NAAN MUDHALVAN-IBM(AI) PROJECT

IBM AL 101 ARTIFICIAL INTELLIGENCE-GROUP 1(TEAM 5)

PROJECT TITLE:

CREATE A CHATBOT USING PYTHON

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Phase 2: DEVELOPMENT PART 1:

1.What is a Chatbot?

- A chatbot is an AI-based software designed to interact with humans in their natural languages. These chatbots are usually converse via auditory or textual methods, and they can effortlessly mimic human languages to communicate with human beings in a human-like manner. A chatbot is arguably one of the best applications of natural language processing.

2.How to Make a Chatbot in Python?

- In the past few years, chatbots in Python have become wildly popular in the tech and business sectors. These intelligent bots are so adept at imitating natural human languages and conversing with humans, that companies across various industrial sectors are adopting them. From e-commerce firms to healthcare institutions, everyone seems to be leveraging this nifty tool to drive business benefits.

- To build a chatbot in Python, import all the necessary packages and initialize the variables you want to use in chatbot project. Also, when working with text data, we need to perform data preprocessing on your dataset before designing an ML model.

- This is where tokenizing helps with text data – it helps fragment the large text dataset into smaller, readable chunks (like words). Once that is done, you can also go for lemmatization that transforms a word into its lemma form. Then it creates a pickle file to store the python objects that are used for predicting the responses of the bot.

- Another vital part of the chatbot development process is creating the training and testing datasets.

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I. Import Libraries:

This code snippet imports TensorFlow, NumPy, Pandas, Matplotlib, Seaborn, and various components from TensorFlow's Keras module. It also imports the re and string modules for regular expressions and string manipulation. The code prepares your environment for working with deep learning and natural language processing.

Input 1-2:

```
import tensorflow as tf
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
from tensorflow.keras.layers import TextVectorization
import re,string
from tensorflow.keras.layers import
LSTM,Dense,Embedding,Dropout,LayerNormalization
```

II. Data Preprocessing:

➢ Data Visualization:

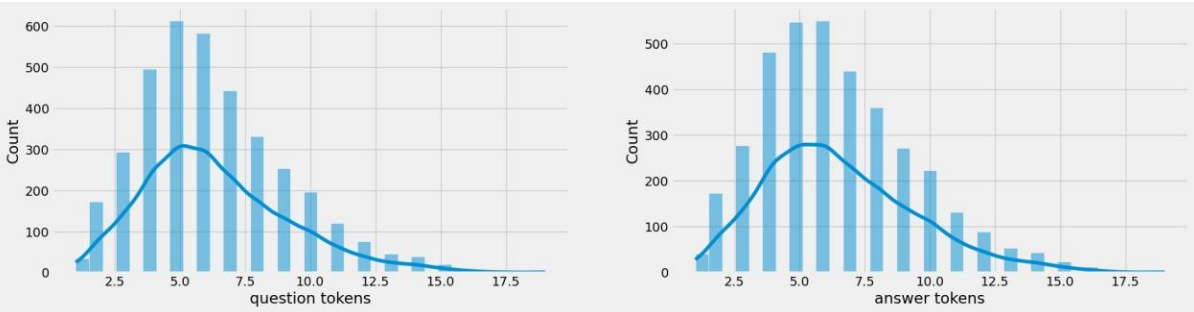
This code calculates the number of tokens (words) in the 'question' and 'answer' columns of a Pandas DataFrame and then visualizes the token distribution using Matplotlib and Seaborn. The resulting plots are displayed in a single figure with two subplots for token distributions and a joint distribution between 'question' and 'answer' tokens.

