CREATE A CHATBOT IN PYTHON

**PHASE 5:** Project Documentation & Submission

**TEAM MEMBERS:**

* v.vishnu kumar
* k.s sriram
* R.AADHIKESAVAN
* R.ADHITHIYAN
* SAKTHIRAMAN

**TOPIC:**Document the Project and Prepare it for Submission.

## INTRODUCTION:

###### A chatbot is a computer program that simulates and processes human conversation, allowing humans to interact with digital devices as if they were communicating with a real person.



Chatbots, also known as conversational agents, are designed with the help of AI software. They simulate a conversation (or a chat) with users in a natural language via messaging applications, websites, mobile apps, or phone.

## OBJECTIVES:

Chatbot is a Python library that is developed to provide automated responses to user inputs. It makes utilization of a combination of Machine Learning algorithms in order to generate multiple types of responses.

**DATA SOURCES:**

With a data source, you can connect your Interfaces AI Chatbot to your own knowledge sources and tailor the responses for your business or project. You can restrict your bot from using its training information to provide answers and set custom responses when information doesn't exist.

## TASKS:

1. Chat bot questions and answers preparing manually.
2. Storing questions and answers in database.
3. Connecting front page with questions and answers using python code.

## DESIGN THINKING :

Design thinking is a human-centered method that aims to understand the user’s problems and generate ideas to solve them. It can be used for digital products and services, but also chatbots. Follow our lesson, learn the fundamentals of design thinking, and find out how to apply it to build user-friendly chatbots.

1. Environment Setup:
   * Install Python: Make sure you have Python installed on your system.
   * Choose an IDE or text editor for coding (e.g., VSCode, PyCharm, Jupyter Notebook).
2. Select a Chatbot Framework:
   * Choose a Python chatbot framework/library to work with, like ChatterBot, NLTK, or Rasa.
3. Data Collection:
   * Gather or create a dataset of conversation examples to train your chatbot. This data is crucial for teaching the chatbot how to respond.
4. Data Preprocessing:
   * Clean and preprocess the conversation data, including text normalization, tokenization, and stemming.
5. Training:
   * Use your chosen framework to train the chatbot on the preprocessed data. This involves teaching the chatbot how to understand and respond to user queries.
6. Integration with Natural Language Processing (NLP):
   * Implement NLP techniques to improve the chatbot's ability to understand and generate human-like responses. Libraries like spaCy or NLTK can be helpful here.
7. Create User Interfaces:
   * Develop a user interface for your chatbot. This can be a web app, a command-line interface, or an integration with a messaging platform.
8. Testing and Debugging:
   * Test your chatbot thoroughly to identify and fix issues. Pay attention to both the chatbot's ability to understand input and generate coherent responses.
9. Deployment:
   * Deploy your chatbot on a server or platform of your choice so that users can interact with it.
10. Continuous Improvement:
    * Continuously collect user feedback and improve your chatbot's responses. You can also consider adding more features and capabilities over time.

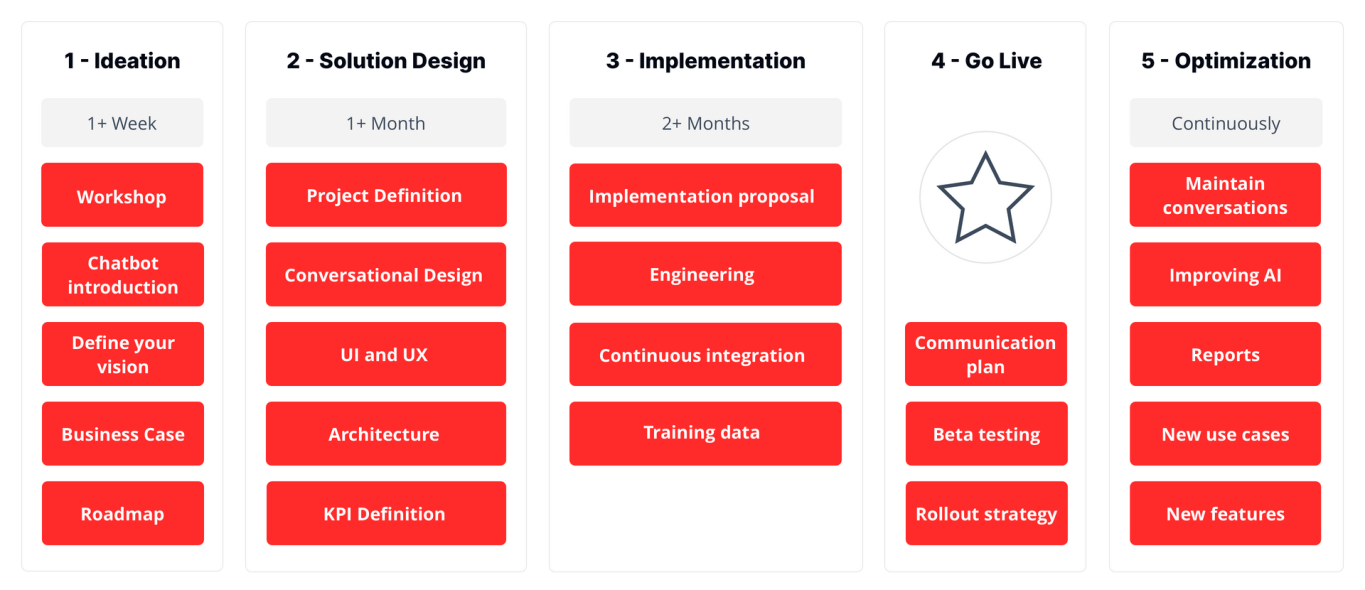
## PHASES OF DEVELOPMENT:

Step 1: Make a list of ideas and define business cases.

Step 2: Bring all the experts together and define the solution end to end.

Step 3: Build your ideas into the chatbot. Step 4: From training to go-live.

Step 5: Optimization.



**LIBRARIES USED IN CHATBOT:**

Creating a chatbot in Python often involves using various libraries and frameworks to facilitate natural language processing, web interactions, and other essential functionalities. Here are some commonly used libraries and frameworks for building chatbots in Python:

1. Natural Language Processing (NLP) Libraries:
   * NLTK (Natural Language Toolkit): NLTK is a popular library for NLP tasks, including tokenization, stemming, lemmatization, and sentiment analysis.
   * spaCy: spaCy is a fast and efficient NLP library for various NLP tasks, such as part-of-speech tagging, entity recognition, and dependency parsing.
   * TextBlob: TextBlob is a simple library for processing textual data, including sentiment analysis, translation, and text classification.
2. Machine Learning Libraries:
   * Scikit-Learn: If your chatbot requires machine learning, Scikit-Learn is a powerful library for tasks like text classification and clustering.
   * TensorFlow and Keras: These libraries are suitable for creating and training deep learning models for more complex chatbots.
3. Chatbot Frameworks:
   * Rasa: Rasa is an open-source framework specifically designed for building conversational AI chatbots. It provides tools for dialogue management, intent recognition, and entity extraction.
   * BotPress: BotPress is another open-source chatbot framework that offers a visual interface for building and managing chatbots.
   * Microsoft Bot Framework: If you want to develop chatbots that work across multiple platforms (e.g., Microsoft Teams, Skype, Slack), the Microsoft Bot Framework is a valuable option.
4. Web Frameworks:
   * Flask and Django: These web frameworks are commonly used for building web-based chatbots that interact with users via a web interface.
5. Database Libraries:
   * SQLAlchemy and Django ORM: These libraries help in connecting your chatbot to databases to store and retrieve information.
6. API Libraries:
   * Requests: The Requests library is used to make HTTP requests to external APIs, which can be valuable for integrating data and services into your chatbot.
7. Front-End Libraries:
   * JavaScript libraries like React or Vue.js can be used if you're building a web-based chatbot with a front-end interface.
8. Deployment and Hosting:
   * Docker: Docker can be used to containerize your chatbot application for easy deployment.
   * Cloud Platforms (e.g., AWS, Azure, Google Cloud): These platforms provide hosting and serverless options for deploying your chatbot.
9. Version Control and Collaboration:
   * Git and platforms like GitHub or GitLab are useful for version control and collaboration when developing chatbots with a team.
10. Other Specialized Libraries:
    * OpenAI's GPT-3 (or its successors): These libraries can be used to integrate powerful natural language generation capabilities into your chatbot.
    * Speech recognition libraries (e.g., SpeechRecognition) if your chatbot needs to handle voice interactions.

The choice of libraries and frameworks depends on your specific chatbot requirements and the technologies you are comfortable with. When developing a chatbot, it's crucial to select the tools that best match the objectives and capabilities you want to implement.

# INTEGRATION OF NLP TECHNIQUES:

Integrating Natural Language Processing (NLP) techniques into a chatbot in Python is a fundamental aspect of building a chatbot that can understand and generate human-like text responses. Here are the key steps for integrating NLP techniques into a chatbot:

1. Text Preprocessing:
   * Tokenization: Break the user's input and responses into individual words or tokens.
   * Lowercasing: Convert all text to lowercase to ensure consistency.
   * Stopword Removal: Remove common words like "a," "an," "the" to reduce noise.
   * Lemmatization or Stemming: Reduce words to their base form to improve matching.
2. Intent Recognition:
   * Use techniques like rule-based approaches, machine learning, or deep learning to determine the user's intent. This involves understanding what the user wants from their input.
3. Entity Recognition:
   * Identify specific pieces of information (entities) in the user's input, such as dates, names, or locations. This is important for extracting actionable information from the user's request.
4. Response Generation:
   * Given the recognized intent and entities, generate a response that is contextually appropriate and relevant. You can use templates, rule-based responses, or more advanced techniques like generative models (e.g., GPT-3).
5. Dialog Management:
   * Keep track of the conversation's context and manage the flow of conversation. Ensure that the chatbot remembers the user's previous inputs and responses for context-aware interactions.
6. Sentiment Analysis:
   * Analyze the sentiment of user input to understand the user's emotional state. This can be used to tailor responses accordingly.
7. Named Entity Recognition (NER):
   * Identify and extract named entities, such as names of people, organizations, and locations, which can be crucial for understanding and responding to user queries accurately.
8. Word Embeddings:
   * Utilize word embeddings like Word2Vec, FastText, or pre-trained embeddings (e.g., GloVe) to represent words in a dense vector space, enabling better understanding of word relationships.
9. Language Models:
   * Employ pre-trained language models like BERT, GPT-2, or GPT-3 to improve the chatbot's language understanding and generation capabilities.
10. Conversational Memory:
    * Maintain a memory of the conversation history to allow the chatbot to maintain context and provide more coherent responses.
11. Error Handling:
    * Implement robust error handling to manage situations where the chatbot does not understand the user's input.
12. Testing and Fine-Tuning:
    * Continuously test and fine-tune the chatbot's NLP components using real user interactions to improve its performance and understanding over time.
13. Integration with APIs and Databases:
    * Integrate the chatbot with external data sources, APIs, and databases to fetch information or perform specific tasks.
14. User Experience (UX) Design:
    * Consider the user experience and design a conversational flow that guides users effectively and ensures a natural interaction.
15. Deployment:
    * Deploy the chatbot using a suitable web framework (e.g., Flask, Django) and host it on a web server or a cloud platform.

When integrating NLP techniques into a chatbot, you can use libraries like NLTK, spaCy, TextBlob, and machine learning

frameworks (e.g., Scikit-Learn, TensorFlow) for the various NLP tasks mentioned above.

