DocBot: A Medical Consultant ChatBot Using Deep Learning approach

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***Abstract* - Deep learning has been around a while and it has been creating wonderful things to make our lives better than ever. Chatbots have provided amazing and seamless abstraction as well assistance for many complex things. In this paper we have proposed robust architecture for medical consultancy chatbot with 5-stage pipeline. The model would provide cutting edge experience to the users who don't know what the symptoms are suggesting and what they are for. Earlier, there was development of interactive system such as WebMD [4]. But, they don't provide communication with user in free-form natural language. The proposed model interacts with the user in very natural way. It also suggests expert who can cure the disease beforehand.**

Keywords-seq2seq, Natural language processing, deep learning, chatbot, medical

I. Introduction

Medical domain is huge and complicated where effective knowledge representation plays a vital role in understanding and supporting disease diagnosis. Not all people experience the same symptoms and the appearance of some symptoms can be more significant than others.

Chatbots provide sophisticated interface for interacting with users. Users can more naturally communicate with the system. But extracting relevant information from natural language is a huge challenge.

Although, there are already some platforms which provide information pertaining to drugs and healthcare services like WebMD [4], they limit the interactivity of users by only allowing them to select from the options presented. This restricts user interaction with free form natural language and hence user can not fully express symptoms or any other information.

After studying different systems, we felt the need for medical consultancy chatbot which can address the user queries related to medical domain in real time. The chatbot is closed domain chatbot for disease related queries. The main aim is design of chatbot which can emulate behavior very close to professional doctors.

We propose 5 stage pipeline for the system which can infer medical knowledge from the sequence of text entered by user and predict the outcomes using machine learning and deep learning techniques to generate relevant response for user.

II. Literature Survey

In [1],a clinical decision support system(CDS-wide range) is described which supports medical disease diagnosis by making recommendations(using a standardization and classification system).The paper mainly focuses on information exchanging, reasoning help, knowledge extension, and awareness of possible diseases, through natural language. Problems discussed are Communication efficiency and info exchange problems between machines and humans. A semantic data model **by the OWL-DL semantic web community** was used. The system uses Three-level disease ontology: Disease level, symptom level, concept level.

In [2] the authors proposed an symptom based disease prediction system which gives age based medicine dosage details. Intake dosage is categorized based on the age and weight of the person. The system is platform independent system with user authentication, DB connectivity (containing the Chatbot API Medicine API, Symptoms) and the developers' side for updating and monitoring the system. They used json object for medicine search.

In [3], the system collects medical information with the help of web spider from different professional sites. Main aim of system is healthcare improvement and disease prevention. Description logic reasoner is used which helps to infer logical consequence for DL query as input(health level, sickness level, loss of functions and lab values).Contains 3 parameters property(relationship), mode and name. These parameters are used for disease prevention.

In [5] .the paper reviews the application and ability of artificial neural network (ANN), support vector machines (SVM), Naïve Bayes, and fuzzy logic in solving personalized medicine problems and shows that the obtained results meet expectations. Detection and prediction using various algorithms helped in diagnosis and treatment.ANN based medical diagnosis consists of collection data, feature selection, preprocessing, eliminating the outliers and finally doctor evaluates the model.

In [6] the authors used artificial neural network [ANN] in disease diagnosis. Two cases are studied; first one is acute nephritis disease which is trained on disease symptoms data. The second is the heart disease which uses data on cardiac Single Proton Emission Computed Tomography (SPECT) images. Each patient is classified into two categories viz. infected and non-infected using Feed-forward back propagation neural network in both cases. Neural network toolboxes from Matlab 7.9 are used to evaluate the performance of the proposed networks.

In [7], the authors proposed a virtual healthcare assistant, a chatbot that will integrate an existing healthcare information sources that will act as personal healthcare assistant for the user. It will provide advice on various topics such as healthy eating habits, exercise, medicine, diseases, etc. Further the authors proposed to implement their chatbot using a Pandora chatbot, a web based hosting service for bots.

In [8], the authors proposed a new semantic web rules based on Case Based Fuzzy Cognitive Maps (CBFCM) and notation3. The framework is used to develop a clinical decision support system. As a front end they used Euler GUI for personalized medicine.

Further we surveyed the main two types of neural networks used in chatbots.