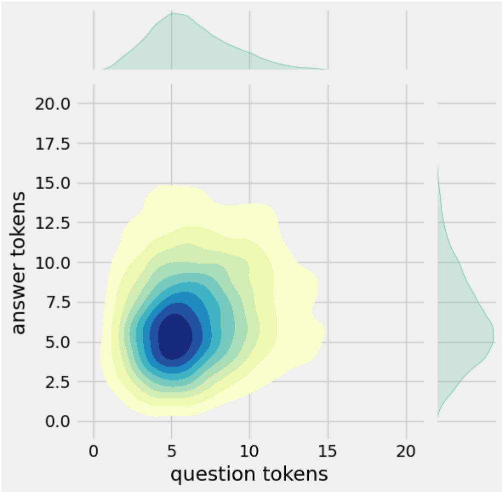
Input 3:

```
df['question tokens'] = df['question'].apply(lambda x: len(x.split()))
df['answer tokens'] = df['answer'].apply(lambda x: len(x.split()))

import matplotlib.pyplot as plt
import seaborn as sns

plt.style.use('fivethirtyeight')
fig, ax = plt.subplots(nrows=1, ncols=2, figsize=(20, 5))
sns.set_palette('Set2')
sns.histplot(x=df['question tokens'], data=df, kde=True, ax=ax[0])
sns.histplot(x=df['answer tokens'], data=df, kde=True, ax=ax[1])
sns.jointplot(x='question tokens', y='answer tokens', data=df, kind='kde',
fill=True, cmap='YlGnBu')
plt.show()
```





➢ Text Cleaning:

This code defines a clean_text function to clean the text and then applies this function to the 'question' and 'answer' columns in the DataFrame. It also modifies the DataFrame by creating 'encoder_inputs', 'decoder_targets', and 'decoder_inputs' columns.

Input 4:

```
def clean_text(text):
 text = re.sub('-', ' ', text.lower())
 text = re.sub('[.]', ' . ', text)
 text = re.sub('[1]', ' 1 ', text)
 text = re.sub('[2]', ' 2 ', text)
 text = re.sub('[3]', ' 3 ', text)
 text = re.sub('[4]', ' 4 ', text)
 text = re.sub('[5]', ' 5 ', text)
 text = re.sub('[6]', ' 6 ', text)
 text = re.sub('[7]', ' 7 ', text)
 text = re.sub('[8]', ' 8 ', text)
 text = re.sub('[9]', ' 9 ', text)
 text = re.sub('[0]', ' 0 ', text)
 text = re.sub(',', ' , ', text)
 text = re.sub('?', ' ? ', text)
 text = re.sub('!', ' ! ', text)
 text = re.sub('$', ' $ ', text)
 text = re.sub('&', ' & ', text)
 text = re.sub('/', ' / ', text)
```

```
    text = re.sub(':', ' : ', text)
    text = re.sub(';', ' ; ', text)
    text = re.sub('*', ' * ', text)
    text = re.sub("'", " ' ", text)
    text = re.sub('"', ' " ', text)
    text = re.sub('\t', ' ', text)
    return text

df.drop(columns=['answer tokens', 'question tokens'], axis=1,
inplace=True)
df['encoder_inputs'] = df['question'].apply(clean_text)
df['decoder_targets'] = df['answer'].apply(clean_text) + ' <end>'
df['decoder_inputs'] = '<start> ' + df['answer'].apply(clean_text) + '
<end>'

df.head(10)
```

0	hi, how are you doing?	i'm fine. how about yourself?	hi , how are you doing ?	i ' m fine . how about yourself ? <end>	<start> i ' m fine . how about yourself ? <end>
1	i'm fine. how about yourself?	i'm pretty good. thanks for asking.	i ' m fine . how about yourself ?	i ' m pretty good . thanks for asking . <end>	<start> i ' m pretty good . thanks for asking...
2	i'm pretty good. thanks for asking.	no problem. so how have you been?	i ' m pretty good . thanks for asking .	no problem . so how have you been ? <end>	<start> no problem . so how have you been ? ...
3	no problem. so how have you been?	i've been great. what about you?	no problem . so how have you been ?	i ' ve been great . what about you ? <end>	<start> i ' ve been great . what about you ? ...
4	i've been great. what about you?	i've been good. i'm in school right now.	i ' ve been great . what about you ?	i ' ve been good . i ' m in school right now ...	<start> i ' ve been good . i ' m in school ri...
5	i've been good. i'm in school right now.	what school do you go to?	i ' ve been good . i ' m in school right now .	what school do you go to ? <end>	<start> what school do you go to ? <end>

