200
1/1 [==============================] - 0s 28ms/step - loss: 0.8558 - accuracy:
Epoch 35/200
1/1 [==============================] - 0s 31ms/step - loss: 0.9476 - accuracy:
Epoch 36/200
1/1 [==============================] - 0s 30ms/step - loss: 1.0713 - accuracy:
Epoch 37/200
1/1 [==============================] - 0s 26ms/step - loss: 0.8195 - accuracy:
Epoch 38/200
1/1 [==============================] - 0s 27ms/step - loss: 0.8106 - accuracy:
Epoch 39/200
1/1 [==============================] - 0s 28ms/step - loss: 0.7299 - accuracy:
Epoch 40/200
1/1 [==============================] - 0s 29ms/step - loss: 0.8040 - accuracy:
Epoch 41/200
1/1 [==============================] - 0s 28ms/step - loss: 0.7984 - accuracy:
Epoch 42/200
1/1 [==============================] - 0s 38ms/step - loss: 0.6913 - accuracy:
Epoch 43/200
1/1 [==============================] - 0s 31ms/step - loss: 0.7451 - accuracy:
Epoch 44/200
1/1 [==============================] - 0s 30ms/step - loss: 0.7139 - accuracy:
Epoch 45/200
1/1 [==============================] - 0s 30ms/step - loss: 0.7991 - accuracy:
Epoch 46/200
1/1 [==============================] - 0s 30ms/step - loss: 0.6728 - accuracy:
Epoch 47/200
1/1 [==============================] - 0s 29ms/step - loss: 0.7795 - accuracy:
Epoch 48/200
1/1 [==============================] - 0s 30ms/step - loss: 0.6595 - accuracy:
Epoch 49/200
1/1 [==============================] - 0s 30ms/step - loss: 0.7689 - accuracy:
Epoch 50/200
1/1 [==============================] - 0s 27ms/step - loss: 0.6507 - accuracy:
Epoch 51/200
1/1 [==============================] - 0s 29ms/step - loss: 0.7951 - accuracy:
Epoch 52/200
1/1 [==============================] - 0s 34ms/step - loss: 0.6401 - accuracy:
Epoch 53/200
1/1 [==============================] - 0s 26ms/step - loss: 0.7113 - accuracy:
Epoch 54/200
1/1 [==============================] - 0s 29ms/step - loss: 0.6144 - accuracy:
Epoch 55/200
1/1 [==============================] - 0s 28ms/step - loss: 0.7072 - accuracy:
Epoch 56/200
1/1 [==============================] - 0s 31ms/step - loss: 0.5851 - accuracy:
Epoch 57/200
1/1 [==============================] - 0s 31ms/step - loss: 0.6237 - accuracy:
Epoch 58/200
1/1 [==============================] - 0s 27ms/step - loss: 0.5848 - accuracy:
Epoch 59/200
1/1 [==============================] - 0s 28ms/step - loss: 0.6251 - accuracy:
Epoch 60/200
1/1 [==============================] - 0s 30ms/step - loss: 0.5721 - accuracy:
Epoch 61/200
1/1 [==============================] - 0s 29ms/step - loss: 0.5915 - accuracy:
Epoch 62/200
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1/1 [==============================] - 0s 34ms/step - loss: 0.5596 - accuracy:
Epoch 63/200
1/1 [==============================] - 0s 27ms/step - loss: 0.5868 - accuracy:
Epoch 64/200
1/1 [==============================] - 0s 26ms/step - loss: 0.5565 - accuracy:
Epoch 65/200
1/1 [==============================] - 0s 29ms/step - loss: 0.5657 - accuracy:
Epoch 66/200
1/1 [==============================] - 0s 28ms/step - loss: 0.5430 - accuracy:
Epoch 67/200
1/1 [==============================] - 0s 26ms/step - loss: 0.5612 - accuracy:
Epoch 68/200
1/1 [==============================] - 0s 30ms/step - loss: 0.5424 - accuracy:
Epoch 69/200
1/1 [==============================] - 0s 29ms/step - loss: 0.5514 - accuracy:
Epoch 70/200
1/1 [==============================] - 0s 30ms/step - loss: 0.5337 - accuracy:
Epoch 71/200
1/1 [==============================] - 0s 30ms/step - loss: 0.5431 - accuracy:
Epoch 72/200
1/1 [==============================] - 0s 36ms/step - loss: 0.5306 - accuracy:
Epoch 73/200
1/1 [==============================] - 0s 28ms/step - loss: 0.5375 - accuracy:
Epoch 74/200
1/1 [==============================] - 0s 28ms/step - loss: 0.5266 - accuracy:
Epoch 75/200
1/1 [==============================] - 0s 27ms/step - loss: 0.5311 - accuracy:
Epoch 76/200
1/1 [==============================] - 0s 27ms/step - loss: 0.5252 - accuracy:
Epoch 77/200
1/1 [==============================] - 0s 28ms/step - loss: 0.5266 - accuracy:
Epoch 78/200
1/1 [==============================] - 0s 29ms/step - loss: 0.5234 - accuracy:
Epoch 79/200
1/1 [==============================] - 0s 29ms/step - loss: 0.5201 - accuracy:
Epoch 80/200
1/1 [==============================] - 0s 28ms/step - loss: 0.5196 - accuracy:
Epoch 81/200
1/1 [==============================] - 0s 31ms/step - loss: 0.5157 - accuracy:
Epoch 82/200
1/1 [==============================] - 0s 35ms/step - loss: 0.5179 - accuracy:
Epoch 83/200
1/1 [==============================] - 0s 28ms/step - loss: 0.5131 - accuracy:
Epoch 84/200
1/1 [==============================] - 0s 26ms/step - loss: 0.5148 - accuracy:
Epoch 85/200
1/1 [==============================] - 0s 31ms/step - loss: 0.5102 - accuracy:
Epoch 86/200
1/1 [==============================] - 0s 29ms/step - loss: 0.5123 - accuracy:
Epoch 87/200
1/1 [==============================] - 0s 31ms/step - loss: 0.5086 - accuracy:
Epoch 88/200
1/1 [==============================] - 0s 27ms/step - loss: 0.5096 - accuracy:
Epoch 89/200
1/1 [==============================] - 0s 28ms/step - loss: 0.5065 - accuracy:
Epoch 90/200
1/1 [==============================] - 0s 27ms/step - loss: 0.5066 - accuracy:
Epoch 91/200
1/1 [==============================] - 0s 28ms/step - loss: 0.5049 - accuracy:
Epoch 92/200
1/1 [==============================] - 0s 32ms/step - loss: 0.5045 - accuracy:
Epoch 93/200
```

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Epoch 93/200
1/1 [==============================] - 0s 35ms/step - loss: 0.5036 - accuracy:
Epoch 94/200
1/1 [==============================] - 0s 28ms/step - loss: 0.5021 - accuracy:
Epoch 95/200
1/1 [==============================] - 0s 29ms/step - loss: 0.5016 - accuracy:
Epoch 96/200
1/1 [==============================] - 0s 29ms/step - loss: 0.5001 - accuracy:
Epoch 97/200
1/1 [==============================] - 0s 27ms/step - loss: 0.5001 - accuracy:
Epoch 98/200
1/1 [==============================] - 0s 27ms/step - loss: 0.4984 - accuracy:
Epoch 99/200
1/1 [==============================] - 0s 32ms/step - loss: 0.4983 - accuracy:
Epoch 100/200
1/1 [==============================] - 0s 28ms/step - loss: 0.4967 - accuracy:
Epoch 101/200
1/1 [==============================] - 0s 27ms/step - loss: 0.4965 - accuracy:
Epoch 102/200
1/1 [==============================] - 0s 26ms/step - loss: 0.4953 - accuracy:
Epoch 103/200
1/1 [==============================] - 0s 33ms/step - loss: 0.4949 - accuracy:
Epoch 104/200
1/1 [==============================] - 0s 31ms/step - loss: 0.4937 - accuracy:
Epoch 105/200
1/1 [==============================] - 0s 28ms/step - loss: 0.4932 - accuracy:
Epoch 106/200
1/1 [==============================] - 0s 27ms/step - loss: 0.4923 - accuracy:
Epoch 107/200
1/1 [==============================] - 0s 27ms/step - loss: 0.4916 - accuracy:
Epoch 108/200
1/1 [==============================] - 0s 28ms/step - loss: 0.4909 - accuracy:
Epoch 109/200
1/1 [==============================] - 0s 26ms/step - loss: 0.4901 - accuracy:
Epoch 110/200
1/1 [==============================] - 0s 28ms/step - loss: 0.4894 - accuracy:
Epoch 111/200
1/1 [==============================] - 0s 31ms/step - loss: 0.4886 - accuracy:
Epoch 112/200
1/1 [==============================] - 0s 28ms/step - loss: 0.4881 - accuracy:
Epoch 113/200
1/1 [==============================] - 0s 37ms/step - loss: 0.4872 - accuracy:
Epoch 114/200
1/1 [==============================] - 0s 28ms/step - loss: 0.4867 - accuracy:
Epoch 115/200
1/1 [==============================] - 0s 27ms/step - loss: 0.4858 - accuracy:
Epoch 116/200
1/1 [==============================] - 0s 28ms/step - loss: 0.4853 - accuracy:
Epoch 117/200
1/1 [==============================] - 0s 34ms/step - loss: 0.4845 - accuracy:
Epoch 118/200
1/1 [==============================] - 0s 29ms/step - loss: 0.4840 - accuracy:
Epoch 119/200
1/1 [==============================] - 0s 27ms/step - loss: 0.4832 - accuracy:
Epoch 120/200
1/1 [==============================] - 0s 32ms/step - loss: 0.4826 - accuracy:
Epoch 121/200
1/1 [==============================] - 0s 27ms/step - loss: 0.4819 - accuracy:
Epoch 122/200
1/1 [==============================] - 0s 26ms/step - loss: 0.4814 - accuracy:
Epoch 123/200
1/1 [==============================] - 0s 37ms/step - loss: 0.4807 - accuracy:
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Epoch 124/200
1/1 [==============================] - 0s 26ms/step - loss: 0.4801 - accuracy:
Epoch 125/200
1/1 [==============================] - 0s 28ms/step - loss: 0.4795 - accuracy:
Epoch 126/200
1/1 [==============================] - 0s 28ms/step - loss: 0.4789 - accuracy:
Epoch 127/200
1/1 [==============================] - 0s 29ms/step - loss: 0.4783 - accuracy:
Epoch 128/200
1/1 [==============================] - 0s 27ms/step - loss: 0.4777 - accuracy:
Epoch 129/200
1/1 [==============================] - 0s 28ms/step - loss: 0.4771 - accuracy:
Epoch 130/200
1/1 [==============================] - 0s 28ms/step - loss: 0.4765 - accuracy:
Epoch 131/200
1/1 [==============================] - 0s 31ms/step - loss: 0.4759 - accuracy:
Epoch 132/200
1/1 [==============================] - 0s 28ms/step - loss: 0.4753 - accuracy:
Epoch 133/200
1/1 [==============================] - 0s 34ms/step - loss: 0.4747 - accuracy:
Epoch 134/200
1/1 [==============================] - 0s 28ms/step - loss: 0.4741 - accuracy:
Epoch 135/200
1/1 [==============================] - 0s 27ms/step - loss: 0.4736 - accuracy:
Epoch 136/200
1/1 [==============================] - 0s 28ms/step - loss: 0.4730 - accuracy:
Epoch 137/200
1/1 [==============================] - 0s 27ms/step - loss: 0.4724 - accuracy:
Epoch 138/200
1/1 [==============================] - 0s 28ms/step - loss: 0.4719 - accuracy:
Epoch 139/200
1/1 [==============================] - 0s 30ms/step - loss: 0.4713 - accuracy:
Epoch 140/200
1/1 [==============================] - 0s 29ms/step - loss: 0.4707 - accuracy:
Epoch 141/200
1/1 [==============================] - 0s 27ms/step - loss: 0.4702 - accuracy:
Epoch 142/200
1/1 [==============================] - 0s 26ms/step - loss: 0.4696 - accuracy:
Epoch 143/200
1/1 [==============================] - 0s 33ms/step - loss: 0.4691 - accuracy:
Epoch 144/200
1/1 [==============================] - 0s 30ms/step - loss: 0.4685 - accuracy:
Epoch 145/200
1/1 [==============================] - 0s 30ms/step - loss: 0.4680 - accuracy:
Epoch 146/200
1/1 [==============================] - 0s 30ms/step - loss: 0.4674 - accuracy:
Epoch 147/200
1/1 [==============================] - 0s 33ms/step - loss: 0.4669 - accuracy:
Epoch 148/200
1/1 [==============================] - 0s 26ms/step - loss: 0.4664 - accuracy:
Epoch 149/200
1/1 [==============================] - 0s 27ms/step - loss: 0.4658 - accuracy:
Epoch 150/200
1/1 [==============================] - 0s 25ms/step - loss: 0.4653 - accuracy:
Epoch 151/200
1/1 [==============================] - 0s 27ms/step - loss: 0.4648 - accuracy:
Epoch 152/200
1/1 [==============================] - 0s 28ms/step - loss: 0.4642 - accuracy:
Epoch 153/200
1/1 [==============================] - 0s 33ms/step - loss: 0.4637 - accuracy:
Epoch 154/200
1/1 [==============================] - 0s 28ms/step - loss: 0.4632 - accuracy:
```