1. GAN(Generative Adversarial Networks)-

Generative adversarial networks (GANs) [9] are a class of artificial intelligence algorithms used in unsupervised machine learning, implemented by a system of two neural networks contesting with each other in a zero-sum game framework. One network generates candidates (generative) and the other evaluates them (discriminative).Typically, the generative network learns to map from a latent space to a particular data distribution of interest, while the discriminative network discriminates between instances from the true data distribution and candidates produced by the generator.

A known dataset serves as the initial training data for the discriminator. Training the discriminator involves presenting it with samples from the dataset, until it reaches some level of accuracy. Typically the generator is seeded with a randomized input that is sampled from a predefined latent space (e.g. a multivariate normal distribution). Thereafter, samples synthesized by the generator are evaluated by the discriminator. Back propagation is applied in both networks so that the generator produces better images, while the discriminator becomes more skilled at flagging synthetic images.[8] The generator is typically a deconvolutional neural network, and the discriminator is a convolutional neural network.
Generative Adversarial Bots (GABs) are bots that are pitched up against each other, and generate a conversation that is used to train a third bot.

2. SEQ2SEQ-

A basic sequence-to-sequence model [10], consists of two recurrent neural networks (RNNs): an encoder that processes the input and a decoder that generates the output. Encoder and decoder can share weights or, as is more common, use a different set of parameters. Every input has to be encoded into a fixed-size state vector, as that is the only thing passed to the decoder. The model is mainly applied to the problem of machine translation.

III. Gap Analysis

Medical attention is the need of the day because of the rapidly increasing types of diseases. But day-by-day the doctor's fees are increasing making it cumbersome for us to manage the expenses as fees are heavy on our pocket. The system will eliminate the need of visiting the Doctor in case of petty issues like headaches, fever, cold etc. The poor and the middle-class sometimes are unable to pay the Doctor's extravagant fees.

Previously, attempts were made to develop a system which will act as an alternative to Doctor using artificial intelligence and machine learning. But, most of them lack efficiency and reliability. For example, WebMD an American corporation which is an online publisher of news pertaining to human health [3] has proved to be a great tool for predicting the disease based on the symptoms provided by the user. But it restricts the choices which user can select and thus does not use free form of natural language.

After survey, we came to conclusion that there should be an efficient system which will interact with the user in free form natural language and act as an alternative to a Doctor. The system is intended to detect disease and suggest drugs or cure.

IV. Proposed Model

The proposed model contains 5-stage pipeline to provide sophisticated and rational decision making for identification of diseases. Following are the stages:-

1. Natural language processor
2. Decider
3. Model selector and preparator
4. Task executor and analyzer
5. Response generator

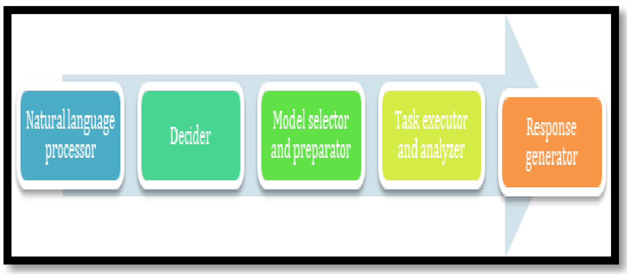

Fig 1 -Overview of 5-stage pipeline

The proposed system uses 5-stage pipeline as its core mechanism. There are helping modules which help in execution of the system. Natural language processor uses corpus of medical data. This corpus contains medical data represented in general statements. The corpus is used for training Named Entity Recognizer (NER) and Part of speech (POS) tagging for patient identification.

Decider uses intent analysis for finding out the action to be performed. Relevant words and verbs are used for this purpose. Model selector and data preparator selects model from model repository and prepares data which can be suitably executed on selected model. Model repository stores already trained Machine Learning models and general executable models along with their intent. Intent is simply the decision made by decider.

Task executor uses database for execution of selected execution model. The output of Task executor is validated and analyzed by execution engine. It uses Skip-gram and Continuous Bag of Words (CBOW) to measure the distance between the query and results generated by task executor.

Response generator with the help of Seq2Seq neural networks generates the response in natural language which can be presented to the user. Seq2Seq neural networks are trained with conversational corpus. Sentences generated by response generator are incomplete in the sense that they do not contain the user's name or the patient's relation with user on behalf of whom user is asking the query. So Name Substituter (NS) substitutes the name to complete the response.

