Deep Learning Algorithms for Suicide Prediction Based on Bilateral Long-Term Memory Using Social Media Behaviour Dataset

S. Siva Selvi[1], R. Parthiban[2*], G.Sivakumar[3]
[1]*Assistant Professor, Department of Computer Science and Engineering, Erode Sengunthar EngineeringCollege (Autonomous), Perundurai, Erode-638057*
[2]*Master of Engineering In Computer Science And Engineering, Department of Computer Science and Engineering, Erode Sengunthar Engineering College (Autonomous), Perundurai, Erode-638057*
[3]*Head of the Department, Department of Computer Science and Engineering, Erode Sengunthar Engineering College (Autonomous),Perundurai, Erode-638057*

***Abstract*— Suicide rates are one of the most severe issues in the world. The rate of suicides is rising at a rapid rate over time. To predict the causes of suicide in India, this work uses deep learning algorithms to identify the underlying causes of suicides. However, identifying and understanding patterns of suicidal ideation can be difficult. Hence, there is a need to develop deep learning systems that can automatically and proactively detect suicidal thoughts and sudden changes in user behaviour by analyzing users' social media posts. We suggest an experimental research-based approach to create a method to detect suicidal ideation using word-encoding techniques like TF-IDF and Word2Vec and deep learning for classification using the publicly available Reddit dataset. Utilize a Bilateral Long-Term Memory (BiLSTM) model to categorize social media messages as suicidal. Initially collecting the data from the standard repository and then reducing the missing and irrelevant dataset values in the preprocessing stage. The second stage is extracting the features based on the threshold weights using Deep Convolutional Neural Networks (DCNN) are often used for feature extraction and data dimensionality reduction. DCNN can extract complex features, describe images in more detail, learn task-specific features, and be more efficient. Bilateral Long-Term Memory (BiLSTM) is widely used in text mining and sentiment analysis. On the other hand, it uses BiLSTM to extract the most essential and reliable features for classification automatically. To estimate the standard metrics such as precision, accuracy, Recall, and F1 score to evaluate model performance.**

***Index terms*—Suicide rates, TF-IDF, deep learning, Bilateral Long-Term Memory (BiLSTM), Deep Convolutional Neural Networks (DCNN), sentiment analysis, features.**

I. INTRODUCTION

One of the most significant problems in society is suicide. The World Health Organization (WHO) has estimated that 700 billion people attempt suicide each year and die by suicide. The most frequent age range for suicide attempts is between 20 and 30. The second most common cause of death for people between the ages of 10 and 34 is suicide. Suicidal ideation, also called suicidal ideation, includes ending one's existence. Suicidal thoughts can affect people of all ages for various causes, such as assault, rage, guilt, depression, and anxiety. Suicide can result from extended depression if it is not handled correctly, even though the majority of people who have suicidal thoughts do not end their lives. With medication and a medical expert, suicidal thoughts can be controlled.

In any case, the extended majority with self-destructive considerations stay away from treatment due to the disgrace related with them, and on second thought, many decide to impart their self-destructive aims via virtual entertainment. Early detection of warning signs and risk factors is a very effective way to prevent suicide. A rapidly expanding technology that automatically detects users' feelings is sentiment analysis. Sentiment analysis makes use of information from social media to spot early signs of suicidal ideation and stop suicide attempts. As a result, Deep Learning (DL) and Natural Language Processing are increasingly used to infer suicidal intent from social

media content. A previous study used a smaller dataset to detect suicidal ideation in tweets using DL algorithms and a dataset of 50,000 tweets from various online and news sources using keywords. BiLSTM models perform better than single LSTM classifiers and traditional machine learning systems on suicide-related topics. Online forums or blogs may also be embedded in the dataset.