6	what school do you go to?	i go to pcc.	what school do you go to ?	i go to pcc . <end>	<start> i go to pcc . <end>
7	i go to pcc.	do you like it there?	i go to pcc .	do you like it there ? <end>	<start> do you like it there ? <end>
8	do you like it there?	it's okay. it's a really big campus.	do you like it there ?	it ' s okay . it ' s a really big campus . <...	<start> it ' s okay . it ' s a really big cam...
9	it's okay. it's a really big campus.	good luck with school.	it ' s okay . it ' s a really big campus .	good luck with school . <end>	<start> good luck with school . <end>

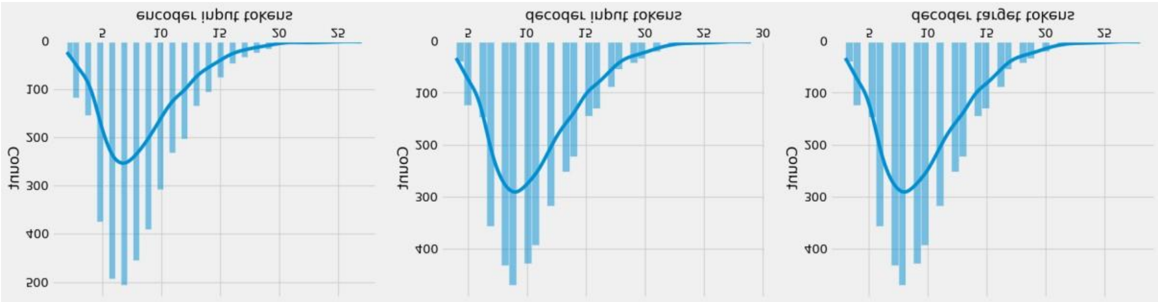
Input 5:

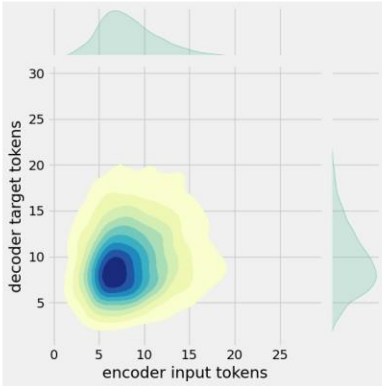
```
df['encoder input tokens'] = df['encoder_inputs'].apply(lambda x:
len(x.split()))
df['decoder input tokens'] = df['decoder_inputs'].apply(lambda x:
len(x.split()))
df['decoder target tokens'] = df['decoder_targets'].apply(lambda x:
len(x.split()))

import matplotlib.pyplot as plt
import seaborn as sns

plt.style.use('fivethirtyeight')
fig, ax = plt.subplots(nrows=1, ncols=3, figsize=(20, 5))
sns.set_palette('Set2')
sns.histplot(x=df['encoder input tokens'], data=df, kde=True, ax=ax[0])
sns.histplot(x=df['decoder input tokens'], data=df, kde=True, ax=ax[1])
sns.histplot(x=df['decoder target tokens'], data=df, kde=True, ax=ax[2])
sns.jointplot(x='encoder input tokens', y='decoder target tokens',
data=df, kind='kde', fill=True, cmap='YlGnBu')
plt.show()
```

This code calculates the token counts for 'encoder_inputs', 'decoder_inputs', and 'decoder_targets' columns in the DataFrame and then visualizes the token distribution using Matplotlib and Seaborn. The resulting plots are displayed in a single figure with three subplots for the token counts and a joint distribution between 'encoder input tokens' and 'decoder target tokens'.





