Generating Crisis Situation by Using Ontology and Fuzzy Theory

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ABSTRACT

A crisis is a complex situation, difficult to manage by the actors. Some of them are under stress it is difficult to deal with problems when consequences cannot be predict. The human conditions (concerning familial and life) and, the influence of the environment related to politics, economic, and media pushe the actors to lose control of the crisis situation. The question we face in this paper is: "is it possible to use the fuzzy theory for predicting the stress impact in crisis?" Our main hypothesis to represent experience feedback in a situation prediction in order to show negative consequences and correctness actions is taken account. Fuzzy theory concept is used in prediction in order to generate several situations.

Keywords

Crisis management, Fuzzy Theory, Ontology, Collaboration, Stress.

INTRODUCTION

A crisis situation generates a collective stress. This kind of situation request an organization to manage it and, to make pertinent decisions with the aim to reduce the effects in a short time with minimal damage. This paper shows us, how is possible to generate a predict stress impact situation by using fuzzy sets and knowledge management. This can help crisis management actors to learn by exploring different situations due to stress impacts. So, the main questions can be: Is it possible to use the ontology in the prediction of the impact of the stress during a crisis situation? Is it possible to use the fuzzy theory for predicting the stress impact situation in crisis? In this paper, some answers to this question are explored, especially, the generation of the stress impact situations by using the experience feedback and the fuzzy theory. Firstly, a description of the uncertainty and the fuzzy theory were addressed. Then, the crisis management as a collaborative situation and the impact of the stress during the crisis that can generate some uncertainty situations is studied. Also, an otology is identified for our study. And then, the use of the fuzzy theory in the representation of the stress impact during a crisis situation is discussed and a representation of the structure of the fuzzy generator called "NOE" is proposed.

THE FUZZY THEORY AS UNCERTAIN REASONING TOOLS

The uncertainty is a situation of inadequate information. It can be of three sorts: inexactness, unreliability, and borders with ignorance (Funtowicz, Ravetz 1990). For Zadeh, "Uncertainty is an attribute of information" (Zadeh 1997). It can prevail in situations where a lot of information is available (Van Asselt, Rotmans 2002). A new information or knowledge can decrease or increase the uncertainty. Some researchers suggest that uncertainty may be an important mediator of the impact of role stressors on the stress (Beehr 2000; Beehr, Bhagat 1985; O'Driscoll, Beehr 1994). The uncertainty concern all phenomena or systems whose behavior is generally disordered and irregular, which can often appear unpredictable and random.

Fuzzy Theory Principles

It is a mathematical theory of Zadeh (Zadeh 1996) based on intuitive reasoning. This theory considers the subjectivity and the imprecision. It may treat digital literacy; non-measurable values and for a linguistic issue (Bouchon-Meunier, Yager, Zadeh 1995). Fuzzy sets provide techniques to represent subjective and uncertain reasoning. Its goal is to build a formal system that it can make a qualitative reasoning (Rosental 2004). The fuzzy sets are used in different domains like pattern recognition, robotics, biology, economy, medicine, ecology, etc. (Zimmermann 2010). From this theory, we used the linguistic modifiers for using adverbs. The linguistic modifier permeate to attenuate or amplify the initial meaning of a number of attributes by the action of adverbs such as: very, more, at least, slightly. And, we use the multi-objective decision-making. It involves a selection of one alternative from a universe of alternatives given a set of criteria or objectives. For this study, we seek a decision that simultaneously satisfies all of the decision objectives.

THE CRISIS MANAGEMENT AS COLLABORATIVE ACTIVITY

During a crisis management, actors come from different organizations. They work, communicate, cooperate, coordinate and, exchange their own experiences. Their main common objective is how to deal with the crisis for reducing its effect? In this relationship, is noted that multiple actors are interdependent in their work. They interact each other to improve the state of their common field. They use resources like computers; plans; procedures; schemes; etc. This distributed activity can be represented as Triple C (Communication, Coordination, Cooperation). Several papers in the literature mention the role of Triple C in crisis management, and their interdependence (Martin, Nolte, Vitolo 2016). The interdependence of the 3C is affected by the regulation. Indeed, the regulation adjusting consists of sending or to receiving information, giving a warning (Communication); using means (Coordination); and to use the procedure, decision and organization (Cooperation).

