

Recent Deep Learning Based NLP Techniques for Chatbot Development: An Exhaustive Survey

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Abstract—Chatbots are becoming popular as many applications need it. E-commerce, aviation, supply chain management companies etc. are using AI based chatbots to attract customers. Deep learning is another vertical impacting chatbots' behavior by bringing it close to human physiology. Ways of interaction directly enhance the business productivity that is the main reason for the rise of chatbots. Chatbots are evolving with the use of emerging techniques. In this paper we are making a detailed study of recent deep learning techniques for chatbots. It will bring understanding of developers closer towards good chatbot design. We will cover current gaps and solutions to catalyze current research.

Keywords—Chatbots, Deep learning, Customer engagement, AI.

I. INTRODUCTION

With the advancement of emerging technologies, it is becoming increasingly simple for people to interact with machines in an effective manner. There are many applications called assistant through which a user can instruct a computer to do a specific task. This is especially beneficial for those users who find it difficult to give commands in writing such as in google. Although there exist several apps, chatbot is one of the software which is used widely by users. The chatbot can be defined as software which help humans to make coherent conversation with machines using natural language like English, etc [1]. The conversation can be engaging at times depending upon the size of vocabularies. In recent times the use of deep learning techniques has increased significantly by researchers and scientists to find new ways to solve current problems [2]. Deep learning techniques have been used in a wide variety of applications including chatbot. The chatbot is being used in several fields such as healthcare, education and E-service and assistant. Among other challenges in the development of a good chatbot the main challenge is to build a conversation chatbot. Though the field of natural language processing and deep learning has matured to some extent, a good conversation agent is still a challenge for the scientist and researchers [3].

In this paper, we discuss recently developed deep learning based natural language processing techniques for the development of the chatbot [4]. This exhaustive survey also focuses on how the advancement in AI, in particular deep learning, has deeply impacted the behavior of a chatbot and brought it closer to human physiology [5]. In the end

suggestions are provided on how to develop a good chatbot which includes qualities such as having human touch, making things easier for user, easy to use, having high level of precision, motivates user to talk, learn from the conversation, among others [6].

II. OVERVIEW OF CHATBOT

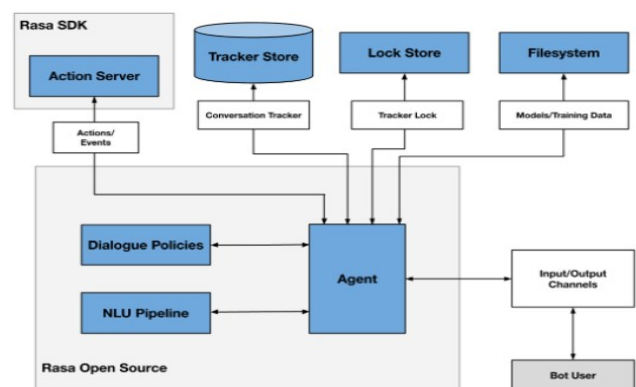


Fig. 1. RASA framework technical architecture

There are various open source platforms with extended paid services. One of the frameworks is **RASA** i.e. used by various developers to build the chatbot application Fig 1 [2]. There are various advantages of this framework. Easy to plug in, flexible and customizable, up to date configuration, easy to add in favorite platform, flawless intent support, strong learning, deployment support, analytics support etc [7]. makes it useful in all current scenarios [8]. Just like RASA there is another framework mentioned in Fig 2. Thirty-three Pre-built agents, Reusability and allotment texture, Simple import and dig out processes, Multiple language support, Integration with discussion channel, Software development kit for different programming languages, speech to text support, simple interface, easy to train makes it better for various development procedures [9].

A. Issues with chatbot framework

- It is extremely difficult to manage if the identical intent are there in the different perspective
- Hard to control the stream of the discussion and the bot tends to misinterpret the user needs

- **Restrictions of interpreting the synonyms and hyponyms**

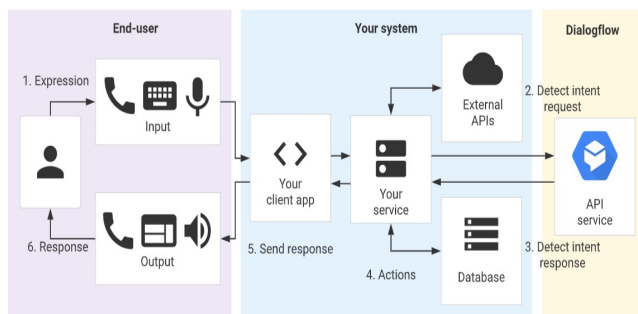


Fig. 2. Emerging deep learning NLP techniques for chatbot design

Deep learning is a branch of artificial intelligence which has been used in several areas. In recent times deep learning techniques have begun to use in the development of chatbot design [10]. In this section we discuss several prominent emerging deep learning techniques to build smart chatbot [11].

III. NATURAL LANGUAGE PROCESSING (NLP)

Natural language processing is a field of artificial intelligence widely used for processing human language to machine understandable language [12]. It has also begun to be used for the development of chatbot design in recent years. NLP is used to examine and interpret voice, handwritten text and speech by computer. Relevant information is collected regarding comprehension and usage of human language to build programs that can carry out a variety of tasks [13]. In this context, it is necessary to mention that the majority of NLP techniques rely on machine learning to perform their specific tasks [14].

A. Natural Language Understanding

In majority of chatbots natural language understanding is used to comprehend the context from the given user question in a language that can be easily understood by human beings and respond based on current user need [15]. **The three major problems raised during the NLU process are the mechanisms of thought, the interpretation, and the general knowledge of the user. Intent classification and entity extraction are two major components of natural language processing. The entity can be categorized as user defined or system defined [16].** On the other hand, context is the strings which are stored by objects and refers to user input. **For the building of intent classification machine learning algorithms such as support vector machines can be effectively used [17].**

B. Artificial Neural Network Artificial

Neural networks play a key role in the design of various types of chatbot [18]. For example, **retrieval and generative chatbots use ANN. It is worth mentioning the working of such a system briefly. The system takes the user input, transforms it into vector representation and provides it to the neural network and generates the response [19]. This process of converting words into vectors is called embedding and deep learning techniques are generally used in this context such as Word to Vec [20]. Retrieval based technique works by considering input vectors and intent and outputs the probability of every intent [21]. Generative-based chatbots**

are useful for involving a person in informal open-domain conversations [22].

C. Recurrent Neural Networks

The most striking feature of recurrent neural networks is its **ability to consider previous conversations in the current context to comprehend the user's query in an effective manner [23].** In other words, we can say the information is passed from one layer of the network to another layer [24].

D. Sequence to Sequence Model

The perfect exam of sequence-to-sequence model is **generative based model [25]. It works by creating a target sequence model using the source sequence model [26]. In this context, the source sequence model is the user's input, and the target sequence model is the response generated by a chatbot. Multiple recurrent neural networks can be employed which is the most basic version of the model [27].**

E. Deep Seq2seq Model

This model is generally used to create chatbots which perform like humans and are closer to human conversation [28]. **The unique feature of such a model is that they utilized more parameters for example having multiple layers of LSTM networks [29].**

IV. DEEP LEARNING IMPACT ON CHATBOT DESIGN

AI techniques involve Machine learning and Deep learning, impact of Deep learning techniques in the domain of NLP is very huge and evolving with time [30]. There are so networks that, as mentioned the previous section, created a wide difference in conversation patterns by learning the behavior of human conversation [31]. Role of data is also significant and various open source data sets are also available if anyone wants to develop a prototype Fig 3 [32]. Some algorithms like **BERT** are gaining popularity in the domain and impacting NLP activities [33].