**HOW THE CHATBOT INTERACTS WITH USERS AND THE WEB APPLICATION:**

A chatbot interacts with users and a web application through a combination of frontend and backend components, communication protocols, and data exchange. Here's an overview of how this interaction typically works:

1. User Interface (Frontend):
   * Users interact with the chatbot through a user interface on a web application. This can be a chat window embedded in a website, a messaging platform, or a dedicated chatbot app.
2. User Input:
   * Users enter text or voice input in the chat interface, which serves as their communication with the chatbot.
3. Web Application (Frontend):
   * The user input is typically collected and sent to the web application's frontend.
4. User Input Processing (Frontend):
   * The frontend may perform basic preprocessing on the user input, such as removing extra whitespace or formatting.
5. Communication with Backend:
   * The frontend communicates with the backend of the web application, where the chatbot logic resides. This communication can happen via HTTP requests or WebSocket connections, depending on the architecture.
6. Backend (Chatbot Logic):
   * The backend is responsible for processing user input and generating responses. It contains the chatbot's core logic, which includes:
   * Natural Language Processing (NLP): Understanding the user's intent and extracting entities from the input.
   * Dialog Management: Maintaining the conversation context, tracking previous messages, and managing the ﬂow of the conversation.
   * Response Generation: Generating text or voice responses that are contextually relevant to the user's input.
   * Interaction with External Services: If the chatbot needs to access external databases, APIs, or services, this is where the interaction happens.
7. Backend Response:
   * The chatbot's backend generates a response based on the user's input and context.
8. Communication with Frontend:
   * The backend sends the response back to the frontend using an appropriate protocol (e.g., HTTP or WebSocket).
9. Frontend Rendering:
   * The frontend receives the response and renders it in the chat interface, displaying the chatbot's reply to the user.
10. User Interaction Continues: -
    * The user can continue the conversation by providing further input, and the process repeats.
11. Context Maintenance: -
    * The backend is responsible for maintaining the conversation context, allowing the chatbot to remember and refer to prior messages in a conversation, ensuring a coherent interaction.
12. Data Storage (if necessary): -
    * Depending on the chatbot's design, the backend may store conversation history and user data in a database for later reference or analysis.
13. Error Handling: -
    * The chatbot should have error-handling mechanisms to deal with cases where it cannot understand the user's input or when errors occur in external service interactions.

This interaction cycle continues as long as the user engages with the chatbot. The chatbot's ability to understand and respond to user input effectively, along with its ability to maintain context, is crucial for providing a seamless and natural user experience.

The speciﬁc implementation details, including the choice of programming languages, libraries, and frameworks, may vary based on the design and requirements of the web application and chatbot.

# INNOVATIVE TECHNIQUES USED DURING THE DEVELOPMENT:

During the development of chatbots in Python, several innovative techniques and approaches can be applied to enhance the chatbot's functionality, interactivity, and user experience. Here are some innovative techniques and approaches that can be incorporated into chatbot development:

1. Conversational AI and Pre-trained Models:
   * Leveraging state-of-the-art pre-trained language models like GPT-3, BERT, or T5 for more natural language understanding and generation.
2. Generative Chatbots:
   * Developing chatbots that can generate creative and contextually relevant responses by using deep learning and generative models. These can create engaging and interactive conversations.
3. Multimodal Chatbots:
   * Integrating both text and voice interactions, allowing users to communicate with the chatbot through both written messages and spoken language.
4. Personalization:
   * Implementing personalization techniques to tailor responses and recommendations to individual users based on their past interactions and preferences.
5. Emotion Detection:
   * Integrating sentiment analysis and emotion detection to recognize and respond to users' emotional states, providing empathetic and appropriate responses.
6. Contextual Memory:
   * Enhancing the chatbot's ability to maintain context throughout a conversation, allowing it to recall previous messages and respond coherently.
7. Transfer Learning:
   * Applying transfer learning techniques to adapt

pre-trained models to speciﬁc chatbot tasks, reducing the need for extensive training data.

1. Behavior Analysis:
   * Analyzing user behavior to gain insights into their preferences, patterns, and conversational history, enabling more personalized and effective interactions.
2. Interactive Learning:
   * Implementing reinforcement learning and interactive learning techniques to improve the chatbot's performance over time through user feedback.
3. Dynamic Responses:
   * Creating dynamic and context-aware responses by integrating data from real-time sources, such as live news feeds or weather updates.
4. Knowledge Graphs:
   * Building and utilizing knowledge graphs to enhance the chatbot's understanding of complex topics and relationships between entities.
5. Conversational Flow Control:
   * Implementing advanced conversational ﬂow control techniques that guide users through complex interactions, such as multi-step tasks or decision trees.
6. Content Generation and Summarization:
   * Integrating content generation and summarization techniques to provide users with concise information or to create detailed responses from extensive text.
7. Multi-Language Support:
   * Supporting multiple languages and enabling translation capabilities, allowing users to interact with the chatbot in their preferred language.
8. Privacy and Security Measures:
   * Implementing advanced privacy and security features to protect user data and ensure compliance with data protection regulations.
9. Voice Biometrics:
   * Integrating voice biometric recognition for secure authentication and user identiﬁcation in voice-enabled chatbots.
10. Augmented Reality (AR) Integration:
    * Exploring AR integration for chatbots, allowing them to provide information or guidance in augmented reality environments.
11. Human-Agent Hybrid Chatbots:
    * Combining human agents with chatbots in a seamless manner, where chatbots assist and collaborate with human agents to provide better customer support.

# GIVEN DATASET:

[Dataset.CSV](https://docs.google.com/spreadsheets/u/0/d/1c9k5vq04jBf2NYjpSa-b4kCNRg1Nt56l9Jebyi8p-nQ/edit)

# CHATBOT IMPLEMENTATION:

* + Preparing the Dependencies.
  + The right dependencies need to be established before we can create a chatbot.
  + Creating and Training the Chatbot.
  + Once the dependence has been established, we can build and train our chatbot.

**PROGRAM:**

In[1]:

import numpy as np import pandas as pd

import matplotlib.pyplot as plt import tensorflow as tf

import keras

from keras.layers import Dense import json

import re import string

from sklearn.feature\_extraction.text import TfidfVectorizer import unicodedata

from sklearn.model\_selection import train\_test\_split

In[2]:

question =[] answer = []

with open("../input/simple-dialogs-for-chatbot/dialogs.txt",'r') as f : for line in f :

line = line.split('\t') question.append(line[0]) answer.append(line[1])

print(len(question) == len(answer))

**True**

In[3]:

Question[:5]

Out[3]:

['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?"]

In[4]:

Answer[:5]

Out[4]:

["i'm fine. how about yourself?\n",

"i'm pretty good. thanks for asking.\n", 'no problem. so how have you been?\n', "i've been great. what about you?\n",

"i've been good. i'm in school right now.\n"]

In[5]:

answer = [ i.replace("\n","") for i in answer]

In[6]:

Answer[:5]

Out[6]:

["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."]

In[7]:

data = pd.DataFrame({"question" : question ,"answer":answer}) data.head()

**question answer**

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

In[8]:

def unicode\_to\_ascii(s):

return ''.join(c for c in unicodedata.normalize('NFD', s) if unicodedata.category(c) != 'Mn')

In[9]:

def clean\_text(text):

text = unicode\_to\_ascii(text.lower().strip()) text = re.sub(r"i'm", "i am", text)

text = re.sub(r"\r", "", text)

text = re.sub(r"he's", "he is", text) text = re.sub(r"she's", "she is", text) text = re.sub(r"it's", "it is", text)

text = re.sub(r"that's", "that is", text) text = re.sub(r"what's", "that is", text)

text = re.sub(r"where's", "where is", text) text = re.sub(r"how's", "how is", text) text = re.sub(r"\'ll", " will", text)

text = re.sub(r"\'ve", " have", text)

text = re.sub(r"\'re", " are", text)

text = re.sub(r"\'d", " would", text)

text = re.sub(r"\'re", " are", text)

text = re.sub(r"won't", "will not", text) text = re.sub(r"can't", "cannot", text) text = re.sub(r"n't", " not", text)

text = re.sub(r"n'", "ng", text)

text = re.sub(r"'bout", "about", text)

text = re.sub(r"'til", "until", text)

text = re.sub(r"[-()\"#/@;:<>{}`+=~|.!?,]", "", text)

text = text.translate(str.maketrans('', '', string.punctuation)) text = re.sub("(\\W)"," ",text)

text = re.sub('\S\*\d\S\*\s\*','', text) text = "<sos> " + text + " <eos>" return text

In[10]:

Data["question"][0]

Out[10]:

'hi, how are you doing?'

In[11]:

data["question"] = data.question.apply(clean\_text)

In[12]:

Data["question"][0]

Out[12]:

'<sos> hi how are you doing <eos>'

In[13]:

data["answer"] = data.answer.apply(clean\_text)

In[14]:

question = data.question.values.tolist() answer = data.answer.values.tolist()

In[15]:

def tokenize(lang):

lang\_tokenizer = tf.keras.preprocessing.text.Tokenizer( filters='')

lang\_tokenizer.fit\_on\_texts(lang)

tensor = lang\_tokenizer.texts\_to\_sequences(lang)

tensor = tf.keras.preprocessing.sequence.pad\_sequences(tensor,

padding='post')

return tensor, lang\_tokenizer

In[16]:

input\_tensor , inp\_lang = tokenize(question)

In[17]:

target\_tensor , targ\_lang = tokenize(answer)

In[18]:

#len(inp\_question) == len(inp\_answer)

In[19]:

def remove\_tags(sentence):

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

In[20]:

max\_length\_targ, max\_length\_inp = target\_tensor.shape[1], input\_tensor.shape[1]

In[21]:

# Creating training and validation sets using an 80-20 split input\_tensor\_train, input\_tensor\_val, target\_tensor\_train, target\_tensor\_val = train\_test\_split(input\_tensor, target\_tensor, test\_size=0.2)

In[22]:

#print(len(train\_inp) , len(val\_inp) , len(train\_target) , len(val\_target))

In[23]:

BUFFER\_SIZE = len(input\_tensor\_train)

BATCH\_SIZE = 64

steps\_per\_epoch = len(input\_tensor\_train)//BATCH\_SIZE embedding\_dim = 256

units = 1024

vocab\_inp\_size = len(inp\_lang.word\_index)+1 vocab\_tar\_size = len(targ\_lang.word\_index)+1

dataset = tf.data.Dataset.from\_tensor\_slices((input\_tensor\_train, target\_tensor\_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

2022-10-20 06:33:56.495284:

I tensorflow/stream\_executor/cuda/cuda\_gpu\_executor.cc:937] successful NUMA node read from SysFS had negative value (-1), but there must be at least one NUMA node, so returning NUMA node zero

2022-10-20 06:33:56.619975: I

tensorflow/stream\_executor/cuda/cuda\_gpu\_executor.cc:937] successful NUMA node read from SysFS had negative value (-1), but there must be at least one NUMA node, so returning NUMA node zero

2022-10-20 06:33:56.620805: I

tensorflow/stream\_executor/cuda/cuda\_gpu\_executor.cc:937] successful NUMA node read from SysFS had negative value (-1), but there must be at least one NUMA node, so returning NUMA node zero

2022-10-20 06:33:56.624402: I

tensorflow/core/platform/cpu\_feature\_guard.cc:142] This TensorFlow binary is optimized with oneAPI Deep Neural Network Library (oneDNN) to use the following CPU instructions in performance-critical operations: AVX2 AVX512F FMA

To enable them in other operations, rebuild TensorFlow with the appropriate compiler flags.

2022-10-20 06:33:56.624816: I

tensorflow/stream\_executor/cuda/cuda\_gpu\_executor.cc:937] successful NUMA node read from SysFS had negative value (-1), but there must be at least one NUMA node, so returning NUMA node zero

2022-10-20 06:33:56.625829: I

tensorflow/stream\_executor/cuda/cuda\_gpu\_executor.cc:937] successful NUMA node read from SysFS had negative value (-1), but there must be at least one NUMA node, so returning NUMA node zero

2022-10-20 06:33:56.626693: I

tensorflow/stream\_executor/cuda/cuda\_gpu\_executor.cc:937] successful NUMA node read from SysFS had negative value (-1), but there must be at least one NUMA node, so returning NUMA node zero

2022-10-20 06:33:59.460823: I

tensorflow/stream\_executor/cuda/cuda\_gpu\_executor.cc:937] successful NUMA node read from SysFS had negative value (-1), but there must be at least one NUMA node, so returning NUMA node zero

2022-10-20 06:33:59.461762: I

tensorflow/stream\_executor/cuda/cuda\_gpu\_executor.cc:937] successful NUMA node read from SysFS had negative value (-1), but there must be at least one NUMA node, so returning NUMA node zero

2022-10-20 06:33:59.462456: I

tensorflow/stream\_executor/cuda/cuda\_gpu\_executor.cc:937] successful NUMA node read from SysFS had negative value (-1), but there must be at least one NUMA node, so returning NUMA node zero

2022-10-20 06:33:59.463056: I

tensorflow/core/common\_runtime/gpu/gpu\_device.cc:1510] Created device

/job:localhost/replica:0/task:0/device:GPU:0 with 15401 MB memory: -> device: 0, name: Tesla P100-PCIE-16GB, pci bus id: 0000:00:04.0, compute capability: 6.0

Out[23]:

(TensorShape([64, 22]), TensorShape([64, 22]))

In[24]:

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))

In[25]:

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.shape))

print ('Encoder Hidden state shape: (batch size, units)

{}'.format(sample\_hidden.shape))

