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Mental Illness Detection and Monitoring Bot using Predictive Analysis Approach

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Abstract - *This work presents a solution for improving the traditional mental health remedies and the overall process of treatment for mental disorders. We are using Artificial Intelligence techniques like Natural Language Processing with Text Analysis and web application services to create a physical virtual assistant that will have the ability to analyze the voice inputs by the prospective subject in doubt after converting the speech to a text format and provide initial first aid so that the immediate mental health does not turn into terminal illness with the passage of time and if the condition gets worse, alerting the acquaintances of the said subject and also pass on the ominous message to a predetermined psychiatrist to take certain measures and remedy for the conditions where it requires human help. The virtual assistant will achieve the connectivity with the psychiatrists using connectivity via the application layer APIs deployed in it.*

***Key Words*: Artificial Intelligence (AI), Natural Language Processing, Virtual Assistant, Mental Health,API.**

1. INTRODUCTION

Mental illnesses have taken rapid growth among all the other diseases in the world in recent years. Studies have shown that as of 2017, around 18% of the total world population which roughly accounts for about 970 million people are dealing with various types of mental illnesses. It is an alarming situation as the number is increasing rapidly converting the younger sections of the society to mental patients.

Even though medical advancements are being done to prevent the build-up of mental illness, there are still many patients across the globe who fall prey to these illnesses and lose their lives. It is evident from the studies that, most of these prolonged mental illnesses lead to depression and suicidal tendencies among the patients which account to be the major factor for the deaths of the patients. In a report presented by WHO, it was stated that about 800,000 people commit suicide every year. It was also known that about 75% of these suicides happen in countries where mental illness is not given prominence. In countries like India, there has been a tremendous increase in the number of such patients.

The increase in the number of mental illness patients is observed mostly due to the depleting lifestyle of the majority population. The disastrous effects are mostly seen in the younger population of the world who are aged between 18 and 32. Apart from this, it is also known that even the youths aged between 13 and 18 are also under the radar of mental illness. There is an increasing number of teenage suicides around the world which puts the future of humanity in threat. We cannot expect to build a strong world with wisdom and knowledge if the population stays weak from within.

We as engineers felt that there is a need to contribute towards the betterment of the humankind against this alarming situation so we came up with an idea to tackle the issue by building an Emotionally Intelligent robot which cures and assists the patients suffering from various mental illnesses.

Our prime focus with this project is to reduce and eventually end the suicides being caused due to acquired depression. The bot will be developed and trained to be one of the best companions filled with emotional and artificial intelligence along with learning and predicting capabilities, built especially for all the patients detected with or suffering from any type of mental diseases.

According to our observation, there are many cases of adverse effects of these diseases even if the patients are seeing a psychiatrist because of the unavailability of a doctor 24x7. This creates a break in the treatment procedure within the scheduled visits to the psychiatrist. On further investigation, we found that this small factor creates a major void in the recovery process. Therefore, we have come up with this project which is merely a combination of a small processor combined with some peripherals and powered with artificial intelligence to take a first step towards tackling this major global cause. The prime aim of this project would be to develop into something that proves to be a savior for people who are detected with such diseases and to give them a hope of leading a normal life again thus by making this world a better place.

2. LITERATURE REVIEW

There has not been the exact same methodology of the study what we adopted to solve this problem, so we have used many

different references for all the different technical processes already developed which we have adopted in our implementation.

The **International Classification of Diseases** (**ICD**) is a globally used diagnostic tool for epidemiology, health management and clinical purposes. The ICD is maintained by the World Health Organization (WHO). The ICD is a major project to statistically classify all health disorders, and provide diagnostic assistance. The ICD is a core statistically based classificatory diagnostic system for health care related issues of the WHO Family of International Classifications [14]. The medical advices present in this work come mostly from the sections of ICD-10 which deal with mental illnesses. The information extracted from ICD-10 for the space of medical diagnosis required for this work was essential as this was one of the main reliable sources out there for the common people to refer. The next phase was to convert the medical examination study into an engineered approach of understanding how to deal with a subject who might be a potential patient of any mental illness.

[1] proposes the idea where the voice input can be converted to text for further analysis. The process of converting speech input into digital text is called speech to text conversion. It effectively takes audio content and transcribes it into words in a word processor or other display destination. speech-to-text is the process of converting an acoustic signal which is captured using a microphone to a set of words.

