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AINA

AI and Analytics

Volume 2 • Edition 2020-21

COVER STORY

ART IS MATH

Annual Analytics Magazine from the Students of PGDBA

Post Graduate Diploma in Business Analytics : Jointly offered by IIM Calcutta, ISI Kolkata & IIT Kharagpur

AI & Mental Health

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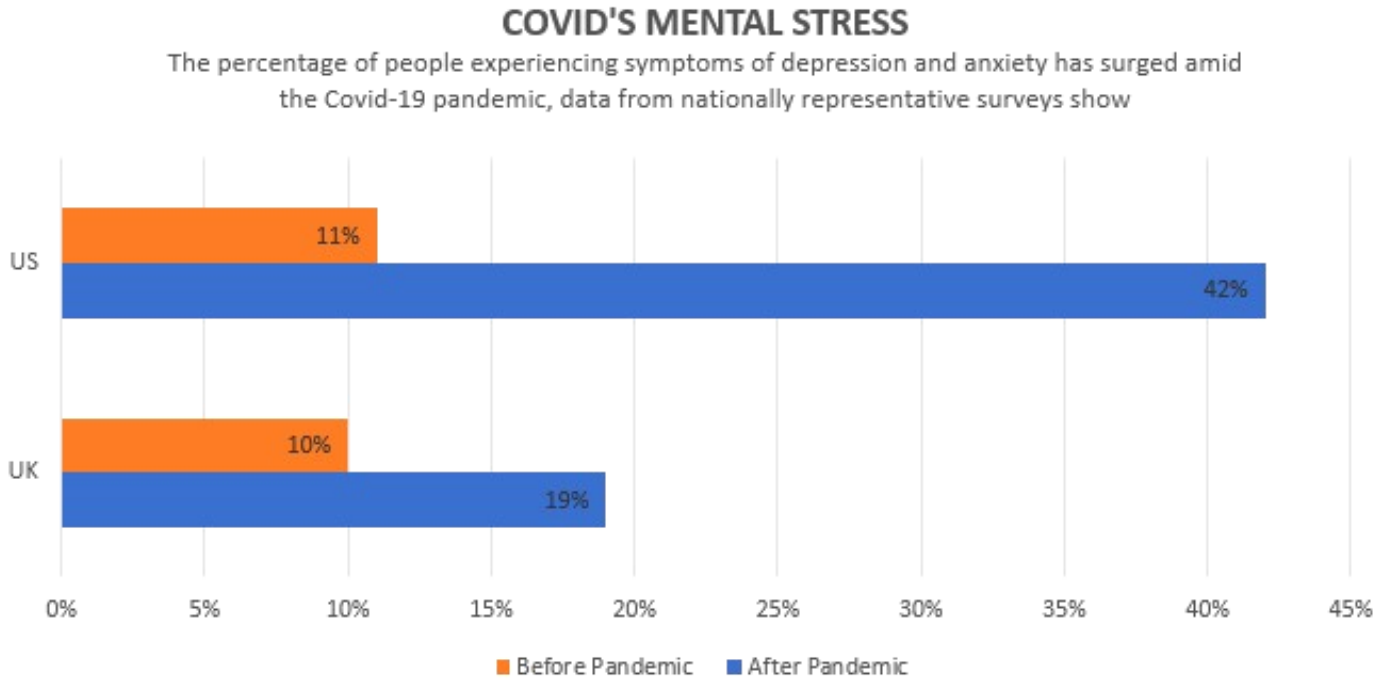
According to a WHO report, 7.5% of Indians, or 97 million people out of 1.3 Billion, have some mental disorder. It also states that there is a massive scarcity of medical care for such patients in India. For the 100k population, there are only 0.3 psychiatrists, 0.12 nurses, and 0.07 psychologists, which is far from the recommended 3 number of psychiatrists and psychologists. Such a crippling healthcare system, and the growing number of people struggling with mental health problems, suggest that a crisis is looming over India. According to an estimate by WHO, between 2012-2030, India will incur an economic loss of USD 1.03 Trillion due to the mental health issues with its young population. Disability-adjusted life year (DALY) is expressed as the number of years lost due to disability, ill health, or early death. The mental health burden for India is 2443 disability-adjusted life years per 10000 population and 21.1 age-adjusted suicide rate per 100,000 population.

