MACHINE LEARNING BASED DEPRESSION LEVEL PREDICTOR FOR INDIAN FARMERS

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Introduction:

1.1 Indian Agriculture and Farmers Depression

Agriculture has experienced significant changes and agriculturists confront a wide assortment of stress. Our intent is to investigate the levels of anxiety and depression symptoms among Indian farmers.

If you’ve idealized farming as an easy occupation, it’s not. Farming is characterized by high stress. A farmer is both boss and employee. Sick benefits and medical leave depend on the same person. Financial pressures, livestock disease, poor harvest, climate change, government policies and legislation can devastate farmers.

The exact numbers for farmer suicides is difficult to determine because farmer deaths are often reported as hunting, equipment or farming accidents instead of suicides. Access to highly lethal means — firearms, poisons, machinery — result in a large proportion of fatal suicide attempts. There are stories of farmers jumping to their deaths from the top of silos, hanging themselves in wells or deliberately falling into harvesters. Also according to the article by Brian Bienkowski, “Recent research has linked long-term use of pesticides to higher rates of depression and suicide. Evidence also suggests that pesticide poisoning—a heavy dose in a short amount of time—doubles the risk of depression.”

The report points out that a look at the number of suicides for categories of professions unrelated to farming or cultivation, like government service, private service, or among students, shows Andhra Pradesh and Maharashtra have reported significantly higher number of suicides in each category compared to UP and Bihar.

The suicides point to two things: first, a serious agrarian crisis shaped by an increase in cultivation costs and a decline in agricultural income, which is pushing farmers into a debt trap; and second, the sociological pressures that farmers face because of the disparity between their income and those in urban areas.

High stress combined with frustration can lead to depression. When you feel or believe you have nowhere to turn for help, the idea of suicide starts to look really good. The present way of life of people across globe is loaded with exercises performed with worry because of competition, volume of work, travel needs, arranging and characterized execution. The review demonstrates that the most modified age gathering is the youthful people who contribute a great deal of improvement exercises. The review demonstrates that, one among five is inclined to depression which may prompt non-performance or endeavour to destroy self from life. Depression is one of the deadliest diseases hitting about a noteworthy populace.
around the world. It causes extreme manifestations that influence how you feel, think, and handle every day exercises, for example, resting, eating, or working. And furthermore, flow into proposes that sadness is brought on by a blend of hereditary, organic, natural, and mental variables. Discouragement can occur at any age, yet frequently starts in adulthood. To be determined to have sadness, the manifestations must be available for no less than two weeks. Despondency is currently perceived as happening in kids and young people, despite the fact that it here and there presents with more conspicuous fractiousness than low disposition. Numerous perpetual state of mind and uneasiness issue in grown-ups start as large amounts of nervousness in youngsters.

1.2 Literature Survey

A review of literature survey is made here to understand the usage of brainwave signal processing and utilizing it for depression detection techniques. A study of various research works published in reputed journals is made. The extract of each literature is depicted for better understanding of the work in this chapter.

The author [1] used depression screening measurements of Patient Health Questionnaire-9 (PHQ-9) and Depression Anxiety Stress Scale-21 (DASS-21) in order to identify the normal and depression groups. A 32 channels EEG was used to detect the difference of alpha waves in depression and normal groups. The alpha waves in depression group were found out to be lower compared to the normal group in both close eyes and open eyes conditions. [1]

The authors [2] have estimated the depression level using I-Vector technique and fuzzy membership functions. Depression level is evaluated of each speaker by using these two algorithms. After that they have compared the results of these two methods. Fuzzy membership functions give more accuracy as compared to the I-Vector method. Fuzzy membership functions give better performance as compared with earlier techniques. They got 99 per cent accuracy in depression level estimation in audios using fuzzy membership function method. [2]

The author [3] with his work presents the usefulness of the forehead EEG with advanced sensing technology and signal processing algorithms to support people with healthcare needs such as monitoring sleep, predicting headaches, and treating depression. The proposed system for evaluating sleep quality is capable of identifying five sleep stages to track nightly sleep patterns. The depression treatment screening system can predict the efficacy of rapid antidepressant agents. It is evident that frontal EEG activity is critically involved in sleep management, headache prevention, and depression treatment. The use of dry electrodes on the forehead allows for easy and rapid monitoring on an everyday basis. The advances in EEG recording and analysis ensure a promising future in support of personal healthcare solutions. [3]

The author [4] proposed a formalization of the analytic system based on machine learning algorithm, which would predict the level of depression for individuals and suggest respective remedy. The “Healing Hands for Depressed People System” (DHH) performs to accurately correlate the level of depression and justify the remedy given with the opinions of experts in domain. [4]

