Develop a Chatbot Using Python, NLTK, and TensorFlow

In [1]:
```
# Run this cell so you do not see GPU availibility errors from tensorflow
import os
os.environ['TF_CPP_MIN_LOG_LEVEL'] = '3'
```

Task 1: Import the Required Libraries

In [2]:
```
import json
import pickle
import random
import nltk
from nltk.stem import WordNetLemmatizer
import numpy as np
from tensorflow.keras.models import Sequential
from tensorflow.keras.optimizers import SGD
from tensorflow.keras.layers import Dense
from tensorflow.keras.layers import Activation
from tensorflow.keras.layers import Dropout
import matplotlib.pyplot as plt
from matplotlib import rcParams
```

Task 2: Load the Data

In [5]:
```
#Load the data
nltk.download('omw-1.4')
with open(r'intents.json') as data:
    intents = json.loads(data.read())
```

```
[nltk_data] Downloading package omw-1.4 to /root/nltk_data...
[nltk_data]   Package omw-1.4 is already up-to-date!
```

Task 3: Tokenization

In [6]:
```
words = []
classes = []
documents = []

for intent in intents['intents']:
    for pattern in intent['patterns']:
        w = nltk.word_tokenize(pattern)
        words.extend(w)
        classes.append(intent['tag'])
        documents.append((w, intent['tag']))
```

Task 4: Lemmatization

In [8]:
```
lemmatizer = WordNetLemmatizer()
ignore_words = ['?', '!']
words = [lemmatizer.lemmatize(w.lower())for w in words if w not in ignore_words]
words = sorted(list(set(words)))
classes = sorted(list(set(classes)))

pickle.dump(words, open('words.pkl', 'wb'))
pickle.dump(classes, open('classes.pkl', 'wb'))
```

Task 5: Create Data for Training

In [9]:
```
training = []
output_empty = [0]*len(classes)

for doc in documents:
    bag = []
    pattern_words = doc[0]
    pattern_words = [lemmatizer.lemmatize(word.lower())for word in pattern_words]
    for w in words:
        if w in pattern_words:
            bag.append(1)
        else: bag.append(0)
    output_row = list(output_empty)
    output_row[classes.index(doc[1])] = 1
    training.append([bag, output_row])

random.shuffle(training)
a = int(0.7*len(training))
training = np.array(training, dtype = 'object')
X_train = list(training[:a, 0])
y_train = list(training[:a, 1])
X_val = list(training[a:, 0])
y_val = list(training[a:, 1])
```

Task 6: Design the Model

In [10]:
```
model = Sequential()
model.add(Dense(128, input_shape=(len(X_train[0]),), activation='relu'))
model.add(Dropout(0.5))
model.add(Dense(64, activation='relu'))
model.add(Dropout(0.5))
model.add(Dense(len(y_train[0]), activation='softmax'))
```

