

Suicidal ideation detection. A review of machine learning and applications

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Abstract

Suicide is a critical issue in modern society. Early detection and prevention of suicide attempts should be addressed to save people's life. Current suicidal ideation detection (SID) methods include clinical methods based on the interaction between social workers or experts and the targeted individuals and machine learning techniques with feature engineering or deep learning for automatic detection based on online social contents. This article is the first survey that comprehensively introduces and discusses the methods from these categories. Domain-specific applications of SID are reviewed according to their data sources, i.e., questionnaires, electronic health records, suicide notes, and online user content. Several specific tasks and data sets are introduced and summarized to facilitate further research. Finally, we summarize the limitations of current work and provide an outlook of further research directions.

Keyword: Suicidal ideation detection, social content, feature engineering, deep learning.

1. INTRODUCTION

1.1 Introduction:

MENTAL health issues, such as anxiety and depression, are becoming increasingly concerned in modern society, as they turn out to be especially severe in developed countries and emerging markets. Severe mental disorders without effective treatment can turn to suicidal ideation or even suicide attempts. Some online posts contain much negative information and generate problematic phenomena, such as cybers talking and cyber bullying.

Consequences can be severe and risky since such lousy information is often engaged in some form of social cruelty, leading to rumors or even mental damage. Research shows that there is a link between cyber bullying and suicide. Victims overexposed to too many negative messages or events may become depressed and

desperate; even worse, some may commit suicide. The reasons that people commit suicide are complicated. People with depression are highly likely to commit suicide, but many without depression can also have suicidal thoughts. According to the American Foundation for Suicide Prevention (AFSP), suicide factors fall under three categories: health factors, environmental factors, and historical factors. Ferrari et al found that mental health issues and substance use disorders are attributed to the factors of suicide.

O'Connor and Nock conducted a thorough review of the psychology of suicide and summarized psychological risks as personality and individual differences, cognitive factors, social factors, and negative life events. Suicidal ideation detection (SID) determines whether the person has suicidal ideation or thoughts by

given tabular data of a person or textual content written by a person. Due to the advances in social media and online anonymity, an increasing number of individuals turn to interact with others on the Internet. Online communication channels are becoming a new way for people to express their feelings, suffering, and suicidal tendencies. Hence, online channels have naturally started to act as a surveillance tool for suicidal ideation, and mining social content can improve suicide prevention.

Strange social phenomena are emerging, e.g., online communities reaching an agreement on self-mutilation and copycat suicide. For example, a social network phenomenon called the “Blue Whale Game”¹ in 2016 uses many tasks (such as self-harming) and leads game members to commit suicide in the end. Suicide is a critical social issue and takes thousands of lives every year. Thus, it is necessary to detect suicidality and prevent suicide before victims end their life. Early detection and treatment are regarded as the most effective ways to prevent potential suicide attempts. Potential victims with suicidal ideation may express their thoughts of committing suicide in fleeting thoughts, suicide plans, and role-playing. SID is to find out these risks of intentions or behaviors before tragedy strikes.

A meta-analysis conducted by McHugh et al. shown statistical limitations of ideation as a screening tool but also pointed out that people’s expression of suicidal ideation represents their psychological distress. Effective detection of early signals of suicidal ideation can identify people with suicidal thoughts and open a communication portal to let social workers mitigate their mental issues. The reasons for suicide are complicated and attributed to a

complex interaction of many factors. To detect suicidal ideation, many researchers conducted psychological and clinical studies and classified responses of questionnaires [. Based on their social media data, artificial intelligence (AI) and machine learning techniques can predict people’s likelihood of suicide, which can better understand people’s intentions and pave the way for early intervention. Detection on social content focuses on feature engineering, sentiment analysis, and deep learning. Those methods generally require heuristics to select features or design artificial neural network (ANN) architectures for learning rich representation.