2022-10-20 06:34:00.854919: I

tensorflow/stream\_executor/cuda/cuda\_dnn.cc:369] Loaded cuDNN version 8005

Encoder output shape: (batch size, sequence length, units) (64, 22, 1024) Encoder Hidden state shape: (batch size, units) (64, 1024)

In[26]:

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 score

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

In[27]:

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\_weights.shape))

Attention result shape: (batch size, units) (64, 1024)

Attention weights shape: (batch\_size, sequence\_length, 1) (64, 22, 1)

In[28]:

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

In[29]:

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.shape))

Decoder output shape: (batch\_size, vocab size) (64, 2347)

In[30]:

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\_)

In[31]:

@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([targ\_lang.word\_index['<sos>']] \* 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

In[32]:

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))

2022-10-20 06:34:22.115124: I

tensorflow/compiler/mlir/mlir\_graph\_optimization\_pass.cc:185] None of the MLIR Optimization Passes are enabled (registered 2)

Epoch: 4 Loss:1.5734

Epoch: 8 Loss:1.3385

Epoch: 12 Loss:1.1549

Epoch: 16 Loss:0.9987

Epoch: 20 Loss:0.8251

Epoch: 24 Loss:0.6379

Epoch: 28 Loss:0.4403

Epoch: 32 Loss:0.2550

Epoch: 36 Loss:0.1160

Epoch: 40 Loss:0.0544

In[33]:

def evaluate(sentence):

sentence = clean\_text(sentence)

inputs = [inp\_lang.word\_index[i] for i in sentence.split(' ')]

inputs = tf.keras.preprocessing.sequence.pad\_sequences([inputs],

maxlen=max\_length\_inp, 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([targ\_lang.word\_index['<sos>']], 0)

for t in range(max\_length\_targ):

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 += targ\_lang.index\_word[predicted\_id] + ' ' if targ\_lang.index\_word[predicted\_id] == '<eos>':

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)

In[34]:

questions =[] answers = []

with open("../input/simple-dialogs-for-chatbot/dialogs.txt",'r') as f : for line in f :

line = line.split('\t') questions.append(line[0]) answers.append(line[1])

print(len(question) == len(answer))

**True**

In[35]:

def ask(sentence):

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

ask(questions[100])

Out[35]:

Question: <sos> i believe so <eos>

Predicted answer: good good you are hot <eos>

In[36]:

ask(questions[50])

Question: <sos> i wish it would cool off one day <eos>

Predicted answer: that is how i feel i want winter to come soon <eos>

In[37]:

print(answers[50])

that's how i feel, i want winter to come soon.

## CHATBOT WEB APPLICATION:

* Creating a chatbot web application involves combining web development and chatbot development to offer a chatbot interface within a web application.
* A chatbot is software that simulates human-like conversations with users via chat. Its key task is to answer user questions with instant messages.

## PROGRAM:

In[1]:

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

In[2]:

df=pd.read\_csv('/kaggle/input/simple-dialogs-for-chatbot/dialogs.txt',s ep='\t',names=['question','answer'])

print(f'Dataframe size: {len(df)}') df.head()

Dataframe size: 3725

**Out[2]:**

|  |  |  |
| --- | --- | --- |
|  | **question** | **answer** |
| **0** | **hi, how are you doing?** | **i'm fine. how about yourself?** |
| **1** | **i'm fine. how about yourself?** | **i'm pretty good. thanks for asking.** |
| **2** | **i'm pretty good. thanks for asking.** | **no problem. so how have you been?** |
| **3** | **no problem. so how have you been?** | **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.** |

**Data Preprocessing:**

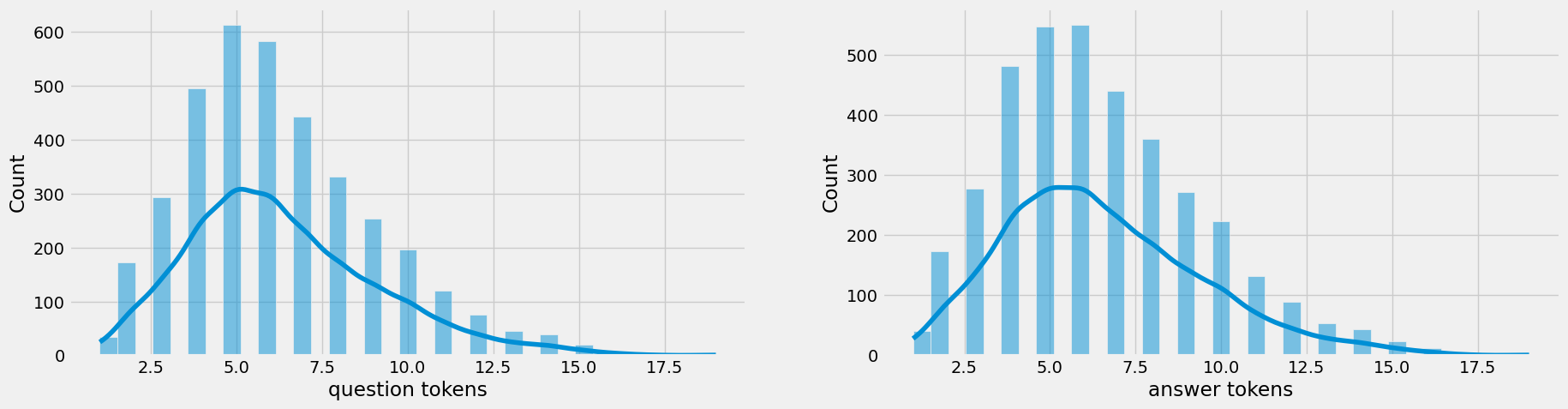
Data Visualization:

In[3]:

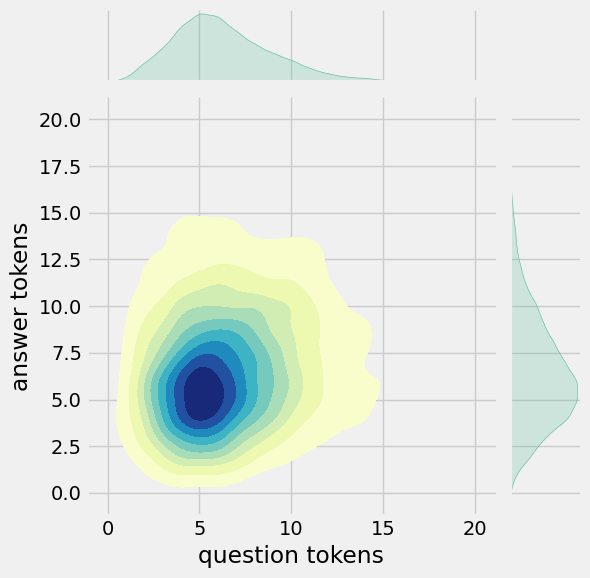
df['question tokens']=df['question'].apply(lambda x:len(x.split())) df['answer tokens']=df['answer'].apply(lambda x:len(x.split())) plt.style.use('fivethirtyeight') fig,ax=plt.subplots(nrows=1,ncols=2,figsize=(20,5)) sns.set\_palette('Set2')

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()



**Out[3]:**



Text Cleaning:

**In[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)

**Out[4]:**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **question** | **answer** | **encoder\_inputs** | **decoder\_targets** | **decoder\_inputs** |
| **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>** |

**In[5]:**

df['encoder input tokens']=df['encoder\_inputs'].apply(lambda x:len(x.split()))

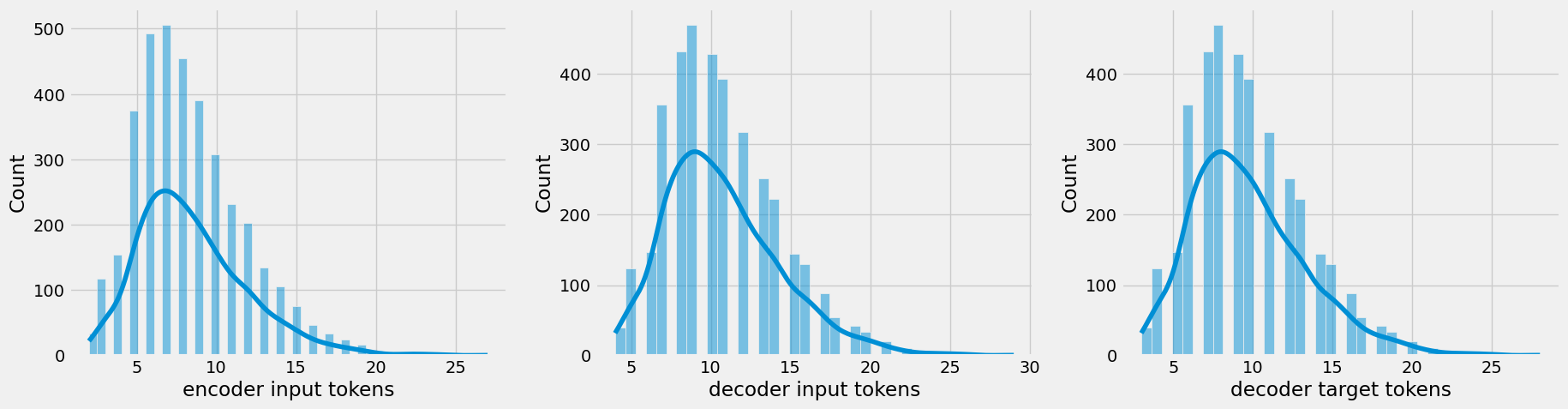
df['decoder input tokens']=df['decoder\_inputs'].apply(lambda x:len(x.split()))

df['decoder target tokens']=df['decoder\_targets'].apply(lambda x:len(x.split()))

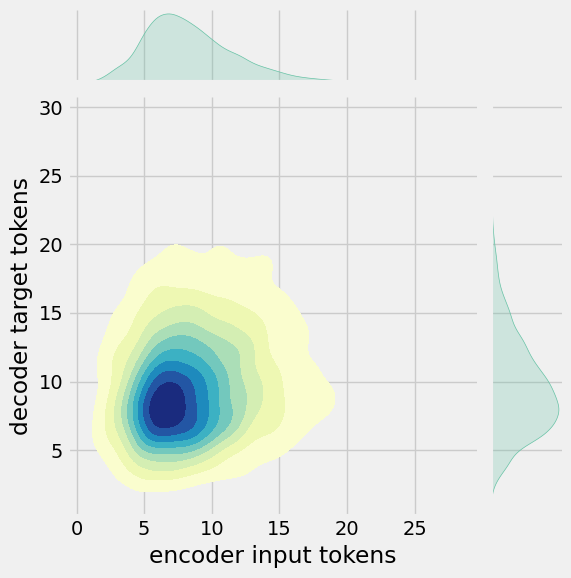
plt.style.use('fivethirtyeight') fig,ax=plt.subplots(nrows=1,ncols=3,figsize=(20,5)) sns.set\_palette('Set2')

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()



**Out[5]:**



In[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)

After preprocessing: for example , if your birth date is january 1 2

, 1 9 8 7 , write 0 1 / 1 2 / 8 7 . Max encoder input length: 27

Max decoder input length: 29 Max decoder target length: 28

**Out[6]:**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **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:

In[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']

In[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}')

**Out[8]:**

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)

In[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]} ...')**

**Out[9]:**

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] ...

