

Journal of Advances in Mathematical & Computational Sciences
An International Pan-African Multidisciplinary Journal of the SMART Research Group
International Centre for IT & Development (ICITD) USA
© Creative Research Publishers - Available online at
<https://www.isteam.net/socialinformaticsjournal>
CrossREF Member Listing - <https://www.crossref.org/06members/50go-live.html>

A Mathematical Model for Undergraduate Suicide Ideation Detection

Ezea, I. L.

Department of Math/Computer Science/Statistics/Informatics
Federal University
Ndufu Alike, Ikwo, Ebonyi State, Nigeria
E-mail; ezeaikenna@yahoo.com

ABSTRACT

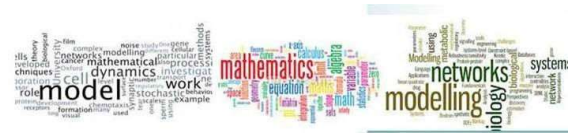
Young adults of undergraduate age range are the most vulnerable group of global suicide death according to the world health organization. Student's academic and social media activities provides plethora of opportunities to determine the students who are at risk of developing depression or suicide ideation. These opportunities have been overlooked as most research has been based on predicting individuals who are at immediate risk of suicide attempt or death using their (the students) social media texts streams and suicide notes. This research approach is reactive rather than proactive and based on that has failed as suicide is a cumulative process that is developed over a long period of time (Ren, Kang, & Quan, 2016). The aim of this thesis is to build a mathematical model that will predict students who are at risk of depression or suicide ideation using a proactive approach of suicide prevention which involves applying the model to the result gotten from machine learning prediction.

Keywords: Mathematical Model, Undergraduates, Suicide, Ideation and Detection

Ezea, I.L. (2020): A Mathematical Model for Undergraduate Suicide Ideation Detection. *Journal of Advances in Mathematical & Computational Sciences* Vol. 8, No. 3. Pp 109-115. Available online at www.isteam.net/mathematics-computationaljournal.

1. INTRODUCTION

The university assumes a time frame for every student's undertaking, the lectures, reading, social activities, sports, recreation, religious activities etc are to be carried out within a specific time frame. Even though these are not enforced on students it is believed that every student should maintain a balance so that no single activity should overshadow the other. When a student dedicates his or her time only to lecture and reading, then that might be an indication that the student is under pressure and might likely develop depression. On the other hand a student might be at risk of dropping out of the university and subsequently developing depression or suicide ideation if all his time is channeled on social activities, religion and making and keeping friends. The worst is when a student prefers to be alone, that is no lectures, no friends, no social activities, no time for reading, no time even for the family (Vioul'es, B. Moulahi, & Bringay, 2018) such students should be referred to see a mental health professional as that is a serious warning sign



that the student is depressed and may likely resort to suicide. The student's activities on the social media are equally another way of predicting those who are exhibiting depression or suicidal signs. When a student spends more time on social media making friends or when there is a sudden decrease in the student's friendship and followership or when there is an indication of unusual rhythm in sleep due to social media activities then that might be a cause for concern (Vioul'es, B. Moulahi, & Bringay, 2018). Another social media related activity that might be of concern is increase in the frequency of tweets or posting. Since suicide is an accumulative process (Ren, Kang, & Quan, 2016) that might occur when all or part of the above mentioned factors are in effect this research takes a proactive approach in depression and suicide ideation detection using the following methodology.

2. RELATED LITERATURES

Suicide detection has drawn the attention of many researchers due to an increasing suicide rate in recent years and has been studied extensively from many perspectives. The research techniques used to examine suicide also span many fields and methods, for example, clinical methods with patient-clinic interaction (Venek, Scherer, Morency, A, & Pestian, 2017) and automatic detection from user-generated content (mainly text) (O'Dea, et al., 2015), (Ji, Yu, Sai-fu Fung, Pan, & Long, 2018). Machine learning techniques are widely applied for automatic detection.

Traditional suicide detection relies on clinical methods, including self-reports and face-to-face interviews. Venek et al. (2017) designed a five-item ubiquitous questionnaire for the assessment of suicidal risks and applied a hierarchical classifier on the patients' response to determine their suicidal intentions. Through face-to-face interaction, verbal and acoustic information can be utilized. Scherer (2013) investigated the prosodic speech characteristics and voice quality in a dyadic interview to identify suicidal and nonsuicidal juveniles. Other clinical methods examine resting state heart rate from converted sensing signals (Sikander, et al., 2016), classify functional magnetic resonance imaging-based neural representations of death- and life-related words (Just, et al., 2017), and event-related instigators converted from EEG signals (Jiang, Wang, Sun, Song, & Sun, 2015). Another aspect of clinical treatment is the understanding of the psychology behind suicidal behavior (C, Nock, & K, 2014), which, however, relies heavily on the clinician's knowledge and face-to-face interaction. Suicide risk assessment scales with clinical interview can reveal informative cues for predicting suicide (Lotito & Cook, 2015). Tan et al. (2013) conducted an interview and survey study in Weibo, a Twitter-like service in China, to explore the engagement of suicide attempters with intervention by direct messages.