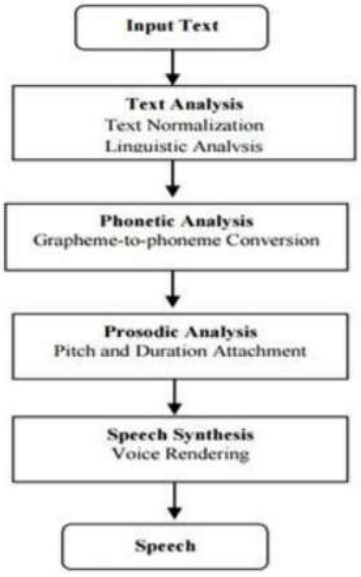


Figure 1: Flowchart of the Implementation

The methods followed are pre-emphasis of signals, feature extraction and recognition of the signals which help us in training and testing mechanism.

[2] proposes the reverse idea where all the text output is converted to speech. Text-To-Speech is a process in which input text is first analyzed, then processed and understood, and then the text is converted to digital audio and then spoken through a speaker or other voice output device. To compute the output, the system consults

1. A database containing the parameter values for the sounds within the word,
2. A knowledge base enumerating the options for synthesizing the sound.

The entire speech to text and back to speech process can be demonstrated through fig. 1

[3] reviews the basic idea behind Machine Learning and techniques used in it. Machine learning is used to teach machines how to handle the data more efficiently. Sometimes after viewing the data, we cannot interpret the pattern or extract information from the data. In that case, we apply machine learning. There are two wide areas of Machine Learning namely supervised and unsupervised. We have used supervised learning to predict the labels which we are using in our dialogue flow system. Here we have used certain algorithms such as Support Vector Machines, Random Forest, Decision Trees etc.

Most of the chatbots initially incorporated a rather simpler approach towards handling conversation, the *If-This-Then-That* approach.[4] This was a simpler approach and easier to develop. This constituted of small blocks of Boolean logics which decided the outcome of the conversation. These kind of chatbots were useful for smaller tasks but couldn't handle bigger conversations. They operated only within a boundary of operation for which they were designed. Such systems are also called Goal Oriented Dialogue Systems that help users achieve a predefined goal.[5].

One of the feasible conceptual approaches consisted of five components with the associated responsibilities: dialog manager (manages natural language dialog with the user); inference engine (extracts user intents); knowledge base (supports inference and planning); planner (produces execution plans); and external services interface (operationalizes plans).[3]

The dialogue manager manages a natural language dialog with a user and interacts with services such as an inference engine, knowledge base, planner, and external business services to carry out the user's request. The supported user interaction modalities may be text and voice. Dialog management employs natural language processing techniques to extract meaning from a user's messages. For example, it may identify a symptom from a request by extracting named entities and employ the inference engine to capture the relationships between the entities and to invoke a specific rule to infer a symptom. The inference engine receives requests from the dialog manager and interacts with the knowledge base to infer an appropriate intent based on a user's request. In addition, it may infer entities from the user's request to map them to appropriate actions. The purpose of the inference engine is to identify a closest possible intent for a given request. In several cases, the initial corpus required to train a classifier could be small. Thus,

the intent inference could have either low recall or low precision. The knowledge base represents the chatbot knowledge, including inputs received from a user and about available services and how they relate to the domain. The knowledge base includes a knowledge graph constituting a set of entities and their relationships, and a set of rules that make inferences based on entities and their relationships. The chatbot designers need to populate the knowledge base with expert knowledge. The dialog manager interacts with external services to execute business functions, such as for change request approval, business intelligence service, and remote system management. [3]

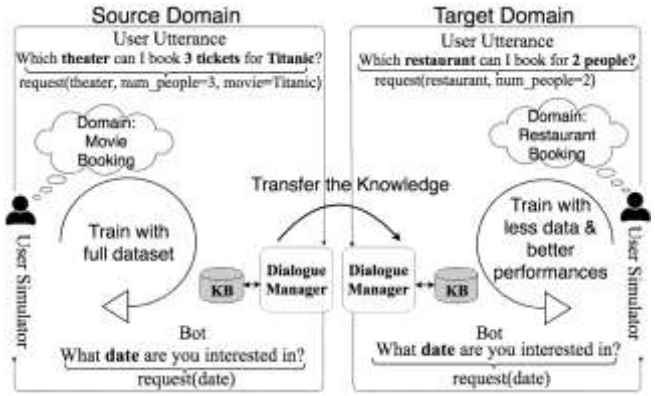


Figure 2: Model of the Goal-Oriented Dialogue System operating on a semantic level. [5]