In[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}')

**Out[10]:**

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)

### Build Models:

Build Encoder:

In[11]:

class Encoder(tf.keras.models.Model):

def None:

\_\_init\_\_(self,units,embedding\_dim,vocab\_size,\*args,\*\*kwargs) ->

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='encoder') encoder.call(\_[0])

Out[11]:

(<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**

In[12]:

class Decoder(tf.keras.models.Model):

def None:

\_\_init\_\_(self,units,embedding\_dim,vocab\_size,\*args,\*\*kwargs) ->

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\_sta tes)

x=self.normalize(x) x=Dropout(.4)(x) return self.fc(x)

decoder=Decoder(lstm\_cells,embedding\_dim,vocab\_size,name='decoder') decoder(\_[1][:1],encoder(\_[0][:1]))

Out[12]:

<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 Mode:

In[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\_varia bles

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

In[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])

Out[14]:

<tf.Tensor: shape=(149, 30, 2443), dtype=float32, numpy= array([[[3.40592262e-04, 5.73484940e-05, 2.12948853e-05, ...,

7.20679745e-05, 1.54536311e-03, 2.35993255e-04], [1.46621116e-03, 8.02504110e-06, 5.40619949e-05, ...,

1.91874733e-05, 9.72440175e-05, 7.64339056e-05], [9.69291723e-05, 2.74417835e-05, 1.37613132e-03, ...,

3.60095728e-05, 1.55378671e-04, 1.83973272e-04],

...,

[1.90027885e-03, 6.92659756e-04, 1.43461803e-04, ..., 1.95525470e-04, 1.71066222e-05, 1.02524005e-04],

[1.90027885e-03, 6.92659756e-04, 1.43461803e-04, ..., 1.95525470e-04, 1.71066222e-05, 1.02524005e-04],

[1.90027885e-03, 6.92659756e-04, 1.43461803e-04, ..., 1.95525470e-04, 1.71066222e-05, 1.02524005e-04]],

[[9.24730921e-05, 3.46553512e-04, 2.07866033e-05, ..., 3.65934626e-04, 7.63039337e-04, 5.52638434e-04],

[8.46863186e-05, 3.65541164e-05, 2.54740953e-05, ..., 7.12379551e-05, 3.62201303e-04, 4.16714087e-04],

[2.30146630e-04, 3.91469621e-06, 2.72463716e-04, ..., 9.26126595e-05, 1.03836363e-04, 1.40792166e-04],

...,

[6.84961735e-04, 9.07644513e-04, 2.86691647e-04, ..., 3.87946144e-04, 6.09236558e-05, 1.12995331e-05],

[6.84961735e-04, 9.07644513e-04, 2.86691647e-04, ..., 3.87946144e-04, 6.09236558e-05, 1.12995331e-05],

[6.84961735e-04, 9.07644513e-04, 2.86691647e-04, ..., 3.87946144e-04, 6.09236558e-05, 1.12995322e-05]],

[[1.19036995e-03, 8.10516722e-05, 2.42324077e-05, ..., 4.99442758e-05, 6.67208573e-04, 9.55566764e-04],

[1.53046989e-04, 9.76863957e-05, 4.96972689e-06, ..., 3.24743196e-05, 2.12563842e-04, 1.18708890e-03],

[9.40205529e-04, 1.80782794e-04, 7.26205144e-06, ..., 1.96355060e-04, 8.16940737e-05, 1.38416886e-03],

...,

[3.52622545e-03, 1.26781175e-03, 1.02695449e-04, ..., 2.35450850e-03, 3.25187625e-06, 9.46984728e-05],

[3.52622545e-03, 1.26781175e-03, 1.02695449e-04, ..., 2.35450850e-03, 3.25187625e-06, 9.46984728e-05],

[3.52622545e-03, 1.26781175e-03, 1.02695449e-04, ..., 2.35450850e-03, 3.25187625e-06, 9.46984728e-05]],

...,

[[9.03617911e-05, 1.57651404e-04, 1.02747028e-04, ..., 2.20922651e-04, 3.61504179e-04, 2.32456136e-03],

[1.55469708e-04, 1.53608169e-04, 1.14945491e-04, ..., 1.88878359e-04, 5.11967926e-04, 5.13108505e-04],

[8.27641197e-05, 2.83437112e-05, 6.29429938e-04, ..., 2.15980137e-04, 3.02832137e-04, 1.77760507e-04],

...,

[2.41102395e-03, 1.29279669e-03, 9.11735406e-05, ..., 4.06600971e-04, 7.58682154e-06, 6.05909081e-05],

[2.41102395e-03, 1.29279669e-03, 9.11735406e-05, ..., 4.06600971e-04, 7.58682154e-06, 6.05909081e-05],

[2.41102395e-03, 1.29279669e-03, 9.11735406e-05, ..., 4.06600971e-04, 7.58682154e-06, 6.05909081e-05]],

[[3.99837241e-04, 2.36026899e-05, 6.89777007e-05, ..., 5.94239136e-05, 4.32556757e-04, 4.60232928e-04],

[3.88111075e-04, 8.31133584e-05, 1.11861555e-04, ..., 3.03280340e-05, 2.54765386e-04, 2.82170397e-04],

[2.12516752e-03, 7.19837190e-05, 1.88700986e-04, ..., 1.86366087e-04, 7.02239413e-05, 2.54370330e-04],

...,

[4.56329063e-03, 2.23812275e-03, 2.37343236e-04, ..., 2.64523784e-04, 4.05454011e-05, 1.55662783e-04],

[4.56329063e-03, 2.23812275e-03, 2.37343236e-04, ..., 2.64523784e-04, 4.05454011e-05, 1.55662783e-04],

[4.56329063e-03, 2.23812275e-03, 2.37343236e-04, ..., 2.64523784e-04, 4.05454011e-05, 1.55662783e-04]],

[[3.24600202e-04, 9.31067043e-05, 4.60048941e-05, ..., 6.66230699e-05, 5.76460850e-04, 1.52416309e-04],

[7.51478728e-05, 7.63997741e-05, 2.09082973e-05, ..., 2.55555002e-04, 2.28998848e-04, 4.37303359e-04],

[1.03114333e-04, 1.55743372e-04, 9.97955431e-06, ..., 1.12485175e-03, 4.80950950e-03, 6.83143327e-04],

...,

[5.20280097e-03, 3.23211338e-04, 2.47709468e-05, ..., 3.07609705e-04, 6.09844255e-06, 8.61325825e-05],

[5.20280097e-03, 3.23211338e-04, 2.47709468e-05, ..., 3.07609705e-04, 6.09844255e-06, 8.61325825e-05],

[5.20280097e-03, 3.23211338e-04, 2.47709468e-05, ...,

3.07609705e-04, 6.09844255e-06, 8.61325825e-05]]],

dtype=float32)>

Train Model:

In[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=True

)

]

)

**Out[15]:**

Epoch 1/100

23/23 [==============================] - ETA: 0s - loss: 1.6590 -

accuracy: 0.2180

Epoch 1: val\_loss improved from inf to 1.21875, saving model to ckpt 23/23 [==============================] - 68s 3s/step - loss: 1.6515 -

accuracy: 0.2198 - val\_loss: 1.2187 - val\_accuracy: 0.3072 Epoch 2/100

23/23 [==============================] - ETA: 0s - loss: 1.2327 -

accuracy: 0.3087

Epoch 2: val\_loss improved from 1.21875 to 1.10877, saving model to ckpt

23/23 [==============================] - 53s 2s/step - loss: 1.2287 -

accuracy: 0.3092 - val\_loss: 1.1088 - val\_accuracy: 0.3415 Epoch 3/100

23/23 [==============================] - ETA: 0s - loss: 1.1008 -

accuracy: 0.3368

Epoch 3: val\_loss did not improve from 1.10877

23/23 [==============================] - 22s 973ms/step - loss: 1.0984

- accuracy: 0.3370 - val\_loss: 1.1161 - val\_accuracy: 0.3315 Epoch 4/100

23/23 [==============================] - ETA: 0s - loss: 1.0209 -

accuracy: 0.3536

Epoch 4: val\_loss improved from 1.10877 to 0.95189, saving model to ckpt

23/23 [==============================] - 53s 2s/step - loss: 1.0186 -

accuracy: 0.3540 - val\_loss: 0.9519 - val\_accuracy: 0.3718 Epoch 5/100

23/23 [==============================] - ETA: 0s - loss: 0.9622 -

accuracy: 0.3673

Epoch 5: val\_loss did not improve from 0.95189

23/23 [==============================] - 23s 979ms/step - loss: 0.9672

- accuracy: 0.3670 - val\_loss: 0.9642 - val\_accuracy: 0.3666 Epoch 6/100

23/23 [==============================] - ETA: 0s - loss: 0.9159 -

accuracy: 0.3801

Epoch 6: val\_loss improved from 0.95189 to 0.94015, saving model to ckpt

23/23 [==============================] - 53s 2s/step - loss: 0.9182 -

accuracy: 0.3796 - val\_loss: 0.9401 - val\_accuracy: 0.3598 Epoch 7/100

23/23 [==============================] - ETA: 0s - loss: 0.8737 -

accuracy: 0.3908

Epoch 7: val\_loss improved from 0.94015 to 0.83293, saving model to ckpt

23/23 [==============================] - 52s 2s/step - loss: 0.8746 -

accuracy: 0.3900 - val\_loss: 0.8329 - val\_accuracy: 0.4180 Epoch 8/100

23/23 [==============================] - ETA: 0s - loss: 0.8389 -

accuracy: 0.4013

Epoch 8: val\_loss improved from 0.83293 to 0.77748, saving model to ckpt

23/23 [==============================] - 53s 2s/step - loss: 0.8395 -

accuracy: 0.4013 - val\_loss: 0.7775 - val\_accuracy: 0.4305 Epoch 9/100

23/23 [==============================] - ETA: 0s - loss: 0.8148 -

accuracy: 0.4094

Epoch 9: val\_loss did not improve from 0.77748

23/23 [==============================] - 23s 983ms/step - loss: 0.8187

- accuracy: 0.4084 - val\_loss: 0.8608 - val\_accuracy: 0.3830 Epoch 10/100

23/23 [==============================] - ETA: 0s - loss: 0.7889 -

accuracy: 0.4200

Epoch 10: val\_loss improved from 0.77748 to 0.73131, saving model to ckpt

23/23 [==============================] - 53s 2s/step - loss: 0.7923 -

accuracy: 0.4188 - val\_loss: 0.7313 - val\_accuracy: 0.4515 Epoch 11/100

|  |  |  |
| --- | --- | --- |
| **23/23 [==============================]** | **- ETA: 0s - loss: 0.7624** | **-** |
| **accuracy: 0.4284** |  |  |
| **Epoch 11: val\_loss did not improve from** | **0.73131** |  |
| **23/23 [==============================]** | **- 22s 965ms/step - loss:** | **0.7615** |
| **- accuracy: 0.4282 - val\_loss: 0.8036 -** | **val\_accuracy: 0.4472** |  |
| **Epoch 12/100** |  |  |
| **23/23 [==============================]** | **- ETA: 0s - loss: 0.7433** | **-** |
| **accuracy: 0.4361** |  |  |
| **Epoch 12: val\_loss did not improve from** | **0.73131** |  |
| **23/23 [==============================]** | **- 23s 984ms/step - loss:** | **0.7452** |
| **- accuracy: 0.4354 - val\_loss: 0.7384 -** | **val\_accuracy: 0.4623** |  |
| **Epoch 13/100** |  |  |
| **23/23 [==============================]** | **- ETA: 0s - loss: 0.7246** | **-** |
| **accuracy: 0.4493** |  |  |
| **Epoch 13: val\_loss did not improve from** | **0.73131** |  |
| **23/23 [==============================]** | **- 23s 988ms/step - loss:** | **0.7281** |
| **- accuracy: 0.4488 - val\_loss: 0.8017 -** | **val\_accuracy: 0.4449** |  |
| **Epoch 14/100** |  |  |
| **23/23 [==============================]** | **- ETA: 0s - loss: 0.7080** | **-** |
| **accuracy: 0.4513** |  |  |
| **Epoch 14: val\_loss did not improve from** | **0.73131** |  |
| **23/23 [==============================]** | **- 23s 995ms/step - loss:** | **0.7080** |
| **- accuracy: 0.4509 - val\_loss: 0.7568 -** | **val\_accuracy: 0.4259** |  |
| **Epoch 15/100** |  |  |
| **23/23 [==============================]** | **- ETA: 0s - loss: 0.6853** | **-** |
| **accuracy: 0.4620** |  |  |
| **Epoch 15: val\_loss did not improve from** | **0.73131** |  |
| **23/23 [==============================]** | **- 22s 974ms/step - loss:** | **0.6826** |
| **- accuracy: 0.4616 - val\_loss: 0.7376 -** | **val\_accuracy: 0.4502** |  |
| **Epoch 16/100** |  |  |
| **23/23 [==============================]** | **- ETA: 0s - loss: 0.6731** | **-** |
| **accuracy: 0.4673** |  |  |
| **Epoch 16: val\_loss did not improve from** | **0.73131** |  |
| **23/23 [==============================]** | **- 23s 983ms/step - loss:** | **0.6733** |
| **- accuracy: 0.4672 - val\_loss: 0.7646 -** | **val\_accuracy: 0.4538** |  |
| **Epoch 17/100** |  |  |
| **23/23 [==============================]** | **- ETA: 0s - loss: 0.6576** | **-** |
| **accuracy: 0.4732** |  |  |