The author [5] in his work recorded the Encephalogram (EEG) activities from 37 participants during processing of facial expression stimuli. With both high-gamma and low-gamma bands, the coherence in the right hemisphere of normal controls was greater than that of mildly depressive subjects, especially for electrodes P8, TP8, C4, FC4, and F8. In the low gamma band, the clustering coefficients of healthy controls in the prefrontal lobe (AF4, AFz, AF3, FC5, F4, and F6) and the parietal lobe (P03, P04, and P2) were significantly higher than those of mildly depressive subjects. The ratio of the characteristic path length
between the functional network of the mildly depressed group and the small-world network was greater than 1. For the normal group, the ratio was near 1. Here, the results show closer cooperation in the brain areas of right hemisphere in normal controls during the cognitive process compared with the mildly depressed group, while the activity of the prefrontal and parietal regions in mild depression was significantly lower than that of normal controls. [5] The authors [6] through this paper have estimated the depression level of each speech signal using I-Vector technique. Here, they have removed silence from the speech signal then extracted features from audio using I-Vector after which split overlapping function was applied to evaluate overlapped audio beats. In the end, they have evaluated depression using relationship matrix. This technique has better performance as compared with existing techniques. The overall result has shown that the I-Vector technique has good accuracy to detect depression in audios. [6]

The authors [7] in their work steps towards developing a classification system-oriented approach, where feature selection, classification and fusion-based experiments are conducted to infer which types of behaviour (verbal and nonverbal) and behaviour combinations can best discriminate between depression and non-depression. Using statistical features extracted from speaking behaviour, eye activity, and head pose, they characterize the behaviour associated with major depression and examine the performance of the classification of individual modalities and when fused. Among the different fusion approaches used here, feature fusion performed best with up to 88% average accuracy. [7]

The author [8] uses three-electrode pervasive EEG collector to collect EEG data from Fp1, Fp2, and Fpz as locations of scalp electrodes, since these locations are closely related to emotions, and uncovered by hair. Special designed experiment was conducted and totally 178 subjects’ EEG data were collected. Then the research uses K-NN (K-Nearest Neighbor), SVM (Support Vector Machine), ANN (Artificial Neuro Network) and DBN (Deep Belief Network) to analyze the data. The results show DBN performed better than traditional methods using shallow algorithms. Moreover, the results suggested the absolute power of beta wave is a valid characteristic, which could be used for detection of depression. The accuracy reached 78.24% using the combination of DBN and the absolute power of beta wave. This research proves the feasibility of smaller-size pervasive system for depression diagnosis. [8]

Times of India states that “Depression drives maximum farmers to suicide, not debt, finds Brookings study” said a paper by an American think-tank after analyzing suicide-related information provided by the National Crime Records Bureau (NCRB). Suicides due to bankruptcy or sudden change in economic status accounted for an average of 5% of farmer suicides in Maharashtra and Andhra Pradesh between 2002 and 2013. "In shocking contrast, illness or poor health (mental and physical) accounts for approximately 30% of all (farmer) suicides in Andhra and Maharashtra. So, health reforms at the state level and particularly in rural areas are likely to have a greater impact on distress and suicides than forgiving institutional loans,” said the report. [9]

Times of India [10] says “Farmers’ suicides continue even amid good crop”-NAGPUR: Despite good output in the fields, farmers’ suicides are continuing. Data from the suicide prone Amravati division of the region shows 319 farmers have ended their lives in three months since November. Investigations have categorized 89 of these as due to agrarian crisis. Another 113 deaths have been attributed to other reasons, while the rest of the cases are still under investigation. The data coincides with the harvest time, in a year when there have been no crop losses in general due to natural calamity. The suicide numbers on year-on-year basis have come down by nearly 8% in 2016. Also, the cases attributed to farm crisis have nearly halved to 498 in 2016, as compared to 828 in 2015. All the five districts under Amravati division, which includes Yavatmal, Akola, Amravati,
Buldhana and Washim, have been declared suicide prone since last over a decade, when the phenomenon began. Yavatmal has recorded the highest number of suicides. With 116 ending their life in November alone in the division, experts earlier thought it may have been due to cash crunch on account of demonetization. However, the trend continued even after the cash flow has normalized. In January, 89 farmers suicides were recorded in Amravati division with 18 in February as yet. [10]

Farmers’ suicide in Karnataka: Report of the Fact-finding Team on Farmers’ suicide in Mysore and Chamraj Nagar districts. It states that When the Bank authorities issued notice to Siddaraju for recovery of installment Siddaraju, unable to bear the depression committed suicide on 19th Dec 2007 by consuming pesticide. Also on 5th December by 10.30 in the morning Manjunath (Hosapura village of Nanjangud Taluk, who had borrowed from ICICI Bank Mysore for purchase of a tractor) dead body was found in the water tank in his land and Manjunath had committed suicide by consuming pesticide. [11]