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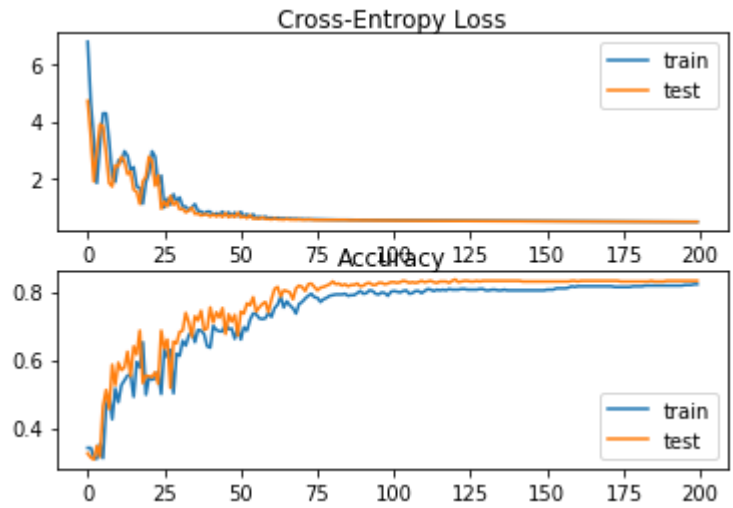
Epoch 155/200
1/1 [==============================] - 0s 31ms/step - loss: 0.4627 - accuracy:
Epoch 156/200
1/1 [==============================] - 0s 29ms/step - loss: 0.4621 - accuracy:
Epoch 157/200
1/1 [==============================] - 0s 29ms/step - loss: 0.4616 - accuracy:
Epoch 158/200
1/1 [==============================] - 0s 28ms/step - loss: 0.4611 - accuracy:
Epoch 159/200
1/1 [==============================] - 0s 29ms/step - loss: 0.4606 - accuracy:
Epoch 160/200
1/1 [==============================] - 0s 27ms/step - loss: 0.4601 - accuracy:
Epoch 161/200
1/1 [==============================] - 0s 27ms/step - loss: 0.4596 - accuracy:
Epoch 162/200
1/1 [==============================] - 0s 29ms/step - loss: 0.4591 - accuracy:
Epoch 163/200
1/1 [==============================] - 0s 34ms/step - loss: 0.4586 - accuracy:
Epoch 164/200
1/1 [==============================] - 0s 28ms/step - loss: 0.4581 - accuracy:
Epoch 165/200
1/1 [==============================] - 0s 30ms/step - loss: 0.4576 - accuracy:
Epoch 166/200
1/1 [==============================] - 0s 29ms/step - loss: 0.4571 - accuracy:
Epoch 167/200
1/1 [==============================] - 0s 28ms/step - loss: 0.4566 - accuracy:
Epoch 168/200
1/1 [==============================] - 0s 26ms/step - loss: 0.4562 - accuracy:
Epoch 169/200
1/1 [==============================] - 0s 30ms/step - loss: 0.4557 - accuracy:
Epoch 170/200
1/1 [==============================] - 0s 28ms/step - loss: 0.4552 - accuracy:
Epoch 171/200
1/1 [==============================] - 0s 29ms/step - loss: 0.4547 - accuracy:
Epoch 172/200
1/1 [==============================] - 0s 30ms/step - loss: 0.4542 - accuracy:
Epoch 173/200
1/1 [==============================] - 0s 38ms/step - loss: 0.4538 - accuracy:
Epoch 174/200
1/1 [==============================] - 0s 29ms/step - loss: 0.4533 - accuracy:
Epoch 175/200
1/1 [==============================] - 0s 30ms/step - loss: 0.4528 - accuracy:
Epoch 176/200
1/1 [==============================] - 0s 32ms/step - loss: 0.4524 - accuracy:
Epoch 177/200
1/1 [==============================] - 0s 33ms/step - loss: 0.4519 - accuracy:
Epoch 178/200
1/1 [==============================] - 0s 28ms/step - loss: 0.4515 - accuracy:
Epoch 179/200
1/1 [==============================] - 0s 27ms/step - loss: 0.4510 - accuracy:
Epoch 180/200
1/1 [==============================] - 0s 28ms/step - loss: 0.4506 - accuracy:
Epoch 181/200
1/1 [==============================] - 0s 28ms/step - loss: 0.4501 - accuracy:
Epoch 182/200
1/1 [==============================] - 0s 28ms/step - loss: 0.4497 - accuracy:
Epoch 183/200
1/1 [==============================] - 0s 34ms/step - loss: 0.4492 - accuracy:
Epoch 184/200
1/1 [==============================] - 0s 27ms/step - loss: 0.4488 - accuracy:
Epoch 185/200
1/1 [==============================] - 0s 28ms/step - loss: 0.4484 - accuracy:
```

```
1/1 [==============================] - 0s 28ms/step - loss: 0.4484 - accuracy:
Epoch 186/200
1/1 [==============================] - 0s 26ms/step - loss: 0.4479 - accuracy:
Epoch 187/200
1/1 [==============================] - 0s 30ms/step - loss: 0.4475 - accuracy:
Epoch 188/200
1/1 [==============================] - 0s 29ms/step - loss: 0.4471 - accuracy:
Epoch 189/200
1/1 [==============================] - 0s 26ms/step - loss: 0.4466 - accuracy:
Epoch 190/200
1/1 [==============================] - 0s 31ms/step - loss: 0.4462 - accuracy:
Epoch 191/200
1/1 [==============================] - 0s 29ms/step - loss: 0.4458 - accuracy:
Epoch 192/200
1/1 [==============================] - 0s 28ms/step - loss: 0.4454 - accuracy:
Epoch 193/200
1/1 [==============================] - 0s 35ms/step - loss: 0.4450 - accuracy:
Epoch 194/200
1/1 [==============================] - 0s 26ms/step - loss: 0.4446 - accuracy:
Epoch 195/200
1/1 [==============================] - 0s 29ms/step - loss: 0.4442 - accuracy:
Epoch 196/200
1/1 [==============================] - 0s 27ms/step - loss: 0.4438 - accuracy:
Epoch 197/200
1/1 [==============================] - 0s 30ms/step - loss: 0.4434 - accuracy:
Epoch 198/200
1/1 [==============================] - 0s 29ms/step - loss: 0.4431 - accuracy:
Epoch 199/200
1/1 [==============================] - 0s 28ms/step - loss: 0.4427 - accuracy:
Epoch 200/200
1/1 [==============================] - 0s 29ms/step - loss: 0.4423 - accuracy:
Train: 0.822, Test: 0.832
```




