Various Approaches for Suicidal Tendency Detection: A Literature Review

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Abstract: Suicidal Tendency or the intention to kill oneself and end their life is a catastrophic situation which is mostly unknown by any person in the victim's life. In many studies it is evident that, victims tend to kill themselves either to end their pain, pressure or to have a relief that they are not going to live in this world anymore. Current suicidal tendency detection methods include numerous machine learning and deep learning approaches using clinical data or online social media, provide a solution to this existing problem. This paper aims to review various methods and approaches that can be followed in view of detecting suicidal tendency in a person. It also provides a deep understanding on how various sources of data can be gathered in terms of suicidal cases. Providing a multi-faceted method that can detect this tendency and intimate the family, friends or the close ones beforehand can prove to be a boon for the invention. This paper also clearly suggests about various approaches like facial gestures, text pattern recognition, speech recognition, daily physical activity analysis etc to present numerous ways to detect suicidal tendency with higher accuracy. Finally, the limitations and future scope are extrapolated to provide an overview for the future research.

Index Terms: Suicidal Tendency, Speech recognition, Human Computer Interaction, facial gestures, text pattern recognition.

I. INTRODUCTION

Suicide is the intention to kill oneself by injuring themselves and it happens impulsively in the moment of breakdown to deal with life's stress. It not only affects the person but leaves a long-lasting impact on the families and the people to whom they are connected. Some thoughts like talking about suicide, wanting to be alone, feeling trapped about a situation, increasing in the use of narcotics, changing normal routine, saying goodbye abruptly with no reason, being lost, etc. are a few psychological behaviors that can be noticed in depressed people who are having an intent of committing suicide, but they vary from person to person where some of them choose to make it clear while others keep it to themselves. Psychiatric issues like anxiety and depression are some of the prominent problems faced by people in society. These mental disorders without proper medical treatment can lead to an intention of killing oneself. This complex tendency is influenced by biological, clinical, psychological, and social considerations. According to WHO (World Health Organization), it is noted that, every year 703,000 people end their own lives and there is still an unimaginable count of people who attempt suicide across the world [1].

The rate of suicide is higher for the people who face discrimination in their life, it is directly proportional to high-stress circumstances and lifestyle changes. With the outbreak of the novel Coronavirus in 2019, the combination of the physical distancing, isolation, and at the same time the economic stress due to increase in the unemployment alarmed suicidal mortality rate. There are multiple factors that have consequently increased the risk of the suicide attempts like the reduction in the physical contact etc. Though some people mask up their feelings still their behavior such as seeming sad, agitation and hyperactivity can indicate that they have an underlying depression which can eventually lead to suicidal thoughts as well as an attempt.

Furthermore, nowadays with the advent of social networks, people are using social media as a medium of communication between people and expressing their thought process. Participating in discussion forums, community forums and posting their feelings enhances their intention to share their emotions with the world. Some users avail the feature of anonymity in the social media as an advantage to disclose their intention to commit suicide. There are few online platforms that encourage such fatal consequences and persuade people with their attractive motives. For example, a social networking game invented in 2016 called the "Blue Whale Game" uses self-hurting strategy and leads game members to commit suicide at the end. Thousands of people were dead in a year, and it emerged as a critical social issue. Therefore, it is necessary to detect suicidal tendency and prevent suicides before victims end their lives. Detecting the tendency at an early stage can save the victims life and proper medical treatment can show effective results in the future. Suicidal tendency detection discovers the risks of suicidal intentions before the tragedy strikes.

There are several methodologies that are introduced so far to detect suicidal tendencies which address several factors like online user content, texting patterns, voice analysis, etc. The methodologies that are known to be implemented include lexicon-based filtering, word cloud visualization, NLP (Natural Language Processing), J83 Binary tree classifiers, RNN and Deep learning-based representation learning like CNN and LSTM-based text encoders for observing the behavior based on textual analysis by extracting the necessary features which depict suicidal tendencies. Similarly, for the purpose of detecting the suicidal tendencies based on voice or audio was performed using SVM (Support Vector Machines), MFCC (Mel Frequency Cepstral Coefficients) gives the frequency patterns of the audio based on voice modulation and focused mainly on how the paralinguistic speech characteristics were affected by depression. Artificial Neural Networks like LVQ (Learning Vector Quantization), KNN (K- Nearest Neighbors), LSTM neural network and Ensemble averaging algorithm were noticed to be used most commonly. Many other approaches such as HCI (Human Computer Interaction), OpenFace 2.0 which is a toolkit intended for machine learning and computer vision were used to analyze facial expressions and non-verbal behavior of the user to detect these tendencies. Apart from these, there are many approaches used

in the existing systems such as multi-layer perceptron, Random Forest, and Radial biased function. It is also found that there are few existing systems which are trying to integrate both voice and text analysis showed better accuracies.

