

Design and Development of Retrieval-Based Chatbot Using Sentence Similarity



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Abstract Chatbots or the well-known automated conversational agents have become a raging trend among all the sectors of businesses as a result of the rapid transition happening towards automation in processes. They are already being used extensively and will spread their wings to newer horizons shortly. The basic model of Chatbots is to interact with the user to answer their questions using various modes like text messages, voice replies, or any other predefined suitable interface. This paper discusses the development of a Chatbot for the college, Prasad V Potluri Siddhartha Institute of technology, to answer various questions related to the college like the facilities, procedures, policies, etc. This is a web-based software application implemented using Flask framework. This model is designed to capture text inputs from the user through a console and outputs the response in text format using machine learning concepts. A retrieval approach is implemented to process the input and to respond with an appropriate answer using logic adapters. The performance of this model is analyzed using a questionnaire that uses various parameters like performance, humanity, effect, and accessibility. This paper presents the overall approach used to design the Chatbot and compares the web application as-is study with the to-be website when the Chatbot is incorporated. The web application along with the Chatbot showed a 20% improvement in performance and 5% increase in accessibility by analyzing the performance metrics.

Keywords Chatbot · Machine learning · Retrieval approach · Flask framework

1 Introduction

The usage of Chatbots has skyrocketed in the recent times. They have a strong footing in the customer support industry which involves text-based dealings or support. A chatbot is basically a term for a conversational agent which in actual is a computer system software that can take natural language input and returns a chatty response instantaneously [1]. As observed, chatbots have been in great demand over the past

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few years. The number of internet users is increasing year-by-year. Proportionately, we can also observe a significant rise in the e-commerce sector which in turn demands increased customer support services for these online digital platforms. A delay of even 5 minutes in providing the customer support could reduce the chances of reaching out and selling to a customer [2]. A Chatbot of any particular organization is designed to perform certain tasks pertaining to their requirements. In reality, if the chatbots do not exist, the chances of getting the information across to each and every person of a particular organization (college in this case) are very meek. A Chatbot completes almost 25–30% of the tasks that are done by the organization to the end-user.

The College Enquiry Chatbot uses Machine Learning (ML) algorithms. The chatbot provides simple and trouble-free query clarification platform to students by addressing their queries in text format. The chatbot system makes it easy for the student to clarify his/her queries in lesser time. It is used to perform tasks like answering the questions related to the organization, supply the relevant links for the questions encountered by the user (if necessary), etc.

Basically, the initial chatbot named “ELIZA” was designed by Joseph Weizenbaum. With the innovation of the existing Chatbots, there came the evolution of the Chatbot technology. Chatbots can be implemented based on two approaches; Rule-Based Approach and Self-Learning Approach. In rule-based approach, there are some specific rules to be followed when training the bot. Here, the chatbot cannot answer complex questions triggered by the user. In self-learning approach, the chatbot follows the machine learning approach. This approach can further be divided into two models; Retrieval-Based Model (Chatbot retrieves the best response from the collection of responses) and Generative Model (Chatbot answers the question asked by the user from the set of answers). Chatbots that implement generative models are termed as intelligent chatbots.

The main sequence of flow for a functional chatbot involves three stages: (i) to get natural language user input, (ii) generate most appropriate automated response, and (iii) returning prudent natural language output. This College Enquiry Chatbot is developed using the Python Flask framework, where the front-end is written in HTML, CSS, and internal JavaScript. To implement the working of College Enquiry Chatbot, Chatterbot Library is used. Chatterbot is language independent and makes it easy to design a product that takes part in conversation. The inspiration to build this chatbot came when going through our college’s website. This Chatbot follows the generative approach, which answers the user from a predefined set of answers. This Chatbot functions similar to the initial chatbot “ELIZA.” Section 2 discusses the motivation behind developing this chatbot. Section 3 talks about the related work done in this area. Section 4 is about the proposed approach and Sect. 5 shows the implementation part and results. Section 6 is the conclusion part.

