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Design and Development of Diagnostic Chabot for supporting Primary Health Care Systems.

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Abstract

Technology is increasingly becoming a massive part of today's healthcare scenario. Technology has changed the way how patients communicate with doctors and not only that, but also how healthcare is administered. Artificial intelligence and Chabots are two groundbreaking technologies that have changed how patients and doctors perceive healthcare. To make healthcare system more interactive a diagnostic Chabot is designed and developed using latest algorithms in machine learning, decision tree algorithm to help the user to form a diagnosis of their condition based on their symptoms. The system will be fed with information pertaining to various diseases and using NLP, it will be able to understand the user query and give a suitable response. The system can be used for effective information retrieval in a similar manner like siri, alexa etc but the scope will be limited to disease diagnosis.

*Keywords:*Artificial Intelligence;Chatbots, decision tree; natural language processing;

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1. Introduction

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The traditional doctor-patient relationship has evidently remained the same over the course of time. The patient goes to the doctor if he/she feels unwell. The doctor listens to the patient, evaluates the symptoms and forms a diagnosis. If the information that doctors possess is fed into an intelligent system and the system is designed smart enough to understand the natural language of the patient, the system can help in answering queries about primary diagnosis. This will not only be cost efficient but will also be very convenient. Chabots, also called chatter-bots are designed to initiate a conversation with a person and seem as human-like as possible. The conversation can be conducted via text or speech. ChatBots can be designed keeping a particular function in mind, for example a medical ChatBot can respond only to queries pertaining to healthcare. The efficiency of such a smart system can be judged according to its ability to pass the turing test. The Turing test is comprises of a person, A who is made to have a conversation with X. A does not know if X is a smart system or a real person. Chatbots nowdays have found use in every sphere from commercial use like analytics, communication, customer support, education, entertainment, finance to personal use like food, games, health, shopping, social, sports, travel and utilities. Machine learning is the study of algorithms and scientific models that a computer system can use to ensure learning a task without any explicit instructions by only relying on patterns and inferences instead. It is broadly classified into two types namely supervised learning and unsupervised learning. Supervised learning is used in the proposed system.

Supervised learning: It basically means that the machine is taught or trained using data which is already labelled. In other words it means that we already have data which is tagged with the correct answer. The machine analyses this training data and comes up with a mapping function between the input and output. For example there are a number of diseases in the dataset. The first step will be to train the system with different diseases.

- If the person has fever and headache then it will be labelled as –cold/flu
- If the person has redness in eye and itching it will be labelled as –conjunctivitis

Now after the training of dataset if the user inputs he/she has a red eye with itching the system will know it is conjunctivitis. Classification is used since the output variable is a category such as ‘conjunctivitis’ or ‘cold/flu’ and not a continuous value. In order, to process the text from the speech recognition system which converts the user speech input into text we need a toolkit. The specific toolkits help to split sentences into word, perform functions like stemming and parts of speech tagging to extract the semantic meaning of the user input. One such toolkit is The Natural Language ToolKit (NLTK), it is a module used in python. It is broadly utilized in python applications including normal language processing.

NLTK comprises of a lot of a set of libraries, instructional exercises and activities which are open source. NLTK was created at the University of Pennsylvania in 2001. NLTK is used to separate words in a string of content and divide the text into parts of speech by tagging word labels according to their positions and functions in the sentence. The subsequent labelled words are then handled to separate the significance and produce an output to as needed.

2. Related Works

Sameera A. Abdul-Kader et al. [1] showcase a study on the strategies used to structure Chatbots and an examination is made between various plan systems from nine cautiously chosen papers as per the primary techniques received. The papers used in the study are illustrative of the critical enhancements in ChatBots in the most recent decade. The author talks about the likenesses and contrasts in the methods and inspects specifically the Loebner prize-winning Chatbots. The techniques involve the use of Human-Computer Speech interaction, Natural Language Toolkit (NLTK) and the identification of its constituent parts which can be divided into three major parts: Responder, Classifier and Graphmaster [1]. The author discusses various fundamental bot implementation techniques like parsing, AIML script, pattern matching and use of SQL and relational database are. The author also throws light on the Turing Test and Loebner Prize. Turing suggests the “imitation game. It is basically a way of determining if a machine can think like a human and be intelligent enough. Loebner Prize again is a competition where a person has to guess if it is interacting with a machine or a real person. The main objective is to determine whether the chatbot is intelligent enough to pass for a machine. It also throws light on how speech recognition is performed for the use of a

