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

INPUT:

```
data=open('dialogs.txt','r').read()

QA_list=[QA.split('\t') for QA in data.split('\n')]
print(QA_list[:5])
```

OUTPUT:

```
[['hi, how are you doing?', "i'm fine. how about yourself?"], ["i'm fin
e. 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."]]
```

INPUT:

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

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

OUTPUT:

```
['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 b
een great. what about you?"]
["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've been good. i'm in school right now."]
```

Normalization

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

INPUT:

```
def remove_diacritic(text):
    return ''.join(char for char in unicodedata.normalize('NFD',text)
                  if unicodedata.category(char) !='Mn')
def preprocessing(text):
    text=remove_diacritic(text.lower().strip())
    text=re.sub(r"([?.!,¿])", r" \1 ", text)
    text= re.sub(r'[" "]+', " ", text)
    text=re.sub(r"[^a-zA-Z?.!,¿]+", " ", text)
    text=text.strip()
    text='<start> ' + text + ' <end>'
    return text

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

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

OUTPUT:

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

Tokenization

INPUT:

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

    lang_tokenizer.fit_on_texts(lang)

    return lang_tokenizer
```

Word Embedding

representing words in form of real-valued vetors

INPUT:

```
def vectorization(lang_tokenizer,lang):
    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

INPUT:

```
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
```

```
size=30000
data=preprocessed_answers,preprocessed_questions\
X_tensor,X_tokenizer, y_tensor, y_tokenizer=load_Dataset(data,size)
```

```
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

INPUT:

```
X_train, X_val, y_train, y_val = train_test_split(X_tensor, y_tensor, test_
size=0.2)
print(len(X_train), len(y_train), len(X_val), len(y_val))
```

OUTPUT:

```
2980 2980 745 745
```

Tensorflow Dataset

INPUT:

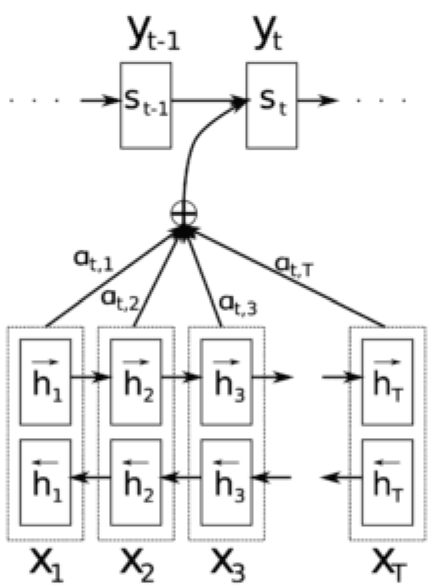
```
BUFFER_SIZE = len(X_train)
BATCH_SIZE = 64
steps_per_epoch = len(X_train)//BATCH_SIZE
embedding_dim = 256
units = 1024
vocab_inp_size = len(X_tokenizer.word_index)+1
vocab_tar_size = len(y_tokenizer.word_index)+1
dataset = tf.data.Dataset.from_tensor_slices((X_train, y_train)).shuffle(BU
FFER_SIZE)
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
```

OUTPUT:

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

Model



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

INPUT:

```
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_m)
        self.gru = tf.keras.layers.GRU(self.enc_units,
                                       return_sequences=True,
                                       return_state=True,
                                       recurrent_initializer='glorot_unim')

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

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) {}'.form
at(sample_output.shape))
print ('Encoder Hidden state shape: (batch size, units) {}'.format(sample_h
idden.shape))
```

OUTPUT:

```
Encoder output shape: (batch size, sequence length, units) (64, 24, 102
4)
Encoder Hidden state shape: (batch size, units) (64, 1024)
```

Attention Mechanism

INPUT:

```
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_with_time_axis = tf.expand_dims(query, 1)

        score = self.V(tf.nn.tanh(
            self.W1(query_with_time_axis) + self.W2(values)))

        context_vector = attention_weights * values
        context_vector = tf.reduce_sum(context_vector, axis=1)

        return context_vector, attention_weights
attention_layer = BahdanauAttention(10)
attention_result, attention_weights = attention_layer(sample_hidden, sample
_output)

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

OUTPUT:

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

Decoder

INPUT:

```
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_unifor
m')
        self.fc = tf.keras.layers.Dense(vocab_size)

 self.attention = BahdanauAttention(self.dec_units)
    def call(self, x, hidden, enc_output):
          context_vector, attention_weights = self.attention(hidden, enc_ou
tput)
        x = self.embedding(x)
        x = tf.concat([tf.expand_dims(context_vector, 1), x], axis=-1)
         output, state = self.gru(x)
        output = tf.reshape(output, (-1, output.shape[2]))
        x = self.fc(outpuT
        return x, state, attention_weights
```

In [21]:

```
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_de
coder_output.shape))
```

OUTPUT:

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

Training Model

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

INPUT:

```
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_)
@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>']] * BA
TCH_SIZE, 1)
        for t in range(1, targ.shape[1]):
            predictions, dec_hidden, _ = decoder(dec_input, dec_hidden, enc
_output)
            loss += loss_function(targ[:, t], predictions)
            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))
```

OUTPUT:

```
Epoch:  4 Loss:1.5338
Epoch:  8 Loss:1.2803
Epoch: 12 Loss:1.0975
Epoch: 16 Loss:0.9404
Epoch: 20 Loss:0.7773
Epoch: 24 Loss:0.6040
Epoch: 28 Loss:0.4042
Epoch: 32 Loss:0.2233
```

```
Epoch: 36 Loss:0.0989
Epoch: 40 Loss:0.0470
```

Model Evaluation

INPUT:

```
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_lengthX
                                                           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)
        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)
        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))
```

INPUT:

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

OUTPUT:

```
Question:  i m fine . how about yourself ?
Predicted answer: i m pretty good . thanks for asking .
```

TEAM MEMBERS:

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