2 Motivation

For every student, to get the information related to the fee structure, due fees, events that are being organized, etc., is a lengthy and difficult process most of the times. Some of the events that are being organized by one department are not known to the other departments due to lack of effective communication channels. Sometimes, the changes in the fee structure are often not known to many students. We are living in a world where people are striving towards increased automation rather than manual intervention for repetitive tasks to arrive at faster and simpler solutions for the complex problems. This is the main reason behind building the College enquiry Chatbot where the user can ask the queries and a bot responds within no time. It reduces the users' time and can be easily available to any user with a mobile phone as well. With this Chatbot, the student no longer needs to take trips to notice boards or contact his/her friends or faculty to get timely information. This Chatbot in turn reduces the work of the organization. The user can get answers for any questions related to the college like address, admission process, and subsequent procedures which may be very difficult to find out for many students due to the pandemic situations.

3 Related Work

Harsh Pawar et al. developed College Enquiry Chatbot using Knowledge Database. This System is built using LUIS.ai, Microsoft Bot builder, and MongoDB for database. The user can interact with this system through web interface, in which the web application is connected to the bot through bot connector. This system will be a chatbot that responds to the questions by the user. In this system, they used LUIS.ai for training language model, which is used to identify the intention of the user and fetches the adequate response using pattern matching algorithm [3].

Nidhi Mishra et al. developed Dr. Vdoc, a medical Chatbot in 2018 which acts as a virtual doctor. The interaction can take place between a patient and a virtual chatbot, and this is made possible using natural language processing and pattern matching algorithms. It is more useful to provide awareness on the disease in case of unavailability of the doctors. The results showed that Dr. Vdoc is capable of returning the responses with 80% accuracy [4].

Pooja Prashanth et al. designed a college enquiry chatting system using knowledgeable database. In education system, few works can be very lengthy, time consuming, and require extra manpower. But in today's world, we see that almost everything is turning to digital format. This chatbot updates the students with college's cultural activities. It is based on client server architecture. All the information is kept in the database on the central server. By installing application in the smart phone, a user can access the information from the database. This system is

developed with the combined technologies of Artificial Intelligence, Knowledgeable Database, and Virtual Assistance, such that the chatbot can make conversations between humans and machine [5].

Sagar Pawar et al. developed a web-based college enquiry chatbot with results. The system uses bigram and some sentence similarity algorithms to provide answers to student or any other user queries. If the response is invalid or irrelevant to the user query, then user can mark the response as invalid. This is sent to the admin. The admin will be able to delete or modify the data [6].

Jayesh Gangrade et al. designed a Review on College Enquiry Chatbot in 2019. An intelligent voice recognition chatbot is designed and developed which replies to the user queries in a graphical user interface, which gives them a feel of talking to a person. In this system, the user must login into the web application to ask queries. This system also contains a notice board where the important notices are placed in the form of documents or portable document formats (pdf). Here, important keywords are fetched from the query, and those keywords are searched in the knowledge database using keyword matching algorithms. If the answer is not found, then the system displays the following—“Answer to this query is not available at the moment, please revert after some time” [7].

4 Proposed Approach

The proposed system is designed to solve the user queries in no time without the user approaching the college or contacting any other person. A retrieval-based model uses an archive of predefined responses and performs some analysis to pick a desired response based on the given input and text [8]. This analysis can be a simple expression match, or Machine Learning classifiers that work on the principle directed towards flows of graphs. The systems that are designed using this model choose an appropriate response from a fixed set instead of returning a new text. The chatbot is trained based on existing information in the database to provide best possible responses from the predefined responses. In case of retrieval-based chatbot [9], the selection of appropriate responses can be determined based on techniques like machine learning, deep learning, and keywords matching. This model cannot generate new output and can only provide predefined responses. Retrieval-based chatbot design is shown in Fig. 1.

User Query: The students can approach the Chatbot to resolve their queries related to the College. This Chatbot receives the queries that are of any type (Greetings, College related queries, General questions, etc.) by the user in the form of text. The user inputs his queries in the textbox.