The dialog management system plays a vital role in the development of an Emotional Assistant demonstrated in fig 2. The key feature of the respective chatbot is the machine learning aspect of it which is responsible for analysis and response generation. It is also important for the chatbot to interact with the human being in order to collect the vital information, necessary for the analysis. The motive of a good chat assistant is always to perform its tasks in a very sophisticated manner by minimizing the error and difference between a real person instead of it. A decent dialog flow manager with various states of transfer of data and numerous layers of conversation building subroutines is a necessary aspect. It also helps the assistant to monitor the emotion continuously over the period of conversation and process all the incoming data thereby making the conversation a good user experience and useful. [5]

3. MATERIALS AND METHODS

A. Dataset collection and Description

The most crucial part of solving a learning problem is data acquisition. Since the study we have undertaken has not been done before in the exact form we needed so, none of the datasets of that were available on Kaggle or any such open source website. Since we have identified this problem as Multi Label Classification problem, so the dataset is prepared according to the meeting arranged with a consulting psychiatrist and it is in compliance with the ICD standards which ensures its accuracy and authenticity. These are CSV [Comma Separated Values] files which have the labels which the algorithm is trying to predict as per the dialogue flow management system.

B. Target Vector Description

Target vectors are the final labels we are trying to predict which in this particular case study are limited to four different types of Mental Illness namely: Depression, Anxiety, Stress and Obsessive-Compulsive Disorder.

1. **Depression**: Depression is a mental health disorder characterized by persistently depressed mood or loss of interest in activities, causing significant impairment in daily life. Possible causes of depression include a combination of biological, psychological and social sources of distress. Increasingly, research suggests that these factors may cause changes in brain function, including altered activity of certain neural circuits in the brain. The persistent feeling of sadness or loss of interest that characterizes major depression can lead to a range of behavioral and physical symptoms. These may include changes in sleep, appetite, energy level, concentration, daily behavior or self-esteem. Depression can also be associated with thoughts of suicide.

   Attributes like reduced interest, joy, energy, self-esteem, appetite and sleep form some of the important features of occurrence. Although these attributes are important to predict depression, they cannot be called as the striking features which can be used to differentiate depression from other mental illnesses, especially the ones like anxiety which also show similar symptoms in the beginning. [6]
   Attributes such as having pessimistic views about the future leading to attributes as dangerous as having suicidal tendencies are a clear sign of clinical depression. Moreover, such attributes also define the severity of the problem in a very apt manner which is very critical for a psychiatrist to address. [6]
   In the proposed methodology incorporated to predict mental illnesses and then process a response for the same via a chatbot, these attributes pertaining to each of the target vector is very essential.
2. **Anxiety**: Anxiety is arguably an emotion that predates the evolution of man. Its ubiquity in humans, and its presence in a range of anxiety disorders, makes it an important clinical focus. Anxiety is a normal human emotion. In moderation, anxiety stimulates an anticipatory and adaptive response to challenging or stressful events. In excess, anxiety destabilizes the individual and dysfunctional state results. Anxiety is considered excessive or pathological when it arises in the absence of challenge or stress, when it is out of proportion to the challenge or stress in duration or severity, when it results in significant distress, and when it results in psychological, social, occupational, biological, and other impairment.

Anxiety disorders typically follow a chronic or recurring course in which full symptomatic remission is uncommon; they are associated with the temporal accumulation of comorbid disorders and with an increased suicide risk.[7]

There are many psychotropic drugs and psychotherapies available for the treatment of patients with anxiety disorders, overall clinical outcomes and the standard of care for most patients are far from optimal. Cognitive and neural mechanisms involved in emotion processing can be manipulated pharmacologically, and research continues to identify genetic polymorphisms and interactions with environmental risk factors that co-vary with anxiety-related behaviour and neuro-cognitive endophenotypes[8]

The identification of clinical markers that are predictive of treatment response and that might help inform the selection of appropriate pharmacological interventions remains an important goal for anxiety research. Despite initial evidence of clinical and biological candidate predictors, many individuals still respond poorly.

3. **Stress:** Stress is a condition of mental pressure for particular individual facing problems from environmental and social well-being which leads to so many diseases. Young age is the critical period because at this time youth faces

lots of changes in his/her life. They are expected to be the elites in the society. Thus, they should enhance their stress management abilities so as to live a healthy life after entering the society.