3. METHODOLOGY

This thesis relies on the student's attendance and social media data as a means of collecting information used for suicide ideation detection.

3.1. Sources of Data

The three categories of data (depression, suicideWatch and University Data) used for this thesis were collected from both the university and online community. The depression and suicideWatch data were collected from r/depression and r/suicideWatch, which are sub reddits in Reddit website forum. This website forum is a community dedicated for those having suicide ideation and depression. The community (r/suicideWatch and r/depression) at the time of this research has a collective membership population of 1,005, 000 (264, 000 for r/suicideWatch and 741, 000 for r/depression). The users share text, image and visual information to express their thoughts on a daily basis. The university community on the other hand served as a source of data for student's daily academic activities.



The collection of the data used for this research work was facilitated through the assistance of some members of staff in Alex Ekwueme Federal University Ndufu-Alike. The University is one of the new generation universities in Nigeria established in 2011. It has student strength of 4, 000 and staff strength of 1000 at the time of this research.

3.2. Method of Data Collection

The three categories of data used for this research was collected following the standard ethics of global data collection practice. The research ensured that express permission was obtained and that the rights of the individuals whose data were used were not violated.

i) University Timetable Data (UTD)

The UTD was collected from all the course coordinators from the thirty three departments running 61 programmes in Alex-Ekwueme Federal University, Ndufu Alike (AEFUNAI). The data collected from the University was facilitated through express permission from the Academic Director through the University Timetable Committee Chairman and a written consent and a questionnaire to all the heads of department and course coordinators in the University.

ii) Depression and SuicideWatch Data

The depression data was collected from r/depression a subreddit of Reddit Website forum which is an online community that gives users with depression the opportunity to express their thoughts. The website grants access to users who are 18 or above and who do not have any intention of using the services for profit or any other purpose contrary to the user agreement policy. The data collected from r/depression was collected from 600,000 users of the community using python web scraping tool.

The same website also has r/suicideWatch which is an online community that provides peer support for anyone struggling with suicide thoughts. The same python scrapping tool was also used for collection of data from 200, 000 users of the community.

3.3 Analysis of the Existing System

Mental health professionals are the primary front line health care providers for those having suicide ideation or plans. However there are still many others who are providing a complimentary role which is targeted at helping the mental health care professionals identifying those with high mental risk factors. Many researchers and health care professionals have used clinical methods, content analysis, feature engineering and deep learning approach for suicide ideation detection. These approaches as can be seen in Figure 1 have relied on the use of clinical interview, questionnaires, electronic health records, suicide notes and social contents. The social media contents from Reach out, Weibo, Twitter and Reddit is gaining popularity in suicide ideation detection as many researchers believe that clinical interview and questionnaire has failed in their ability to reach out to all the people with mental health issues based on distance and unwillingness of the patients to communicate their intentions. secondly most people with suicide ideation would rather express their thought through social media than discussing it with people through interview or questionnaire as research has shown that some people commit suicide some days or weeks after getting in contact with mental health professionals.

Figure 1 shows the various methods and domains used in suicide ideation detection.