The research trend focuses on selecting more useful features from people’s health records and developing neural architectures to understand the language with suicidal ideation better. Mobile technologies have been studied and applied to suicide prevention, for example, the mobile suicide intervention application I Bobby [19] developed by the Black Dog Institute.² Many other suicide prevention tools integrated with social networking services have also been developed, including Samaritans Radar³ and Woebot.⁴ The former was a Twitter plug in that was later discontinued because of privacy issues. For monitoring alarming posts, the latter is a Face book chat bot based on cognitive behavioral therapy and natural language processing (NLP) techniques for relieving people’s depression and anxiety.

Applying cutting-edge AI technologies for SID inevitably comes with privacy issue and ethical concerns. Linthicum et al. put forward three ethical issues, including the influence of bias on machine learning algorithms, the prediction on time of suicide act, and ethical and legal questions raised by false positive and false

negative prediction. It is not easy to answer ethical questions for AI as these require algorithms to reach a balance between competing values, issues, and interests. AI has been applied to solve many challenging social problems. Detection of suicidal ideation with AI techniques is one of the potential applications for social good and should be addressed to improve people's wellbeing meaningfully. The research problems include feature selection on tabular and text data and representation learning on natural language. Many AI-based methods have been applied to classify suicide risks. However, there remain some challenges. There are a limited number of benchmarks for training and evaluating SID. AI-powered models, sometimes, learn statistical clues but fail to understand people's intentions.

Moreover, many neural models are lack of interpretability. This survey reviews SID methods from the perspective of AI and machine learning and specific domain applications with social impact. The categorization from these two perspectives is shown in Fig. 1. This article provides a comprehensive review of the increasingly important field of SID with machine learning methods. It proposes a summary of current research progress and an outlook of future work. The contributions of our survey are summarized as follows. 1) To the best of our knowledge, this is the first survey that conducts a comprehensive review of SID, its methods, and its applications from a machine learning perspective. 2) We introduce and discuss the classical content analysis and modern machine learning techniques, plus their application to questionnaires, EHR data, suicide notes, and online social content. 3) We enumerate existing and less explored tasks and discuss their limitations.

We also summarize existing data sets and provide an outlook of future research directions in this field. The remainder of this article is organized as follows. Methods and applications are introduced and summarized in Sections II and III, respectively. Section IV enumerates specific tasks and some data sets. Finally, we have a discussion and propose some future directions in Section V.

1.2 Purpose:

Consequences can be severe and risky since such lousy information is often engaged in some form of social cruelty, leading to rumors or even mental damage. Research shows that there is a link between cyber bullying and suicide. Victims overexposed to too many negative messages or events may become depressed and desperate; even worse, some may commit suicide. The reasons that people commit suicide are complicated. People with depression are highly likely to commit suicide, but many without depression can also have suicidal thoughts.

1.3 Scope:

Online social networks (OSNs), such as Facebook,¹ Twitter,² and LinkedIn,³ has created a fruitful environment for the spread of positive information. However, the high openness and autonomy of the OSNs also enable the spread of negative information, such as unsubstantiated rumors, conspiracy theories, and other forms of misinformation.

1.4 Motivation:

According to the American Foundation for Suicide Prevention (AFSP), suicide factors fall under three categories: health factors, environmental factors, and historical factors. Ferrari et al. found that mental health issues and substance use disorders are attributed to the factors of suicide.

1.5 Overview:

Detection of suicidal ideation with AI techniques is one of the potential

applications for social good and should be addressed to improve people's wellbeing meaningfully. The research problems include feature selection on tabular and text data and representation learning on natural language. Many AI-based methods have been applied to classify suicide risks. However, there remain some challenges. There are a limited number of benchmarks for training and evaluating SID. AI-powered models, sometimes, learn statistical clues but fail to understand people's intentions.

