

# Baymax- Your Mental Health Care Companion

## An Artificial Intelligence based Chat bot for Mental Health Care

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**Abstract**—Artificial intelligence (AI) technologies and techniques have useful purposes in every domain of mental health care including clinical decision-making, treatments, assessment, self-care, mental health care management and more. Recent technological innovations are highlighted to demonstrate capabilities and opportunities. This application involves an AI based Expert System which can significantly contribute to improving mental health of an individual to lead a better life without any stress or melancholy. The expert system provides expert advice and therapy to overcome negative thoughts. This app can also help to reduce the number of suicides caused due to extreme depression.

It is about virtual human conversation with the system to support user's interaction within a mental health care context. It provides private online healthcare guidance and support where the app can serve the role of a clinician or a psychotherapist. It uses Smartphone technology particularly relevant for applications in Mental health. Recent advances in artificial intelligence are providing an unprecedented ability of online mental health care research and clinical organizations to collect and analyse data that is broader in scope. This application provides a system capable of calculating the depression level using Fuzzy Logic Controller. It sends an alert message to user's acquaintance thereby preventing the user from causing harm to himself. It tries to imbibe happy thoughts and optimism into the user. Thus, this system can have a meaningful impact on people's lives by improving their mental health.

**Keywords**—Expert System; artificial intelligence; chat bot; mental health; depression; suicide; psychotherapy

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### I. INTRODUCTION

As per a survey by WHO in 2016, close to 800,000 people die due to suicide every year and there are many more who attempt suicide. Hence, many millions of people are affected or experience suicide bereavement every year. Suicide occurs throughout the lifespan and is the second leading cause of death among 15-29-year-old's globally. Suicide is a global phenomenon in all regions of the world; in fact, 78% of global suicide occurred in low- and middle-income countries in 2015. Suicide accounted for 1.4% of all deaths worldwide, making it the 17th leading cause of death in 2015. In India, over 5 crore people suffer from depression. Every 3 seconds a person attempts to die in India. Many people of all age groups suffer from melancholy due to various reasons. As extreme depression may lead to suicidal thoughts, there is a need of an app which will help to reduce the depression and mental stress thereby combating the suicide rate.

Looking at the severity of mental illness, there is a need of some application which can act as your mental health care companion. An application in your mobile phone that can handle whatever life throws at you and helps you live the best life you can. We need an application which will help people to deal with depression, anxiety, social distress, relationship stress, career stress, body image, loneliness. Various technologies like Artificial Intelligence, Expert System, Fuzzy Logic can be used in making such an application.

Artificial intelligence (AI) based tools hold potential to extend the current capabilities of clinicians, to deal with complex problems and ever-expanding information streams that stretch the limits of human ability. The (treatment)

choices we make change what we observe (clinically, or otherwise), which changes future choices, which affects future observations, and so forth. As humans (clinicians or otherwise), we leverage this fact every day to act "intelligently" in our environment. To best assist us, our clinical computing tools should approximate the same process. Such an approach ties to future developments across the broader healthcare space, e.g., cognitive computing.

Expert system is a branch of Artificial Intelligence which offers benefits in many areas of health care. The system allows experts without experience of computers to build and evaluate complex disease models or psychiatric schedules which condense symptoms, pathological factors and social factors into international disease classifications. The knowledge of human expert system in mental ill and disorder is transformed and often encoded into the knowledgebase using a fuzzy logic and then provide the severity of any disorder.

### II. STUDY OF EXISTING SYSTEM

Health informatics (HI) is an interdisciplinary domain, which attempts to merge 'Healthcare' and 'Technology', effectively. One developing domain of HI is the application of intelligent algorithms in the clinical decision making, popularly known as 'Artificial Intelligence in Medicine' (AIM). Psychiatry is a special domain in Health Sciences that deals with organic brain disorders due to various causes. Psychiatric diseases or mental illnesses present with subjective symptoms, which cannot be measured directly. Application of Soft Computing (SC) techniques in depression-screening and predicting the

respective severity yields a huge research challenge, concepts of Fuzzy-C Means (FCM) and K-means (KM) clustering techniques were used for classifying depression grades.

