School Shooting
Threat Detection and Classification in Textual Leakage

Ajmal Khan
Abstract

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The continual occurrence of school shooting incidents underscores the need of taking preventive measures. Inductive measures of threat assessment have proved to be a bad strategy to solve the problem and new research is focusing on deductive approaches. Deductive threat assessment approaches are gaining ground and efforts are underway to mine text for automatic detection of threats in written text. Automatic detection and classification of threats in the digital world can help the decision makers focus energies on imminent threats of school shooting and take preventive measures in time to save precious lives and other resources.

The contribution of this study is criticism of the previous work done on the problem of school shooting, collection of data of previous cases of school shootings in order to find out the factors that affect the school shooting problem and the development of an algorithm that could be used to detect threat of school shooting in written text in the English language. The algorithm proposed in this study classifies text on the basis of seriousness of the threat of school shooting in to four categories i.e., "High", "Medium", "Low", and "Not a threat". The seriousness of the threat is decided based on different indicators present in the text of the threat and presence of factors that has affected previous school shooters. A prototype is implemented to demonstrate the classification in to the categories mentioned above.
Dedicated to my son Russell Junaid
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Abbreviations

AI       Artificial Intelligence
AP       American Psychological Association
CSV      Comma Separated Values
FBI      Federal Bureau of Investigation
GAM      General Aggressiveness Model
L        Linguistic Markers Detection Sub Module
M        Motive Detection Sub Module
P        Place Detection Sub Module
R        Rehearsal Detection Sub Module
S        Suicide and Hatred Detection Sub Module
T        Time Detection Sub Module
US       United States
W        Weapons Detection Sub Module
S_L      Score allotted by Linguistic Marker Module
S_M      Score allotted by Motive Detection sub module
S_P      Score allotted by Place sub module
S_R      Score allotted by Rehearsal Detection sub module
S_S      Score allotted by Suicide & Hatred sub module
S_T      Score allotted by Time Detection sub module
S_Tar    Score allotted by Target Detection sub module
S_W      Score allotted by Weapons Finding sub module
R_T_L    Running Total of Linguistic Markers sub module
R_T_M    Running Total of Motive sub module
R_T_P    Running Total of Place sub module
R_T_R    Running Total of Rehearsal sub module
R_T_S    Running Total of Suicide sub module
R_T_T    Running Total of Time sub module
R_T_Tar  Running Total of Target sub module
Introduction

The current cases of school shootings in many countries and especially in the United States (US) emphasize the need of preventive security measures other than just physical security measures in the form of metal detectors, iron gates and increased number of Security guards. Reddy et al. (2001) state that most of the schools in US have focused their “preventive resources” on hiring more security officers, installation of cameras, metal detectors, and implementation of a range of programs e.g., “conflict resolution” and “legal education” programs. We think that perpetrators will always find one way or another to beat the physical security measures taken. Imparting legal education as part of curriculum might be useful to some extent but from our experience of day to day life we know that people break red traffic lights in spite of knowing that it is a criminal offence. Training in conflict resolution imparted to teachers and educational administrators might reduce the damage by equipping them with techniques to be able to persuade school shooter not to shoot but there is no guarantee that they will succeed in all cases. Even in case of successful conflict resolution, one cannot avoid the damage done by the trauma that the incident causes. Therefore, we agree with Reddy et al. (2001) that “these responses are not likely to be effective in preventing planned school attacks”. Several studies (e.g., Sewell & Mendelsohn, 2000), (Borum, Otto, & Golding, 1993), (Cooper, 2000), (Morse, 2000), (Mossman, 1994), (Semenov, Viejalainen, & Kyppö, 2010), (Borum, 2000), (O'Toole, 1999), (Ferguson, Coulson, & Barnett, 2011), (Vossekul B., Fein, Reddy, Borum, & Modzeleski, 2002), (Lieberman, 2008)) have been conducted to evaluate the value of already existing preventive measures, tools and techniques such as “profiling” (Homant & Kennedy, 1998), “guided professional judgement” (Borum, 2000) (Otto, 2000), “actuarial equations/formulas” (Dawes, Faust, & Meehl, 1989), “expert systems” (Beaumont, 1991), or systems using Artificial Intelligence (AI) approaches and threat assessment approaches (Reddy, Borum, Berglund, Vossekul, Fein, & Modzeleski, 2001) (O'Toole, 1999). Approaches adopted in Reddy et al. (2001) and Semenov et al. (2010) look quite promising as preventive measures and, therefore, in this study we used a similar approach towards preventing school shooting but we go one step further. We have proposed an algorithm, and developed a tool in Java based on that algorithm, that automatically classifies written text in to one of the four categories i.e., High, Medium, Low and Not a threat.

Aims and Objectives

The aim of this research is to study the school shooting problem from the perspective of threat and its criticality in an attempt to prevent school shooting incidents in the future. Most of the school shooters express their intentions of carrying out an attack in one way or another to some peers, close relatives, the potential victim, or/and other potential perpetrators in their environment or in the digital world intentionally or accidently. This expression of intention may be in one or many forms e.g., spoken, written, graphic, symbolic, audio-visual, or through carelessly and unintentionally drawn doodles. We believe that this “leakage” (O'Toole, 1999) (Weisbrot, 2008) or/and any leakage done in the digital world can be automatically analysed to decide whether the leakage contains any threat or not. This research will focus on automatic detection of threats and their classification according to the level of severity of the threats, if any, in written text including text on the Internet. The objectives of this study are given below:

1. Defining school shooting and scope for this study.
2. Conducting literature review of some studies on preventing school shooting.
3. Collection of data from media about identified incidents for all the school shooting incidents that have happened until the end of January, 2013 and studying the data to find out useful parameters for the development of a threat detection and classification tool in unseen text.
4. Discuss the threats, its types and levels of seriousness in the context of school shootings.
5. Explore the possibilities of an automatic mechanism that can classify a threat, in a piece of text, according to its criticality.
6. Develop a tool that can automatically detect a threat in written text, if any, and classify it in one of the four categories/classes High, Medium, Low and Not a threat.

Research Questions

The following research questions will be considered during this study.

a. What are the different factors that influence school shootings as stated in the existing scientific literature?

b. What risk assessment measures have been suggested in the scientific literature to prevent school shootings?

c. How can an algorithm automatically identify and classify a threat in unseen text, if threat is found in the text, into different categories/levels?

d. Is it possible to write a tool to automatically detect unseen text in the digital world and classify it into “High”, “Medium”, “Low” and “Not a threat” categories?

Contributions of this study

The contribution of this study is the development of an algorithm that could be used to find out whether a leakage in the form of written text (in the English language) contains a threat or not. The algorithm can also be used to classify a threat on the basis of its seriousness in to four categories, i.e., “High”, “Medium”, “Low”, and “Not a threat”. A prototype is implemented to demonstrate automatic classification of threats in written text.
Background and Related Work

Definition

The term school-shooting, in the published scientific literature, describes cases of school violence “where a student or an ex-student of a junior high school or university college carries out a planned attack against his peers, teachers, other personnel or passersby in school buildings or on the campus. The target of an attack can be the entire society, the institution itself, the social order among peers or a group of hated individuals” (Newman, Fox, Harding, Mehta, & Roth, 2005) (Ferguson, Coulson, & Barnett, Psychological Profiles of School Shooters: Positive Directions and One Big Wrong Turn, 2011). Semenov et al. (2010) say that the goal of such attacks is to kill as many as possible randomly.

On Wednesday, 30th January, 2013, a blast occurred around lunch times at the Kvarnbergskolan, in Huddinge, south of Stockholm in which a plastic bottle with chemicals, inflammable matter, and bits of foil were used. This incident is the latest example of school violence that is included in this research. This incidence was planned to attack many people at random and involved no firearms (The Local (a), 2013; Sveriges Radio, 2013; Göteborgs-Posten, 2013). To cover this and many more acts of school violence that were carried out using other weapons or tools we have modified Larkin’s definition (2009) of school shootings which will be used in this research. This modified version is given below:

- In order to kill or hurt someone, a student(s) or an ex-student(s) brings a weapon, a tool, any device or some chemicals in liquid, solid or gas form to school, school bus or a school function or party (that might be outside the school premises but allows no outsiders) and uses it intentionally.
- At least one person is injured due to the intentional attack. An event where the use of the tools, weapons and things mentioned above is accidental excludes this research.
- The perpetrator attempts to or practically succeeds to hurt or kill more than one person, at least one of whom is not specifically targeted.

For the purpose of this research, our definition of school shooters exclude personal scuffles, attempts to settle personal scores, violence done by juvenile gangsters, political, racial or religious groups, fights related to sports competitions, and the routine bullying (that goes on in most of the schools). However, if during an attempt of settling a personal score or a personal fight, the perpetrators shoot others deliberately then we consider the case as a school shooting. Fighting between groups is not considered at all.

The Origin

Attacks fulfilling our definition of school-shooting, as given above, originated in the 1960s in the USA. Earlier incidents are not covered by our definition of school shooting. According to Semenov et al. (2010), over 300 incidents have been reported in the published literature fulfilling Larkin’s definition (2009) of school shooting. This number might not represent the number of real incidences of school shooting due to two reasons. First, the media are strictly controlled in many countries and the government does not allow media to report cases of school shootings. Second, in some countries school shootings are reported but no details are given since in most cases the persons involved are juvenile. In this later case, it is difficult to decide if the case was really a case of school shooting or school violence and terrorism.

The number of incidents that could be found using the open source media, and that is used in this study, is 159. The main source for the data is Wikipedia but 178 other sources (Details of the On line Sources from which the events of School Shooting were collected, 2013) are used to complement the information taken from Wikipedia as the information on Wikipedia is not complete to provide all the parameters needed for this study. Details of these events of school shooting along with their relevant links are available in a separate Microsoft Excel Sheet with the author. Semenov et al. (2010) has justified why one can rely on the use of Wikipedia as a "global information source of school-related shootings". There
are several other researchers ((Verlinden, Hersen, & Thomas, 2000); (Risk factors in schools shootings: Erratum, 2000)) that have used media reports to investigate the problem of school shooting.
Factors Related to School Shooting

It is imperative to understand the problem in its context and study all the factors that affect School shooting problem. The study of these factors will help focus more on relevant factors and dispel the myths around the problem. This will ultimately help in giving correct representation to more important factors in the algorithm proposed for the classification of text on the basis of seriousness of the threat of school shooting found in the text.

Roles of Psychological Factors

Ferguson (2008) is of the view that mental illness, and not external factors (watching violent movies, violent video games, wearing “Gothic” clothes or listening to “weird” music) are mainly responsible for school shootings. He terms these events as a “failure of the society more broadly to provide adequate mental health services”. He further clarifies that all people with mental illness are not prone to violence and most of them are peaceful citizens. Douglas et al. (2009) agree with Ferguson that there is enough evidence that “mental illness can be a risk factor for violence, particularly in those individuals with antisocial personality traits” (Ferguson, 2008). Semenov et al. (2010) discusses the different reasons of school shootings and say that copycat is not a reason to perform a school shooting. They consider psychological reasons and mental illness of the school shooters as a more “credible explanation”. They give the example of Eric Harris and Dylan Klebold from the Columbine Shooting (Muschert & Spencer, 2009) and say that the former was “a psychopath” where as the later suffered from “a deep depression” ((Semenov, Veijalainen, & Kyppö, 2010); (Cullen, 2009)). Langman (2009) also mentions the mental illness of these two perpetrators. He says that Klebod was suffering from Schizophrenia where as Harris was a psychopath. We agree with Semenov et al. (2010) that mental sickness is not a “sufficient reason” for school shootings as there are millions of people in the world that have some kind of psychological problems but they don’t go on rampages. Like male students, a large number of female students also suffer from mental sickness but the number of female students going on rampages is far less than the number of male students with a recorded history of mental sickness (Semenov et al. 2010).

Role of Social Factors

The role of sociological factors in school shootings is also relevant. Social explanation of school shooting has been done by many researchers ((Newman, Fox, Harding, Mehta, & Roth, 2005); (Preti, 2008); (Oksanen, 2010); (Waldrich & Blattner-Hauser, 2007)). We think that rampages including school shootings could be a reaction to the social milieu of the society or the social milieu of the school where the shooting happens. A school environment that allows “physical or relational aggression” by a student or a group of students, such as athletes or rich students belonging to elite class, is always prone to school violence and the risk of school shooting is high (Twemlow, Fonagy, Sacco, O’Toole, & Vernberg, 2002). Newman et al. (2005) say that rampages are socially and culturally determined and are one way how the young Caucasians try to solve their problems in small towns and villages. Social problems can cause psychological problems and serious mental disorders. Therefore, a perpetrator having social problems could get mentally ill or develop serious depression and, therefore, the real reason of school shooting in such a case is not the mental illness as that was a consequent and not the antecedent. Waldrich (2007) also ascribes school shootings to the social factors.
Role of Political Factors
Semenov et al. (2010) mention the politics of school shooting and as an example mentions the effects of the Columbine school shooting on other perpetrators that later on did school shootings. The shooters in the Columbine incidence wanted to rise against the “humiliation and isolation” suffered by many students at the hand of the “jocks” or snobs. Larkin (2009) says that “Klebold and Harris, in their spectacular assault on Columbine High School, gave voice to outsiders, to loser students, to those left out of the mainstream, to the victims of jock and “prep” predation”.