When a child enters into the youth age, they need to not only adapt themselves to the new life and new environment but also be familiar with many new people, events, and things. The life stress on them is considerable. Therefore, understanding the sources of stress among them and how they can cope with the stress is very important. The study found that the stress mainly comes from academic tests, interpersonal relations, relationship problems, life changes, and career exploration. Such stress may usually cause psychological, physical, and behavioral problems. [12]

For PTSD, useful treatments include cognitive-behavioral therapy (CBT), along with exposure and the more controversial Eye Movement Desensitization and Reprocessing. Psychopharmacological approaches have also been suggested. In addition, writing about trauma has been helpful both for affective recovery and for potential health benefit[13]

4. **OCD:** Obsessive-compulsive disorder is a severe and disabling clinical condition that usually arises in late adolescence or early adulthood and, if left untreated, has a chronic course. OCD comes in many forms, but most cases fall into at least one of four general categories:

Checking, such as locks, alarm systems, ovens, or light switches, or thinking you have a medical condition like pregnancy or schizophrenia.

Contamination, a fear of things that might be dirty or a compulsion to clean. Mental contamination involves feeling like you've been treated like dirt

Symmetry and ordering, the need to have things lined up in a certain way.

Ruminations and intrusive thoughts, an obsession with a line of thought. Some of these thoughts might be violent or disturbing.

C. Theoretical Considerations

For data analysis part, several machine learning algorithms were used. Following are the lists of algorithms with their description:

Logistic Regression (LR) is a discriminative model which depends on the quality of the dataset. Given the features X = X1, X2, X3, . . ., Xn (where, X1 − Xn = Distinct f eatures), weights W = W1,W2,W3, . . .,Wn, bias b = b1, b2, . . ., bn and Classes C = c1, c2, . . ., cn (in our case, we have eight classes) the equation for estimation of posterior is given in following [9].

$$\text{Predicted Value: } p(y = C|X;W,b) = \frac{1}{1 + exp(-W^{transpose}X - b)}$$

Support Vector Machine is another discriminative model like LR. It is a supervised learning model for analyzing the data used for classification, regression, and outliers detection [25,26]. SVM is most applicable in the case of Non-Linear data[10]. Given Input x, Class or Label c and LaGrange multipliers α; weight vector can be calculated by following equation:

$$\Theta = \sum_{i=1}^{m} \alpha_i c_i x_i$$

The target of the SVM is to optimize the following equation:

$$\text{Maximize}_{\alpha_i} \sum_{i=1}^{m} \alpha_i - \sum_{i=1}^{m} \sum_{j=1}^{m} \alpha_i \alpha_j c_i c_j < x_i x_j >$$

Decision Tree allows each node to weigh possible actions against one another based on their benefits, costs, and probabilities [11]. Overall, it is a map of the possible outcomes of a series of related choices. A DT generally starts with a single node and then it branches into possible outcomes. Each of these outcomes lead to additional nodes, which branch off into other instances. So, from there, it became a tree-like shape; in other words, a flowchart-like structure.

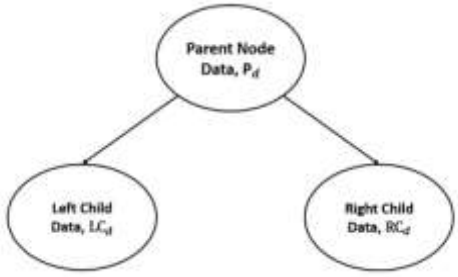


Figure 3: Decision Tree Split

Considering a binary tree Fig. where a parent node is split into two children node a left child and a right child. Parent node, left child and right child contains data Pd, LCd, RCd, respectively. Given, features x, impurity measure I(data), the number of samples in parent node Pn, the number of samples in left child LCn and the number of samples in right child RCn; DT's target is to maximize following Information Gain :

$$\text{Information Gain}(P_d,x) = I(P_d) - \frac{LC_n}{P_n} I(LC_d) - \frac{RC_n}{P_n} I(RC_d)$$