Epoch 17: val\_loss improved from 0.73131 to 0.66131, saving model to ckpt

23/23 [==============================] - 52s 2s/step - loss: 0.6539 -

accuracy: 0.4738 - val\_loss: 0.6613 - val\_accuracy: 0.4714 Epoch 18/100

23/23 [==============================] - ETA: 0s - loss: 0.6468 -

accuracy: 0.4807

Epoch 18: val\_loss improved from 0.66131 to 0.65303, saving model to ckpt

23/23 [==============================] - 53s 2s/step - loss: 0.6458 -

accuracy: 0.4805 - val\_loss: 0.6530 - val\_accuracy: 0.4993 Epoch 19/100

23/23 [==============================] - ETA: 0s - loss: 0.6353 -

accuracy: 0.4881

Epoch 19: val\_loss did not improve from 0.65303

23/23 [==============================] - 23s 994ms/step - loss: 0.6357

- accuracy: 0.4876 - val\_loss: 0.7331 - val\_accuracy: 0.4677 Epoch 20/100

23/23 [==============================] - ETA: 0s - loss: 0.6194 -

accuracy: 0.4968

Epoch 20: val\_loss improved from 0.65303 to 0.55054, saving model to ckpt

23/23 [==============================] - 54s 2s/step - loss: 0.6188 -

accuracy: 0.4967 - val\_loss: 0.5505 - val\_accuracy: 0.5221 Epoch 21/100

|  |  |  |
| --- | --- | --- |
| **23/23 [==============================]** | **- ETA: 0s - loss: 0.6160** | **-** |
| **accuracy: 0.4978** |  |  |
| **Epoch 21: val\_loss did not improve from** | **0.55054** |  |
| **23/23 [==============================]** | **- 23s 987ms/step - loss:** | **0.6182** |
| **- accuracy: 0.4965 - val\_loss: 0.6790 -** | **val\_accuracy: 0.4979** |  |
| **Epoch 22/100** |  |  |
| **23/23 [==============================]** | **- ETA: 0s - loss: 0.6011** | **-** |
| **accuracy: 0.5052** |  |  |
| **Epoch 22: val\_loss did not improve from** | **0.55054** |  |
| **23/23 [==============================]** | **- 23s 996ms/step - loss:** | **0.6011** |
| **- accuracy: 0.5051 - val\_loss: 0.6221 -** | **val\_accuracy: 0.5277** |  |
| **Epoch 23/100** |  |  |
| **23/23 [==============================]** | **- ETA: 0s - loss: 0.5950** | **-** |
| **accuracy: 0.5079** |  |  |
| **Epoch 23: val\_loss did not improve from** | **0.55054** |  |
| **23/23 [==============================]** | **- 23s 987ms/step - loss:** | **0.5934** |
| **- accuracy: 0.5081 - val\_loss: 0.6142 -** | **val\_accuracy: 0.5198** |  |
| **Epoch 24/100** |  |  |
| **23/23 [==============================]** | **- ETA: 0s - loss: 0.5810** | **-** |
| **accuracy: 0.5160** |  |  |
| **Epoch 24: val\_loss did not improve from** | **0.55054** |  |
| **23/23 [==============================]** | **- 22s 971ms/step - loss:** | **0.5803** |
| **- accuracy: 0.5170 - val\_loss: 0.5759 -** | **val\_accuracy: 0.5137** |  |

|  |  |  |
| --- | --- | --- |
| **Epoch 25/100**  **23/23 [==============================]** | **- ETA: 0s - loss: 0.5716** | **-** |
| **accuracy: 0.5227** |  |  |
| **Epoch 25: val\_loss did not improve from** | **0.55054** |  |
| **23/23 [==============================]** | **- 23s 986ms/step - loss:** | **0.5733** |
| **- accuracy: 0.5229 - val\_loss: 0.6344 -** | **val\_accuracy: 0.5169** |  |
| **Epoch 26/100** |  |  |
| **23/23 [==============================]** | **- ETA: 0s - loss: 0.5676** | **-** |
| **accuracy: 0.5225** |  |  |
| **Epoch 26: val\_loss did not improve from** | **0.55054** |  |
| **23/23 [==============================]** | **- 22s 963ms/step - loss:** | **0.5708** |
| **- accuracy: 0.5210 - val\_loss: 0.6254 -** | **val\_accuracy: 0.4882** |  |
| **Epoch 27/100** |  |  |
| **23/23 [==============================]** | **- ETA: 0s - loss: 0.5616** | **-** |
| **accuracy: 0.5291** |  |  |
| **Epoch 27: val\_loss did not improve from** | **0.55054** |  |
| **23/23 [==============================]** | **- 23s 988ms/step - loss:** | **0.5624** |
| **- accuracy: 0.5280 - val\_loss: 0.6774 -** | **val\_accuracy: 0.5379** |  |
| **Epoch 28/100** |  |  |
| **23/23 [==============================]** | **- ETA: 0s - loss: 0.5531** | **-** |
| **accuracy: 0.5318** |  |  |
| **Epoch 28: val\_loss did not improve from** | **0.55054** |  |
| **23/23 [==============================]** | **- 22s 949ms/step - loss:** | **0.5543** |
| **- accuracy: 0.5310 - val\_loss: 0.7284 -** | **val\_accuracy: 0.5302** |  |
| **Epoch 29/100** |  |  |
| **23/23 [==============================]** | **- ETA: 0s - loss: 0.5398** | **-** |
| **accuracy: 0.5389** |  |  |
| **Epoch 29: val\_loss did not improve from** | **0.55054** |  |
| **23/23 [==============================]** | **- 23s 1s/step - loss: 0.5391 -** | |

accuracy: 0.5398 - val\_loss: 0.7385 - val\_accuracy: 0.5193 Epoch 30/100

23/23 [==============================] - ETA: 0s - loss: 0.5375 -

accuracy: 0.5416

Epoch 30: val\_loss improved from 0.55054 to 0.50346, saving model to ckpt

23/23 [==============================] - 53s 2s/step - loss: 0.5384 -

accuracy: 0.5417 - val\_loss: 0.5035 - val\_accuracy: 0.5411 Epoch 31/100

23/23 [==============================] - ETA: 0s - loss: 0.5270 -

accuracy: 0.5481

Epoch 31: val\_loss did not improve from 0.50346

23/23 [==============================] - 22s 958ms/step - loss: 0.5262

* **accuracy: 0.5477 - val\_loss: 0.5805 - val\_accuracy: 0.5457**

|  |  |  |
| --- | --- | --- |
| **Epoch 32/100**  **23/23 [==============================]** | **- ETA: 0s - loss: 0.5304** | **-** |
| **accuracy: 0.5447** |  |  |
| **Epoch 32: val\_loss did not improve from** | **0.50346** |  |
| **23/23 [==============================]** | **- 22s 963ms/step - loss:** | **0.5329** |
| **- accuracy: 0.5435 - val\_loss: 0.5374 -** | **val\_accuracy: 0.5725** |  |
| **Epoch 33/100** |  |  |
| **23/23 [==============================]** | **- ETA: 0s - loss: 0.5196** | **-** |
| **accuracy: 0.5520** |  |  |
| **Epoch 33: val\_loss did not improve from** | **0.50346** |  |
| **23/23 [==============================]** | **- 23s 975ms/step - loss:** | **0.5211** |
| **- accuracy: 0.5518 - val\_loss: 0.6217 -** | **val\_accuracy: 0.5066** |  |
| **Epoch 34/100** |  |  |
| **23/23 [==============================]** | **- ETA: 0s - loss: 0.5129** | **-** |
| **accuracy: 0.5558** |  |  |
| **Epoch 34: val\_loss did not improve from** | **0.50346** |  |

23/23 [==============================] - 23s 1000ms/step - loss: 0.5129

* **accuracy: 0.5556 - val\_loss: 0.6070 - val\_accuracy: 0.5653 Epoch 35/100**

23/23 [==============================] - ETA: 0s - loss: 0.5059 -

accuracy: 0.5620

Epoch 35: val\_loss did not improve from 0.50346

23/23 [==============================] - 22s 966ms/step - loss: 0.5081

* **accuracy: 0.5614 - val\_loss: 0.6153 - val\_accuracy: 0.5452 Epoch 36/100**

23/23 [==============================] - ETA: 0s - loss: 0.5037 -

accuracy: 0.5619

Epoch 36: val\_loss did not improve from 0.50346

23/23 [==============================] - 23s 980ms/step - loss: 0.5063

* **accuracy: 0.5617 - val\_loss: 0.5328 - val\_accuracy: 0.5873 Epoch 37/100**

23/23 [==============================] - ETA: 0s - loss: 0.4977 -

accuracy: 0.5682

Epoch 37: val\_loss did not improve from 0.50346

23/23 [==============================] - 22s 969ms/step - loss: 0.4980

* **accuracy: 0.5682 - val\_loss: 0.5976 - val\_accuracy: 0.5693 Epoch 38/100**

23/23 [==============================] - ETA: 0s - loss: 0.4939 -

accuracy: 0.5704

Epoch 38: val\_loss did not improve from 0.50346

23/23 [==============================] - 23s 993ms/step - loss: 0.4953

* **accuracy: 0.5687 - val\_loss: 0.5937 - val\_accuracy: 0.5236 Epoch 39/100**

23/23 [==============================] - ETA: 0s - loss: 0.4860 -

accuracy: 0.5758

Epoch 39: val\_loss did not improve from 0.50346

23/23 [==============================] - 23s 986ms/step - loss: 0.4868

* **accuracy: 0.5746 - val\_loss: 0.6155 - val\_accuracy: 0.5457 Epoch 40/100**

23/23 [==============================] - ETA: 0s - loss: 0.4809 -

accuracy: 0.5778

Epoch 40: val\_loss did not improve from 0.50346

23/23 [==============================] - 23s 1s/step - loss: 0.4821 -

accuracy: 0.5760 - val\_loss: 0.5046 - val\_accuracy: 0.5662 Epoch 41/100

|  |  |  |
| --- | --- | --- |
| **23/23 [==============================]** | **- ETA: 0s - loss: 0.4781** | **-** |
| **accuracy: 0.5817** |  |  |
| **Epoch 41: val\_loss did not improve from** | **0.50346** |  |
| **23/23 [==============================]** | **- 23s 990ms/step - loss:** | **0.4782** |
| **- accuracy: 0.5821 - val\_loss: 0.5256 -** | **val\_accuracy: 0.5907** |  |
| **Epoch 42/100** |  |  |
| **23/23 [==============================]** | **- ETA: 0s - loss: 0.4713** | **-** |
| **accuracy: 0.5836** |  |  |
| **Epoch 42: val\_loss did not improve from** | **0.50346** |  |
| **23/23 [==============================]** | **- 23s 982ms/step - loss:** | **0.4729** |
| **- accuracy: 0.5824 - val\_loss: 0.6387 -** | **val\_accuracy: 0.5456** |  |
| **Epoch 43/100** |  |  |
| **23/23 [==============================]** | **- ETA: 0s - loss: 0.4641** | **-** |
| **accuracy: 0.5904** |  |  |
| **Epoch 43: val\_loss did not improve from** | **0.50346** |  |
| **23/23 [==============================]** | **- 23s 1s/step - loss: 0.4627 -** | |