Any person infused with suicidal thoughts generally are the ones who suffer with depression or are filled with either anger, grief, or guilt. There are many ways to identify a person who experiences suicidal thoughts, for example, they might make few statements like "I wish I were dead" or "I wish I hadn't born", etc. Also, sometimes they seem to be emotionally very high one day and deeply discouraged the other day. They also develop personality changes or become severely anxious or agitated. These can be majorly detected by noticing the way they communicate with everyone daily, that is, their voice in the form of audio could be analyzed, their texting patterns in social media with their friends and the type of posts they like and share can also be studied closely, change in day-to-day activities, their facial expressions while talking to people are important aspects that must be investigated. Many other factors such as stress analysis, depression analysis and social media analysis can be performed to detect the suicidal tendencies in any person.

II. RELATED WORK

Due to an alarming suicide rate across the world, it has drawn the attention of many researchers who are in pursuit of finding a solution to end this fatal problem. With the evolution of technology many methods had been invented to curb the suicidal tendency in the minds of people. Obtaining suicidal data in any form has become as difficult as working on an efficient algorithm for detection. In the recent years, Shaoxiong Ji.*et.al* [7] reviewed various kinds of machine learning methods along with their applications to early detect and prevent suicide attempts. An elaborated description was provided on different datasets, tasks, and methodologies. They have extensively inferred applications that are domain-specific for suicidal ideation. Similarly, suicidal risk assessment is one of the most important factors for detection according to Gema Castillo-Sanchez.et.al [8] reviewed Suicidal Risk Assessment in Social Networks. Databases like PubMed, ScienceDirect, etc. were used. Their study also proved that 75% of the analysis used machine-learning models based on Python. Precision, F-Score, and other performance parameters indicated 80% in total.

Capturing the motive that social media encourages users to express their emotions and feelings to the rest of the individuals, many researchers have experimented that people who have suicidal tendency leave clues about their demise on these platforms. Recently, Snigdha Ramkumar. *et.al* [9] designed a model to identify sudden changes in a person's posts or online content which were considered as alarming signs for a person's mental health. Using Natural Language Processing, textual and behavioral features are passed to a framework which were used to detect suicidal intent. Considering the youth to be very active on social media where they completely expose their lives on the internet, P Sai Bhargavi. *et.al* [10] detailed a project which used a neural network to find the tendencies of suicide and their types especially to the teenage people committing suicide and the group of people undergoing suicidal thoughts.

On a minor scale, there are some people who don't like to express themselves to unknown people in the world. They feel comfortable by sharing their thoughts very rarely to their close ones or the people whom they trust. In this context, suicide notes are one of the most common ways of expressing grief written by a person before committing suicide. Handwriting analysis and detection of emotion with machine learning techniques can help us understand the emotion and psychological trauma undergone by a particular victim. Similarly, text analysis plays a pivot role as it helps to analyze the suicidal intent of a person engaged in any one-to-one communication. For example, Genevieve Lam.*et.al* [11] proposed a method that involves an augmentation procedure on topic modelling by using deep ID CNN and transformer. It is effective for training of models with multi-modal structure which can achieve good performance for audio and text models.