2. RELATED WORKS

Opinion mining involves several important tasks, including sentiment polarity and intensity assignment. Polarity assignment is concerned with determining whether a text has a positive, negative, or neutral semantic orientation. Sentiment intensity assignment looks at whether the positive/negative sentiments are mild or strong. Given the two phrases "I don't like you" and "I hate you," both would be assigned a negative semantic orientation but the latter would be considered more intense. Effectively classifying sentiment polarities and intensities entails the use of classification methods applied to linguistic features. While several classification methods have been employed for opinion mining, Support Vector Machine (SVM) has outperformed various techniques including Naive Bayes, Decision Trees, Winnow, etc. . The most popular class of features used for opinion mining is n-grams. Various n-gram categories have attained state-of-the-art results. Larger n-gram feature sets require the use of feature selection methods to extract appropriate attribute subsets. Next, we discuss these two areas: n-gram features and feature selection techniques used for Author profiling.

2.1 N-GRAM FEATURES FOR AUTHOR PROFILING

N-gram features can be classified into two categories: fixed and variable. Fixed n-grams are exact sequences occurring at either the character or token level. Variable n-grams are extraction patterns capable of representing more sophisticated linguistic phenomena. A plethora of fixed and variable n-grams have been used for opinion mining, including word, part-of-speech (POS), character, legomena, syntactic, and semantic n-grams. Word n-grams include bag-of-words (BOWs) and higher order word n-grams (e.g., bigrams, trigrams). Word n-grams have been used effectively in several studies [28]. Typically, unigrams to trigrams are used, though 4-grams have also been employed. Word n-grams often provide a feature set foundation, with additional feature categories added to them. Given the pervasiveness of adjectives and adverbs in opinion-rich text, POS tag, n-grams are very useful for sentiment classification. Additionally, some studies have employed word plus part-of-speech (POS Word) n-grams. These n-grams consider a word along with its POS tag in order to overcome word-sense disambiguation in situations where a word may otherwise have several senses . For example, the phrase "quality of the" can be represented with the POS Word trigram "quality-noun of prep the-det." Character n-grams are letter sequences. For example, the word "like" can be represented with the following two and three letter sequences "li, ik, ke, lik, ike." While character n-grams were previously used mostly for style classification, they have recently been shown to be useful in related affect classification research attempting to identify emotions in text. Legomena n-grams are collocations that replace once (hapax legomena) and twice occurring words (dis legomena) with "HAPAX" and "DIS" tags [2], [38].

2.2 FEATURE SELECTION FOR AUTHOR PROFILING

Prior sentiment classification studies have placed limited emphasis on feature selection techniques, despite their benefits. Feature selection can potentially improve classification accuracy, narrow in on a key feature subset of sentiment discriminators, and provide greater insight into important class attributes. There are two categories of feature selection methods, both of which have been used in prior Author profiling work: univariate and multivariate.

Univariate methods consider attributes individually. Examples include information gain, chi-squared, log likelihood, and occurrence frequency. Although univariate methods are computationally efficient, evaluating individual attributes can also be disadvantageous since important attribute interactions are not considered. It is also easier to interpret the contribution of individual attributes using univariate methods. Most opinion mining studies have used univariate feature selection methods such as minimum frequency thresholds and the log-likelihood ratio [12], [27], [39]. Information gain (IG) [44], [45] has also been shown to work well for various text categorization tasks, including Author profiling [3]. Tsutsumi et al. [35] used the Chi-Squared test to select features for text sentiment classification.

2.3 OTHER FEATURE SELECTION METHODS

2.4 In addition to prior sentiment feature selection methods, it is important to briefly discuss multivariate and hybrid methods used in related tasks. Principal component analysis (PCA) has been used considerably for dimensionality reduction in text style classification problems. Recently, many powerful dimensionality reduction techniques

have also been applied to non text feature selection problems

3. EXISTING SYSTEM

Traditional suicide detection relies on clinical methods, including self-reports and face-to-face interviews. Venek *et al.* [9] 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 [23] investigated the prosodic speech characteristics and voice quality in a dyadic interview to identify suicidal and non suicidal juveniles. Other clinical methods examine the resting state heart rate from converted sensing signals and classify the functional magnetic resonance imaging-based neural representations of death- and life-related word and event-related instigators converted from EEG signals. Another aspect of clinical treatment is the understanding of the psychology behind suicidal behavior, 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 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.

