

## A survey on Different Algorithms used in Chatbot

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**Abstract** - Machines are working similar to humans because of advanced technological concepts. Best example is chatbot which depends on advanced concepts in computer science. Chatbots serve as a medium for the communication between human and machine. There are a number of chatbots and design techniques available in market that perform different function and can be implemented in sectors like business sector, medical sector, farming etc. The technology used for the advancement of conversational agent is natural language processing (NLP). Due to these advancements in artificial intelligence concepts, the precision and perfection has been greatly improved, chatbots have become a good and optimal option for many organizations. There is also a chatbot system in the travel sector which collects user searches and provides appropriate search results, but still the research is going on to improve customer satisfaction. We introduce the background of chatbots so as to get an idea of how chatbots have been developed. This paper also gives a brief look on recent design techniques used and thus one can get to know what advancements can still be done in the chatbot system for various sectors.

**Key Words:** Artificial Intelligence, Chatbot, Natural Language Processing, LSTM, HEIM, Sequence to Sequence, RNN, Pattern Matching, Naïve Bayes.

### 1. INTRODUCTION

A bot is a software application that accomplishes computerized, robotic tasks and hence is used for work automation. A chatbot is a software that can converse with the users in natural language. For that purpose it makes the use of artificial intelligence. The main aim of chatbot is to converse with humans and with the help of that it makes many redundant task easy for humans. Nowadays, chatbots are used in number of sectors. Some of the popular sectors are used, educational, e-commerce, gaming and are also becoming competitors for various cab booking systems.

Basically chatbots have two types:

**Rule-based/Command based:** In these types of chatbots, predefined rules are stored which includes questions and answers. Based on what question has requested by the user chatbot searches for an answer. But this gives limitations on the type of questions and answers to be stored.

**Intelligent Chatbots/AI Chatbots:** To overcome the issue faced by rule based chatbots intelligent chatbots are developed. As these are based on advanced machine learning concepts, they have the ability to learn on their own depending on questions requested by the user.

Mostly it depends on for what purpose it's being used. Command-based or rule-based chatbots have a number of disadvantages but still they have advantages too. Number of companies depends on these chatbots as they provide guidance to focus on improving the experience of customers. Intelligent or AI chatbots are more convenient to use as they can handle simple as well as complex questions.

Chatbots which can reply through voice are becoming more popular due to the technologies like AI, ML etc. Chatbot provides an artificial service through which it can handle very difficult user queries of humans. Thus chatbots which interact via voice are equipt with advance features to respond to humans. Natural Language Processing (NLP) technology can understand all kinds of user requests along with their sentiments, and this widens the use chatbot.

Chatbots are not time bounded and hence can service the user anytime. Chatbots provides efficient customer service and thus benefits to businesses and companies. Businesses also don't have to pay much if they use chatbots instead of employees to sell their products. Thus chatbots thereby improves efficiency. Chatbots are also used in the real estate sector, education system, entertainment sector Apple Siri, Amazon Alexa, Facebook Messenger, WeChat are the examples of some famous chatbots.

In this paper, we are introducing a number of design techniques widely used by the chatbot These techniques

identified by us are , Sequence to Sequence model, pattern matching, LSTM, HEIM, Naive Bayes, and NLP.

## 2. BACKGROUND

The fascinating history of bots started way back in 1950's when Alan Turing (a British computer scientist) published an article 'Computing Machinery and Intelligence' followed by the Turing Test . This lead to further research and emphasis on the thought that 'Can machine think and converse like humans'. ELIZA and ALICE were two prominent research results which are explained below.

**ELIZA:** The concept of chatbot was first coined by MIT professor Joseph Weizenbaum in the year 1966. Carrying forward Turing thought Weizenbaum developed first chatbot called ELIZA which seemed to make user believe that they are actually conversing with a real human. ELIZA was basically developed to bridge the conversation gap between machine and humans. ELIZA simulates a psychotherapist and it does so by using pattern matching and substitution methodologies. 'Scripts' which were originally written in MAD-slip were used to direct ELIZA on how to interact with user. Eliza was also an early test case for Turing test, which is an Artificial Intelligence(AI) method which determines does computer has ability to think like human. However, ELIZA lacked to maintain conversation with humans or answer complicated questions.