Task 7: Train and Save the Model

In [12]:
```
sgd = SGD(learning_rate=0.01, momentum=0.9, nesterov=True)
model.compile(loss='categorical_crossentropy',
              optimizer=sgd,
              metrics=['accuracy'])
hist = model.fit(np.array(X_train),
                 np.array(y_train),
                 epochs = 200,
                 batch_size=5, validation_data=(X_val, y_val),
                  verbose =1 )
model.save('trained_model.h5', hist)
```

```
Epoch 1/200
7/7 [==============================] - 2s 93ms/step - loss: 2.2500 - accuracy: 0.0
625 - val_loss: 2.2055 - val_accuracy: 0.0000e+00
Epoch 2/200
7/7 [==============================] - 0s 12ms/step - loss: 2.1612 - accuracy: 0.1
562 - val_loss: 2.2325 - val_accuracy: 0.0000e+00
Epoch 3/200
7/7 [==============================] - 0s 12ms/step - loss: 2.2104 - accuracy: 0.0
938 - val_loss: 2.2512 - val_accuracy: 0.0000e+00
Epoch 4/200
7/7 [==============================] - 0s 12ms/step - loss: 2.0374 - accuracy: 0.2
188 - val_loss: 2.2456 - val_accuracy: 0.0000e+00
Epoch 5/200
7/7 [==============================] - 0s 13ms/step - loss: 1.9191 - accuracy: 0.3
125 - val_loss: 2.2549 - val_accuracy: 0.0000e+00
Epoch 6/200
7/7 [==============================] - 0s 13ms/step - loss: 1.9125 - accuracy: 0.3
750 - val_loss: 2.2266 - val_accuracy: 0.0667
Epoch 7/200
7/7 [==============================] - 0s 13ms/step - loss: 1.7730 - accuracy: 0.4
062 - val_loss: 2.2071 - val_accuracy: 0.0667
Epoch 8/200
7/7 [==============================] - 0s 13ms/step - loss: 1.8684 - accuracy: 0.3
438 - val_loss: 2.1752 - val_accuracy: 0.0667
Epoch 9/200
7/7 [==============================] - 0s 14ms/step - loss: 1.5751 - accuracy: 0.4
688 - val_loss: 2.1223 - val_accuracy: 0.2000
Epoch 10/200
7/7 [==============================] - 0s 12ms/step - loss: 1.4212 - accuracy: 0.5
625 - val_loss: 2.0427 - val_accuracy: 0.2667
Epoch 11/200
7/7 [==============================] - 0s 13ms/step - loss: 1.4701 - accuracy: 0.5
312 - val_loss: 1.9338 - val_accuracy: 0.2667
Epoch 12/200
7/7 [==============================] - 0s 12ms/step - loss: 1.2642 - accuracy: 0.7
500 - val_loss: 1.8588 - val_accuracy: 0.2667
Epoch 13/200
7/7 [==============================] - 0s 13ms/step - loss: 1.1839 - accuracy: 0.6
875 - val_loss: 1.7940 - val_accuracy: 0.2667
Epoch 14/200
7/7 [==============================] - 0s 12ms/step - loss: 0.9592 - accuracy: 0.8
125 - val_loss: 1.7093 - val_accuracy: 0.3333
Epoch 15/200
7/7 [==============================] - 0s 12ms/step - loss: 1.1757 - accuracy: 0.6
250 - val_loss: 1.6763 - val_accuracy: 0.4000
Epoch 16/200
7/7 [==============================] - 0s 12ms/step - loss: 0.9869 - accuracy: 0.7
812 - val_loss: 1.6333 - val_accuracy: 0.4000
Epoch 17/200
7/7 [==============================] - 0s 12ms/step - loss: 0.9872 - accuracy: 0.6
562 - val_loss: 1.5206 - val_accuracy: 0.4667
Epoch 18/200
7/7 [==============================] - 0s 12ms/step - loss: 0.7473 - accuracy: 0.8
438 - val_loss: 1.4496 - val_accuracy: 0.5333
Epoch 19/200
7/7 [==============================] - 0s 13ms/step - loss: 0.7632 - accuracy: 0.8
```

```
750 - val_loss: 1.4279 - val_accuracy: 0.4667
Epoch 20/200
7/7 [==============================] - 0s 13ms/step - loss: 0.5263 - accuracy: 0.8
438 - val_loss: 1.3996 - val_accuracy: 0.4667
Epoch 21/200
7/7 [==============================] - 0s 12ms/step - loss: 0.6128 - accuracy: 0.8
438 - val_loss: 1.3407 - val_accuracy: 0.6000
Epoch 22/200
7/7 [==============================] - 0s 12ms/step - loss: 0.5262 - accuracy: 0.8
438 - val_loss: 1.2556 - val_accuracy: 0.6667
Epoch 23/200
7/7 [==============================] - 0s 12ms/step - loss: 0.3843 - accuracy: 0.9
375 - val_loss: 1.2088 - val_accuracy: 0.6000
Epoch 24/200
7/7 [==============================] - 0s 13ms/step - loss: 0.4832 - accuracy: 0.8
438 - val_loss: 1.1384 - val_accuracy: 0.6667
Epoch 25/200
7/7 [==============================] - 0s 13ms/step - loss: 0.4309 - accuracy: 0.9
062 - val_loss: 1.0939 - val_accuracy: 0.6667
Epoch 26/200
7/7 [==============================] - 0s 13ms/step - loss: 0.4147 - accuracy: 0.9
062 - val_loss: 1.0767 - val_accuracy: 0.6667
Epoch 27/200
7/7 [==============================] - 0s 12ms/step - loss: 0.4136 - accuracy: 0.9
062 - val_loss: 1.0560 - val_accuracy: 0.6000
Epoch 28/200
7/7 [==============================] - 0s 12ms/step - loss: 0.4768 - accuracy: 0.9
062 - val_loss: 1.0434 - val_accuracy: 0.6667
Epoch 29/200
7/7 [==============================] - 0s 12ms/step - loss: 0.4384 - accuracy: 0.8
750 - val_loss: 1.0315 - val_accuracy: 0.6667
Epoch 30/200
7/7 [==============================] - 0s 12ms/step - loss: 0.4184 - accuracy: 0.9
375 - val_loss: 1.0580 - val_accuracy: 0.6667
Epoch 31/200
7/7 [==============================] - 0s 12ms/step - loss: 0.2653 - accuracy: 0.9
