Create a chatbot in python

Phase 3: Development part 1

Introduction:

Loading and preprocessing a dataset in a chatbot using Python means getting the data ready for the chatbot to use. It involves steps like importing libraries, reading the dataset, understanding its structure, handling missing values, cleaning the text, and converting it into a format that the chatbot can understand. This helps ensure that the data is organized and prepared for the chatbot to learn and respond effectively.

Dataset used:

https://www.kaggle.com/datasets/grafstor/simple-dialogs-for-chatbot

Program

[1]:

```
# **Importing libraries**
```

[2]:

```
#model
import tensorflow as tf
from sklearn.model_selection import train_test_split

#nlp processing
import unicodedata
import re
import numpy as np


import warnings
warnings.filterwarnings('ignore')
```

Data preprocessing

The basic text processing in NLP are:

1. Sentence Segmentation
2. Normalization
3. Tokenization

Segmentation

formatting data to be in a question answer format

[3]:

```
#reading data
data=open('/kaggle/input/simple-dialogs-for-chatbot/dialogs.txt','r').read()
```

[4]:

```
#paried list of question and corresponding answer
QA_list=[QA.split('\t') for QA in data.split('\n')]
print(QA_list[:5])
```

```
[['hi, how are you doing?', "i'm fine. how about yourself?"], ["i'm fine. how about yourself?",
"i'm pretty good. thanks for asking."], ["i'm pretty good. thanks for asking.", 'no problem. so how
have you been?'], ['no problem. so how have you been?', "i've been great. what about you?"], ["i've
been great. what about you?", "i've been good. i'm in school right now."]]
```

[5]:

```
questions=[row[0] for row in QA_list]
answers=[row[1] for row in QA_list]
```

[6]:

```
print(questions[0:5])
print(answers[0:5])
```

```
['hi, how are you doing?', "i'm fine. how about yourself?", "i'm pretty good. thanks for asking.",
'no problem. so how have you been?', "i've been great. what about you?"]
["i'm fine. how about yourself?", "i'm pretty good. thanks for asking.", 'no problem. so how have y
ou been?', "i've been great. what about you?", "i've been good. i'm in school right now."]
```

Normalization

To reduce its randomness, bringing it closer to a predefined "standard"

[7]:

```
def remove_diacritic(text):
    return ''.join(char for char in unicodedata.normalize('NFD',text)
                   if unicodedata.category(char) !='Mn')
```

[8]:

```
def preprocessing(text):

    #Case folding and removing extra whitespaces
    text=remove_diacritic(text.lower().strip())

    #Ensuring punctuation marks to be treated as tokens
    text=re.sub(r"([?.!,¿])", r" \1 ", text)

    #Removing redundant spaces
    text= re.sub(r'[" "]+', " ", text)

    #Removing non alphabetic characters
    text=re.sub(r"[^a-zA-Z?.!,¿]+", " ", text)

    text=text.strip()

    #Indicating the start and end of each sentence
    text='<start> ' + text + ' <end>'

    return text
```

[9]:

```
preprocessed_questions=[preprocessing(sen) for sen in questions]
preprocessed_answers=[preprocessing(sen) for sen in answers]

print(preprocessed_questions[0])
print(preprocessed_answers[0])
```

```
<start> hi , how are you doing ? <end>
<start> i m fine . how about yourself ? <end>
```

Tokenization ¶

[10]:
```
def tokenize(lang):
    lang_tokenizer = tf.keras.preprocessing.text.Tokenizer(
      filters='')

    #build vocabulary on unique words
    lang_tokenizer.fit_on_texts(lang)

    return lang_tokenizer
```

Word Embedding

representing words in form of real-valued vetors

[11]:
```
def vectorization(lang_tokenizer,lang):

    #word embedding for training the neural network
    tensor = lang_tokenizer.texts_to_sequences(lang)

    tensor = tf.keras.preprocessing.sequence.pad_sequences(tensor,
                                                           padding='post')

    return tensor
```