**ALICE:** ALICE chatbot system which is an acronym for Artificial Linguistic Internet Computer Entity and was developed by Dr. Richard S. Wallace in the year 1995 [13]. ALICE is a chatbot which mainly focuses on the areas such as knowledge representation and algorithm like pattern matching algorithm. ALICE has won prizes such as Leobner thrice, thus it is an award winning chatbot with open source Natural Language Artificial Intelligence. ALICE is also called as a modified version of ELIZA chatbot system. To take the user inputs ALICE uses techniques like depth-first search [13].

AIML which is an acronym for Artificial Intelligent Mark-up Language. They are the files where the knowledge about the English conversation patter of ALICE is gathered. It is basically derived from XML which is an acronym for Extensible Mark-up language. [11] AIML also has its own templates which are used to produce response given to user's utterance and also dialogue history. The user sentence are taken as input by AIML first and then stored which is called as category. [11] Here, each category comprises of response template and a set of conditions which provide significance to the template and called as content. The model then influences it and compared to the decision tree nodes. Thus, the response is generated by the chatbot whenever user input gets matched. By using Recursive technique, the template in AIML repeats the input utterance generated by the user. However, the response generated is not meaningful every time.

### How is ALICE better than Eliza?

1) Both ALICE and Eliza uses techniques like pattern matching and knowledge representation but ALICE uses

simple pattern matching algorithm and also easy template pattern for representation of input and output. Also for simplifying the input ALICE uses recursive techniques.

2) The pattern matching algorithm used by ALICE is easy to implement and it depends on depth-first search.

### Drawbacks of ALICE chatbot :-

ALICE lacks behind in providing the relevant response and has no reasoning functionalities also it is not capable of generating human-like responses. Since for generating such response it requires huge number of categories for creating a robust bot but this may cause unfeasibility and difficulties to maintain and may lead to a time consuming application.

ALICE does not possess features such as grammatical and sentiment analysis also intelligent features like NLU, for structuring a particular sentence. During conversation whenever ALICE is provided with the same repetitive inputs most of the time it produces same response.

In upcoming years Artificial Intelligence AI came into existence. AI is a computer science area that affirm the development of intelligent machine which can response and work like humans. It can perform task like speech recognition, translation between language, decision making and visual perception. AI can provide human like response from every conversational chatbot. The chatbot can understand users query and can give accurate response.

## 3. OVERVIEW ON ALGORITHMS USED IN CHATBOT

### 3.1 Natural language processing (NLP) :-

Chatbot can answer users queries in natural language which is made possible by using an artificial intelligence term natural language processing or NLP. Natural language processing gives machine the ability to ingest the given input, break it down, extract it's meaning , determining appropriate action and answering user in there natural language.

Natural language processing (NLP) has two subsets Natural language understanding (NLU) and natural language generation (NLG).

NLU takes unstructured data as input and convert it into structured data so machine can understand and act upon it. NLU focuses on extracting the meaning from user input query.

Natural language generation (NLG) simply converts the answer generated by chatbot in structured data to human understandable natural language.

Natural language processing (NLP) does processing in 5 steps. The unstructured data is first passed for lexical analysis. The structure of words is analyzed and identified. The whole input text is divided into tokens. Then the tokens are passed to syntax analysis where tokens are analyzed for grammar and arranged in a way in which relationship among the word is easy to understood. Then the input is passed to semantic analysis. The meaning of words or tokens is extracted in this step. Object in task domain and mapping

syntactic structure are responsible for meaning extraction from input. Next step is discourse integration where the meaning of sentence is tried to extracted using the previous sentence meaning. Final step is pragmatic analysis. In this analysis, the main emphasis is on what was said is reinterpreted on what does it actually meant. After all this steps the meaning of sentence is known to machine and it finds answer to user query and passes it to Natural language generation (NLG) for generation of final output. Natural language processing (NLP) is used in many chatbot for effective communication with humans. Below figure 1 shows Basic working of chatbot using Natural language processing (NLP).



Figure 1: Understanding Language

### 3.2 Pattern Matching Algorithm:-

Pattern matching was one of the most used algorithms in chatbots Pattern Matching Algorithm contains questions and answers stored into a database. Questions are named as patterns whereas answers are named as templates. The answer for the particular question consists of Artificial Intelligent Mark-up Language (AIML) tags. Patterns and templates are stored in the form of a tree. Questions are on the branches and answers are at the nodes so whenever the question is asked by the user first that question is searched for an answer word by word, then it fetches the particular answer from the node. This type of structure is used in the ALICE chatbots. The advantage of this algorithm is that user can easily get answer to the question as it's already store. And thus it is widely used because of it's incomplextiy . This algorithm stores only particular types of questions and thus if any question other than the stored is asked by the user it would not be able to give an answer. And thus, it lacks self learning capability.

```
<aiml version="1.0.1" encoding="UTF-8?">
<category>
<pattern>Who is Narendra Modi</pattern>
<template>Narendra Modi is an Indian politician serving as the 14th and
current (2020) Prime Minister of India since 2014.</template>
</category>

<category>
<pattern>Do you know who * is</pattern>
<template>
<srai>Who is <star/></srai>
</templat>
</category>
</aiml>
```

Figure 2: AIML Structure

Figure 2 shows example explaining the working of pattern matching algorithm. In figure 2, the question 'Who is Narendra Modi' is stored into database on the branches of a hierarchical structure as each word on each branch. Then the answer for this question is stored into node. So,when the question like 'do you know who Narendra Modi is' is asked to the bot ,it will first search the 'who' and 'is' word then will search for 'Narendra' and then 'Modi'. Then it will fetch the answer stored into database and according to what type of bot it is, whether a chatbot or voice bot it will give an answer to the user accordingly.

The machine then produces:

Human: Who is Narendra Modi?

Robot: Narendra Modi is an Indian politician serving as the 14<sup>th</sup> and current(2020) Prime Minister of India since 2014.

### 3.3 Naive Bayes Algorithm:-

Naive Bayes is another efficient algorithm used for chatbot. In this algorithm the first step is tokenization and then stemming. In tokenization, the whole sentence is divided into words called tokens. Then each token is stemmed. For example 'have a great day' is tokenized and stemmed as 'have', 'a', 'great', 'day'. Next step is to give training data. This data is stored in the form of list or dictionaries where dictionary has class and sentence as attributes. For example, for the above sentence class will be 'greeting'. Then the data is organized by making the list of words of each class. When we give the input sentence it checks for each word and compares with all the tokens then it predicts which class has possibility of having the input sentence. There can be 2 or more predicted classes for each sentence we give as input so score is also calculated for each class. Then from those 2 or more classes 1 with highest score is selected. In this way this algorithm works.



Let's see in the above example, suppose we give more training data as-'Have a great day', 'Good morning', 'Hello there', 'is the weather rainy?', 'it is too cold today'. Suppose we give the input as 'Hii, good morning'.

Training data set:-

```
class:greeting
  'Have a great day'
  'Good morning'
  'Hello there'
class:weather
  'is the weather rainy?'
  'it is too cold today'
```

Input:-'Hii, good morning'

term:-Hii(no match)

term:-good(1match,class:greeting)

term:-morning(1 match, class : greeting).

Hence, output will be classifier :Greeting and score:2

The advantage of this algorithm is that if there are predefined classes it becomes easy to predict. But in case if the data given as input does not belong to any predefined class it becomes impossible to predict the output sentence. Hence because of this disadvantage it has limited usage.

### 3.4 The Sequence to Sequence Model(seq2seq):-

In Sequence to Sequence Model (seq2seq) model the model takes input as sequence of words or sentences and then generates an output which is sequence of words. This is done with the help of recurrent neural network (RNN).Hence input to this model is token of words and the output of this model is the translated token of words. The seq2seq model takes the current word or input along with the neighbouring words while translating it into output.

The seq2seq model has an encoder and a decoder. This task is sequence based. The encoder and decoder uses RNNs, LSTMs to process. The hidden state vector in this model can be of any size but in most of the cases it is taken as a power of 2 and a large number like 256, 512, 1024 which may represent the complexity of the complete sequence as well as the domain.

The recurrent neural networks (RNNs) takes inputs from the current example they are fed and also some inputs from the representation of the previous input. Thus, the output of seq2seq model at time T is dependent on the current input as well as the previous input that is at time T-1. This serves as the reason for the better performance of seq2seq model in sequence related tasks. The sequential information which is collected is stored in a hidden state vector of the network and then it is used in the next instance of the sequence.

As seq2seq model mainly has two components namely Encoder and Decoder so this model is also called as the Encoder-Decoder Network.

#### Role of Encoder:

The main motive of the encoder is to capture the context of the input sequence in the form of a hidden state vector and then the encoder feeds it to the decoder which at the last produces the output sequence. The encoder converts the input words to corresponding hidden vectors by using deep neural network layers. The current word and the context of the word is represented by each vector. The Encoder takes the sequence of words as an input and generates a final embedding words at the end of the sequence with the help of RNNs. This final embedding sequence of words is then sent to the Decoder. The Decoder uses it to predict a sequence, and after every successful predictions, it uses the previous hidden state vector to predict the next instance of the sequence.