375 - val_loss: 1.1151 - val_accuracy: 0.6667
Epoch 32/200
7/7 [==============================] - 0s 13ms/step - loss: 0.1618 - accuracy: 1.0
000 - val_loss: 1.1221 - val_accuracy: 0.6667
Epoch 33/200
7/7 [==============================] - 0s 12ms/step - loss: 0.3129 - accuracy: 0.9
375 - val_loss: 1.0824 - val_accuracy: 0.6667
Epoch 34/200
7/7 [==============================] - 0s 12ms/step - loss: 0.3890 - accuracy: 0.8
438 - val_loss: 1.0636 - val_accuracy: 0.6667
Epoch 35/200
7/7 [==============================] - 0s 12ms/step - loss: 0.4178 - accuracy: 0.8
750 - val_loss: 1.1538 - val_accuracy: 0.6667
Epoch 36/200
7/7 [==============================] - 0s 12ms/step - loss: 0.1553 - accuracy: 1.0
000 - val_loss: 1.1656 - val_accuracy: 0.6667
Epoch 37/200
7/7 [==============================] - 0s 12ms/step - loss: 0.1687 - accuracy: 1.0
000 - val_loss: 1.1479 - val_accuracy: 0.6667
Epoch 38/200
```

```
7/7 [==============================] - 0s 13ms/step - loss: 0.1440 - accuracy: 1.0
000 - val_loss: 1.0596 - val_accuracy: 0.6667
Epoch 39/200
7/7 [==============================] - 0s 12ms/step - loss: 0.2693 - accuracy: 0.9
375 - val_loss: 1.0283 - val_accuracy: 0.6667
Epoch 40/200
7/7 [==============================] - 0s 13ms/step - loss: 0.2796 - accuracy: 0.8
750 - val_loss: 0.9859 - val_accuracy: 0.6667
Epoch 41/200
7/7 [==============================] - 0s 12ms/step - loss: 0.1960 - accuracy: 1.0
000 - val_loss: 0.9695 - val_accuracy: 0.6667
Epoch 42/200
7/7 [==============================] - 0s 12ms/step - loss: 0.1774 - accuracy: 0.9
375 - val_loss: 0.9957 - val_accuracy: 0.6667
Epoch 43/200
7/7 [==============================] - 0s 13ms/step - loss: 0.3233 - accuracy: 0.9
062 - val_loss: 1.0210 - val_accuracy: 0.6667
Epoch 44/200
7/7 [==============================] - 0s 13ms/step - loss: 0.1144 - accuracy: 1.0
000 - val_loss: 1.0439 - val_accuracy: 0.6667
Epoch 45/200
7/7 [==============================] - 0s 12ms/step - loss: 0.1400 - accuracy: 1.0
000 - val_loss: 1.0371 - val_accuracy: 0.6667
Epoch 46/200
7/7 [==============================] - 0s 13ms/step - loss: 0.1258 - accuracy: 0.9
688 - val_loss: 0.9631 - val_accuracy: 0.6667
Epoch 47/200
7/7 [==============================] - 0s 13ms/step - loss: 0.2358 - accuracy: 0.9
688 - val_loss: 0.9645 - val_accuracy: 0.6667
Epoch 48/200
7/7 [==============================] - 0s 12ms/step - loss: 0.1843 - accuracy: 0.9
688 - val_loss: 0.9953 - val_accuracy: 0.6667
Epoch 49/200
7/7 [==============================] - 0s 12ms/step - loss: 0.1232 - accuracy: 1.0
000 - val_loss: 1.0202 - val_accuracy: 0.6667
Epoch 50/200
7/7 [==============================] - 0s 12ms/step - loss: 0.1437 - accuracy: 0.9
688 - val_loss: 1.0312 - val_accuracy: 0.6667
Epoch 51/200
7/7 [==============================] - 0s 12ms/step - loss: 0.1657 - accuracy: 1.0
000 - val_loss: 1.0649 - val_accuracy: 0.6667
Epoch 52/200
7/7 [==============================] - 0s 12ms/step - loss: 0.0947 - accuracy: 0.9
375 - val_loss: 1.1078 - val_accuracy: 0.6667
Epoch 53/200
7/7 [==============================] - 0s 13ms/step - loss: 0.0823 - accuracy: 1.0
000 - val_loss: 1.1394 - val_accuracy: 0.6667
Epoch 54/200
7/7 [==============================] - 0s 13ms/step - loss: 0.0939 - accuracy: 1.0
000 - val_loss: 1.1118 - val_accuracy: 0.6667
Epoch 55/200
7/7 [==============================] - 0s 12ms/step - loss: 0.1656 - accuracy: 0.9
688 - val_loss: 1.0632 - val_accuracy: 0.6667
Epoch 56/200
7/7 [==============================] - 0s 13ms/step - loss: 0.0634 - accuracy: 1.0
000 - val_loss: 1.0198 - val_accuracy: 0.6667
```

```
Epoch 57/200
7/7 [==============================] - 0s 13ms/step - loss: 0.1117 - accuracy: 1.0
000 - val_loss: 1.0248 - val_accuracy: 0.7333
Epoch 58/200
7/7 [==============================] - 0s 12ms/step - loss: 0.0847 - accuracy: 0.9
688 - val_loss: 1.0436 - val_accuracy: 0.6667
Epoch 59/200
7/7 [==============================] - 0s 13ms/step - loss: 0.0715 - accuracy: 1.0
000 - val_loss: 1.0720 - val_accuracy: 0.6667
Epoch 60/200
7/7 [==============================] - 0s 12ms/step - loss: 0.1177 - accuracy: 1.0
000 - val_loss: 1.0802 - val_accuracy: 0.6667
Epoch 61/200
7/7 [==============================] - 0s 13ms/step - loss: 0.1020 - accuracy: 1.0
000 - val_loss: 1.0460 - val_accuracy: 0.6667
Epoch 62/200
7/7 [==============================] - 0s 13ms/step - loss: 0.1369 - accuracy: 0.9
375 - val_loss: 1.0484 - val_accuracy: 0.6667
Epoch 63/200
7/7 [==============================] - 0s 12ms/step - loss: 0.1170 - accuracy: 1.0
000 - val_loss: 1.0840 - val_accuracy: 0.7333
Epoch 64/200
7/7 [==============================] - 0s 12ms/step - loss: 0.0891 - accuracy: 1.0
000 - val_loss: 1.1159 - val_accuracy: 0.6667
Epoch 65/200
7/7 [==============================] - 0s 12ms/step - loss: 0.0687 - accuracy: 1.0
