



A Smart Chatbot Architecture based NLP and Machine learning for health care assistance.

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ABSTRACT

A chatbot or conversational agent is a software that can communicate with a human by using natural language. One of the essential tasks in artificial intelligence and natural language processing is the modeling of conversation. Since the beginning of artificial intelligence, its been the hardest challenge to create a good chatbot. Although chatbots can perform many tasks, the primary function they have to play is to understand the utterances of humans and to respond to them appropriately. In the past, simple statistic methods or handwritten templates and rules were used for the constructions of chatbot architectures. With the increasing learning capabilities, end-to-end neural networks have taken the place of these models in around 2015. Especially now, the encoder-decoder recurrent model is dominant in the modeling of conversations. This architecture is taken from the neural machine translation domain, and it performed very well there. Until now, plenty of features and variations are introduced that have remarkably enhanced the conversational capabilities of chatbots.

In this paper, we performed a detailed survey on recent literature. We examined many publications from the last five years, which are related to chatbots. Then we presented different related works to our subject, and the AI concepts needed to build an intelligent conversational agent based on deep learning models. Finally, we presented a functional architecture that we propose to build an intelligent chatbot for health care assistance.

Keywords

Chatbots, artificial intelligence, conversational agents, modeling of conversations, natural language, neural machine translation.

1. INTRODUCTION

The chatbot is also known as chatter robots, are software agents that simulate human conversation via text or voice messages. One of the 1st and main goals of Chatbot had always been to resemble an intelligent human and make it hard for others to understand their real nature. With the development of more Chatbots of

various architectures and capabilities, their usage has widely expanded [11].

These conversational agents can go into a point of fooling the users and making them believe they are talking to a human, but are very limited in improving their knowledge base at runtime.

In order to understand the user input and provide a meaningful response, the chatbot uses artificial intelligence and deep learning methods. Moreover, they interact with humans, using natural language, different applications of Chat-bots such as medical chatbots, call centers, etc.

A chatbot could help doctors, nurses, patients or their families. Better organization of patient information, medication management, helping in emergencies or with first aid, offering a solution for superficial medical issues: these are all possible situations for chatbots to step in and reduce the burden on medical professionals.

2. RELATED WORKS

The mean research topics in natural language processing (NLP) are user intention identification and Information extraction. In past years researchers presented several models. Recently the development of Artificial intelligence and especially deep learning and deep neural network models have helped a lot in building self-learning chatbots. However, several attempts have been made to treat the seq2seq model problems with the help of deep learning concepts such as deep neural networks (DNN), recurrent neural networks (RNN), and convolutional neural networks (CNN).

Wu and. Al. (2017) analyzed the problem of answer selection for long conversations in retrieval-based chatbots. The goal here is to match between a response candidate and the context in a given conversation, the challenge is to find significant pieces of the context, and know how to implement the relationships between speeches in this context. The matching methods that already exist could lose important information in contexts. The authors proposed a unified framework in which the context is transformed into a fixed-length vector, with no interaction with the answer before matching. This new framework is known as a sequential matching framework (SMF); it can adequately take significant information from the contexts to match the relations between speeches. As the first step, SMF matches a response and converts the pair into a matching vector. Then, the matching vectors are gathered with the help of an RNN. The final step is the calculation of the context-response matching.

The tests of the model's performance were made on two public datasets. The results reveal that both models can surpass the state-of-art matching methods.

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Saurav Kumar Mishra [5] describes that medical chatbot will behave as a virtual doctor, which will be allowed to interact with the patients. This chatbot is developed in python language using pattern matching algorithms and Natural Language Processing techniques. According to the survey, which was conducted to check the performance of this chatbot, 80% is the correct answers given by chatbot, while ambiguous/incorrect answers given by this chatbot are 20%. According to the results of this survey, this chatbot can be primarily used as a virtual doctor for care and awareness as well as for teaching medical students.

Divya Madhu [1] says that Artificial Intelligence can be used to predict any disease and to provide the list of possible treatments based on given symptoms. Moreover, if periodically analysis is performed on a person's body, AI can help to predict any possible disease even before any damage occurs to the body. The significant challenges for this study are research and development cost and support from the government for the proper successful implementation of all medicines, which are not described in this research paper.