```
# mlp for the blobs problem with batch gradient descent
from sklearn.datasets.samples_generator import make_blobs
from tensorflow.keras.layers import Dense
from tensorflow.keras.models import Sequential
from tensorflow.keras.optimizers import SGD
```

```
from tensorflow.keras.utils import to_categorical
from matplotlib import pyplot
# generate 2d classification dataset
X, y = make_blobs(n_samples=1000, centers=3, n_features=2, cluster_std=2, rand
# one hot encode output variable
y = to_categorical(y)
# split into train and test
n_train = 500
trainX, testX = X[:n_train, :], X[n_train:, :]
trainy, testy = y[:n_train], y[n_train:]
# define model
model = Sequential()
model.add(Dense(50, input_dim=2, activation='relu', kernel_initializer='he_uni
model.add(Dense(3, activation='softmax'))
# compile model
opt = SGD(lr=0.001, momentum=0.9)
model.compile(loss='categorical_crossentropy', optimizer=opt, metrics=['accura
# fit model
history = model.fit(trainX, trainy, validation_data=(testX, testy), epochs=200,
batch_size=len(trainX))
# evaluate the model
_, train_acc = model.evaluate(trainX, trainy, verbose=0)
_, test_acc = model.evaluate(testX, testy, verbose=0)
print('Train: %.3f, Test: %.3f' % (train_acc, test_acc))
# plot loss learning curves
pyplot.subplot(211)
pyplot.title('Cross-Entropy Loss', pad=-40)
pyplot.plot(history.history['loss'], label='train')
pyplot.plot(history.history['val_loss'], label='test')

pyplot.legend()
# plot accuracy learning curves
pyplot.subplot(212)
pyplot.title('Accuracy', pad=-40)
pyplot.plot(history.history['accuracy'], label='train')
pyplot.plot(history.history['val_accuracy'], label='test')
pyplot.legend()
pyplot.show()
```

```
Epoch 1/200
1/1 [==============================] - 0s 98ms/step - loss: 5.7624 - accuracy:
Epoch 2/200
1/1 [==============================] - 0s 28ms/step - loss: 5.3331 - accuracy:
Epoch 3/200
1/1 [==============================] - 0s 26ms/step - loss: 4.5240 - accuracy:
Epoch 4/200
1/1 [==============================] - 0s 26ms/step - loss: 3.3944 - accuracy:
Epoch 5/200
1/1 [==============================] - 0s 28ms/step - loss: 2.0857 - accuracy:
Epoch 6/200
1/1 [==============================] - 0s 26ms/step - loss: 1.3064 - accuracy:
Epoch 7/200
1/1 [==============================] - 0s 25ms/step - loss: 1.5772 - accuracy:
Epoch 8/200
1/1 [==============================] - 0s 28ms/step - loss: 1.9947 - accuracy:
Epoch 9/200
1/1 [==============================] - 0s 28ms/step - loss: 2.3269 - accuracy:
Epoch 10/200
1/1 [==============================] - 0s 30ms/step - loss: 2.5530 - accuracy:
Epoch 11/200
1/1 [==============================] - 0s 38ms/step - loss: 2.6764 - accuracy:
Epoch 12/200
1/1 [==============================] - 0s 30ms/step - loss: 2.7066 - accuracy:
Epoch 13/200
1/1 [==============================] - 0s 28ms/step - loss: 2.6560 - accuracy:
Epoch 14/200
1/1 [==============================] - 0s 28ms/step - loss: 2.5392 - accuracy:
Epoch 15/200
1/1 [==============================] - 0s 28ms/step - loss: 2.3737 - accuracy:
Epoch 16/200
1/1 [==============================] - 0s 29ms/step - loss: 2.1803 - accuracy:
Epoch 17/200
1/1 [==============================] - 0s 31ms/step - loss: 1.9822 - accuracy:
Epoch 18/200
1/1 [==============================] - 0s 34ms/step - loss: 1.8013 - accuracy:
Epoch 19/200
1/1 [==============================] - 0s 29ms/step - loss: 1.6436 - accuracy:
Epoch 20/200
1/1 [==============================] - 0s 27ms/step - loss: 1.4926 - accuracy:
Epoch 21/200
1/1 [==============================] - 0s 36ms/step - loss: 1.3357 - accuracy:
Epoch 22/200
1/1 [==============================] - 0s 30ms/step - loss: 1.2075 - accuracy:
Epoch 23/200
1/1 [==============================] - 0s 28ms/step - loss: 1.2001 - accuracy:
Epoch 24/200
1/1 [==============================] - 0s 26ms/step - loss: 1.2630 - accuracy:
Epoch 25/200
1/1 [==============================] - 0s 28ms/step - loss: 1.2331 - accuracy:
Epoch 26/200
1/1 [==============================] - 0s 36ms/step - loss: 1.0848 - accuracy:
Epoch 27/200
1/1 [==============================] - 0s 26ms/step - loss: 0.9546 - accuracy:
Epoch 28/200
1/1 [==============================] - 0s 26ms/step - loss: 0.9587 - accuracy:
Epoch 29/200
1/1 [==============================] - 0s 28ms/step - loss: 1.0296 - accuracy:
Epoch 30/200
1/1 [==============================] - 0s 26ms/step - loss: 1.0939 - accuracy:
Epoch 31/200
```

```
1/1 [==============================] - 0s 26ms/step - loss: 1.1250 - accuracy:
Epoch 32/200
1/1 [==============================] - 0s 33ms/step - loss: 1.1179 - accuracy:
Epoch 33/200
1/1 [==============================] - 0s 28ms/step - loss: 1.0783 - accuracy:
Epoch 34/200
1/1 [==============================] - 0s 29ms/step - loss: 1.0195 - accuracy:
Epoch 35/200
1/1 [==============================] - 0s 27ms/step - loss: 0.9636 - accuracy:
Epoch 36/200
1/1 [==============================] - 0s 27ms/step - loss: 0.9395 - accuracy:
Epoch 37/200
1/1 [==============================] - 0s 28ms/step - loss: 0.9583 - accuracy:
Epoch 38/200
1/1 [==============================] - 0s 29ms/step - loss: 0.9818 - accuracy:
Epoch 39/200
1/1 [==============================] - 0s 29ms/step - loss: 0.9644 - accuracy:
Epoch 40/200
1/1 [==============================] - 0s 29ms/step - loss: 0.9121 - accuracy:
Epoch 41/200
1/1 [==============================] - 0s 28ms/step - loss: 0.8666 - accuracy:
Epoch 42/200
1/1 [==============================] - 0s 37ms/step - loss: 0.8495 - accuracy:
Epoch 43/200
1/1 [==============================] - 0s 27ms/step - loss: 0.8503 - accuracy:
Epoch 44/200
1/1 [==============================] - 0s 27ms/step - loss: 0.8525 - accuracy:
Epoch 45/200
1/1 [==============================] - 0s 27ms/step - loss: 0.8475 - accuracy:
Epoch 46/200
1/1 [==============================] - 0s 29ms/step - loss: 0.8340 - accuracy:
Epoch 47/200
1/1 [==============================] - 0s 27ms/step - loss: 0.8163 - accuracy:
Epoch 48/200
1/1 [==============================] - 0s 28ms/step - loss: 0.8011 - accuracy:
Epoch 49/200
1/1 [==============================] - 0s 27ms/step - loss: 0.7947 - accuracy:
Epoch 50/200
1/1 [==============================] - 0s 28ms/step - loss: 0.7982 - accuracy:
Epoch 51/200
1/1 [==============================] - 0s 26ms/step - loss: 0.8056 - accuracy:
Epoch 52/200
1/1 [==============================] - 0s 32ms/step - loss: 0.8075 - accuracy:
Epoch 53/200
1/1 [==============================] - 0s 32ms/step - loss: 0.8000 - accuracy:
Epoch 54/200
1/1 [==============================] - 0s 30ms/step - loss: 0.7872 - accuracy:
Epoch 55/200
1/1 [==============================] - 0s 29ms/step - loss: 0.7758 - accuracy:
Epoch 56/200
1/1 [==============================] - 0s 30ms/step - loss: 0.7691 - accuracy:
Epoch 57/200
1/1 [==============================] - 0s 29ms/step - loss: 0.7659 - accuracy:
Epoch 58/200
1/1 [==============================] - 0s 26ms/step - loss: 0.7632 - accuracy:
Epoch 59/200
1/1 [==============================] - 0s 27ms/step - loss: 0.7588 - accuracy:
Epoch 60/200
1/1 [==============================] - 0s 28ms/step - loss: 0.7522 - accuracy:
Epoch 61/200
1/1 [==============================] - 0s 28ms/step - loss: 0.7445 - accuracy:
Epoch 62/200
```

