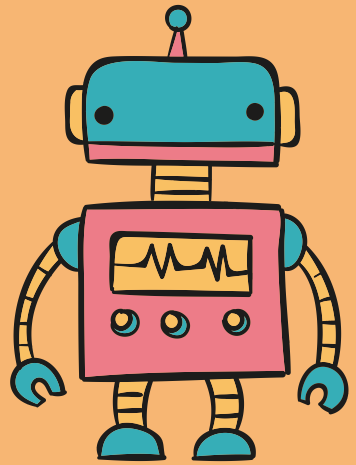
Developing a Bangla Chat Bot using Bidirectional LSTM Neural Network and Attention Mechanism



CSE 715: Neural Network and Fuzzy Systems

Project Group: 06

Group Members

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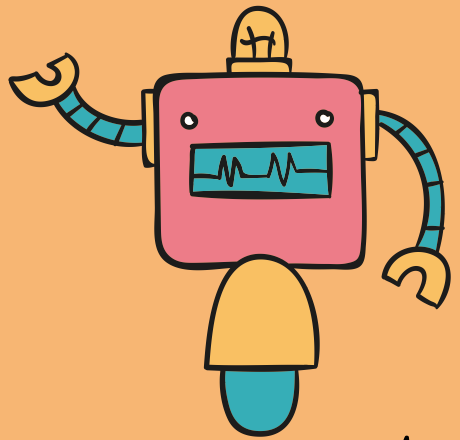

Overview

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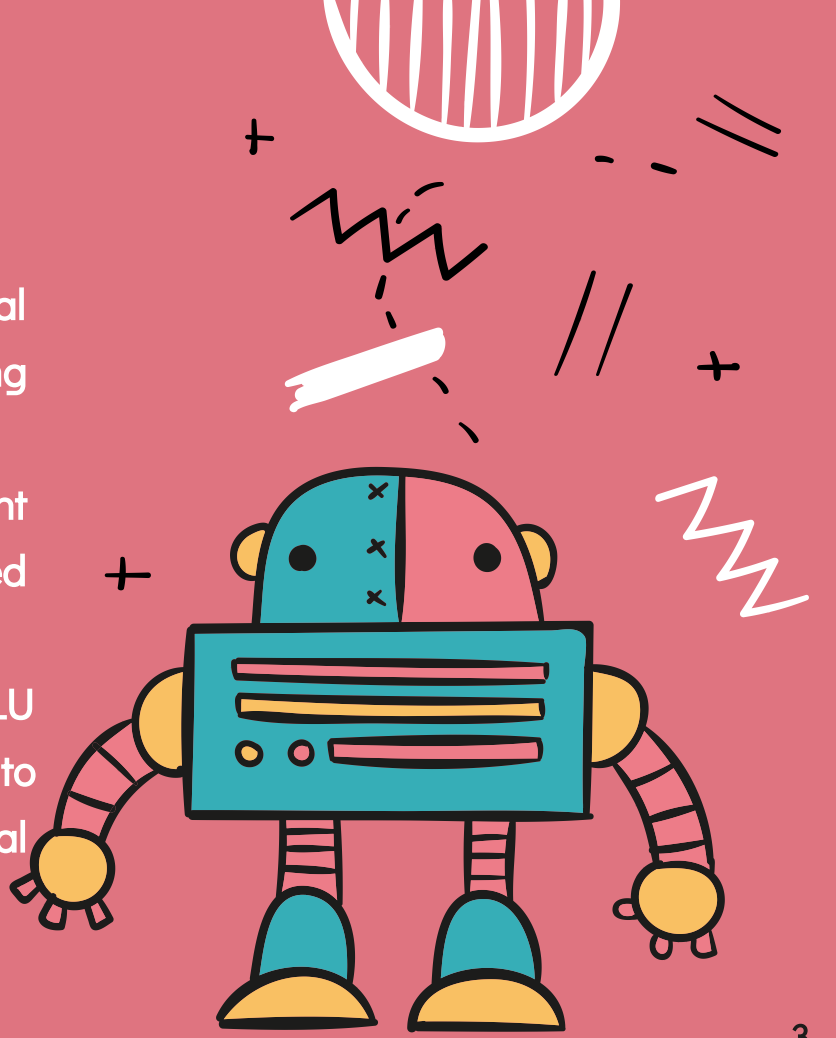
Introduction

- Conversational AI Agents strive to offer virtual assistant services through dialog systems using natural languages.
- Present chatbot systems often lack sufficient resources to support less commonly used languages, such as Bangla.
- Our goal is to construct a comprehensive NLU pipeline for a Bangla Chatbot, designed to function as a virtual assistant in professional settings.



Motivation

- Increased demand for virtual customer service
- To understand and respond to cultural nuances, idioms, and expressions specific to the Bengali culture.

