Red Teaming Military Intelligence - a New Approach based on Neutrosophic Cognitive Mapping

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Abstract— **One of the key methods of ensuring effectiveness and actionability of military intelligence is "Red Teaming". Red Teaming involves questioning the conventional analyst-driven military intelligence constructs. This paper proposes a new Red teaming approach based on Neutrosophic Cognitive Mapping, that helps combine various multi-disciplinary intelligence inputs in a non-linear and complex manner. Such an approach is used to cross-verify the conventional analyst constructed causalities of military threats. The approach is demonstrated with the help of an example on the perceived existence of a common national security threat-a suspected impending terror attack. Red teaming the intelligence that warns of this threat is achieved by objectively casting the maze of causalities as suggested by five military intelligence agencies in appropriate Neutrosophic Cognitive Maps and combining them in an integrated manner.**

Keywords- military intelligence, red teaming, neutrosophic cognitive maps

I. INTRODUCTION (HEADING 1)

Military Intelligence (MI) is an omnipresent component of a nation's security. History is witness to the fact that many wars have been won and many national security threats have been identified and action taken depending on actionable intelligence received in time. However, intelligence failures as evidenced in the 9/11 terror attacks in the U.S. or the 26/11 terror attacks in Mumbai have highlighted the need for questioning existing analytic methods of MI. In this context, various intelligence experts have emphasized the need for more effective "Red Teaming". For example, as mentioned in the United States National Intelligence strategy 2009 [1], "Expanded use of techniques such as red-teaming can help ensure quality and integrity in analytic products, and potentially produce fresh insights into our toughest challenges".

Red Teaming is defined as: "structured, iterative process executed by trained, educated and practiced team members that provides commanders an independent capability to continuously challenge plans, operations, concepts, organizations and capabilities in the context of the operational environment and from our partners' and adversaries' perspectives" [2]. Though this definition looks limited to field operations, over time, the notion of red teaming has expanded to challenge analyst constructs covering all spheres of MI and not just limited to operational battle-field level intelligence. Red teaming is essential to help MI analysts and Decision-makers avoid surprise and overcome cognitive biases by considering problems from a contrarian point of view.

A person who follows the profession of Red teaming is known as a "Red teamer".

II. MILITARY INTELLIGENCE (MI) – CURRENT METHODS

MI comprises of mainly 6 subcomponents: Strategic Intelligence (STRATINT), Imagery Intelligence (IMINT), Tactical Intelligence (TACINT), Human Intelligence (HUMINT), Counter Intelligence (CI), Signals Intelligence (SIGINT) [3]. Various MI analytical methods are used to manipulate intelligence information with a view to providing timely and actionable intelligence to the decision-makers. The effectiveness of these methods is dependent on whether or not the analysts and their models have managed to identify the causal connections between events and intentions as discerned from unsupervised intelligence data correctly. The fact that often times the underlying intelligence data is unavoidably incomplete, inadequate or hazy makes the task even more challenging.

A. Current Analytical Methods employed in MI

Multitude of analytical methods is used in the context of military intelligence. They range from simple methods such as activity/event flow charts to relatively complex methods such as ONA (Operational Net Assessment) and computational approaches. Understandably, these approaches are under continuous research and updation. Constraints of space prohibit a discussion of all of these methods; however two analytical approaches are discussed in brief detail: ONA and Disciple-LTA. ONA is an approach that is widely practiced in this field and Disciple –LTA (cognitive assistant) is a proposed (research) approach.

Operational Net Assessment (ONA): The ONA is a "nodal analysis," which looks at the adversary as a "system of systems," looking at not only his military capabilities, but also political, economic, and social factors, and information systems and economic infrastructure. Included in this assessment, is a look at the battle space, capabilities, and enemy's perceptions about the (analyzing) country. This assessment is used to provide a clear pointer to the kind of effects the (analyzing) country wants to achieve. The means to generate the desired effects are not limited to military ones, but can include diplomatic, information, and economic means, as well. The

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desired effects are used to design an "effects-based" operation; and "decision superiority" means being able to make decisions faster than the enemy. All of this, employed together, is supposed to result in the execution of a "rapid, decisive operation [4]."

Disciple-LTA: This is a cognitive assistant that helps intelligence analysts evaluate the likelihood of hypotheses by developing Wigmorean probabilistic inference networks that link evidence to hypotheses in argumentation structures that establish the relevance, believability and inferential force or weight of evidence [5].