Tokenizing the words: Tokenization is a process of breaking a sentence or the sequence into pieces called tokens, perhaps eliminating the special characters like punctuation marks. For example, if the input is “Hello, How are you?,” then the tokens obtained after tokenization are “Hello,” “How,” “are,” and “you.” After tokenizing,

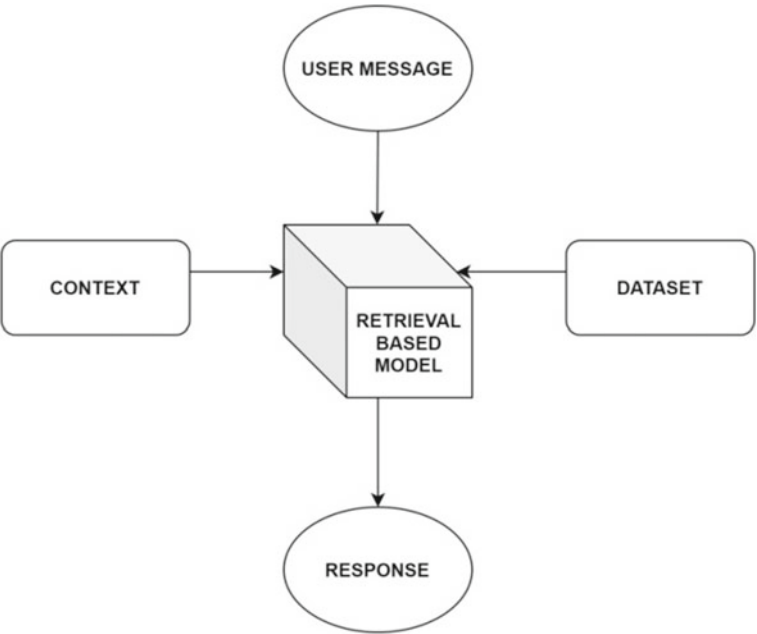


Fig. 1 Retrieval-based chatbot design

the tokens are processed by normalizer and matcher. Tables 1 and 2 depict how the normalizer and matcher process the tokens.

A normalizer processes the tokens by matching them with the patterns stored in the dataset. It matches the keywords of the input sentence with the patterns of the dataset and stores the matched keywords. A Matcher is used to find out the appropriate output

Table 1 Processing of the normalizer

S. No	Input	Output of the normalizer
1	I want	I want
2	to talk	to talk
3	in Hindi	in Hindi

Table 2 Processing of matcher

S. No	Input sentence	Pattern in database	Similarity threshold	Output sentence
1	I code in python	I prefer to code in python	0.5	The output will be “I prefer to code in python”
		I like coding in python	0.33	

for the user query from the existing dataset. The Matcher checks by converting text into ASCII and checks the sensitivity of the characters (lower/upper case).

Retrieving the matched response: Upon finding a sentence similar to the query from the predefined dataset, the chatbot retrieves an appropriate response from the same [10].

Calculating the similarity: The similarity threshold is calculated for the input query, out of many sentences of the dataset that match with the input. The higher threshold valued sentence is sent to the user.

For example, Input—"I code in python" and the dataset has two related sentences, Sentence 1—"I love to code in python" and Sentence 2—"I code in python language."

The similarity is checked by calculating the threshold of the input query with each of the two sentences in the dataset. The similarity threshold of the "Sentence 2" is higher than that of the "Sentence 1." So, the appropriate answer for the "Sentence 2" is returned to the user.

The intersection between two sentences, one which is the user query and the other is the pattern in database, gives the sentence similarity score. It is represented by $S1 \cap S2$ and $S2 \cap S1$, where $S1$ and $S2$ are two sentences.

The formula to calculate sentence similarity score is shown in Eq. (1).

$$Count(S1 \cap S2) \cup Count(S2 \cap S1) / Count(S1) \cup Count(S2) \quad (1)$$

Sample user input statement

$S1$ = "I code in python." and the pattern in the database as: $S2$ = "I prefer to code in python."

Using the similarity algorithm, we get:

$S1 = \{I \text{ code, code in, in python}\}$ Count ($S1$) = 3

$S2 = \{I \text{ prefer, prefer to, to code, code in, in python}\}$ Count ($S2$) = 5

Now, $S1 \cap S2 = 2$ and $S2 \cap S1 = 2$.