Problem Statement

- For constructing a seamless end-to-end NLU pipeline for chatbots functioning as Business Assistants

Dataset Collection

A manual dataset creation process was undertaken to tailor specific conversational scenarios for the Bangla Chatbot

Bangla Dataset Collection

- Web Scraping from Financial Service FAQs
- Comprehension Based Question Answering Dataset
- Bangla Healthcare Dataset
- Bangla General Knowledge Dataset

English Dataset Collection

- English Conversations from ESL Websites
- Publicly Available English Seq2Seq Datasets

Custom Dataset Creation for Language Support

- To enrich our conversational datasets,we manually created "Greeting", "Time and Weather" question-answer pairs from scratch.
- Also introduced regional dialects of Sylhet and Chittagong.

Dialect	Question	Response
No Dialect	তুমি ভালো আছো আশা করি?	ভালো আছি, কিভাবে সাহায্য করতে পারি?
	কি খবর, আপনার?	আমি ভালো আছি আপনি?
Sylhet	তুই ভালা আসোস আশা খরি?	এইতো ভালা আসি, আফনেরে কেমনে সাহায্য খরতে ফারি?
	কিতা খবর, আফনার?	আমি ভালা, আফনে?
Chittagong	ভালা আছো আশা গরি?	ভালা আছি, অনেরে কেনে সাহায্য গরিত ফারি?
	কি হবর তোমার?	আয় ভালা আছি অনে?

Dataset Cleaning Process

Bangla

- Mobile Banking Dataset
- Healthcare Dataset
- General Knowledge Dataset
- Comprehension-Based Dataset

English

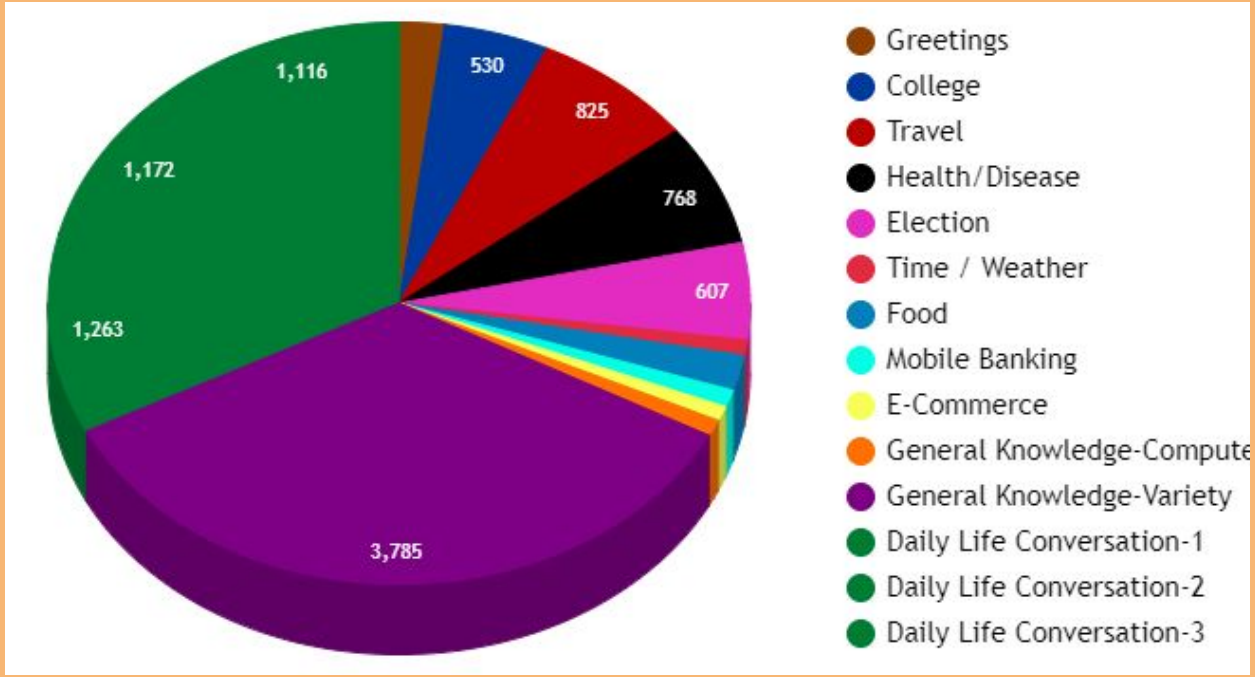
- ESL Website Conversations
- Kaggle Dataset Conversations

Translation & Revision

After removing unnecessary components, an Excel formula utilizing Google Translate was applied to translate the English texts into Bengali.