chatbot.It involves use of digital signal processing to convert the input speech into output text[1]. In their works, Kyo-Joong Oh et al. [2] propose a counselling bot, which provides conversational service for mental health care based on deep learning, such as convolution neural network. The training data ranges from image, video, audio to text. The application uses high-level language processing (NLP) and natural language generation (NLG) methods to understand and generate dialogues with users. The system also uses emotional intelligence as it is necessary as an essential function of the medical chatbot. It must take into account emotional aspects apart from the linguistics in order to assess the condition of the patient and give a fitting reply. The natural language understanding has parts like understanding Sentence Entailment which means collecting all the relevant corpuses of the target language. In addition to multimodal emotion recognition along with NLP the system will also involve Continuous Emotional Monitoring of the patient to find any emotional changes overtime [2]. The author cites the present patterns and practices in AI and tries to suggest alternative approach to improve some of the existing approaches in AI. Focus is made on the structure and working of a basic Artificial Intelligence. framework - chatbots (or chatter bots) is made. The author indicates how current methodology towards A.I. isn't satisfactory and offers another hypothesis which talks about machine insight, to the eventual fate of such frameworks. AnirudhKhanna at al. [3] contrast two chatbots namely SARANG created using AIML and FUTURE using C++. It showcases how using Artificial Intelligence Markup Language (AIML) is more beneficial. AIML gives the advantage of using the pre-existing ALICE (Artificial Linguistic Internet Computer Entity) chatbot which has about 50,000 responses. The SARANG chatbot gave an accuracy of 80% by answering 1200 of the 1500 questions asked. The paper discusses the limitations of the Turing Test which involve Limitedness, Short purview and unproductive development. Anirudh Khanna et al. [3] list 5 fundamental abilities of intelligent systems namely: Arithmetic, Comparison, Logic and Reasoning, Learning, Heuristics and Memory, Senses, Perception, Consciousness .The system which satisfies a subset of the above abilities is partially intelligent while the one which will satisfy all are completely intelligent. Nowadays machines can not satisfy all of the abilities mentioned [3]. Specifically, a set of objectives can exist together amid a single discussion, and that every objective might be introduced in a non concurrent way.

Victor Hung et al. [4] proposed a technique for managing the communication exchange in light of perceiving the human client's objectives while using an expert system. Such a stipulation exists to improve the expectation of the communication. Motivated by the Context-Based Reasoning paradigm, the Lifelike exchange framework portrayed thus highlights an objective administration framework that at last controls the behaviour of the expert system. The author presents a survey of NLP, dialog system manager and Context based Reasoning. Goal manager alludes to the procedures that perceive and fulfill the conversationalist's needs as passed on by his or her expressions. The dialog system should understand the need of the user is the primary goal[4].The greater part of the earlier chatbots utilized the pattern matching advancement to shape reactions. A.L.I.C.E, which is the winner of loebner prize is an open source natural language chat robot. It uses AIML to frame reactions to questions .F.O. Adibe et al [5] also discuss various key word matching algorithm works, the following search engines should be built: Special Search Engines and Matrix Search Engines. The advancement of a Chatbot has been portrayed in three distinct stages: a beginning time before the improvement of the Internet, where bots utilized simple pattern recognition and interacted just with text; a second duration where the interactive systems turned out to be all the more broadly accessible because of the development of the Internet; and a third time in which the innovation turns out to be progressively commercial, utilising speech synthesis and visual avatars. This innovation gives clients the feeling of speaking with a real human and decreases the abnormal state of irregularity and false information. Today, various business sites on the Internet make use of chatbots to manage clients in finding the data for which they are looking. Commonly, a bot will speak with a real individual; however the best test presently is to build up an application which will empower two visit bots to speak with one another [5]. Jennifer Zamora[6]in her study shows how interactive systems can become a part of the day to day life of a person. Chatbot advancement has expanded while by and large its motivation still remains inexactly characterized. Because of its novel and generally new innovation, there is a chance to make important encounters with bots in a run of the mill individual's life. Subjective experiences were gathered from 54 members in India and the US throughout two weeks. To distinguish open doors for chatter bots, we should see how these projects are seen and what needs exist for individuals. The exploration targets incorporate understanding the accompanying: 1) anticipations for chatbots 2) preferred input modalities 3) opportunities for chatbots based on user needs [6].