REPRESENTING CRISIS SITUATION BY USING ONTOLOGY

Ontology is generally defined as a conceptualization of entities used in a specific domain (Gruber 1995). There are three levels of ontologies: Top, domain and applications (Guarino 1998). Identifying different concepts that represent crisis situations is needed before dealing with uncertainty in this type of situation. Related ontologies are then studied in this aim. For our study we choice the ontology named ResOnt (CHEHADE, Samer; Matta, Nada; POTHIN, Jean-Batiste; COGRANNE 2018) for rescue operations. In these ontologies, entities like tasks, actors, roles, organizations, materials, infrastructures are defined. These entities are specialized to answer our specific needs: representing main factors that influence uncertainty in crisis situations. Firstly, physical objects are distinguished from mental ones as recommended in top-level Ontology as Dolce (Guarino 1998) and SUMO (Niles, Pease 2001).

- Physical Objects emphasize Means, Persons, etc. (Fig. 1)
- Mental Constructs specify Task, roles, Influence, etc. (**Erreur ! Source du renvoi introuvable.**)

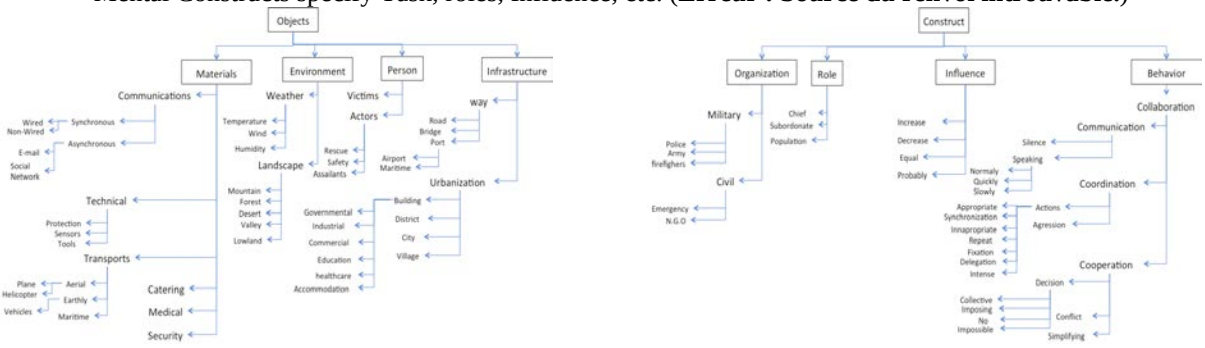

Fig. 1. Physical Object and Mental construct Ontology

Relationships between these concepts are then identified in order to reflect the dynamicity of crisis situations. Sediri propose to represent this dynamicity using state and events (Sediri, Matta, Loriette, Hugerot 2013). Crisis situations can be then seen as a sequence of events modifying states (0).