3.1 Disadvantages:

In the existing work, the system is Traditional suicide detection which relies on clinical methods, including self-reports and face-to-face interviews.

This system is analyzed word frequencies in suicide notes using a fuzzy cognitive map to discern causality which is less effective.

4. PROPOSED SYSTEM

To the best of our knowledge, this is the first survey that conducts a comprehensive review of SID, its methods, and its applications from a machine learning perspective.

The proposed system introduces and discusses the classical content analysis and modern machine learning techniques, plus their application to questionnaires, EHR data, suicide notes, and online social content.

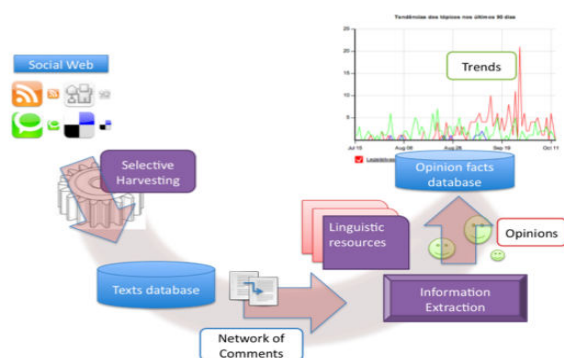
The proposed system enumerates existing and less explored tasks and discusses their limitations. We also summarize existing data sets and provide an outlook of future research directions in this field.

4.1 Advantages

The popularization of machine learning has facilitated research on SID from multimodal data and provided a promising way for effective early warning.

2) Massive data mining and machine learning algorithms have achieved remarkable outcomes by using DNNs.

5. ARCHITECTURE



6. Modules Description:

Tweet Server

In this module, the Server has to login by using valid user name and password. After login successful he can perform some operations such as View All Users, Add Filter, View All Friend Request and Response, View All Users Tweets, View Tweets All Topic & Comments, View All Suicide-related and non Suicide-related Posts, View Suicide-related posts Results, View Tweet Topics Rank Results.

Friend Request & Response

In this module, the admin can view all the friend requests and responses. Here all the requests and responses will be displayed with their tags such as Id, requested user photo, requested user name, user name request to, status and time & date. If the user accepts the request then the status will be changed to accepted or else the status will remain as waiting.

User

In this module, there are n numbers of users are present. User should register before performing any operations. Once user registers, their details will be stored to the database. After registration successful, he has to login by using authorized user name and password. Once Login is successful user can perform some operations like View My Profile, Search Friends And Request, Friend Requests By Me, Friend Requests By Others, All My Friends, View My Friends Tweets and Re Tweet, Create Tweets, All My Tweets with Ranks.

7 CONCLUSION AND FUTURE ENHANCEMENTS

Suicide prevention remains an essential task in our modern society. Early detection of

suicidal ideation is an important and effective way to prevent suicide. This survey investigates existing methods for SID from a broad perspective that covers clinical methods, such as patient–clinician interaction and medical signal sensing; textual content analysis, such as lexicon-based filtering and word cloud visualization; feature engineering, including tabular, textual, and affective features; and deep learning-based representation learning, such as CNN and LSTM-based text encoders. Four main domain-specific applications on questionnaires, EHRs, suicide notes, and online user content are introduced. Psychological experts have conducted most work in this field with statistical analysis and computer scientists with feature engineering-based machine learning and deep learning-based representation learning. Based on current research, we summarized existing tasks and further proposed new possible tasks. Last but not least, we discuss some limitations of current research and propose a series of future directions, including utilizing emerging learning techniques, interpretable intention understanding, temporal detection, and proactive conversational intervention. Online social content is very likely to be the main channel for SID in the future. Therefore, it is essential to develop new methods, which can heal the schism between clinical mental health detection and automatic machine detection, to detect online texts containing suicidal ideation in the hope that suicide can be prevented.

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