Dataset Distribution

Total Count - 12,687



Data Preprocessing

- Remove null values, multiple spaces and punctuations
- Remove '**Tag**' column
- Add special token in response শুরু, শেষ
- Fixed sentences word length to 30

	Queries	Response
0	এই যে	শুরু হাই আমি কীভাবে সাহায্য করতে পারি শেষ
1	হেলো	শুরু হ্যালো আমি আপনাকে কীভাবে সাহায্য করতে পার...
2	হ্যালো	শুরু হ্যালো আমি আপনার জন্য কী করতে পারি শেষ
3	হাই	শুরু হাই আমি আপনাকে কীভাবে সাহায্য করতে পারি শেষ
4	হে	শুরু হাই আমি আপনার জন্য কী করতে পারি শেষ

Tokenization

- Encoded each word into a unique numeric number
- Using texts_to_sequences method
- We added plus 1 for unknown word (zero padding) in vocab size

```
শুরু হাই আমি কীভাবে সাহায্য করতে পারি শেষ
শুরু হ্যালো আমি আপনাকে কীভাবে সাহায্য করতে পারি শেষ
শুরু হ্যালো আমি আপনার জন্য কী করতে পারি শেষ
শুরু হাই আমি আপনাকে কীভাবে সাহায্য করতে পারি শেষ
শুরু হাই আমি আপনার জন্য কী করতে পারি শেষ
[1, 371, 3, 223, 131, 15, 44, 2]
[1, 394, 3, 42, 223, 131, 15, 44, 2]
[1, 394, 3, 7, 19, 72, 15, 44, 2]
[1, 371, 3, 42, 223, 131, 15, 44, 2]
[1, 371, 3, 7, 19, 72, 15, 44, 2]
```

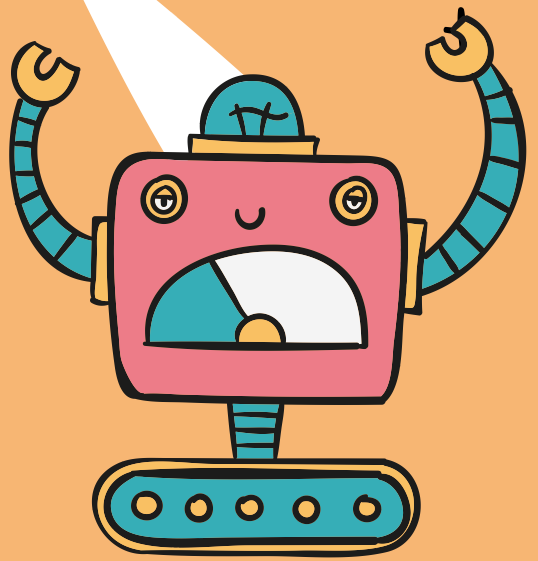
Padding

- In real-world sentences vary in length
- Padding ensure a consistent lengths
- Pad_sequences function padded with zeros
- Max length 30
- Post Padding

```
array([[   1,  371,    3, ...,    0,    0,    0],
       [   1,  394,    3, ...,    0,    0,    0],
       [   1,  394,    3, ...,    0,    0,    0],
       ...,
       [   1,  148, 8453, ...,    0,    0,    0],
       [   1, 8454,    2, ...,    0,    0,    0],
       [   1, 8455,    2, ...,    0,    0,    0]], dtype=int32)
```

Data Splitting

- Using train_test_split function
- Shuffling before the split
- 80% for training
- 20% for testing

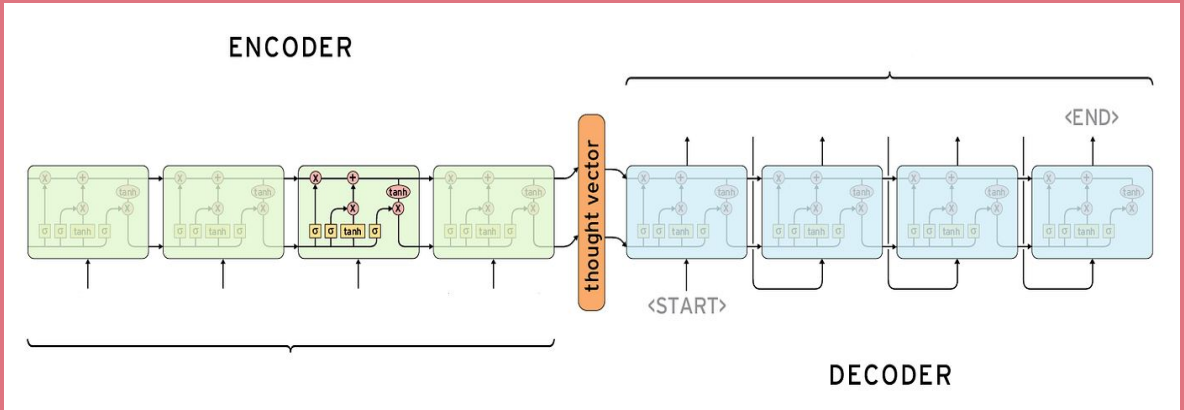


Embedding Layer

- Dimensionality reduction compared to one-hot encoding
- Transform sequences into dense vectors
- Transform into a vector with 1024 dimensions
- Applied for both encoder and decoder inputs