The COVID-19 pandemic has worsened the situation further. A survey conducted by US Census Bureau revealed that 42% of people reported symptoms of anxiety and depression in December 2020, while it was 11% the previous year (see Figure-1). Similar observations were made from other surveys worldwide.

This sudden influx of patients suffering from mental health issues can be attributed to the limited social interactions, fear of illness, financial distresses due to job losses, and others. Amidst all these, one major problem has emerged. Many psychiatrists are reporting burnout due to the increased number of patients and the emotional nature of their work.

In such a grim situation where the mental health workforce is in short supply, the advent of AI and Machine Learning has brought extreme hope to solve this task, which has been considered very difficult to tackle. Healthcare is one of the most challenging paradigms for machine learning methods because of the risk associated with the wrong prediction and the lack of suitable data. The human brain has always been a hard nut to crack for scientists. But recently, researchers have made significant progress in applying machine learning techniques to help patients struggling with mental health problems.



Source: Office for National Statistics (UK data); Centers for Disease Control and Prevention (US data)

Why is a new method needed?

The traditional methods of diagnosing mental illness include physical examination, lab tests, and psychological evaluations. They have not proved very helpful as far as the treatment of mental diseases is concerned. Physical examination includes observing facial expressions, eyebrow shapes, sudden changes in pupil dilation, and different blinking rates. The person who suffers from such problems might show some peculiar physical characteristics. Psychological evaluations include Interviewing the individual and asking questions which gives us a deeper view inside the person's brain. For preliminary detection, these are great tools, but it becomes difficult to find the right path of treatment due to inherent complexity.

What makes mental illness different from other health conditions is the stigma associated with it. These stigmas affect patients at their workplace, home as well as educational institutions. People who had dealt with mental diseases said that the stigmas were more disabling than the disease itself. One of the worst consequences of these stigmas is that the patients are reluctant to seek medical treatment, and thus lead to worse situations day by day. As patients are hesitant to seek medical advice, it exacerbates their problem with time.

Here comes the power of anonymity of AI to our rescue. A conversational chatbot designed to talk to a person suffering from mental issues can help them express themselves freely. They can live without the fear of being judged by the people. The ease of access to these bots and its lower cost compared to psychiatrists make it a lucrative choice in the initial days of the problem.. The importance of psychiatrists and psychologists cannot be replaced; instead, the new AI systems add to what psychiatrists can already do. These advantages help us find the undiagnosed person, speed up the recovery process, and increase the probability of being cured at the right time. Also, the patient needs to be constantly monitored when they are struggling with mental diseases as the panic episodes can come at any time. Technological progress has made it possible by constantly monitoring the patients by sensors and devices that can continuously read the brain wave signals and alert concerned people by sending an alert message if there are significant changes in the brain wave signals.

Data Collection

The backbone of any machine learning model is suitable and relevant data. Let us look at some of the ways in which we can collect and use data for treating patients.

Electronic Health Record (EHR)

In recent times, the promise of machine learning methods in helping doctors to predict, diagnose and treat mental health issues have attracted many researchers. Thanks to the structured healthcare system in the US, researchers can easily access vast amounts of data sets in the form of Electronic Health Record (EHR). EHR data are collected routinely when an individual takes medical consultation. It comprises two types of data: structured data such as medical reports, diagnostic tests, and unstructured data such as prescriptions, clinical notes, and other text -based data.