Numerous conversation agents (CAs) are created to reply clients' inquiries in a particular area. In regular utilization of CAs, the client satisfaction can extend well beyond the requirements to a more socially fun filled interaction. Q. Vera Liao et al. [7] suggest ways to improve the client experience by suggesting the areas of interest of the client. Through the viewpoint of statistical modelling, they additionally feature rich flags in conversational communications for inducing client fulfilment with the instrumental utilization and enjoyable interaction with the agent. These signs can be used to create agents that adjust usefulness and collaboration styles. By differentiating these signs, we shed light on the changing elements of conversational collaborations. The structure suggestions for CAs, and headings for creating versatile agents dependent on clients' conversational practices are discussed. In short the author basically suggests ways to improve the natural language classifiers such that they have more human-like responses which include sarcasm and humour. The proposed system suggests the chatbot should dynamically adapt to the client they are dealing with and take into account the likings and disliking of the client. The fundamental territories of discussions incorporate feedback-giving, playful chit-chat, system inquiry, and ongoing open utterances. Through the focal point of measurable displaying, they feature the rich flags in conversational associations for gathering client fulfilment, which can be used to create operators that can adjust algorithmic exhibitions and collaboration styles[7].

Intelligent bot frameworks connect with clients in Natural language. The existing chatbots are rule based and fail to satisfy real world problems. While utilizing deep learning strategies, all dialogs in the chatbot framework are prepared from the dialogs themselves gets away from the impediments of this. Jincy Susan Thomas and Seena Thomas[8] propose deep learning strategy gated start to finish memory systems and we can demonstrate how chatbot frameworks can be utilized continuously applications. This model is found out in a start to finish model of any extra supervision. The system has a setting of a doctor facility that produces, and controls sentences for legitimately directing discussions, issue API calls and retrieve reactions based on Application Programming Interface (API) calls. It breaks down the downsides of existing rule based system and propose adjustments to those in the new dataset with doctor's facility data that enhance the reactions [8].AmeyaVichare et al. [9] cite ways in which existing systems like ELIZA, Siri and ALICE can influence the proposed system. The olden days chatbot ELIZA helped in seeing how reframing the inquiries will make the discussions increasingly human-like. ALICE helped in seeing how we can utilize AIML in our framework. At long last, Siri helped us comprehend the limitations of language processing in speech to speech agents, the client will be incited to ask a question which is identified with sports. The client will speak out his inquiry on his/her telephone utilizing the application UI. A scope of games related inquiries and their reactions will be coded into AIML and put away into the database. At the point when the client will ask an inquiry, this question will be coordinated against the different examples present in the database and the format comparing to that example will be returned in type of discourse to the user[9].

Marc Moreno Lopez[10]presents state-of-the-art deep learning tools for Natural Language Processing. The principle commitments of this work are a diagram of CNN and its diverse subtypes. It is a rundown of the considerable number of issues that have been illuminated utilizing state-of-the-art CNN innovations. A general perspective on how CNN have been connected to various NLP issues, with results included. After the advances made in Computer Vision utilizing deep learning instruments, NLP has adjusted a portion of these systems to make significant leaps forward. Be that as it may, the outcomes, for the time being, are just encouraging. There is proof that deep learning tools give great solutions, however they haven't given such a major jump as the one in Computer Vision. One of the principle issues is that CNN begun being utilized in light of the extraordinary accomplishment in CV. Because of this current there's an absence of a shared objective. This vulnerability of what to do makes the outcomes be great yet not on a par with anticipated. One reason could be on the grounds that CNN are believed to be connected to pictures and not to words. Be that as it may, the outcomes are empowering and are an improvement over the past state-of-the-art techniques[10]. In the quest for making bots fit for communicating with people in this way normally that people can't distinguish among machines and people, we tend to focused on the significance of free will[11]. Yoshiteru Ishida et al [11] have suggested that free will has advanced to keep away from deadlock among operators (or among operators and nature). Like the framework, an unconstrained nature is additionally credited to self-enhancement, which can be utilized to abstain from applying similar answers for similar problems. The discretion of artificial consciousness is also outlined mathematically exploitation the operational definition of epsilon-delta and ought to be tried relatively with various agents, together with every human and machines[11]. This study shows how