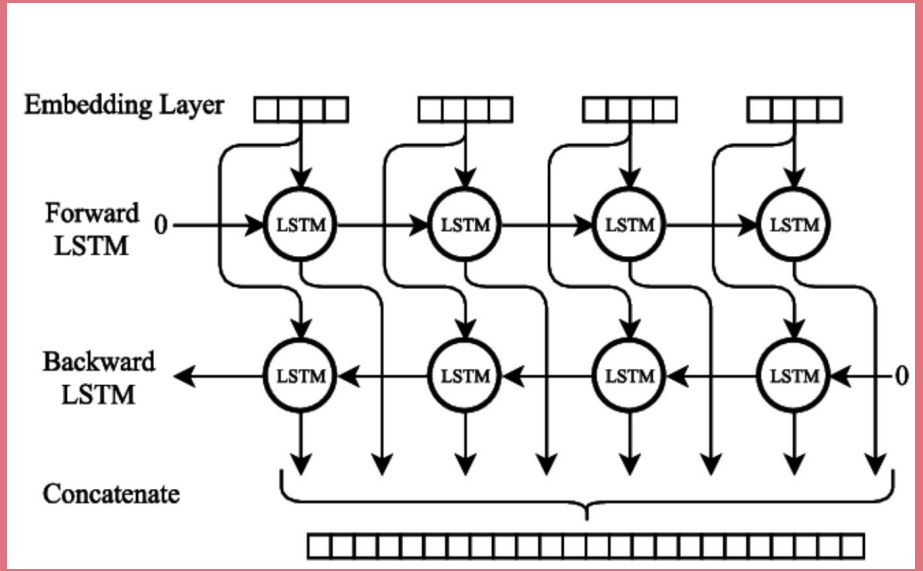
Encoder-Decoder Architecture

- Encoder generate a context vector and passed to decoder
- Bidirectional LSTM in encoder
- Single LSTM in decoder
- Teaching force technique



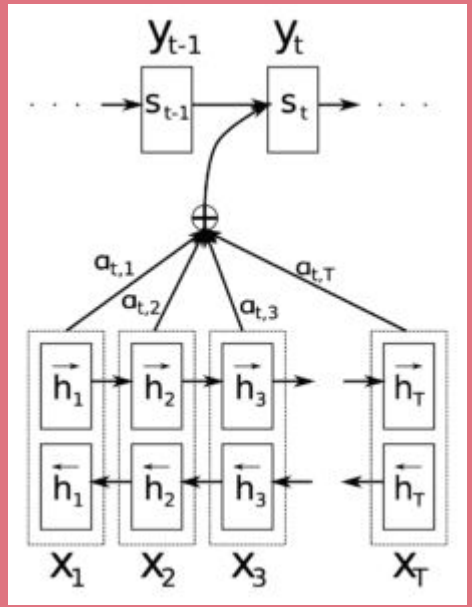
Bidirectional LSTM

- Traditional LSTMs have only a forward direction
- Used in Encoder layer
- Input is passed in forward and backward direction
- The final states [h, c] concatenated
- Context vector is passed to Decoder