In the case of Sebastian Bosse, who did a shooting at Geschwister Scholl High School, Emsdetten, Nordrhein-Westfalen, Germany, one of the motives was also political since he stated: “life is meaningless in a society based on market economy. Running after money all the time is no life” (Rueters, 2013; School Violence 2006-2007; (Wikipedia (a), 2012); (Internet Archive, 2006); (Spiegel on line, 2006); (Wikipedia (b))).

Another example of shootings with politics as one of the motives was conducted by Wellington Menezes de Oliveira who did shootings at Tasso da Silveira Municipal School, Realengo, Rio de Janeiro (Wikipedia (b)); (Wikipedia (c)); (Murderpedia); (School Violence 2010-2011)). Among the notes found at his home there were things that suggested that he was obsessed with terrorist acts. He also recorded a video two days before the shooting which shows him saying: “The struggle for which many brothers died in the past, and for which I will die, is not solely because of what is known as bullying. Our fight is against cruel people, cowards, who take advantage of the kindness, the weakness of people unable to defend themselves” (Wikipedia (b)); (Wikipedia (c)); (Murderpedia); (School Violence 2010-2011)).

Harris, one of the shooters in the Columbine school shooting, also had a political motive since he mentioned Nazism in his postings on the Internet (Semenov, Veijalainen, & Kyppö, 2010).

Role of Cultural Factors
Many of the school shooters could not depict their motive in the suicide notes that they left, in postings on the Internet or in videos that they posted on the Internet. Many simply wrote that they “hate the human race”. Researchers ((Semenov, Veijalainen, & Kyppö, 2010); (Oksanen, 2010)) think that this is because they were following a “cultural script”. Oksanen (2010) gives the example of Matti Saari that he could not explain his reason for doing the shooting and his suicide note just says that he hates the human race. Semenov et al. say that if Matti Saari hated human race then why he decided to shoot at school. Why did he decide to kill students ((Semenov, Veijalainen, & Kyppö, 2010); (Oksanen, 2010))? They also give the example of Harris, one of the Columbine shooter, and say that Harris was aware of the “contradictions in the culture” to which he belonged as Harris mentioned it that “you are required to be an individual – which in his view means to be different from anybody else – but at the same time you have to obey the same rules and be interested in the same things as the others are” (Semenov, Veijalainen, & Kyppö, 2010).

Group Dynamics and School Shooting
The Role of Bullying
Olewus (1993) stated that “A student is being bullied or victimized when he or she is exposed, repeatedly and over time, to negative reactions on the part of one or more other students”. Besag (1989) says that bullying is aggressive behaviour with the intention to cause harm to others expressed through some acts repeated over time. Nansel et al. (2001) summarized the different elements in different definitions in the literature as follows. Bullying is “a specific type of aggression in which, (1) the behaviour is intended to harm or disturb, (2) the behaviour occurs repeatedly over time, and (3) there is an imbalance of power, with a more powerful person or group attacking a less powerful one”.

The victims of bullying displays different symptoms some of which are headaches, sleep disorders, depression, stomach aches, attempting suicides or planning/fantasizing about it, and the need or desire to carrying some kind of weapon for self defence ((Garrity & Baris, 1996); (Glew, Rivara, & Feudtner); (Muscari, 2002)). Karin Reuter-Rice (2008) describes in detail the family factors, school factors,
community factors related to bullying as well as suggestions for parents how to identify the symptoms of bullying in their child and how to deal with it.

Threat and its relationship to bullying in the context of school violence was established in the Safe School Initiative Study (Vossekuil B. , Fein, Reddy, Borum, & Modzeleski, 2002) which reports that 71% (N=41 where “N” refers to the number of attackers that correspond to the reported percentage) of the perpetrators felt threatened, teased, bullied, attacked, or injured by others before they did the attack. Weisbrot (2008) says that 50% of students (N= 114 where “N” refers to the number of students that she evaluated in her study) evaluated by her, after they threatened someone, were “intensely teased”. She calls such students as “injustice collectors” who are often loners, hold thoughts of retaliations inside, do not intend to forget and forgive, and brood on some “real or perceived injustices”. Further, Weisbrot (2008) says that it is not clear “whether students who threaten school violence are teased and bullied more than their peers”.

Copycat

Many people including some government representatives, film producers writers and journalists are of the opinion that copycat is one reason of school shootings. Many films have been made showing the copycat phenomena of other crimes. Semenov et al. (2010) claim that in USA and Europe, school shooters have copied previous school shooters in dress, choice of weapons, and some cultural symbols but they reject the idea that someone will do a school shooting just because others have done it before. We agree with these researchers (Semenov, Veijalainen, & Kypö, 2010) since school shooting is not playing a video game that a student will take part in just for fun or to repeat some event done by others before them. This seems to be no motive at all for school shootings. Destroying one’s own life as well as others at a mass level cannot have copycat as a motive.

There are studies that consider media responsible for the copycat phenomenon. The media presents the news not only in a detailed way but uses language and style that gives the impression of the perpetrators being heroes ((Lieberman, 2008); (DIE WELT, 2009)). Other studies ((Semenov, Veijalainen, & Kypö, 2010); (Cullen, 2009); (Grandt, 2010)) make the media responsible for “spreading rumours and speculations about the motives, experiences and mental state of the perpetrators and survivors and these begin to circulate as truths”.

Conspiracy of Silence

The report of Bill Dedman (2000) points out to another important group dynamics which is that of not telling the school authorities about any leakage or threat that they know of because they feel it as a betrayal with their peers. Another reason mentioned in that report (Dedman, 2000) is that students feel that no heed is paid to their reporting of bullying or threatening behaviour by the school administration. Weisbrot (2008) underscores the importance of another hypothesis that is related to the “presence of covert power dynamics in schools with high level of violent episodes”. She gives the example of situations in which other students witnessing the bullying remain silent while their peers are harassed, bullied and teased. Other works ((Twemlow, Fonagy, & Sacco, 2001); (Twemlow, Fonagy, Sacco, O’Toole, & Vernberg, 2002) mention the term “conspiracy of silence” to depict such situations. Weisbrot suggests making intense enquiries by a clinician in order to find out if the victim of bullying entertains any retaliatory fantasies specially those that include retaliation not only against the bully but also about those “who are perceived as colluding in the bullying” (Weisbrot, 2008).

Video games, “Goth” Culture and Music with Dark and Morbid Themes

Every report of school shooting violence is followed by many speculations in the media especially after some of the peers of the perpetrator tell that the perpetrator played violent games, liked horror movies, took part in “Goth” culture or listened to “music with dark and morbid themes” (Weisbrot, 2008). ‘General Aggressiveness Model’ (GAM), given in the work of Anderson et al., (2002) claims that the consumption of violent media content desensitizes the user to violence in his/her real life as well as on media such as Internet. Further, they say that this desensitization in turn makes aggressive behaviour more likely as a result of “developing stable patterns of aggressive cognitions, emotions, and aggression-legitimating attitudes over time” (Holtz & Markus, 2010). We agree with Weisbrot (2008), as our data proves it so,
that there is no evidence that these things are directly related to threatening behaviours in perpetrators. Of course, taking part in drug related gangs, criminal mafias, and other groups involved in antisocial activities might promote behaviours that are antisocial and threatening. Lawrence and Birkland (2004) severely criticized the focus on external factors e.g., video games, music, movies, and Gothic culture instead of internal factors, e.g., mental illness, severe depression etc. Fergusan et al. (2011) points out towards a very interesting consequence of holding such a view that it gives more and more power and control to governments for intervention. We also think that it might cause violation of certain liberties in the name of public welfare, protections and security. The US Secret Service Report on school shooters (Voskekuil B., Fein, Reddy, Borum, & Modzeleski, 2002) found out that “the attackers interest in violent themes took various forms” and that “there was no one common type of interest in violence indicated”. The results of this study (Voskekuil B., Fein, Reddy, Borum, & Modzeleski, 2002) has more force to prove the point since this study used legal, medical, social, and educational documents of shooters along with interviews of ten of the perpetrators who survived shootings.

Miscellaneous Factors

“Eric Haris wanted to become famous”, says Semenov et al. (2010), and that is one reason of leaving behind a lot of material on the Internet. There are other examples that reinforce this point of view. Matti Juhani Saari posted videos on YouTube. Georg Ran, who did a shooting at Carolinium High School Ansbach Bavaria Germany, ((School Violence 2009-2010); (USATODAY, 2009); (Illmer, 2009)) maintained an 80-page long diary, stored into his personal notebook in which he explained his views, intentions and plans. He surely did not need to write his views to look at it and remind himself what his views were but left it to be found after his death and get famous.

Subhert et al. (1999) investigated school shootings that took place from October 1997 to May 1998 and summarized some of the possible causes for school shootings as given in the national press reports. There are several other researchers ((Verlinden, Hersen, & Thomas, 2000); (Risk factors in schools shootings: Erratum, 2000)) that have used media reports to investigate the problem of school shooting.
Revealing Plans - Leakage

Weisbort (2008) claims that the term “leakage” was used for the first time in the context of threat assessment by O’Toole et al. (1999) to describe potential “clues signaling a potentially violent act including feelings, thoughts, fantasies, attitudes, and intentions” (O’Toole, 1999). Some researchers ((O’Toole, 1999); (Vossekuiil B., Fein, Reddy, Borum, & Modzeleski, 2002)) are of the opinion that leakage is a “cry for help” that the perpetrators give to friends and/or relatives and in the process expose their lethal plot to those involved in leakage. Weisbrot (2008) says that the examples of leakage “include direct threats or leakage boasts, doodles, Internet sites (e.g., MySpace, YouTube), songs, tattoos, stories, and yearbook comments with themes like death, dismemberment, blood, or end-of-the-world philosophies”. Bender, W.N. et al. (2001) gives the example of the video that Harris and Klebold produced as part of the class work in which they showed boys “acting out a scene that involved anger, violence, and revenge”.

We agree with Weisbort (2008) that the leakage must be considered in its proper context otherwise correct conclusion cannot be arrived at if the leakage is treated in isolation without any context or in a wrong context. If a person is obsessed with some ideas e.g., school shooting, the obsession will in one way or another come to the front and will affect that person’s behaviour even if (s)he tries to keep it a secret. This change in behaviour could be noted by the peers, teachers or parents but is often ignored, thus throwing away a golden chance of preventing the incidence of school shooting.

Many psychological tests use this tendency of human beings of leaking information in spite of a conscious effort to hide it. Some examples are sentence completion test, writing a story about oneself or a given drawing/picture. Weisbrot says that in some cases one can discover the leakage by asking simple and “traditional questions” about his/her life story revealing the “underlying violent preoccupations”, if any (Weisbrot, 2008). Ferguson (2008) gives a very good example of how to identify leakage in literary writings e.g., in a story involving terrorists, weapons, firing, and hostage making. He says that stories with these elements could be purely fictional and its sole purpose might be entertainment.

“For example, a story in which a terrorist breaks into the school, shooting teachers and students, but the individual student in question then kills the terrorist and becomes the hero would be far less worrisome than a story in which the individual student kills teachers and students, particularly those who have “wronged” him”. (Ferguson, The school shooting/violent video game link: causal relationship or moral panic?, 2008)

In 1999, the National Centre for the Analysis of Violent Crime organized a symposium that studied 18 cases of school shootings (including both attempted and foiled cases). The major finding of this symposium as reported by Weisbrot (2008) is that “school shooters indicated their plans before shootings occurred through direct threats or by implication in drawings, diaries, or school essays”. Twemlow et al. (2002) say that denial of recognition of potential school shootings “can blind the school staff” to such “warning communications”.

As of today, the most authentic study (Vossekuiil B., Fein, Reddy, Borum, & Modzeleski, 2002) ever conducted to deal with school violence with solid empirical proof is the one conducted by the Unites States (US) secret service and the US Department of Education. The aim was to get adequate information that will enable the authorities to make effective strategies and policies for the prevention of school attacks in future. This study (Vossekuiil B., Fein, Reddy, Borum, & Modzeleski, 2002) considered 37 cases involving 41 school shooters. Each case was handed over to two persons who were taken from a pool of the resource persons for the study comprising of trained criminal investigators and social scientists. The researchers found out that in 81% of the incidents, at least one uninvolved person, mostly a peer, had information indicating that the attacker was thinking about or planning the school attack: in nearly two thirds of incidents, more than one person had information about the attack before it occurred. In one case, “at least 24 friends and classmates were told” and in other cases, some perpetrators warned their close friends not to go to school on the day of the shooting (Twemlow, Fonagy, Sacco, O’Toole, & Vernberg, 2002). However, the information known by other students or friends was rarely communicated to adults.
The leakage can occur at any of the places in the social environment of the child but school is probably the place where there are more chances of leakage. While the child is in school, his violent intent leaks out from him, says Twemlow et al. (2002). Ferguson states (2008) that the US Secret Service reports that in 93% of the cases, “the attackers had engaged in other behaviours that caused alarm in peers, parents, teachers, or mental health professionals. These behaviours include fantasizing about violence, particularly toward innocent targets”.

Semenov et al. (2010) claim that all major school shooters that have done school shooting after 2005 have had presence on the Internet and have "left traces that would have made possible to evaluate their intention to carry out a rampage“. One example is Harris’ message to the world that he posted well before the actual shooting. Another example of leakage is the flash cartoons made by Jeffrey Weise, the shooter who did a shooting at Red Lake Senior High School, Minnesota (Semenov, Veijalainen, & Kyppö, 2010). These cartoons show shootings and suicide and Jeffrey uploaded them to his profile on newgrounds.com.
Critical Evaluation of Existing Risk Assessment Approaches to the School Shooting Problem

Many approaches of assessing the risks of school shooting have been mentioned in the published literature. Some of these approaches are used while others are partially used. Many schools, especially in the US, use a combination of these approaches. Some of the threat assessment approaches e.g., the approach given in Semenov’s et al. (2010) are still in infancy and scalable algorithms and technologies are needed to put them into practice. Another obstruction for implementing these approaches is that it requires access to medical, legal, social and personal digital accounts which invades the privacy of the individuals. Hence their realization seems to be far from practical in the immediate present. The risk assessment approaches that have been discussed in the relevant literature are given below.

Profiling and Warning/Check lists

The term "profiling" connotes a range of identification techniques used in the process of assessment of people under consideration for a particular purpose. These techniques are often used by different agencies involved in the identification of persons and include governmental agencies (Homant & Kennedy, 1998). Criminal investigators make profile of suspects; credit recommendation officers make profiles of their customers who give applications for loans; marketing companies make profiles of their customers. To make his point, why profiling is not a suitable technique for threat assessment, Reddy et al. (2001) explains the difference between crime scene profiling, and prospective profiling. In crime scene profiling the start is taken from the crime scene to collect all the available information from the traces of the crime and the criminal. Next, a set of hypotheses is developed about the personality of the most likely criminal from the characteristics e.g., demographics or physical, related to the information retrieved from the crime scene (Douglas, Ressler, Burgess, & Hartman, 1986). This makes the process of investigation faster and easier as the hypothesis can be used to narrow down a list of suspects. Reddy et al. say that this is a "retrospective technique" as it works backwards from behaviour to a person suspected of crime (Reddy, Borum, Berglund, Vossekui, Fein, & Modzeleski, 2001).

The technique mentioned above has been reversed in prospective profiling in which instead of starting from a behaviour/crime, start is taken from a suspect, a person, and projecting forward an attempt is made to “predict the future likelihood that the person in question will commit the crime of concern” (Reddy, Borum, Berglund, Vossekui, Fein, & Modzeleski, 2001). Coming back to our case of school shooting, using prospective profiling a profile of a school shooter is constructed from the common characteristics of the students who have already done school shootings ((Reddy, Borum, Berglund, Vossekui, Fein, & Modzeleski, 2001); (Homant & Kennedy, 1998); (Pinizzotto, 1984)). Using this profile as a touchstone, every suspect of a school shooting is compared to it to assess an individual who has caught some one’s attention or given a threat as well as identify types of individuals that might become school shooters (Reddy, Borum, Berglund, Vossekui, Fein, & Modzeleski, 2001).

In the last decade of the twentieth century, one of the preventive measures that the society in general and researchers in particular took most interest in was making a “profile” of the school shooter. This interest was partly due to the increasing number of school violence in that decade. Borum (2000), Ferguson (2008), Hong, Cho et al., (2011), Langman (2009), and Wike & Fraser (2009) depicted the lack of empirical evidence on school shooters in their studies. Mulvey & Cauffman (2001) warned against the over fitting of the profiles developed due to this lack of empirical evidence.

Many organizations and researchers leapt in, to give their versions of the profile of a potential school shooter. McGee and DeBermardo (1999) offered their hypothesis of “the classroom avenger”. On the basis of their study (N = 14), they have made a profile that presented the classroom scavenger as a male, Caucasian, loner, belonging to urban/rural middle-class, having interest in violence but not yet participated in
it, no recorded history of “disability”, retardation or mental illness, adolescent, appears normal, and fantasizes about revenge and mass murders (McGee & DeBernardo, 1999). Making a profile on the basis of 14 cases is not a good idea and that is one of the limitations of their study.

Bender, W.N, et al. (2001) also attempted to find out some common factors among school shooters. The factors that they gave are emotional factors, alienation from family and friends, showing warning of violence before the shooting, accessibility to guns, and low or decreasing respect for life. Bender, W. N. (1999) uses the term “the invisible kids” for school shooters. He explains that he is using this term to emphasise that these kids are generally not famous in the school as they have “no overt behaviour problems in school”. Further he says that these kids are emotionally wounded by other students and are essentially “invisible to the adults in the school”. Their violence is an attempt to come out of this anonymity, get control and try to reject the peer-imposed labels e.g., “nerd” or “geek” or “walking dictionary” (Bender W. N., 1999). O’Driscol (1999) and Paulson (1999) say the same thing but in different words when they say that “these students do not make trips to the principal’s office.”

The American Psychological Association (APA) published a pamphlet on the Internet in which they mentioned a potential school shooter to be a person “who enjoys hurting animals”, has “detailed plans to commit acts of violence”, “announces threats or plans for hurting others”, “feels rejected or alone”, has “poor school performance”, is involved in “frequent physical fighting”, and “has access to or fascination with weapons, especially guns (APA.org). These are some of the prominent features given in their study. C. J. Ferguson et al. (2011) have pointed out that this latest characteristic is “probably quite common in males” whereas the last but one characteristic is vague as we cannot understand “how frequent is frequent”. Continuing his attack against similar vague features of potential school shooters in the report of Federal Bureau of Investigation (FBI) (O'Toole, 1999), Ferguson (2011) points out the use of “vague descriptors” e.g., “unreasonable” in the feature “unreasonable interest in sensational violence” (O'Toole, 1999). He claims that interest in violent themes is common “in moderate amounts to almost all males and many females” in “moderate amounts” (Ferguson, Coulson, & Barnett, 2011). For a complete list of features of school shooters of the FBI report, please see O’Toole et al. (1999). The difference between the APA’s and FBI’s report is that FBI warns against the use of warning signs in a potential perpetrator and depicts clearly that their “profile” of the school shooter should be used only after someone has made a threat and that threat needs to be assessed.

Another relevant study under this subheading is the United States (US) secret service and the US Department of Education’s study (Vossekuil B., Fein, Reddy, Borum, & Modzeleski, 2002), which is considered as the best research on school shootings due to its use of empirical data, used legal, medical, social, and educational documents of the shooters along with interviews of ten of the perpetrators who survived the shootings. The distinction of this study is that it clearly states that no “profile” of a school shooter exists. Twemlow et al. (2002) also imply that there is no “profile” of a school shooter by saying that the attackers were from a “range of family situations, from intact to neglectful and a range of academic performances, from outstanding to failing, socially isolated to popular and had variable behavioural problems including discipline problems”. The aforementioned study also reports that few of the shooters had a recorded psychiatric illness and/or substance abuse history. Many of the shooters were successful in “manipulating their parents into defending extreme behaviours” (Twemlow, Fonagy, Sacco, O’Toole, & Vernberg, 2002). Consequently, the parents never noticed what was going on with the child and the child got more and more privacy at home and therefore increased opportunities to make bombs, and store guns and ammunitions in their rooms.

The following warning signs should be observed in a potential perpetrator and if two of these signs are found then the person should be considered for future investigations (Lieberman, 2008).

- The person has been bullied at school.
- The person is depressed to the point of suicidal or homicidal ideation or has been prescribed anti-depressants.
- The person is reclusive.
- The person has access to weapons.
- The person plays violent games.
- The person watches violence laden movies.
- The person has acquired bomb making recipes.
- The person has bought material that could be used in making a bomb or explosives.
- The person is obsessed with knives or swords.
- The person praises other school shooters.
The person maintains a hit list.
The person draws maps of the school for use later on.
The person has a history of producing violent audio visual material.
The person has talked to someone or written somewhere about a plan to do shooting and refusing to confess when asked to explain it.

There are many problems using this approach.

a. There is a “considerable risk of false positives”, i.e., since the phenomenon of school shooting is rare, therefore, most of the students who “fit” the profile will not actually do a school shooting ((Reddy, Borum, Berglund, Vossekuil, Fein, & Modzeleski, 2001); (Sewell & Mendelsohn, 2000)).

b. The use of warning signs might erroneously exclude those students who do not “fit” the profile but who in fact pose a high risk of committing the school shooting. Another concern is that the warning signs are considered as questionable and inaccurate by many researchers. When the criteria’s are touchstone is inaccurate, we cannot expect to get good results. The best research available uses 37 cases that involve 41 shooters spanning 20 years back in time (Vossekuil B., Fein, Reddy, Borum, & Modzeleski, 2002). As an example of an inaccurate profile let us take the “classroom avenger” profile (McGee & DeBernardo, 1999) which states that all school shooters are Caucasians but Reddy et al. (2001) mentions at least three perpetrators which were not.

c. The technique itself has not been proved valid and there is no data that prove the validity of prospective profiling for the identification of a potential perpetrator (Reddy, Borum, Berglund, Vossekuil, Fein, & Modzeleski, 2001).

d. Reddy et al. (2001) stated that “representative heuristic can bias decision making”. Research has shown that the use of touchstones and prototypes for the classification or categorization can “increase the effects of judgement bias” (Reddy, Borum, Berglund, Vossekuil, Fein, & Modzeleski, 2001). Relying on typical representative characteristics for the purpose of categorization or classification “may inadvertently render faulty decisions” ((Sewell & Mendelsohn, 2000); (Kahneman & Tversky, 1972); (Tversky & Kahneman, 1974)). Reddy et al. (2001) gives a very good example and says that “when the characteristics an evaluator uses (e.g., “wears black trench coat”) are in fact less informative than others that may appear less typical of previous shooters (e.g., has asked friends where he could get a gun)”, there are chances that the representative heuristic will bias the decision making (Reddy, Borum, Berglund, Vossekuil, Fein, & Modzeleski, 2001).

e. Some researchers suggest that in order to prove that their working hypothesis is valid; the evaluators will only consider information that is consistent with their hypothesis and ignore other information that proves otherwise ((Reddy, Borum, Berglund, Vossekuil, Fein, & Modzeleski, 2001); (Borum, Otto, & Golding, 1993); (Nisbett & Ross, 1980); (Snyder & Swann, 1978)). This effect is known as hypothesis confirmation bias and may increases the number of false positives if the evaluator begins with the hypothesis that a given student fits the profile instead of beginning that the student under consideration does not fit the profile (Reddy, Borum, Berglund, Vossekuil, Fein, & Modzeleski, 2001) (Sewell & Mendelsohn, 2000) (Borum, Otto, & Golding, 1993).

f. Stigmatization of students is the biggest drawback of using “profiling” because it labels a student as dangerous, thus “depriving them of their civil liberties” (Reddy, Borum, Berglund, Vossekuil, Fein, & Modzeleski, 2001) (Sewell & Mendelsohn, 2000) (Morse, 2000).

Peer Scanning

It is common for the perpetrators to show warning signals to a peer instead of an adult. In the 37 school shootings reported in (Vossekuil B., Fein, Reddy, Borum, & Modzeleski, 2002) three quarters of the perpetrators leaked their intention to peers but in only 2 cases out of 37 an adult got a hint of it ((Twemlow, Fonag, Sacco, O'Toole, & Vernberg, 2002); (Vossekuil B., Fein, Reddy, Borum, & Modzeleski, 2002)). Bender, W.N.et al. (2001) says that “the most effective sets of eyes and ears in the school building” for the purpose of identification of potential school shooters are that of students and, therefore, he claims that peer-screening “holds promise for violence prevention in schools”. Bender et al claims that in all the cases that they have studied, the principal of the school did not have much clue but students knew “that something was not quite right” (Bender, Shubert, & McLaughlin, 2001). Bender et al.
(2001) give the example of the Columbine shooting where students knew about the “trench-coat mafia” and even a teacher knew that something was wrong after noticing the leakage in an English essay by one of the perpetrators but when the principal of Columbine was interviewed after the shooting, he said that he did not know about the presence of the “trench-coat mafia”. Bender et al. (2001) recommends the use of “roster rating” which is a socio-metric that tries to find out loners or unpopular and disliked kids in the class.

Usually some students at the school get information about the violent intentions of the school shooters but these students think that it will be a betrayal of trust if they tell the school administration. Some of these students are caught between the deep devil and the blue sea as it also bothers them that they should “try to prevent harm to others at school” (Twemlow, Fonagy, Sacco, O’Toole, & Vernberg, 2002). It is common that peers relieve themselves that the person does not really mean any harm and is just giving vent to his/her personal anger against the target.

**Comprehensive Teacher Discussions**

Another technique that is used to prevent school shootings is to have a meeting with the school teachers at the end of the year for two complete days and consider the question “Which adult in this school has connected emotionally with this kid this year?” (Bender, Shubert, & McLaughlin, 2001). Bender et al. (2001) say that by the end of the year all the teachers know all the students well enough due to their interaction over one year with them. This question would enable multiple teachers to “confer and arrive collectively at a conclusion” for all the students in the school (Bender, Shubert, & McLaughlin, 2001). Teachers must be trained in threat assessment and leakage detection otherwise they won’t be able to differentiate between a real threat and an art work in a video, drama, poetry or any other piece of art. On one hand, there is a danger of completely missing and not been able to see these warning signals if the signals are weak and vague. On the other hand, there is a danger of confusing “just eccentric schoolwork or common adolescent reactiveness” with real danger of school shooting (Bender, Shubert, & McLaughlin, 2001).

**Guided Professional Judgement**

Guided professional judgment or structural clinical assessment is a technique that uses evaluation and an interview with the potential school shooter. The interview and the whole process of evaluation is “informed by the base rate for violence within the individual’s population, and by the risk factors known to be related to the risk of violent behaviour” (Borum, Assessing violence risk among youth, 2000); (Otto, 2000); (Borum, 1996)). A check list or some instruments e.g., forms might be used for the collection of data or for streamlining/structuring the process of evaluation. Everyone in school is not authorized to use this kind approach for threat assessment themselves. Only a trained and licensed mental health profession is authorised to do this kind of evaluation of a potential school shooter (Borum, 2000); (Borum, 1996)). Borum (2000) says that new research in the field should be used probably with some scoring criteria in the process of evaluation. The professional may adjust, up or down, the baseline probability or risk after all the interviews and studying of available school and/or health records. This adjustment of the base line depends upon the “presence or absence” of the “relevant risk factors”. The purpose of this adjustment is to find out the most suitable representation of the “individual’s risk for violent behaviour” (Reddy, Borum, Berglund, Vossekuil, Fein, & Modzeleski, 2001).

There are many problems using this approach. Examples are:

a. The cost of making a type 1 error is too high. Type 1 error would mean that assessing a student as not a potential school shooter whereas in fact the student poses a high risk of doing the school shooting. Reddy et al. (2001) explain it with an example. If a student has warned many other students not to “go near the library at 09:00 A.M.”, and the students know that he has acquired a gun also somehow, then the threat assessing team cannot simply ignore this because “the base rate for school shooting is miniscule” ((Reddy, Borum, Berglund, Vossekuil, Fein, & Modzeleski, 2001); (Sewell & Mendelsohn, 2000)).

b. Borum (2000) says that the factors for targeted school violence has not been proved by any empirical research yet, and therefore, no adequately suitable knowledge base exists that can “inform
guided professional judgements” for school shootings. Reddy et al. (2001) agree with Borum and states that different kinds “of violence has different antecedents”.

c. The tools used by licensed mental professionals have been designed keeping in mind mentally ill persons and hence their utility for school shooters is questionable ((Reddy, Borum, Berglund, Vossekuil, Fein, & Modzeleski, 2001); (Sewell & Mendelsohn, 2000)).

Use of Actuarial Formulas/Tools to find School Shooters

Equations that combine the involved risk factors statistically or mechanically, after giving them some sort of weightage, form the basis of actuarial tools/formulas. Empirical research is behind all such formulas and actuarial tools. Since different behavioural problems have different antecedents ((Dishion, McCord, & Poulin, 1999); (Hoagwood, 2000); (Quay, 1987)), therefore one actuarial formula is made for one particular behaviour, e.g., paedophilia, domestic violence and the strength of the actuarial formula depends on “the existence of sufficient knowledge of known variables that contribute to the outcome in question” (Reddy, Borum, Berglund, Vossekuil, Fein, & Modzeleski, 2001). This existence of sufficient knowledge is possible if “there is a sufficient frequency of occurrence of that event to permit statistically derived prediction” (Reddy, Borum, Berglund, Vossekuil, Fein, & Modzeleski, 2001). The problem with this approach is obvious now after considering how the actuarial formulas are made. Lack of enough empirical data to back the actuarial formulas makes this technique once again inapplicable for finding school shooters. As stated in (Reddy, Borum, Berglund, Vossekuil, Fein, & Modzeleski, 2001) “The base rate of school shootings is too low for any statistically derived equation to attain any discriminant accuracy”. Due to this factor derivation of any formulas or making any rules to be used in the expert system cannot be made.

“Any equation derived from empirically researched risk factors for targeted school violence would never be sufficiently sensitive (minimizing the number of false positives) to reasonably estimate the probability that a given student would engage in targeted violence in school” (Reddy, Borum, Berglund, Vossekuil, Fein, & Modzeleski, 2001) (Sewell & Mendelsohn, 2000).

Use of Expert Systems to find out School Shooters

Expert systems are systems that use artificial intelligence (AI) to solve a problem using a knowledge base that contains knowledge extracted from the experience of experts on the matter. This expertise is used by an inference engines that contains logic based on some rules in the program or any algorithm ((Beaumont, 1991); (Fox, 1996)). The system helps the user to arrive at a decision on the basis of the rules used in the program and the relevant expertise from the knowledge base that was used for comparing it with the case in hand. Borum (1996) claims that the use of expert system help in the reduction of decision bias due to subjectivity if human were to do the decision. The problem with expert system and actuarial system is the same when they are used in the process of threat assessment for school shooting. Some of the problems are:

a. Deriving meaningful knowledge to populate a knowledge base is not possible since there isn’t enough empirical data on school shootings that can help in the determination of risk factors involved.

b. Experts may not agree on the involved risk factors and an expert consensus has not been made for targeted violence in general and school shooting in particular (Reddy, Borum, Berglund, Vossekuil, Fein, & Modzeleski, 2001).

c. Existing expert systems wrongly claim comparing a potential perpetrator to “thousands of known cases” (Morse, 2000) (Steinberg, 2000). The total incidence of school shootings are far lower (Henry, 2000).

d. There is also a risk of totally depending upon the advice of the expert systems and disregarding the actual knowledge about the potential school shooters. Even a primary dependence on expert systems, if not entirely, and ignoring the firsthand knowledge available about the school shooters is extremely risky.
Use of Probabilistic Models Based on the Data Partly Gathered from Social Media Mining

This is an approach (Semenov, Veijalainen, & Kyppö, 2010) that has been suggested in 2010 and is therefore, theoretical in the sense that it is not being used currently to prevent school shootings.

The core of social media mining, presented by Semenov et al. (2010) is based on two assumptions. First, “since about 2005, all major school shooters have had a presence in Social Networking Sites (SNS) and some have left traces that would have made possible to evaluate their intentions to carry out a rampage”. Secondly, that the potential school shooters would also behave in the same way as previous school shooters did thus leaving traces on the Internet at SNS or other forums. On the basis of these two assumptions they suggest that the digital sphere should be mined for the public or if possible for all information including information that is not publically available. They are of the opinion that this will reveal the “digital path”, with chronological details, of the would-be perpetrators and expose their intentions of carrying out an attack. This exposure will be due to the leakage anywhere through audio-video or in text format on the Internet. Using examples of some shooters who have been using Internet continuously and did some leakage along the way through videos, flash movies and text, Semenov et al. (2010) indicates that school shooters tend to leaks information before an actual school shooting and that a shooting could be prevented if social media was mined well in time.

There are many problems in the approach of social media mining to make a digital path. First, currently, there are 1.06 billion monthly active users of Facebook and the daily active users were 618 million in December 2012 (Key Facts - Facebook News). More than 1 billion users visit YouTube each month and 72 hours of video are uploaded to YouTube every minute (Statistics - YouTube, 2013). Twitter had “over 500 million registered users as of 2012, generating over 340 million tweets daily” (Twitter, 2013). Looking at the data generated at these three sites, one can just imagine the amount of data available on the Internet if we include all the forums, websites and chats in different messengers. Scalable algorithms and technologies will be required to mine this sea of data and then do it continuously in order to make chronological digital paths of the movement of everyone to find potential perpetrators. Is it financially feasible? Will the government and education departments be willing to pay for it? Will the social networks still convince users to use their sites in spite of knowing that their postings are mined? Will the potential shooters continue to post violent material once the mining of the social media practically begins? These are just a few questions related to the practicality of this approach that needs to be answered.

Second, this approach assumes that access will be granted for mining data that is publically not available. There are different laws in different countries and the privacy level differs. Many countries would not be ready to give access to mine the data of the citizens just to make digital paths of the people on the Internet.

Finally, potential shooters might not use their own computers or they might use various anonymity services which makes them difficult to trace.
Threats

The increasing number of school shooting activities and death toll in each incident necessitates practical steps to identify threats of these kinds of incidents well in advance so that effective preventive measures can be taken in time. Looking for threats in the digital world is one such attempt to identify perpetrators before they attack.

Definition

O’Toole et al. (1999) defines threat as “an expression of intent to do harm or act out violently against someone or something.”

Types

“A threat may be verbal, an action such as the purchase of weapons, or symbolic such as the school essay or video”, says Twemlow et al. (2002). O’Toole et al. (1999) clarifies the difference between making a threat and posing a threat and say that many students will make a threat but will never carry it out. On the other hand, there are those that never make a threat and directly carry out their plan. This latter category poses a threat but they do not make threats. O’Toole et al. (1999) also makes a distinction between direct, indirect, veiled and conditional threats. In a direct threat the target is specific and the action that will be taken against the target is specific and the threat is directly delivered. This threat is explicit, clear and straightforward.

“Indirect threat tends to be vague, unclear and ambiguous. Violence is implied, but threat is phrased tentatively, and suggest that a violent act could occur, not that it will occur” (O’Toole, 1999).

Seriousness of Threats

Twemlow et al. (2002) depicts three levels of seriousness of a threat which are high-risk, “medium-level”, and “low-level. Threats are high risk if they are “direct, specific”, and “plausible”. Moreover, there is adequate proof that “concrete plans and steps have been taken” for the implementation of threat. If “active preparation is not detectable” and there is no plan but the threat is detailed and is concrete, then it is medium-level threat. Low-level threats are implausible, inconsistent in details given and indirect. Twemlow et al., (2002) state that “a veiled threat is one that strongly implies but does not explicitly threaten violence”. In a conditional threat, the happening of the threat depends upon fulfilling some kind of demand and is often used for extortion (O’Toole, 1999).

Threat Prediction and Threat Assessment

Threat prediction becomes inevitable when there is uncertainty about future events, phenomena or type or class of things. Everyone knows that weather prediction cannot be accurate all the time but still everybody values weather forecast. Similarly, economic forecasting, and strategic forecasting are part of our daily lives. Forecast is typically done using extrapolation, intuition or other such techniques, tools, and algorithms on the available data/information. Another way of forecasting is using the knowledge and expertise of different experts “each using the present as a base line” (Milburn & Milburn, 1966). By using
his or her own set of rules, each expert handles the process of forecasting in his/her own way. The rules used might be “implicit and intuitive or explicit and analytic” (Milburn & Milburn, 1966).

Twemlow et al. (2002) says that most of the schools have teams for the assessment of threats posed by potential school shooters and that a clinical psychologist is part of their threat assessment team. The team uses the traditional parameters of means, motive, and method that clinicians also use for finding out suicidal intent. Twemlow et al. (2002) advises school authorities to take guidance from the US Secret Service school report (Vossekul B. , Fein, Reddy, Borum, & Modzeleski, 2002) and FBI’s report (O’Toole, 1999) on threat assessment in case any school does not have their own threat assessment plan.

Twemlow et al. also suggest that other factors needs to be considered along with the threat to assess whether a threat is real or not. These factors are access to guns, “victimization by social groups or individuals”, concerns of the adults or peers, imitation of media figures, demand of enhanced privacy at home, sudden change in interests and emotional status, and obsession with idea or things e.g., guns etc (Twemlow, Fonagy, Sacco, O’Toole, & Vernberg, 2002).

Weisbrot (2008) relates an interesting fact that threatening behaviour is devastating for those who threaten besides the one who is threatened. If not part of an antisocial or bullying group, the individual may find himself alone, being avoided, hated by other students and stigmatized even after being proved that he/she did not really mean it. He or she might be labelled as a school-shooter and it is not easy to remove that label.
A Deductive Approach to Threat Assessment

Deductive and Inductive Approaches

Most of the existing approaches are inductive (Turvey, 1999). Approaches like profiling, automated decision making, actuarial formulas, expert systems containing records of people who have already done shootings, and guided professional judgement which uses the base rate of violence in the individual's population; all use induction to approach the school shooting problem. The shortcomings of all these inductive approaches have been discussed above. The continuation of school shooting attacks on a regular interval proves that the inductive approaches do not work as a preventive measure and therefore it is necessary to look towards some kind of methodology that uses a deductive approach. Fein et al. (1995) suggested their deductive approach, the "threat assessment approach", after conducting empirical research on school shootings. We agree with Reddy et al. (2001) that a good preventive measure for school shooting will be to use a method that uses a deductive approach as in (Turvey, 1999) instead of any of the prevalent inductive approaches.

An overall deductive approach will help in many ways. First, a deductive approach will focus on a particular potential school shooter and not on a set of characteristics that have been gathered from previous cases of school shootings. This will reduce the number of false positives. Second, the problem of stigmatizing a student will be handled in a better way as every case will be thoroughly investigated by a threat assessment team after it is proved that the student under consideration delivered the threat.

The approach proposed in this study uses a deductive approach. The basic idea is to detect and classify a threat in written text automatically. Each threat is considered independently and is evaluated independent of its writer or any other associations. If a threat is detected, the threat is categorized which helps the user to focus their energy and time on threats that have a higher level of seriousness instead of considering each threat in a chronological order or order of discovery. This helps decision makers in deciding which cases to consider first and which cases can be deferred to a later time.
Techniques for Automatic Assessment of Threats

Nelleke Oostdijk and Hans van Halteren (Oostdijk, 2013) have carried out a study in which they used Dutch Tweets to find threats in them automatically. They manually removed those tweets that did not conform to their definition of a threat from a collection of 5000 tweets and as a result were left with 4, 564 tweets. Along with the machine learning approach, they also used another approach that they named as “Manually Constructed Recognition Patterns” and compared the results of the two approaches. One difference between the study mentioned above and our study is the availability of data. No database or any other collection of threats given by school shooters exit that can be used to train a classifier and apply a machine learning algorithm. Another difference is that they removed all the tweets manually that did not conform to their definition of threats and as a result of that were left with tweets that contained threats. The input of the algorithm proposed in this study is text written by students that might contain threats.

As of today, there are no tools or algorithms that can be used to automatically assess threats or/and classify threats of school shooting. Today threat assessment is done by group of human beings using different threat assessment approaches. Different threat assessment approaches and their pros and cons are discussed in previous chapters.

Automatic assessment of threats belongs to the field of mining text since written threats are delivered by human beings using textual symbols. Therefore, the fields of information retrieval, information extraction, natural language processing, artificial intelligence, machine learning, data mining, databases, computational linguistics, web mining, text mining, statistics, and information sciences are all relevant fields. In spite of their relevancy, there is a fine distinction between them.

Information retrieval is used to obtain relevant information. For example key words can be used to make a logical query and using that query information is retrieved in the form of a set of documents that are distinguished from a larger set of documents. Since we are not concerned with retrieving information, it is not relevant for our purpose of threat detection and threat assessment.

In the case of information extraction, the aim is not to extract a set of documents but to extract specific information from documents. That information may be further analyzed, for example, for the determination of some trends or patterns. The problem with this approach is that it extracts specific facts and does not deal with the overall understanding of the material in hand. Extraction of information is done on a set of documents which are used an input. This input is pre-processed by tagging each document on the basis of its contents or an identified relationship between these documents. Since we do not have a set of documents to find relationship between or to tag, we cannot apply techniques from information extraction to detect threat and categorize threats of school shootings.

Dale et al. (2000) has given the following stages of analysis in natural language processing.

Tokenization ➔ Lexical Analysis ➔ Semantic Analysis ➔ Extraction of information related to meaning ➔ Author’s intended meaning

In tokenization, the text is broken into words, phrases, symbols, or other meaningful elements called tokens. Lexical analysis is the process of converting a sequence of characters into a sequence of tokens. Semantic analysis is the process of relating syntactic structures, from the level of phrases, clauses, sentences and paragraphs to the level of the writing as a whole, to their language independent meanings. An example of use of this technique is its use in machine translations where the text of the source language is tokenized first and then the tokens are passed to the next stage which is lexical analysis. A lexicon is used in the lexical analysis stage. A lexicon contains words and the features associated with those words stored in the lexicon. The tokens are stemmed to its base form. For example the word bought is stemmed to buy. Other forms of the verb buy are then derived by adding suffixes e.g., -ing etc. This technique works satisfactorily with machine translation and can also be applied to detection of threats in a piece of text but it cannot be applied in assessing the levels of threats in a piece of text due to the loss of information and loss of meaning due to stemming. For example, if a perpetrator says that (s)he has bought a gun. If we stem the word bought to its basic form buy, the information is lost and we cannot be certain whether the
perpetrator wants to buy a gun or he actually possesses a gun and is in a position to practically do school shooting. The semantic analysis can help in finding the meaning in the text to a very limited degree. For example look at the two sentences *John won the Eurovision Songs contest. He is very lucky.* Now if we have the second sentence without the first sentence, then we don't know what is meant by the pronoun "He". Semantic analysis can help in this situation by associating the pronoun "He" to the previous noun John. But semantic analysis cannot find deeper meanings that can be used in finding out the plausibility, practicality and details of a threat in order to find its level of seriousness. Referring to the contextual content alone is not adequate in order to find the seriousness of the level of a threat since one needs additional information about all the factors that help in determining if the person has taken practical steps (for example, getting access to personal or parents' weapons, deciding time, target and place to attack and making a real plan) required to carry out a school shooting attack. To summarize, we can say that the current state-of-the-art methods in text analysis rely on bag-of-words approaches, which does not allow for very deep semantic reasoning.

Supervised learning algorithms perform better with more data, but even a few hundred texts containing threats of various degrees would probably suffice to construct a first prototype system which could work satisfactorily, especially if combined with expert knowledge. The problem is where we get real school shooting threats. Real threats that have been delivered by students along with a historical record of how many of them carried out the threat and how many did not is not available. The problem with all the techniques of machine learning and data mining is that they depend on data and their division in to training set and test set. The classifiers are built on the training data and the performance of those classifiers is tested on the test data. The existence of sufficient number of threats to use for training would be possible if there was an adequate frequency of occurrence of school shootings that permits statistically derived prediction (Reddy, Borum, Berglund, Vossekuil, Fein, & Modzeleski, 2001). But as stated in Reddy et al. (2001), "the base rate of the school shootings is too low for any statistically derived equation to attain any discriminant accuracy". Due to this fact application of data mining and machine learning techniques is not possible to assess the level of seriousness of a threat. Any classifier built on a small set of data derived from empirically researched risk factors for targeted school violence would never be sufficiently sensitive to estimate the probability that a given student would engage in school shooting.

As discussed in (O'Toole, 1999), only a trained team of human beings can assess the level of seriousness of a threat. A tool can find a threat in a text but since making a threat and posing a threat are two different phenomena (O'Toole, 1999), a tool or an algorithm cannot tell them apart. The algorithm proposed in this study and the prototype developed could, therefore only be used to assist a team of human beings trained specially in assessing threats of school shooting. This assistance is in the form of prioritization of the innumerable threats that are present in the digital world. Evaluating each and every threat is a herculean task and some sort of automatic prioritization is inevitable. The purpose of this algorithm and the developed prototype is prioritization of threats.

The algorithm proposed in this study uses ontology. An ontology is defined in (Miner, 2012) as “An ontology can be viewed as the set of all concepts of interest and the relationship between them in a given domain knowledge base”. We have used the techniques of knowledge engineering to develop the ontology. Knowledge Engineering is an engineering discipline that involves integrating knowledge into computer systems in order to solve complex problems, problems that normally require a high level of human expertise (Feigenbaum & McCorduck, 1983). Although we are indebted to all the researchers whose research has been cited in the reference section but the expertise from the researchers in ((Reddy, Borum, Berglund, Vossekuil, Fein, & Modzeleski, 2001); (O'Toole, 1999); (Twemlow, Fonagy, Sacco, O’Toole, & Vernberg, 2002)) made this work possible. The knowledge of these experts has been encoded in the form of rules and in the knowledge base used by the prototype. The domain of this ontology is school shooting and the ontology could be used by any trained educationist, psychologist, school counsellor, or threat assessor.

An iterative approach has been used to develop the ontology. The ontology used in the prototype is in its basic crude form and is used to test the suggested approach. The ontology encodes not only the objects (e.g., different kinds of weapons) but also logical relationships between the objects and the concepts involved. Taking the example of the weapon sub module, the concepts involved are the relationship network that the perpetrator is a part of and the possibility of existence of a weapon somewhere with someone in this network and the chances that the perpetrator will get access to this gun as well as the kind of access, the places the perpetrator is thinking of using the gun and the concept of time. The knowledge encoded in the ontology takes into consideration the method of getting the weapon (e.g., buying, borrow-
ing, stealing), the chances of getting a weapon from a close relative (father, mother, uncle, friend, etc.) and the place (cafeteria, school bus, classroom etc.) where the perpetrator intends to use the weapon.

The objects in the ontology are in the form of nouns and verbs. The relationships are encoded in phrases that are dynamically made at run time using the objects (nouns and verbs) and other parts of speech e.g., preposition of place, time, etc. to glue the objects together to express relationships. The ontology is then used to determine the category of the text passed to the algorithm. This initial version of the ontology will perform better with evolution as it has been designed in an iterative fashion and the iterations will continue throughout the lifecycle of this ontology. The ontology needs to be developed and refined if it should be used for prioritizing threats of school shooting.
Automatic Detection and Classification of Threats in Written Text

Four Categories of Threats

O’Toole et al. (1999) presents guidelines for categorization of threats. Using those guidelines we use the four categories to classify threats. The categories are high, medium, low and not a threat. Each category is described below.

1. High: A high level threat is imminent, direct, specific, and plausible. Plausibility can be judged by considering the threat not only in the context of possibility but also probability. The seriousness of the threat is high level if concrete steps have been taken before the delivery of the threat and the text of the threat proves that practical steps have been taken to carry out the threat. The threat should also pose serious danger to the safety of other people (O’Toole, 1999).

2. Medium: A threat that is direct, but less concrete and realistic compared to a high level threat is a medium level threat. The language of the threat indicates that the perpetrator has given some thought to carry out the threats and there may be a general indication of possible place and time for the school shooting but the details given in the text of the threat still fall short of a detailed plan and suggests that practical steps have not been taken on that level as required to carry out a threat. There might be vague statements about the availability of some weapons but other details about time or place might be missing (O’Toole, 1999).

3. Low: Low level threats are vague, empty and indirect. Information given in the text of the threat is not consistent; details are either missing/inadequate or implausible. The content of the text suggest that the person cannot carry out the threat practically (O’Toole, 1999).

4. Not a threat: A category for written text that cannot be considered as threats.

Assessment of Threats

Text that might contain a threat is evaluated by 8 different sub modules. The sub modules evaluate the text using different criteria and the result of each evaluation is combined to give an overall assessment of the threat according to the four different categories. The evaluation procedure in each sub module has its base in the discussion of the factors related to the phenomena of school shooting. These factors along with relevant references from previous research have been discussed in the section “Factors Related to School Shootings” in this report.

The sub modules are:

1. Time Detection sub module (T): This sub module scans the text to find out time of the threat, its plausibility, details, and the degree of imminence.

2. Place Detection sub module (P): This sub module looks for places in the text and decides whether the place is special (such as classroom etc.) to schools or a general place (such as pool, garden or roof etc.) The module classifies the text at its own level on the basis of these details of specificity. This sub module also considers factors like the presence of school related terminology in the text and presence of weapons while classifying the threat at its own level.

3. Weapons sub module (W): The weapons sub module checks if the perpetrator has already acquired or has easy access to some kind of weapons to carry out the threat. Just unigrams e.g., “gun” or “AK47” or “revolver” will get classified as “Not a threat” since that does not prove possession of weapons, access to weapons; or intention to buy, steal or borrow a weapon on the part of the perpetrator.

4. Rehearsal Detection sub module (R): This sub module scans the text for proof of any rehearsal done for the purpose of school shooting or practicing a weapon. It also looks for proofs of targeting ani-
mals or torturing animals and finding out in the text for any proof of previous behaviour involving the use of weapons or events involving cruelty to animals or human beings.

5. **Target Detection sub module (Tar):** This sub module looks for details of plausibility of the target, if given, in terms of number of targets, absence or presence of opposing groups, the depiction of presence of revenge as a motive and the observation of routine of the target.

6. **Motive Detection sub module (M):** This sub module detects the motive for doing the school shooting and seriousness of the motive(s) if given in the text. Details are given in the sub module section.

7. **The Linguistic Markers sub module (L):** This sub module tries to find out the excitement, emotional status, and mental condition of the perpetrator by looking for linguistic markers that indicate the seriousness of the threat. This sub module takes many factors in to account such as the use of dirty words, slangs, repetition of exclamation marks, or question marks and periods. It also checks the text for names of previous school shooters, famous murderers, wanted terrorists and extremist ideas e.g., Nazism, fascism etc.

8. **Suicide and Hatred Detection sub module (S):** This sub module scans the text to find out the possibility of suicidal attacks by looking for proofs if the perpetrator has tried to commit suicide in the past or intends to commit suicide in the future. The sub module looks for expressions of self hatred, self contempt, psychiatric problems, withdrawal from prescribed drugs, recent human loss, serious economic problems, depression related problems or unrequited love.

**Assessment of Threats in the Sub modules**

The 8 sub modules, mentioned in the previous section, evaluate the text at their own level and return a score (from the possible ranges as shown in Table 1), which is used for the overall assessment of the text. The overall assessment is done in the main module. Each sub module returns a score in the range 0 to 3, corresponding to the four categories of threats “Not a threat”, “Low”, “Medium”, and “High”. The main module uses a weighted score for deciding the final category of the input text.

The scores from the Place Detection sub module, the Time Detection sub module, the Weapons sub module and the rehearsal sub module are considered to have more impact on the final assessment of the threat and are, therefore, weighted with twice the weight of any other sub module. In table 1, the weights of the place, time, weapons and rehearsal sub modules are multiplied with 10 and the score of the rest of the sub modules with 5. There is no special importance of 10 and 5. The place, time, weapons and rehearsal sub modules could be multiplied with 2 and the score of the rest of the sub modules could be multiplied with 1. Our choice of multiplying them with 10 and 5 was to make the score distinct from the scoring system that each sub module uses internally. Each sub module uses a scoring system and the final step of each sub module uses the criteria’s to assign a category to the text considered for categorization. The criteria in each sub module uses small numbers (mostly in the range of 0 to 10), therefore, larger numbers were used in the main module. To make the numbers returned by the sub modules larger, the score is multiplied by larger numbers i.e., 10 and 5 instead of 2 and 1. Multiplying the scores of the sub modules with 2 and 1 or any multiple of 2 and 1 that maintains the same ratio does not matter and does not affect the algorithm. The weights have been assigned on the basis of importance of the place, time and weapons in the determination of plausibility, degree of detail present, degree of imminence, and degree of practicality of a threat in a piece of text. Guidelines have been taken from the examples of different threats and discussion regarding the practical scanning of text by human users to find the degree of seriousness of a threat in the FBI’s study as reported by O’Toole et al. (O’Toole, 1999).

The notation used in this chapter to represent the score given by each sub module is given below.

- \( S_T \) = Score allotted by the Time Detection sub module
- \( S_P \) = Score allotted by the Place sub module
- \( S_W \) = Score allotted by the Weapons Detection sub module
- \( S_R \) = Score allotted by the Rehearsal Detection sub module
- \( S_{Tar} \) = Score allotted by the Target Detection sub module
- \( S_M \) = Score allotted by the Motive Detection sub module
- \( S_L \) = Score allotted by the Linguistic Marker sub module
- \( S_S \) = Score allotted by the Suicide Intention Detection sub module
An Algorithm for Classification of Threats

The algorithm works in four different steps.
1. The written text is passed to each of the 8 sub modules.
2. The total score is calculated by adding the weighted score of all the sub modules as shown in column 3 of table 1.
   \[
   \text{Total} = 10(S_T) + 10(S_P) + 10(S_W) + 10(S_R) + 5(S_{Tar}) + 5(S_M) + 5(S_L) + 5(S_S)
   \]
3. The total of P, T, and W modules is calculated by adding the weighted scores of these three sub modules. The sum is denoted as PTW.
   \[
   PTW = 10(S_T) + 10(S_P) + 10(S_W)
   \]
4. The final category of the threat is decided according to the rules given below.
   - If PTW is greater than or equal to 70 (PTW \(\geq\) 70), then mark the text as “High”.
   - If PTW is less than 70 (PTW < 70) then the final category cannot be high. In this case the final category is decided on the basis of the total score. If the total score is greater than 80 (Total > 80) then mark the threat as “Medium”.
   - If the total score is equal to or less than 80 and the total score is greater than 35 (Total \(\leq\) 80 && Total > 35) the category for the threat is set to “Low”.
   - If the total score is less than or equal to 35 (Total \(\leq\) 35) then the threat is categorized as “Not a threat”.

The weightage of S_R is also 10 but it is not included in the calculation of PTW since it is not a practice to mention rehearsal or practicing an attack while delivering a threat or leaking a plan. Similarly, S_Tar is excluded in calculating the PTW since the target is often understood in most of the threats. Since the algorithm deals with assessing threats of school shootings the target is already clear and, therefore, S_Tar does not play a vital role to be included in PTW.

Figure 1 shows the motives and contributing factors to school shooting in the 159 cases of school shootings (from 1st August, 1966 to 30th January, 2013) that were analyzed in this study. The scatter of the plot in this figure indicates that there is no clear cut motive and even the two topmost motives or contributing factor together sum up to less than 31% of the total cases. Moreover, a perpetrator might have the strongest possible motive to carry out an attack but if (s)he doesn’t have access to a weapon or has a weapon but has not made a plan by deciding appropriate time and a suitable place for the attack, the perpetrator cannot carry out an attack. A threat that mentions a motive but does not depict a weapon, place or time is actually not a threat but complain made to some friend, teacher parent or any other member of the society.

The practicality of a threat delivered is measured by the capability of the perpetrator to carry out the threat and this capability is measured by the detail of the plan that the perpetrator has made. A more detailed plan increases the likelihood that the perpetrator has taken practical steps to carry out an attack. Previous cases of school shootings prove that the steps taken by the perpetrators include getting weapons, deciding suitable time for the attack, making sketches, and visiting the area that they had in mind to decide the best possible place inside the school premises in order to increase the damage. These are the reasons for giving more impact (by adding weights) to the sub modules Place, Time and Weapons. The report from FBI (O'Toole, 1999) also highlighted the importance of these factors when assessing a threat of school shooting based on studying previous school shootings. Reddy et al. also mention these three fac-
tors in the example of a serious threat in their study (Reddy, Borum, Berglund, Vossekuil, Fein, & Modzeleski, 2001).

Figure 1. Motives and contributing factors in school shootings based on the analysis of previous school shootings.

The threshold of 70 for the high level threat category ensures that not only two of the three important submodules (S_T, S_P and S_W) mark it as a high level category but also that the threat has got some score from at least one of the other sub modules. O'Toole et al. gives examples of threats belonging to the high, medium and low categories based on the research carried out by FBI (O'Toole, 1999) and they are also of the opinion that place, time and weapons are the most important factors when evaluating the practicality, plausibility of a threat during the threat assessment process. They argue that if a threat mentions place, time and weapon then the situation is extremely serious and immediate remedial actions are needed to prevent the damage. The total score of the threat classification is an indicator of the details given in a piece of text. More details signify that the perpetrators have taken more practical steps and they have planned in detail giving attention to details. The higher the total score of a threat gets, the more proof of details in the text suggesting a higher degree of plausibility and practicality of the threat.

The Weapons Sub module

The weapons sub module start the process of detection of the threat after it finds a weapon in the text. The text is scanned and all weapons that this sub module has in its knowledge base are identified. If no weapon is mentioned in the text, the sub module marks the text as “Not a threat”. In case a weapon is mentioned in the text, the weapon sub module continues and does the following:

- Check if the perpetrator possesses a personal weapon. If so, a score of 9 on a range of 0 to 10 is given. The sub module checks the possession of weapons using syntactical rules for expressing possession in the English language. The syntactical structure is defined in the rules of the module and the vocabulary comes from the knowledge base of the sub module.
- If the perpetrator does not have a personal gun, check if the perpetrator has access to relatives’ guns. If true, give a score of 7.
- If all the cases mentioned above are false then check for intention to buy weapons in the text. If an intention to buy a weapon is found in the text, then check the following.
  I  Check if the perpetrator has money to buy weapons, award a score of 5.
  II  If the perpetrator has no money, award a score of 2.
  III  If money is not mentioned in the text, award score 3.
- Scan the text to find out if the perpetrator intends to borrow a weapon. If an intention to borrow a weapon is found in the text, then check the following.
I If the text also mentions a friend of the perpetrator having a gun then award score 4.
II If nothing is depicted about a friend having any gun, award score 3.
• Check the text if the perpetrator has any intention to steal a weapon. If an intention to steal a weapon is found then award the score 6.
• Calculate S_W from the steps above.
   I If S_W is greater than or equal to 9 (S_W >= 9); mark the category as “High” and assign 3 to S_W.
   II If S_W is less than 9 but greater than or equal to 6 (S_W < 9 && S_W >= 6); mark the category as “Medium” and assign 2 to S_W.
   III If S_W is less than 6 but greater than 0 (S_W < 6 && S_W > 0) then mark the category as “Low” and assign 1 to S_W.
IV If S_W is equal to zero (S_W = 0) then mark the category as Not a threat and assign 0 to S_W.
• Report the category in terms of 0, 1, 2 or 3 to the main module.

Figure 2 explains why possessing personal guns carries the highest score and buying weapons carries the lowest score. The figure shows that in the previous cases of school shootings that were analyzed in this study, most of the perpetrators owned weapon. The next highest group of perpetrators was the group that had access to family weapon(s).

Details of Weapons used in School Shootings

Figure 2. Details of how the perpetrators got the weapons

The Place Sub module

The place sub module keeps count of the score by adding scores of different factors mentioned below. We use a variable R_T_P (Running Total of Place sub module) to keep the cumulative score throughout this sub module. The algorithm is given below.
1. R_T_P = 0
2. Checks for places in the text and crosscheck if the place(s) exist in the knowledge base of the Place sub module. If the text does not contain any place or the place mentioned in the text does not match with the places in the knowledge base, mark the text as No Threat and go to step 10.
3. Check for school related words (e.g., classrooms, students, teachers, lab etc.) in the text of the threat.
   I R_T_P = R_T_P + 2, if more than three words are found.
   II R_T_P = R_T_P + 1, if less than 3 but greater than 0 words were found.
4. Check if the perpetrator mentions moving from one place to another place inside the school giving some kind of detail how (s)he would proceed during the attack. Movement from place to place can be detected using the preposition of places in combination and close proximity to different places inside the school premises. If no such movement is found, go to step 5. If such movement is found then check for weapons in the text.
I. If a weapon(s) is/are found then, \(R_{T_P} = R_{T_P} + 9\)
II. If a weapon(s) is/are not found in the text then, \(R_{T_P} = R_{T_P} + 6\)

5. Check for school related places in the text of the threat. School related places are those places that are associated with an educational institution e.g., classroom. If no school related place is found, go to step 6. If found then check for weapons in the text of the threat.
   I. If weapon is found too then, \(R_{T_P} = R_{T_P} + 9\)
   II. If weapon is not found in the text then, \(R_{T_P} = R_{T_P} + 6\)

6. Check for movement from place to place containing places that indicate a place but those places could be found both inside the school building as well as outside the school premises. The idea of keeping these places separate is to give them a lower score as these places might be there in the text but the attack might not belong to the category of school shooting. Some examples of such places are staircase, pool, roof etc. If no movement from to place is found go to step 7. If found then check for weapons in the text of the threat.
   I. If weapon is found too then, \(R_{T_P} = R_{T_P} + 9\)
   II. If weapon is not found in the text then, \(R_{T_P} = R_{T_P} + 6\)

7. Check for statements containing places that indicate a place but those places could be found both inside the school building as well as in the society outside the school premises. If no such place is found, go to step 7. If found then check for weapons in the text of the threat.
   III. If weapon is found too then, \(R_{T_P} = R_{T_P} + 9\)
   I. If weapon is not found in the text then, \(R_{T_P} = R_{T_P} + 6\)

8. Check for statements that have no explicit places in them but show that the perpetrator has a place in mind. Some examples of such knowledge is "I have followed them", "I know where to place the", "I know where all of them", "I know where some of them" etc. If no knowledge of places is found in the text, go to step 9. If found then check for weapons in the text of the threat.
   I. If weapon is found too then, \(R_{T_P} = R_{T_P} + 9\)
   II. If weapon is not found in the text then, \(R_{T_P} = R_{T_P} + 3\)

9. Check the text if the perpetrator mentions making some sketches or talking about maps. If no such knowledge is shown go to step 10. If found then check for weapons in the text of the threat.
   I. If a weapon(s) is/are found too then, \(R_{T_P} = R_{T_P} + 5\)
   II. If a weapon(s) is/are not found in the text then, \(R_{T_P} = R_{T_P} + 3\)

10. Decide the final category as shown below.
   I. If the \(R_{T_P} \geq 9\) then \(S_P = 3\) and award category “High”.
   II. If \(R_{T_P} < 9 \& \& R_{T_P} \geq 6\) then \(S_P = 2\) and award category “Medium”.
   III. If \(R_{T_P} < 6 \& \& R_{T_P} > 0\) then \(S_P = 1\) and award category “Low”.
   IV. If \(R_{T_P}\) is equal to zero, then \(S_P = 0\) and award category “Not a threat”.

11. Report the category in terms of 0, 1, 2 or 3 to the main module.

The Time Sub module

The Time sub module keeps count of the score by adding scores of different factors. We use a variable \(R_{T_T}\) (Running Total of Time sub module) to keep the cumulative score throughout this sub module. The algorithm is given below.
1. \(R_{T_T} = 0\)
2. Check for exact time in the threat both in civilian format and military format. \(R_{T_T} = R_{T_T} + 9\), if exact time is found otherwise \(R_{T_T} = R_{T_T} + 0\).
3. If the time is not exact clock time but is close to exact e.g., “after an hour”, “today”, “tomorrow” etc. Then \(R_{T_T} = R_{T_T} + 9\) otherwise \(R_{T_T} = R_{T_T} + 0\). This means that if the threat contains “tomorrow at 1300 hours” then \(R_{T_T}\) will get 9 from step 2 and another 9 from step 3.
4. Check for expressions of time in terms of after or before some event e.g., “after lunch” or “before the lunch”. Also check for cardinal numbers in combination with some event e.g., “after the first lesson” or “before the third class”. Similarly expressions representing part of the day e.g., “in the morning” or “in the afternoon” and time mentioned in terms of lessons e.g., “after the Chemistry lesson” or “during the Geography class” etc. come under this subheading. If any of them is found \(R_{T_T} = R_{T_T} + 8\), otherwise \(R_{T_T} = R_{T_T} + 0\).
5. Check if the perpetrator has decided some exact future date or future day e.g., “next Monday” etc. If found \(R_{T_T} = R_{T_T} + 7\), otherwise \(R_{T_T} = R_{T_T} + 0\).
6. Check the text for week e.g., “next week” or “in the first week of January” etc. If found then \( R_{T\_T} = R_{T\_T} + 3 \).
7. Check the text for month e.g., “In January” etc. If found \( R_{T\_T} = R_{T\_T} + 2 \), otherwise \( R_{T\_T} = R_{T\_T} + 0 \).
8. If only a year is given in the text then check that it is not a year in the past and that the year is not 5 years more than the present year. If found then \( R_{T\_T} = R_{T\_T} + 1 \), otherwise \( R_{T\_T} = R_{T\_T} + 0 \).
9. Decide the final category as shown below.
   I  If the \( R_{T\_T} \geq 10 \) then \( S_T = 3 \) and award category “High”.
   II If \( R_{T\_T} < 10 \) \&\& \( R_{T\_T} \geq 6 \) then \( S_T = 2 \) and award category “Medium”.
   III If \( R_{T\_T} < 6 \) \&\& \( R_{T\_T} > 0 \) then \( S_T = 1 \).
   IV If \( R_{T\_T} \) is equal to zero, then \( S_T = 0 \) and award category “Not a threat”.
10. Report the category in terms of 0, 1, 2 or 3 to the main module.

The Rehearsal Sub module

The Rehearsal sub module keeps count of the score by adding scores of different factors already mentioned in the section Function of Sub modules. We use a variable \( R_{T\_R} \) (Running Total of Rehearsal sub module) to keep the cumulative score throughout this sub module. The algorithm is given below.
1. \( R_{T\_R} = 0 \)
2. Check if the threat mentions doing some rehearsal for a planned attack carried out recently or some training or practice of assembling, disassembling, and usage of some weapon. Check for most of the popular names of boys and girls and subjective pronouns in combination with information practicing some weapon or doing some rehearsal at the moment for the purpose of planning an attack. Also check for completed practice or training in the past. If any proof is found in the text, then \( R_{T\_R} = R_{T\_R} + 8 \), otherwise \( R_{T\_R} = R_{T\_R} + 0 \).
3. Check if the perpetrator has tortured any human beings or animals in the past and has mentioned enjoying it or depicting the situation with pleasure. If found \( R_{T\_R} = R_{T\_R} + 9 \) otherwise \( R_{T\_R} = R_{T\_R} + 0 \).
4. This means that if the threat contains “tomorrow at 1300 hours” then \( R_{T\_T} \) will get 9 from step 2 and another 9 from step 3.
5. Check for negative cases in the text where the perpetrator wants practice some weapon but due to some reason (s)he could not do practice or training. In negative case make the \( R_{T\_R} \) equal to zero. \( R_{T\_R} = 0 \), otherwise go to step 6.
6. Decide the final category as shown below.
   I  If the \( R_{T\_R} \geq 9 \) then \( S_R = 3 \) and award category “High”.
   II If \( R_{T\_R} < 9 \) \&\& \( R_{T\_R} \geq 6 \) then \( S_R = 2 \) and award category “Medium”.
   III If \( R_{T\_R} < 6 \) \&\& \( R_{T\_R} > 0 \) then \( S_R = 1 \).
   IV If \( R_{T\_R} \) is equal to zero, then \( S_R = 0 \) and award category “Not a threat”.
7. Report the category in terms of 0, 1, 2 or 3 to the main module whichever is applicable.

The Motive Sub module

The Motive sub module keeps count of the score by adding scores of different factors. We use a variable \( R_{T\_M} \) (Running Total of Motive sub module) to keep the cumulative score throughout this sub module. The algorithm is given below.
1. \( R_{T\_M} = 0 \)
2. Check if the perpetrator mentions being bullied extremely, harassed, teased etc. If found \( R_{T\_M} = R_{T\_M} + 9 \), otherwise go to step 3.
3. Check the text for hatred of humanity, society, customs, economic or political system, or the whole world. Check for contempt of any particular class or group in the social structure of the school as well as the society. If found \( R_{T\_M} = 9 \), otherwise go to step 4.
4. Check if the perpetrator mentions taking revenge from some group or society or any one. If found then \( R_{T\_M} = R_{T\_M} + 7 \), otherwise go to step 5.
5. Check the text if the perpetrator is having severe depression or anxiety and/or is using some prescribed medicine for depression or some serious mental condition. Check specially for “withdrawal” from prescribed medications. If found R_T_M = 7, otherwise go to step 6.

6. Check the text if the perpetrator has some serious failures or setbacks in life due to some rejections in employment interviews or any other failures. If found then R_T_M = R_T_M + 6, else go to step 7.

7. Check if the threat mentions loss of a parent, a close friend; break up with a girl friend or death of some close relative. If found then R_T_M = R_T_M + 5, otherwise go to step 8.

8. Check if the perpetrator is an extremist and/or likes extremism in any form. Check if the perpetrator wants to become a martyr or praises some kind of “martyrs” or likes fascism, Stalinism or Nazism. If found then R_T_M = R_T_M + 4, otherwise go to step 9.

9. Check the text if the perpetrator is talking about bringing some kind of change using his plan. For example, if (s)he plans to change the judicial system or economic system or changing the government etc. The perpetrator might be trying to change the school system using weapons but might be “leaking” using terminology as changing the whole system etc. Also check if the perpetrator is involved in some kind of Satanism or any other violent fantasies. If found then R_T_M = R_T_M + 4, otherwise go to step 10.

10. Decide the final category as shown below.
   I  If the R_T_M >= 18 then S_M = 3 and award category “High”.
   II If R_T_M < 18 && R_T_M > 9 then S_M = 2 and award category “Medium”.
   III If R_T_M <= 9 && R_T_M > 0 then S_M = 1 and award category “Low”.
   IV If R_T_M is equal to zero, then S_M = 0 and award category “Not a threat”.

11. Report the category in terms of 0, 1, 2 or 3 to the main module.

The Target Sub module

The Target sub module keeps count of the score by adding scores of different factors that helps in finding out the seriousness of the threat in terms of target group or persons. We use a variable R_T_Tar (Running Total of Target sub module) to keep the cumulative score throughout this sub module. The algorithm is given below.

1. R_T_Tar = 0
2. Check if the perpetrator is following the target, observing their routine or activities to ultimately chalk out a plan to attack them. If such knowledge is found alongside with revenge as a motive then R_T_Tar = R_T_Tar + 10, otherwise go to step 3.
3. Check if the perpetrator has mentioned the target directly with Revenge as a motive along with the target. If found then R_T_Tar = 9, otherwise go to step 4.
4. Check for step number 2 without mentioning Revenge as a motive. If found then R_T_Tar = R_T_Tar + 9, otherwise go to step 5.
5. Check for step number 3 without the motive of revenge. If found R_T_Tar = R_T_Tar + 8, otherwise go to step 6.
6. Check for step number 3 but with a smaller group of people or a few persons as a target only. If found then R_T_Tar = R_T_Tar + 4, else go to step 7.
7. Check for step number 4 with a smaller group of people or a few persons as a target only. If found then R_T_Tar = R_T_Tar + 4, otherwise go to step 8.
8. Check for number 5 but with a smaller group of people or a few persons as a target only. If found then R_T_Tar = R_T_Tar + 3, otherwise go to step 9.
9. Decide the final category as shown below.
   I  If the R_T_Tar >= 9 then S_Tar = 3 and award category “High”.
   II If R_T_Tar < 9 && R_T_Tar >= 6 then S_Tar = 2 and award category “Medium”.
   III If R_T_Tar < 6 && R_T_Tar > 0 then S_Tar = 1 and award category “Low”.
   IV If R_T_Tar is equal to zero, then S_Tar = 0 and award category “Not a threat”.
10. Report the category in terms of 0, 1, 2 or 3 to the main module.
The Linguistic Markers Sub module

The Linguistic Markers sub module keeps count of the score by adding scores of different factors mentioned earlier in this report. We use a variable R_T_L (Running Total of Linguistic Markers sub module) to keep the cumulative score throughout this sub module. The algorithm is given below.

1. \( R_{T\_L} = 0 \)
2. Check the text for opposing groups e.g. in terms of “me” and “them” or “us” and the “jocks” etc. If found \( R_{T\_L} = R_{T\_L} + 3 \), otherwise go to step 3.
3. Check the text for anger, negative emotional excitation or disturbed state of mind by checking the number of ..., or ?? or !!!!! or broken sentences and repetition of words and phrases etc. If found \( R_{T\_L} = R_{T\_L} + 2 \), otherwise go to step 4.
4. Check for violent words in the text. Add one to \( R_{T\_L} \) for each violent word in the text and do not ignore repetitions. If no violent word is found then go to step 5.
5. Check for slangs and improper language including “dirty words” in the text. Add one to \( R_{T\_L} \) for each violent word in the text and do not ignore repetitions. Let’s denote the number of such terms by count_slangs.
6. Now calculate the total number of words in the text and lets denote it with total_words.
7. Decide the final category as shown below.
   - I If the \( R_{T\_L} \geq 5 \) and \( \text{total\_words} \geq 6 \) then \( S_{L} = 3 \) and award category “High”.
   - II If \( R_{T\_L} \geq 5 \) but \( \text{total\_words} < 6 \) then \( S_{L} = 2 \) and award category “Medium”. Similarly, if \( R_{T\_L} < 5 \) but greater than or equal to 2 and \( \text{total\_words} \) is greater than or equal to 4, then \( S_{L} = 10 \ (2 \times 5) \) and award category “Medium”.
   - III If \( R_{T\_L} < 5 \) but greater than or equal to 2 and \( \text{total\_words} \) is less than 4, then \( S_{L} = 5 \ (1 \times 5) \) and award category “Low”.
   - IV If \( R_{T\_L} < 2 \) but greater than zero, then \( S_{L} = 1 \) and award category “Low”.
   - V If \( R_{T\_L} \) is equal to zero, then \( S_{L} = 0 \) and award category “Not a threat”.
8. Report the category in terms of 0, 1, 2 or 3 to the main module.