II. RELATED WORK

In modern society, the prevalence of suicide has emerged as a serious public health issue. Suicidal behavior's causes, methods, and effects are complicated, but identifying those at risk of suicide and providing timely intervention can reduce loss of life. A lexicon of potential factors influencing suicide risk was established through a comprehensive analysis of several suicide texts and specialized medical literature [1]. The correlation between psychological anxiety and suicidal ideation, however, is only marginally detectable using conventional statistical techniques [2]. People can now track their suicide risk because of the development of numerous detection technologies [3]. More individuals are posting their final words online, according to research on suicide prevention. Researchers are now analysing the data due to the social media sites' unprecedented access to text data [4]. Consequently, it is increasingly done to infer suicidal intent from content on social media using Deep Learning (DL) and Natural Language Processing (NLP) [5]. However, difficulties with data and expertise continue to be obstacles and lessen the efficacy of social media-based diagnostics. [6]. Suicide can be caused by a variety of critical emotions, including anxiety, depression, and tension. Early identification of those with suicidal ideation may lower the risk of suicide [7]. The goal is to develop a learning model that evaluates social media data to identify individuals who are suicidal [8]. Military personnel experience more stress and are at a higher risk of suicide attempts than civilians. Increased psychological stress triggers suicidal ideation, actively contributing to suicide attempts [9]. However, since suicide diagnosis and prevention are primarily performed in medical centres, effective treatment is limited to limited populations [10]. Identifying and understanding the complex Suicide Risk Factors and Warning Signs is the Hardest Part of Suicide Prevention [11]. It is possible to distinguish between various psychological states from an open-ended verbal speech in both written and spoken forms using Natural Language Processing (NLP) techniques. These instruments are especially helpful in identifying suicidal risk and may help worldwide suffering [12].

III. PROPOSED METHOD

Identifying the significant indicators of what a suicidal person shares on social media are essential to use those posts to identify suicidal ideation. Sentiment analysis of article titles and body text was used to extract features such as word frequency, inverse document frequency, language query, and word count of suicide and non-suicide posts from the Reddit public dataset. BiLSTM-based models have advantages over other deep learning and machine learning classifiers in detecting suicidality because they can store relevant data without long-term bias.

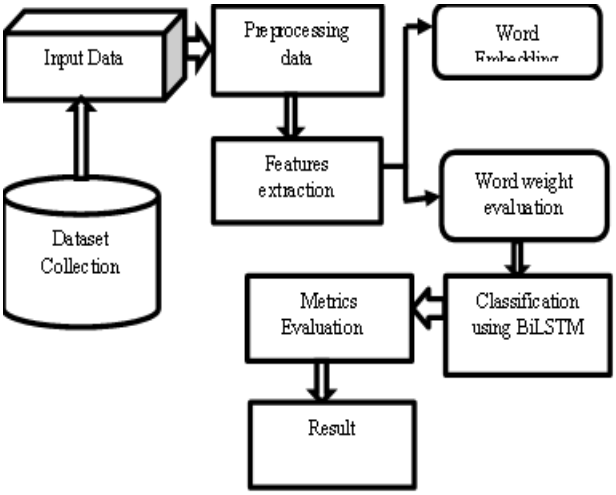
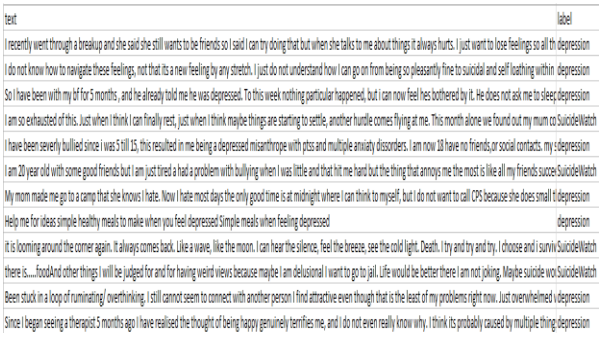


Figure 1: Proposed diagram

Figure 1 shows that the in this section, the key elements of the suggested Suicidal Ideation Detection System (SIDS) framework are presented. The social media news site Reddit has a section dedicated to suicide that uses language, coding, and features. The steps involved in this architecture are shown in Fig. 1.