accuracy: 0.5908 - val\_loss: 0.5668 - val\_accuracy: 0.5741 Epoch 44/100

23/23 [==============================] - ETA: 0s - loss: 0.4608 -

accuracy: 0.5921

Epoch 44: val\_loss improved from 0.50346 to 0.49920, saving model to ckpt

23/23 [==============================] - 53s 2s/step - loss: 0.4618 -

accuracy: 0.5920 - val\_loss: 0.4992 - val\_accuracy: 0.5768 Epoch 45/100

23/23 [==============================] - ETA: 0s - loss: 0.4592 -

accuracy: 0.5902

Epoch 45: val\_loss did not improve from 0.49920

23/23 [==============================] - 22s 970ms/step - loss: 0.4599

* **accuracy: 0.5887 - val\_loss: 0.5423 - val\_accuracy: 0.5854 Epoch 46/100**

23/23 [==============================] - ETA: 0s - loss: 0.4535 -

accuracy: 0.5978

Epoch 46: val\_loss improved from 0.49920 to 0.48429, saving model to ckpt

23/23 [==============================] - 53s 2s/step - loss: 0.4552 -

accuracy: 0.5966 - val\_loss: 0.4843 - val\_accuracy: 0.6049 Epoch 47/100

23/23 [==============================] - ETA: 0s - loss: 0.4528 -

accuracy: 0.5987

Epoch 47: val\_loss improved from 0.48429 to 0.47868, saving model to ckpt

23/23 [==============================] - 54s 2s/step - loss: 0.4537 -

accuracy: 0.5990 - val\_loss: 0.4787 - val\_accuracy: 0.5906 Epoch 48/100

|  |  |  |
| --- | --- | --- |
| **23/23 [==============================]** | **- ETA: 0s - loss: 0.4441** | **-** |
| **accuracy: 0.6016** |  |  |
| **Epoch 48: val\_loss did not improve from** | **0.47868** |  |
| **23/23 [==============================]** | **- 23s 982ms/step - loss:** | **0.4439** |
| **- accuracy: 0.6025 - val\_loss: 0.5746 -** | **val\_accuracy: 0.5542** |  |
| **Epoch 49/100** |  |  |
| **23/23 [==============================]** | **- ETA: 0s - loss: 0.4436** | **-** |
| **accuracy: 0.6041** |  |  |
| **Epoch 49: val\_loss did not improve from** | **0.47868** |  |
| **23/23 [==============================]** | **- 22s 951ms/step - loss:** | **0.4432** |
| **- accuracy: 0.6045 - val\_loss: 0.5058 -** | **val\_accuracy: 0.5753** |  |
| **Epoch 50/100** |  |  |
| **23/23 [==============================]** | **- ETA: 0s - loss: 0.4435** | **-** |
| **accuracy: 0.6033** |  |  |
| **Epoch 50: val\_loss did not improve from** | **0.47868** |  |
| **23/23 [==============================]** | **- 22s 949ms/step - loss:** | **0.4441** |
| **- accuracy: 0.6043 - val\_loss: 0.6037 -** | **val\_accuracy: 0.5473** |  |
| **Epoch 51/100** |  |  |
| **23/23 [==============================]** | **- ETA: 0s - loss: 0.4382** | **-** |
| **accuracy: 0.6069** |  |  |
| **Epoch 51: val\_loss did not improve from** | **0.47868** |  |
| **23/23 [==============================]** | **- 22s 957ms/step - loss:** | **0.4383** |
| **- accuracy: 0.6067 - val\_loss: 0.5206 -** | **val\_accuracy: 0.6154** |  |
| **Epoch 52/100** |  |  |
| **23/23 [==============================]** | **- ETA: 0s - loss: 0.4293** | **-** |
| **accuracy: 0.6125** |  |  |
| **Epoch 52: val\_loss did not improve from** | **0.47868** |  |
| **23/23 [==============================]** | **- 23s 971ms/step - loss:** | **0.4284** |
| **- accuracy: 0.6123 - val\_loss: 0.4997 -** | **val\_accuracy: 0.5840** |  |

Epoch 53/100

23/23 [==============================] - ETA: 0s - loss: 0.4309 -

accuracy: 0.6109

Epoch 53: val\_loss improved from 0.47868 to 0.42987, saving model to ckpt

23/23 [==============================] - 52s 2s/step - loss: 0.4317 -

accuracy: 0.6094 - val\_loss: 0.4299 - val\_accuracy: 0.6062 Epoch 54/100

|  |  |  |
| --- | --- | --- |
| **23/23 [==============================]** | **- ETA: 0s - loss: 0.4292** | **-** |
| **accuracy: 0.6120** |  |  |
| **Epoch 54: val\_loss did not improve from** | **0.42987** |  |
| **23/23 [==============================]** | **- 22s 980ms/step - loss:** | **0.4309** |
| **- accuracy: 0.6115 - val\_loss: 0.6996 -** | **val\_accuracy: 0.5592** |  |
| **Epoch 55/100** |  |  |
| **23/23 [==============================]** | **- ETA: 0s - loss: 0.4225** | **-** |
| **accuracy: 0.6115** |  |  |
| **Epoch 55: val\_loss did not improve from** | **0.42987** |  |
| **23/23 [==============================]** | **- 22s 976ms/step - loss:** | **0.4224** |
| **- accuracy: 0.6102 - val\_loss: 0.5500 -** | **val\_accuracy: 0.5769** |  |
| **Epoch 56/100** |  |  |
| **23/23 [==============================]** | **- ETA: 0s - loss: 0.4220** | **-** |
| **accuracy: 0.6180** |  |  |
| **Epoch 56: val\_loss did not improve from** | **0.42987** |  |
| **23/23 [==============================]** | **- 23s 995ms/step - loss:** | **0.4236** |
| **- accuracy: 0.6169 - val\_loss: 0.5689 -** | **val\_accuracy: 0.5817** |  |
| **Epoch 57/100** |  |  |
| **23/23 [==============================]** | **- ETA: 0s - loss: 0.4173** | **-** |
| **accuracy: 0.6210** |  |  |
| **Epoch 57: val\_loss did not improve from** | **0.42987** |  |
| **23/23 [==============================]** | **- 22s 976ms/step - loss:** | **0.4161** |
| **- accuracy: 0.6217 - val\_loss: 0.4614 -** | **val\_accuracy: 0.6048** |  |
| **Epoch 58/100** |  |  |
| **23/23 [==============================]** | **- ETA: 0s - loss: 0.4183** | **-** |
| **accuracy: 0.6198** |  |  |
| **Epoch 58: val\_loss did not improve from** | **0.42987** |  |
| **23/23 [==============================]** | **- 23s 1s/step - loss: 0.4183 -** | |

accuracy: 0.6201 - val\_loss: 0.4372 - val\_accuracy: 0.6067 Epoch 59/100

23/23 [==============================] - ETA: 0s - loss: 0.4120 -

accuracy: 0.6251

Epoch 59: val\_loss did not improve from 0.42987

23/23 [==============================] - 23s 994ms/step - loss: 0.4136

* **accuracy: 0.6237 - val\_loss: 0.6183 - val\_accuracy: 0.5948**

Epoch 60/100

23/23 [==============================] - ETA: 0s - loss: 0.4090 -

accuracy: 0.6239

Epoch 60: val\_loss did not improve from 0.42987

23/23 [==============================] - 23s 980ms/step - loss: 0.4101

* **accuracy: 0.6225 - val\_loss: 0.5042 - val\_accuracy: 0.6161 Epoch 61/100**

23/23 [==============================] - ETA: 0s - loss: 0.4051 -

accuracy: 0.6314

Epoch 61: val\_loss did not improve from 0.42987

23/23 [==============================] - 23s 1s/step - loss: 0.4077 -

accuracy: 0.6296 - val\_loss: 0.5100 - val\_accuracy: 0.6128 Epoch 62/100

23/23 [==============================] - ETA: 0s - loss: 0.4016 -

accuracy: 0.6326

Epoch 62: val\_loss did not improve from 0.42987

23/23 [==============================] - 24s 1s/step - loss: 0.4029 -

accuracy: 0.6322 - val\_loss: 0.5295 - val\_accuracy: 0.6005 Epoch 63/100

23/23 [==============================] - ETA: 0s - loss: 0.4049 -

accuracy: 0.6323

Epoch 63: val\_loss did not improve from 0.42987

23/23 [==============================] - 23s 981ms/step - loss: 0.4069

* **accuracy: 0.6316 - val\_loss: 0.5103 - val\_accuracy: 0.6088 Epoch 64/100**

23/23 [==============================] - ETA: 0s - loss: 0.3951 -

accuracy: 0.6335

Epoch 64: val\_loss did not improve from 0.42987

23/23 [==============================] - 22s 981ms/step - loss: 0.3943

* **accuracy: 0.6341 - val\_loss: 0.5366 - val\_accuracy: 0.5869 Epoch 65/100**

23/23 [==============================] - ETA: 0s - loss: 0.3967 -

accuracy: 0.6344

Epoch 65: val\_loss improved from 0.42987 to 0.40702, saving model to ckpt

23/23 [==============================] - 53s 2s/step - loss: 0.3972 -

accuracy: 0.6352 - val\_loss: 0.4070 - val\_accuracy: 0.6452 Epoch 66/100

23/23 [==============================] - ETA: 0s - loss: 0.3942 -

accuracy: 0.6351

Epoch 66: val\_loss did not improve from 0.40702

23/23 [==============================] - 22s 961ms/step - loss: 0.3954

* **accuracy: 0.6337 - val\_loss: 0.4963 - val\_accuracy: 0.6039**

Epoch 67/100

23/23 [==============================] - ETA: 0s - loss: 0.3884 -

accuracy: 0.6409

Epoch 67: val\_loss did not improve from 0.40702

23/23 [==============================] - 22s 951ms/step - loss: 0.3879

* **accuracy: 0.6424 - val\_loss: 0.4651 - val\_accuracy: 0.6276 Epoch 68/100**

23/23 [==============================] - ETA: 0s - loss: 0.3876 -

accuracy: 0.6398

Epoch 68: val\_loss improved from 0.40702 to 0.38016, saving model to ckpt

23/23 [==============================] - 52s 2s/step - loss: 0.3870 -

accuracy: 0.6388 - val\_loss: 0.3802 - val\_accuracy: 0.6614 Epoch 69/100

|  |  |  |
| --- | --- | --- |
| **23/23 [==============================]** | **- ETA: 0s - loss: 0.3897** | **-** |
| **accuracy: 0.6394** |  |  |
| **Epoch 69: val\_loss did not improve from** | **0.38016** |  |
| **23/23 [==============================]** | **- 22s 961ms/step - loss:** | **0.3895** |
| **- accuracy: 0.6395 - val\_loss: 0.4046 -** | **val\_accuracy: 0.6587** |  |
| **Epoch 70/100** |  |  |
| **23/23 [==============================]** | **- ETA: 0s - loss: 0.3855** | **-** |
| **accuracy: 0.6433** |  |  |
| **Epoch 70: val\_loss did not improve from** | **0.38016** |  |
| **23/23 [==============================]** | **- 22s 967ms/step - loss:** | **0.3870** |
| **- accuracy: 0.6432 - val\_loss: 0.4162 -** | **val\_accuracy: 0.6475** |  |
| **Epoch 71/100** |  |  |
| **23/23 [==============================]** | **- ETA: 0s - loss: 0.3828** | **-** |
| **accuracy: 0.6422** |  |  |
| **Epoch 71: val\_loss did not improve from** | **0.38016** |  |
| **23/23 [==============================]** | **- 23s 986ms/step - loss:** | **0.3828** |
| **- accuracy: 0.6423 - val\_loss: 0.4099 -** | **val\_accuracy: 0.6612** |  |
| **Epoch 72/100** |  |  |
| **23/23 [==============================]** | **- ETA: 0s - loss: 0.3825** | **-** |
| **accuracy: 0.6460** |  |  |
| **Epoch 72: val\_loss did not improve from** | **0.38016** |  |
| **23/23 [==============================]** | **- 24s 1s/step - loss: 0.3831 -** | |

accuracy: 0.6449 - val\_loss: 0.5160 - val\_accuracy: 0.6117 Epoch 73/100

23/23 [==============================] - ETA: 0s - loss: 0.3795 -

accuracy: 0.6451

Epoch 73: val\_loss did not improve from 0.38016

23/23 [==============================] - 23s 1s/step - loss: 0.3797 -

accuracy: 0.6448 - val\_loss: 0.4963 - val\_accuracy: 0.6231

|  |  |  |
| --- | --- | --- |
| **Epoch 74/100**  **23/23 [==============================]** | **- ETA: 0s - loss: 0.3769** | **-** |
| **accuracy: 0.6479** |  |  |
| **Epoch 74: val\_loss did not improve from** | **0.38016** |  |
| **23/23 [==============================]** | **- 22s 975ms/step - loss:** | **0.3783** |
| **- accuracy: 0.6459 - val\_loss: 0.4888 -** | **val\_accuracy: 0.6084** |  |
| **Epoch 75/100** |  |  |
| **23/23 [==============================]** | **- ETA: 0s - loss: 0.3719** | **-** |
| **accuracy: 0.6541** |  |  |
| **Epoch 75: val\_loss did not improve from** | **0.38016** |  |
| **23/23 [==============================]** | **- 22s 971ms/step - loss:** | **0.3724** |
| **- accuracy: 0.6538 - val\_loss: 0.5175 -** | **val\_accuracy: 0.6032** |  |
| **Epoch 76/100** |  |  |
| **23/23 [==============================]** | **- ETA: 0s - loss: 0.3697** | **-** |
| **accuracy: 0.6555** |  |  |
| **Epoch 76: val\_loss did not improve from** | **0.38016** |  |
| **23/23 [==============================]** | **- 23s 1s/step - loss: 0.3687 -** | |
| **accuracy: 0.6548 - val\_loss: 0.4598 - val\_accuracy: 0.6059 Epoch 77/100** | |  |
| **23/23 [==============================]** | **- ETA: 0s - loss: 0.3702** | **-** |
| **accuracy: 0.6552** |  |  |
| **Epoch 77: val\_loss did not improve from** | **0.38016** |  |
| **23/23 [==============================]** | **- 22s 954ms/step - loss:** | **0.3713** |
| **- accuracy: 0.6540 - val\_loss: 0.5650 -** | **val\_accuracy: 0.5824** |  |
| **Epoch 78/100** |  |  |
| **23/23 [==============================]** | **- ETA: 0s - loss: 0.3685** | **-** |
| **accuracy: 0.6548** |  |  |
| **Epoch 78: val\_loss did not improve from** | **0.38016** |  |
| **23/23 [==============================]** | **- 23s 982ms/step - loss:** | **0.3675** |
| **- accuracy: 0.6557 - val\_loss: 0.4115 -** | **val\_accuracy: 0.6292** |  |
| **Epoch 79/100** |  |  |
| **23/23 [==============================]** | **- ETA: 0s - loss: 0.3659** | **-** |
| **accuracy: 0.6584** |  |  |
| **Epoch 79: val\_loss did not improve from** | **0.38016** |  |
| **23/23 [==============================]** | **- 22s 970ms/step - loss:** | **0.3662** |
| **- accuracy: 0.6577 - val\_loss: 0.3868 -** | **val\_accuracy: 0.6516** |  |
| **Epoch 80/100** |  |  |
| **23/23 [==============================]** | **- ETA: 0s - loss: 0.3626** | **-** |
| **accuracy: 0.6628** |  |  |
| **Epoch 80: val\_loss did not improve from** | **0.38016** |  |
| **23/23 [==============================]** | **- 23s 994ms/step - loss:** | **0.3627** |
| **- accuracy: 0.6638 - val\_loss: 0.4733 -** | **val\_accuracy: 0.6388** |  |
| **Epoch 81/100** |  |  |