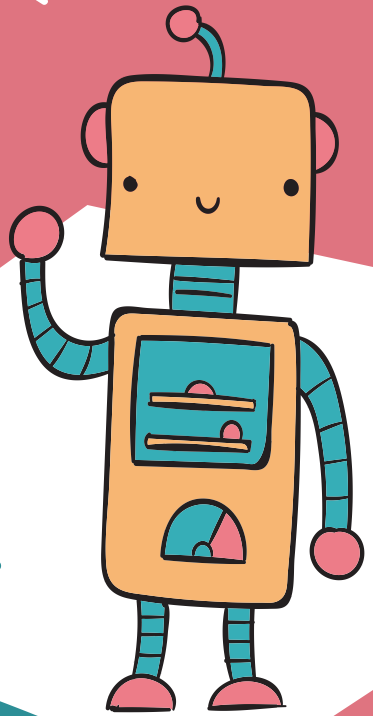


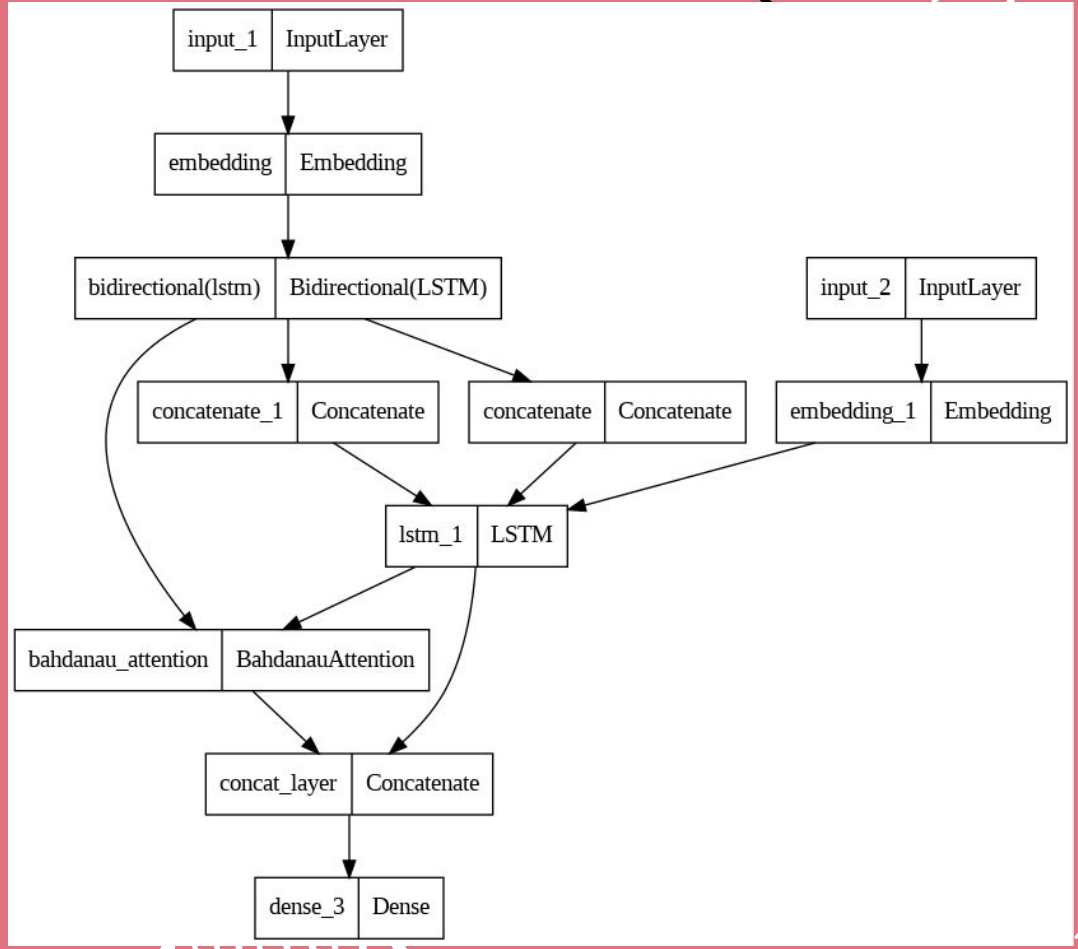
Bahdanau Attention Mechanism

- Generate context vectors and attention weights
- Attention output is used in the decoder layer
- Observes huge improvement in accuracy