A. Collection of the dataset

Use a downloadable public Reddit dataset from the Kaggle websitee. The dataset contains 332,064 suicide surveillance posts between December 16, 2008, and January 2, 2022, of which 126,037 were suicidal and 116,038 were non-suicidal.



text	label
I recently went through a breakup and she said she still wants to be friends so I said I can try doing that but when she talks to me about things it always hurts. I just want to lose feelings so all th	depression
I do not know how to navigate these feelings, not that its a new feeling by any stretch. I just do not understand how I can go on from being so pleasantly fine to suicidal and self loathing within	depression
So I have been with my bf for 5 months , and he already told me he was depressed. To this week nothing particular happened, but i can now feel hes bothered by it. He does not ask me to sleep	depression
I am so exhausted of this. Just when I think I can finally rest, just when I think maybe things are starting to settle, another hurdle comes flying at me. This month alone we found out my mum co	SuicideWatch
I have been severly bullied since i was 5 till 15, this resulted in me being a depressed misanthrope with ptss and multiple anxiety dissorders. I am now 18 have no friends,or social contacts. my s	depression
I am 20 year old with some good friends but I am just tired a had a problem with bullying when I was little and that hit me hard but the thing that annoys me the most is like all my friends succe	SuicideWatch
My mom made me go to a camp that she knows I hate. Now I hate most days the only good time is at midnight where I can think to myself, but I do not want to call CPS because she does small ti	depression
Help me for ideas simple healthy meals to make when you feel depressed Simple meals when feeling depressed	depression
it is looming around the corner again. It always comes back. Like a wave, like the moon. I can hear the silence, feel the breeze, see the cold light. Death. I try and try and try. I choose and i surviv	SuicideWatch
there is.....floodAnd other things I will be judged for and for having weird views because maybe I am delusional I want to go to jail. Life would be better there I am not joking. Maybe suicide wo	SuicideWatch
Been stuck in a loop of ruminating/ overthinking. I still cannot seem to connect with another person I find attractive even though that is the least of my problems right now. Just overwhelmed v	depression
Since I began seeing a therapist 5 months ago I have realised the thought of being happy genuinely terrifies me, and I do not even really know why. I think its probably caused by multiple thing	depression

Figure 2: Dataset Description

"Suicide monitoring" refers to monitoring procedures designed to prevent attempted suicide. The term is often used to refer to individuals in prisons, hospitals, psychiatric hospitals and military bases shown in Fig. 2.

B. pre-processing data

This step filters out text entries before generating word vectors for classification using feature extraction and embedding techniques. This includes stopping word removal, punctuation removal, lowercase letters, word segmentation and lemmatization. Use the Natural Language Toolkit (NLTK) to perform the primary task of dataset pre-processing. Remove punctuation marks, emoji's, and numbers: This process removes "?!,:,;, '" and emojis to make the text work more accessible.

- Stop removing words: This process eliminates words like "in", "a", "an", and "in" that do not contribute to the model's performance.
- Lowercase: This process will convert all words to lowercase.
- Tokenization: This method separates each statement into its component words, phrases, and other elements.

C. Feature extraction using Deep Convolutional Neural Networks (DCNN)

The feature maps for this layer are created by convolutional combining the feature extraction matrices that make up the layer's input data. For the words selected by the embedding layer, the convolutional layer performs calculations on the input embedding matrix. Filters traverse matrices, collect sequence data, and reduce the input sequence's dimensionality. The following layers' feature maps are created using the four essential variables (number of filters, kernel size, desired padding type, and nonlinear activation function).