People experiencing suicidal tendency, always express grief, or sadness in their behavior. Due to this reason, it drastically impacts the nature of their voice or speech. It is either very low, or sometimes may sound angry or disgust. Using this analysis researchers found a way to detect suicidal tendency using voice pattern detection. For example, it was first tested using manual data by conducting interviews. Zhiyong Wang et al. [12], developed a model which manually extracts emotions of individuals based on speech using the properties of acoustic speech that probed to depression making use of SVM and MFCC (Mel Frequency Cepstral Coefficients) classifiers by mainly focusing on how common paralinguistic speech characteristics are affected by depression. Kwon N, Kim S.*et al.*[13], detected the severity of depression using the speech of the user by following the divide and conquer approach where the features of the speech were divided based on their attributes such as acoustic, prosodic and language features. They have performed the experiment using the data of 76 patients who were clinically depressed having half of them to be severe and the other half to be moderate in respect of MADRS. It has shown an accuracy of 0.69 for the fusion model and an accuracy of 0.78 for multiplication layer fusion model. Shuangshuang Zhao.*et.al*[14], worked on a model that processes the audio files received from the user, thereby the features of speech signal are extracted into matrix vector feature which are then imported into CNN for training and evaluation which results in 0.82 accuracy on DAIC-WOZ dataset.

Suicidal tendency detection can prove to be effective when a patient's health record is analyzed. It is a great resource to help a victim save their life before demise. The medical records contain important information about the patient's health status and mental well-being. P. Kharel.*et.al*[15], developed a model for detecting depression at an early stage and predict the treatment response using Machine learning models. The models which are used in the neuroimaging dataset were reviewed to foretell the reaction to antidepressant and CNN was used for distinct medical diagnoses whereas the SVM models used imaging for diagnosing depression. Similarly, Andrea C. Fernandes.*et.al* [16], has presented the NLP approaches for the classification and identification of the attempts of suicide in the psychiatric database. The remarkable performance of these classification algorithms had made them to accurately detect the suicidal mentions and the attempts in the text documents that are present in the psychiatric database.

Not only there is research on various machine learning techniques but also there are mobile applications that facilitate features to detect suicidal tendency in people. For example, Santosh Kumar Uppada.*et.al* [17] proposed an application that inputs the facial gesture of the person and captures the emotion. The state is immediately identified, and the user is encouraged to play or engage in respective activities proposed by the system and without human intervention. Anti-suicidal videos are also recommended to the users.

III. VARIOUS SOURCES OF DATA

Suicide Notes

Suicide notes are one of the most common means of expressing victim's grief in a piece of paper, discussion forums in social media platforms or any forms of audio/video. These are left by victims before committing suicide. With the evolution of technology in today's world, suicidal notes are written in the form of web blogs which facilitate the use of machine learning techniques by performing sentiment analysis. Similarly, in the case of comments in online forums the text in the post can be a visual clue that can be analyzed using Natural Language Processing.

Questionnaires/Interviews

(IPDE-SQ) provides tools for evaluating an individual's potential to commit suicide. Similarly, Tuka Alhanai.et.al [2] developed an automated depression detection model that was based on a set of questionnaires asked to 142 individuals undergoing depression screening through which the audio files were evaluated. The inter activities with the text and audio features were modelled using LSTM neural network model to detect the depression.

Electronic Health Records

Electronic Health Records (EHR) have paved a way for technology in various domains to predict the intention of suicide attempters. Since EHRs contain valuable information about patients' psychological analysis, medical history etc., it is feasible to determine the intent before tragedy attacks. K Haerian.et.al [3] proposed an algorithm to automatically detect suicidal intent. It combines ICD-9 codes and NLP concepts and resulted a PPV of 0.98. Similarly, Bhat.et.al [4] applied neural networks as a classification model by using an anonymized general EHR dataset.

Social Media Content

Researchers have found that 8 out of 10 people tend to post their suicidal thoughts on social media. These victims post their thoughts on websites like Twitter, WhatsApp, Reddit, Facebook and many more. Mental health prediction by online user content has shown a way towards new methodologies of research in the context of suicidal intent detection. Fatima Chiroma.*et.al* [5] aimed to determine a model for detecting the suicide-related texts from Twitter by designing a model using four machine learning classifiers and then conducted the experiment which showed the F-measures from 0.346 to 0.778 for the texts related to suicide and has found out that decision tree classifier classified the texts best. Similarly, Michael Mesfin Tadesse.*et.al* [6] developed a model using Reddit social media platform to obtain a dataset for machine-learning based classification. An LSTM-CNN combined architecture with techniques for word embedding had been used to obtain best classification results. Limitations are depicted that data is deficient and contains annotation bias.