#### Role of Decoder:

The input to decoder is the hidden vector which is generated and fed by Encoder. The decoder reverses the process of Encoder. It turns the hidden state vector fed by the encoder into an output sequence of words. It uses the previous output as the input context for doing this. It also uses its own hidden states and current word to predict the next word.

This model's different applications can be seen in conversational models, image captioning, text summarization etc.

#### Drawback of seq2seq model:

The output sequence of words in seq2seq model depends entirely on the context defined by the hidden state vector in the terminating output of the encoder. This brings difficulties for the seq2seq model to process long sentences which consist of long sequence of words. In such cases there is a strong possibility that the beginning context gets vanished by the end of the sequence.

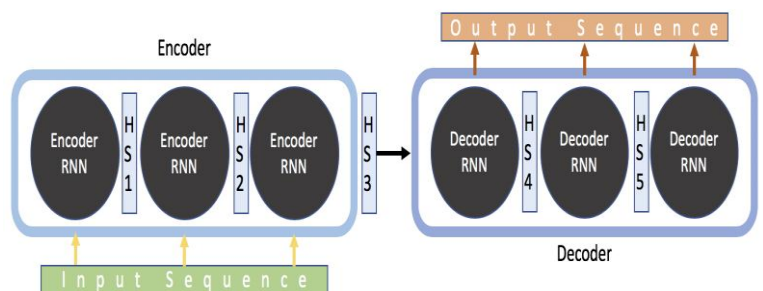


Figure 3: Seq2seq Model

### 3.5 Hybrid Emotion Interference Model (HEIM):-

Tone of voice, expression and even other information are factors that help humans to understand others emotions.

Humans can understand emotions through the tone of voices, expressions, body language along with some other information. In case of chatbot this can be made possible using model called Hybrid Emotion Interference Model (HEIM). HEIM model entails two different models, First model is Latent Dirichlet Allocation (LDA) and second is Long Short-Term Memory (LSTM) model.

Analogous to humans, machine can develop the proficiency to read, comprehend and derive meaning from human languages with an Artificial intelligence field called Natural language processing (NLP). LDA is a generative statistical model of NLP. LDA is used to extract text features of input text. LDA generates topics based on word frequency. LDA uses bag of words feature representation. LDA works by computing the probability that a word belongs to a topic. Table 1 shows an example of text processing done by LDA.

Original texts	When is our bus coming? When does the bus come to station 1? Is there still a city-bus today? When does a public transport go? I want a bus
Normalizing texts	when is our bus coming when does the bus come to station is there still a citybus today when does a public transport go i want a bus
Removing stopwords	bus coming bus come station still citybus today public transport go want bus
Stemming texts	bus come bus come station still citybus today public transport go want bus

Table 1: Processing example texts

LSTM is used to model the acoustic features of input text. LSTM does modeling of word-level audio features. LSTM is convenient to deal with time sequences like voices as it is capable of acquiring contextual dependencies.

The text information, the acoustic data of users' queries and query attributes are incorporated by HEIM in a joint framework. HEIM combines together LSTM generated high level delegation of acoustic features and the text features that are generated by LDA. To compute the probability of every emotion category HEIM feeds the combined output generated by LDA and LSTM to a softmax classifier. Softmax classifiers give probability for each class label while hinge loss gives you the margin. In some chatbot to improve efficiency a Recurrent Auto encoder Guided by Query Attributes (RAGQA)

which incorporates other emotion-related query attributes is used to pre-train LSTM.

HEIM is used in Sogou Voice Assistant (Chinese Siri).

### 3.6 Long Short Term memory(LSTM):-

LSTM an acronym for Long Short Term memory is an Artificial RNN that is Recurrent Neural Network. LSTM provide great advantage not only in processing the single data input like images but also the entire sequence of data like speech or video. Handwriting recognition and Speech recognition are the major task done by LSTM algorithm. LSTM in chatbot is mainly used for speech recognition. LSTM algorithm is best-suited in classifying techniques, processing, making prediction's based on time series data. They were specially developed for solving vanishing gradient problems.