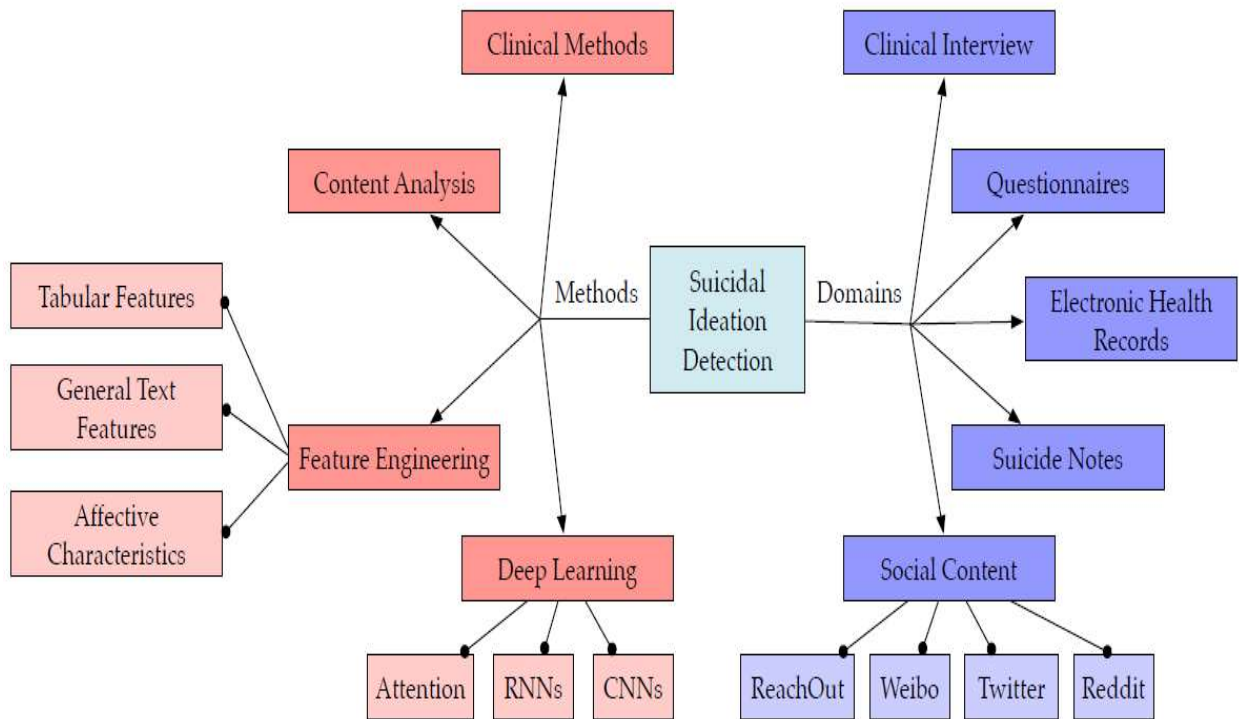


Figure 1: Methods and Domains used in suicide ideation detection

3.3.1 Weaknesses of the Existing System

Most traditional mental health systems used by mental health professionals lacks the ability to predict with high degree of accuracy the percentage of people that may commit suicide in the nearest future. This is because some people with pronounced suicide risk factors have been seen dropping the idea and living a normal life, while those with relatively no suicide risk factors have taking to suicide some weeks after visiting the mental health professionals. The most difficult challenge faced by mental health professionals in treating people with suicide ideation is that most of the suicidal people tend to confide more on the online community rather than seeking help in the traditional medical setting. More so the stigma associated with mental health problems (Gaur, et al., 2019) and the distance of the medical facility to the suicide population makes it difficult for those with the problems to seek medical help.

The traditional mental health system has failed in their ability to proactively detect and manage suicide due to believe that suicide is only the consequence of mental health problems rather than a prolonged accumulation of other psychosocial issues. This is the reason why most systems tend to predict suicide from the time of depression when the patient has started expressing his or her suicide plans in social network forums. An ideal system however should be able to detect the possibility of depression or suicide ideation in an individual through his or her life style, failures or daily undertakings and based on that make recommendation on how to address the failures before it degenerate to depression.

3.4 Analysis of the Proposed System

Intelligent Synchronization Model for suicide Ideation Detection and Prevention (ISMSIDP) provides a proactive support for suicide ideation and prevention among the university undergraduate students. The system as shown in figure 2 provides a synchronization model that interfaces with the Machine Learning (ML) module and the undergraduate students application (USA) to provide to the mental health professional the information (i.e suicide ideation information/suicide risk ratio) needed to help a student cope with academic and other psychosocial stressors that might trigger suicide. The USA is made up of the social network and academic application which interacts with the Application Programming Interface (API) through the internet to get student's information (e.g. daily routing) which is sent along with the student's social media friendship for synchronization. The ML module is made up of the Support Vector Machine (SVM) for student's social network text classification and Random Forest (RF) for prediction of depression in students. At the ML module is the classification and prediction result from the information (text streams/depression prediction values) gotten from the USA database. The result is synchronized along with the students daily routing/friendship information to get the student's suicide risk ratio.