```
1/1 [==============================] - 0s 36ms/step - loss: 0.7381 - accuracy:
Epoch 63/200
1/1 [==============================] - 0s 29ms/step - loss: 0.7343 - accuracy:
Epoch 64/200
1/1 [==============================] - 0s 29ms/step - loss: 0.7332 - accuracy:
Epoch 65/200
1/1 [==============================] - 0s 27ms/step - loss: 0.7327 - accuracy:
Epoch 66/200
1/1 [==============================] - 0s 26ms/step - loss: 0.7306 - accuracy:
Epoch 67/200
1/1 [==============================] - 0s 32ms/step - loss: 0.7265 - accuracy:
Epoch 68/200
1/1 [==============================] - 0s 27ms/step - loss: 0.7218 - accuracy:
Epoch 69/200
1/1 [==============================] - 0s 28ms/step - loss: 0.7180 - accuracy:
Epoch 70/200
1/1 [==============================] - 0s 27ms/step - loss: 0.7156 - accuracy:
Epoch 71/200
1/1 [==============================] - 0s 30ms/step - loss: 0.7139 - accuracy:
Epoch 72/200
1/1 [==============================] - 0s 35ms/step - loss: 0.7119 - accuracy:
Epoch 73/200
1/1 [==============================] - 0s 26ms/step - loss: 0.7092 - accuracy:
Epoch 74/200
1/1 [==============================] - 0s 30ms/step - loss: 0.7059 - accuracy:
Epoch 75/200
1/1 [==============================] - 0s 28ms/step - loss: 0.7027 - accuracy:
Epoch 76/200
1/1 [==============================] - 0s 29ms/step - loss: 0.7002 - accuracy:
Epoch 77/200
1/1 [==============================] - 0s 30ms/step - loss: 0.6985 - accuracy:
Epoch 78/200
1/1 [==============================] - 0s 28ms/step - loss: 0.6974 - accuracy:
Epoch 79/200
1/1 [==============================] - 0s 26ms/step - loss: 0.6962 - accuracy:
Epoch 80/200
1/1 [==============================] - 0s 27ms/step - loss: 0.6948 - accuracy:
Epoch 81/200
1/1 [==============================] - 0s 27ms/step - loss: 0.6931 - accuracy:
Epoch 82/200
1/1 [==============================] - 0s 27ms/step - loss: 0.6916 - accuracy:
Epoch 83/200
1/1 [==============================] - 0s 35ms/step - loss: 0.6904 - accuracy:
Epoch 84/200
1/1 [==============================] - 0s 29ms/step - loss: 0.6896 - accuracy:
Epoch 85/200
1/1 [==============================] - 0s 29ms/step - loss: 0.6889 - accuracy:
Epoch 86/200
1/1 [==============================] - 0s 29ms/step - loss: 0.6881 - accuracy:
Epoch 87/200
1/1 [==============================] - 0s 28ms/step - loss: 0.6870 - accuracy:
Epoch 88/200
1/1 [==============================] - 0s 27ms/step - loss: 0.6859 - accuracy:
Epoch 89/200
1/1 [==============================] - 0s 27ms/step - loss: 0.6850 - accuracy:
Epoch 90/200
1/1 [==============================] - 0s 30ms/step - loss: 0.6842 - accuracy:
Epoch 91/200
1/1 [==============================] - 0s 27ms/step - loss: 0.6836 - accuracy:
Epoch 92/200
1/1 [==============================] - 0s 30ms/step - loss: 0.6831 - accuracy:
Epoch 93/200
```

```
Epoch 93/200
1/1 [==============================] - 0s 32ms/step - loss: 0.6825 - accuracy:
Epoch 94/200
1/1 [==============================] - 0s 28ms/step - loss: 0.6819 - accuracy:
Epoch 95/200
1/1 [==============================] - 0s 27ms/step - loss: 0.6813 - accuracy:
Epoch 96/200
1/1 [==============================] - 0s 27ms/step - loss: 0.6807 - accuracy:
Epoch 97/200
1/1 [==============================] - 0s 29ms/step - loss: 0.6803 - accuracy:
Epoch 98/200
1/1 [==============================] - 0s 29ms/step - loss: 0.6799 - accuracy:
Epoch 99/200
1/1 [==============================] - 0s 32ms/step - loss: 0.6795 - accuracy:
Epoch 100/200
1/1 [==============================] - 0s 29ms/step - loss: 0.6791 - accuracy:
Epoch 101/200
1/1 [==============================] - 0s 29ms/step - loss: 0.6786 - accuracy:
Epoch 102/200
1/1 [==============================] - 0s 28ms/step - loss: 0.6781 - accuracy:
Epoch 103/200
1/1 [==============================] - 0s 36ms/step - loss: 0.6777 - accuracy:
Epoch 104/200
1/1 [==============================] - 0s 31ms/step - loss: 0.6772 - accuracy:
Epoch 105/200
1/1 [==============================] - 0s 31ms/step - loss: 0.6769 - accuracy:
Epoch 106/200
1/1 [==============================] - 0s 29ms/step - loss: 0.6765 - accuracy:
Epoch 107/200
1/1 [==============================] - 0s 28ms/step - loss: 0.6760 - accuracy:
Epoch 108/200
1/1 [==============================] - 0s 29ms/step - loss: 0.6756 - accuracy:
Epoch 109/200
1/1 [==============================] - 0s 26ms/step - loss: 0.6752 - accuracy:
Epoch 110/200
1/1 [==============================] - 0s 29ms/step - loss: 0.6748 - accuracy:
Epoch 111/200
1/1 [==============================] - 0s 31ms/step - loss: 0.6744 - accuracy:
Epoch 112/200
1/1 [==============================] - 0s 30ms/step - loss: 0.6741 - accuracy:
Epoch 113/200
1/1 [==============================] - 0s 33ms/step - loss: 0.6737 - accuracy:
Epoch 114/200
1/1 [==============================] - 0s 28ms/step - loss: 0.6733 - accuracy:
Epoch 115/200
1/1 [==============================] - 0s 27ms/step - loss: 0.6729 - accuracy:
Epoch 116/200
1/1 [==============================] - 0s 32ms/step - loss: 0.6726 - accuracy:
Epoch 117/200
1/1 [==============================] - 0s 28ms/step - loss: 0.6722 - accuracy:
Epoch 118/200
1/1 [==============================] - 0s 27ms/step - loss: 0.6719 - accuracy:
Epoch 119/200
1/1 [==============================] - 0s 28ms/step - loss: 0.6715 - accuracy:
Epoch 120/200
1/1 [==============================] - 0s 28ms/step - loss: 0.6712 - accuracy:
Epoch 121/200
1/1 [==============================] - 0s 28ms/step - loss: 0.6708 - accuracy:
Epoch 122/200
1/1 [==============================] - 0s 29ms/step - loss: 0.6705 - accuracy:
Epoch 123/200
1/1 [==============================] - 0s 35ms/step - loss: 0.6701 - accuracy:
```

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Epoch 124/200
1/1 [==============================] - 0s 29ms/step - loss: 0.6698 - accuracy:
Epoch 125/200
1/1 [==============================] - 0s 27ms/step - loss: 0.6695 - accuracy:
Epoch 126/200
1/1 [==============================] - 0s 33ms/step - loss: 0.6692 - accuracy:
Epoch 127/200
1/1 [==============================] - 0s 27ms/step - loss: 0.6688 - accuracy:
Epoch 128/200
1/1 [==============================] - 0s 26ms/step - loss: 0.6685 - accuracy:
Epoch 129/200
1/1 [==============================] - 0s 28ms/step - loss: 0.6682 - accuracy:
Epoch 130/200
1/1 [==============================] - 0s 27ms/step - loss: 0.6679 - accuracy:
Epoch 131/200
1/1 [==============================] - 0s 31ms/step - loss: 0.6676 - accuracy:
Epoch 132/200
1/1 [==============================] - 0s 31ms/step - loss: 0.6673 - accuracy:
Epoch 133/200
1/1 [==============================] - 0s 31ms/step - loss: 0.6670 - accuracy:
Epoch 134/200
1/1 [==============================] - 0s 38ms/step - loss: 0.6667 - accuracy:
Epoch 135/200
1/1 [==============================] - 0s 30ms/step - loss: 0.6664 - accuracy:
Epoch 136/200
1/1 [==============================] - 0s 30ms/step - loss: 0.6661 - accuracy:
Epoch 137/200
1/1 [==============================] - 0s 27ms/step - loss: 0.6658 - accuracy:
Epoch 138/200
1/1 [==============================] - 0s 26ms/step - loss: 0.6655 - accuracy:
Epoch 139/200
1/1 [==============================] - 0s 26ms/step - loss: 0.6652 - accuracy:
Epoch 140/200
1/1 [==============================] - 0s 30ms/step - loss: 0.6649 - accuracy:
Epoch 141/200
1/1 [==============================] - 0s 29ms/step - loss: 0.6647 - accuracy:
Epoch 142/200
1/1 [==============================] - 0s 28ms/step - loss: 0.6644 - accuracy:
Epoch 143/200
1/1 [==============================] - 0s 27ms/step - loss: 0.6641 - accuracy:
Epoch 144/200
1/1 [==============================] - 0s 32ms/step - loss: 0.6638 - accuracy:
Epoch 145/200
1/1 [==============================] - 0s 31ms/step - loss: 0.6635 - accuracy:
Epoch 146/200
1/1 [==============================] - 0s 27ms/step - loss: 0.6633 - accuracy:
Epoch 147/200
1/1 [==============================] - 0s 25ms/step - loss: 0.6630 - accuracy:
Epoch 148/200
1/1 [==============================] - 0s 26ms/step - loss: 0.6627 - accuracy:
Epoch 149/200
1/1 [==============================] - 0s 31ms/step - loss: 0.6625 - accuracy:
Epoch 150/200
1/1 [==============================] - 0s 28ms/step - loss: 0.6622 - accuracy:
Epoch 151/200
1/1 [==============================] - 0s 29ms/step - loss: 0.6619 - accuracy:
Epoch 152/200
1/1 [==============================] - 0s 29ms/step - loss: 0.6617 - accuracy:
Epoch 153/200
1/1 [==============================] - 0s 29ms/step - loss: 0.6614 - accuracy:
Epoch 154/200
1/1 [==============================] - 0s 33ms/step - loss: 0.6611 - accuracy:
```