000 - val_loss: 1.1345 - val_accuracy: 0.6667
Epoch 66/200
7/7 [==============================] - 0s 13ms/step - loss: 0.0741 - accuracy: 0.9
688 - val_loss: 1.1365 - val_accuracy: 0.6667
Epoch 67/200
7/7 [==============================] - 0s 13ms/step - loss: 0.0745 - accuracy: 1.0
000 - val_loss: 1.1371 - val_accuracy: 0.6667
Epoch 68/200
7/7 [==============================] - 0s 14ms/step - loss: 0.0356 - accuracy: 1.0
000 - val_loss: 1.1289 - val_accuracy: 0.6667
Epoch 69/200
7/7 [==============================] - 0s 12ms/step - loss: 0.0178 - accuracy: 1.0
000 - val_loss: 1.1221 - val_accuracy: 0.6667
Epoch 70/200
7/7 [==============================] - 0s 12ms/step - loss: 0.0340 - accuracy: 1.0
000 - val_loss: 1.1158 - val_accuracy: 0.6667
Epoch 71/200
7/7 [==============================] - 0s 12ms/step - loss: 0.0769 - accuracy: 1.0
000 - val_loss: 1.1059 - val_accuracy: 0.6667
Epoch 72/200
7/7 [==============================] - 0s 12ms/step - loss: 0.0832 - accuracy: 1.0
000 - val_loss: 1.1015 - val_accuracy: 0.6667
Epoch 73/200
7/7 [==============================] - 0s 12ms/step - loss: 0.0413 - accuracy: 1.0
000 - val_loss: 1.0887 - val_accuracy: 0.6667
Epoch 74/200
7/7 [==============================] - 0s 12ms/step - loss: 0.0709 - accuracy: 0.9
688 - val_loss: 1.0694 - val_accuracy: 0.6667
Epoch 75/200
7/7 [==============================] - 0s 12ms/step - loss: 0.0403 - accuracy: 1.0
```

```
000 - val_loss: 1.0639 - val_accuracy: 0.6667
Epoch 76/200
7/7 [==============================] - 0s 13ms/step - loss: 0.0757 - accuracy: 1.0
000 - val_loss: 1.0649 - val_accuracy: 0.6667
Epoch 77/200
7/7 [==============================] - 0s 12ms/step - loss: 0.0173 - accuracy: 1.0
000 - val_loss: 1.0722 - val_accuracy: 0.6667
Epoch 78/200
7/7 [==============================] - 0s 13ms/step - loss: 0.1212 - accuracy: 0.9
375 - val_loss: 1.0749 - val_accuracy: 0.6667
Epoch 79/200
7/7 [==============================] - 0s 13ms/step - loss: 0.0578 - accuracy: 1.0
000 - val_loss: 1.0506 - val_accuracy: 0.6667
Epoch 80/200
7/7 [==============================] - 0s 13ms/step - loss: 0.0616 - accuracy: 1.0
000 - val_loss: 1.0815 - val_accuracy: 0.6667
Epoch 81/200
7/7 [==============================] - 0s 12ms/step - loss: 0.0901 - accuracy: 0.9
688 - val_loss: 1.0586 - val_accuracy: 0.6667
Epoch 82/200
7/7 [==============================] - 0s 13ms/step - loss: 0.0181 - accuracy: 1.0
000 - val_loss: 1.0493 - val_accuracy: 0.6667
Epoch 83/200
7/7 [==============================] - 0s 12ms/step - loss: 0.0608 - accuracy: 1.0
000 - val_loss: 1.0689 - val_accuracy: 0.6667
Epoch 84/200
7/7 [==============================] - 0s 12ms/step - loss: 0.1262 - accuracy: 0.9
688 - val_loss: 1.0842 - val_accuracy: 0.6667
Epoch 85/200
7/7 [==============================] - 0s 12ms/step - loss: 0.0609 - accuracy: 1.0
000 - val_loss: 1.0930 - val_accuracy: 0.6667
Epoch 86/200
7/7 [==============================] - 0s 12ms/step - loss: 0.0220 - accuracy: 1.0
000 - val_loss: 1.1047 - val_accuracy: 0.6667
Epoch 87/200
7/7 [==============================] - 0s 12ms/step - loss: 0.0158 - accuracy: 1.0
000 - val_loss: 1.1062 - val_accuracy: 0.6667
Epoch 88/200
7/7 [==============================] - 0s 12ms/step - loss: 0.1188 - accuracy: 0.9
688 - val_loss: 1.0812 - val_accuracy: 0.6667
Epoch 89/200
7/7 [==============================] - 0s 12ms/step - loss: 0.0298 - accuracy: 1.0
000 - val_loss: 1.0862 - val_accuracy: 0.6667
Epoch 90/200
7/7 [==============================] - 0s 13ms/step - loss: 0.1362 - accuracy: 0.9
375 - val_loss: 1.0964 - val_accuracy: 0.6667
Epoch 91/200
7/7 [==============================] - 0s 13ms/step - loss: 0.1266 - accuracy: 0.9
688 - val_loss: 1.1316 - val_accuracy: 0.7333
Epoch 92/200
7/7 [==============================] - 0s 12ms/step - loss: 0.0796 - accuracy: 0.9
688 - val_loss: 1.2488 - val_accuracy: 0.7333
Epoch 93/200
7/7 [==============================] - 0s 12ms/step - loss: 0.0312 - accuracy: 1.0
000 - val_loss: 1.2984 - val_accuracy: 0.7333
Epoch 94/200
```

```
7/7 [==============================] - 0s 12ms/step - loss: 0.0719 - accuracy: 1.0
000 - val_loss: 1.2628 - val_accuracy: 0.6667
Epoch 95/200
7/7 [==============================] - 0s 13ms/step - loss: 0.0144 - accuracy: 1.0
000 - val_loss: 1.2647 - val_accuracy: 0.6667
Epoch 96/200
7/7 [==============================] - 0s 13ms/step - loss: 0.0161 - accuracy: 1.0
000 - val_loss: 1.2657 - val_accuracy: 0.6667
Epoch 97/200
7/7 [==============================] - 0s 13ms/step - loss: 0.0506 - accuracy: 1.0
000 - val_loss: 1.2252 - val_accuracy: 0.6667
Epoch 98/200
7/7 [==============================] - 0s 12ms/step - loss: 0.0512 - accuracy: 1.0
000 - val_loss: 1.2033 - val_accuracy: 0.6667
Epoch 99/200
7/7 [==============================] - 0s 12ms/step - loss: 0.0616 - accuracy: 1.0