Model Architecture

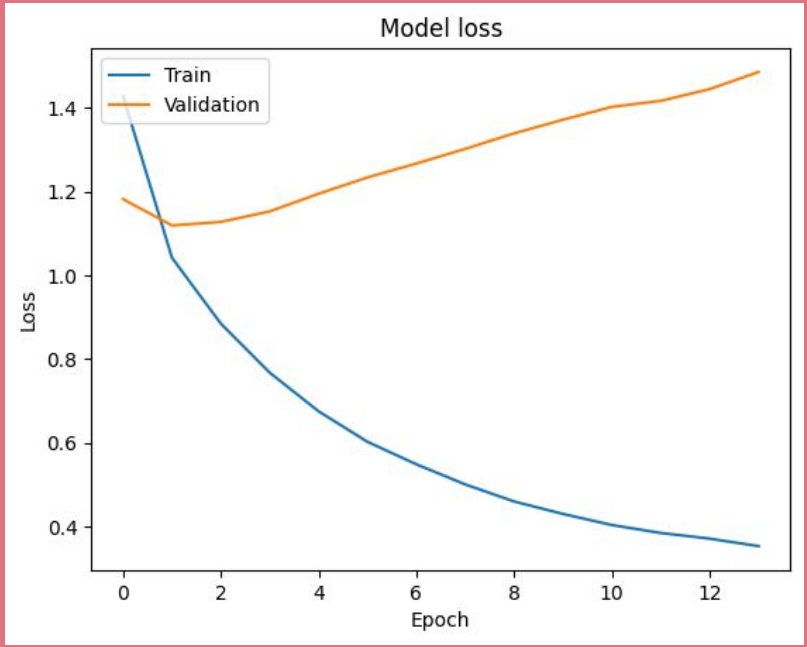


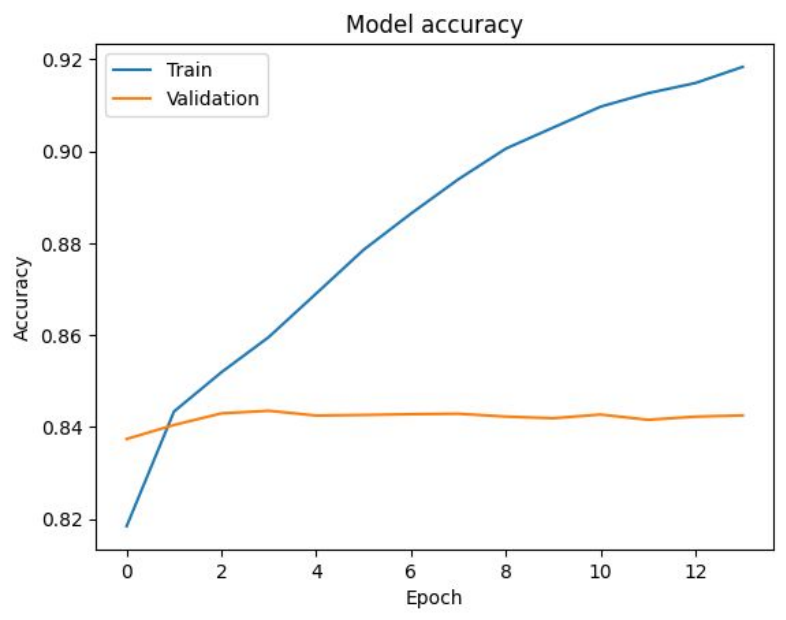


Hyperparameters

Hyperparameters	*Values*
Epochs	*100*
Batch Size	*64*
Loss Function	*Sparse Categorical Crossentropy*
Learning Rate	*0.01*
Optimizer	*Adam*
Monitor	*Test accuracy*
Patience	*10*

Result Analysis





Testing process

- Model predicts output sequences using weights learned during training
- Encoder model learns features in input sentences
- Decoder takes encoders states
- Model predicts using decoder inputs

Test Result **No Dialect**

```
Predicted Response:  আমি বিভিন্ন ধরনের গান শুনি।
যেমন কি, উদাহরণস্বরূপ?
1/1 [==============================] - 0s 28ms/step
1/1 [==============================] - 0s 25ms/step
1/1 [==============================] - 0s 32ms/step
1/1 [==============================] - 0s 25ms/step
1/1 [==============================] - 0s 25ms/step
1/1 [==============================] - 0s 24ms/step
1/1 [==============================] - 0s 26ms/step
Predicted Response:  না আমি এটা পছন্দ করিনি।
আমি রক এবং আরএন্ডবি উপভোগ করি।
1/1 [==============================] - 0s 44ms/step
1/1 [==============================] - 0s 37ms/step
1/1 [==============================] - 0s 28ms/step
1/1 [==============================] - 0s 35ms/step
Predicted Response:  এটা কেন
সঙ্গীত আপনার প্রিয় ধরনের কি?
1/1 [==============================] - 0s 30ms/step
1/1 [==============================] - 0s 26ms/step
1/1 [==============================] - 0s 25ms/step
1/1 [==============================] - 0s 26ms/step
1/1 [==============================] - 0s 25ms/step
1/1 [==============================] - 0s 27ms/step
1/1 [==============================] - 0s 24ms/step
Predicted Response:  আমি বিভিন্ন ধরনের গান শুনি।
আমি সব ধরনের গান শুনতে উপভোগ করি।
1/1 [==============================] - 0s 28ms/step
1/1 [==============================] - 0s 24ms/step
1/1 [==============================] - 0s 24ms/step
1/1 [==============================] - 0s 24ms/step
Predicted Response:  কি ধরনের
তারা যে ধরনের যন্ত্র ব্যবহার করে আমি তা পছন্দ করি।
1/1 [==============================] - 0s 65ms/step
1/1 [==============================] - 0s 38ms/step
1/1 [==============================] - 0s 39ms/step
1/1 [==============================] - 0s 37ms/step
1/1 [==============================] - 0s 38ms/step
1/1 [==============================] - 0s 37ms/step
1/1 [==============================] - 0s 40ms/step
Predicted Response:  আপনি কি এই ধরনের সঙ্গীত আগ
আমি মনে করি এটি কিছু পছন্দ করার একটি চমৎকার কারণ।
1/1 [==============================] - 0s 55ms/step
1/1 [==============================] - 0s 35ms/step
1/1 [==============================] - 0s 24ms/step
1/1 [==============================] - 0s 28ms/step
1/1 [==============================] - 0s 27ms/step
1/1 [==============================] - 0s 25ms/step
1/1 [==============================] - 0s 25ms/step
Predicted Response:  সঙ্গীত আপনার প্রিয় ধরনের কি
```

Test Result **With Sylhet Dialect**

```
হ্যালো খ্যামুন আছুইন?
1/1 [==============================] - 0s 35ms/step
1/1 [==============================] - 0s 29ms/step
1/1 [==============================] - 0s 28ms/step
1/1 [==============================] - 0s 28ms/step
Predicted Response:  ভালাই আসি
কিতা অবস্থা, আফনার?
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 20ms/step
Predicted Response:  ভালা
আফনে আমার ল্যাগা এখটা খাম করতে ফারবেন?
1/1 [==============================] - 0s 35ms/step
1/1 [==============================] - 0s 27ms/step
1/1 [==============================] - 0s 27ms/step
Predicted Response:  অয়
সিলোটি মাত্তা ফারোস নি?
1/1 [==============================] - 0s 28ms/step
1/1 [==============================] - 0s 29ms/step
1/1 [==============================] - 0s 27ms/step
1/1 [==============================] - 0s 27ms/step
1/1 [==============================] - 0s 27ms/step
Predicted Response:  জ্বি তুরা তুরা
দয়া করি আমার লগে সিলোটি ভাষায় খতা কউক্কা
1/1 [==============================] - 0s 19ms/step
1/1 [==============================] - 0s 19ms/step
1/1 [==============================] - 0s 19ms/step
Predicted Response:  অয়
তোমার খবর কিতা?
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 19ms/step
1/1 [==============================] - 0s 18ms/step
Predicted Response:  ভালা খবর
```