The Suicide and Hatred Detection Sub module

The Suicide sub module keeps count of the score by adding scores of different factors that contribute to suicidal thoughts, intentions or factors that probe the perpetrator has either attempted to commit suicide or intends to commit suicide. This sub module helps in detecting the possibility of suicidal attack, self hatred, hatred of society, hatred of world and hatred of humanity. We use a variable R_T_S (Running Total of Suicide sub module) to keep the cumulative score throughout this sub module. The algorithm is given below.

1. \( R_{T\_S} = 0 \)
2. Check if the perpetrator mentions that (s)he has previously attempted to commit suicide. If found \( R_{T\_S} = R_{T\_S} + 10 \), and jump to step 5.
3. Check the text for intentions of suicide. If found \( R_{T\_S} = R_{T\_S} + 9 \), and jump to step 5.
4. If the text indicates self-hatred and contempt for self or the perpetrator looks down upon himself, then \( R_{T\_S} = R_{T\_S} + 8 \), and jump to step 5.
5. If the text depicts breaking up or equalling previous records of school shooting then \( R_{T\_S} = R_{T\_S} + 6 \), and jump to step 8.
6. If the text depicts breaking up or equalling previous records of famous murderers then \( R_{T\_S} = R_{T\_S} + 6 \), and jump to step 8.
7. If the text depicts breaking up or equalling previous records of famous terrorist then \( R_{T\_S} = R_{T\_S} + 6 \), and jump to step 8.
8. If the text proves that the perpetrator hates the society or the world then \( R_{T\_S} = R_{T\_S} + 6 \).
9. If the perpetrator is using or has done “withdrawal” from prescribed psychiatric medicine then \( R_{T\_S} = R_{T\_S} + 6 \).
10. If the perpetrator is praising ex-school shooters and is idealizing them in some way then \( R_{T\_S} = R_{T\_S} + 6 \).
11. If the perpetrator has lost a close relative, parent, friend or have had breakup with girl/boy friend then \( R_{T\_S} = R_{T\_S} + 2 \).
12. If the perpetrator is in debt, is unemployed and is homeless or has severe economic problems then $R_{T_S} = R_{T_S} + 4$.

13. Count the words related to depression, and anxiety and if the number of such words is greater than zero, then $R_{T_S} = R_{T_S} + 1$.

14. Check for school related words e.g., teachers, students, etc in combination with hatred and its synonyms. I found then $R_{T_S} = R_{T_S} + 4$.

15. Decide the final category as shown below.
   
   I. If $R_{T_S} \geq 10$ then $S_S = 3$ and award category “High”.
   
   II. If $R_{T_S} < 10$ && $R_{T_S} \geq 6$ then $S_S = 2$ and award category “Medium”.
   
   III. If $R_{T_S} < 6$ && $R_{T_S} > 0$ then $S_S = 1$.
   
   IV. If $R_{T_S}$ is equal to zero, then $S_S = 0$ and award category “Not a threat”.

16. Report the category in terms of 0, 1, 2 or 3 to the main module.
Implementation

We have implemented a prototype in Java that can detect a threat and classify the threat as a high level, medium level or low level threat. The source code of the prototype is available on https://bitbucket.org/ajmalkhan/schoolshootingthreatclassifier/src and can be accessed when invited by the author of the application. The source code of the Graphical User Interface version of the tool is also available on https://ajmalkhan@bitbucket.org/ajmalkhan/sstc.git. Screenshots of the graphical user interface are shown in figure 3 and 4.

The implementation of the algorithm proposed in this study is independent of the implementation details. In this project, we implemented the algorithm in Java to test that the idea works. We used decision structures (switch, if-else) inside repetitive structures (while, do-while, for) to dynamically generate phrases using the vocabulary stored in arrays for faster access and efficient execution. Many arrays were accessed often in the same iteration of the loop to get different parts of speech (nouns, their synonyms, prepositions of place, time, helping verbs, verbs etc.) for the phrases generated. This ensures the extensibility as the knowledge base supplying the vocabulary allows addition or deletion of words and their synonyms through the provided interface in the GUI version. This makes the number of phrases checked by a particular method in any sub module extensible. The best implementation of the algorithm would be one that supports parallel processing of the eight sub modules to reduce the response time. To see the details of our implementation please see the source code on the links mentioned above.

![Figure 3. Screen for evaluating a threat by typing one threat at a time](image)

The screenshot in Figure 3 shows the tabbed page that enables the user to type a threat manually in the text box and let the tool evaluate the text. The prototype will automatically classify the typed threat into one of the four categories and gives the final category in front of the label results. To see the details of the process of evaluation, the user can click the button “Show Details”.

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The screenshot in Figure 4 shows the tabbed page that enables the user to give more than one threat as input from a Google on line Excel Sheet. This option is for processing a batch of threats. The prototype will automatically send the results through email to the user when it has finished the process of evaluation of the text.

The fourth tab from the left side allows uploading a file from the computer to evaluate its text and classify it. The last tab is an admin panel that the administrator of the tool can use to update the knowledge base of the software after authenticating by entering the correct password. The knowledge base can be updated by adding more words and their synonyms or deleting the existing words. This ensures that the phrases generated at run time are not fixed and the application gets the ability to generate new phrases by adding new parts of speech (nouns, verbs, prepositions etc) only to the data structures in the sub modules.
In order to evaluate the prototype, as a first step, an online Google Form was created to collect school shooting threats written by real users and the form was made public. The link of the form was posted at many public forums, websites, social networking services (such as Facebook, Twitter), and mailing lists (including the Yahoo mailing list of Information Technology Department of Uppsala University). Some threats were also collected from relevant literature and case studies about school shootings. A total of 150 “unseen pieces of text” were used for the evaluation of the prototype. In the second step, the guidelines given in the O’Toole et al. (1999) were used to assign each piece of unseen text manually to one of the four categories/classes.

In the third step, a temporary java file was written that worked as a main method of the prototype so that the prototype could automatically make an output file in the CSV (Comma Separated Values) format taking input from two separate on line Google Excel Sheets. Column B of the first sheet was used to input the unseen text to the prototype. The prototype evaluated the text and sent both the text and its class to the text file in the CSV format. The second on line Google Excel Sheet supplied the manually assigned class/category to the same unseen text which was printed as a third column in the same CSV file in the same iteration of the loop. After 150 runs of the loop, the text file had 150 lines of output that were comma separated and ready to be opened in Microsoft Excel or Google Excel on line.

In the fourth step, the file was uploaded to on line Google Documents with the conversion option and the data was analyzed in the on line Google Excel Sheet available at (Evaluation of the Prototype, 2013). Table 2 shows the confusion matrix. A list of the school shooting threats along with their categories automatically assigned by the prototype can be accessed on line (Threats and Categories Automatically Assigned by the Prototype, 2013). Details of the manually assigned categories can be accessed on line too (Evaluation of the Prototype, 2013). Figure 6 gives class-wise visual comparison of the automatic classification done by the prototype with the classification done by a human being.

Table 2. Confusion Matrix Showing the Performance of the Prototype

<table>
<thead>
<tr>
<th>Classes Assigned by the Prototype</th>
<th>NOT A THREAT</th>
<th>LOW</th>
<th>MEDIUM</th>
<th>HIGH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classes Assigned Manually</td>
<td>NOT A THREAT</td>
<td>65</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Assigned</td>
<td>LOW</td>
<td>11</td>
<td>16</td>
<td>2</td>
</tr>
<tr>
<td>Manually</td>
<td>MEDIUM</td>
<td>7</td>
<td>19</td>
<td>9</td>
</tr>
<tr>
<td>HIGH</td>
<td>1</td>
<td>7</td>
<td>1</td>
<td>8</td>
</tr>
</tbody>
</table>

From figure 5, we can see that the prototype has placed 65.3 % of the unseen snippets of text in the correct class indicating a performance above 65 %. This is a high performance keeping in view the small knowledge base that the rules of classification of the prototype rely upon. Since this is a prototype and due to constraint of the time and human resource arrays were used to store the bits of knowledge needed by the rules of classification. A full version of the tool will use a larger knowledge base stored in a robust and scalable database that can easily support the growth of the knowledge base of the application.
A reason for using the array data structure is to minimize the response time of the application for the purpose of demonstration but another data structure can be used in future versions of the tool since being a data mining tool performance will be more important compared to the speed while considering the speed vs. performance trade off. This does not mean that a future version of the software cannot be made faster with a larger knowledge base. The eight sub modules of the tool have been written independent of each other and, therefore, can be easily run on 8 different machines in parallel making the tool 8 times faster in that case but that would definitely involve the trade off of cost vs. speed.

Some inaccurate categorization is unavoidable and is not due to the small size of the current knowledge base but due to the classification rules. We cannot, probably, tweak the internal classification rules to give a higher performance keeping in view the variety of expression a human being can use to deliver threats and express oneself. Language being a live organism changes from place to place and time to time and its roots are in the culture, communal groups, as well as a host of other sociological, economical, and cultural factors. There is also a risk of over fitting. The chances of over fitting will increase if the internal classification rules of the model are tweaked for different kinds of inputs resulting in poor prediction of unseen texts. For example, if we see a threat on some website which states “I buy a gun and kill them tomorrow in the classroom”. The weapons sub module of the prototype will not mark it as a serious threat as it is not just the word that stands for some weapon but the practical steps that the perpetrator has already taken to make the threat real. The text does not prove that the perpetrator owns a gun, has access to a family gun, has money to buy a gun, or has a plan to steal a gun. If a human beings consider...
the present indefinite tense used in the text of this threat as a grammar mistake on the part of the perpetrator and decides to include all such cases in the weapons sub module that uses “buy a gun” then the weapons sub module will not be able to see the plausibility of the steps taken by the perpetrator in the text of the threat and will not be able to categorize it in to different level of seriousness.

Figure 7. Class Distance of inaccurately categorized threats by the prototype

Figure 7 shows the class distance of inaccurately categorized pieces of unseen text. Class distance is a measure of the degree of inaccurate classification of a piece of text done by the prototype when compared to the class assigned by a human being to the same piece of text. Class distance was calculated by transforming the four categories High, Medium, Low and Not a threat to numbers 3, 2, 1, 0 in the on line Google Excel Sheet and then the class distance was calculated by finding the difference threat-wise. For example, if an unseen text piece A was placed by the human in category 3 (High Level Threat) but the prototype placed it in category 0 (Not a threat) then the class distance in case of unseen text A is 3 – 0 = 3. Figure 7 shows that the curve is coming down sharply to touch the horizontal axis which shows increasing class distance from left to right. There are more cases of class distance of 1 which shows that the performance of the prototype is quite impressive and promising. The prototype placed 65.33 % text snippets in the same class in which the human being placed it. In 24.67 % of the cases, the prototype placed the text snippets in the neighboring category. The prototype made a mistake in 10 % of the cases by keeping them at a distance of two classes. The most serious mistake was done by the prototype in 0.67 % of the cases where the class distance was 3.
Conclusions and Future Work

In this study we have discussed the school shooting problem, its background, and factors that might affect school shootings. We have discussed the existing threat assessment approaches and proposed an algorithm that automatically detects threats in written text and classifies the written text into four categories: high, medium low, and not a threat. The algorithm has been implemented in a prototype in Java. The algorithm was evaluated by testing it on 150 threats collected from various sources. The accuracy was above 65% in terms of class distance.

A natural extension of this project is to expand the ontology used after getting feedback from the actual use of the prototype. The size of the ontology needs to be increased and better data structures needs to be used that can make the extension easier and the maintenance of the ontology simpler.

Another future direction is to develop ontologies for detection and automatic classification of other kinds of threats given by terrorists.
References


https://docs.google.com/spreadsheet/ccc?key=0Ao_0RMqWCUXvdEhCb3ZySW00YUZsTUZsc2l4R0djaEE&usp=sharing