Any decision-making pertaining to MI has to take into account diverse inputs flowing out of many different analyst methods. The conventional analyst supported methods as above have many disadvantages, some of which are listed below:

i) A major weakness in contemporary intelligence community is perceived to be its difficulty in providing strategic intelligence--the comprehensive overviews that put disparate events and the fragmentary snapshots provided by different intelligence sources into a contextual framework that makes it meaningful for the intelligence consumer. This criticism applies to intelligence prepared both for a national policy audience and for more specialized audiences, such as battlefield commanders [6].

ii) Ways in which the intelligence is disseminated and used by the end customers (analysts) differ. For example, in the case of SIGINT, after collecting a signal, the NSA (National Security Agency of USA), analyses it, produces information and then distributes this information to a variety of customers and agencies. However in the case of IMINT, an image obtained is sent to a variety of organizations and is subject to their interpretation. Naturally, this leads to a possibility of non-standard interpretations of the same intelligence data, which when input into different Decision Making models will produce diverse output.

iii) CI is an essential part of MI. However CI is often the most arcane and organizationally fragmented, the least doctrinally clarified, and legally, and thus politically, the most sensitive intelligence activity [7]. Thus due to the difficulties involved in gaining CI, information from CI can be incomplete, inadequate, and even misleading if the enemy is a master in deception. Conventional analytical models largely depend on the world-view of the analyst when factoring in such information into decision-making models.

Despite knowing the limitations of the conventional MI analytic methods as above, Red Teamers have to combine all the 6 sub-components of MI (as mentioned earlier in this section) in a complex and non-linear manner in order to effectively challenge conventional analyst constructs. Various Red teaming methods are currently in use –they are briefly described below

B. Red Teaming Methods

Historically Red Teaming formats have included Red teamers playing the role of a “devil’s advocate” by a simple vulnerability analysis, proposing alternative hypotheses, war games and simulation etc. [8]. Key analytical techniques used by Red teamers are [9]:

Key assumptions check, Quality of information check Indicators or signposts of change track, Deception detection Analysis of Competing Hypothesis, Devil’s advocacy, Team A/Team B contrarian technique, High-Impact/Low-probability Analysis, What-if Analysis, Brain storming, Outside-in Thinking, Surrogate Adversary/Role Play, Alternative Futures Analysis

Red Teamers are exhorted to challenge constructs of intelligence analysts and ask the “right” questions while at the same time reminded that (military) decision making is heavily dependent on experience and instinct [10].Surprisingly though, despite the complexity of their tasks, much of the red teaming exercises are done in a conventional way-they are heavily people dependent and demonstrate scope for benefitting from computational/cognitive approaches.

To some extent researchers have claimed that existing techniques (e.g. Disciple-LTA mentioned above) can help with certain methods of red teaming –e.g. ACH –However there exists no tool that can provide a comprehensive direction to the red teamers who struggle with discerning causalities from multi-disciplinary intelligence data that is often times incomplete, indeterminate and inadequate for purposes of causal analysis. In summary, they need a robust method to put disparate and multi-disciplinary intelligence data pertaining to the 6 components of MI into a common framework that can afford both flexibility as well as analytical rigor.

What type of tools would be conducive to Red teaming? A key characteristic of a good Red teamer is being a good causal analyst. Several causal analytic tools are available currently; however dealing with complex systems involving indeterminate causal relationships require specific tools that address this situation.

One such tool is proposed in this paper based on the methodology of Neutrosophic Cognitive Maps developed by W.B.V.Kandasamy and F.Smarandache [11].

III. USING NEUTROSOPHIC COGNITIVE MAPS TO REPRESENT RED TEAMING PROBLEM

First a brief background about cognitive maps in general is discussed followed by key features of Neutrosophic Cognitive Mapping.

A. Neutrosophic Cognitive Maps

A recent advance in the field of cognitive maps is Neutrosophic Cognitive Maps. This is based on neutrosophic logic created by Florentine Smarandache, which is an extension / combination of the fuzzy logic in which indeterminacy is included. A Neutrosophic Cognitive Map (NCM) is a neutrosophic directed graph with concepts like policies, events etc. as nodes and causalities or indeterminates as edges. It represents the causal relationship between concepts. A key difference between Fuzzy Cognitive Maps (FCM) and Neutrosophic Cognitive maps is that Neutrosophic

maps permit the relationship of "indeterminacy" between nodes which is not possible to perform in a FCM. Given the discussion in Section II above on the need to incorporate indeterminate relationships in causal analysis, NCM is a very useful way of causal representations for MI, especially for the Red teamers.

Some of the essentials pertaining to NCM are listed [12]:

i) Let Ci and Cj denote the two nodes of the NCM. The directed edge from Ci to Cj denotes the causality of Ci on Cj called connections. Every edge in the NCM is weighted with a number in the set {-1, 0, 1, I}. Let eij be the weight of the directed edge CiCj, eij $\in$ {–1, 0, 1, I}. eij denotes the strength of causality. eij = 0 if Ci does not have any effect on Cj, eij = 1 if increase (or decrease) in Ci causes increase (or decreases) in Cj, eij = –1 if increase (or decrease) in Ci causes decrease (or increase) in Cj . eij = I if the relation or effect of Ci on Cj is an indeterminate.

ii) Let C1, C2,…Cn be n nodes of the NCM. Let S = (s1,s2,…sn) where si belongs to{0,1,I}. S is called the instantaneous state neutrosophic vector and it denotes the on-off-indeterminate state position of the node at an instant.

si=0 if si is off (no effect)

si=1 if si is on (has effect)

si=I if si is indeterminate (effect cannot be determined) for i=1,2,…n

iii) If the equilibrium state of a dynamical system is a unique state vector, then it is called a "fixed point". If the NCM settles with a neutrosophic state vector repeating in the form S1 → S2 →… → Si → S1, then this equilibrium is called a limit cycle of the NCM.

iv) Let C1, C2,…, Cn be the nodes of an NCM, with feedback. Let E be the associated adjacency matrix. The "hidden pattern" is found as follows: When C1 is switched on, an input is given as the vector S1 = (1, 0, 0,…, 0) and the data passes through the neutrosophic matrix N(E). This is done by multiplying A1 by the matrix N(E).

Let S1N(E) = (s1, s2,…, sn) with the threshold operation that is performed by replacing si by 1 if si > k and si by 0 if si < k (k – a suitable positive integer) and si by I if si is not an integer. The resulting concept is updated and the concept C1 is included in the updated vector by making the first coordinate as 1 in the resulting vector. Suppose S1N(E) → S2 then consider S2N(E) and repeat the same procedure. This procedure is repeated till a "limit cycle" or a "fixed point" is obtained. (→ stands for vector thresholding and updation).

v) Finite number of NCMs can be combined together to produce the joint effect of all NCMs. If N(E1), N(E2),…, N(Ep) be the neutrosophic adjacency matrices of a NCM with nodes C1, C2,…, Cn then the combined NCM is got by adding all the neutrosophic adjacency matrices N(E1),…, N(Ep). We denote the combined NCMs adjacency neutrosophic matrix by N(E) = N(E1) + N(E2)+…+ N(Ep).

IV. USING NEUTROSOPHIC COGNITIVE MAPS TO REPRESENT RED TEAMING PROBLEM

A. Red Teaming problem construction

Red teaming problem definition: Consider a national security threat e.g. Impending Terror attack. Information on such issues is gathered and analyzed by 5 different MI agencies A1, A2,…A5. Based on intelligence data gathered, MI analysts with these agencies process the information differently and provide intelligence inputs which are sometimes disparate and not in tandem with each other. The offshoot is that some agencies believe there is a cause for concern regarding a perceived impending terror attack whereas others believe it is not the case. Under such circumstances, how can the Red teamer review all of that MI information and arrive at a definitive conclusion as to whether or not there is indeed a cause for concern regarding an impending terror attack?

B. Red Teaming Solution construct using NCMs

The first task of the Red teamer is to classify the intelligence information received from various agencies under major categories. In this paper it is assumed that he/she places all MI data received under the 6 categories of intelligence as discussed before: STRATINT, IMINT, TACINT, HUMINT, CI and SIGINT.

These intelligence concepts that contribute causal evidence to the national security threat are labeled C2, C3…C7 – whereas their suspected effect viz. the impending terror attack is labeled as C1. Based on the techniques as described in the section above, the Red teamer can arrive at an edge value of eij $\in$ {–1, 0, 1, I} between concepts Ci and Cj, where eij denotes the strength of causality. eij = 0 if Ci does not have any effect on Cj, eij = 1 if increase (or decrease) in Ci causes increase (or decreases) in Cj, eij = –1 if increase (or decrease) in Ci causes decrease (or increase) in Cj . eij = I if the relation or effect of Ci on Cj is an indeterminate.

NCMs are constructed for the Red teamer's assessment of causal relations as proposed by the various agencies. E.g., Agency A1 may, based on Strategic Intelligence obtained through diplomatic channels, say that state supported terrorism situation of a target country is currently not causal to a situation of an impending terror attack in the (analyst) country. However another agency A5 can actually come up with a piece of counter-intelligence that they suspect (but can't conclusively prove) that lot of government misinformation and misrepresentation is in vogue in the target country rendering state-sponsored terrorism as suspected to be prevalent which may cause a terror attack in the (analyst) country. On the basis of A1, the Red Teamer will assign 0 to the edge relation of STRATINT-IMPENDING TERROR ATTACK in A1's NCM whereas he/she will assign the value I to the edge relation CI – IMPENDING TERROR ATTACK in the NCM of A5.

C. Concept definition for Red Teaming NCMs

- Impending Terror Attack (C1) : Imminent Terrorist attack on the (analyst) country

- Strategic Intelligence (STRATINT - C2): This is "the Intelligence that is required for the formulation of strategy, policy, and military plans and operations at national and theater levels" [13]. Intelligence information about the causal strategic capabilities and intentions of target country in initiating a terrorist attack in the (analyst) country is included here [14].
- Imagery Intelligence (IMINT - C3): This is a means of obtaining information about distant topics by creating an image of it, most often using visible light photography [15]. Images that may lead investigators to believe that there is an imminent terrorist attack in the (analyst) country would be included here.
- Tactical Intelligence (TACINT - C4): This is the (battle field) intelligence required by the commander to provide a basis for planning and conduct of tactical operations. It deals with the local tactical situation, particularly with the environment and threat [16].Ground level intelligence obtained as pertaining to the activities of the target country (especially in the analyst country) can provide causal connections to the perception of an imminent terrorist attack.
- Human Intelligence (HUMINT - C5): This is derived from human sources. HUMINT collection is performed by overt collectors such as diplomats and military attaches in addition to covert collectors such spies and undercover agents. Collection includes clandestine acquisition of photography, documents, and other material; overt collection by personnel in diplomatic and consular posts; debriefing of foreign nationals and US citizens who travel abroad; and official contacts with foreign governments [17]. The human intelligence that points towards causal evidence of moves towards an imminent terror attack in the (analyst) country will be considered here.
- Counter Intelligence (CI - C6): This is the study of the organization and behavior of the intelligence services of foreign states and entities, and the application of the resulting knowledge [18]. CI forms an important part of providing crucial information on imminent terror attacks in the analyst country.
- Signals Intelligence (SIGINT - C7): The interception of foreign signals provides data on a nation's diplomatic, scientific, and economic plans or events as well as the characteristics of radars, spacecraft and weapons systems. Such intelligence is called Signals Intelligence (SIGINT) - this can be further broken down into five components: communications intelligence (COMINT), electronics intelligence (ELINT), radar intelligence (RADINT), laser intelligence (LASINT), non-imaging infrared [19].However, for purposes of this paper, SIGINT would be considered as one consolidated concept which provided pointers to the causation of conditions conducive for an impending terror attack.

It is important to note that the above intelligence classifications are based on the nature of MI information and not source/format based. E.g. CI will involve imagery, TACINT will involve signal processing but nevertheless, image based intelligence will be considered under IMINT and signal processing output would be considered under SIGINT.

In this paper, the red teamer's assessment of each Agency Ai's causal intelligence data would be discussed in light of the 6 intelligence concepts (C2-C7) as articulated above.

D. Red Teaming NCMs

The following are the NCMs framed by the Red teamer post receiving inputs from the five agencies. Note that these NCMs do not reflect the causality perceptions of the agencies themselves-this would have been already captured in their intelligence reporting -but reflect the causality assessment of the Red Teamer post reviewing the intelligence reporting from the five agencies.