communication changes when individuals speak with a smart operator rather than with another human. Around 100 texting discussions were contrasted with 100 interactions with the prominent chatbot Cleverbot based on seven measurements: words per message, words per discussion, messages per discussion, word uniqueness, and utilization of foulness, shorthand, and emojis. A MANOVA showed that individuals spoke with the bot for longer lengths than they did with another human. [12]. Alexandru Topˆırceanu and Gabriela Grosseck demonstrate the normal examples which characterize the interaction type, dedication amount, and conclusion point of view of courses. They present a unique arrangement of understudy profiles explicit to online courses, and it does as such by methods for information mining and directed learning[13]. Antonio J. Fern'andezLeiva and Jorge L. O'ValleBarrag' [14] depict two ways to deal with utilizing decision trees. The first methodology pursues the customary procedure existing in business videogames to program the game artificial intelligence, in other words, it comprises of coding the system physically as indicated by the AI software engineer's involvement with the point of expanding player fulfilment. The second methodology depends on developmental programming procedures and has the goal of consequently creating the amusement AI. A correlation is made of the two approaches [14]. Cloud based health monitoring systems helps the doctors to monitor the health status of the patient using cloud computing [15].

3. Proposed Methodology

The proposed system will work as a healthcare application. The user can make an account on the portal and can also live chat with a doctor. In case the doctor is not available the portal has a preliminary diagnostic chatbot. The user can input his/her symptoms using speech or text. The chatbot will use NLP to understand the user query. Once the bot understands the initial symptoms it will ask to follow up questions and try to make a diagnosis based on user answers. The system uses a decision tree algorithm and follows a top-down approach to help form an accurate diagnosis. The initial symptom entered will form the root of the decision tree. The bot will then ask to follow up questions which will help ruling out other diseases with similar symptoms. The system makes a questionnaire-based approach to question the user and then the decision tree is traversed accordingly until a leaf node is reached. The leaf node will contain the diagnosis formed.

3.1 System Architecture

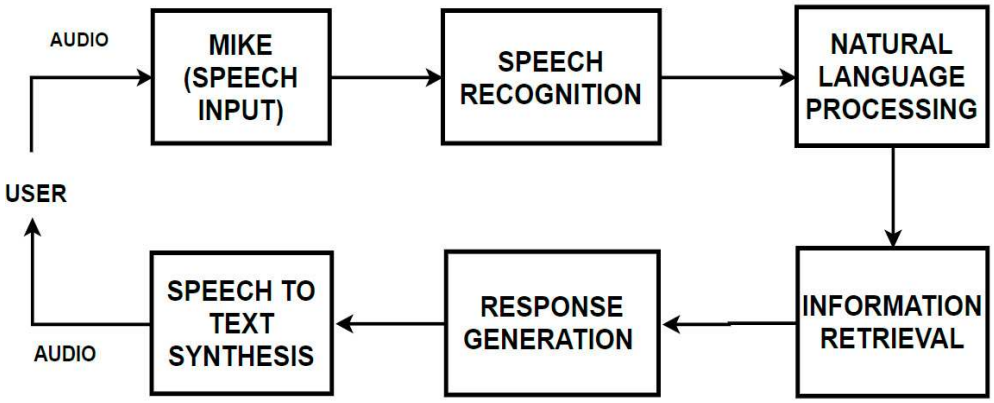

Fig. 1. System Architecture

The system will have a number of modules, but the 3 core modules are as follows

- Conversion of user query for speech to text and text to speech for the output
- The processing of the entered response with NLP to understand user intent
- Form a decision tree and traverse it until a leaf node is reached

3.2 Natural Language Processing NLP

The input given by the user is processed through a number of stages to understand what the user is trying to say. Natural language processing (NLP) is the ability of a program to make use of the natural language spoken by a human and comprehend it's meaning. NLP is the study of the computational treatment of natural (human) language. The development of NLP is challenging because computers are used to of getting a highly structured input whereas natural language is highly complex and ambiguous with different linguistic structures and complex variables.

NLP has various stages as follows:

- Tokenisation(lexical analysis), also referred as segmentation involves breaking up a sentence or paragraph into tokens or individual words, numbers or meaning full phrases. Tokens can be thought of as a small part like a word is a token in a sentence and a sentence is a token in a paragraph. The words are separated with the help of word boundaries. English is space delimited hence, word boundaries are the space between ending of one word and starting of the next one.

  Example: "I am suffering with fever!"

  The output after tokenisation would be: ['I' ,'am' , 'suffering' , 'with' , ' fever']
- Syntactic analysis involves analysis of words for grammar and putting the words together in a manner which can show their relationship. This can be done with a data structure such as a parse tree or syntax tree. The tree is constructed with the rules of grammar of the language. If the input can be produced using the syntax tree the input is found to have correct syntax.