IV. DRAWBACKS OF EXISTING SYSTEM

Data Deficiency and Inconsistency

To obtain efficient results and elaborated solutions it is important to have large and accurate data on suicidal tendency. Some of the existing systems fail to obtain higher results due to smaller datasets, less reliable data, and inconsistent information. Posts in the social media are phenomenal with respect to suicides fail to treat the data as ill-balanced. The psychology behind suicide is complex, it is important to have phenomenology of intention understanding before incorporating the psychology of suicide data inconsistency and annotation problems according to Shaoxiong Ji.*et.al.* [7]. Annotation can lead to bias in labelling and can prove to mislead the suicidal results according to Michael Mesfin Tadesse.*et.al.* [6].

Computational Time and Power Consumption

Since the data sometimes could be inconsistent, there is a less chance of obtaining the results in the expected period. Therefore, algorithms and models must be chosen in a manner that can reduce huge consumption of time and power. When there is a requirement for large scale datasets for mobile applications, consumption power, and time are important for both training and testing phases [17].

False Implication of Data

While conducting experimental research on data obtained from social media platforms, it is sometimes unpredictable that the data obtained may be false or generated for the purpose of humor or by any other means of explanation to the public rather than the suicidal intent [16].

The above related work raises to a few discussions that are mentioned below. The following are various approaches that can be used to detect suicidal tendency in people.

V. FINDINGS OF EXISTING SYSTEMS

Voice Pattern Analysis

People suffering from depression or undergoing any kind of suicidal thoughts try to isolate themselves and talk very less. Their voice modulations help in discovering their emotions. At the same time along with the frequency of the voice it is also very important to examine their choice of sentences and the words they choose while talking or expressing their feelings. So far, it has been noticed that most of them followed audio splitting approach majorly to detect suicidal tendencies from speech. This method takes audio files as input and eliminates the long silent sections and splicing the required parts of speech into new files, thereby labelling each file as healthy and unhealthy based on the extracted attributes of speech signals using MFCC (Mel Frequency Cepstral Coefficients) and the properties of acoustic speech that are probed to depression which are then imported into CNN model to detect depression after training and evaluation. The formula stated below is used for converting the common frequency domain scale of audio to MFCCs frequency scale.

$$f\_mel = 2595 \log(1 + f\_Hz/700) \quad \ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Here, f_mel is Mel frequency scale, f_Hz is common frequency.

$$c(m) = h(m-1) = l(m+1) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

c(m) is center limit frequency, h(m-1) is upper limit frequency, l(m+1) is lower limit frequency

Performing logarithmic operation on the output of the filter to obtain MFCCs:

$$Cn = \sum_{m=1}^{M} LogX(m)\cos((m - 0.5)\frac{n\pi}{M}) \quad n=1,2\ldots n \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

In some cases, instead of using CNN, few of them manually extracted the emotions of individuals from speech using MFCC and SVM classifiers. Apart from this, there have been methods where the detection of depression from speech was performed based on ensemble learning for CNN.

Social Media Analysis

Numerous experiments had been conducted in the recent years to understand the potential of social media on suicidal ideation. It proved to show a great influencing power as it serves as a platform to express one's ideas publicly. There are various ways to detect suicidal intent using many social media platforms like Reddit, Twitter, Facebook etc. by performing machine learning and deep learning techniques. These platforms provide community forums/discussion forums which are very sophisticated for the victims to disclose their tendency to kill themselves. Since a huge amount of data is sent and received on these social platforms, it is necessary to collect and filter the required information obtained from the raw data. For instance, in Twitter there are about 500 million tweets that are posted every day. Among these, the tweets related to suicidal behavior can be identified using #(hashtag) such as #sucide, #feelinglow, #depressed, etc. The detection of suicidal behavior from these tweets can be done by collecting the tweets that are related to Suicidal tendencies stored in CSIRO from Twitter. Later the pre-processing can be done by human coding to classify data on the severity of emotion and genuineness of suicidal behavior. The number of posts on Twitter is weighted based on words present in tweets based on the formula below.

$$tfidf(t) = freq(t) \, X \, ln(N/|d \in D : t \in d\}|) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Where t is the word feature, N is the number of tweets, and d is a tweet in the tweets D and the weighted frequency is represented as tfidf and the original frequency is given as freq. There are two machine learning algorithms like SVM and Linear Regression which can be used to test the efficiency of the model.