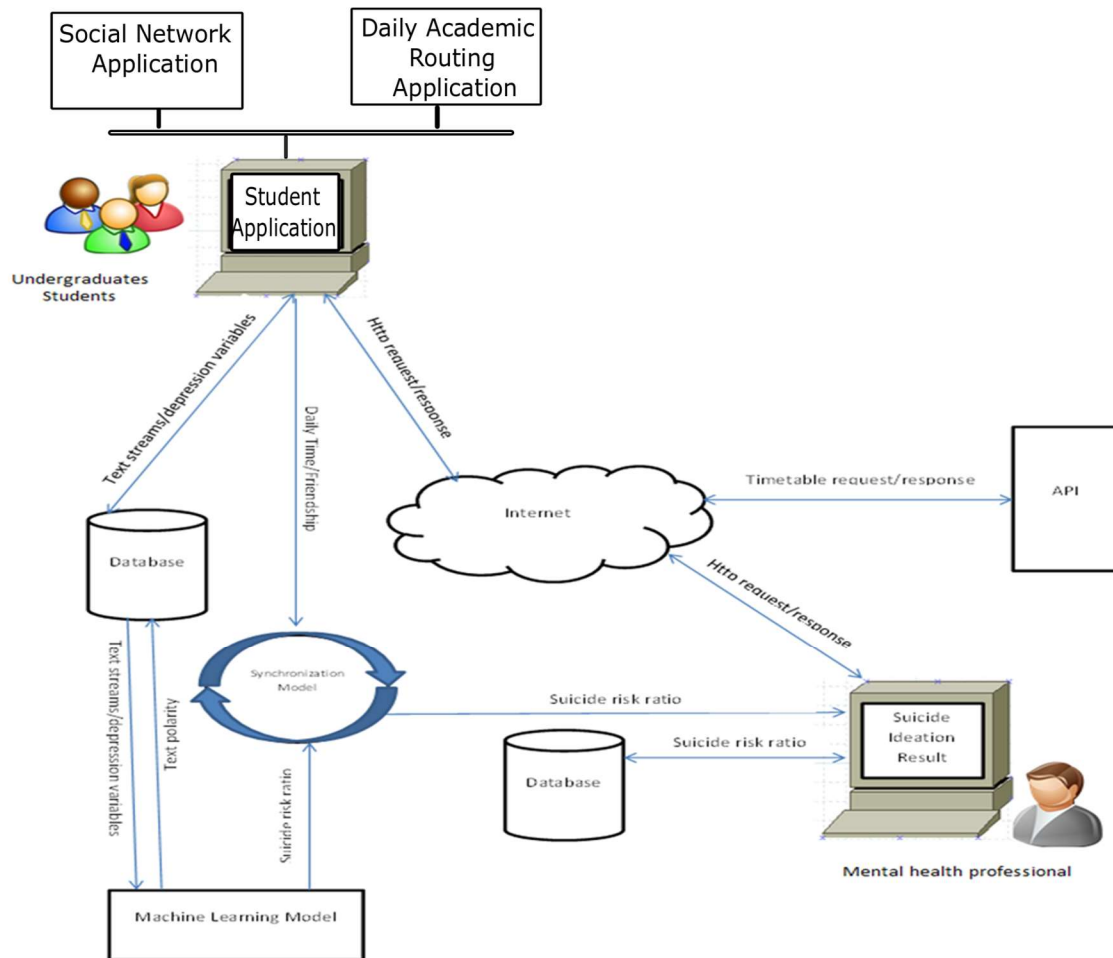


Figure 2: The synchronization model architecture

4. ANALYSIS OF THE MODEL

The synchronization model (SM) or time utilization (TU) is combined in an expression (see equation 2) with total academic duration (TAD) and spillover ratio to give the Suicide Risk Ratio (SRR). The SM as shown in equation 1 is composed of μ the least amount of friendship, λ the number of hours spent on daily academic routings, friendship the number of friends on the academic social network (it is taking to be a constant value 1 if no friend exists), α the depression ratio and Daily Routing Time (DRT) which is the daily allotted time on the academic daily routing. The SM can be calculated daily, weekly, monthly or even yearly depending on the requirement. The SM can be calculated using the expression in equation 1. the α value is used in the expression only when it is equal or greater than 1 otherwise it is not used.

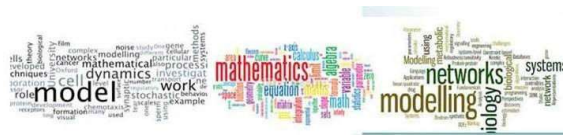
The SRR as shown in equation 2 is the product of the ration TAD:TU and spillover ratio. The expression shows the rate at which an individual's depression or suicide ideation score is rising. When an individual has no spillover ration the SRR is determined only by the ration TAD:TU. Depending on the need the SRR like the SM can be calculated daily, weekly, monthly or yearly.