000 - val_loss: 1.1942 - val_accuracy: 0.7333
Epoch 100/200
7/7 [==============================] - 0s 12ms/step - loss: 0.0983 - accuracy: 0.9
688 - val_loss: 1.1899 - val_accuracy: 0.6667
Epoch 101/200
7/7 [==============================] - 0s 12ms/step - loss: 0.0920 - accuracy: 0.9
688 - val_loss: 1.1606 - val_accuracy: 0.7333
Epoch 102/200
7/7 [==============================] - 0s 13ms/step - loss: 0.0926 - accuracy: 0.9
688 - val_loss: 1.1770 - val_accuracy: 0.7333
Epoch 103/200
7/7 [==============================] - 0s 13ms/step - loss: 0.0521 - accuracy: 0.9
688 - val_loss: 1.2038 - val_accuracy: 0.6000
Epoch 104/200
7/7 [==============================] - 0s 13ms/step - loss: 0.0724 - accuracy: 1.0
000 - val_loss: 1.2060 - val_accuracy: 0.6000
Epoch 105/200
7/7 [==============================] - 0s 13ms/step - loss: 0.0531 - accuracy: 0.9
688 - val_loss: 1.1534 - val_accuracy: 0.7333
Epoch 106/200
7/7 [==============================] - 0s 12ms/step - loss: 0.1528 - accuracy: 0.9
688 - val_loss: 1.1300 - val_accuracy: 0.7333
Epoch 107/200
7/7 [==============================] - 0s 12ms/step - loss: 0.0483 - accuracy: 1.0
000 - val_loss: 1.1246 - val_accuracy: 0.7333
Epoch 108/200
7/7 [==============================] - 0s 13ms/step - loss: 0.0555 - accuracy: 1.0
000 - val_loss: 1.1287 - val_accuracy: 0.7333
Epoch 109/200
7/7 [==============================] - 0s 13ms/step - loss: 0.0149 - accuracy: 1.0
000 - val_loss: 1.1311 - val_accuracy: 0.7333
Epoch 110/200
7/7 [==============================] - 0s 13ms/step - loss: 0.0279 - accuracy: 1.0
000 - val_loss: 1.1332 - val_accuracy: 0.7333
Epoch 111/200
7/7 [==============================] - 0s 12ms/step - loss: 0.0869 - accuracy: 0.9
688 - val_loss: 1.1470 - val_accuracy: 0.7333
Epoch 112/200
7/7 [==============================] - 0s 12ms/step - loss: 0.0128 - accuracy: 1.0
000 - val_loss: 1.1595 - val_accuracy: 0.7333
```

```
Epoch 113/200
7/7 [==============================] - 0s 12ms/step - loss: 0.0697 - accuracy: 0.9
688 - val_loss: 1.1601 - val_accuracy: 0.7333
Epoch 114/200
7/7 [==============================] - 0s 13ms/step - loss: 0.0377 - accuracy: 1.0
000 - val_loss: 1.1555 - val_accuracy: 0.7333
Epoch 115/200
7/7 [==============================] - 0s 13ms/step - loss: 0.0274 - accuracy: 1.0
000 - val_loss: 1.1457 - val_accuracy: 0.7333
Epoch 116/200
7/7 [==============================] - 0s 12ms/step - loss: 0.0181 - accuracy: 1.0
000 - val_loss: 1.1534 - val_accuracy: 0.6667
Epoch 117/200
7/7 [==============================] - 0s 13ms/step - loss: 0.0135 - accuracy: 1.0
000 - val_loss: 1.1671 - val_accuracy: 0.6667
Epoch 118/200
7/7 [==============================] - 0s 13ms/step - loss: 0.0434 - accuracy: 1.0
000 - val_loss: 1.1835 - val_accuracy: 0.6667
Epoch 119/200
7/7 [==============================] - 0s 13ms/step - loss: 0.0151 - accuracy: 1.0
000 - val_loss: 1.2058 - val_accuracy: 0.6667
Epoch 120/200
7/7 [==============================] - 0s 13ms/step - loss: 0.0077 - accuracy: 1.0
000 - val_loss: 1.2130 - val_accuracy: 0.6667
Epoch 121/200
7/7 [==============================] - 0s 13ms/step - loss: 0.0240 - accuracy: 1.0
000 - val_loss: 1.2168 - val_accuracy: 0.6667
Epoch 122/200
7/7 [==============================] - 0s 13ms/step - loss: 0.1383 - accuracy: 0.9
375 - val_loss: 1.2615 - val_accuracy: 0.6667
Epoch 123/200
7/7 [==============================] - 0s 13ms/step - loss: 0.0150 - accuracy: 1.0
000 - val_loss: 1.3089 - val_accuracy: 0.6667
Epoch 124/200
7/7 [==============================] - 0s 13ms/step - loss: 0.0857 - accuracy: 0.9
688 - val_loss: 1.3417 - val_accuracy: 0.6667
Epoch 125/200
7/7 [==============================] - 0s 13ms/step - loss: 0.0071 - accuracy: 1.0
000 - val_loss: 1.3625 - val_accuracy: 0.6667
Epoch 126/200
7/7 [==============================] - 0s 13ms/step - loss: 0.0527 - accuracy: 1.0
000 - val_loss: 1.3523 - val_accuracy: 0.6667
Epoch 127/200
7/7 [==============================] - 0s 15ms/step - loss: 0.0283 - accuracy: 1.0
000 - val_loss: 1.3583 - val_accuracy: 0.6667
Epoch 128/200
7/7 [==============================] - 0s 12ms/step - loss: 0.0167 - accuracy: 1.0
000 - val_loss: 1.3704 - val_accuracy: 0.6667
Epoch 129/200
7/7 [==============================] - 0s 12ms/step - loss: 0.0511 - accuracy: 1.0
000 - val_loss: 1.3721 - val_accuracy: 0.6667
Epoch 130/200
7/7 [==============================] - 0s 13ms/step - loss: 0.0332 - accuracy: 1.0
000 - val_loss: 1.4315 - val_accuracy: 0.6667
Epoch 131/200
7/7 [==============================] - 0s 13ms/step - loss: 0.0376 - accuracy: 1.0
```

```
000 - val_loss: 1.4543 - val_accuracy: 0.6667
Epoch 132/200
7/7 [==============================] - 0s 13ms/step - loss: 0.0343 - accuracy: 1.0
000 - val_loss: 1.4592 - val_accuracy: 0.6667
Epoch 133/200
7/7 [==============================] - 0s 13ms/step - loss: 0.0289 - accuracy: 1.0