Hameedullah Kazi [2] proposed an idea of developing a medical chatbot for medical students. This chatbot uses an open-source AIML based Chatter bean. This AIML based chatbot can accurately convert natural human language queries into the relevant queries of SQL. Ninety-seven sample questions were collected, and after that, these questions were divided into different groups based upon their types. Depending upon the total number of issues present in each group, the resultant groups were ranked accordingly. According to the queries, questions were made, where 47% of questions are posed questions while other groups have less than 7 percent questions. This system is not specially developed to respond to student queries or, to support natural dialogue in chatbots.

3. SIMILAR CHATBOTS

3.1 Casper: Helping Insomniacs pass the Night

Insomnia is, by definition, a form of sleep disorder. Individuals with insomnia have difficulties falling asleep; it is the most common sleep disorder, according to the American Psychiatric Association (APA) [3]. The APA says that about 30% of all adults have insomnia symptoms. But between 5 to 10 percent have symptoms serious enough for them to be diagnosed with insomnia.

Here comes Casper or (Insomnobot-3000) to provide company in the middle of the night.

It is the only bot in the world that is available for a chat between 12 pm - 4 am — the exact time when you struggle to sleep and all your friends have already silenced their phones for the night. You can discuss almost any subject with the bot, and it was developed to simulate human-to-human conversation.

Ask it about his holiday plans or maybe his previous relationship, like any normal person trying to have a conversation.

This entertainment bot was developed by an American company called Casper and was advertised in about 30 channels like New York Magazine, Elite Daily, CNET, Digital Arts, and American Genius etc... And it's one of the three Examples of Tech Marketing We Wish We Thought of First. Screenshots of funny conversations with was all over the newsfeeds, and people continue to chat with this friendly bot night after night.

3.2 One Remission chatbot

One Remission is a chatbot launched by a New York-based company, with the goal of helping those involved in the fight against cancer with the information they need.

This helpful chatbot provides the users with a comprehensive list of post-cancer practices, diets, daily exercises so that they do not have to rely constantly on doctors. For example, they can search for the cancer-related risks and benefits of a certain food product, with the possibility to consult a real oncologist 24/7 [4].

The chatbot act like a mental and physical health assistant, it gives the patients the ability to share any positive or negative thoughts; they can communicate either verbally or by text messages, and in return, they get an accurate explanation of their questions. If they need advice on diets, exercise or sleep, One Remission is here to provide them with the right advice possible.

3.3 Babylon Health

The name is inspired by the ancient city of Babylon, almost 2500 years ago, the people of this city needing medical advice gathers in the middle of the town to share information about treatments for common diseases.

Now in the 21st century, Babylon health chatbot is here to accomplish almost the same function, founded in 2013, and is now valued at more than \$2 billion. The company offers an A.I solution of consultation based on medical history and common medical knowledge as well as a video chat consultation with a real doctor if the patient needs it [4].

For the first case, users describe the symptoms of their illness to the chatbot, which uses a database of diseases to compare with, and speech recognition to understand what the users say, and then propose the adequate actions to take. The second case, which already surpasses the classic functions of a chatbot, The direct interaction with a real doctor, which listens and analyses carefully, to diagnose the patient and then write an appropriate prescription or send him to a specialist if needed.

In 2017, The United Kingdom National Health Service (NHS) began to use the chatbot for a trial period. Nowadays, the company has grown even more, as it provides NHS patients near London and Birmingham with online consultations with doctors (over 700,000 so far) [4].

4. CHATBOTS & IA CONCEPTS

4.1 How a chatbot works

We can say that selecting the right engine for natural language processing (NLP) is the most important step of creating a chatbot [6]. If you interact with the chatbot through voice, for example, then it needs a speech recognition engine to transform the voice into text.

Programmers also must decide whether they want structured or unstructured conversations. Chatbots built for structured conversations are highly scripted, which simplifies programming but reduce the possible questions a user can ask. Nowadays, chatbots have become much more advanced because of the use of artificial intelligence (AI) technologies, including deep learning, natural language processing, and machine learning (ML) algorithms, and it requires a huge amount of data to give accurate results. The more you interact with the bot, the better precision you get.