  For example the string "I pick that have to" will be considered incorrect syntax.
- Semantic analysis picks up the dictionary meaning of words and tries to understand the actual meaning of the sentence. It is the process of mapping syntactic structures with the actual or text independent meaning of the words. Strings like "hot winter" will be disregarded.
- Pragmatic analysis: Pragmatic investigation manages outside word information, which implies learning the outer to the archives and additionally inquiries. Pragmatics analysis that centers around what was portrayed reinterpreted by what it really implied, inferring the different parts of language that require true learning.

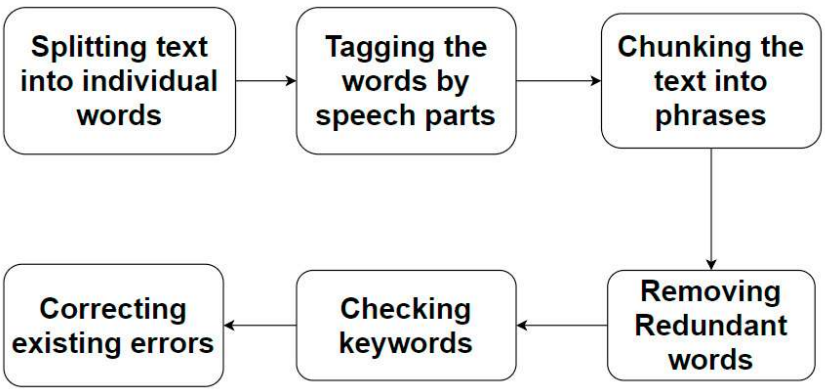

Fig. 2. Pre-processing of text input

To put it plainly, the subsequent content is part into independent words for labeling with grammatical forms marks as indicated by their positions and neighbors in the sentence. Distinctive kinds of sentence structure can be utilized in this phase to chunk the individual labeled words so as to frame phrases. Keywords can be removed from these

expressions by dispensing with undesirable words in chinking activities. These catchphrases can be checked and corrected in the off chance that they are wrong.

3.3 Decision Tree

They are the most popular choice for prediction as well as classification because not only are they simple to understand but can also be very powerful. The decision tree gets it's name from it's tree like structure where the nodes denote a test, in our case a symptom and the branch denotes the outcome (if the user has that symptom or not) and the leaf nodes hold a possible diagnosis. In our system the chatbot needs to make a decision based on each user input for example if the user enters he/she has fever then how will the bot respond? How will the user be cross questioned or how we will arrive at a diagnosis. The decision tree algorithm helps us perform this function. The decision making is the main module of our system. The decision making is very important for the functioning of the system as well as the accuracy of the results. The system will be perception based and will be dependent on the user input at each step. The decision tree algorithm will help us traverse to find a solution by matching the user input with the symptoms at each level. If no match is found the system will continue the loop until the end or a leaf node of the tree is reached. Decision tree is a supervised learning algorithm hence the motive is to create a training model which will then be used to predict value of target (in our case the possible disease) by learning decision rules the data already fed to the system(training data).
The dataset used is in a tabular format which states about 50 diseases along with their symptoms. It was hard to find an accurate medical dataset therefore, the dataset has been curated to ensure that only general diseases are listed with accurate symptoms to ensure efficiency in disease diagnosis.

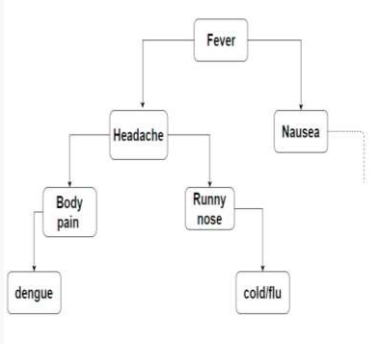

Fig. 3. A possible structure of the decision tree

The functioning of the system is better illustrated with the help of use diagram in the figure below