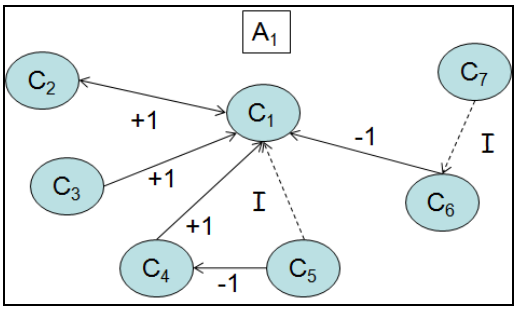

Figure 1. NCM pertaining to Agency 1 (A1)

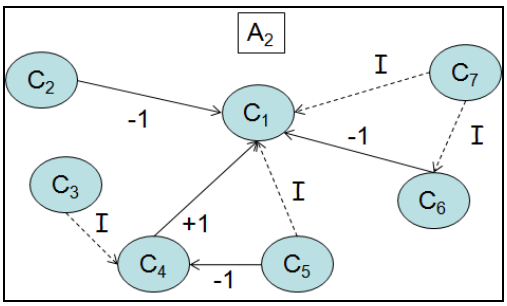

Figure 2. NCM pertaining to Agency 2 (A2)

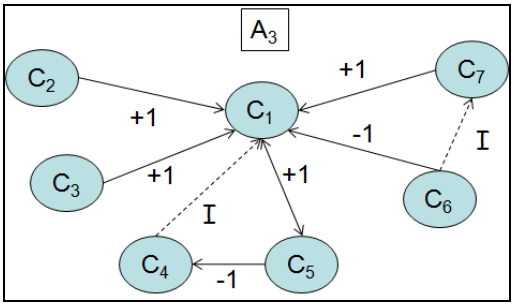

Figure 3. NCM pertaining to Agency 3 (A3)

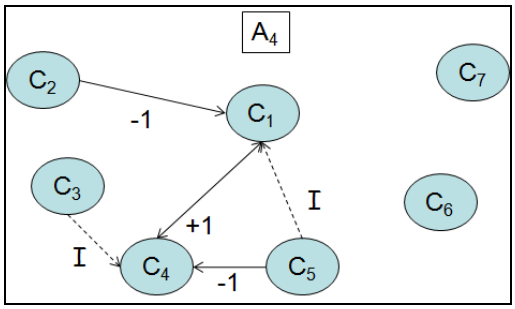

Figure 4. NCM pertaining to Agency 4 (A4)

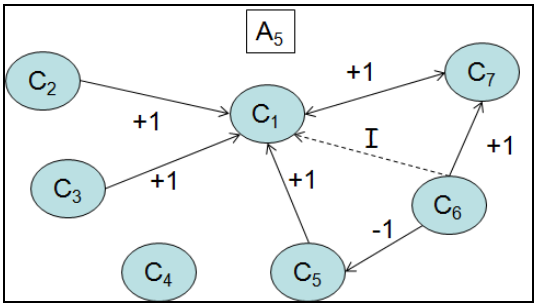

Figure 5. NCM pertaining to Agency 5 (A5)

The Neutrosophic adjacency matrices pertaining to the above are given below:

N(A1)	C1	C2	C3	C4	C5	C6	C7
C1	0	1	0	0	0	0	0
C2	1	0	0	0	0	0	0
C3	1	0	0	0	0	0	0
C4	1	0	0	0	0	0	0
C5	I	0	0	-1	0	0	0
C6	-1	0	0	0	0	0	0
C7	0	0	0	0	0	I	0

N(A2)	C1	C2	C3	C4	C5	C6	C7
C1	0	0	0	0	0	0	0
C2	-1	0	0	0	0	0	0
C3	0	0	0	I	0	0	0
C4	1	0	0	0	0	0	0
C5	I	0	0	-1	0	0	0
C6	-1	0	0	0	0	0	0
C7	I	0	0	0	0	I	0

N(A3)	C1	C2	C3	C4	C5	C6	C7
C1	0	0	0	0	1	0	0
C2	1	0	0	0	0	0	0
C3	1	0	0	0	0	0	0
C4	I	0	0	0	0	0	0
C5	1	0	0	-1	0	0	0
C6	-1	0	0	0	0	0	I
C7	1	0	0	0	0	0	0

N(A4)	C1	C2	C3	C4	C5	C6	C7
C1	0	0	0	1	0	0	0
C2	-1	0	0	0	0	0	0
C3	0	0	0	I	0	0	0
C4	1	0	0	0	0	0	0
C5	I	0	0	-1	0	0	0
C6	0	0	0	0	0	0	0
C7	0	0	0	0	0	0	0

N(A5)	C1	C2	C3	C4	C5	C6	C7
C1	0	0	0	0	0	0	1
C2	1	0	0	0	0	0	0
C3	1	0	0	0	0	0	0
C4	0	0	0	0	0	0	0
C5	1	0	0	0	0	0	0
C6	I	0	0	0	-1	0	1
C7	1	0	0	0	0	0	0

