In [ ]:
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# ML Midsem Question 4: Neural Network
#10190900042
```

In [ ]:
```
#from sklearn.datasets import load_boston
from sklearn.model_selection import train_test_split
from keras.models import Sequential
from keras.layers import Dense
from keras.utils import to_categorical
import numpy as np
import matplotlib.pyplot as plt
from sklearn.datasets import make_classification
```

In [ ]:
```
x,y = make_classification(n_samples=100000, n_features=2, n_classes=4,
                                    random_state=42)
```

In [ ]:
```
from sklearn.preprocessing import StandardScaler
scaler = StandardScaler()
X = scaler.fit_transform(x)
y = to_categorical(y)
```

In [ ]:
```
X_train, X_test, y_train, y_test = train_test_split(X, y,
test_size=0.3,
random_state=42)
```

In [ ]:
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In [ ]:

```
# Implementation of the neural network model with 4 hidden layers of 32
#and tanh activation function using Keras.

model = Sequential()
model.add(Dense(128, activation='relu', input_dim=X_train.shape[1]))
model.add(Dense(64, activation='sigmoid'))
model.add(Dense(32, activation='elu'))
model.add(Dense(16, activation='selu'))
model.add(Dense(4))
model.compile(optimizer='adam', loss='mse', metrics=['accuracy'])