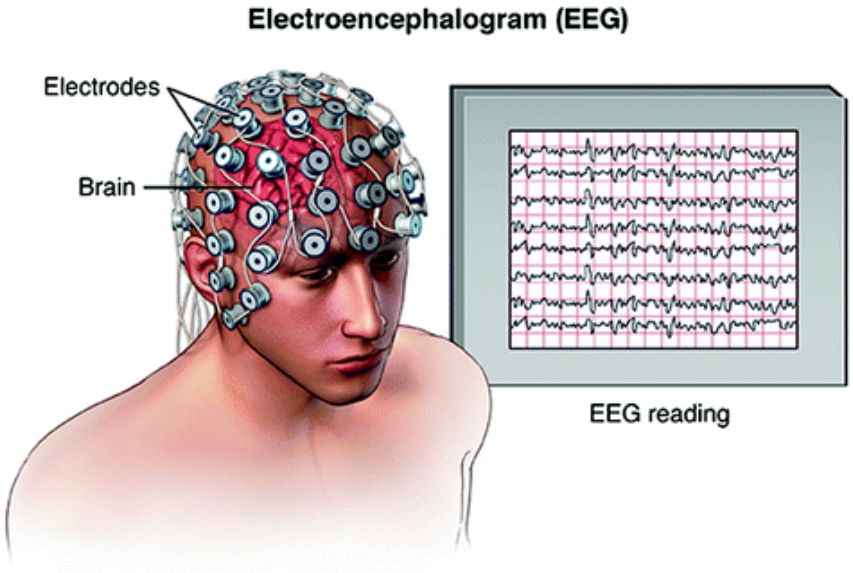
According to the article "the future of electronic health record" published in the journal Nature, the USA started a significant push to digitize its health record in 2009. In 2008, only 9% of hospitals in the US had electronic health records, but in 2017, it had reached 96%.

The big challenge in using EHR data is the underrepresentation of healthy people in

the dataset. Electronic Health Record exists mainly for people suffering from health issues, but the data does not accurately represent healthy people's features. This problem is tackled by using the standardized values of health measures already available with the clinicians. The man-made errors in data entry and poor labeling are among other issues with EHR data.

Social Media Data

Social media data can mostly provide the language and activity-related information that can prove to be very useful in assessing the state of mind of someone struggling with mental health issues. But we don't have many instances where this was used by researchers. The primary issue with social media data in this context is the presence of a lot of noise and irrelevant information, which are not very useful from the mental health research point of view. The noise with such data can hinder the ability of the model to predict well and thus can give erroneous results. Researchers have tackled this issue, in some cases, by taking repeated samples for testing the hypothesis since sample size can compensate for the noise in the data.



Source: Siuly S., Li Y., Zhang Y. (2016) Electroencephalogram (EEG) and Its Background.

In: EEG Signal Analysis and Classification. Health Information Science. Springer, Cham

Smartphone and Sensor Data

Some of the most crucial pieces of information which is helpful to analyze the mental health of an individual are obtained using smartphone sensors, which are difficult to obtain otherwise. Sleep quality, location, exercise, heart rate, communication pattern, and language use are generally extracted to analyze an individual's mental health. Among sensor data collection, the contribution of smartphones is immense because most people own a smartphone these days, and they keep it with them most of the time. Smartphones also have various measurement sensors already in place. Mobile phone sensors can also allow researchers to collect data at regular intervals for monitoring purposes, which can prove to be very useful in the case of mental illness. Smartphone also seems to be very promising in terms of collecting cognitive data at large scale.

Genetic Data

Our genes contain vital information about our characteristics. The genetic data can be very helpful in predicting the outcome of a particular treatment given to a patient. Pharmacogenomics is the field in which scientists try to find the relation between medical treatment and genetic background. A study carried out by Tansey et al. over ~3000 patients suffering from depression found that variation in genetic patterns can explain up to 42% of the differences observed in the

antidepressant treatment response of individuals. This further suggests that genetic data can be useful in predicting the treatment response. However, researchers still need to find some substantial success in using genetic data for treating mental issues.

Brain Measurement Data

Even after multiple attempts, researchers faced a lot of difficulties in working with genetic data. Thus, the brain measurement came into the picture, which has shown promising results. There are various ways in which brain activities can be measured.

Electroencephalogram (EEG)

EEG is a technique to detect the electrical activities of our brain using metal electrodes attached to our brain. Our brain cells are active all the time and communicate with each other using electrical signals. These electrical signals come as wavy lines on EEG, which contain information about brain activities.

Magnetoencephalography (MEG)

At cellular levels, each neuron has electrochemical properties, which causes charged ions to flow through the cell. This current creates quite a weak electromagnetic field. The strength of the electromagnetic field becomes measurable only when around 50k neurons are excited together in a specific area. Such a weak electromagnetic field is detected using Superconducting Quantum Interference Device (SQUID).