|  |  |  |
| --- | --- | --- |
| **23/23 [==============================]** | **- ETA: 0s - loss: 0.3623** | **-** |
| **accuracy: 0.6578** |  |  |
| **Epoch 81: val\_loss did not improve from** | **0.38016** |  |
| **23/23 [==============================]** | **- 22s 970ms/step - loss:** | **0.3621** |
| **- accuracy: 0.6577 - val\_loss: 0.5189 -** | **val\_accuracy: 0.5979** |  |
| **Epoch 82/100** |  |  |
| **23/23 [==============================]** | **- ETA: 0s - loss: 0.3603** | **-** |
| **accuracy: 0.6612** |  |  |
| **Epoch 82: val\_loss did not improve from** | **0.38016** |  |
| **23/23 [==============================]** | **- 23s 982ms/step - loss:** | **0.3600** |
| **- accuracy: 0.6614 - val\_loss: 0.4210 -** | **val\_accuracy: 0.6280** |  |
| **Epoch 83/100** |  |  |
| **23/23 [==============================]** | **- ETA: 0s - loss: 0.3608** | **-** |
| **accuracy: 0.6604** |  |  |
| **Epoch 83: val\_loss did not improve from** | **0.38016** |  |
| **23/23 [==============================]** | **- 23s 1s/step - loss: 0.3627 -** | |
| **accuracy: 0.6592 - val\_loss: 0.5621 - val\_accuracy: 0.6082 Epoch 84/100** | |  |
| **23/23 [==============================]** | **- ETA: 0s - loss: 0.3605** | **-** |
| **accuracy: 0.6640** |  |  |
| **Epoch 84: val\_loss did not improve from** | **0.38016** |  |
| **23/23 [==============================]** | **- 23s 998ms/step - loss:** | **0.3628** |
| **- accuracy: 0.6634 - val\_loss: 0.4241 -** | **val\_accuracy: 0.6462** |  |
| **Epoch 85/100** |  |  |
| **23/23 [==============================]** | **- ETA: 0s - loss: 0.3498** | **-** |
| **accuracy: 0.6713** |  |  |
| **Epoch 85: val\_loss did not improve from** | **0.38016** |  |
| **23/23 [==============================]** | **- 23s 976ms/step - loss:** | **0.3484** |
| **- accuracy: 0.6713 - val\_loss: 0.4425 -** | **val\_accuracy: 0.6489** |  |
| **Epoch 86/100** |  |  |
| **23/23 [==============================]** | **- ETA: 0s - loss: 0.3537** | **-** |
| **accuracy: 0.6663** |  |  |
| **Epoch 86: val\_loss did not improve from** | **0.38016** |  |
| **23/23 [==============================]** | **- 23s 1s/step - loss: 0.3543 -** | |
| **accuracy: 0.6656 - val\_loss: 0.4006 - val\_accuracy: 0.6716 Epoch 87/100** | |  |

23/23 [==============================] - ETA: 0s - loss: 0.3503 -

accuracy: 0.6698

Epoch 87: val\_loss did not improve from 0.38016

23/23 [==============================] - 23s 987ms/step - loss: 0.3493

* **accuracy: 0.6697 - val\_loss: 0.4375 - val\_accuracy: 0.6527 Epoch 88/100**

|  |  |  |
| --- | --- | --- |
| **23/23 [==============================]** | **- ETA: 0s - loss: 0.3497** | **-** |
| **accuracy: 0.6714** |  |  |
| **Epoch 88: val\_loss did not improve from** | **0.38016** |  |
| **23/23 [==============================]** | **- 23s 986ms/step - loss:** | **0.3495** |
| **- accuracy: 0.6710 - val\_loss: 0.5339 -** | **val\_accuracy: 0.6160** |  |
| **Epoch 89/100** |  |  |
| **23/23 [==============================]** | **- ETA: 0s - loss: 0.3500** | **-** |
| **accuracy: 0.6671** |  |  |
| **Epoch 89: val\_loss did not improve from** | **0.38016** |  |
| **23/23 [==============================]** | **- 22s 970ms/step - loss:** | **0.3501** |
| **- accuracy: 0.6666 - val\_loss: 0.4148 -** | **val\_accuracy: 0.6438** |  |
| **Epoch 90/100** |  |  |
| **23/23 [==============================]** | **- ETA: 0s - loss: 0.3494** | **-** |
| **accuracy: 0.6661** |  |  |
| **Epoch 90: val\_loss did not improve from** | **0.38016** |  |
| **23/23 [==============================]** | **- 23s 995ms/step - loss:** | **0.3529** |
| **- accuracy: 0.6647 - val\_loss: 0.4992 -** | **val\_accuracy: 0.6324** |  |
| **Epoch 91/100** |  |  |
| **23/23 [==============================]** | **- ETA: 0s - loss: 0.3479** | **-** |
| **accuracy: 0.6718** |  |  |
| **Epoch 91: val\_loss did not improve from** | **0.38016** |  |
| **23/23 [==============================]** | **- 23s 986ms/step - loss:** | **0.3482** |
| **- accuracy: 0.6715 - val\_loss: 0.6037 -** | **val\_accuracy: 0.6195** |  |
| **Epoch 92/100** |  |  |
| **23/23 [==============================]** | **- ETA: 0s - loss: 0.3436** | **-** |
| **accuracy: 0.6767** |  |  |
| **Epoch 92: val\_loss did not improve from** | **0.38016** |  |
| **23/23 [==============================]** | **- 22s 964ms/step - loss:** | **0.3452** |
| **- accuracy: 0.6764 - val\_loss: 0.4368 -** | **val\_accuracy: 0.6462** |  |
| **Epoch 93/100** |  |  |
| **23/23 [==============================]** | **- ETA: 0s - loss: 0.3377** | **-** |
| **accuracy: 0.6793** |  |  |
| **Epoch 93: val\_loss did not improve from** | **0.38016** |  |
| **23/23 [==============================]** | **- 23s 984ms/step - loss:** | **0.3372** |
| **- accuracy: 0.6795 - val\_loss: 0.5267 -** | **val\_accuracy: 0.6275** |  |
| **Epoch 94/100** |  |  |
| **23/23 [==============================]** | **- ETA: 0s - loss: 0.3433** | **-** |
| **accuracy: 0.6743** |  |  |
| **Epoch 94: val\_loss did not improve from** | **0.38016** |  |
| **23/23 [==============================]** | **- 22s 964ms/step - loss:** | **0.3453** |
| **- accuracy: 0.6736 - val\_loss: 0.4532 -** | **val\_accuracy: 0.6314** |  |
| **Epoch 95/100** |  |  |

23/23 [==============================] - ETA: 0s - loss: 0.3409 -

accuracy: 0.6780

Epoch 95: val\_loss did not improve from 0.38016

23/23 [==============================] - 23s 987ms/step - loss: 0.3407

* **accuracy: 0.6775 - val\_loss: 0.4901 - val\_accuracy: 0.6680 Epoch 96/100**

23/23 [==============================] - ETA: 0s - loss: 0.3378 -

accuracy: 0.6791

Epoch 96: val\_loss did not improve from 0.38016

23/23 [==============================] - 23s 991ms/step - loss: 0.3388

* **accuracy: 0.6793 - val\_loss: 0.5620 - val\_accuracy: 0.6063 Epoch 97/100**

23/23 [==============================] - ETA: 0s - loss: 0.3389 -

accuracy: 0.6763

Epoch 97: val\_loss improved from 0.38016 to 0.33265, saving model to ckpt

23/23 [==============================] - 53s 2s/step - loss: 0.3402 -

accuracy: 0.6765 - val\_loss: 0.3327 - val\_accuracy: 0.6854 Epoch 98/100

23/23 [==============================] - ETA: 0s - loss: 0.3408 -

accuracy: 0.6768

Epoch 98: val\_loss did not improve from 0.33265

23/23 [==============================] - 22s 974ms/step - loss: 0.3407

* **accuracy: 0.6766 - val\_loss: 0.4046 - val\_accuracy: 0.6695 Epoch 99/100**

23/23 [==============================] - ETA: 0s - loss: 0.3388 -

accuracy: 0.6795

Epoch 99: val\_loss did not improve from 0.33265

23/23 [==============================] - 23s 985ms/step - loss: 0.3394

* **accuracy: 0.6791 - val\_loss: 0.4475 - val\_accuracy: 0.6622 Epoch 100/100**

23/23 [==============================] - ETA: 0s - loss: 0.3358 -

accuracy: 0.6787

Epoch 100: val\_loss did not improve from 0.33265

23/23 [==============================] - 22s 968ms/step - loss: 0.3385

* **accuracy: 0.6773 - val\_loss: 0.3742 - val\_accuracy: 0.6796**

Visualize Metrics:

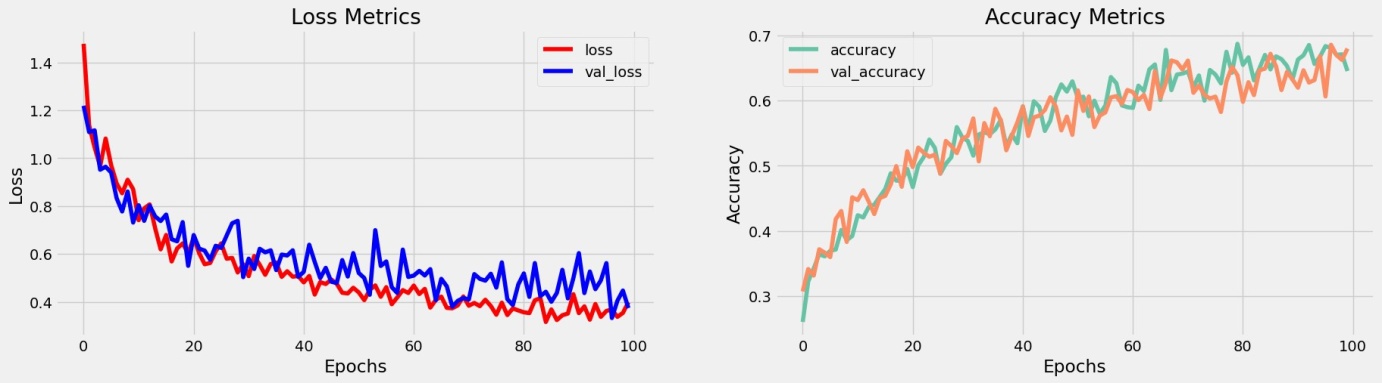
In[16]:

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()



**Out[16]:**

#### Save Model:

In[17]:

model.load\_weights('ckpt') model.save('models',save\_format='tf')

In[18]:

for idx,i in enumerate(model.layers):

print('Encoder layers:' if idx==0 else 'Decoder layers: ') for j in i.layers:

print(j)

print(' ')

**Out[18]:**

Encoder layers:

<keras.layers.core.embedding.Embedding object at 0x782084b9d190>

<keras.layers.normalization.layer\_normalization.LayerNormalization object at 0x7820e56f1b90>

<keras.layers.rnn.lstm.LSTM object at 0x7820841bd650>

Decoder layers:

<keras.layers.core.embedding.Embedding object at 0x78207c258590>

<keras.layers.normalization.layer\_normalization.LayerNormalization object at 0x78207c78bd10>

<keras.layers.rnn.lstm.LSTM object at 0x78207c258a10>

<keras.layers.core.dense.Dense object at 0x78207c2636d0>

#### Create Inference Model:

In[19]:

class ChatBot(tf.keras.models.Model):

def

\_\_init\_\_(self,base\_encoder,base\_decoder,\*args,\*\*kwargs): super().\_\_init\_\_(\*args,\*\*kwargs)

self.encoder,self.decoder=self.build\_inference\_model(base\_encoder,base\_ decoder)

def build\_inference\_model(self,base\_encoder,base\_decoder): encoder\_inputs=tf.keras.Input(shape=(None,)) x=base\_encoder.layers[0](encoder\_inputs) x=base\_encoder.layers[1](x) x,encoder\_state\_h,encoder\_state\_c=base\_encoder.layers[2](x)

encoder=tf.keras.models.Model(inputs=encoder\_inputs,outputs=[encoder\_st ate\_h,encoder\_state\_c],name='chatbot\_encoder')

decoder\_input\_state\_h=tf.keras.Input(shape=(lstm\_cells,)) decoder\_input\_state\_c=tf.keras.Input(shape=(lstm\_cells,)) decoder\_inputs=tf.keras.Input(shape=(None,)) x=base\_decoder.layers[0](decoder\_inputs) x=base\_encoder.layers[1](x)

x,decoder\_state\_h,decoder\_state\_c=base\_decoder.layers[2](x,initial\_stat e=[decoder\_input\_state\_h,decoder\_input\_state\_c])

decoder\_outputs=base\_decoder.layers[-1](x) decoder=tf.keras.models.Model(

inputs=[decoder\_inputs,[decoder\_input\_state\_h,decoder\_input\_state\_c]],

outputs=[decoder\_outputs,[decoder\_state\_h,decoder\_state\_c]],name='chatb ot\_decoder'

)

return encoder,decoder

def summary(self): self.encoder.summary() self.decoder.summary()

def softmax(self,z):

return np.exp(z)/sum(np.exp(z))

def sample(self,conditional\_probability,temperature=0.5): conditional\_probability =

np.asarray(conditional\_probability).astype("float64") conditional\_probability = np.log(conditional\_probability) /

temperature

reweighted\_conditional\_probability = self.softmax(conditional\_probability)

probas = np.random.multinomial(1, reweighted\_conditional\_probability, 1)

return np.argmax(probas)

def preprocess(self,text): text=clean\_text(text)

seq=np.zeros((1,max\_sequence\_length),dtype=np.int32) for i,word in enumerate(text.split()):

seq[:,i]=sequences2ids(word).numpy()[0] return seq

def postprocess(self,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) return text

def call(self,text,config=None): input\_seq=self.preprocess(text) states=self.encoder(input\_seq,training=False) target\_seq=np.zeros((1,1)) target\_seq[:,:]=sequences2ids(['<start>']).numpy()[0][0] stop\_condition=False

decoded=[]

while not stop\_condition:

decoder\_outputs,new\_states=self.decoder([target\_seq,states],training=Fa lse)

***#***

***index=tf.argmax(decoder\_outputs[:,-1,:],axis=-1).numpy().item()* index=self.sample(decoder\_outputs[0,0,:]).item() word=ids2sequences([index])**

if word=='<end> ' or len(decoded)>=max\_sequence\_length: stop\_condition=True

else:

decoded.append(index) target\_seq=np.zeros((1,1)) target\_seq[:,:]=index states=new\_states

return self.postprocess(ids2sequences(decoded))

chatbot=ChatBot(model.encoder,model.decoder,name='chatbot') chatbot.summary()

**Out[19]:**

Model: "chatbot\_encoder"

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Layer (type) Output Shape Param #

=================================================================

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **input\_1 (InputLayer)** | **[(None,** | **None)]** |  | **0** |
| **encoder\_embedding (Embeddin g)** | **(None,** | **None,** | **256)** | **625408** |
| **layer\_normalization (LayerN ormalization)** | **(None,** | **None,** | **256)** | **512** |
| **encoder\_lstm (LSTM)** | **[(None,** | **None,** | **256),** | **525312** |
|  | **(None,** | **256),** |  |  |
|  | **(None,** | **256)]** |  |  |

=================================================================

Total params: 1,151,232

Trainable params: 1,151,232

Non-trainable params: 0

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Model: "chatbot\_decoder"

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Layer (type) Output Shape Param # Connected to

=======================================================================

===========================

|  |  |  |  |
| --- | --- | --- | --- |
| **input\_4 (InputLayer)** | **[(None, None)]** | **0** | **[]** |
| **decoder\_embedding (Embedding)** | **(None, None, 256)** | **625408** |  |

['input\_4[0][0]']

layer\_normalization (LayerNorm (None, None, 256) 512 ['decoder\_embedding[0][0]']

alization)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **input\_2 (InputLayer)** | **[(None,** | **256)]** |  | **0** | **[]** |
| **input\_3 (InputLayer)** | **[(None,** | **256)]** |  | **0** | **[]** |
| **decoder\_lstm (LSTM)** | **[(None,** | **None,** | **256),** | **525312** |  |
| **['layer\_normalization[1][0]',** |  |  |  |  |  |
|  | **(None,** | **256),** |  |  |  |
| **'input\_2[0][0]',** |  |  |  |  |  |
|  | **(None,** | **256)]** |  |  |  |
| **'input\_3[0][0]']** |  |  |  |  |  |

decoder\_dense (Dense) (None, None, 2443) 627851 ['decoder\_lstm[0][0]']

=======================================================================

===========================

Total params: 1,779,083

Trainable params: 1,779,083

Non-trainable params: 0

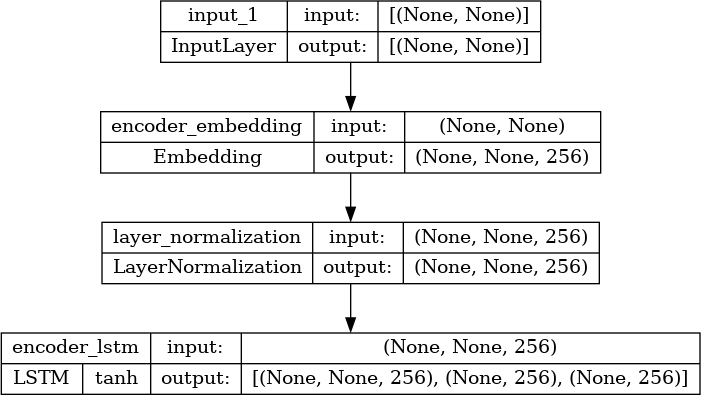
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

In[20]:

tf.keras.utils.plot\_model(chatbot.encoder,to\_file='encoder.png',show\_sh apes=True,show\_layer\_activations=True)

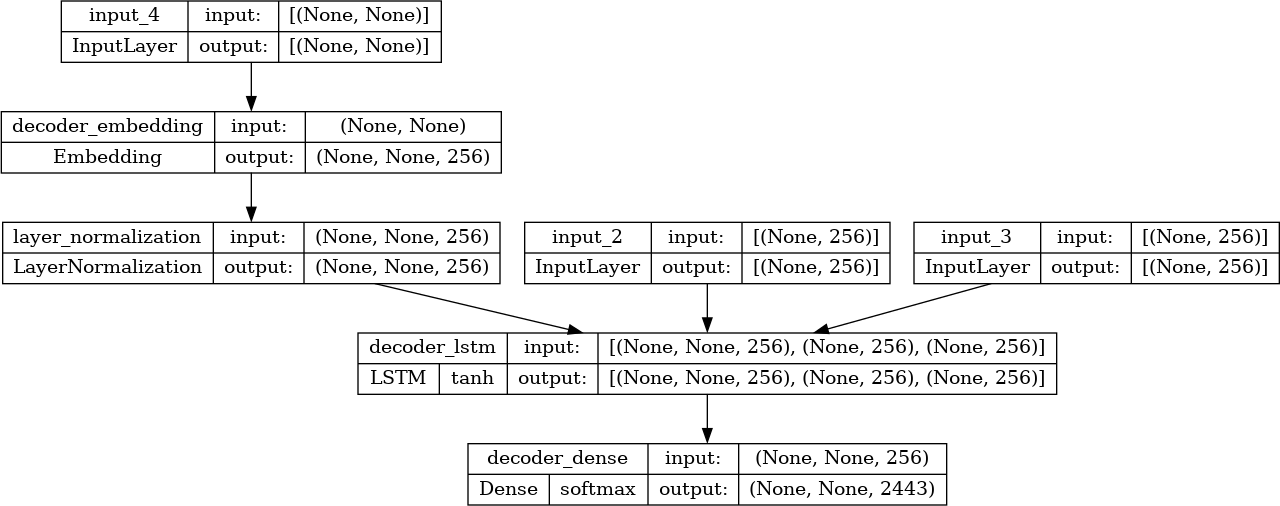
Out[20]:



**In[21]:**

tf.keras.utils.plot\_model(chatbot.decoder,to\_file='decoder.png',show\_sh apes=True,show\_layer\_activations=True)

**Out[21]:**



#### Time to Chat:

**In[22]:**

def print\_conversation(texts):

for text in texts: print(f'You: {text}')

print(f'Bot: {chatbot(text)}') print('========================')

In[23]:

print\_conversation([ 'hi',

'do yo know me?', 'what is your name?', 'you are bot?',

'hi, how are you doing?',

"i'm pretty good. thanks for asking.", "Don't ever be in a hurry",

***'''I'm gonna put some dirt in your eye '''*,**

***'''You're trash '''*,**

***'''I've read all your research on nano-technology '''*, *'''You want forgiveness? Get religion'''*,**

***'''While you're using the bathroom, i'll order some food.'''*, *'''Wow! that's terrible.'''*,**

***'''We'll be here forever.'''*,**

***'''I need something that's reliable.'''*,**

***'''A speeding car ran a red light, killing the girl.'''*, *'''Tomorrow we'll have rice and fish for lunch.'''*,**

***'''I like this restaurant because they give you free bread.'''***

])

**Out[23]:**

You: hi

Bot: i have to go to the bathroom.

========================

You: do yo know me?

Bot: yes, it's too close to the other.

========================

You: what is your name?

Bot: i have to walk the house.

========================

You: you are bot?

Bot: no, i have. all my life.

========================

You: hi, how are you doing? Bot: i'm going to be a teacher.

========================

You: i'm pretty good. thanks for asking.

Bot: no problem. i'll have to give you the english assignments from my mind.

========================

You: Don't ever be in a hurry Bot: it's not a great.

========================

You: I'm gonna put some dirt in your eye Bot: that's a good idea.

========================

You: You're trash

Bot: the tv news is reporting a bank robbery.

========================

You: I've read all your research on nano-technology Bot: it's the weather. i've gone around the world.

========================

You: You want forgiveness? Get religion Bot: no, i'll be my.

========================

You: While you're using the bathroom, i'll order some food. Bot: don't order for me. i've been a cheater.

========================

You: Wow! that's terrible.

Bot: never park your car under the house.

========================

You: We'll be here forever.

Bot: we'll be there in half an hour.

========================

You: I need something that's reliable. Bot: you need a car with low mileage.

========================

You: A speeding car ran a red light, killing the girl. Bot: what happened?

========================

You: Tomorrow we'll have rice and fish for lunch. Bot: i'll make a sandwich.

========================

You: I like this restaurant because they give you free bread. Bot: well, i think that's a good idea.

========================

## Chatbot benefits for businesses:

* + Improve service with every interaction.
  + Collect customer feedback.
  + Reduce customer requests.
  + Detect customer intent for added context.
  + Boost customer engagement.
  + Streamline service with routing and triage.
  + Boost sales.
  + Increase lead generat.

**CONCLUSION:**

* + Chatbots are conversational tools that perform routine tasks efficiently. People like them because they help them get through those tasks quickly so they can focus their attention on high-level, strategic, and engaging activities that require human capabilities that cannot be replicated by machines.
  + Users can easily type their query in natural language and retrieve information.
  + AI chatbots offered personalized, real-time feedback and on-demand support to users continuously and indefinitely.