This paper proposes an automatic tool to screen and grade possible causes of depression and take appropriate referral decisions. The Neuro-Fuzzy based system uses Fuzzy Logic Controller (FLC) and Back Propagation Neural Network (BPNN). The FLC is trained off-line with the help of a BPNN. For tuning of the FLC, a set of 78 training data (responses of the 78 different doctors for different input conditions) is considered. There are seven inputs and one output of the system. Therefore, both training as well as test data consists of variation of depression output corresponding to the different values of seven inputs, namely Feeling Sad (I1), Loss of Pleasure (I2), Weight Loss (I3), Insomnia (I4), Hypersomnia (I5), amount of corrections necessary in the weight values is calculated. Performance of the back-propagation algorithm largely depends on the learning rate ( $\eta$ ) value. Therefore, an attempt was made to get a value of learning rate ( $\eta$ ), for which the value of Mean Squared Error (MSE) (see equation 5) becomes minimum. [1]

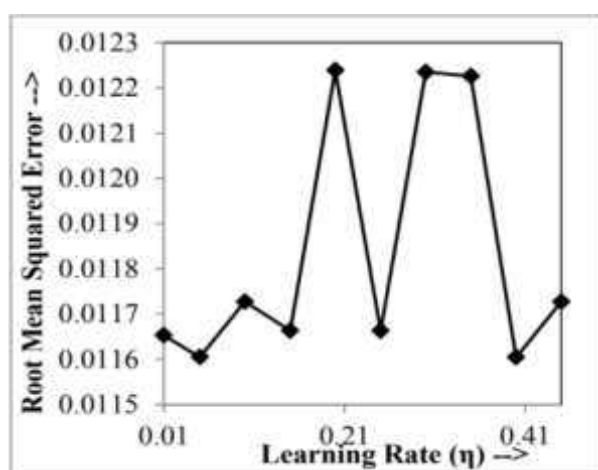


Figure 1. Selection of optimal  $\eta$  (Error vs. learning rate) [1]

This paper is not yet implemented due to the complexity of neuro-fuzzy system in AI. Furthermore, this system analyses the possible causes of depression whereas our system will analyse the level of depression.

In the following section we find number of machine learning techniques available to construct expert systems. This section provides a comparison necessary to identify the best technique that suits the domain of interest. The paper has compared eight machine learning techniques (classifiers) on classifying the dataset to different mental health problems. It is evident from the results that the three classifiers viz., Multilayer Perceptron, Multi class Classifier and LAD Tree produce more accurate results than the others. Performance analysis of eight classification algorithms is done with a common dataset using WEKA tool. WEKA tool provides various measures to understand the classification, like e-Kappa Statistic, Accuracy and ROC Area. For example, the Kappa Statistic measures the agreement of prediction with the true class. A measure of 1

signifies complete agreement and a measure of 0 signifies complete disagreement between prediction and the true class. [2] In this paper we came to know about various Machine Learning Techniques used to implement expert systems.

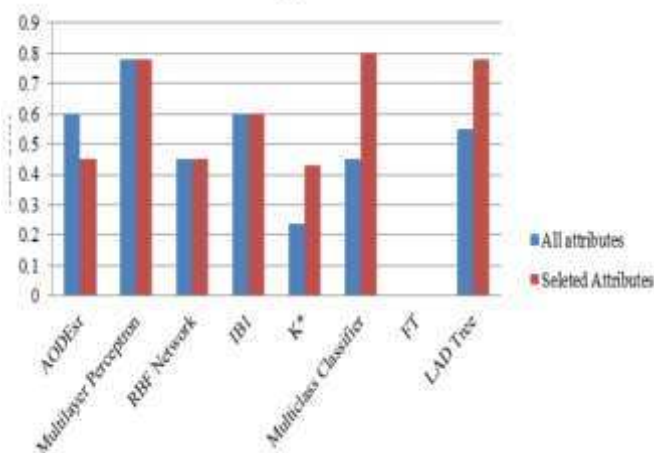


Figure 2. Kappa Statistic for all classifiers [2]

Apart from the above-mentioned machine learning techniques there are some Biomedical Signal devices such as ECG (Electrocardiogram) which are being used for diagnosing stress and most available Computer Aided Diagnostic Systems for managing stress rely heavily on these devices which are not common especially in rural areas, difficult to handle and very expensive. These among other reasons have led to many undiagnosed cases of stress.