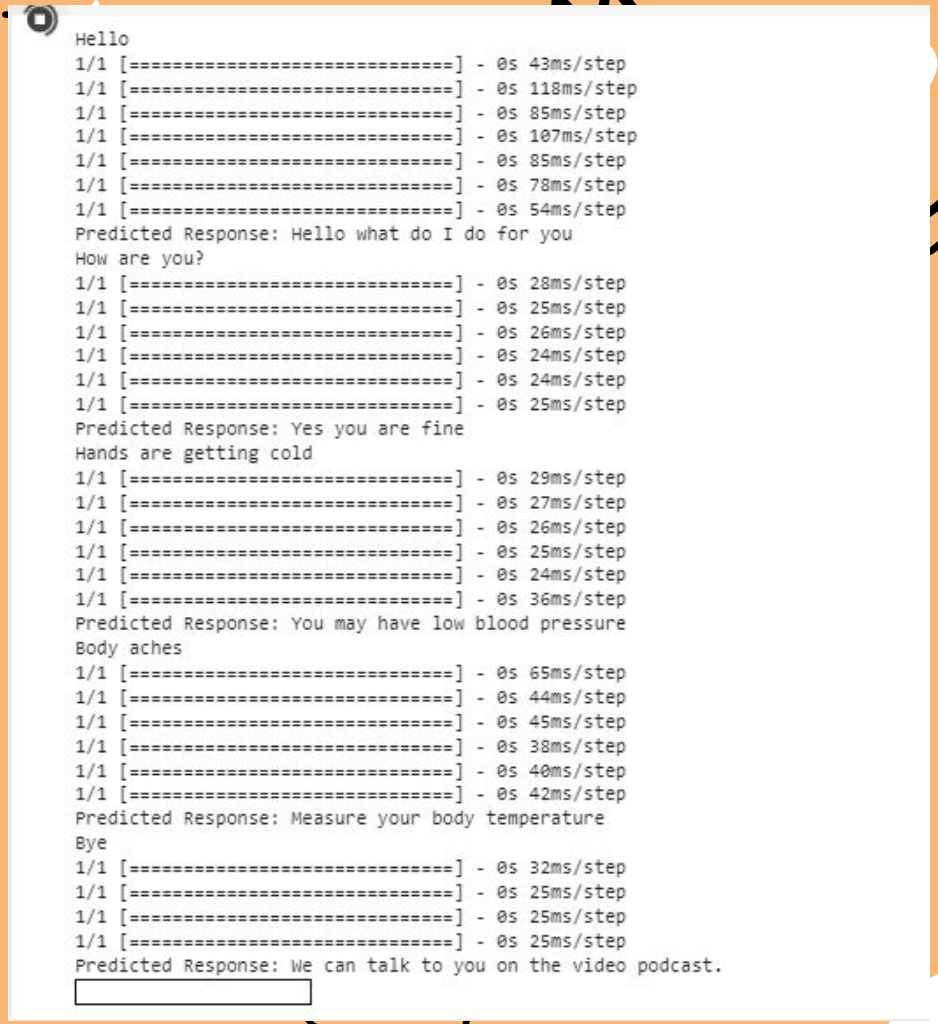
Test Result : **Chittagong Dialect**

```
কি অবস্থা অনের?
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 19ms/step
1/1 [==============================] - 0s 19ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 18ms/step
Predicted Response:  আয় ভালা আছি অনে
আমি ভালা আছি
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 23ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 20ms/step
Predicted Response:  হুনিয়েরে ভালা লাইজ্জি।
আর হথা কি বুঝা যার?
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 19ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 19ms/step
Predicted Response:  বুঝিবার চেস্টা গরির
আয় কী হইতে চাইন্দ ইবে বুঝিবার চেষ্টা গর
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 19ms/step
1/1 [==============================] - 0s 19ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 19ms/step
1/1 [==============================] - 0s 19ms/step
Predicted Response:  আরিক্কিনি সহজ সাবলীল ভাবে হই
হথা বন্ধ গইজ্জুন
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 19ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 18ms/step
Predicted Response:  ঠিক আছে অনেরে বিরক্তি গরি
বিদায় অনেরে ধইন্যবাদ
1/1 [==============================] - 0s 19ms/step
1/1 [==============================] - 0s 19ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 18ms/step
Predicted Response:  ফরে দেহা অইবু।
```

Test Result :
Voice Support
[Audio Input & Output]

Test Result:

Language Support : English



```
Hello
1/1 [==============================] - 0s 43ms/step
1/1 [==============================] - 0s 118ms/step
1/1 [==============================] - 0s 85ms/step
1/1 [==============================] - 0s 107ms/step
1/1 [==============================] - 0s 85ms/step
1/1 [==============================] - 0s 78ms/step
1/1 [==============================] - 0s 54ms/step
Predicted Response: Hello what do I do for you
How are you?
1/1 [==============================] - 0s 28ms/step
1/1 [==============================] - 0s 25ms/step
1/1 [==============================] - 0s 26ms/step
1/1 [==============================] - 0s 24ms/step
1/1 [==============================] - 0s 24ms/step
1/1 [==============================] - 0s 25ms/step
Predicted Response: Yes you are fine
Hands are getting cold
1/1 [==============================] - 0s 29ms/step
1/1 [==============================] - 0s 27ms/step
1/1 [==============================] - 0s 26ms/step
1/1 [==============================] - 0s 25ms/step
1/1 [==============================] - 0s 24ms/step
1/1 [==============================] - 0s 36ms/step
Predicted Response: You may have low blood pressure
Body aches
1/1 [==============================] - 0s 65ms/step
1/1 [==============================] - 0s 44ms/step
1/1 [==============================] - 0s 45ms/step
1/1 [==============================] - 0s 38ms/step
1/1 [==============================] - 0s 40ms/step
1/1 [==============================] - 0s 42ms/step
Predicted Response: Measure your body temperature
Bye
1/1 [==============================] - 0s 32ms/step
1/1 [==============================] - 0s 25ms/step
1/1 [==============================] - 0s 25ms/step
1/1 [==============================] - 0s 25ms/step
Predicted Response: We can talk to you on the video podcast.
```

Bug fixes

- Iterate over a tensor with unknown first dimension
- Attention output 1 tensor while you are expecting 2.
- Solution - (70% test accuracy)

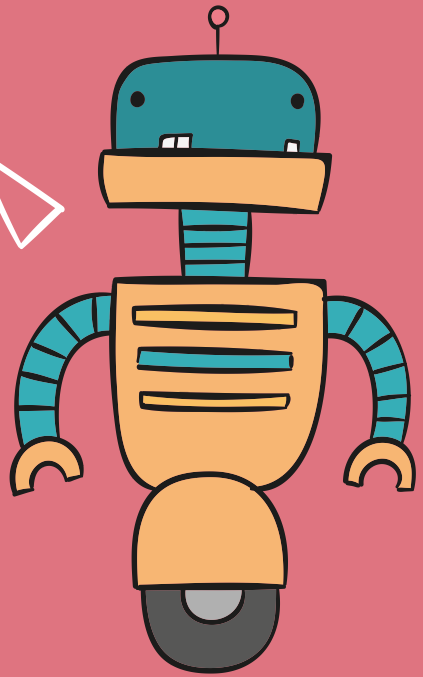
attn_out, attn_states = tf.keras.layers.Attention()([encoder_output, decoder_output])

to

attn_out = tf.keras.layers.Attention()([encoder_output, decoder_output])

Improvement

Using Bahdanau Attention Mechanism (84% test accuracy)



Challenges & Limitations

- Accuracy of Google Translations
- Unresolved Translation Issues
- Speech Support Accuracy
- Human Resource Constraints
- Large Sentences Prediction

Future Work

- Increase dataset size for better Accuracy
- Build an User Interface for convenient use
- Implement with Transformer, LLM models
- Use Multi-head attention mechanisms

Goals Achieved

Natural Language Understanding : **Model Accuracy above 84%**

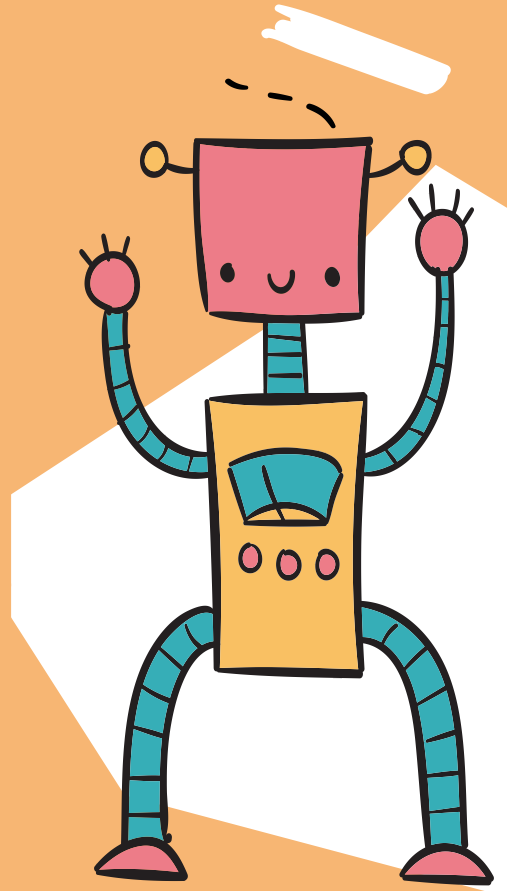
Contextual Conversation : **Accuracy around 80%**

Predefined Responses: **20+ Scenarios**

Dialect Support : **Sylhet and Chittagong**

Multimodal Input : **Voice Support [Audio Input & Output]**

Additional Language Support **English**



Thank You