Input 6:

```
print(f"After preprocessing: {' '.join(df[df['encoder input
tokens'].max()==df['encoder input
tokens']]['encoder_inputs'].values.tolist())}")
print(f"Max encoder input length: {df['encoder input tokens'].max()}")
print(f"Max decoder input length: {df['decoder input tokens'].max()}")
print(f"Max decoder target length: {df['decoder target tokens'].max()}")

df.drop(columns=['question','answer','encoder input tokens','decoder
input tokens','decoder target tokens'],axis=1,inplace=True)
params={
    "vocab_size":2500,
    "max_sequence_length":30,
    "learning_rate":0.008,
    "batch_size":149,
    "lstm_cells":256,
    "embedding_dim":256,
    "buffer_size":10000
}
learning_rate=params['learning_rate']
batch_size=params['batch_size']
```

```
embedding_dim=params['embedding_dim']
lstm_cells=params['lstm_cells']
vocab_size=params['vocab_size']
buffer_size=params['buffer_size']
max_sequence_length=params['max_sequence_length']
df.head(10)
```

Output:

encoder_inputs	decoder_targets	decoder_inputs	
0	hi , how are you doing ?	i ' m fine . how about yourself ? <end>	<start> i ' m fine . how about yourself ? <end>
1	i ' m fine . how about yourself ?	i ' m pretty good . thanks for asking . <end>	<start> i ' m pretty good . thanks for asking...
2	i ' m pretty good . thanks for asking .	no problem . so how have you been ? <end>	<start> no problem . so how have you been ? ...
3	no problem . so how have you been ?	i ' ve been great . what about you ? <end>	<start> i ' ve been great . what about you ? ...
4	i ' ve been great . what about you ?	i ' ve been good . i ' m in school right now ...	<start> i ' ve been good . i ' m in school ri...
5	i ' ve been good . i ' m in school right now .	what school do you go to ? <end>	<start> what school do you go to ? <end>
6	what school do you go to ?	i go to pcc . <end>	<start> i go to pcc . <end>
7	i go to pcc .	do you like it there ? <end>	<start> do you like it there ? <end>
8	do you like it there ?	it ' s okay . it ' s a really big campus . <...	<start> it ' s okay . it ' s a really big cam...
9	it ' s okay . it ' s a really big campus .	good luck with school . <end>	<start> good luck with school . <end>

➢ **Tokenization:**

This code snippet involves data preprocessing, including text vectorization using TensorFlow's TextVectorization layer, conversion between sequences and IDs, and the creation of training and validation datasets using TensorFlow's Dataset API. It also prints various details about the data, such as batch sizes and shapes.

Input 7:

```
vectorize_layer=TextVectorization(
    max_tokens=vocab_size,
    standardize=None,
    output_mode='int',
    output_sequence_length=max_sequence_length
)
vectorize_layer.adapt(df['encoder_inputs']+' '+df['decoder_targets']+' <start> <end>')
vocab_size=len(vectorize_layer.get_vocabulary())
print(f'Vocab size: {len(vectorize_layer.get_vocabulary())}')
print(f'{vectorize_layer.get_vocabulary()[:12]}')
```

```
Vocab size: 2443
['', '[UNK]', '<end>', '.', '<start>', "'", 'i', '?', 'you', ',', 'the', 'to']
```

Input 8:

```
def sequences2ids(sequence):
    return vectorize_layer(sequence)

def ids2sequences(ids):
    decode=''
    if type(ids)==int:
        ids=[ids]
    for id in ids:
        decode+=vectorize_layer.get_vocabulary()[id]+' '
    return decode

x=sequences2ids(df['encoder_inputs'])
yd=sequences2ids(df['decoder_inputs'])
y=sequences2ids(df['decoder_targets'])

print(f'Question sentence: hi , how are you ?')
```

```
print(f'Question to tokens: {sequences2ids("hi , how are you ?")[:10]}')
print(f'Encoder input shape: {x.shape}')
print(f'Decoder input shape: {yd.shape}')
print(f'Decoder target shape: {y.shape}')
```

```
Question sentence: hi , how are you ?
Question to tokens: [1971    9   45   24    8    7    0    0    0    0]
Encoder input shape: (3725, 30)
Decoder input shape: (3725, 30)
Decoder target shape: (3725, 30)
```