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Epoch 155/200
1/1 [==============================] - 0s 28ms/step - loss: 0.6609 - accuracy:
Epoch 156/200
1/1 [==============================] - 0s 26ms/step - loss: 0.6606 - accuracy:
Epoch 157/200
1/1 [==============================] - 0s 28ms/step - loss: 0.6604 - accuracy:
Epoch 158/200
1/1 [==============================] - 0s 26ms/step - loss: 0.6601 - accuracy:
Epoch 159/200
1/1 [==============================] - 0s 27ms/step - loss: 0.6599 - accuracy:
Epoch 160/200
1/1 [==============================] - 0s 38ms/step - loss: 0.6596 - accuracy:
Epoch 161/200
1/1 [==============================] - 0s 29ms/step - loss: 0.6594 - accuracy:
Epoch 162/200
1/1 [==============================] - 0s 27ms/step - loss: 0.6591 - accuracy:
Epoch 163/200
1/1 [==============================] - 0s 26ms/step - loss: 0.6589 - accuracy:
Epoch 164/200
1/1 [==============================] - 0s 35ms/step - loss: 0.6586 - accuracy:
Epoch 165/200
1/1 [==============================] - 0s 29ms/step - loss: 0.6584 - accuracy:
Epoch 166/200
1/1 [==============================] - 0s 29ms/step - loss: 0.6581 - accuracy:
Epoch 167/200
1/1 [==============================] - 0s 31ms/step - loss: 0.6579 - accuracy:
Epoch 168/200
1/1 [==============================] - 0s 26ms/step - loss: 0.6576 - accuracy:
Epoch 169/200
1/1 [==============================] - 0s 27ms/step - loss: 0.6574 - accuracy:
Epoch 170/200
1/1 [==============================] - 0s 26ms/step - loss: 0.6572 - accuracy:
Epoch 171/200
1/1 [==============================] - 0s 34ms/step - loss: 0.6569 - accuracy:
Epoch 172/200
1/1 [==============================] - 0s 29ms/step - loss: 0.6567 - accuracy:
Epoch 173/200
1/1 [==============================] - 0s 26ms/step - loss: 0.6564 - accuracy:
Epoch 174/200
1/1 [==============================] - 0s 33ms/step - loss: 0.6562 - accuracy:
Epoch 175/200
1/1 [==============================] - 0s 31ms/step - loss: 0.6560 - accuracy:
Epoch 176/200
1/1 [==============================] - 0s 26ms/step - loss: 0.6557 - accuracy:
Epoch 177/200
1/1 [==============================] - 0s 28ms/step - loss: 0.6555 - accuracy:
Epoch 178/200
1/1 [==============================] - 0s 29ms/step - loss: 0.6553 - accuracy:
Epoch 179/200
1/1 [==============================] - 0s 30ms/step - loss: 0.6550 - accuracy:
Epoch 180/200
1/1 [==============================] - 0s 28ms/step - loss: 0.6548 - accuracy:
Epoch 181/200
1/1 [==============================] - 0s 27ms/step - loss: 0.6546 - accuracy:
Epoch 182/200
1/1 [==============================] - 0s 26ms/step - loss: 0.6543 - accuracy:
Epoch 183/200
1/1 [==============================] - 0s 28ms/step - loss: 0.6541 - accuracy:
Epoch 184/200
1/1 [==============================] - 0s 35ms/step - loss: 0.6539 - accuracy:
Epoch 185/200
1/1 [==============================] - 0s 28ms/step - loss: 0.6537 - accuracy:
```

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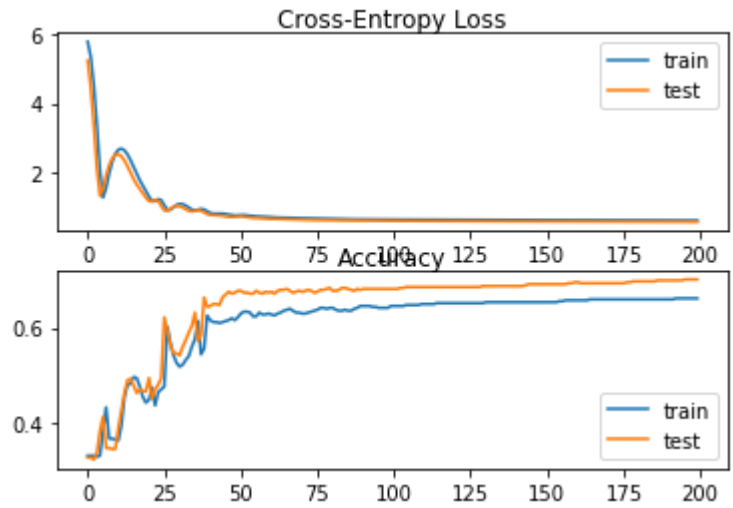
1/1 [==============================] - 0s 28ms/step - loss: 0.6537 - accuracy:
Epoch 186/200
1/1 [==============================] - 0s 29ms/step - loss: 0.6534 - accuracy:
Epoch 187/200
1/1 [==============================] - 0s 26ms/step - loss: 0.6532 - accuracy:
Epoch 188/200
1/1 [==============================] - 0s 27ms/step - loss: 0.6530 - accuracy:
Epoch 189/200
1/1 [==============================] - 0s 34ms/step - loss: 0.6527 - accuracy:
Epoch 190/200
1/1 [==============================] - 0s 33ms/step - loss: 0.6525 - accuracy:
Epoch 191/200
1/1 [==============================] - 0s 27ms/step - loss: 0.6523 - accuracy:
Epoch 192/200
1/1 [==============================] - 0s 27ms/step - loss: 0.6521 - accuracy:
Epoch 193/200
1/1 [==============================] - 0s 27ms/step - loss: 0.6519 - accuracy:
Epoch 194/200
1/1 [==============================] - 0s 32ms/step - loss: 0.6516 - accuracy:
Epoch 195/200
1/1 [==============================] - 0s 28ms/step - loss: 0.6514 - accuracy:
Epoch 196/200
1/1 [==============================] - 0s 27ms/step - loss: 0.6512 - accuracy:
Epoch 197/200
1/1 [==============================] - 0s 31ms/step - loss: 0.6510 - accuracy:
Epoch 198/200
1/1 [==============================] - 0s 32ms/step - loss: 0.6507 - accuracy:
Epoch 199/200
1/1 [==============================] - 0s 27ms/step - loss: 0.6505 - accuracy:
Epoch 200/200
1/1 [==============================] - 0s 25ms/step - loss: 0.6503 - accuracy:
Train: 0.662, Test: 0.702
```




```
# mlp for the blobs problem with batch gradient descent
from sklearn.datasets.samples_generator import make_blobs
from tensorflow.keras.layers import Dense
from tensorflow.keras.models import Sequential
from tensorflow.keras.optimizers import SGD
```

```
from tensorflow.keras.utils import to_categorical
from matplotlib import pyplot
# generate 2d classification dataset
X, y = make_blobs(n_samples=1000, centers=3, n_features=2, cluster_std=2, rand
# one hot encode output variable
y = to_categorical(y)
# split into train and test
n_train = 500
trainX, testX = X[:n_train, :], X[n_train:, :]
trainy, testy = y[:n_train], y[n_train:]
# define model
model = Sequential()
model.add(Dense(50, input_dim=2, activation='relu', kernel_initializer='he_uni
model.add(Dense(3, activation='softmax'))
# compile model
opt = SGD(lr=0.0001, momentum=0.9)
model.compile(loss='categorical_crossentropy', optimizer=opt, metrics=['accura
# fit model
history = model.fit(trainX, trainy, validation_data=(testX, testy), epochs=200,
batch_size=len(trainX))
# evaluate the model
_, train_acc = model.evaluate(trainX, trainy, verbose=0)
_, test_acc = model.evaluate(testX, testy, verbose=0)
print('Train: %.3f, Test: %.3f' % (train_acc, test_acc))
# plot loss learning curves
pyplot.subplot(211)
pyplot.title('Cross-Entropy Loss', pad=-40)
pyplot.plot(history.history['loss'], label='train')
pyplot.plot(history.history['val_loss'], label='test')

pyplot.legend()
# plot accuracy learning curves
pyplot.subplot(212)
pyplot.title('Accuracy', pad=-40)
pyplot.plot(history.history['accuracy'], label='train')
pyplot.plot(history.history['val_accuracy'], label='test')
pyplot.legend()
pyplot.show()
```

```
Epoch 1/200
1/1 [==============================] - 0s 100ms/step - loss: 1.7354 - accuracy
Epoch 2/200
1/1 [==============================] - 0s 29ms/step - loss: 1.7184 - accuracy:
Epoch 3/200
1/1 [==============================] - 0s 28ms/step - loss: 1.6873 - accuracy:
Epoch 4/200
1/1 [==============================] - 0s 30ms/step - loss: 1.6456 - accuracy:
Epoch 5/200
1/1 [==============================] - 0s 27ms/step - loss: 1.5971 - accuracy:
Epoch 6/200
1/1 [==============================] - 0s 27ms/step - loss: 1.5459 - accuracy:
Epoch 7/200
1/1 [==============================] - 0s 35ms/step - loss: 1.4955 - accuracy:
Epoch 8/200
1/1 [==============================] - 0s 26ms/step - loss: 1.4489 - accuracy:
Epoch 9/200
1/1 [==============================] - 0s 33ms/step - loss: 1.4082 - accuracy:
Epoch 10/200
1/1 [==============================] - 0s 30ms/step - loss: 1.3745 - accuracy:
Epoch 11/200
1/1 [==============================] - 0s 30ms/step - loss: 1.3481 - accuracy:
Epoch 12/200
1/1 [==============================] - 0s 36ms/step - loss: 1.3284 - accuracy:
Epoch 13/200
1/1 [==============================] - 0s 30ms/step - loss: 1.3144 - accuracy:
Epoch 14/200
1/1 [==============================] - 0s 32ms/step - loss: 1.3047 - accuracy:
Epoch 15/200
1/1 [==============================] - 0s 31ms/step - loss: 1.2979 - accuracy:
Epoch 16/200
1/1 [==============================] - 0s 29ms/step - loss: 1.2929 - accuracy:
Epoch 17/200
1/1 [==============================] - 0s 29ms/step - loss: 1.2884 - accuracy:
Epoch 18/200
1/1 [==============================] - 0s 28ms/step - loss: 1.2839 - accuracy:
Epoch 19/200
1/1 [==============================] - 0s 28ms/step - loss: 1.2787 - accuracy:
Epoch 20/200
1/1 [==============================] - 0s 30ms/step - loss: 1.2725 - accuracy:
Epoch 21/200
1/1 [==============================] - 0s 29ms/step - loss: 1.2651 - accuracy:
Epoch 22/200
1/1 [==============================] - 0s 34ms/step - loss: 1.2564 - accuracy:
Epoch 23/200
1/1 [==============================] - 0s 30ms/step - loss: 1.2464 - accuracy:
Epoch 24/200
1/1 [==============================] - 0s 28ms/step - loss: 1.2352 - accuracy:
Epoch 25/200
1/1 [==============================] - 0s 28ms/step - loss: 1.2230 - accuracy:
Epoch 26/200
1/1 [==============================] - 0s 27ms/step - loss: 1.2100 - accuracy:
Epoch 27/200
1/1 [==============================] - 0s 27ms/step - loss: 1.1964 - accuracy:
Epoch 28/200
1/1 [==============================] - 0s 31ms/step - loss: 1.1824 - accuracy:
Epoch 29/200
1/1 [==============================] - 0s 34ms/step - loss: 1.1683 - accuracy:
Epoch 30/200
1/1 [==============================] - 0s 32ms/step - loss: 1.1543 - accuracy:
Epoch 31/200
```

```
1/1 [==============================] - 0s 28ms/step - loss: 1.1405 - accuracy:
Epoch 32/200
1/1 [==============================] - 0s 35ms/step - loss: 1.1272 - accuracy:
Epoch 33/200
1/1 [==============================] - 0s 29ms/step - loss: 1.1145 - accuracy:
Epoch 34/200
1/1 [==============================] - 0s 29ms/step - loss: 1.1026 - accuracy:
Epoch 35/200
1/1 [==============================] - 0s 29ms/step - loss: 1.0914 - accuracy:
Epoch 36/200
1/1 [==============================] - 0s 30ms/step - loss: 1.0810 - accuracy:
Epoch 37/200
1/1 [==============================] - 0s 27ms/step - loss: 1.0713 - accuracy:
Epoch 38/200
1/1 [==============================] - 0s 30ms/step - loss: 1.0623 - accuracy:
Epoch 39/200
1/1 [==============================] - 0s 28ms/step - loss: 1.0539 - accuracy:
Epoch 40/200
1/1 [==============================] - 0s 27ms/step - loss: 1.0458 - accuracy:
Epoch 41/200
1/1 [==============================] - 0s 28ms/step - loss: 1.0381 - accuracy:
Epoch 42/200
1/1 [==============================] - 0s 27ms/step - loss: 1.0305 - accuracy:
Epoch 43/200
1/1 [==============================] - 0s 34ms/step - loss: 1.0230 - accuracy:
Epoch 44/200
1/1 [==============================] - 0s 30ms/step - loss: 1.0154 - accuracy:
Epoch 45/200
1/1 [==============================] - 0s 30ms/step - loss: 1.0078 - accuracy:
Epoch 46/200
1/1 [==============================] - 0s 31ms/step - loss: 1.0001 - accuracy:
Epoch 47/200
1/1 [==============================] - 0s 31ms/step - loss: 0.9923 - accuracy:
Epoch 48/200
1/1 [==============================] - 0s 34ms/step - loss: 0.9846 - accuracy:
Epoch 49/200
1/1 [==============================] - 0s 34ms/step - loss: 0.9768 - accuracy:
Epoch 50/200
1/1 [==============================] - 0s 30ms/step - loss: 0.9692 - accuracy:
Epoch 51/200
1/1 [==============================] - 0s 31ms/step - loss: 0.9618 - accuracy:
Epoch 52/200
1/1 [==============================] - 0s 30ms/step - loss: 0.9546 - accuracy:
Epoch 53/200
1/1 [==============================] - 0s 35ms/step - loss: 0.9477 - accuracy:
Epoch 54/200
1/1 [==============================] - 0s 31ms/step - loss: 0.9410 - accuracy:
Epoch 55/200
1/1 [==============================] - 0s 30ms/step - loss: 0.9347 - accuracy:
Epoch 56/200
1/1 [==============================] - 0s 31ms/step - loss: 0.9286 - accuracy:
Epoch 57/200
1/1 [==============================] - 0s 35ms/step - loss: 0.9228 - accuracy:
Epoch 58/200
1/1 [==============================] - 0s 32ms/step - loss: 0.9172 - accuracy:
Epoch 59/200
1/1 [==============================] - 0s 32ms/step - loss: 0.9119 - accuracy:
Epoch 60/200
1/1 [==============================] - 0s 30ms/step - loss: 0.9067 - accuracy:
Epoch 61/200
1/1 [==============================] - 0s 29ms/step - loss: 0.9017 - accuracy:
Epoch 62/200
```

```
1/1 [==============================] - 0s 31ms/step - loss: 0.8969 - accuracy:
Epoch 63/200
1/1 [==============================] - 0s 37ms/step - loss: 0.8922 - accuracy:
Epoch 64/200
1/1 [==============================] - 0s 34ms/step - loss: 0.8876 - accuracy:
Epoch 65/200
1/1 [==============================] - 0s 32ms/step - loss: 0.8832 - accuracy:
Epoch 66/200
1/1 [==============================] - 0s 30ms/step - loss: 0.8789 - accuracy:
Epoch 67/200
1/1 [==============================] - 0s 32ms/step - loss: 0.8747 - accuracy:
Epoch 68/200
1/1 [==============================] - 0s 29ms/step - loss: 0.8707 - accuracy:
Epoch 69/200
1/1 [==============================] - 0s 32ms/step - loss: 0.8668 - accuracy:
Epoch 70/200
1/1 [==============================] - 0s 33ms/step - loss: 0.8630 - accuracy:
Epoch 71/200
1/1 [==============================] - 0s 30ms/step - loss: 0.8594 - accuracy:
Epoch 72/200
1/1 [==============================] - 0s 30ms/step - loss: 0.8560 - accuracy:
Epoch 73/200
1/1 [==============================] - 0s 34ms/step - loss: 0.8526 - accuracy:
Epoch 74/200
1/1 [==============================] - 0s 30ms/step - loss: 0.8495 - accuracy:
Epoch 75/200
1/1 [==============================] - 0s 28ms/step - loss: 0.8464 - accuracy:
Epoch 76/200
1/1 [==============================] - 0s 30ms/step - loss: 0.8435 - accuracy:
Epoch 77/200
1/1 [==============================] - 0s 31ms/step - loss: 0.8407 - accuracy:
Epoch 78/200
1/1 [==============================] - 0s 31ms/step - loss: 0.8380 - accuracy:
Epoch 79/200
1/1 [==============================] - 0s 29ms/step - loss: 0.8354 - accuracy:
Epoch 80/200
1/1 [==============================] - 0s 30ms/step - loss: 0.8329 - accuracy:
Epoch 81/200
1/1 [==============================] - 0s 28ms/step - loss: 0.8306 - accuracy:
Epoch 82/200
1/1 [==============================] - 0s 32ms/step - loss: 0.8283 - accuracy:
Epoch 83/200
1/1 [==============================] - 0s 34ms/step - loss: 0.8260 - accuracy:
Epoch 84/200
1/1 [==============================] - 0s 27ms/step - loss: 0.8239 - accuracy:
Epoch 85/200
1/1 [==============================] - 0s 28ms/step - loss: 0.8219 - accuracy:
Epoch 86/200
1/1 [==============================] - 0s 29ms/step - loss: 0.8199 - accuracy:
Epoch 87/200
1/1 [==============================] - 0s 29ms/step - loss: 0.8180 - accuracy:
Epoch 88/200
1/1 [==============================] - 0s 33ms/step - loss: 0.8161 - accuracy:
Epoch 89/200
1/1 [==============================] - 0s 34ms/step - loss: 0.8144 - accuracy:
Epoch 90/200
1/1 [==============================] - 0s 31ms/step - loss: 0.8127 - accuracy:
Epoch 91/200
1/1 [==============================] - 0s 30ms/step - loss: 0.8110 - accuracy:
Epoch 92/200
1/1 [==============================] - 0s 32ms/step - loss: 0.8095 - accuracy:
Epoch 93/200
```

```
Epoch 93/200
1/1 [==============================] - 0s 43ms/step - loss: 0.8079 - accuracy:
Epoch 94/200
1/1 [==============================] - 0s 30ms/step - loss: 0.8065 - accuracy:
Epoch 95/200
1/1 [==============================] - 0s 30ms/step - loss: 0.8051 - accuracy:
Epoch 96/200
1/1 [==============================] - 0s 27ms/step - loss: 0.8038 - accuracy:
Epoch 97/200
1/1 [==============================] - 0s 27ms/step - loss: 0.8025 - accuracy:
Epoch 98/200
1/1 [==============================] - 0s 27ms/step - loss: 0.8012 - accuracy:
Epoch 99/200
1/1 [==============================] - 0s 28ms/step - loss: 0.8000 - accuracy:
Epoch 100/200
1/1 [==============================] - 0s 34ms/step - loss: 0.7988 - accuracy:
Epoch 101/200
1/1 [==============================] - 0s 37ms/step - loss: 0.7977 - accuracy:
Epoch 102/200
1/1 [==============================] - 0s 32ms/step - loss: 0.7966 - accuracy:
Epoch 103/200
1/1 [==============================] - 0s 37ms/step - loss: 0.7956 - accuracy:
Epoch 104/200
1/1 [==============================] - 0s 28ms/step - loss: 0.7946 - accuracy:
Epoch 105/200
1/1 [==============================] - 0s 28ms/step - loss: 0.7936 - accuracy:
Epoch 106/200
1/1 [==============================] - 0s 29ms/step - loss: 0.7926 - accuracy:
Epoch 107/200
1/1 [==============================] - 0s 31ms/step - loss: 0.7917 - accuracy:
Epoch 108/200
1/1 [==============================] - 0s 29ms/step - loss: 0.7908 - accuracy:
Epoch 109/200
1/1 [==============================] - 0s 28ms/step - loss: 0.7900 - accuracy:
Epoch 110/200
1/1 [==============================] - 0s 33ms/step - loss: 0.7891 - accuracy:
Epoch 111/200
1/1 [==============================] - 0s 28ms/step - loss: 0.7883 - accuracy:
Epoch 112/200
1/1 [==============================] - 0s 28ms/step - loss: 0.7876 - accuracy:
Epoch 113/200
1/1 [==============================] - 0s 30ms/step - loss: 0.7868 - accuracy:
Epoch 114/200
1/1 [==============================] - 0s 35ms/step - loss: 0.7861 - accuracy:
Epoch 115/200
1/1 [==============================] - 0s 28ms/step - loss: 0.7854 - accuracy:
Epoch 116/200
1/1 [==============================] - 0s 31ms/step - loss: 0.7847 - accuracy:
Epoch 117/200
1/1 [==============================] - 0s 28ms/step - loss: 0.7840 - accuracy:
Epoch 118/200
1/1 [==============================] - 0s 30ms/step - loss: 0.7833 - accuracy:
Epoch 119/200
1/1 [==============================] - 0s 29ms/step - loss: 0.7827 - accuracy:
Epoch 120/200
1/1 [==============================] - 0s 33ms/step - loss: 0.7821 - accuracy:
Epoch 121/200
1/1 [==============================] - 0s 29ms/step - loss: 0.7815 - accuracy:
Epoch 122/200
1/1 [==============================] - 0s 29ms/step - loss: 0.7809 - accuracy:
Epoch 123/200
1/1 [==============================] - 0s 29ms/step - loss: 0.7803 - accuracy:
```