4.2 The Limitations of chatbots

There are a lot of studies trying to develop such an amazing chatbot that will perform natural conversation and which will be indistinguishable from humans. But it is not possible to create such a chatbot. From the previous studies, the following are the major drawbacks in achieving effective and efficient conversation with a chatbot.

- **Fixed Rule-based:** Existing chatbots are developed by using straightforward machine learning techniques, fixed set of rules, and matching based on templates [10].
- **Grammatical Errors:** Grammar mistakes cannot be recognized.
- **Predefined or Closed-domain:** previous studies show that most of the chatbots only answer the questions from a closed domain, or answer those questions, which are defined in the database.
- **Ambiguity:** The meaning or the context of a sentence is not apparent or has not any appropriate purpose
- **Language Structure:** The structure of sentence making differ from language to language. For example, each language has its own rules for punctuation, text structure, and use of spaces. While existing chatbots cannot distinguish it.
- **Semantics:** It means words or sentences in a human natural language format. The current chatbots cannot handle natural language processing whether these chatbots only show a response, or they make the analysis of questions.
- **Sentiment Analysis:** The previous chatbots cannot identify the emotions of any subject about which human talks. A chatbot should be capable of identifying whether a human is happy, sad, or angry from the way any speech or text pattern is presented to it.
- **Recommender Systems:** The previous chatbots are not able to advise or explain any human topic. Even they cannot ask any questions. Chatbots only gather information from the user and generate a response from the knowledge base. A chatbot must be able to create queries based on previously answered questions [9].
- **Accuracy:** The chatbots should be designed in such a way that their conversation is like a human to complete any task. But existing chatbots are bad at suddenly changing any subject and provide an unpredictable response. Sometimes chatbots respond without any context. Thus, we cannot achieve a satisfactory level of accuracy.
- **Self-learning:** Supervised machine learning techniques are not used in previous chatbots. They are bad at learning the latest patterns of words or speech. They cannot discover context from logical reasoning and interaction. Most of the chatbots cannot train any classifier to map from the sentence to the intent and sequence model to the slot filter.
- **Support Third-party Integration:** The current chatbots cannot support third-party integration, for example,

knowledge-based, and they do not support multiple languages.

- A large number of chatbots only support the English language. It is challenging to embed them on any web page because of tough and challenging integration.
- **Data Processing:** The existing chatbots do not directly process the structured data, and there is no relational database. Besides this, datasets are complicated to prepare, mapping of entities and utterances is critical.
- **User Interface:** The interface of existing chatbots is inadequate; it is not user-friendly, and documentation is also abysmal.

To overcome all the mentioned limitations, a new chatbot must be developed that possess all the deep learning capabilities. With analyzing human input, it will also be responsible for generating a proper response. If we train chatbots properly, they will quickly and easily recognize the natural language of humans and will react adequately in each situation. But the major drawback is, to generate these innate responses a considerable amount of time and data required so that all huge amounts of possible inputs will be learned. Training will prove if Artificial Intelligence chatbots are capable of handling more challenging problems that are a hurdle for the simpler chatbots.

4.3 Artificial intelligence concepts

Before few years, a computer could hardly think as the human brain do. But today, AI has changed everything we can now solve complicated problems easily. The fundamental technologies for chatbot are machine learning, natural language processing (NLP), and Artificial intelligence (AI). These technologies brought chatbot invention hereafter brands communication, to a completely new personalized level. Although chatbot solutions for business are mostly used in the industry of customer service, the technical giants such as IBM, Google, and Microsoft suggest that the true potential of chatbots still needs to be fully revealed.

AI provides many opportunities, as it includes such capabilities that allow the software to perform such tasks that humans perform. Natural language processing is the foundation of AI-based chatbots. By using sophisticated algorithms of NLP, chatbots can process the input text: understand, conclude, and determine that what was said or written and then state a list of all suitable actions.

If there was no development in the field of NLP, chatbots had to be at the same spammy and awkward situation as they were at their beginning.