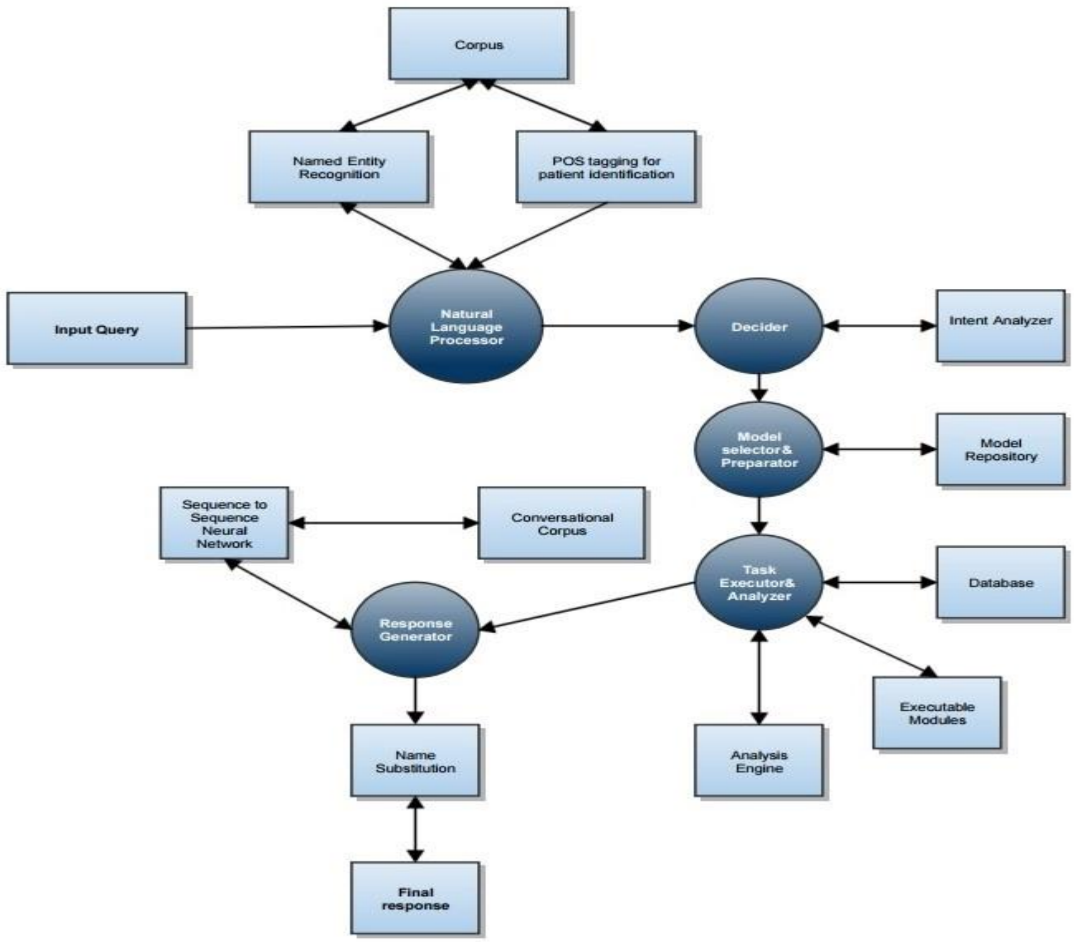

Fig 2: Proposed System

1. **Natural language processor:-**

This stage takes the input from the user in the form of natural language. First task is preprocessing which includes sentence segmentation, stopword removal and lemmatization.

Next step identifies the medical words by custom pre-trained Entity Recognizer (ER).This means that it tags the keywords with its category. E.g. stress, anxiety , migraines these are all types of headaches. So ER tags them like (anxiety, 'A') where HA stands for Headaches.

Next stage identifies characterizing words such as 'suffer', 'develop', 'feel', 'dizzy' etc. These words are then converted into their equivalent numerical form by technique of word embedding and this list along with tagged entities are passed on to next stage.

2. **Decider:-**

Main function of decider is to decide what is to be done. It decides from the context whether the task is disease prediction, cure suggestion or drug suggestion. This stage takes tagged words from previous stage along with word embeddings and uses Support vector machine with Gaussian kernel to decide the targeted task.