4.1. The Mathematical Expression of the Model

$$TU = \begin{cases} \sum_{d=1}^{week} \frac{DRT}{(\mu + (\sum_{t=1}^{day} \lambda) + friendship) \times \alpha} & \text{if } \alpha \geq 1 \\ \sum_{d=1}^{week} \frac{DRT}{(\mu + (\sum_{t=1}^{day} \lambda) + friendship)} & \text{if } \alpha = 0 \end{cases} \quad \text{Equation .1}$$

$$SRR = \begin{cases} \left(\sum_{w=1}^{month} \frac{TAD}{TU} \right) \times \prod_{y=1}^{year} \beta & \text{if } \beta \geq 1 \\ \left(\sum_{w=1}^{mont} \frac{TAD}{TU} \right) & \text{if } \beta = 0 \end{cases} \quad \text{Equation .2}$$

- α = suicide risk factor e.g. family suicide history, previous suicide attempt, poor academic records, mental disorder, etc. (No risk factor = 1, risk factor = 0.5 * number of risk factors)
- β = spillover ratio (Non-spillover students = 1, spillover students = 0.5 * number of years)
- μ = List amount of friendship (it is a constant value 1)
- λ = Time spent on academic activities
- Time/Day = Time for academic activities per day
- Friendship = activities with friends on social network
- TU = Time Utilization
- SRR = Suicide Risk Ratio
- α = depression ratio



5. CONCLUSION

This paper developed a mathematical model that was used to synchronize the machine learning prediction result from students network application with their daily academic routine. The synchronization helps to determine students who are having serious academic problems and based on that can predict the likelihood of the students falling into depression or developing suicide ideation.

REFERENCES

- C, O., Nock, R., & K, M. (2014). The psychology of suicidal behaviour. *The Lancet Psychiatry*, 1(1), 73–85.
- Gaur, M., Alambo, A., Sain, J. P., Kursuncu, U., Thirunarayan, K., Kavuluru, R., . . . Pathak, J. (2019). Knowledgeaware assessment of severity of suicide risk for early intervention. *The World Wide Web Conference* (pp. 514–525). ACM.
- Ji, S., Yu, C. P., Sai-fu Fung, Pan, S., & Long, G. (2018). Supervised Learning for Suicidal Ideation Detection in Online User Content.
- Jiang, N., Wang, Y., Sun, L., Song, Y., & Sun, H. (2015). An erp study of implicit emotion processing in depressed suicide attempters. *2015 7th International Conference on Information Technology in Medicine and Education (ITME)* (pp. 37–40). IEEE.
- Just, M. A., Pan, L., Cherkassky, V. L., McMakin, D. L., Cha, C., Nock, M. K., & Brent, D. (2017). Machine learning of neural representations of suicide and emotion concepts identifies suicidal youth. *Nature human behaviour*, 1(12), 911.
- Lotito, M., & Cook, E. (2015). A review of suicide risk assessment instruments and approaches. *Mental Health Clinician*, 5(5), 216–223.
- O’Dea, B., Wan, S., Batterham, P. J., Calear, A. L., Paris, C., & Christensen, H. (2015). Detecting suicidality on twitter. *Internet Interventions*, 2(2), 183–188.
- Ren, F., Kang, X., & Quan, C. (2016). Examining accumulated emotional traits in suicide blogs with an emotion topic model. *IEEE journal of biomedical and health informatics*, 20(5), 11384-1396.
- Scherer, S., Pestian, J., & Morency, L. (2013). Investigating the speech characteristics of suicidal adolescents. *2013 IEEE International Conference on Acoustics, Speech and Signal Processing*, (pp. 709–713).
- Sikander, D., Arvaneh, M., Amico, F., Healy, G., Ward, T., Kearney, D., . . . al., e. (2016). Predicting risk of suicide using resting state heart rate. *2016 Asia-Pacific Signal and Information Processing Association Annual Summit and Conference (APSIPA)* (pp. 1–4). Jeju: IEEE.
- Tran, T., Phung, D., Luo, W., Harvey, R., Berk, M., & Venkatesh, S. (2013). An integrated framework for suicide risk prediction. *Proceedings of the 19th ACM SIGKDD international conference on Knowledge discovery and data mining* (pp. 1410–1418). ACM.
- Venek, V., Scherer, S., Morency, L., A, R., & Pestian, J. (2017). Adolescent suicidal risk assessment in clinician-patient interaction. *IEEE Transactions on Affective Computing*, 8(2), 204–215.
- Vioul’es, M. J., B. Moulahi, J. A., & Bringay, S. (2018). Detection. *IBM Journal of Research and Development*, 62(1), 1-12.