000 - val_loss: 1.4694 - val_accuracy: 0.6667
Epoch 134/200
7/7 [==============================] - 0s 13ms/step - loss: 0.0067 - accuracy: 1.0
000 - val_loss: 1.4783 - val_accuracy: 0.6667
Epoch 135/200
7/7 [==============================] - 0s 12ms/step - loss: 0.0797 - accuracy: 0.9
688 - val_loss: 1.4822 - val_accuracy: 0.6667
Epoch 136/200
7/7 [==============================] - 0s 13ms/step - loss: 0.0189 - accuracy: 1.0
000 - val_loss: 1.4774 - val_accuracy: 0.6667
Epoch 137/200
7/7 [==============================] - 0s 13ms/step - loss: 0.0467 - accuracy: 1.0
000 - val_loss: 1.4243 - val_accuracy: 0.6667
Epoch 138/200
7/7 [==============================] - 0s 13ms/step - loss: 0.0491 - accuracy: 1.0
000 - val_loss: 1.3780 - val_accuracy: 0.6667
Epoch 139/200
7/7 [==============================] - 0s 13ms/step - loss: 0.0223 - accuracy: 1.0
000 - val_loss: 1.3501 - val_accuracy: 0.6667
Epoch 140/200
7/7 [==============================] - 0s 12ms/step - loss: 0.1253 - accuracy: 0.9
688 - val_loss: 1.3472 - val_accuracy: 0.6667
Epoch 141/200
7/7 [==============================] - 0s 12ms/step - loss: 0.0244 - accuracy: 1.0
000 - val_loss: 1.3479 - val_accuracy: 0.7333
Epoch 142/200
7/7 [==============================] - 0s 13ms/step - loss: 0.0588 - accuracy: 1.0
000 - val_loss: 1.3665 - val_accuracy: 0.7333
Epoch 143/200
7/7 [==============================] - 0s 13ms/step - loss: 0.0119 - accuracy: 1.0
000 - val_loss: 1.3972 - val_accuracy: 0.7333
Epoch 144/200
7/7 [==============================] - 0s 13ms/step - loss: 0.0335 - accuracy: 1.0
000 - val_loss: 1.3821 - val_accuracy: 0.7333
Epoch 145/200
7/7 [==============================] - 0s 12ms/step - loss: 0.0102 - accuracy: 1.0
000 - val_loss: 1.3338 - val_accuracy: 0.7333
Epoch 146/200
7/7 [==============================] - 0s 12ms/step - loss: 0.1138 - accuracy: 0.9
688 - val_loss: 1.3184 - val_accuracy: 0.7333
Epoch 147/200
7/7 [==============================] - 0s 12ms/step - loss: 0.0165 - accuracy: 1.0
000 - val_loss: 1.3190 - val_accuracy: 0.7333
Epoch 148/200
7/7 [==============================] - 0s 12ms/step - loss: 0.0191 - accuracy: 1.0
000 - val_loss: 1.3083 - val_accuracy: 0.7333
Epoch 149/200
7/7 [==============================] - 0s 13ms/step - loss: 0.0418 - accuracy: 1.0
000 - val_loss: 1.2948 - val_accuracy: 0.7333
Epoch 150/200
```

```
7/7 [==============================] - 0s 13ms/step - loss: 0.0092 - accuracy: 1.0
000 - val_loss: 1.2777 - val_accuracy: 0.6667
Epoch 151/200
7/7 [==============================] - 0s 12ms/step - loss: 0.0448 - accuracy: 1.0
000 - val_loss: 1.2774 - val_accuracy: 0.6667
Epoch 152/200
7/7 [==============================] - 0s 12ms/step - loss: 0.0038 - accuracy: 1.0
000 - val_loss: 1.2809 - val_accuracy: 0.6667
Epoch 153/200
7/7 [==============================] - 0s 12ms/step - loss: 0.0819 - accuracy: 0.9
688 - val_loss: 1.2869 - val_accuracy: 0.6667
Epoch 154/200
7/7 [==============================] - 0s 12ms/step - loss: 0.0202 - accuracy: 1.0
000 - val_loss: 1.2930 - val_accuracy: 0.6667
Epoch 155/200
7/7 [==============================] - 0s 12ms/step - loss: 0.0639 - accuracy: 1.0
000 - val_loss: 1.3002 - val_accuracy: 0.6667
Epoch 156/200
7/7 [==============================] - 0s 13ms/step - loss: 0.0167 - accuracy: 1.0
000 - val_loss: 1.3148 - val_accuracy: 0.6667
Epoch 157/200
7/7 [==============================] - 0s 12ms/step - loss: 0.0158 - accuracy: 1.0
000 - val_loss: 1.3186 - val_accuracy: 0.6667
Epoch 158/200
7/7 [==============================] - 0s 12ms/step - loss: 0.0318 - accuracy: 0.9
688 - val_loss: 1.3894 - val_accuracy: 0.6667
Epoch 159/200
7/7 [==============================] - 0s 12ms/step - loss: 0.0300 - accuracy: 1.0
000 - val_loss: 1.6595 - val_accuracy: 0.6667
Epoch 160/200
7/7 [==============================] - 0s 13ms/step - loss: 0.0062 - accuracy: 1.0
000 - val_loss: 1.7891 - val_accuracy: 0.6667
Epoch 161/200
7/7 [==============================] - 0s 13ms/step - loss: 0.0390 - accuracy: 1.0
000 - val_loss: 1.8364 - val_accuracy: 0.6667
Epoch 162/200
7/7 [==============================] - 0s 13ms/step - loss: 0.0553 - accuracy: 1.0
000 - val_loss: 1.8188 - val_accuracy: 0.6667
Epoch 163/200
7/7 [==============================] - 0s 12ms/step - loss: 0.0501 - accuracy: 1.0
000 - val_loss: 1.8457 - val_accuracy: 0.6667
Epoch 164/200
7/7 [==============================] - 0s 13ms/step - loss: 0.0623 - accuracy: 0.9
688 - val_loss: 1.7515 - val_accuracy: 0.6667
Epoch 165/200
7/7 [==============================] - 0s 12ms/step - loss: 0.0169 - accuracy: 1.0
000 - val_loss: 1.6808 - val_accuracy: 0.6667
Epoch 166/200
7/7 [==============================] - 0s 13ms/step - loss: 0.0068 - accuracy: 1.0
000 - val_loss: 1.6467 - val_accuracy: 0.6667
Epoch 167/200