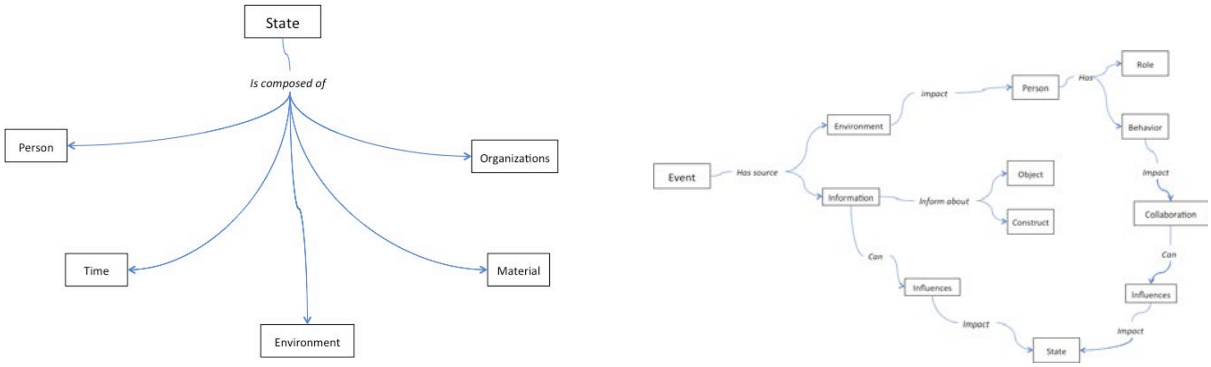

Fig. 2. State and Event relationships

These relationships are used in "NOE" situation generator that we defined (Teffali Sammy; Matta Nada; Chatelet Eric 2018). It is based on fuzzy theory.

APPLICATION ON STRESS IMPACT DURING A CRISIS MANAGEMENT

The Stress

The stress is an important factor in the success or the failure of the decision-making in a situation of crisis management. It is a particular relation between an actor and his specific environment. Its evaluation can be weak or exceed the actor resources and can be endangered his well-being (Lazarus, Folkman 1984). It was noticed that "Some policymakers reveal resourcefulness in crisis situations seldom seen in their day-to-day activities; others appear erratic, devoid of sound judgment, and disconnected" (Hermann 1979). Several approaches for the stress have been proposed, in the case of this study, the transactional approach is chosen (Cox, Griffiths, Rial-González 2000). It is related to cognitive and emotional processes, which gives interaction between a person and his environment (Boswell, Olson-Buchanan, LePine 2004). This indicates that the individual and the demand are two components. Indeed, an actor possesses personal characteristics that differentiate him from others. He is under the influence of environmental variables. He uses the coping. Lazarus defined the coping as "the overall cognitive and behavioral efforts, continuously changing, deployed by an actor for managing specific internal and/or external requirements, which are evaluated as consuming or exceeding his resource" (Lazarus, Folkman 1984). There are different studies that propose training and mental preparation methods to help actors to face the stress in crisis management (Ducrocq, Vaiva, Cottencin, Molenda, Bailly 2000; Pauchant, Mitroff, Lagadec 1991). This paper focus on the impact of stress on decision-making in order to promote learning from fails and guides based on experience feedback.

The Stress Impact During a Crisis

Boswel present four classes of indicators that influence stress conditions (Boswell, Olson-Buchanan, LePine 2004). (1) Task conditions: workload, etc; (2) relational conditions: conflict, harassment, etc; (3) job conditions: Mobility, no promotion, etc; (4) interaction private/profession: husband, children, family, etc. Different observable indicators of the stress are considered in psychology as manifestations of stress. Some of these are mainly noted: Speech rhythm (Siegman, Pope 2016), repetition of expressions and words (Kasl, Mahl 1965), using specific words (Kasl, Mahl 1965) etc; super activity, inadequate movement (Dittmann 1962) etc; silence (Weintraub, Aronson 1967); ambivalence, self-confidence (Aronson, Weintraub 1972); hostility and aggression (Gottschalk, Winget, Gleser, Springer 1966); inappropriate behavior and actions (Mehrabian 1968a, 1968b). Other studies have shown some manifestations of stress impact on decision-making as: Situation and context simplification (Lazarus et al, 1966); fixation on one possibility without any flexibility and alternatives (De Rivera 1968); consulting several opinions without concluding on a decision (Cooper et al., 1988); imposing a decision without measuring the impact and the consequences (Holsti 1972); missing decision-making and actions (Schlenker, Miller 1977). In this work, some of these indicators that can be measured directly from crisis management actions feedback are selected: super activity and imposing decision without considering the impact; silence, missing decision and actions; speech rhythm, aggression, and conflict of opinions and decisions; simplification of the situation and inadequate means and actions. Based on this study of stress impact, an expert dealing with military crisis situations has been interviewed in order to identify the influence types related to stress impacts. Ontologies entities previously defined are used as a guide in these interviews; the experts are solicited to specialize these entities and especially relationships between events and states.