Calculated score for Sentence Similarity

Let $a = \text{Count}(S1 \cap S2) \cup \text{Count}(S1 \cap S2) = 2 \cup 2 = 4$.

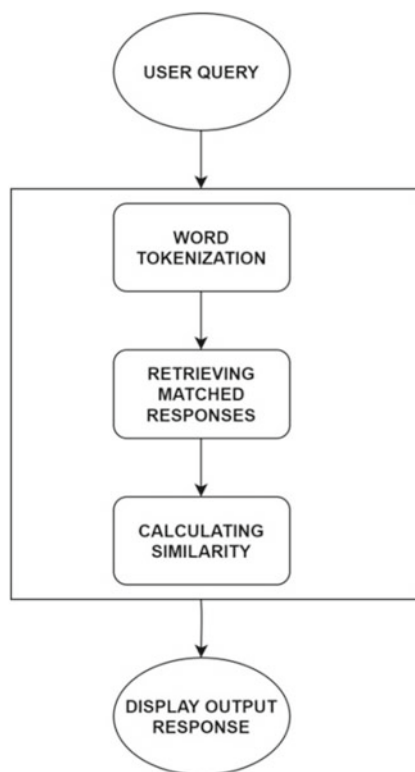
Let $b = \text{Count}(S1) \cup \text{Count}(S2) = 3 \cup 5 = 8$.

Similarity score is $a/b = 0.5$.

This procedure is adopted to calculate the sentence similarity score for each pattern stored in the database. The output for the users input query is displayed in the designed College enquiry Chatbot web app.

The proposed system design is shown in Fig. 2 which depicts the procedure of how the system is developed.

Fig. 2 College enquiry chatbot system design



5 Results and Discussion

This system follows three main steps as shown in Fig. 3, i.e., Get Input, Process Input, and Return Response.

Get Input: In the first step, the user asks the Chatbot a question from any source (sources can be screen, speech recognition, or API). In this project, the user uses a console to converse with the Chatbot [11]. The initial message is displayed as “Hi, Welcome to PVPSIT Chatbot. I am at your service. You can ask me questions!!”

Process Input: The input given by the user is processed by the logic adapters. The logic adapters are those which are used to decide the logic for the Chatterbot to select a response for the input asked by the user. Any number of logic adapters can be used in the project. There are two logic adapters used in this paper; “Mathematical Evaluation and “Best Match.” The bot gives back the response of the logic adapter that has higher confidence value. If any two logic adapters have the same threshold/confidence, then the first logic adapters’ response is returned to the user. One can set the parameters for the logic adapters like setting the default response, threshold, paths, etc. The “Best Match” logic adapter responds the user with the confidence level of 0.70, and when the bot does not find the best match for the input, it gives the default response

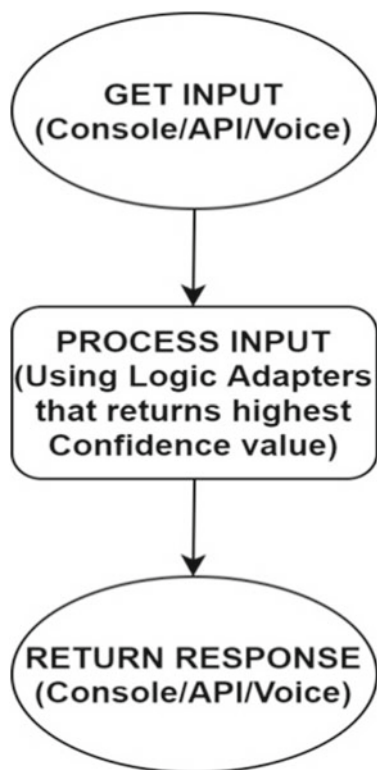


Fig. 3 Flow chart diagram of college enquiry chatbot

saying “I am sorry, but I do not understand. I am still learning.” Figure 4 gives the responses after processing the input data by the Chatbot.

Return Response: The bot returns the response through the console. The bot in this project is trained with the data related to the college and English language. This Chatbot can also respond to the input of various kinds like mathematical calculations, sports, emotions, and simple conversations. Figure 5 depicts the logic of how training is performed.