7/7 [==============================] - 0s 14ms/step - loss: 0.1007 - accuracy: 0.9
688 - val_loss: 1.6412 - val_accuracy: 0.6667
Epoch 168/200
7/7 [==============================] - 0s 13ms/step - loss: 0.0654 - accuracy: 0.9
688 - val_loss: 1.5411 - val_accuracy: 0.7333
```

```
Epoch 169/200
7/7 [==============================] - 0s 13ms/step - loss: 0.0138 - accuracy: 1.0
000 - val_loss: 1.4700 - val_accuracy: 0.7333
Epoch 170/200
7/7 [==============================] - 0s 13ms/step - loss: 0.0138 - accuracy: 1.0
000 - val_loss: 1.4348 - val_accuracy: 0.7333
Epoch 171/200
7/7 [==============================] - 0s 13ms/step - loss: 0.0042 - accuracy: 1.0
000 - val_loss: 1.4233 - val_accuracy: 0.7333
Epoch 172/200
7/7 [==============================] - 0s 13ms/step - loss: 0.0937 - accuracy: 0.9
688 - val_loss: 1.3906 - val_accuracy: 0.7333
Epoch 173/200
7/7 [==============================] - 0s 13ms/step - loss: 0.0073 - accuracy: 1.0
000 - val_loss: 1.3634 - val_accuracy: 0.7333
Epoch 174/200
7/7 [==============================] - 0s 13ms/step - loss: 0.0067 - accuracy: 1.0
000 - val_loss: 1.3575 - val_accuracy: 0.7333
Epoch 175/200
7/7 [==============================] - 0s 13ms/step - loss: 0.0401 - accuracy: 1.0
000 - val_loss: 1.3522 - val_accuracy: 0.7333
Epoch 176/200
7/7 [==============================] - 0s 13ms/step - loss: 0.0054 - accuracy: 1.0
000 - val_loss: 1.3477 - val_accuracy: 0.6667
Epoch 177/200
7/7 [==============================] - 0s 12ms/step - loss: 0.0222 - accuracy: 1.0
000 - val_loss: 1.3502 - val_accuracy: 0.6667
Epoch 178/200
7/7 [==============================] - 0s 12ms/step - loss: 0.0098 - accuracy: 1.0
000 - val_loss: 1.3493 - val_accuracy: 0.6667
Epoch 179/200
7/7 [==============================] - 0s 13ms/step - loss: 0.0656 - accuracy: 0.9
688 - val_loss: 1.3379 - val_accuracy: 0.6667
Epoch 180/200
7/7 [==============================] - 0s 12ms/step - loss: 0.1291 - accuracy: 0.9
688 - val_loss: 1.3714 - val_accuracy: 0.6667
Epoch 181/200
7/7 [==============================] - 0s 12ms/step - loss: 0.0176 - accuracy: 1.0
000 - val_loss: 1.4049 - val_accuracy: 0.6667
Epoch 182/200
7/7 [==============================] - 0s 12ms/step - loss: 0.0065 - accuracy: 1.0
000 - val_loss: 1.4250 - val_accuracy: 0.6667
Epoch 183/200
7/7 [==============================] - 0s 13ms/step - loss: 0.0114 - accuracy: 1.0
000 - val_loss: 1.4356 - val_accuracy: 0.6667
Epoch 184/200
7/7 [==============================] - 0s 13ms/step - loss: 0.0426 - accuracy: 0.9
688 - val_loss: 1.4570 - val_accuracy: 0.6667
Epoch 185/200
7/7 [==============================] - 0s 13ms/step - loss: 0.0451 - accuracy: 1.0
000 - val_loss: 1.5621 - val_accuracy: 0.6667
Epoch 186/200
7/7 [==============================] - 0s 14ms/step - loss: 0.0091 - accuracy: 1.0
000 - val_loss: 1.6246 - val_accuracy: 0.6667
Epoch 187/200
7/7 [==============================] - 0s 12ms/step - loss: 0.0225 - accuracy: 1.0
```

```
000 - val_loss: 1.6463 - val_accuracy: 0.6667
Epoch 188/200
7/7 [==============================] - 0s 12ms/step - loss: 0.0074 - accuracy: 1.0
000 - val_loss: 1.6548 - val_accuracy: 0.6667
Epoch 189/200
7/7 [==============================] - 0s 12ms/step - loss: 0.0196 - accuracy: 1.0
000 - val_loss: 1.6476 - val_accuracy: 0.6667
Epoch 190/200
7/7 [==============================] - 0s 12ms/step - loss: 0.0163 - accuracy: 1.0
000 - val_loss: 1.6451 - val_accuracy: 0.6667
Epoch 191/200
7/7 [==============================] - 0s 12ms/step - loss: 0.0042 - accuracy: 1.0
000 - val_loss: 1.6447 - val_accuracy: 0.6667
Epoch 192/200
7/7 [==============================] - 0s 13ms/step - loss: 0.0206 - accuracy: 1.0
000 - val_loss: 1.6422 - val_accuracy: 0.6667
Epoch 193/200
7/7 [==============================] - 0s 13ms/step - loss: 0.0188 - accuracy: 1.0
000 - val_loss: 1.6428 - val_accuracy: 0.6667
Epoch 194/200
7/7 [==============================] - 0s 12ms/step - loss: 0.0107 - accuracy: 1.0
000 - val_loss: 1.6432 - val_accuracy: 0.6667
Epoch 195/200
7/7 [==============================] - 0s 13ms/step - loss: 0.0348 - accuracy: 1.0
000 - val_loss: 1.6430 - val_accuracy: 0.6667
Epoch 196/200
7/7 [==============================] - 0s 13ms/step - loss: 0.0232 - accuracy: 1.0
000 - val_loss: 1.5998 - val_accuracy: 0.6667
Epoch 197/200
7/7 [==============================] - 0s 13ms/step - loss: 0.0267 - accuracy: 1.0
000 - val_loss: 1.5053 - val_accuracy: 0.6667
Epoch 198/200
7/7 [==============================] - 0s 12ms/step - loss: 0.0327 - accuracy: 1.0
000 - val_loss: 1.4753 - val_accuracy: 0.6667
Epoch 199/200
7/7 [==============================] - 0s 12ms/step - loss: 0.0330 - accuracy: 1.0
000 - val_loss: 1.4856 - val_accuracy: 0.6667
Epoch 200/200
7/7 [==============================] - 0s 12ms/step - loss: 0.0125 - accuracy: 1.0
000 - val_loss: 1.4908 - val_accuracy: 0.6667
```