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Epoch 124/200
1/1 [==============================] - 0s 35ms/step - loss: 0.7797 - accuracy:
Epoch 125/200
1/1 [==============================] - 0s 26ms/step - loss: 0.7792 - accuracy:
Epoch 126/200
1/1 [==============================] - 0s 27ms/step - loss: 0.7786 - accuracy:
Epoch 127/200
1/1 [==============================] - 0s 37ms/step - loss: 0.7781 - accuracy:
Epoch 128/200
1/1 [==============================] - 0s 32ms/step - loss: 0.7776 - accuracy:
Epoch 129/200
1/1 [==============================] - 0s 28ms/step - loss: 0.7771 - accuracy:
Epoch 130/200
1/1 [==============================] - 0s 28ms/step - loss: 0.7766 - accuracy:
Epoch 131/200
1/1 [==============================] - 0s 35ms/step - loss: 0.7761 - accuracy:
Epoch 132/200
1/1 [==============================] - 0s 31ms/step - loss: 0.7757 - accuracy:
Epoch 133/200
1/1 [==============================] - 0s 31ms/step - loss: 0.7752 - accuracy:
Epoch 134/200
1/1 [==============================] - 0s 36ms/step - loss: 0.7748 - accuracy:
Epoch 135/200
1/1 [==============================] - 0s 30ms/step - loss: 0.7743 - accuracy:
Epoch 136/200
1/1 [==============================] - 0s 29ms/step - loss: 0.7739 - accuracy:
Epoch 137/200
1/1 [==============================] - 0s 29ms/step - loss: 0.7735 - accuracy:
Epoch 138/200
1/1 [==============================] - 0s 30ms/step - loss: 0.7731 - accuracy:
Epoch 139/200
1/1 [==============================] - 0s 29ms/step - loss: 0.7727 - accuracy:
Epoch 140/200
1/1 [==============================] - 0s 30ms/step - loss: 0.7723 - accuracy:
Epoch 141/200
1/1 [==============================] - 0s 28ms/step - loss: 0.7719 - accuracy:
Epoch 142/200
1/1 [==============================] - 0s 31ms/step - loss: 0.7715 - accuracy:
Epoch 143/200
1/1 [==============================] - 0s 30ms/step - loss: 0.7711 - accuracy:
Epoch 144/200
1/1 [==============================] - 0s 36ms/step - loss: 0.7707 - accuracy:
Epoch 145/200
1/1 [==============================] - 0s 28ms/step - loss: 0.7704 - accuracy:
Epoch 146/200
1/1 [==============================] - 0s 34ms/step - loss: 0.7700 - accuracy:
Epoch 147/200
1/1 [==============================] - 0s 35ms/step - loss: 0.7696 - accuracy:
Epoch 148/200
1/1 [==============================] - 0s 37ms/step - loss: 0.7693 - accuracy:
Epoch 149/200
1/1 [==============================] - 0s 34ms/step - loss: 0.7690 - accuracy:
Epoch 150/200
1/1 [==============================] - 0s 32ms/step - loss: 0.7686 - accuracy:
Epoch 151/200
1/1 [==============================] - 0s 30ms/step - loss: 0.7683 - accuracy:
Epoch 152/200
1/1 [==============================] - 0s 35ms/step - loss: 0.7679 - accuracy:
Epoch 153/200
1/1 [==============================] - 0s 35ms/step - loss: 0.7676 - accuracy:
Epoch 154/200
1/1 [==============================] - 0s 33ms/step - loss: 0.7673 - accuracy:
```

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Epoch 155/200
1/1 [==============================] - 0s 38ms/step - loss: 0.7670 - accuracy:
Epoch 156/200
1/1 [==============================] - 0s 34ms/step - loss: 0.7667 - accuracy:
Epoch 157/200
1/1 [==============================] - 0s 34ms/step - loss: 0.7664 - accuracy:
Epoch 158/200
1/1 [==============================] - 0s 35ms/step - loss: 0.7661 - accuracy:
Epoch 159/200
1/1 [==============================] - 0s 36ms/step - loss: 0.7658 - accuracy:
Epoch 160/200
1/1 [==============================] - 0s 32ms/step - loss: 0.7655 - accuracy:
Epoch 161/200
1/1 [==============================] - 0s 32ms/step - loss: 0.7652 - accuracy:
Epoch 162/200
1/1 [==============================] - 0s 29ms/step - loss: 0.7649 - accuracy:
Epoch 163/200
1/1 [==============================] - 0s 29ms/step - loss: 0.7646 - accuracy:
Epoch 164/200
1/1 [==============================] - 0s 29ms/step - loss: 0.7643 - accuracy:
Epoch 165/200
1/1 [==============================] - 0s 36ms/step - loss: 0.7640 - accuracy:
Epoch 166/200
1/1 [==============================] - 0s 30ms/step - loss: 0.7637 - accuracy:
Epoch 167/200
1/1 [==============================] - 0s 30ms/step - loss: 0.7635 - accuracy:
Epoch 168/200
1/1 [==============================] - 0s 28ms/step - loss: 0.7632 - accuracy:
Epoch 169/200
1/1 [==============================] - 0s 31ms/step - loss: 0.7629 - accuracy:
Epoch 170/200
1/1 [==============================] - 0s 31ms/step - loss: 0.7627 - accuracy:
Epoch 171/200
1/1 [==============================] - 0s 28ms/step - loss: 0.7624 - accuracy:
Epoch 172/200
1/1 [==============================] - 0s 30ms/step - loss: 0.7621 - accuracy:
Epoch 173/200
1/1 [==============================] - 0s 27ms/step - loss: 0.7619 - accuracy:
Epoch 174/200
1/1 [==============================] - 0s 29ms/step - loss: 0.7616 - accuracy:
Epoch 175/200
1/1 [==============================] - 0s 33ms/step - loss: 0.7614 - accuracy:
Epoch 176/200
1/1 [==============================] - 0s 34ms/step - loss: 0.7611 - accuracy:
Epoch 177/200
1/1 [==============================] - 0s 28ms/step - loss: 0.7609 - accuracy:
Epoch 178/200
1/1 [==============================] - 0s 28ms/step - loss: 0.7606 - accuracy:
Epoch 179/200
1/1 [==============================] - 0s 31ms/step - loss: 0.7604 - accuracy:
Epoch 180/200
1/1 [==============================] - 0s 28ms/step - loss: 0.7601 - accuracy:
Epoch 181/200
1/1 [==============================] - 0s 27ms/step - loss: 0.7599 - accuracy:
Epoch 182/200
1/1 [==============================] - 0s 30ms/step - loss: 0.7596 - accuracy:
Epoch 183/200
1/1 [==============================] - 0s 29ms/step - loss: 0.7594 - accuracy:
Epoch 184/200
1/1 [==============================] - 0s 30ms/step - loss: 0.7592 - accuracy:
Epoch 185/200
1/1 [==============================] - 0s 37ms/step - loss: 0.7589 - accuracy:
```

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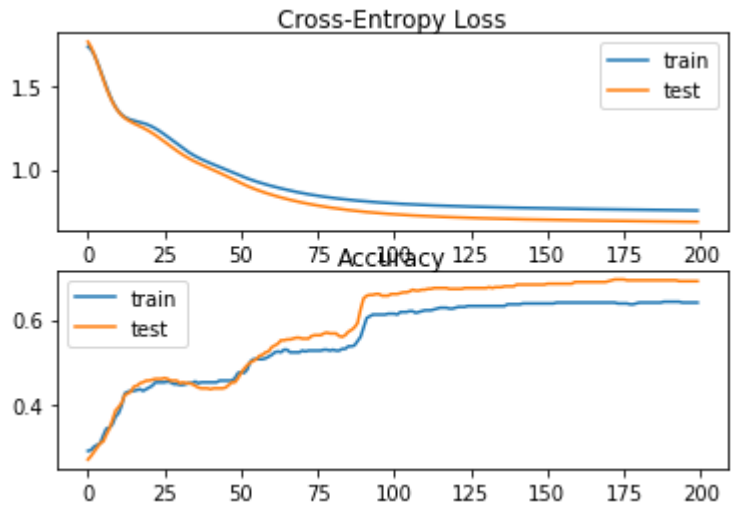
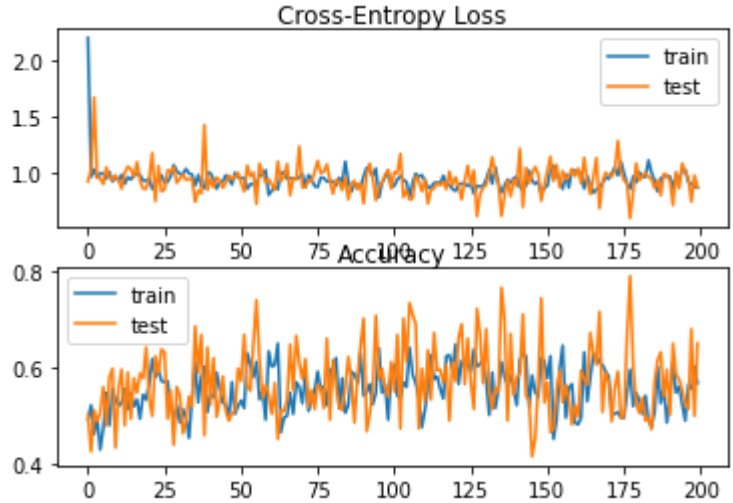
1/1 [==============================] - 0s 37ms/step - loss: 0.7589 - accuracy:
Epoch 186/200
1/1 [==============================] - 0s 28ms/step - loss: 0.7587 - accuracy:
Epoch 187/200
1/1 [==============================] - 0s 28ms/step - loss: 0.7585 - accuracy:
Epoch 188/200
1/1 [==============================] - 0s 27ms/step - loss: 0.7582 - accuracy:
Epoch 189/200
1/1 [==============================] - 0s 30ms/step - loss: 0.7580 - accuracy:
Epoch 190/200
1/1 [==============================] - 0s 34ms/step - loss: 0.7578 - accuracy:
Epoch 191/200
1/1 [==============================] - 0s 30ms/step - loss: 0.7576 - accuracy:
Epoch 192/200
1/1 [==============================] - 0s 28ms/step - loss: 0.7573 - accuracy:
Epoch 193/200
1/1 [==============================] - 0s 25ms/step - loss: 0.7571 - accuracy:
Epoch 194/200
1/1 [==============================] - 0s 28ms/step - loss: 0.7569 - accuracy:
Epoch 195/200
1/1 [==============================] - 0s 32ms/step - loss: 0.7567 - accuracy:
Epoch 196/200
1/1 [==============================] - 0s 27ms/step - loss: 0.7565 - accuracy:
Epoch 197/200
1/1 [==============================] - 0s 29ms/step - loss: 0.7562 - accuracy:
Epoch 198/200
1/1 [==============================] - 0s 27ms/step - loss: 0.7560 - accuracy:
Epoch 199/200
1/1 [==============================] - 0s 29ms/step - loss: 0.7558 - accuracy:
Epoch 200/200
1/1 [==============================] - 0s 31ms/step - loss: 0.7556 - accuracy:
Train: 0.640, Test: 0.690
```