Another paper proposes a new simple system which can manage stress effectively without the use of these expensive devices. The system proposed in this paper uses MySQL as its backend. The rules generated in consultation with Medical Experts served as the engine room of the diagnosis system. A new user interacts with the system by registering with his intending username and password, while existing user just login to the system by supplying appropriate username and password. If these are correct, the next interface-diagnosis section selection interface is displayed. This interface affords the user to select the diagnosis section of interest – Mental Stress Diagnosis Section, Emotional Stress Diagnosis Section, Behavioural Diagnosis Section or Physical Stress Diagnosis Section. After the user selects, the diagnosis section of choice, the interface of the selected section is displayed. The user must answer the set of questions in selected section and submit by clicking on submit button, after which the result of the diagnosis is displayed. [3] In this system the user has to follow a lengthy registration process and moreover the user must select a diagnosis section on its own to diagnose the problem. It could only diagnose the mental illness and did not cure it. Since it was a web application it was not easily accessible like a mobile app.

Artificial Intelligence (AI) is technology designed to perform activities that normally require human intelligence. AI is also defined as the multidisciplinary field of science that is concerned with the development and study of this technology. This article reviews developments in artificial intelligence (AI) technologies and their current and prospective applications in

clinical psychological practice. Some of the principal AI assisted activities reviewed include clinical training, treatment, psychological assessment, and clinical decision making. A concept for an integrated AI-based clinician system is also introduced in this article. The first simulation of a psychotherapist that used a human computer interface was the ELIZA computer program in 1966 (Weizenbaum, 1976). The program was designed to imitate the empathic communication style of Carl Rogers (Rogers, 1951), and it used a question and answer format to respond to statements that its user typed on a keyboard. ELIZA used language syntax to provide formulated responses based a programmed model and therefore only mimicked conversation. Another clinical decision support system is MYCIN which was designed to identify bacteria causing infections and blood clotting diseases. It was built by interviewing experts, MYCIN was a rule based system that used a typed question and answer dialog. Although the system performed well in tests, it was never put to clinical use mostly because of the computing technology limitations of the day. The application of AI technologies in the mental health care field is undoubtedly a growth area that is destined to have a profound influence on psychological practice and research in the years ahead. The field of psychology has historically made important contributions to the field of AI. [4]

AI can be implemented in psychotherapy. One of the renowned technique used in psychotherapy to deal with depression is REBT model. Rational emotive behaviour therapy (REBT), previously called rational therapy and rational emotive therapy, is a comprehensive, active-directive, philosophically and empirically based psychotherapy which focuses on resolving emotional and behavioural problems and disturbances and enabling people to lead happier and more fulfilling lives. The primary goals of REBT focus on helping people realize that they can live more rational and productive life. One way this is accomplished is through the A-B-C-D-E model of REBT:

**A** signifies the activating experience;

**B** represents how the person thinks about the experience (Belief);

**C** is the emotional reaction to **B** (Consequence);

**D** is disputing irrational thoughts (Dispute);

**E** effective thoughts and hopefully a new personal philosophy that will help user achieve great life satisfaction.

REBT model is very useful in treating patients with depression i.e. in psychotherapy. In addition, REBT is used with non-clinical problems and problems of living through counselling, consultation and coaching settings dealing with problems including relationships, social skills, career changes, stress management, assertiveness training, grief, problems with aging, money, weight control etc. [5][6]

Some existing systems which are recently developed to reduce the depression are Wysa App Facebook AI for suicide prevention. Wysa is also an AI driven application which tries to reduce depression. But in extreme cases, for example if someone says, "I am committing suicide", Wysa responds by saying "Please call one of the helplines." Thus, it does not take any practical steps to prevent one from committing suicide.

In March 2017, Facebook started using AI as a tool to prevent suicide. It will keep a track of posts made by people and the searches made by people it will also analyse live streaming videos. If any abnormal behaviour or suicidal tendency is figured out, then it will send a reference of psychotherapist to the depressed user. In this the friends of the depressed user can also report to FB if they notice anything unusual.

### III. BAYMAX

#### A. Problem Definition

Baymax is an AI based application, which serves as a companion and is capable of understanding people's emotions. It helps to deal with depression and stress by guiding the person to think rationally and deal with any situation in an optimistic manner. Baymax is capable of analysing depression levels and provides psychotherapy.

The Baymax software must take care of all the cases that will be encountered during conversation. This application should immediately send an alert to the user's acquaintance when it identifies that the user is going to take a fatal decision. The user must have access to all the tools in the toolkit. The application must be able to respond correctly to all types of emotion. It should be able to make rational decisions and provide favourable advice.

#### B. Operational Feasibility

Operational feasibility is mainly concerned with issues like whether the system will be used if it is developed and implemented; whether there will be resistance from users that will affect the possible application benefits.