Nowadays usage of search engines is increasing tremendously. With access to the browsing history, it is very feasible to analyze the emotional behavior of an individual. An approach where the emotions can be detected using an EmotionC framework can be used to find the emotion of the person which is the key to find their suicidal tendency. The Naive Bayes classification algorithm can be used to classify the emotion and detect the suicidal tendency from the data which has been pre-trained by using a pool of words and the lexical information with semantic connections. According to K.R Rohini. et.al [18] Instagram posts can be also used to detect the suicidal behavior. A J48 binary tree classifier can be used to predict whether a post is having any suicidal intention.

Text Pattern Analysis

The increase in use of smartphones and other social media, blogs, and email created a rapid increase in generation of unstructured text. Most of the millennials use internet where have access to mobile phones while they are the most vulnerable age group prone to suicidal tendency. Analyzing the text in which they are communicating would give an acute information about the suicidal intent. The analysis of text messages sent or received by a person experiencing suicidal behavior would help to identify the patterns. It is then followed by a clinical interview, which would help in understanding the inter-relation between communication and suicidal behavior.

The data could be from personal communication mediums like SMS, emails, or other social media data like Instagram, Twitter, Facebook, browsing history, and medical history. Later the data is labelled based on their history to predict the suicidal behavior, then the supervised classifier algorithms can be used for classification. The classifier can be constructed using the set of features that are important for the model training which comprise the psycho and linguistic features. With the text analysis, the suicidal behavior and stress patterns can be monitored which could help to analyze and predict high risks of suicidal attempts, helping to avoid them.

Daily Physical Activity Analysis

Possessing suicidal thoughts and suffering from depression can majorly affect the day-to-day activities of a person. A lot of changes in their daily routine can be noticed where they prefer to be very lonely, sad, and hopeless. Major sleep problems are also observed where few people tend to oversleep whereas others suffer from Insomnia. They are inclined to isolate themselves by avoiding close ones and loose interest in any activity like cycling or going for a walk etc. which they previously used to enjoy doing. Most of them even increase the intake of alcohol than usual and some even get addicted to drugs. All these show that the person is mentally weak and losing interest in life.

Many researchers have worked towards finding the relation between the mental health which drives them to attempt suicide and their physical activity, sedentary and dietary behaviors. By conducting a survey, they have found that females generally tend to avoid breakfast every day and drink soda or pop. Similarly, males tend to spend more time playing video games and be disconnected with people around. They have also performed data analysis by considering independent variables, dependant variables and control variables where the independent variables include physical exercise, dependent variables include mental health problems, self-harm and suicidal behavior whereas the control variables include sociodemographic information, Body mass index (BMI), sleep duration and alcohol related problems. Hence by experimenting with all these variables they have tried to figure out the relation between these factors and how they affect the mental health which led to suicidal thoughts and gave conclusions accordingly.

VI. CONCLUSION & FUTURE SCOPE

Suicides constitute a major part of deaths in today's world which is not a good sign. It not only impacts the victim, but also leaves their close ones in trauma. Hence, with increased technological advancements, addressing suicidal tendencies in youngsters has become a necessity. The existing systems addressed the problem from different dimensions keeping in mind the wide use of technology by every age group and thereby looking into various behavioral aspects of people. On keen analysis, the methodologies

used in the existing systems to detect suicidal intent focused on ensemble learning models, CNN models, SVM's, LSTM-based text encoders, HCI and NLP techniques. It was also evident that drawbacks of the research were inclined to false implication of data and data inconsistency. Yet, the systems were successfully able to provide a novel approach to the existing problems. The findings for this paper are also focused on various approaches that could be used to determine suicidal tendency like Textual pattern recognition, Voice based analysis, Facial gestures, Day to day activities, and social media analysis. Performing thorough research on aforementioned approaches it was also clear that these systems failed to safeguard user's privacy and understood the human intension to a very small extent. Therefore, this situation leads to highly accurate results but less victim's security. Overall, it can be inferred that a system which can provide a multi-modal approach by addressing multiple detection systems using various deep learning techniques by capturing the real-time data is highly desirable. This can help in achieving better results and rescue the victim at an early stage of suicidal behavior.

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