history = model.fit(X_train, y_train,
                    validation_data=(X_test, y_test), epochs=20,
                    batch_size=100)
```

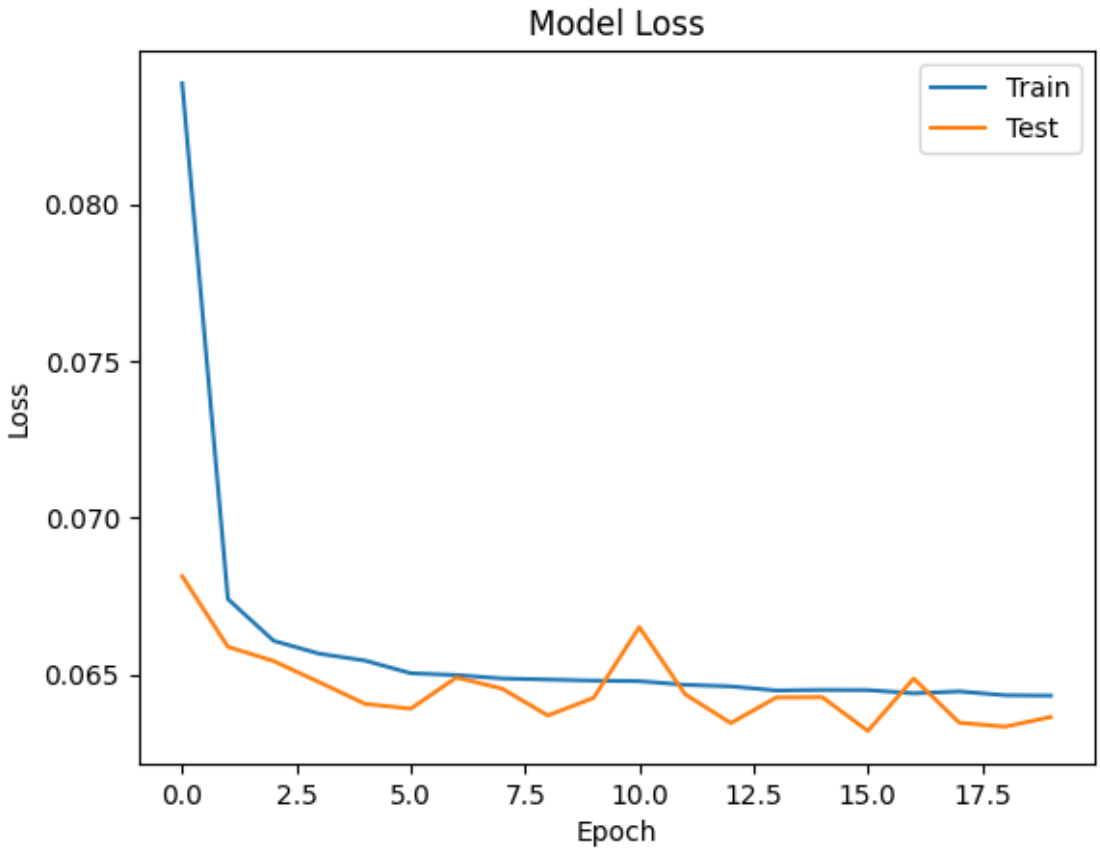
```
Epoch 1/20
700/700 [==============================] - 6s 7ms/step - loss: 0.0838
- accuracy: 0.7925 - val_loss: 0.0681 - val_accuracy: 0.8176
Epoch 2/20
700/700 [==============================] - 6s 9ms/step - loss: 0.0674
- accuracy: 0.8166 - val_loss: 0.0659 - val_accuracy: 0.8184
Epoch 3/20
700/700 [==============================] - 2s 3ms/step - loss: 0.0661
- accuracy: 0.8171 - val_loss: 0.0654 - val_accuracy: 0.8183
Epoch 4/20
700/700 [==============================] - 2s 3ms/step - loss: 0.0657
- accuracy: 0.8169 - val_loss: 0.0648 - val_accuracy: 0.8200
Epoch 5/20
700/700 [==============================] - 2s 3ms/step - loss: 0.0654
- accuracy: 0.8170 - val_loss: 0.0641 - val_accuracy: 0.8201
Epoch 6/20
700/700 [==============================] - 2s 3ms/step - loss: 0.0650
- accuracy: 0.8180 - val_loss: 0.0639 - val_accuracy: 0.8193
Epoch 7/20
700/700 [==============================] - 3s 4ms/step - loss: 0.0650
- accuracy: 0.8175 - val_loss: 0.0649 - val_accuracy: 0.8180
Epoch 8/20
700/700 [==============================] - 2s 3ms/step - loss: 0.0649
- accuracy: 0.8178 - val_loss: 0.0645 - val_accuracy: 0.8193
Epoch 9/20
700/700 [==============================] - 2s 3ms/step - loss: 0.0648
- accuracy: 0.8174 - val_loss: 0.0637 - val_accuracy: 0.8193
Epoch 10/20
700/700 [==============================] - 2s 3ms/step - loss: 0.0648