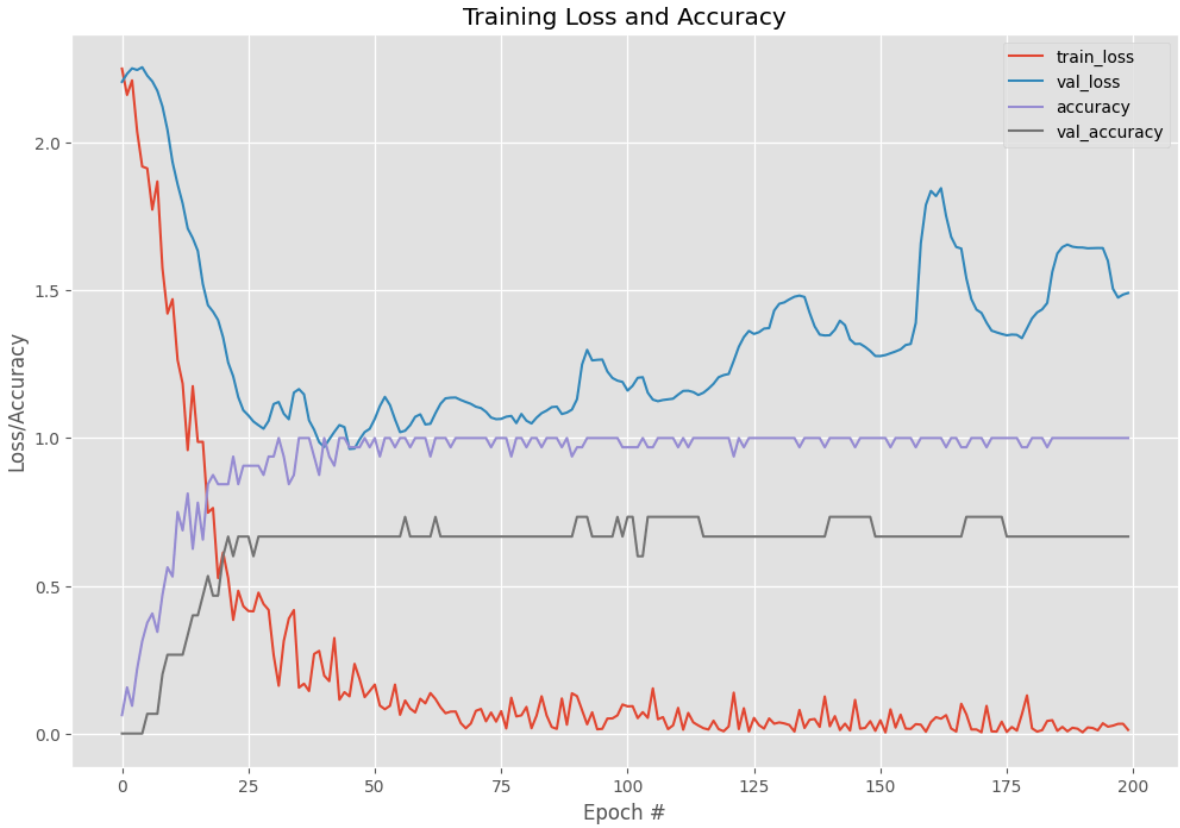
Task 8: Print the training curves

In [13]:

```
plt.rcParams["figure.figsize"]=(12,8)
N = np.arange(0, 200)
plt.style.use("ggplot")
plt.figure()
plt.plot(N, hist.history["loss"], label = 'train_loss')
plt.plot(N, hist.history["val_loss"], label = 'val_loss')
plt.plot(N, hist.history['accuracy'], label = 'accuracy')
plt.plot(N, hist.history["val_accuracy"], label = 'val_accuracy')
plt.title("Training Loss and Accuracy")
plt.xlabel("Epoch #")
```

```
plt.ylabel("Loss/Accuracy")
plt.legend()
```

Out[13]: <matplotlib.legend.Legend at 0x787766a52b20>



In [ ]: