Collective Intelligence for Suicide Surveillance in Web Forums

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Abstract. Internet users may see and comment on suicide expressions in the cyberspace that are not identified by helping professionals. The communication between the two parties is not well facilitated. In light of this situation, we present a system using collective intelligence from Internet users to efficiently and effectively identify suicidal people in order to provide timely intervention and promote better public health. We describe the system architecture involving information retrieval, affect analysis, and opinion summarization technique. The collective intelligence approach incorporates machine learning techniques and Internet users' contributions to facilitate the automated identification of suicide expressions. The system will be examined and evaluated in lab settings and suicide prevention organizations.

Keywords. Text analysis, affect analysis, opinion summarization, collective intelligence, machine learning, suicide surveillance, web forums

1 Introduction

Information on the Internet has been increasingly used to inform public health and policy [1]. One area of application is the surveillance of suicide expression [2]. Some people communicate their suicide intent and leave suicide notes on social networking sites (SNS). SNS users can act as gatekeepers to provide emotional support and may prevent suicide attempt [3]. For example, Facebook users can report to the police when they encounter suicidal SNS users who express suicide thoughts or intent [4]. However, it seems that many other online platforms such as web forums have yet to implement any initiatives for suicide prevention. Some researchers have recommended that Internet service providers report individuals who left suicide messages on the Internet to the police [2]. Also, some non-governmental

organizations have started to identify Internet users who left suicide expressions on the Internet in order to provide help and follow-up services [5]. However, online surveillance and outreach for suicide prevention can be very labor-intensive and inefficient in a vast cyberspace.

Hence, text analysis using automated programs may help reduce the labor cost in the identification process [5]. Moreover, apart from web contents, users' comments may consist of useful information for the process. However, a large amount of comments may overload and perplex the analysis in the identification system. One possible solution is to apply opinion summarization to condense comments in order to maintain system performance [6]. Besides, previous studies have established "expert systems" that act as competently as human experts, by embodying their problem-solving skills in models and data [7]. By incorporating the users' collective contributions into the analysis, our technology may evolve to a synergy between human and machine. In this paper, we propose a system using collective intelligence with affect analysis and opinion summarization technique for automating the identification of suicide expressions in forums.

There are five sections in this paper. The next section presents the related work. Section 3 discusses the architecture of the proposed system. The technical details of collective intelligence are discussed in Section 4. The evaluation plan of the system and our ongoing work are discussed in Section 5.

2 Related Work

There are some previous studies in text analysis, opinion summarization techniques and collective intelligence. Text analysis examines topics, opinions, sentiments and emotions in web contents for a wide range of purposes [8-12]. Previous studies have applied machine learning techniques to group contents into different topics [9]. Furthermore, valuable opinions and commentaries can be extracted by opinion mining and sentiment analysis [10]. Emotion or affect analysis, which has emerged recently, share similar ideas and techniques of well-developed sentiment analysis to classify emotions in contents. Sentiment analysis is used to classify positive, negative or neutral orientation, whereas affect analysis distinguishes different emotions such as happiness, sadness, hate, anger, fear, surprise, and so on. Previous research has provided more understandings on affect analysis by comparing different machine learning techniques [11]. It has been suggested that affect analysis may identify abnormal mood states such as emotional distress [5].

In the era of Web 2.0, people can express their opinions towards a topic, entity, product or service on different online platforms such as forums and blogs. Summarization techniques that produce opinion-oriented [13] and query-focused [14] summaries become more important with the massive textual information on the Internet. Moreover, opinion and sentiment summarization of online conversations has emerged recently to extract valuable information from the Web [15, 16]. Those advanced summarization techniques are originated from text summarization which manages the enormous amount of information, by condensing contents and extracting the most relevant facts or topics [6, 17]. Although typical text summarization

techniques adopt summarization by extraction [18], emerging abstractive techniques become more prominent in the research field [19]. Extraction concatenates important relevant sentences in the contents into a summary, whereas abstraction generates novel sentences for a summary.

Collective intelligence is the value created by the contributions of people writing articles, commenting posts and sharing photos on the Internet [20]. Undoubtedly, the Internet as a prominent social platform provides rich collected knowledge. Machine learning techniques, which efficiently identify structures and patterns in large data, allow better use of collected data [7]. Advanced technologies effectively converge individual intelligence and acquire collected high-quality knowledge to create new inferences and ideas [21, 22]. Since Internet users can act as gatekeepers to prevent suicide attempt [3], comments responding to suicide expressions may become collective intelligence in identification system for life-saving purpose.

3 System Architecture

Here we present the system architecture to provide an overview of the system and implementation of our project on suicidal individuals. We propose a collective intelligence system combining text analysis and summarization techniques to identify suicide expressions in web forums. Forums are composed of units of thread, each having a post written by a main author and a number of comments by reply authors. Comments created by reply authors may be instrumental for adjusting classification decision of a post because the comments may contain anti-suicide and positive wordings. A sample page of a forum (in Chinese) is shown in Fig. 1.

Fig. 1. Forum structure

Fig. 2 shows our system architecture. The system performs information retrieval of threads on forums such as uwants.com and discuss.com.hk, which are popular in

Hong Kong, by a meta-search approach [23]. A forum crawler is created to retrieve all forum threads into our database [24, 25]. After acquisition of threads in HTML format, the files can be read with automated processes, which also separate posts and comments for subsequent analysis. Since the research is conducted in a Chinese context, the system is established to primarily process Chinese forum threads. Chinese sentences at the pre-process stage are broken into Chinese words or phrases using ICTCLAS [26-27]. After that, the system processes posts and their comments in parallel to generate separated classification decision. Forum threads are therefore analyzed by two models, namely affect analysis [5] and collective intelligence. The affect analysis classifies a thread using its main post only, whereas collective intelligence approach examines comments to generate the mainstream opinion from reply authors [13]. The opinion may provide extra information for classification decision at the final stage. Based on suicidal individuals' expressions and Internet users' comments, we hypothesized that the accuracy of the result can be increased.

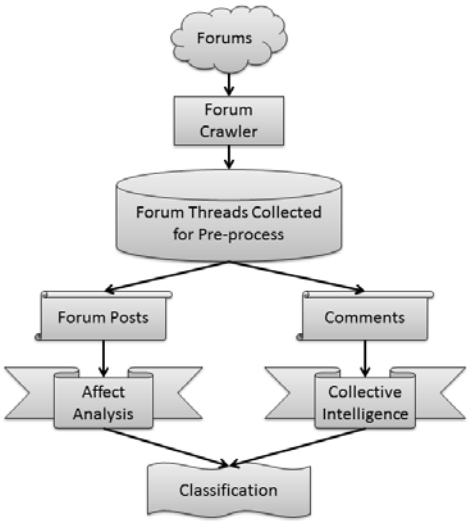

Fig. 2. System architecture

4 Collective Intelligence

Here we illustrate the algorithm of graph-based opinion summarization for generating collective intelligence [19]. Suppose there is a post with 4 reply authors commenting on it. Each reply author may write a different number of comments and each comment may consist of a different number of sentences. Each reply author is represented by an author node (AN). Edge between ANs represents the similarity between the two reply authors. All edges are initialized with a similarity of 0. If two ANs share a common feature, for instance same word or phrase, the similarity of the edge between them will be incremented by 1. The final stage after calculating all their similarities is shown in Fig. 3. The number next to an edge represents the similarity

after the above analysis. After that, a threshold value of similarity is calculated from all edges. If the similarity of an edge is below a threshold value, that edge would be eliminated. The detached AN will not be involved in the subsequent process being shown in Fig. 4. The reply authors contributing to a mainstream opinion will be retained in the analysis.

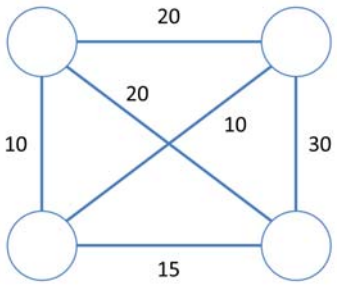

Fig. 3. Network of author nodes

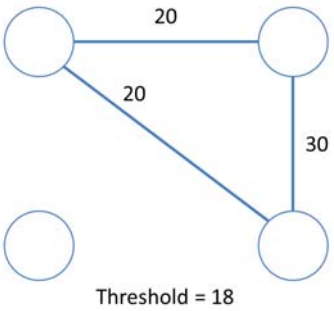

Fig. 4. AN detaches from the main group

After identifying the main reply author group, the comments in the group are processed at a sentence level [13]. ANs comprise a number of sentences (triangular) nodes (SN) in them. Edges are formed among all SNs with an initial similarity of 0. If a sentence has a common word or phrase with another sentence, the similarity of the edge will be incremented by 1. The final stage after calculating all their similarities is shown in Fig. 5. The solid lines represent inter-author edges while the dotted lines represent intra-author edges. The main group in the graph is the group with the largest number of inter-author edges. SNs detached from the main group will not be involved in subsequent process in Fig. 6.

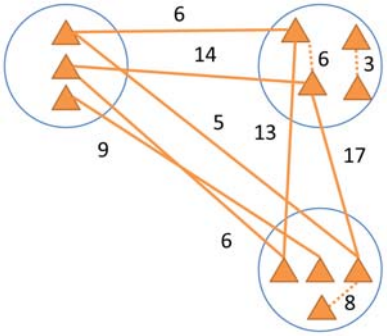

Fig. 5. Final stage of SNs

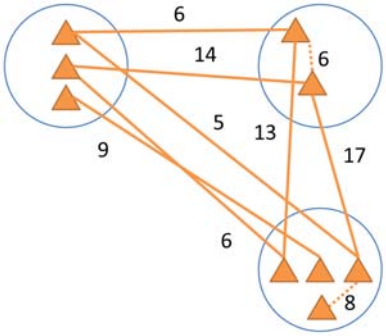

Fig. 6. SNs detach from the main group

A threshold similarity value is then calculated. The edges with similarity below the threshold value will be eliminated shown in Fig. 7. For the sentences still having edges, the SN created by the reply author holding more SNs will be selected and the other will be removed as shown in Fig. 8. Thus, the number of redundant sentences will be minimized. The remaining SNs aggregate to provide a mainstream opinion.

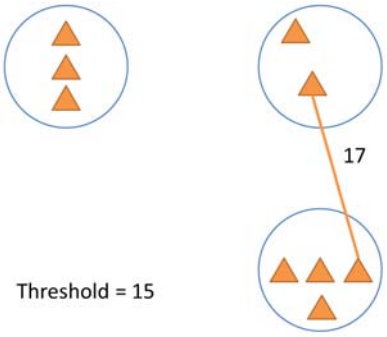

Fig. 7. Eliminating edges under threshold

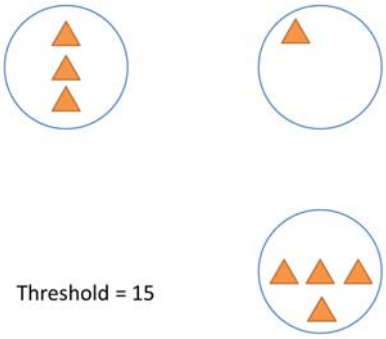

Fig. 8. Optimizing sentence extraction

Below is an example (A, B, C, D and E are ANs. The number means their n-th sentence. The sentences in brackets are English translations.):
A1: 我 想 自殺 。 (I want to suicide.)
B1: 發生 了 甚麼 事 ？ (What happened?)
A2: 父母 完全 唔 知道 我 的 感受 。 (My parents do not know my feelings.)
B2: 普遍 父母 不 明白 孩子 的 感受 。 (In general parents do not understand children's feelings.)
C1: 人 就是 太 顧 自己 感受 。 (Human considers their feelings too important.)
A3: 這樣 的 人生 還有 意義 嗎 ？ (Is a life like this still meaningful?)
C2: 回家 吃 奶 吧 。 (Get away and hide at home.)
B3: 快 告訴 我們 詳情 ！ (Tell us the details!)
A4: 我 很 痛苦，沒有 力量 再 活下去 。 (I am in pain and can no longer live.)
C3: 有 本事 自殺 吧 ！ (Kill yourself to prove your ability.)
D1: 其實 樓主 唔 講，無 人 會 知道 你 想 點 。 (We have no idea what happened if you keep silent.)
E1: 財務 ， 幫助 你 解決 週轉 問題 。 請電 12345678。 (Quick Finance helps you with financial problems. Phone 12345678 for aid.)

The system takes Chinese words with more than 2 Chinese characters into consideration. In this situation, the score would be:

A-B: 2	A-C: 2	A-D: 0	A-E: 0
	B-C: 1	B-D: 1	B-E: 0
		C-D: 0	C-E: 0
			D-E: 0

Taking average of non-zero scores, the threshold is 1.5. Thus only edges A-B and A-C are left. Since D and E form no edges with other ANs, they are eliminated.
Sentence edges are then formed between all sentences of A, B and C. Edges formed and their weight A2-B2: 2, A1-C3: 1, A2-C1: 1, B2-C1: 1 and others: 0
Taking the average of non-zero weight of edges as the threshold, the threshold is 1.5. A2-B2 is above the threshold. A2 and B2 are aggregated to provide a mainstream idea: 普遍 父母 不 明白 知道 孩子 的 感受 。

5 Ongoing Work

We collect forum posts with suicide expression from different sources on the Internet regularly to have a large database reflecting the real-life situation. A large amount of phrases will be stored in the database. The threads will be assessed by professionals. When our database becomes large enough, we will investigate the characteristics of the Internet users who comment on suicide-expressions and act as gatekeeper. By social network analysis, we may find out the relationship between gatekeepers on those online social platforms. The system using collective intelligence will enhance the identification of individuals expressing their suicide intent, in terms of time and cost efficiencies. Resources can be shifted from the labor-intensive identification process to the innovation and development of interventions so that more people can benefit in the future.

We will evaluate the system by conducting experiments to investigate the methodology used. Professionals would participate in the evaluation. We will classify the identified posts into different groups by problem categories. We will conduct content analysis of the collected. We will provide suicide surveillance service to various end-users who are interested in using this identification tool in searching for suicidal people on the Internet. Feedback will be collected and used for improving the system and the effectiveness of the system in real-life situation therefore will be examined.

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