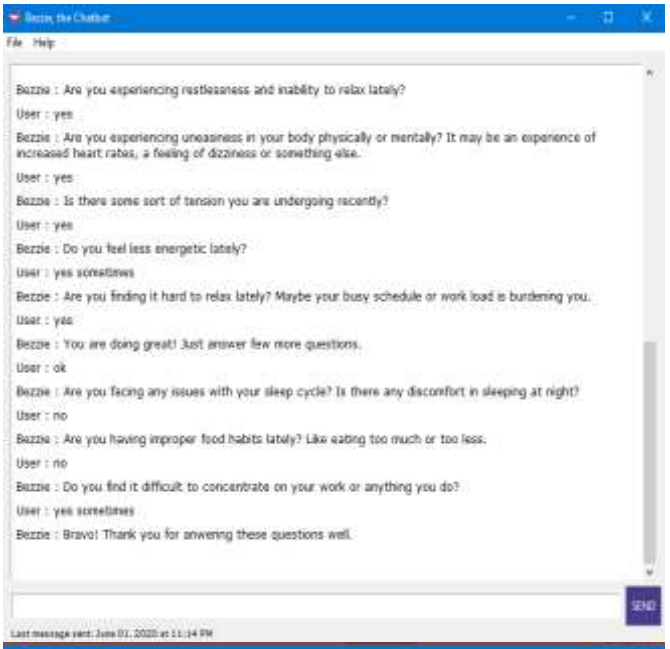
4. IMPLEMENTATION

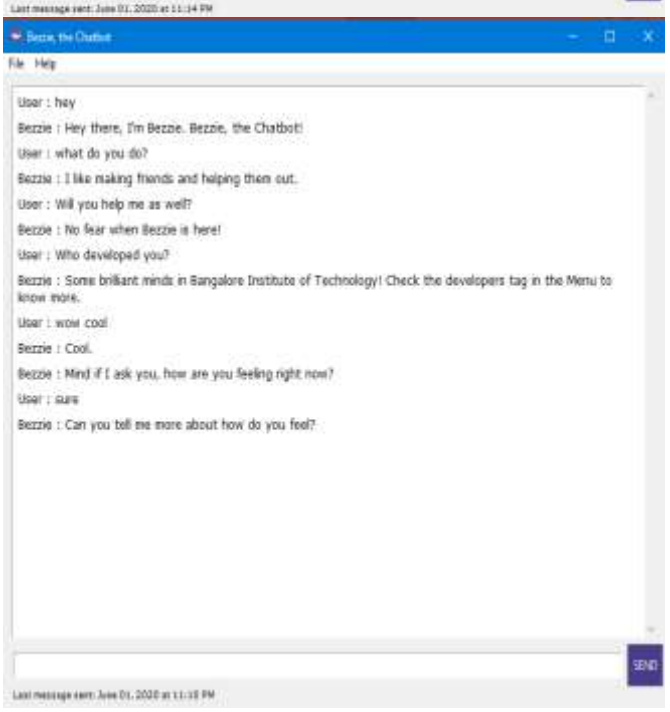
The primitive aim of this work was to enhance the current diagnosis and treatment techniques for mental illnesses by providing an emotional support to the patient and also updating the doctor with the real time status of the patient by sharing reports. This would minimize the time gap between doctor-patient interaction and ensure immediate help to the patient if needed.

The development of the chatbot ensures to achieve the above aim by allowing the users to talk to the chatbot. The chatbot responds to all the questions of the users and then conducts a small diagnosis if it predicts a negative emotion from the user. This diagnosis covers some critical and general symptoms of all the diseases dealt within this chatbot. Using the responses given by the user, the chatbot develops a basic understanding of the user's mental state and provides with a primitive first aid to tackle the phase. Parallelly, the chatbot shares a brief report of the diagnosis with the user's personal psychiatrist/doctor in a graphical format via e-mail using the SMTP protocol, each time it conducts a diagnosis. This helps the medical practitioner to understand the mental state of the patient in small time gaps and call for immediate consultation if it is required urgently. This eventually builds a bridge between two consecutive consultations with the doctor.

5. RESULT ANALYSIS

After creating an UI based application for the chatbot, we tested out the performance of the chatbot, screenshots followed demonstrate some of the results derived.





6.CONCLUSION

We are using Machine Learning, one of the top most trending technologies of our times to achieve the core analysis results for our problem. This work mainly focuses on gathering user data which is further used to analyse if that subject can be a pre case of four mental illness, namely Depression, Anxiety, Stress and OCD. We drive the conversation using a technique called Dialogue Flow Management System to arrive at the conclusion. Finally, we generate a report based on the analysis done on the conversation and send it to the regular consulting psychiatrist for further human intervention in diagnosis.

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