- accuracy: 0.8179 - val_loss: 0.0643 - val_accuracy: 0.8203
Epoch 11/20
700/700 [==============================] - 2s 3ms/step - loss: 0.0648
- accuracy: 0.8178 - val_loss: 0.0665 - val_accuracy: 0.8160
Epoch 12/20
700/700 [==============================] - 3s 5ms/step - loss: 0.0647
- accuracy: 0.8177 - val_loss: 0.0644 - val_accuracy: 0.8197
Epoch 13/20
700/700 [==============================] - 2s 3ms/step - loss: 0.0646
- accuracy: 0.8181 - val_loss: 0.0635 - val_accuracy: 0.8207
Epoch 14/20
700/700 [==============================] - 2s 3ms/step - loss: 0.0645
- accuracy: 0.8177 - val_loss: 0.0643 - val_accuracy: 0.8199
Epoch 15/20
700/700 [==============================] - 2s 3ms/step - loss: 0.0645
- accuracy: 0.8178 - val_loss: 0.0643 - val_accuracy: 0.8190
Epoch 16/20
700/700 [==============================] - 2s 3ms/step - loss: 0.0645
- accuracy: 0.8175 - val_loss: 0.0632 - val_accuracy: 0.8195
Epoch 17/20
700/700 [==============================] - 3s 4ms/step - loss: 0.0644
- accuracy: 0.8180 - val_loss: 0.0649 - val_accuracy: 0.8153
Epoch 18/20
700/700 [==============================] - 3s 4ms/step - loss: 0.0645
- accuracy: 0.8176 - val_loss: 0.0635 - val_accuracy: 0.8201
Epoch 19/20
700/700 [==============================] - 2s 4ms/step - loss: 0.0643
- accuracy: 0.8179 - val_loss: 0.0633 - val_accuracy: 0.8201
```

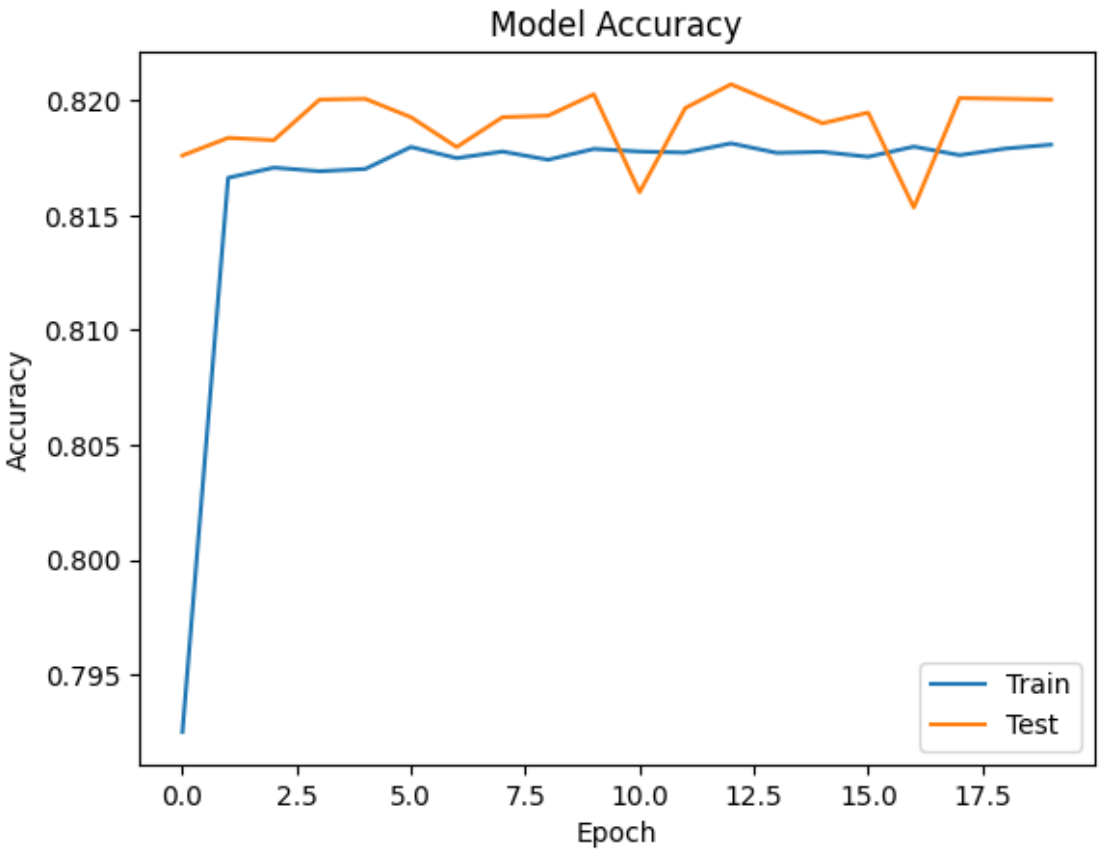
```
Epoch 20/20
700/700 [==============================] - 2s 3ms/step - loss: 0.0643
- accuracy: 0.8181 - val_loss: 0.0636 - val_accuracy: 0.8200
```

In [ ]:

```
plt.plot(history.history['loss'])
plt.plot(history.history['val_loss'])
plt.title('Model Loss')
plt.ylabel('Loss')
plt.xlabel('Epoch')
plt.legend(['Train', 'Test'], loc='upper right')
plt.show()

plt.plot(history.history['accuracy'])
plt.plot(history.history['val_accuracy'])
plt.title('Model Accuracy')
plt.ylabel('Accuracy')
plt.xlabel('Epoch')
plt.legend(['Train', 'Test'], loc='lower right')
plt.show()
```




Model Accuracy
Accuracy
0.820
0.815
0.810
0.805
0.800
0.795
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
Epoch
Train
Test

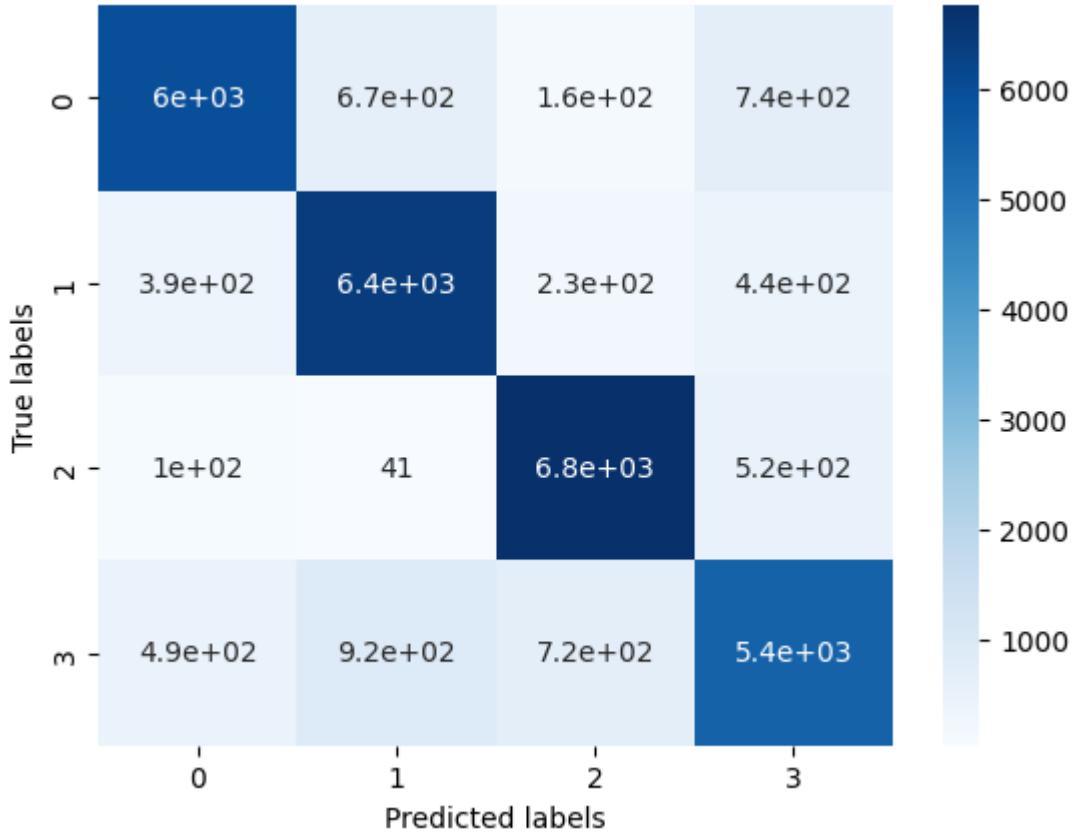
In [ ]:
```
from sklearn.metrics import confusion_matrix
import seaborn as sns

y_pred = model.predict(X_test)
y_pred = np.argmax(y_pred, axis=1)

cm = confusion_matrix(np.argmax(y_test, axis=1), y_pred)
sns.heatmap(cm, annot=True, cmap='Blues')
plt.xlabel('Predicted labels')
plt.ylabel('True labels')
```

```
938/938 [==============================] - 4s 4ms/step
```

Out[17]:
```
Text(50.722222222222214, 0.5, 'True labels')
```



FINDINGS: The model was modified with four hidden layers containing 128, 64, 31, and 16 neurons respectively, using the activation function sigmoid,elu and selu. The validation accuracy of the model was 0.8100, indicating a good fit to the dataset without underfitting or overfitting. Residual training and testing plots were generated, showing a similar trend to the previous model. The graphs displayed the model loss and accuracy approaching 0 and 1 respectively, indicating a well-fitting neural network model for the dataset. However, upon closer examination, it was observed that the exponential testing line in the model loss increased to 0.1 after reaching its minimum point at the 10th epoch, resulting in a slight loss. Similarly, the exponential testing line in the accuracy model decreased to 0.8181 after reaching its maximum point at approximately the 7th epoch, indicating a slight error in accuracy. To evaluate the model's performance, a confusion matrix was plotted. The matrix indicated no type I or type II errors, suggesting good performance in classifying the dataset.