Creating Dataset

for training and testing the model

[12]:
```
def load_Dataset(data,size=None):

    if(size!=None):
        y,X=data[:size]
    else:
        y,X=data

    X_tokenizer=tokenize(X)
    y_tokenizer=tokenize(y)

    X_tensor=vectorization(X_tokenizer,X)
    y_tensor=vectorization(y_tokenizer,y)

    return  X_tensor,X_tokenizer, y_tensor, y_tokenizer
```

[13]:
```
size=30000
data=preprocessed_answers,preprocessed_questions\

X_tensor,X_tokenizer, y_tensor, y_tokenizer=load_Dataset(data,size)
```

[14]:
```
# Calculate max_length of the target tensors
max_length_y, max_length_X = y_tensor.shape[1], X_tensor.shape[1]
```

Splitting Data

Creating training and validation sets using an 80-20 split after the required preprocessing is applied to the whole data

[15]:
```
X_train, X_val, y_train, y_val = train_test_split(X_tensor, y_tensor, test_size=0.2)

# Show length
print(len(X_train), len(y_train), len(X_val), len(y_val))
```

```
2980 2980 745 745
```

Tensorflow Dataset

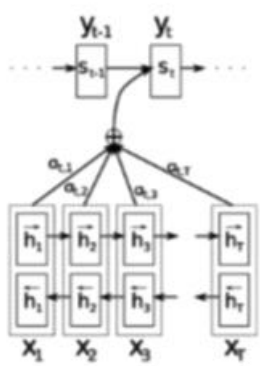
[16]:
```
BUFFER_SIZE = len(X_train)
BATCH_SIZE = 64
steps_per_epoch = len(X_train)//BATCH_SIZE
embedding_dim = 256
units = 1024
vocab_inp_size = len(X_tokenizer.word_index)+1
vocab_tar_size = len(y_tokenizer.word_index)+1

dataset = tf.data.Dataset.from_tensor_slices((X_train, y_train)).shuffle(BUFFER_SIZE)
dataset = dataset.batch(BATCH_SIZE, drop_remainder=True)

example_input_batch, example_target_batch = next(iter(dataset))
example_input_batch.shape, example_target_batch.shape
```

[16…
```
(TensorShape([64, 24]), TensorShape([64, 24]))
```

Model

Bahdanau Attention Mechanism

https://machinelearningmastery.com/the-bahdanau-attention-mechanism/



Adding attention mechanism to an Encoder-Decoder Model to make the model focus on specific parts of input sequence by assigning weights to different parts of the input sequence

Buliding Model Architecture

Encoder

[17]:

```
class Encoder(tf.keras.Model):
    def __init__(self, vocab_size, embedding_dim, enc_units, batch_sz):
        super(Encoder, self).__init__()
        self.batch_sz = batch_sz
        self.enc_units = enc_units
        self.embedding = tf.keras.layers.Embedding(vocab_size, embedding_dim)
        self.gru = tf.keras.layers.GRU(self.enc_units,
                                       return_sequences=True,
                                       return_state=True,
                                       recurrent_initializer='glorot_uniform')

    def call(self, x, hidden):
        x = self.embedding(x)
        output, state = self.gru(x, initial_state = hidden)
        return output, state

    def initialize_hidden_state(self):
        return tf.zeros((self.batch_sz, self.enc_units))
```

[18]:

```
encoder = Encoder(vocab_inp_size, embedding_dim, units, BATCH_SIZE)

# sample input
sample_hidden = encoder.initialize_hidden_state()
sample_output, sample_hidden = encoder(example_input_batch, sample_hidden)
print ('Encoder output shape: (batch size, sequence length, units) {}'.format(sample_output
print ('Encoder Hidden state shape: (batch size, units) {}'.format(sample_hidden.shape))
```

```
Encoder output shape: (batch size, sequence length, units) (64, 24, 1024)
Encoder Hidden state shape: (batch size, units) (64, 1024)
```