N(A)	C1	C2	C3	C4	C5	C6	C7
C1	0	1	0	1	1	0	1
C2	1	0	0	0	0	0	0
C3	3	0	0	2I	0	0	0
C4	3+I	0	0	0	0	0	0
C5	3I+2	0	0	-4	0	0	0
C6	-3+I	0	0	0	-1	0	1+I
C7	2+I	0	0	0	0	2I	0

Note: N(A) is the combined Neutrosophic adjacency matrix pertaining to all the agencies

Applying the state vector V_1=(1 0 0 0 0 0 0) on the state of Node C1, we obtain the effect of V_1 on N(E) as

$V_1 N(E) = (0\ 1\ 0\ 1\ 1\ 0\ 1) \rightarrow (1\ 1\ 0\ 1\ 1\ 0\ 1) = V_2$
Where the symbol → stands for vector thresholding and updation is based on k=1 as per rules specified in section 3.2(iv).

$V_2 N(E) = (8+5I\ 1\ 0\ -3\ 1\ 2I\ 1) \rightarrow (1\ 1\ 0\ 0\ 1\ I\ 1) = V_3$
$V_3 N(E) = (5+2I\ 1\ 0\ -3\ 1\text{-}I\ 2I\ 1+2I) \rightarrow (1\ 1\ 0\ 0\ 1\ I\ 1) = V_4$
$V_3 = V_4$: Fixed point reached.

V. RESULTS AND DISCUSSION

The findings show the Red teamer that:

On an overall basis, the concern about the existence of an impending terror attack is not unequivocally borne out by intelligence gathered so far. The concern is justified by STRATINT, HUMINT and SIGINT-However IMINT and TACINT are not supportive of that concern. In addition, CI based information, which is an important driver of conclusions regarding terrorist threats, is ultimately "Indeterminate". This tells the Red Teamer that he/she has to get back to all agencies A1, A2,…A5 with specific requests for more information gathering on CI and repeat the process of NCM construction and analysis as above. Assume that post revising the causal assessments after receiving additional information the new final thresholded vector is V" = (1 1 0 0 1 1 1) (The NCM method applied on revised data being the same as illustrated in Section V). The Red Teamer can conclude that since 4 out of 6 intelligences suggest existence of an intended terror attack, there is indeed a cause for concern. There could be other approaches to analyzing the results. One such approach consists of attaching simple weights to the various intelligences based on their relevance and importance to decision making. Such an approach is especially useful if the revised thresholded Vector V" displays a tie in the number of concepts suggesting causality of the imminent terror attack.

Weighted Method: Let V" = (1 1 0 0 1 0 1) In this case there is a tie between the intelligence inputs. Three of the intelligences suggest that terrorist threat exists but other three suggest that the threat is not justified on the basis of available intelligence. In this case the Red Teamer adopts a simple weighted approach where in each of the intelligences can be assigned weights.

E.g. C2 – 20%, C3- 20%, C4 -10%, C5-30%, C6-10%, C7=10%

The on off state for each Concept in V" leads to a weighted average score of (20+30+10)/100 = 60% which tends towards existence of the threat (since this is >50%, the point of no difference).

Some of the advantages of the above proposed method for Red Teaming using NCM are:

- Complex non-linear representation and computation of causal intelligence involved in the MI problem.
- Flexibility to include multi agency intelligence inputs on the same platform.

- No imposed pre-designed analyst influenced criteria for red teaming thereby facilitating emergence of hitherto unidentified knowledge patterns.
- Inclusion of indeterminate causalities which is particularly necessary given the incomplete nature of intelligence information.
- The ability to seamlessly combine multi-agency opinion, taking advantage of the fact that NCMs are additive in nature.

There is scope for further research on the above Red Teaming solution construct especially with regard to systematically challenging underlying MI analyst assumptions and quality of MI information using Neutrosohpic subgraphs.

VI. CONCLUSION

Red teamers are tasked with challenging conventional analyst constructs on Military Intelligence issues. However Incomplete/indeterminate intelligence data pertaining to threat event causalities make their task difficult. This paper discussed a new method based on Neutrosophic Cognitive Maps to Red team Military Intelligence findings. The method helps Red teamers to objectively discern causalities from multi-agency intelligence inputs using a non-linear approach and also allows the flexibility to integrate "indeterminacy" in intelligence data processing. The overall approach was demonstrated using an example of a hypothetical concern for existence of an imminent terror attack on the (analyst) country.

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