Input 9:

```
print(f'Encoder input: {x[0][:12]} ...')
print(f'Decoder input: {yd[0][:12]} ...')    # shifted by one time step of the target as input to decoder is the output of the previous timestep
print(f'Decoder target: {y[0][:12]} ...')
```

```
Encoder input: [1971    9   45   24    8  194    7    0    0    0    0    0] ...
Decoder input: [ 4   6   5  38 646   3  45  41 563   7   2   0] ...
Decoder target: [  6   5  38 646   3  45  41 563   7   2   0   0] ...
```

Input 10:

```
data=tf.data.Dataset.from_tensor_slices((x,yd,y))
data=data.shuffle(buffer_size)

train_data=data.take(int(.9*len(data)))
train_data=train_data.cache()
train_data=train_data.shuffle(buffer_size)
train_data=train_data.batch(batch_size)
train_data=train_data.prefetch(tf.data.AUTOTUNE)
train_data_iterator=train_data.as_numpy_iterator()

val_data=data.skip(int(.9*len(data))).take(int(.1*len(data)))
val_data=val_data.batch(batch_size)
val_data=val_data.prefetch(tf.data.AUTOTUNE)

_=train_data_iterator.next()
print(f'Number of train batches: {len(train_data)}')
print(f'Number of training data: {len(train_data)*batch_size}')
print(f'Number of validation batches: {len(val_data)}')
```

```
print(f'Number of validation data: {len(val_data)*batch_size}')
print(f'Encoder Input shape (with batches): {_[0].shape}')
print(f'Decoder Input shape (with batches): {_[1].shape}')
print(f'Target Output shape (with batches): {_[2].shape}')
```

```
Number of train batches: 23
Number of training data: 3427
Number of validation batches: 3
Number of validation data: 447
Encoder Input shape (with batches): (149, 30)
Decoder Input shape (with batches): (149, 30)
Target Output shape (with batches): (149, 30)
```

III. Build Models:

- Build Encoder:

This code defines classes for the encoder and decoder in a sequence-to-sequence model. The encoder processes input sequences, and the decoder generates output sequences. The provided code includes details about the layers, embeddings, and initializations used in both the encoder and decoder components. It also demonstrates the usage of these components by making a forward pass with example data.

Input 11:

```
class Encoder(tf.keras.models.Model):
  def__init__(self,units,embedding_dim,vocab_size,*args,**kwargs) -> None:
      super().__init__(*args,**kwargs)
      self.units=units
      self.vocab_size=vocab_size
      self.embedding_dim=embedding_dim
      self.embedding=Embedding(
        vocab_size,
        embedding_dim,
        name='encoder_embedding',
        mask_zero=True,
        embeddings_initializer=tf.keras.initializers.GlorotNormal()
      )
      self.normalize=LayerNormalization()
      self.lstm=LSTM(
        units,
```

```
        dropout=.4,
        return_state=True,
        return_sequences=True,
        name='encoder_lstm',
        kernel_initializer=tf.keras.initializers.GlorotNormal()
      )

  def call(self,encoder_inputs):
      self.inputs=encoder_inputs
      x=self.embedding(encoder_inputs)
      x=self.normalize(x)
      x=Dropout(.4)(x)
      encoder_outputs,encoder_state_h,encoder_state_c=self.lstm(x)
      self.outputs=[encoder_state_h,encoder_state_c]
      return encoder_state_h,encoder_state_c

encoder=Encoder(lstm_cells,embedding_dim,vocab_size,name='encode
r')
encoder.call(_[0])
```

OUTPUT:

```
(<tf.Tensor: shape=(149, 256), dtype=float32, numpy=
 array([[ 0.16966951, -0.10419625, -0.12700348, ..., -0.12251794,
         0.10568858,  0.14841646],
       [ 0.08443093,  0.08849293, -0.09065959, ..., -0.00959182,
         0.10152507, -0.12077457],
       [ 0.03628462, -0.02653611, -0.11506603, ..., -0.14669597,
         0.10292757,  0.13625325],
       ...,
       [-0.14210635, -0.12942064, -0.03288083, ...,  0.0568463 ,
        -0.02598592, -0.22455114],
       [ 0.20819993,  0.01196991, -0.09635217, ..., -0.18782297,
         0.10233591,  0.20114912],
       [ 0.1164271 , -0.07769038, -0.06414707, ..., -0.06539135,
        -0.05518465,  0.25142196]], dtype=float32)>,
 <tf.Tensor: shape=(149, 256), dtype=float32, numpy=
 array([[ 0.34589   , -0.30134732, -0.43572   , ..., -0.3102559 ,
         0.34630865,  0.2613009 ],
       [ 0.14154069,  0.17045322, -0.17749965, ..., -0.02712595,
         0.17292541, -0.2922624 ],
       [ 0.07106856, -0.0739173 , -0.3641197 , ..., -0.3794833 ,
         0.36470377,  0.23766585],
       ...,
       [-0.2582597 , -0.25323495, -0.06649272, ...,  0.16527973,
```

```
       -0.04292646, -0.58768904],
      [ 0.43155715,  0.03135502, -0.33463806, ..., -0.47625306,
        0.33486888,  0.35035062],
      [ 0.23173636, -0.20141824, -0.22034441, ..., -0.16035017,
       -0.17478186,  0.48899865]], dtype=float32)>)
```

Build Encoder## Build Decoder

Input 12:

```
class Decoder(tf.keras.models.Model):
   def__init__(self,units,embedding_dim,vocab_size,*args,**kwargs) ->
None:
      super().__init__(*args,**kwargs)
      self.units=units
      self.embedding_dim=embedding_dim
      self.vocab_size=vocab_size
      self.embedding=Embedding(
         vocab_size,
         embedding_dim,
         name='decoder_embedding',
         mask_zero=True,
         embeddings_initializer=tf.keras.initializers.HeNormal()
      )
      self.normalize=LayerNormalization()
      self.lstm=LSTM(
         units,
         dropout=.4,
         return_state=True,
         return_sequences=True,
         name='decoder_lstm',
         kernel_initializer=tf.keras.initializers.HeNormal()
      )
      self.fc=Dense(
         vocab_size,
         activation='softmax',
         name='decoder_dense',
         kernel_initializer=tf.keras.initializers.HeNormal()
      )

   def call(self,decoder_inputs,encoder_states):
      x=self.embedding(decoder_inputs)
      x=self.normalize(x)
```

```
        x=Dropout(.4)(x)

x,decoder_state_h,decoder_state_c=self.lstm(x,initial_state=encoder_st
ates)
        x=self.normalize(x)
        x=Dropout(.4)(x)
        return self.fc(x)

decoder=Decoder(lstm_cells,embedding_dim,vocab_size,name='decode
r')
decoder(_[1][:1],encoder(_[0][:1]))
```

OUTPUT:

```
<tf.Tensor: shape=(1, 30, 2443), dtype=float32, numpy=
array([[[3.4059247e-04, 5.7348556e-05, 2.1294907e-05, ...,
         7.2067953e-05, 1.5453645e-03, 2.3599296e-04],
        [1.4662130e-03, 8.0250365e-06, 5.4062020e-05, ...,
        1.9187471e-05, 9.7244098e-05, 7.6433855e-05],
        [9.6929165e-05, 2.7441782e-05, 1.3761305e-03, ...,
        3.6009602e-05, 1.5537882e-04, 1.8397317e-04],
        ...,
        [1.9002777e-03, 6.9266016e-04, 1.4346189e-04, ...,
        1.9552530e-04, 1.7106640e-05, 1.0252406e-04],
        [1.9002777e-03, 6.9266016e-04, 1.4346189e-04, ...,
        1.9552530e-04, 1.7106640e-05, 1.0252406e-04],
        [1.9002777e-03, 6.9266016e-04, 1.4346189e-04, ...,
         1.9552530e-04, 1.7106640e-05, 1.0252406e-04]]], dtype=float32)>
```

➢ Build Training Model:

This code defines a ChatBotTrainer class for training and testing a chatbot model. It includes custom loss and accuracy functions, training and testing steps, and the compilation of the model. The code then performs a forward pass with the model using example data.