```
# mlp for the blobs problem with stochastic gradient descent
from sklearn.datasets.samples_generator import make_blobs
from tensorflow.keras.layers import Dense
from tensorflow.keras.models import Sequential
from tensorflow.keras.optimizers import SGD
```

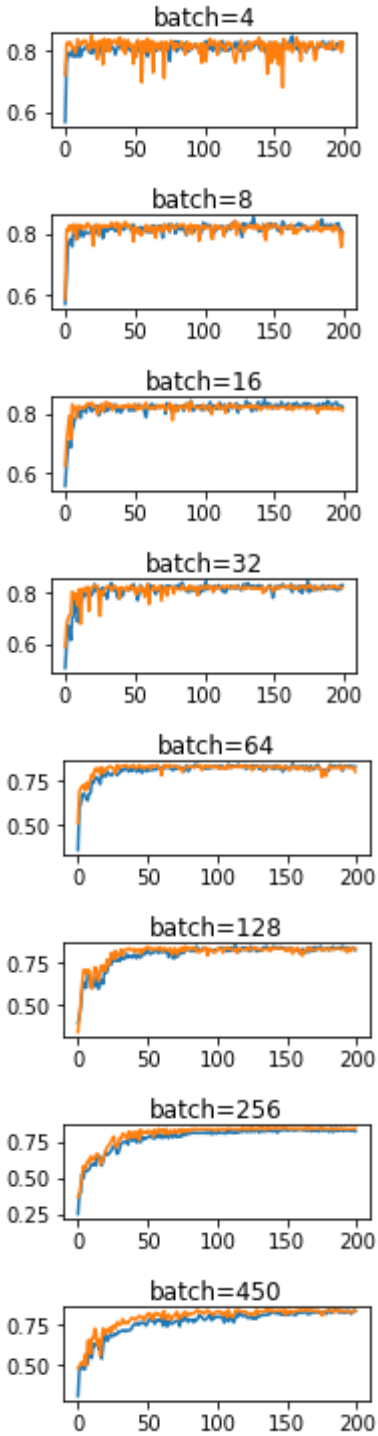
```
from tensorflow.keras.utils import to_categorical
from matplotlib import pyplot
# generate 2d classification dataset
X, y = make_blobs(n_samples=1000, centers=3, n_features=2, cluster_std=2, rand
# one hot encode output variable
y = to_categorical(y)
# split into train and test
n_train = 500
trainX, testX = X[:n_train, :], X[n_train:, :]
trainy, testy = y[:n_train], y[n_train:]
# define model
model = Sequential()
model.add(Dense(50, input_dim=2, activation='relu', kernel_initializer='he_uni
model.add(Dense(3, activation='softmax'))
# compile model
opt = SGD(lr=0.01, momentum=0.9)
model.compile(loss='categorical_crossentropy', optimizer=opt, metrics=['accura
# fit model
history = model.fit(trainX, trainy, validation_data=(testX, testy), epochs=200,
batch_size=1)
# evaluate the model
_, train_acc = model.evaluate(trainX, trainy, verbose=0)
_, test_acc = model.evaluate(testX, testy, verbose=0)
print('Train: %.3f, Test: %.3f' % (train_acc, test_acc))
# plot loss learning curves
pyplot.subplot(211)
pyplot.title('Cross-Entropy Loss', pad=-40)
pyplot.plot(history.history['loss'], label='train')
pyplot.plot(history.history['val_loss'], label='test')
pyplot.legend()
# plot accuracy learning curves
pyplot.subplot(212)
pyplot.title('Accuracy', pad=-40)
pyplot.plot(history.history['accuracy'], label='train')
pyplot.plot(history.history['val_accuracy'], label='test')
pyplot.legend()
pyplot.show()
```

```
Train: 0.654, Test: 0.650
```




```
# mlp for the blobs problem with minibatch gradient descent with varied batch
```

```
from sklearn.datasets.samples_generator import make_blobs
from tensorflow.keras.layers import Dense
from tensorflow.keras.models import Sequential
from tensorflow.keras.optimizers import SGD
from tensorflow.keras.utils import to_categorical
from matplotlib import pyplot
# prepare train and test dataset
def prepare_data():
# generate 2d classification dataset
  X, y = make_blobs(n_samples=1000, centers=3, n_features=2, cluster_std=2, ra
# one hot encode output variable
  y = to_categorical(y)
# split into train and test
  n_train = 500
  trainX, testX = X[:n_train, :], X[n_train:, :]
  trainy, testy = y[:n_train], y[n_train:]
  return trainX, trainy, testX, testy
# fit a model and plot learning curve
def fit_model(trainX, trainy, testX, testy, n_batch):
# define model
  model = Sequential()
  model.add(Dense(50, input_dim=2, activation='relu', kernel_initializer='he_u
  model.add(Dense(3, activation='softmax'))
# compile model
  opt = SGD(lr=0.01, momentum=0.9)
  model.compile(loss='categorical_crossentropy', optimizer=opt, metrics=['accu
# fit model
  history = model.fit(trainX, trainy, validation_data=(testX, testy), epochs=20
  verbose=0, batch_size=n_batch)
# plot learning curves
  pyplot.plot(history.history['accuracy'], label='train')
  pyplot.plot(history.history['val_accuracy'], label='test')
  pyplot.title('batch='+str(n_batch), pad=-40)
# prepare dataset
trainX, trainy, testX, testy = prepare_data()
# create learning curves for different batch sizes
batch_sizes = [4, 8, 16, 32, 64, 128, 256, 450]
for i in range(len(batch_sizes)):
# determine the plot number
  plot_no = 420 + (i+1)
  pyplot.subplot(plot_no)
# fit model and plot learning curves for a batch size
  fit_model(trainX, trainy, testX, testy, batch_sizes[i])
# show learning curves
  pyplot.show()
```


batch=4
batch=8
batch=16
batch=32
batch=64
batch=128
batch=256
batch=450