3. **Model selector and preparator:-**

All the required models are pre-trained and are stored in one 'Model Repository'. Decider selects the targeted task and forwards it to model selector. Model selector chooses the model from Model Repository. It also loads required hyper parameters and data. All the models are either Artificial Neural Networks with backpropagation and feed-forward capabilities or ensemble learning models.After loading all required data and parameters, it also prepares this data in a suitable form which can be fed to the selected model.

4. **Task executor and analyzer:-**

The model selected by Model selector is used to make predictions for the data prepared by preparator. The specified task is executed and the results are prepared for response generator. Following are possible tasks:

1. Disease prediction
2. Drug suggestion
3. Expert doctor suggestion

5. **Response generator:-**

Response generator takes 2 inputs:-

1. Query entered by user
2. Results generated by Task executor and analyzer

Response generator is designed with sequence-to-sequence neural network as proposed by Google in [11].Sequence-to-sequence neural networks consist of two RNNs namely encoder and decoder and also uses attention mechanism to predict responses.

Query entered by user can not be directly fed into seq2seq model. Some words in query are masked by tokens. This partially masked query is then fed to the seq2seq. Predictions made by the model are also masked with some tokens. These tokens in the answer are replaced by the results predicted by Task executor and analyzer.

Finally, this prepared response is shown to the user.

A. Mathematical Model

To process the words, we need to first convert words to their equivalent numeric representation.

Let D be the dictionary such that it stores only those words which are not stopwords as well as they are lemmatized.

$D=\{(W_i,N_i)$ | W_i is i^{th}word,$N_i$is numeric representation of W_i and i varies from 0 to n$\}$

Natural Language Processor which take sequence of strings as input and produces set of tuples of numeric values with the help of D.Let this set of tuple be X.

We use Support Vector Machine (SVM) with Gaussian radial basis function kernel to predict the decision i.e. action to be taken .

$$K(X_i,X_j)=e^{\frac{-\|x_i-x_j\|}{2\sigma^2}}$$

where,

X_i,X_j are adjacent tuples

σ is free parameter which can be assigned with variance/covariance.

Depending on the result predicted by the decider with SVM , one of the following model is chosen .

Feed forward neural network for disease prediction:-

Inputs:-$\{S_1,S_2,S_3,....,S_n\}$

where S_i is symptom and i varies from 0 to n age_group which is bucketized attribute body_temperature which is attribute having continuous value surrounding_temperature which is attribute having continuous value activation function:-

Softmax activation function stated as follows-

$$f(x)=\frac{e^{x_i}}{\sum_{j=0}^{k} e^{x_j}}$$

Output:-d=argmax(P)

where,

P is set of probabilities for diseases predicted by neural network

d is disease predicted

$\operatorname{argmax}_{x \epsilon P} f(x)=\{x \mid f(x)\geq f(y) , \forall y \in P\}$

Relational model for probable symptoms generation from disease:-

Input:-given_age_group,given_disease

$$\sigma_{\text{age\_group=given\_age\_group,disease=given\_disease}} \left(\prod_{symptoms,description,causes,\text{age\_group},disease}(DiseaseDB)\right)$$

output:-Detailed information about disease.

B. Features

1. Prediction of possible disease from symptoms.
2. Information retrieval of particular disease.
3. Natural conversation between user and system .
4. Specialized and professional doctor suggestion for curing disease.

V. Future Scope

1. Expansion the system to understand regional language.
2. Design of some kind of test to validate the outcomes produced by chatbot.

3. Use of computer vision for disease diagnosis.
4. Accomodation of speech synthesis as alternative for interaction .

VI. Conclusion-

In this paper , we proposed a chatbot i.e a system containing 5 stage pipeline which will be used for identification of disease.The user will interact with the system in the natural language ,the system will further extract medical words like headache ,fever etc.Using these words the decider will decide whether the task is disease prediction,cure suggestion or drug suggestion.In next step a model is selected from the model repository which is applied to the data and predictions are made and the response is presented to the user. The important aspect of this system is that it will interact with the user in natural language.The use of Artificial Neural Network will make the system more efficient and thereby increase the user's satisfaction.The chatbot will eliminate the Doctor's extravagant fees .It will provide as a great tool for the middle-class.Although,the system will suggest drugs or cure it is advisable to the user to consult a good doctor and not completely rely on the system.Ultimately,on successful implementation the system will be able to predict disease and suggest cure to a great extent.

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