As evidenced by a recent public survey that found that 76% of 525 respondents would be interested in using their mobile phone for self-management and self-monitoring of mental health if the service were free. Baymax and other technology-based solutions have the potential to play an important part in the future of mental health care, making mental health support more accessible and reducing barriers to seek help. Innovative solutions to self-management of mental health issues are particularly valuable, given that only a small fraction of people suffering from mood or anxiety problems seek professional help. Even when people are aware of their problems and are open to seeking help, support is not always easily accessible, geographically, financially, or socially.

Characteristics of likely competitors: The potential patient and health service benefits that could be achieved through the wider use of high-quality evaluated apps could be considerable. However, despite the potential for apps to play a valuable role within mental health care, not all apps available to consumers are likely to be clinically effective, and of those that are, only a small number can demonstrate a clear picture of real-world effectiveness.

#### C. Functional Requirement

- Chat with the user: Baymax initiates the conversation and makes the user feel comfortable. Baymax also provides the therapy while chatting with the user.

- Analyse depression level: The answers given by the user in the questionnaire are analysed by the Fuzzy Logic Controller. Hence the depression level is calculated. This helps Baymax to identify how chronic the depression of the user is.
- Provide Reference to Psychiatrists via Practo: In case of mild to severe depression, it is recommended to get a psychiatric treatment. Therefore, Baymax provides references of good psychiatrists.
- Provide REBT: REBT stands for Rational Emotive Behavioural Therapy. It is a type of CBT. Baymax will use this therapy to help the user change his negative feelings to positive ones and to replace his irrational thoughts with rational ones.

#### IV. BAYMAX AS A SYSTEM

##### A. Analysis

The system analysis for Baymax contains mental health care support which indicates the mental status of the user upon a comparison based on some specific criteria.

System analysis report for Baymax contains input given by user and output given by system.

It consists of following subsystems:

- a) *Fuzzy Logic Controller*: Fuzzy logic is an approach to computing based on "degrees of truth" rather than the usual "true or false" (1 or 0) Boolean logic on which the modern computer is based. Fuzzy Logic Controller mathematical system that analyses crisp input values in terms of logical variables that take on continuous values between 0 and 1.
- b) *Expert System*: An expert system is a computer system that emulates the decision-making ability of a human expert. Knowledge base and Inference engine are two integral parts of an expert system.
- c) *Knowledge base*: A knowledge base is a technology used to store complex structured and unstructured information used by the expert system
- d) *Inference Engine*: Inference engine is a component of the expert system that applies logical rules to the knowledge base to deduce new information.

##### B. Significance of Baymax:

- Prevents from Thinking about hurting or killing yourself or others.
- Keeps away from experiencing an emotional crisis.
- Helps in avoiding hopelessness, feeling like there's no way out.
- Helps in avoiding talking about death, dying, or suicide.
- Keeps away from self-destructive behaviour, such as drug abuse.
- Prevents from anxiety, agitation, sleeplessness, mood swings.
- Avoids feeling like there is no reason to live.

##### C. Overall System Overview

The system consists of two main components.

1. Fuzzy Logic Controller
2. Expert System

Each of these components are used to analyse the depression level and to provide the therapy to the user respectively.

First, the User must install the Baymax App and give its Name and Age to start conversation with the app. The user will be provided with a questionnaire during the very first session with Baymax. Each questionnaire will have multiple choice questions and the user will provide its response (linguistic values; keywords for FLC). The questionnaire that will be used for evaluation of depression is Beck's Depression Inventory (BDI) and HAM-D. These crisp values (Ex. Depressed, stressed, fed up, frustrated, etc.) are given as input to the Fuzzy Logic Controller. The FLC then maps these values to the rule base to analyse the severity of depression and produces an output (Depression level). This output is defuzzified and stored into the database. The depression level helps Baymax to identify how chronic the depression of the user is.

The Expert system then uses the REBT model to give therapy to the depressed person. This is achieved by the A-B-C-D-E model of REBT which tries to change one's beliefs about the events which contributes to unhealthy feelings and self-defeating behaviours.

The app gives the user positive thoughts, inspirational real-life examples, meditation tips, yoga exercises, etc. These tips and facts are also given to the user in a toolkit along with other tools like chants, quotes from Bhagavad Gita which is the key to leading a fruitful life, links to Youtube videos and music.

If Baymax finds that the user is going to harm himself or cannot cope up with the depression, the app will give a psychiatrist's reference to the user via Practo and in extreme cases will also send an alert message to the most frequently contacted person on the user's phone (The call logs will be scanned to find the frequently contacted person).