Functional Magnetic Resonance Imaging (fMRI)

fMRI measures the variation of blood flow in the parts of the brain as different parts get activated due to different stimuli. It is used to determine which parts of the brain handle critical functions and the effects of diseases or stroke on our brain.

Application of Machine Learning in Mental Health

For a novel method like Machine Learning to be applicable in the mental health domain, it is important for us to know the applicability and feasibility as well as actionable outcome of these methods. Researchers have already tried applying these techniques and have obtained promising results. Recently, researchers have started applying deep learning models for predicting depression using fMRI, EEG, MEG, voice and visual data, webcam video data, audio during the psychiatric interview, and Reddit self-reported depression diagnostic data.

At present, it is very difficult to cure mental illness. Most of the traditional methods are symptomatic treatments, where doctors try to treat the visible symptoms such as restlessness, anxiousness, irritability, irrational thoughts by giving medicines that subdue the adverse effects of these symptoms. Understanding the root cause behind these problems is the inherent difficulty associated with finding the right treatment. Doctors use a trial-and-error approach while deciding the dose of medicines. In some cases, the trial and error approach works well, but since every person's response to these treatments is different, there are many patients who get incorrect treatment.

One interesting and widely used application of Machine Learning is to predict who will drop out after initiating an antidepressant or any kind of medication. In these applications, EHR data have shown promising results, modest but not clinically actionable. Researchers like Hayes, Pradier, and Hughes tried to find out the patients who are likely to stop taking medicines, the patients whose condition will improve upon treatment, and the patients who will transition to a bipolar diagnosis.

When Pradier, in 2018, tried to predict the patients who will drop out of the treatment process only using the demographic data, he did not obtain good results, but on incorporating structured EHR data along with demographic data, the model performance increased by 13%, which proves the importance of EHR data.

The genetic background gives us very useful information about the way a person will respond to the medication. A polygenic risk score, which is a single value estimate of an individual's genetic liability to a trait or disease, is calculated using the genetic data. In 2017, Garcia et al. found that polygenic score for major depression was not a very suitable predictor for finding antidepressant efficacies. There have been various efforts to use genetic data to predict the effectiveness of the medicine for mental health issues, but we are yet to get any promising results. Although still in its infancy state, personal sensing holds great promise for its application in monitoring at-risk populations.

Challenges

All types of issues that exist with a machine learning approach translate directly to the above application. Data bias, model interpretability, poor validation schemes are among some of the issues. In recent times, we increasingly see the use of more and more deep learning methods being applied to solve the problems related to mental health. With the advent of such methods, we face the problem of model interpretability. The deep learning models work like a "black box," which takes data and gives us predictions without providing us information about the reason behind the prediction. In other domains, such as object detection, this can be accepted without any issues, but in the case of clinical applications, doctors and medical researchers need to understand the reason behind the predictions so that they can take action based on the recommendations. These problems occur when the domain knowledge is lacking during a study. The current biomedical knowledge bases, clinical research paper databases in addition to medical experts can be incorporated to address the limitation posed by data quality, model generalizability, and interpretability.

Sometimes, researchers do not create their cross-validation strategy properly and report overly enthusiastic results, which is a big challenge for machine learning practitioners. These models, although performing well on the dataset used, fails to generalize well and can give erroneous results when applied to new patients.

Patients concerned about privacy issues are also a big challenge. Collecting mental health data is very sensitive and requires some personal information to be extracted and analyzed, which makes certain people reluctant for opting such treatments.

Conclusion

Machine Learning has come a long way in the last decade, but despite its progress, its potential in psychiatry has just started to be explored. Advanced techniques like autoencoders and deep belief networks have shown promising results and are widely used in this domain. The application of ML in mental health has demonstrated exciting results and has also signified the immense potential that it carries. However, the current status of the work is limited and there is a lot of scope for researchers to identify the potential benefits and application of machine learning to help patients struggling with mental issues. Given the kind of research and innovations being done in machine learning daily, the field will keep on growing, and novel approaches will solve the current problem one day.