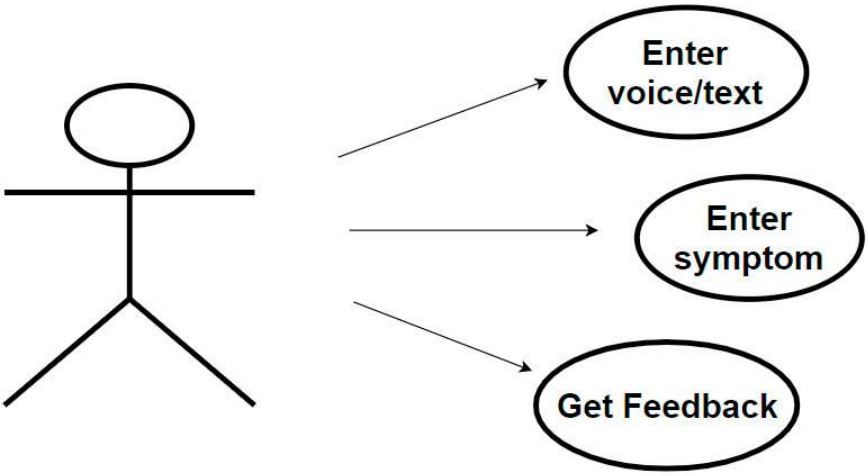

Fig. 4. use case of the proposed system

4. Result and Discussion

The proposed system is a working prototype with about 150 symptoms and 50 diseases and performs diagnosis at several layers of the decision tree using. The algorithm forms the decision tree with the various symptoms and then uses that to cross question the user.

- Round Trip Time: The response time of the system was found to be 10ms to 20ms depending on the number of symptoms.

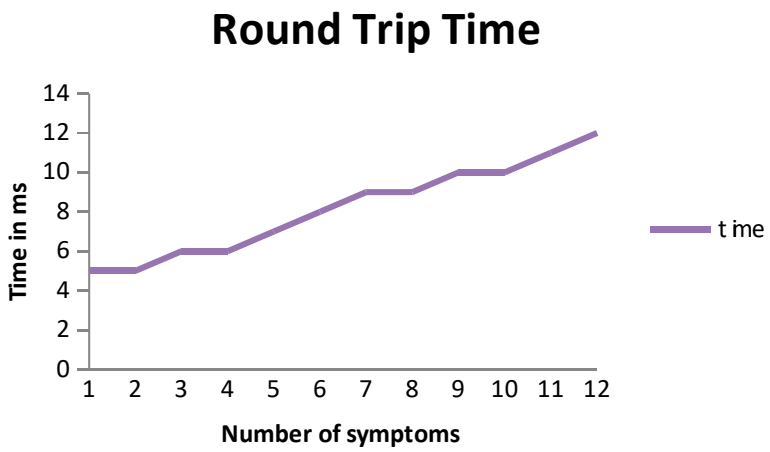

Fig. 5. Round Trip Time

- Accuracy: The proposed system gave an accuracy of 75 correct answers for every 100 queries for common diseases. The accuracy was found to be 75%.

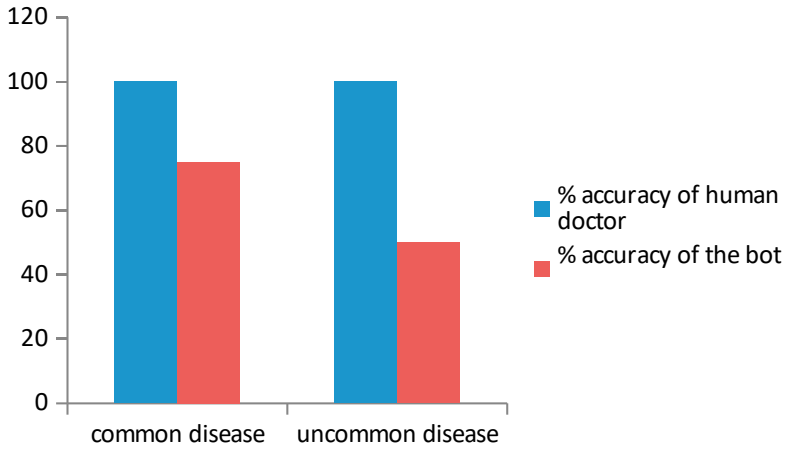

Fig. 6. Accuracy

5. Conclusion

Artificial Intelligence has changed the healthcare scenario today. The proposed system aims to narrow the gap between healthcare and patients further. AI concepts like decision tree and NLP are used to fetch knowledge from medical database containing about 150 diseases to develop an efficient diagnostic chatbot. The chatbot asks the user questions in a format imitating a doctor-patient conversion. The questions are based on the users preceding input and then based on replies forms a possible diagnostic. The diagnostic form is preliminary which might help the user decide on further action. In the future, the system needs to increase its database and improve the machine learning part to ensure better diagnosis.

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