##### D. Proposed Design/Architecture

The system consists of following components:

- 1) *User*: The user (a depressed person) of the system will install the Baymax application. The User will have to provide its name and age to start interacting with Baymax.
- 2) *Fuzzy Logic Controller (FLC)*: The FLC takes crisp values (Answers to the questionnaire by the user) as the input. It fuzzifies those values and maps the fuzzified values with the rules stored in the rule base and produces a fuzzified output (depression level). This output is then defuzzified and stored in the database by the FLC.
- 3) *Database*:
  - a) *Rule Base*: Rule Base consists of rules on which the fuzzified crisp values are mapped to analyse the depression level. The rules are generated using HAM-D, Hamilton Depression Rating Scale. The total score is then calculated, and depression level is analysed by mapping the depression level in one of the given ranges.



- b) *User database*: This database has 6 columns representing the User's Unique id (Primary key), Session id, Name, Age, Session start, Session end.
  - c) *Keywords Database*: This Database has 3 columns namely the foreign key Unique id, Session Key, Keywords.
  - d) *Knowledge Base*: The Knowledge base has the A-B-C-D-E model of REBT, which includes various examples on consequences (both negative and positive) which is determined by mapping the belief of the user. It is used to provide therapy to the user.
- 4) *Expert System*: Expert System is software which uses databases of expert knowledge to offer advice or make decisions in areas such as medical diagnosis. The Expert system will provide therapy to the user using the knowledge base built by the knowledge engineer by extracting the knowledge from the domain expert.
  - 5) *Human Expert*: The knowledge base is built in consultation with the Expert psychiatrist.
- 2) *Baymax acts as a companion or a friend*: A depressed person may isolate himself from the rest of the world. Baymax will act as a friend and will help him to overcome this problem.
  - 3) *Suicide Prevention*: The app can prevent the person from committing suicide, by curbing his depression.
  - 4) *Other benefits*: Baymax can help to deal with anxiety, social distress, relationships, career stress, mild depression, loneliness.

## VI. CONCLUSION

Mental health is still neglected globally due to the prevailing social taboo. Also, the number of psychiatrists is much less compared to the number of patients. Given this scenario, an automatic tool could be useful to handle these issues.

Baymax is an application which works in collaboration with traditional psychotherapy. The main objective of this application is to provide mental support to the user (a depressed person). Adequate, timely and well-co-ordinated support is required for the user at different times and in different ways. As the percentage of people having a smartphone and access to the internet is very large, our application can be easily available and accessible. Since the knowledge base is built in consultation with an expert psychiatrist, the therapy given to the user will be genuine and reliable. Thus, we conclude that, our app will help reduce the depression of the user thereby making him/her feel happier.

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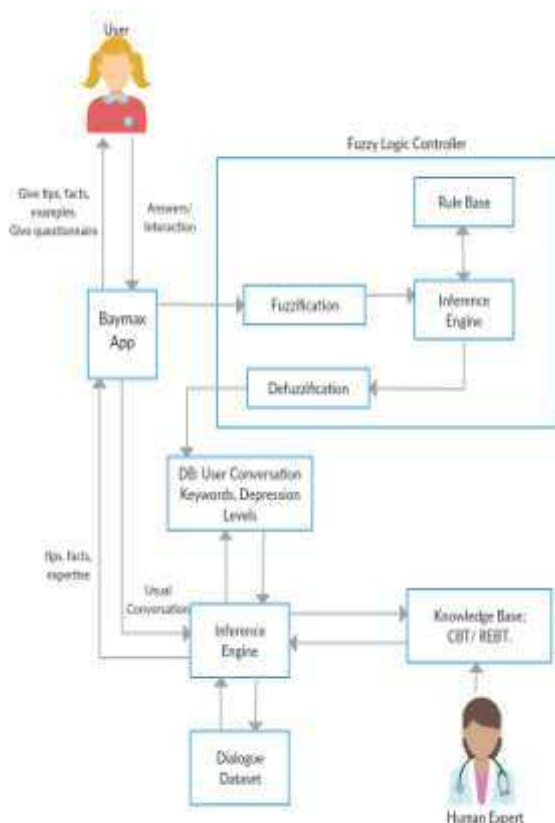


Figure 3. Proposed Design/Architecture

## V. APPLICATIONS

- 1) *Baymax can work in collaboration with psychiatric treatment*: Although, psychiatric treatment is mandatory in case of severe depression, the patient might not want to share his feelings with anybody else, be it a doctor. In this case user can chat with the application and share all his feelings, knowing that it is just a machine. This can help reduce his depression to a certain extent and make him feel better.