A questionnaire was constituted of various questions related to performance levels, humanity, effect, and accessibility, and was distributed among the students of the department. A sample of 240 responses was taken and analyzed, and the results conclude that the performance of the website improved by 20% when the chatbot is included. Considering humanity and affection, when compared to the existing one, it reached an average level and a 5% improvement over the previous version. The statistics are shown in Table 3.

Performance, Humanity, Effect, and Accessibility were the parameters that were considered to analyze the performance of the bot. A questionnaire was used for the comparative analysis [12]. This helps in designing more effective bots. To assess

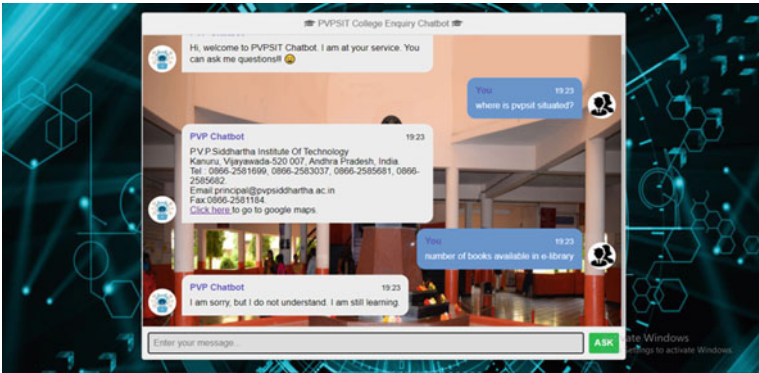


Fig. 4 Responses after processing the input data by the chatbot

```
# Prepare the training data
with open('training_data/personal_ques.txt','r') as fd:
    conv = []
    last = ''
    for line in fd:
        # Remove newline and whitespaces only from the end of the line
        line = line.rstrip()
        if line.startswith(' '):
            last += line
        else:
            if last:
                conv.append(last)
            last = line
    # Add the final string... last will be '' only if the file is empty
    if last:
        conv.append(last)

# Training with Personal Ques & Ans
trainer=ListTrainer(chatbot)
trainer.train(conv)

# Training with English Corpus Data
trainer_corpus = ChatterBotCorpusTrainer(chatbot)
trainer_corpus.train(
    'chatterbot.corpus.english'
)
```

Fig. 5 Training the chatbot

Table 3 ChatBot quality assessment

Category	Quality attribute	Metric	Old system	New system
Performance	Robustness to unexpected input	% of success	60%	80%
Humanity	Able to maintain discussion	Low to high	Low	Low
Affect	Provides greetings	Low to high	Low	Average
Accessibility	Can detect meaning and intent	% of success	70%	75%

the performance questions related to robustness, an unexpected input was questioned on. After analysis, it was evident that respondents stated that there is a clear improvement of 20% over the previous version. Coming to the category of humanity, questions based on maintaining discussion was assessed, and there was a significant improvement from average to high [13]. Coming to the effect, questions on providing greetings were assessed. There is no specific change noted in both the versions [14]. Coming to the accessibility, there was improvement by 5% which is not quite noteworthy. This paper presents the overall approach used to design the chatbot, and compares the web application as-is study with the to-be website when the chatbot is incorporated.

6 Conclusion

In this paper, a machine learning approach for College Enquiry Chatbot has been proposed. The responses of the Chatbot are obtained with the help of a “Retrieval-Based” approach. This Chatbot can perform almost 30% of the entire task of the college. This makes the work easy and provides results within seconds. This proposed chatbot is designed in python using “Flask Framework.” The chatbot mainly follows three steps: Getting input queries from the user, processing the input, and returning the responses to the user. The methodology of the Chatbot is that it takes the input from the user, tokenizes the input, retrieves the matched response, calculates the similarity score, and then returns the appropriate response to the user. The results of to-be website when Chatbot is incorporated and the as-is website are compared based on the performance, humanity, effect, and accessibility. Of all those tests, the website that incorporates the chatbot shows better performance, humanity, effect, and accessibility. Thus, implementing chatbot will reduce the work of the organization. Some of the limitations of the chatbot are domain knowledge, not possessing the personality.

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