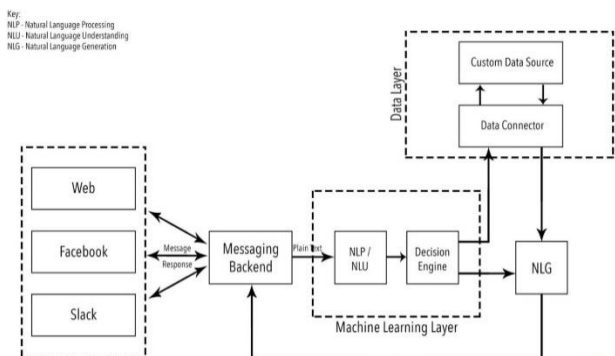


Figure. 1: Artificial Intelligence concepts in a chatbot

As displayed in Fig.1, we have three main concepts of Artificial intelligence, ASR , NLU and NLG that we will explain in the next section

NLP Natural Language Processing acts as a fundamental pillar for recognition of language, which is used by Apple’s Siri and Google. It allows technology to recognize human natural language text and speech-based commands and include two major components natural language generation (NLG) and natural language understanding (NLU).

Natural language understanding is more laborious than natural language generation, as the natural language has a remarkably rich structure and form. It maps the given input and analyzes multiple features of the language.

NLU Natural Language Understanding is responsible for handling and converting formless data into a proper form that the system can easily understand [7].

NLP has further five main steps if we want that message should be easily understandable by a chatbot. These steps are:

- Lexical analysis
- Syntactic analysis (parsing)
- Semantic analysis
- Discourse integration
- Pragmatic analysis

The lexical analysis: Includes analysis and identification of words structure; it splits the text into the chapters, then into sentences, phrases, and words.

Syntactic analyzer: Parsing analyzes grammar and arrangement of words so that the relation among different words become more explicit. Sentences like “the hospital go to the doctor,” Are rejected by Syntactic analyzer.

Semantic Analysis: check that either the text is completely meaningful or not, and it draws its correct meaning while mapping syntactic constructions. The semantic analysis will reject the phrase like “cold fire”.

Pragmatic analysis and discourse integration: analyze the concluding interpretation of the real message of the text. Such as the actual meaning of a phrase or a sentence relies on the overall context.

NLG Natural Language Generation involves text realization and text planning to generate an understandable response. In simple words, language generation is responsible for the formation of linguistically correct sentences and phrases.

The key challenge faced by NLP is to understand the complications of natural human language

The structure of language is itself very vague regarding syntax, lexis, and other components of speech such as similes and metaphors. A single word can be taken as a noun or a verb; a single sentence can be passed in many different ways; moreover, a single input may have multiple meanings, etc.

ASR Automatic Speech Recognition comes under computational linguistics, which develops technologies and methodologies that enable the identification and translation of user speech into text with the help of computers. It is also called

computer speech recognition, automatic speech recognition (ASR), or speech to text (STT). It includes research and knowledge in electrical engineering, linguistics, and computer science fields.

Systems for speech recognition involve “training” which is also called enrollment, where individual speakers read isolated vocabulary or texts into the systems. Systems then analyze the specific voice of a user and use it to fine-tune the identification of that user’s speech, which results in enhanced accuracy. The system that does not require training is known as “speaker-independent systems” on the other side systems that require the training are known as “speaker dependent”.

The terms speaker identification or voice recognition refers to identify the speaker despite what they are trying to say. Identification of the speaker simplifies speech translation in the system, which is skilled in the voice of a particular person, or it can also be used to verify or authenticate the identity of the user for the security process.

From the viewpoint of technology, the history of speech recognition is very vast, having remarkable innovations. Recently this field has progressed a lot by the advancement in big data and deep learning. The advancement is not only proved by the published academic papers but also by the variety of detailed learning methodologies adopted by industry in designing and deployment of speech recognition systems.

5. PROPOSED ARCHITECTURE

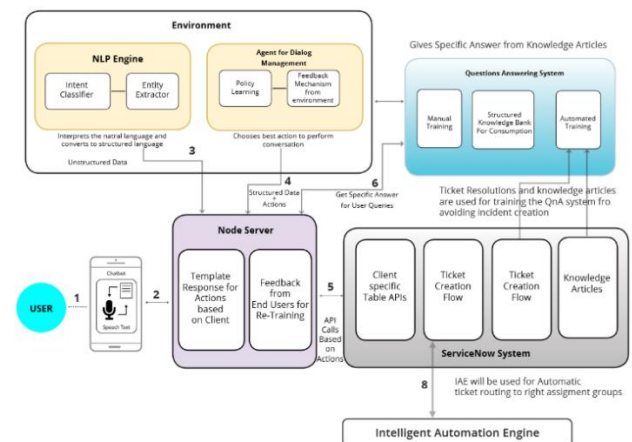


Figure. 2: General architecture of a smart chatbot

As we can see in fig. 2 this is the proposed architecture for our chatbot, and we will explain every part of it in the next section.

1) Environment

The place where the fundamental Natural Learning Process (NLP) engine and context clarification occurs.

• NLP Engine

A fundamental component understands what any user says at a given time and then converts this language into well-defined input that can be further processed by the system. As chatbots are domain-specific so they should support multiple features. The natural language processing engine consists of the latest algorithms of machine learning that are used to identify the intent of the user and then match them with the list of those intents that are supported by the bots [8].

Components of NLP Engine:

Intent Classifier: It takes input from the user, interprets its meaning, and then relates it to that intent which is supported by the chatbot.

Entity Extractor: It extracts the critical information from the query of a user

- **Agent for Dialogue Management**

It can manage the real context of the user saying. For example: If a user said "He needs to call a heart specialist" and then chatbot should make the call. If the user then said that "Change my request to the chest specialist," here the user is referring to that demand, which he has requested earlier, the chatbot must interpret it correctly and should make changes before confirming from the user side. For this purpose, dialogue management plugins are helpful.

Dialogue management further has following key plugins:

Feedback Mechanism: In this mechanism, an agent is responsible for taking the user's feedback from time to time to verify that either the bot is working correctly with the dialogues of the user or the user is satisfied with the Responses of the bot. This thing supports the chatbot to understand all the mistakes and to improve itself for future conversations.

Policy Learning: A framework enables the bot to take a maximum of happy paths from the conversation so that we may increase the satisfaction of the end-user. This higher-level framework creates a network that has happy paths, and then it directs the conversation to the satisfaction of the end-user. After this, the bot goes on learning from interaction and then it follows that flow of communication, which it had in the past with another user.

2) Question and Answer System

It is a fundamental component to answer the users frequently asked questions. This system understands the user's questions properly and responds to those questions with the related answers stored in the knowledge base.

Manual Training: In this training, the domain experts create a list of frequently asked questions and then map the answers. This mechanism is helpful for the bot to recognize the answers to the many important queries.

Automated Training: In this training, different types of company documents such as Q&A documents and policy documents are submitted to the bot, and it is asked to train itself for these documents. This training results in a list of questions and answers from these provided documents. This bot can answer all these questions with full confidence.

3) Plugins/Components

Plugins provide smart chatbot automation components and chatbot solution APIs for those chatbots which are used inside of

the companies such as field worker and HR management chatbots.

4) Node Server / Traffic Server

A server that is responsible for handling the user's request and then route it to the suitable components. This server also directs the response of the internal component back to the front-end system.

5) Front-End Systems

Several systems that has a client-facing platform can be candidate to develop the front-end. These systems can be the chatbot interfaces that exist in many platforms such as:

- Microsoft Teams
- Facebook
- Google Hangouts
- Slack
- Skype for Business

6. CONCLUSION

According to the scientific community, chatbots are user-friendly and any person who has an awareness of typing in their language on the desktop version and in the mobile application can use these chatbots very easily.

The new development in artificial intelligence and the new wave of thinking have the potential to entirely change the experience of customers to provide the best services in such a way that echoes with the modern customers. Especially in the field of medicine, a medical based chatbot offers a personalized analysis based upon symptoms. In the future, the recognition of the symptoms of bots and the performance of diagnosis will be highly improved with the addition of support for further medical features, such as symptoms intensity, duration, location, and a more detailed description of symptoms.

This study presents state of the art in this field, which open us to more exciting works in the future.

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