



Conceptual terrorist attacks classification : pre-processing for artificial intelligence-based classification.

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Abstract

The objective on this paper is to propose a conceptual classification for terrorist attacks that presents a pre-processing for Artificial Intelligence classification model based on two layers. The AI classification intends, firstly, to predict the parameters' values from the Global Terrorism Database by a semi-supervised learning with multi-layer perceptron, and, secondly, to treat uncertainties on the predicted parameters using a fuzzy set system. Our proposed conceptual classification is based on three criteria characterizing the terrorism violence, which are (1) threat, (2) vulnerability, and (3) consequences. Hence, to be able to determine the class of a given attack, we should quantify each criterion. To do so, we study, in this paper, the range of possible values of the various influencing parameters. Therefore, every criterion could be assigned to the three qualitative values: (a) High, (b) Medium, and (c) Low.

Keywords: Terrorist attacks; Classification; Defense; Homeland security

1. Introduction

The security issues such as terrorist attacks have dropped the feeling of security in many countries and enhanced feelings of insecurity among their populations. More than 8544 terrorist events of various types occurred globally in 2019, according to the Global Terrorism Database (GTD). This huge size of terrorist events caused panic in the world due to the geopolitics, economic and humanitarian impacts.

In order to find solutions for the various problems related to terrorist threats, significant efforts have been made (Hu et al., 2019; Kebir et al., 2019; Kebir et al.,

2020). However, forecasting the occurrence of an event remains a difficult task since it is characterised with a high degree of complexity, uncertainty, and imprecision.

Governments begun devoting serious attention to national security affairs. Besides, many intelligence agencies and analysts emphasized counter-terrorism. Experts are trying to find the hidden clues behind the terrorist attacks and hope to get a clear overview of terrorists' behaviours in order to enhance the defense against these organized acts. The initial step in the experts' analysis process is to identify terrorist acts



and classify them according to their criteria. Furthermore, the refinement of the course of action for counter-terrorism missions requires a progressive assessment of terrorist attacks. The precision of the evaluation criteria and the dynamic aspect of the classification are necessary throughout the evaluation. Qualitative criteria could be more meaningful and give experts a better view of the circumstances of the terrorist act. Nevertheless, the difficulty of interpreting these criteria because of their subjectivity poses a real problem for their integration in prediction models. A large number of parameters can be more descriptive but it can be complex like the case of the GTD. Analyzing terrorism data and retrieving relevant results require a simplified metrics of classification. The metric assessment of a classification is highly recommended in artificial intelligence prediction model since it gives an idea on its reliability.

For these reasons, we choose, at the beginning, the three components of terrorism risk presented by Willis et al. (2006). Authors conceptualize their definition of the terrorist risk by analysing the intersections of three entities: the threat to a target, the target's vulnerability to the threat, and the consequences of a successful attack on the target. When individuals and organizations have both the intent and the potential to do harm to a target, they are considered threats. Threats to a target can be scored as the probability that a specific target will be attacked in a specific way during a given time period (Willis et al., 2006). Vulnerability can be assessed as the probability of damage happening, relative to a threat. Damage can be death, injury, property damage, or other consequences; each of them requires a separate vulnerability assessment. Consequences are the extent and type of damage caused by a successful terrorist attack.

In the classification, proposed in this paper, we score these entities by creating some parameters that will be detailed in the third section and combining them with others proposed by Kress and Szechtman (2009a) that is an extension of Lanchester model (Lanchester, 1916). The latter Lanchester (1916) is one of the most used mathematical models for computing the relative strengths of military forces. Based on differential equations, Lanchester describes the temporal dependence of two armies' forces as a function of time.

The rest of this paper is organised as follows. We describe, in the next section, the evolution of the definition of the terrorism in terms of four different waves. We aim, by this historical overview, to highlight the volatility of the definition that creates a huge problem for clustering experts. Within section 3, we focus on analysing different classification methods, from the literature, in order to extract the gaps of each one of them. During section 4, we present our proposal for terrorist attacks' classification. This classification is a pre-processing for artificial intelligence classification

model based on two layers. The first one consists on predicting the classification parameters from GTD criteria by a semi-supervised learning with multi-layer perceptron. The second one treats uncertainty of the predicted parameters using a fuzzy set system. The section 5 is dedicated for studying a real case and testing our proposal of classification on Bardo Attack happened in Tunisia in 2015. Finally, we end with a conclusion.

2. Terrorism

When approaching the concept of terrorism, the religious fanaticism of Salafist-jihadist groups is the first thing that jumps to mind. This automatic and anticipated response is due to the close relationship between Islamic extremism and terrorism at the present stage. However, we should highlight that the first linguistic formulation of this concept, as a term, came at about the end of the 18th century (1798) by adding it to the appendix of the French Academy's dictionary (Française, 1841). It refers to the fear and horror that authoritarian regimes spread among their subjects. This was the case in the period of "Maximilien de Robespierre" (Jordan, 1989), when terrorism was used as a tool to eliminate political opponents of the French revolution and to consolidate the foundations of the republic.

To formulate this concept more clearly, we will adopt the definition of the U.S. Department of Defense of terrorism (Ruby, 2002), which is: *"The calculated use of unlawful violence or threat of unlawful violence to inculcate fear; intended to coerce or to intimidate governments or societies in the pursuit of goals that are generally political, religious, or ideological"*. It is clear from the analysis of this definition that religious motivations are only part of the ideological beliefs that fuel terrorism.

In this section, we attempt to analyze the concept of terrorism from different angles, based on the paradigm shift in the motivations of terrorism within the modern era. Terrorist operations have been divided into four waves (Rapoport, 2004), where each wave is dominated by a specific ideological context.

2.1. The first wave

The first structured modern terrorist ideology emerged in the second half of the nineteenth century by the Russian revolutionaries. From the beginning, the uniqueness of this type of unconventional warfare and its distinctive features is clear. Russian revolutionaries fought against the power of the tsar in the period from 1878 to 1881, and then in the early years of the twentieth century. During this conflict, a policy of hit-and-run and sudden targeted attacks in vital and sensitive areas exhaust the enemy (Wickham-Crowley, 1992).

Along with the use of this policy, the revolutionaries attached an element of intimidation to officials and collaborators of the regime. Later, Irish, Mace-

donian, Serbian and Armenian nationalist groups, in their struggle for internal independence or change of their governing regime, adopted the same approach (Rapoport, 2004).

In the early 20th century, anarchist organizations in France, Spain, Italy, and the United States incite their members to assassinate important political figures (Levy, 2004). The rise of national and democratic thought on a global level was a fundamental factor in the spread of these structures. Despite their different references, they represented the beginning of the international terrorism that transcended national borders, a phase that continued until the outbreak of the WWI (World War I).

2.2. The second wave

The anti-colonial, separatist and nationalist movements of the 1950s and 1960s were considered terrorists. The most important movement was the "Front de Libération Nationale" of Algeria. Similarly, the Irish Republican Army (IRA), led by Michael Collins, achieved internal independence for Ireland from Britain (Radil and Castan Pinos, 2019). During this wave, the concept of terrorism, with its negative background, was used to describe irregular parties in international conflicts.

2.3. The third wave

The third wave began in the late 1960s with Left-wing terrorism and continued until the early 1990s. With the collapse of communism and the end of its sponsorship by the Soviet Union, most leftist terrorist groups disappeared. Following the fall of many communist regimes in Eastern Europe, some groups were disbanded, such as the Red Army Party in Germany. In addition, Western European countries launched an effective attack on some leftist terrorist groups (Parker and Sitter, 2016). At its peak, leftist terrorist groups were very active in Western Europe, Latin America and North America. Even today, there are many leftist terrorist groups in the world.

2.4. The fourth wave

Terrorism based on religious fundamentalist ideology is the contemporary and dominant concept in the fourth wave. Despite the occurrence of some prominent fundamentalist attacks in the late 1970s and 1980s, such as the seizure of the U.S. Embassy in the Iranian capital, Tehran, in November 1979, the real beginning of this wave was in the 1990s with the rise of Al Qaeda, and its network of associated groups (Jackson, 2007). In the late 1990s, the current stereotype of terrorism was formed by the dominance of religious fundamentalist terrorist attacks on the world stage in terms of number and intensity of terrorist attacks. Then, the dominance of this terrorist "color" continued with the

rise of Daech, Boko Haram, the Somali youth movement and Al Qaeda in the Islamic Maghreb and Al Qaeda in the Arabian Peninsula on the international scene.

3. Related works

Although the academic literature on categorical classification analysis of terrorist groups is limited, the body of knowledge is thinner when it comes to the classification of terrorist acts. This fact stems from the inhomogeneity, the diversity of attacks and the ambiguous nature of terrorism definitions that change over time within different geopolitical environments (Bruzzzone et al., 2015).

The GTD is a database of terrorist incidents from 1970 onward. It contains over 200,000 terrorist attacks with at least 45 classification variables for each case. It is considered as the most comprehensive unclassified data on terrorist events in the world (Maryland).

The GTD adopts a specified classification method. There are many categories that constitute the GTD instances. Each one of them is defined by different variables. The categories include the GTD ID, incident date, incident location, incident information, attack information, target/victim information, perpetrator information, perpetrator statistics, claims of responsibility, weapon information, casualty information, consequences, kidnapping/hostage taking information, additional information, and source information.

We aim, in this section, to summarize different methods of terrorist attacks' classifications. In fact, they consist generally in a visualization of analytical data representation and machine learning based models using GTD data.

Based on the five W's (who, what, where, when, and why), a visual analytical system was developed by Vilanova et al. (2008). Those parameters are depicting one of the most fundamental concepts in investigative analysis. With this system, an investigator can categorize terrorists efficiently by discovering reasons of attacks and identifying patterns, temporally or geo-spatially, between multiple terrorist groups and crossing different methods or modes of attacks.

Data Rivers Pagán (2010) is another interactive visual analysis tool for the GTD created at the University of Maryland. This tool allows users to analyse temporal trends of terrorism in GTD by choosing important variables from the database and creates a comprehensible visualization. Five different classes are selected: (1) Countries Attacked, (2) Regions Attacked, (3) Target Nationalities, (4) Types of Targets and (5) Types of Weapons.

Hu et al. (2019) offer a terrorist attack risk rating system. They propose eleven factors to evaluate the level of harm of each act and to reduce correlation and dependence between criteria. Some variables obtained from the dependency relationship, in the correlation

matrix of research indicators, have been assigned to some global unrelated factors. The score of each factor was combined with the composite score in order to obtain the top 20 terrorist attacks.

Another study of Atsa'am et al. (2020) has developed a new method for categorizing terrorist groups. This approach uses the number of victims and the extent of the consequences of terrorist activities as criteria.

3.1. Analysis

By analyzing the nature of the groups that have been classified as terrorists over time, we can notice that the concept of terrorism is relative. It depends on the change of the parties that support the action and their brand images presented in international forums. The relationship of the terrorist groups with those in power and their position in decision-making centers play a pivotal role in the possibility of classifying their activities as terrorist. By modifying these factors, the law is reformulated according to the circumstances of the scene, resulting in a modification of the concept of "unlawful violence or threat". We, therefore, conclude that classifications based on a subjective definition of terrorism derived from shifting concepts cannot be useful. We mention that all researches on the classification of terrorist attacks are partially similar due to the paucity of quantifiable classifications criteria. Each of these researches aims to focus on the key factors required for their studies. The corner stone, for those models, is the GTD. They are based on the notions of combination and fragmentation of criteria of the GTD in order to build a customized classification system. The latter is intended to emphasize the aspects to be dealt with according to the different types of terrorist attacks. Even if some classification models meet the accuracy requirements for machine learning simulation, they are generally too complicated to be well accepted. We propose a simplified method of classification that obey to terrorist risk definition. Our method is the alternative for complex classification. It is the solution to the volatility of the notion of terrorism developed in the section 2.

4. The proposed terrorist attacks' classification

Classifying terrorist attacks is no as obvious as we imagine since they are influenced by various real-world variables and parameters. We present, in Subsection 4.1, the context of such classification and the the concept related to the three basic criteria, where we establish, in Subsection 4.2, the calibration system for each criteria.

4.1. The classification context

In order to improve and simplify the analysis tools of terrorist acts, we offer a new classification of terrorist

attacks according to the nature of the terrorist risk. Our classification method is inspired from the definition of Willis et al. (2006) presented as the product of the occurrence probability of terrorist attack: (a) *the threat* which refers to the probability that an attack of a given type will be successful once it has been launched, (b) *the vulnerability* which presents the probability that damage occurs, given a threat, and the values of the different (c) *consequences*.

The threat of terrorists during an attack depends on their effectiveness and capability to cause damage to a specific target. Several factors are at the origin of this effectiveness. For example, a terrorist with only assaults arms presents a medium level of threat but this level increases when we have a suicide bomber. In addition, a large number of terrorists could present an important threat even if the individual risk of each one of them is low. The size of the terrorist group presents the second factor. It has a major impact on the threat level. In our case, terrorist group's strategy in urban area involves fast concentrated attacks that maximize the chances of achieving the desired damages. This strategy does not need a large number of terrorists as they need discretion.

A quantification based on threat emphasizes on a specific type of terrorists with a certain level of threat on specific targets. For instance, we cite the three following examples of the effect of a same threat on specific targets:

- Bombing attack represents a different threat to a specific target than chemical attack.
- Attacks on stadiums represent a different threat than attacks on military bases.
- A terrorist armed with white weapon presents lower threat for governmental forces than for the civil population.

A complete classification of terrorist attacks based on threats only would require consideration of every target separately. In practice, however, we need to focus on a limited number of attack types which conducts us to consider the vulnerability of target as another scale for recognizing the capacity of a target to respond to a specific threat. The vulnerability criterion increases from low to high level based on the sensibility of the target. Regarding the vulnerability criterion, we cite the following examples:

- Military bases have lower vulnerability than a police patrol because they have higher chance to resist an attack of a given type that were launched on.
- Crowded places, that are full of civilian, are the highest vulnerability targets for terrorists in urban area.

The third criterion of our classification, which refers to the definition of Willis et al. (2006), is the consequence of such a threat on a specific target. We pickup the most significant attributes from the GTD to measure

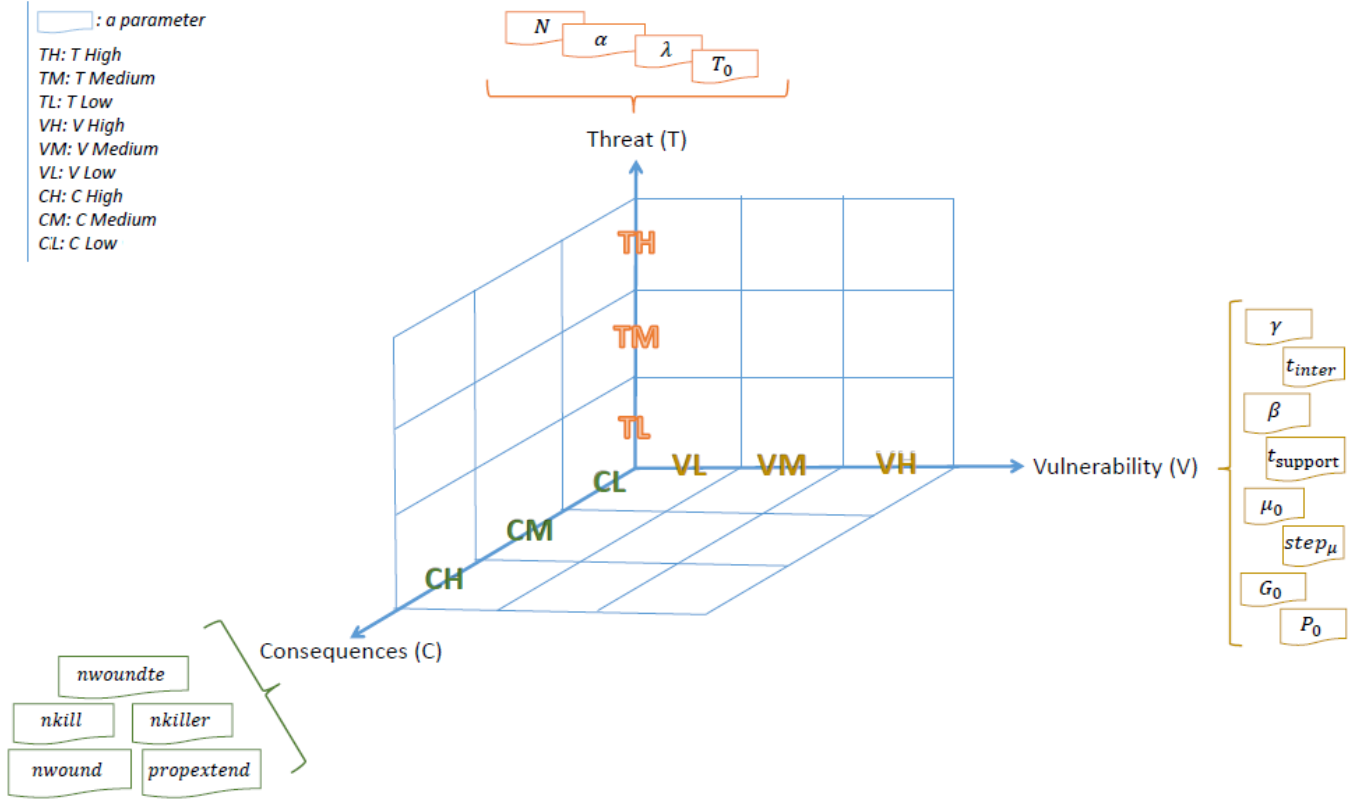


Figure 1. The terrorist attacks classification model

the consequences level. Among these consequences, we may cite the fatality of human resource, the number of killed people, the damaged property, and the number of injured people.

Consequently, we could intuitively plot these three criteria within a space, as done in Figure 1, since they are considered as the basis to identify a terrorist attack' class in this paper. Each axis refers to one criterion, even threat, vulnerability or consequences. Every criterion is characterized by three levels and influenced by various parameters as it will be explained in subsection 4.2.

4.2. The rating system

After precisizing the three criteria, on which our proposed classification is based, we aim to quantify them by assigning for each one a level (High (H), Medium (M) and Low (L)). we describe their levels by nine linguistic terms namely Threat Low (TL), Threat Medium (TM), Threat High (TH), Vulnerability Low (VL), Vulnerability Medium (VM), Vulnerability High (VH), Consequences Low (CL), Consequences Medium (CM), and Consequences High (CH) of the levels of each criterion. The combinations give the resulted classes to which we could assign a new terrorist attack. For the sake of clarity, we may consider every cube, in Figure 1, as a

class. So, we have 27 (3³) classes in total.

Once we describe the three criteria that our new terrorist attacks classification proposal is built upon, we precise seventeen parameters having the highest impact on the levels of threat, vulnerability and consequences based on experts elicitation within the military field. The list of these parameters is presented and described in Table 1, where we find, respectively, the name of the parameter, its definition, the range of values that it can take along with its significance (low, medium, or high), its origin, and the criterion on which it provides significant impact (see also Figure 1). The column *Origin* of Table 1 refers to the provenance of each parameter. Some of these parameters are extracted from the model of Kress and Szechtman (2009b), where some others are obtained from the GTD codebook. After military experts elicitation study, we affirm that four other parameters, which are λ , t_{inter} , $t_{support}$, and $step_{\mu}$, present decisive elements in the classification of terrorist acts. This study allowed us to assign numeric fields for each level (Low (L), Medium (M) and High (H)) of these parameters in the "range" column. The parameter "propextend", extracted from GTD codebook, is defined by 3 categories that have been mentioned in the "range" column of Table 1:

- Catastrophic (likely greater than 1 billion dollars)—

Table 1. The parameters of the terrorist attack classification

Parameters	Description	Range			Origin	Major impact on
		L	M	H		
N	The percentage of well-trained terrorists in defensive position.	[0, 0.3]	]0.3, 0.6]	]0.6, 1]	Created	Threat
α	The attrition coefficient interpreted as the general intensity and effectiveness of terrorists' operations on governmental forces.	[0, 0.2]	]0.2, 2.5]	]2.5, 5]	Kress model	Threat
λ	The attrition coefficient interpreted as the general intensity of terrorists' operations on population.	[0, 0.1]	]0.1, 2]	]2, 5]	Created	Threat
γ	The attrition coefficient interpreted as the general intensity and effectiveness of counter terrorism operations.	[0,0.3]	]0.3, 2]	]2,5]	Kress model	Vulnerability
t_{inter}	The launching time of the first reaction of the government forces.	[0, 5]	]5, 20]	>20	Created	Vulnerability
T_0	The initial size of terrorists	[0, 2]	]2, 5]	>5	Kress model	Threat
β	The constant periodically support to the government force.	[0, 12]	]12, 40]	>40	Kress model	Vulnerability
$t_{support}$	The period of the constant support β .	[0, 10]	]10, 18]	>18	Created	Vulnerability
μ_0	The initial level of intelligence μ , which may be interpreted as the fraction of intelligence reports that correctly identify the location of terrorists.	[0, 0.5]	]0.5, 0.8]	]0.8,1]	Kress model	Vulnerability
$step_{\mu}$	The incremental step of the level of intelligence μ ,	[0, 0.02]	]0.02, 0.04]	]0.04, 0.1]	Created	Vulnerability
G_0	The initial size of governmental forces	[0, 12]	]12, 40]	>40	Kress model	Vulnerability
P_0	The initial size of civilian.	[0, 25]	]25, 35]	>35	Kress model	Vulnerability
nwoundte	The Number of Perpetrators Injured	[0, 2]	]2, 10]	>10	GTD feature	Consequences
nkill	Total Number of Fatalities	[0, 2]	]2, 5]	>5	GTD feature	Consequences
nkillter	Number of Perpetrator Fatalities	[0, 2]	]2, 5]	>5	GTD feature	Consequences
nwound	Total Number of Injured	[0, 20]	]20, 40]	>40	GTD feature	Consequences
propextent	Extent of Property Damage	Minor	Major	Catastrophic	GTD feature	Consequences

>1

- Major (likely greater than 1 million dollars and strictly lower than 1 billion dollars)—>2
- Minor (strictly lower than 1 million dollars)—>3

We mention in Table 1 that each one of those parameters has a major impact on one of the three criteria. Moreover, we do not include the effect of the inter-parameter correlation on the criterion. The levels of each criterion are obtained by the interference of those parameters. We provide in Table 2 the most important interference relation of each criteria level.

Those relations are formulated using logical functions (and, or), combining the level of concerned parameters for each criteria level defined by the nine linguistic terms. In other words, Table 2 is the codebook for our classification because it links the qualitative parameter levels to our criteria levels. Whereas, Table 1 creates the link between the real world, by introducing ranges of quantitative levels, and the parameter levels.

5. Case study: classification of a real example

We aim, in this Section, to analyse Bardo terrorist Attack (BA) and study the values of its different parameters to define its class. This will allow us to classify it according to our proposal in this paper. We provide a summary of what occurred in a real terrorist attack on the BA. Three assaulters attacked tourists at the Bardo National Museum in the city of Tunis, Tunisia. The assailants first started shooting at people who were on buses outside the museum. At least 21 civilians and one police officer were killed. After 15 minutes, government forces intervened. After 2 hours and 30 minutes, two terrorists have been successfully neutralized and the third is currently at large. The first step is the scoring of the parameters, which is presented in Table 3.

In this step, we mention some general information related to the attack and score them in Table 3 with argumentation for each one. Then, we recognize the level for each parameter in order to use those levels in the interference rules. The second step is to interpret the correspondence of parameters level with the rules. We admit that our example obeys to the following three rules:

- α (L) and t_{inter} (H) and $t_{support}$ (H) and G_0 (M) and P_0 (H) and μ_0 (L) and $step_{\mu}$ (H) \longrightarrow VM
- $n_{woundte}$ (L) and n_{kill} (H) and $n_{killter}$ (L) and n_{wound} (H) and $propextent$ (L) \longrightarrow CM
- λ (H) and α (M) and T_0 (M) and N (H) \longrightarrow TH

We conclude that the example of Bardo Attack belongs to the class defined by the triple (VM, CM, TH) and referring to the levels of criteria. This class is clearly visible in the space shown in the plot on Figure 1. This class encompasses the set of attacks that have been well controlled by the governmental forces even if the threat level is high.

6. Conclusion

We proposed, in this paper, a new terrorist attacks classification strategy based on three among the most important criteria for identifying terrorism violence which are *threat*, *vulnerability*, and *consequences*. The quantification of these criteria is measured according to various parameters having impact on them. The values offered by these parameters will decide if each criterion level is *high*, *medium*, or *low*. To study the range of parameters values, we perform, during this research work, an elicitation study from military experts. Since these parameters' values are generally imprecise and/or uncertain, we aim, as a future work, to tackle the problem of imperfection and propose a soft terrorist attacks classification method that deals with imperfect data and based on unsupervised learning.

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Table 3. The parameters' settings used for Bardo attack simulation

Parameters	Values	Argumentation
N	0.62	Just two terrorists get good training in Libyan hot spots.
G_0	14	The initial size of the government forces came into action.
P_0	340	Size of the population inside the museum.
T_0	3	
α	0.022	The terrorist poses a medium threat level to government forces due to his location during their response.
λ	2.1	The terrorist poses a medium threat level to civilians since he is armed only with an assault rifle and has not used any weapons of mass destruction or explosives.
γ	0.0005	the targets are tourists in a crowded museum.
β	15	There is no support until the end of the mission.
$step_{\mu}$	0.065	we use a progressive method of intelligence with a big step due to the high number of the sources of information.
μ_0	0	Government forces have no baseline details of the attack.
t_{inter}	21	The location of the attack is near many bases.
$t_{support}$	20	Information extracted from the course of action.
nwoundte	0	Information extracted from the GTD.
nkill	24	Information extracted from the GTD.
nkillter	2	Information extracted from the GTD.
nwound	42	Information extracted from the GTD.
propextent	3	Information extracted from the GTD.

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