LSTM takes vector data as input. So before actually using LSTM algorithm the text input is first converted into vector form. The process of converting text data into vector is called as word embedding and it can be done using skip-gram. Later when the text is converted into vector form, it is passed to LSTM algorithm as an input for further processing. LSTM algorithm comprises of three gates such as input gate, forget gate, and output gate. It also consists of cell memory, tanh activation function and sigmoid activation function. [17] There are various stacked blocks of LSTM where each block takes three inputs  $e_t$ ,  $c_{t-1}$  and  $h_{t-1}$ , here  $c_{t-1}$  and  $h_{t-1}$  are input from earlier step. Thus, finally the output is computed that is  $h_t$ . Below Figure 4 shows the computation of  $h_t$ .

$$\begin{aligned}
 i_t &= \sigma(W_{ei}e_t + W_{hi}h_{t-1} + b_i) \\
 f_t &= \sigma(W_{ef}e_t + W_{hf}h_{t-1} + b_f) \\
 c_t &= f_t \cdot c_{t-1} + i_t \cdot \tanh(W_{ec}e_t + W_{hc}h_{t-1} + b_c) \\
 o_t &= \sigma(W_{eo}e_t + W_{ho}h_{t-1} + b_o) \\
 h_t &= o_t \cdot \tanh(c_t)
 \end{aligned}$$

$e_t$  = input vector  
 $c_{t-1}$  = previous cell output  
 $h_{t-1}$  = previous cell output  
 $h_t$  = current cell output  
 $c_t$  = current cell memory  
 $W_e, W_h$  = Weight vector for input, output, forget gate and candidate c. They are different weights for different gates and candidate c

Figure 4: Computation of  $h_t$  based on the formulae

#### How is LSTM better than Simple RNN?

Simple RNN is nothing but the product of input  $x_t$  and earlier output  $h_{t-1}$  which further passed to activation function tanh. Here there no gates present as like LSTM algorithm. Whereas LSTM is the updated version of RNN which actually solve the problem of vanishing data by maintaining in addition the three gates input gate  $i_t$ , output gate  $o_t$ , and forget gate  $f_t$  also the cell vector  $c_t$ .

The following table 1 shows the time (in second) required to compute the output for one phrase question by Simple RNN and LSTM [15]. In Table 2 we can see slight difference in computing time between Simple RNN and LSTM. The time difference in random but it is relatively small.

Question	Simple RNN (time in second)	LSTM (time in second)
Hello	0.09	0.83
Morning	1.12	1.10
Noon	1.10	0.90

Table 2: One Phrase Question Test

The following table 3 shows the time (in second) required to compute the output for more than one phrase question by Simple RNN and LSTM [15]. In table 2 we can see LSTM works better than Simple RNN for more than one Phrase. This is because LSTM is created to recognize the word order while Simple RNN algorithm treats every word independently. Also, there is possibility that if less amount of training data is used then Simple RNN algorithm is incapable of reading the phrase pairs which usually occur. Thus, Simple RNN requires more time duration to respond to the question .So, LSTM algorithm provides more controllability and better results.

Question	Simple RNN (time in second)	LSTM (time in second)
Thank you for your help	0.92	1.00
I want to order a ticket	1.66	1.09
Is the ticket to Bangalore still available	2.05	1.19

Table 3: More than One Phrase Question Test

#### 4. CONCLUSIONS

Chatbots are widely in use now-a-days for various business or personal purpose. They brought a new way for businesses to communicate with their customers with the help of emerging technologies like Artificial Intelligence (AI).Not only chatbots can be used for customer support but also it can help users to act as their companion.

In this survey we studied several Deep learning techniques and algorithms like Natural Language Processing (NLP), Long Short-Term Memory(LSTM) and Hybrid Emotion Inference

Model (HEIM) to make the system with self-learning capabilities, user emotion analysis and also provide flexibility for chat interface. We completed the survey on how chatbots can produce more personalized and accurate predictions for a user while having an intelligent conversation in natural language. The Hybrid Emotion Inference Model (HEIM) which we studied can show great results on large real-world data sets.

#### 5. FUTURE SCOPE

While texting, we use tons of abbreviations and also lot of slang words. Sometimes autocorrect feature almost jumbles messages once during a while. The input to conversational agent can also be in form of sentence fragments. As we communicate so differently in various messaging apps from the way we do in spoken conversation, it is important that the chatbot should understand a message despite of containing errors in grammar or spelling in the conversation.

Thus, in future it would be possible to implement chatbot using slang language along with NLP concepts. Voice Dialogue Applications like chatbots recognize users emotions and generate responses which would be more humanized and would be capable of understanding users intention clearly and thus help in optimizing the bot-human interaction.

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