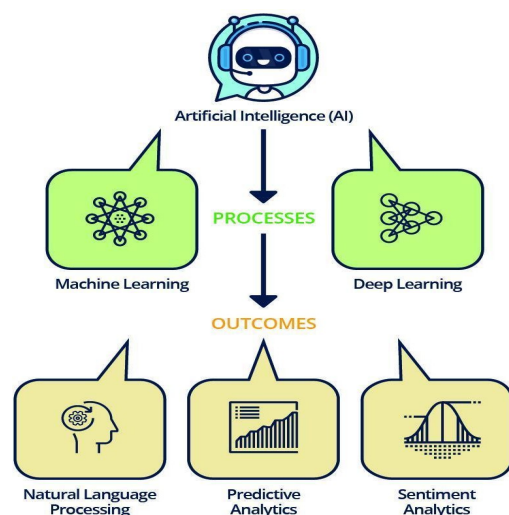


Fig. 3. Flow of AI impacting Chatbots Design

A. BERT

BERT Base contains twelve layers i.e. transformer blocks, twelve attention heads and one hundred ten million parameters [34]. BERT Large contains twenty four layers and sixteen attention heads with three hundred forty million

parameters [35]. Similar networks are emerging to make chatbot activities robust Fig 4 [36].

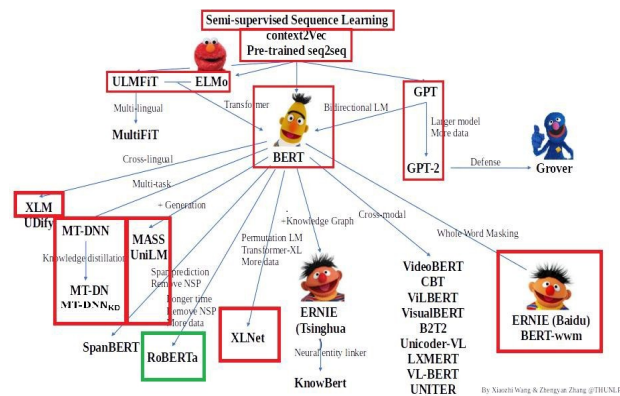


Fig. 4. BERT Algorithm Variants

B. Views on current state of Chatbot

The numerous advantages of chatbot to user such as 24*7 online support on a wide range of services, availability among others make it a perfect online assistant [37]. According to statistics reported in various reliable internet sources it is found that today 27% of consumers are interested in artificial intelligence support tools such as conversation agent, voice assistant, chatbot [38]. In yet another report it is found that 1.4 billion people are using chatbot in some way or other to solve their problem [39]. According to a survey a chatbot can answer 80% of the standard questions. In 2017, 34% of customers preferred to communicate with chatbots in online retail. 67% of users have used chatbots in the past year [40]. In yet another survey people said that the most striking feature of chatbot is 24-hour service. 37% of people takes the help of chatbot in an emergency to get a quick answer [41].

According to experts it would be hugely beneficial for a company to invest in AI based products such as chatbot to enhance user experience [42]. It is estimated that around 50% of organizations are planning to invest in chatbot development for customer support service and the remaining 40% are going to invest in virtual assistants. Chatbots will be a driving force for business communications with a worldwide market size of more than \$1.3 billion by 2024 [43].

The following statistics throw more light on the significance of chatbots in the future. 69% of users recommend chatbot due to their ability to provide quick responses as compared to human beings [44]. 95% of users will be benefit much from the chatbots. One of the main features of chatbot is that they create a link between a company and its customer which is also referred to as a technological link [45]. However, in a survey it was revealed that chatbots were found to be ineffective, in the sense that they provide bad suggestions, are creepy, unhelpful responses, unable to understand accents in some instances [46]. In the most recent report, it is found that chatbots help an organization to streamline their internal workflow [47]. In other words they help to answer questions, communicate with employee and help in completing HR related transactional functions. Chatbots will tremendously help businesses to increase their sale and as a result grow their revenue [48].

V. CONCLUSIONS

In this paper the impact of deep learning techniques for chatbots are discussed. After analyzing the correlation of deep learning and chatbots, it has been concluded that deep learning is drafting major improvements in conversational bots [49]. Still there are many challenges related to context and semantics in real time conversations. Research is going on to fill the gap in linguistic and AI domain. Global quest of finding human-like chatbots may be fulfilled in future with all these advancements [15]. Deep learning and Virtual reality will play an important role to take chatbots to the next level where human-like interaction is possible [50].

ACKNOWLEDGMENT

The authors would like to thank University of Raharja, Graphic Era Hill University for their support in providing a place for this research through analysis of research systems. This research received no external funding.

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