The Hindu revealed incidents describing it as 50 suicides in 15 days. Is it falling prices? Is it a glut in production? Or are farmers just falling into debt because of aspirational spending? Whatever the reason, Karnataka is again facing the spectre of rising suicides Krishna, 32, a farmer in Singamaranahalli, about 30 km from Hunsur in Mysuru district, consumed pesticide and died in the first week of June. The sesame farmer with three acres of land could not survive the debt trap he was in. There is a serious agrarian crisis with an increase in agricultural costs and a decline in earnings. [12]

The literature shows that several factors, including speech patterns, voice prosody, eye moment, blood pressure, heart rate, Electroencephalogram (EEG) signals, and facial expressions can be taken into consideration for detecting the severity of depression. Electroencephalogram (EEG) is a commonly used medical testing device that detects abnormal electrical activity in the brain. Significant advances in neuroscience, sensor technologies, and efficient signal processing algorithms have facilitated the transition from clinical-oriented diagnoses and research to personal healthcare applications. It is evident through the literature that there is promising future for the everyday use of EEG for monitoring and tracking health. Therefore, we propose our system, which will work in real time environment and also produce considerably accurate and reliable results.

Objectives:
The Main objectives of this work includes
- To acquire Indian formers real time EEG signals by using Neurosky’s Mindwave kit.
- To extract different EEG bands and prepare Farmer’s EEG database with known Depression Levels.
- Diagnostic model to alert of different depression levels of the formers upon analyzing EEG signals.
- To use Fuzzy/Neural Network modeling methods to detect / diagnose EEG formers data.

Methodology:
Depression is one of the most common mental disorders that, at its worst, can lead to suicide. Diagnosing depression in its early curable stage is very important.

3.1 Proposed Module
The Depression level prediction is done by collecting the EEG data signal from the brain by using “Neurosky's Mindwave Mobile Kit”, which gives the raw EEG waves. It is a non-invasive method which uses only single electrode. Person is asked with 10 questions from the Standard PHQ.9 questionnaires and depending upon his depression level, the
different EEG waves, namely Alpha, Beta, Theta, Delta and Gamma waves varies which are taken and saved by Lucid Scribe and are fed to the Machine learner. Here, in the proposed module, the Electroencephalogram (EEG) signals of subjects are obtained by interviewing different age group subjects (47 samples) with different depression levels. The features are then extracted from frequency bands (Alpha, Beta, Delta, Gamma and Theta). Data set of 47 subjects are prepared that are fed to the Machine learning classifiers like ANFIS and SVM to detect depression level. The proposed module is as shown in Figure 1.

![Proposed Module](image)

The important milestones of this project are as follows:

- The subjects are asked questions from standard PHQ.9 questionnaires and collection of EEG signal data from the subjects by using Neurosky's Mind wave kit.
- Extraction and exporting the collected parameter from the raw data.
- Statistical computation of the required data of each subject and creation of a new data feature set of all 47 subjects which are to be fed to the Machine learner.
- Classification of the set of test data of parameters to identify the depression level of the subject by using Machine learner.

### 3.2 Neurosky’s Mind wave mobile

Neurosky maker out accompanied the "Mind wave mobile" brain cap work in 512-HZ of recurrence comprising of just sing electrode, the raw EEG signal is transmitted from the instrument by means of Bluetooth to the framework, by the support of "Lucid Scribe" programming which hold he log of the general time, EEG information from the instrument is appeared in Figure 2. Waves for each small scale second is put away with the information sheet of consistently, time, moment and seconds, by sending out this to the exceed expectations design we can get the numerical yield.

EEG Signals are recorded with neuro sky's mindwave pack. Data's of different age gather and unmistakable sex are taken. Lucid Scribe programming gives differing mind wave signals in regards to time. In Lucid Scribe Brain signs are assembled. The data is masterminded age, sex, alpha, gamma, theta, and delta for max, min and average qualities.

![Mind wave mobile](image)
3.3 Patient Health Questionnaires (PHQ-9)

The PHQ-9 is a multipurpose instrument for screening, diagnosing, checking and measuring the severity of depression. The PHQ-9 wires DSM-IV despairing characteristic criteria with other driving genuine depressive symptoms into a compact self-report instrument. The PHQ-9 is done by the patient in minutes and is immediately scored by the clinician. The PHQ-9 can moreover be coordinated on and on, which can reflect change or exacerbating of distress in light of treatment. Figure 3 shows PHQ-9 sample English & Kannada format. Based on PHQ score, we may tabulate the Depression level statistically.