Attention Mechanism

[19]:

```
class BahdanauAttention(tf.keras.layers.Layer):
    def __init__(self, units):
        super(BahdanauAttention, self).__init__()
        self.W1 = tf.keras.layers.Dense(units)
        self.W2 = tf.keras.layers.Dense(units)
        self.V = tf.keras.layers.Dense(1)

    def call(self, query, values):
        # query hidden state shape == (batch_size, hidden size)
        # query_with_time_axis shape == (batch_size, 1, hidden size)
        # values shape == (batch_size, max_len, hidden size)
        # we are doing this to broadcast addition along the time axis to calculate the scor
        query_with_time_axis = tf.expand_dims(query, 1)

        # score shape == (batch_size, max_length, 1)
        # we get 1 at the last axis because we are applying score to self.V
        # the shape of the tensor before applying self.V is (batch_size, max_length, units)
        score = self.V(tf.nn.tanh(
            self.W1(query_with_time_axis) + self.W2(values)))

        # attention_weights shape == (batch_size, max_length, 1)
        attention_weights = tf.nn.softmax(score, axis=1)

        # context_vector shape after sum == (batch_size, hidden_size)
        context_vector = attention_weights * values
        context_vector = tf.reduce_sum(context_vector, axis=1)

        return context_vector, attention_weights
```

[20]:

```
attention_layer = BahdanauAttention(10)
attention_result, attention_weights = attention_layer(sample_hidden, sample_output)

print("Attention result shape: (batch size, units) {}".format(attention_result.shape))
print("Attention weights shape: (batch_size, sequence_length, 1) {}".format(attention_weigh
```

```
Attention result shape: (batch size, units) (64, 1024)
Attention weights shape: (batch_size, sequence_length, 1) (64, 24, 1)
```

Decoder

[21]:

```
class Decoder(tf.keras.Model):
    def __init__(self, vocab_size, embedding_dim, dec_units, batch_sz):
        super(Decoder, self).__init__()
        self.batch_sz = batch_sz
        self.dec_units = dec_units
        self.embedding = tf.keras.layers.Embedding(vocab_size, embedding_dim)
        self.gru = tf.keras.layers.GRU(self.dec_units,
                                       return_sequences=True,
                                       return_state=True,
                                       recurrent_initializer='glorot_uniform')
        self.fc = tf.keras.layers.Dense(vocab_size)

        # used for attention
        self.attention = BahdanauAttention(self.dec_units)

    def call(self, x, hidden, enc_output):
        # enc_output shape == (batch_size, max_length, hidden_size)
        context_vector, attention_weights = self.attention(hidden, enc_output)

        # x shape after passing through embedding == (batch_size, 1, embedding_dim)
        x = self.embedding(x)

        # x shape after concatenation == (batch_size, 1, embedding_dim + hidden_size)
        x = tf.concat([tf.expand_dims(context_vector, 1), x], axis=-1)

        # passing the concatenated vector to the GRU
        output, state = self.gru(x)

        # output shape == (batch_size * 1, hidden_size)
        output = tf.reshape(output, (-1, output.shape[2]))

        # output shape == (batch_size, vocab)
        x = self.fc(output)

        return x, state, attention_weights
```

[22]:

```
decoder = Decoder(vocab_tar_size, embedding_dim, units, BATCH_SIZE)

sample_decoder_output, _, _ = decoder(tf.random.uniform((BATCH_SIZE, 1)),
                                      sample_hidden, sample_output)

print ('Decoder output shape: (batch_size, vocab size) {}'.format(sample_decoder_output.sha
```

```
Decoder output shape: (batch_size, vocab size) (64, 2349)
```

Training model

- Pass the input through the encoder which return encoder output and the encoder hidden state.
- The encoder output, encoder hidden state and the decoder input (which is the start token) is passed to the decoder.
- The decoder returns the predictions and the decoder hidden state.
- The decoder hidden state is then passed back into the model and the predictions are used to calculate the loss.
- Use teacher forcing to decide the next input to the decoder.
- Teacher forcing is the technique where the target word is passed as the next input to the decoder.
- The final step is to calculate the gradients and apply it to the optimizer and backpropagate.