The convolutional operation is expressed by

$$S_y^x = \sigma\left(\sum_{x-1}^{n_{x-1}} con(w_{x,y}^i, w_x^{i-1}\right) + R_y^i \quad (1)$$

Where n_{x-1} represents several features, S_y^x is the feature map of the word embedding in the social media posts, $w_{x,y}^i$ convolutional kernel, R_y^i is the bias of the feature map, $\sigma -$ rectified linear unit (ReLU) function.

D. Word Embedding

Language modelling and NLP feature representation both frequently use the text representation technique known as word embedding. The input text is broken down into low-dimensional feature arrays that deep learning algorithms can use for each word and phrase. Using Word2Vec and TF-IDF, this research extracts vector representations of words and phrases to distinguish between content that is suicidal and content that is not.

i. TF-IDF

In text classification models for understanding natural language and information retrieval, TF-IDF feature extraction method is useful for assessing the significance of textual trends. The first part of it, called TF, locates instances of particular words and the similarity between them as follows:

$$TF(w)_a = \frac{n_w(a)}{|a|} \quad (2)$$

Set (a) Points to a group of papers, while A designates a single one. A collection of sentences and words called w, and $n_w(a)$ symbolizes each file. (a). This is how the amount of document d is determined.

$$|a| = \sum_{w \in a} n_w(a) \quad (3)$$

An expression specifies the frequency of occurrence of a word in a document. $IDF(w)_a = 1 + \log\left(\frac{|a|}{|\{\{a: A|w \in a|}\right)$, IDF, the second portion of TF-IDF, is used to determine how many documents in the text corpus contain a specific term.

Let's calculate the TF-IDF of word w corresponding to document (d) and corpus (a)

$$TF - IDF = TF_{(w)_a} \times TF_{(w)_d} \quad (4)$$

TF-IDF generally uses document vocabulary matrices to construct various text classification systems.

ii. Word Weights evaluation (Word2Vec)

Word2Vec is an alternative method for language modelling and feature learning that extracts word embedding, or the numerical depictions of words,

from texts. The algorithm was created by Google and comprised a two-layer neural network architecture that forecasts the context of particular words in the text and extracts vector representations. It has limitations in considering words outside the chosen vocabulary as the most significant features. In this work, Word2Vec converts and maps every word in the collection transformed into 32-dimensional word representation vectors for both training and testing.

$$Weighted\ vec = \sum_{x=1}^{n}(ix * wx) \Big/ \sum_{x=1}^{n}(wx) \quad (5)$$

Where,$\sum$ $denotes\ the\ sum$,$w\ is\ the\ weights$, $x\ is\ the\ value$

A weighted average is calculated by multiplying the weights by the measured results and adding all the terms together. The weighted vec and the text vec are calculated the same if all the weights are equal.

E. Classification using Bi-LSTM

Deep learning work using LSTMs includes natural language processing (NLP), image processing, sequence mining, and text mining. Information retention can be improved by learning long-term prejudices. The output of previous data operations is eventually transferred to memory cells used in LSTMs.

Deep learning systems perform worse because backward construction is not considered, and feature learning is only done in the forward path. BiLSTM uses two concealed layers oriented in opposition to one another to address this issue. The training data input is therefore handled both forward and backwards.

$$I_p = \sigma(w_{ip}x_p + w_{is}x_{s-1} + J_x) \quad (6)$$

$$o_p = \sigma(w_{op}x_p + w_{os}x_{s-1} + J_x) \quad (7)$$

$$I_p - Input, o_p - Output, w_{ip}x_p - input\ variables, w_{op}x_p - output\ variables \quad (8)$$

The biLSTM is used when transformation layers help extract low-dimensional semantic features from textual data and reduce dimensionality. Furthermore, biLSTM treats text as an array of inputs. In this work, we will use several 1D convolution kernels together to improve the performance of the input vectors.

Begin

For each specific feature, target vectors,

Select the individual vectors features

$$V_{x,y}^{i} = S_{x,y}^{i} + F_x * (S_{x,r}^{i} + S_{x,p}^{i}) \quad (9)$$

Compute each train's features

$$A_{x,y}^{i} \begin{cases} V_{x,y}^{i} & if\ F_x \le cr \\ S_{x,y}^{i} & otherwise \end{cases} \quad (10)$$

Classifier using Bi-LSTM to evaluate fitness function and f and $S_r^i\ and\ S_p^i$

If $(S_r^i) \le f(S_p^i)$ then $S_x^{i+1} = U_x^i$ (11)

Else

$$S_x^{i+1} = S_x^i \quad (12)$$

End for

End if

End

$V_{x,y}^{i} - Vector\ variables,\ S_x^{i+1} - features\ weights,\ A_{x,y}^{i} - Values\ of\ fitness.$

The hidden layer structure consists of four gates determining how much past sequence information to ignore and how much context to forward. This makes BiLSTM ideal for recognizing suicidal content in social media posts.

IV. EVALUATION METRICS

We used a standard evaluation metric focused on the number of false positive and false negative classifications obtained from the provided confusion matrix to assess the efficiency of BiLSTM in classifying this last content as suicidal or non-suicidal. The performance metrics used were precision, accuracy and false classification, calculated as follows:

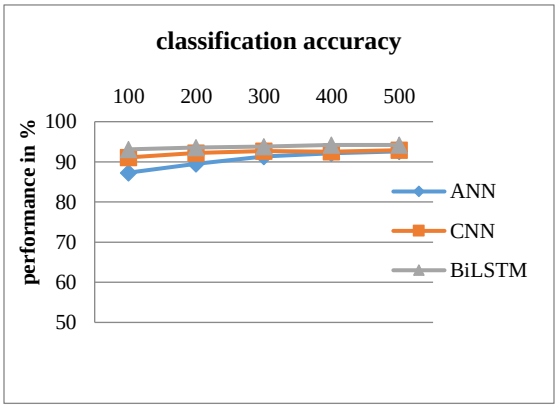


Figure 3 classification accuracy.

The classification defines the precision and specificity of frequent measurements of fit/recall predictions generated by positive values and gives complete results by category. Fig. 3 shows a 94.2% classification accuracy.

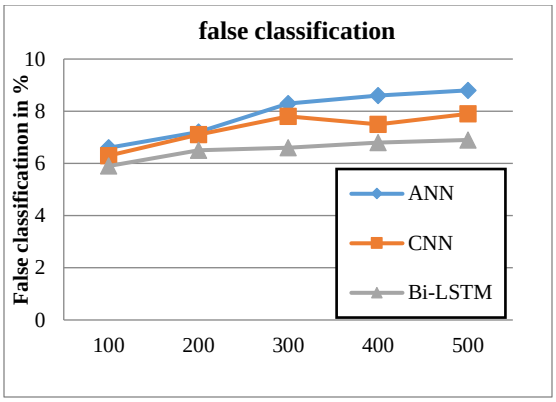


Figure 4 Analysis of false classification

Fig. 4 shows that different methods produce pseudo-proportional variations. The predicted Bi-LSTM method has less false classifications than other methods, offering 6.9%.

V. CONCLUSION

A variety of mental disorders affect millions of people around the world. These disorders can affect everyday life. Worldwide, there are more than 300 million affected individuals, which is rising daily. For instance, 800,000 teenagers kill themselves each year, making it the second most common cause of mortality for young people. People can express their thoughts and opinions on various subjects on social networking sites like Twitter and Facebook. Researching melancholy on a personal, societal, and international scale is crucial. Helping those who are depressed and addressing this problem are top priorities. The biLSTM model was rated as performing better on different metrics when compared to "state-of-the-art" research. Experimental studies have revealed that the biLSTM model is the one that obtained the best accuracy of 94.2%, the precision of 88.3%, false classification of 6.9%, specificity of 89.8%, Recall is 89.6% and sensitivity score of 92.5%.

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