![PHQ-9 sample](image)

3.4 Samples collection and Processing

Lucid Scribe is the product which is utilized to gauge and furthermore to record the mind wave designs utilizing the Neurosky’s unit that is associated with the head. Lucid Scribe is a software to record distinctive brain signals, perceive REM rest and trigger diverse yields when REM rest is distinguished. This document delineates the components of Lucid Scribe, how they work and how to use them. Clear Scribe can be used to record brain wave outlines using an EEG device related with the PC and play back sound archives or trigger another device when REM rest is perceived through eye improvement. For the recording the relating module for the EEG being utilized must be presented nearby the essential programming. For example to use Lucid Scribe with a headset or headband that contains a Think Gear, like the Mindwave, you have to present in any occasion Lucid Scribe and the Neurosky's Think Gear EEG module. Figure 4 shows sample collection by using Mobile mind wave kit by asking PHQ-9.
Results and conclusions:

In this Project work, the subject is tested with basic questionnaires and their brain waves are recorded using Neurosky’s mindwave kit. The extracted dataset is then edited to form the training data set and testing data set as shown in Figure 5 and Figure 6 respectively. In this work, focus is made on Machine learning based Depression prediction. 47 Samples are prepared by asking questions from standard questionnaire. By using Neurosky’s mindwave kit brain waves are recorded at the forehead values are tabulated accordingly.

4.1 ANFIS (Adaptive Neuro Fuzzy-Inference System)

Matlab software plays major role, supporting in processing of mathematical values. Adaptive Neuro Fuzzy-Inference System (ANFIS) is the tool, which is also called as artificial neural network. Network structure developed with the given input data and hidden layers formed, learn by itself without the teacher or algorithm.

Training and testing set is prepared by analysing the PHQ score

- PHQ scores < 10 shows: No Depression (LEVEL 0)
- PHQ score between 10 to 14 shows Depression LEVEL 1
- PHQ score between 15 to 19 shows Depression LEVEL 2
- PHQ score >= 20 shows Depression LEVEL 3
In this project work 43 are trained and 4 are tested in ANFIS. Loaded data is displayed in blue dot in the tool window. Output is on vertical line represent 0, 1, 2, 3 for the different depression level, horizontal line represents 43 the range of training values. Block Generate FIS setting to be changed, grid partition to sub clustering, along with the change in the parameter settings like, Range of influence to 0.5, Squash factor of 1.25, accept ration as 0.5, Reject ratio is 0.15. ANFIS model structure is designed inside the tool, can be view by click on structure in ANFIS information block this is show in Figure 7. Sub clustering is selected on the second block, generate FIS block. Setting to the Hybrid method in option method in Train FIS block, also change in error tolerance, and epochs to 3, and click on train now, in test FIS block select plot against training data refer to the Figure 7, and click on test now.

![Figure 7: Loaded Data is Shown in the Chart](image1)

![Figure 8: ANFIS Structure for the proposed system](image2)

Output is projected on the chart red bubble is the output matched with the blue ring, 0 is the depression level 0, 1 is depression level 1, 2 is depression level 2 and 3 is depression level 3 which we expected output of emotion shown in Figure 9, selected emotions identified successfully by using ANFIs tool.

Depression 0 (0); Depression 1 (1); Depression 2 (2); Depression 3 (3)

In ANFIS; 43 data samples trained and 4 are tested. 7.03x10^-4 testing error is observed after plotting test FIS against training data. As mindwave kit is wearable with Bluetooth support this work may be used in various applications.

![Figure 9: Output of Different Mental States Tested](image3)
4.2 SVM (Support Vector Machine)

In this work focus is made on Identification and classification of Depressed and Normal subject. 47 Samples are prepared by asking questions from PHQ-9 from the person. By using neurosky’s Mindwave kit brain waves are recorded at the forehead values are tabulated accordingly.

- PHQ scores ≥ 10 indicates Depression
- PHQ scores < 10 exhibits subject is Normal

39 data samples trained and 8 are tested. As Mindwave kit is wearable with Bluetooth support this work may be used in various applications. In this work confusion matrix is derived by MATLAB program and accuracy of 75% is achieved. SVM Training and Testing results are as shown in Figure 10.

![SVM Results and Confusion Matrix](image)

Figure 10: Results and Confusion matrix

It is also classified in SVM to identify depression. 47 Samples are set up by making inquiries from standard PHQ-9 in a diverse era from the individual in wearable head unit. 39 samples are trained and 8 are tested. Vectors are classified as binary outputs as depressed and Normal. In this work SVM based confusion matrix as shown in Figure 9 is derived by MATLAB program and accuracy of 75% is achieved.

Scope for future work:

This work contributes the real-time monitoring module to the Indian formers community. Project will be predicting the mental health of the formers. This project indirectly helps to identify the vegetation level where govt may plan subsidy/insurance in drought areas. Depression prediction is a challenging task which place important role in different social applications.
This work may be improved by preparing large data samples and training them in the fuzzy system. Advanced neural network methods with large data samples will give improved result. Also use of large number of electrodes will give clear picture of depression in a person. The binary SVM classifier used could be replaced by multi-level SVM which gives depression in levels similar to ANFIS results shown in this work.

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