[23]:

```
optimizer = tf.keras.optimizers.Adam()
loss_object = tf.keras.losses.SparseCategoricalCrossentropy(
    from_logits=True, reduction='none')

def loss_function(real, pred):
    mask = tf.math.logical_not(tf.math.equal(real, 0))
    loss_ = loss_object(real, pred)

    mask = tf.cast(mask, dtype=loss_.dtype)
    loss_ *= mask

    return tf.reduce_mean(loss_)
```

[24]:

```
@tf.function
def train_step(inp, targ, enc_hidden):
    loss = 0

    with tf.GradientTape() as tape:
        enc_output, enc_hidden = encoder(inp, enc_hidden)

        dec_hidden = enc_hidden

        dec_input = tf.expand_dims([y_tokenizer.word_index['<start>']] * BATCH_SIZE, 1)

        # Teacher forcing - feeding the target as the next input
        for t in range(1, targ.shape[1]):
            # passing enc_output to the decoder
            predictions, dec_hidden, _ = decoder(dec_input, dec_hidden, enc_output)

            loss += loss_function(targ[:, t], predictions)

            # using teacher forcing
            dec_input = tf.expand_dims(targ[:, t], 1)

    batch_loss = (loss / int(targ.shape[1]))

    variables = encoder.trainable_variables + decoder.trainable_variables

    gradients = tape.gradient(loss, variables)

    optimizer.apply_gradients(zip(gradients, variables))

    return batch_loss
```

[*]:

```
EPOCHS = 40

for epoch in range(1, EPOCHS + 1):
    enc_hidden = encoder.initialize_hidden_state()
    total_loss = 0

    for (batch, (inp, targ)) in enumerate(dataset.take(steps_per_epoch)):
        batch_loss = train_step(inp, targ, enc_hidden)
        total_loss += batch_loss

    if(epoch % 4 == 0):
        print('Epoch:{:3d} Loss:{:.4f}'.format(epoch,
                                              total_loss / steps_per_epoch))
```

```
Epoch:   4 Loss:1.5274
```

Model Evaluation

[*]:

```
def remove_tags(sentence):
    return sentence.split("<start>")[-1].split("<end>")[0]
```

[*]:

```
def evaluate(sentence):
    sentence = preprocessing(sentence)

    inputs = [X_tokenizer.word_index[i] for i in sentence.split(' ')]
    inputs = tf.keras.preprocessing.sequence.pad_sequences([inputs],
                                                         maxlen=max_length_X,
                                                         padding='post')
    inputs = tf.convert_to_tensor(inputs)

    result = ''

    hidden = [tf.zeros((1, units))]
    enc_out, enc_hidden = encoder(inputs, hidden)

    dec_hidden = enc_hidden
    dec_input = tf.expand_dims([y_tokenizer.word_index['<start>']], 0)

    for t in range(max_length_y):
        predictions, dec_hidden, attention_weights = decoder(dec_input,
                                                             dec_hidden,
                                                             enc_out)

        # storing the attention weights to plot later on
        attention_weights = tf.reshape(attention_weights, (-1, ))

        predicted_id = tf.argmax(predictions[0]).numpy()

        result += y_tokenizer.index_word[predicted_id] + ' '

        if y_tokenizer.index_word[predicted_id] == '<end>':
            return remove_tags(result), remove_tags(sentence)

        # the predicted ID is fed back into the model
        dec_input = tf.expand_dims([predicted_id], 0)

    return remove_tags(result), remove_tags(sentence)
```

[*]:

```
def ask(sentence):
    result, sentence = evaluate(sentence)

    print('Question: %s' % (sentence))
    print('Predicted answer: {}'.format(result))
```

```
ask(questions[1])
```

+ Code + Markdown