INPUT-13

```
class ChatBotTrainer(tf.keras.models.Model):
    def__init__(self,encoder,decoder,*args,**kwargs):
        super().__init__(*args,**kwargs)
        self.encoder=encoder
        self.decoder=decoder
```

```
    def loss_fn(self,y_true,y_pred):
        loss=self.loss(y_true,y_pred)
        mask=tf.math.logical_not(tf.math.equal(y_true,0))
        mask=tf.cast(mask,dtype=loss.dtype)
        loss*=mask
        return tf.reduce_mean(loss)

    def accuracy_fn(self,y_true,y_pred):
        pred_values = tf.cast(tf.argmax(y_pred, axis=-1), dtype='int64')
        correct = tf.cast(tf.equal(y_true, pred_values), dtype='float64')
        mask = tf.cast(tf.greater(y_true, 0), dtype='float64')
        n_correct = tf.keras.backend.sum(mask * correct)
        n_total = tf.keras.backend.sum(mask)
        return n_correct / n_total

    def call(self,inputs):
        encoder_inputs,decoder_inputs=inputs
        encoder_states=self.encoder(encoder_inputs)
        return self.decoder(decoder_inputs,encoder_states)

    def train_step(self,batch):
        encoder_inputs,decoder_inputs,y=batch
        with tf.GradientTape() as tape:
            encoder_states=self.encoder(encoder_inputs,training=True)

y_pred=self.decoder(decoder_inputs,encoder_states,training=True)
            loss=self.loss_fn(y,y_pred)
            acc=self.accuracy_fn(y,y_pred)


variables=self.encoder.trainable_variables+self.decoder.trainable_variab
les
        grads=tape.gradient(loss,variables)
        self.optimizer.apply_gradients(zip(grads,variables))
        metrics={'loss':loss,'accuracy':acc}
        return metrics

    def test_step(self,batch):
        encoder_inputs,decoder_inputs,y=batch
        encoder_states=self.encoder(encoder_inputs,training=True)
```

```
        y_pred=self.decoder(decoder_inputs,encoder_states,training=True)
        loss=self.loss_fn(y,y_pred)
        acc=self.accuracy_fn(y,y_pred)
        metrics={'loss':loss,'accuracy':acc}
        return metrics
```

INPUT-14

```
model=ChatBotTrainer(encoder,decoder,name='chatbot_trainer')
model.compile(
    loss=tf.keras.losses.SparseCategoricalCrossentropy(),
    optimizer=tf.keras.optimizers.Adam(learning_rate=learning_rate),
    weighted_metrics=['loss','accuracy']
)
model(_[:2])
```

- **Train Model:**

In this code, the model.fit function is used to train the model for 100 epochs with training data (train_data) and validation data (val_data). Two callbacks are specified: the TensorBoard callback for monitoring the training process and the ModelCheckpoint callback to save the best model during training. The training history is stored in the history variable.

Input- 15

```
history=model.fit(
    train_data,
    epochs=100,
    validation_data=val_data,
    callbacks=[
        tf.keras.callbacks.TensorBoard(log_dir='logs'),

tf.keras.callbacks.ModelCheckpoint('ckpt',verbose=1,save_best_only=Tr
ue)
    ]
)
```

Visualize Metrics:

This code creates a figure with two subplots to visualize training and validation loss and accuracy metrics over training epochs. It uses Matplotlib for plotting and shows the resulting figure.

Input-16

```
fig,ax=plt.subplots(nrows=1,ncols=2,figsize=(20,5))
ax[0].plot(history.history['loss'],label='loss',c='red')
ax[0].plot(history.history['val_loss'],label='val_loss',c = 'blue')
ax[0].set_xlabel('Epochs')
ax[1].set_xlabel('Epochs')
ax[0].set_ylabel('Loss')
ax[1].set_ylabel('Accuracy')
ax[0].set_title('Loss Metrics')
ax[1].set_title('Accuracy Metrics')
ax[1].plot(history.history['accuracy'],label='accuracy')
ax[1].plot(history.history['val_accuracy'],label='val_accuracy')
ax[0].legend()
ax[1].legend()
plt.show()
```