INTEGRATING ONTOLOGY IN FUZZY THEORY APPLICATION

The advantage of the fuzzy theory is to use the linguistic value and to give for this value a mathematical sense. The main characteristic of this theory is the quantification of the uncertainty. As we know, the human reasoning in different areas is based on uncertainty. One of our principal preoccupations is how to interpret the impact of the stress in crisis situations using the human behavior and reasoning. The preferred method is to use the natural language. This is most comprehensive and simplest to interpret it. Our proposition is so to use the natural expression or words with fuzzy theory and especially the fuzzy sets. For that, we used a real situation lived as a case studied to apply the fuzzy theory.

Architecture of the Stress Impact Generator

Considering all these components, and the fuzzy logic theory we imagined a fuzzy generator called "NOE" who can generate state by introducing event. In the beginning we feed all the components mentioned above in a knowledge base. The information contained in the event is introduced in the generator. By using the fuzzy theory and the knowledge base, "NOE" generates the output state. For the next phase of this study, we are going to give more precision about some components that will enable us to use this theory.
We define for the first time a number of the sets:

- A is a universe of three actions: $A = \{a_1, a_2, a_3\}$ (1)

Where $a_1 = \text{Communication}$; $a_2 = \text{Coordination}$; $a_3 = \text{Cooperation}$

- B is a universe of n actors: $B = \{b_1, b_2, \dots, b_n\}$ (2)
- C is a universe r places: $C = \{c_1, c_2, \dots, c_r\}$ (3)
- D is a universe of j data:

D includes different kinds of information as weather (w); crisis-place (cp); victims (v); population (p); morphology-of-land (m); assailant (as): infrastructure (in); and crisis-situation (cs). Then the function D is represented as the intersection of r-tuples noted: $D(w_j, v_j, cp_j, v_j, p_j, m_j, as_j, in_j, cs_j)$ (4)

- F is the universe of q means : $F = \{f_1, f_2, \dots, f_q\}$ (5)
- T the set of I time : $T = \{t_1, t_2, \dots, t_i\}$ (6)
- The linguistic modifier is a set of atomic terms defined and in relation to the feedback experience of the expert: $G = \{\text{equal}, \text{increase}, \text{decrease}, \text{probably}, \}$ (7)
- The State is defined as a function composed by actors (b), place (c), means (f) and data (d).

$$\text{State} = \{(b_1, c_1, f_1, d_1), (b_2, c_2, f_2, d_2), \dots, (b_n, c_r, f_q, d_j)\} \quad (8)$$

- The function event is composed by the couple action (1) or data (4), and by actors (2).

$$\text{event} = \{(a \text{ or } d_1, b_1), (a \text{ or } d_2, b_2), \dots, (a \text{ or } d_j, b_n)\} \quad (9)$$

$$\text{For all } a \in \{a_1, a_2, a_3\}.$$

The objective is to define the impact-stress function O composed by the functions state (8), events (9), the sets of the time (6) and the linguistic modifier (7).

$$O = f(\text{state}, \text{event}, T, G) \quad (10)$$

By using the impact-stress function O we can generate several situations during a crisis situation.

"NOE" THE GENERATOR OF THE SITUATION

The generation of situations with "NOE" can be illustrated on a study of a real case.

Example of Stress Impact During a Crisis Situation

A real case is studied in a crisis management situation. The author's observation can reveal some aspects of the impact of the stress during this event. It also provides, a timeline for actors' reaction with a general view on errors committed, means used, the places where the event was reported and, different information and data known. For this, a retired officer of the Algerian Army has been interviewed (as an expert) about one of crisis situations he dealt with. This case is about a terrorist attack on two villages in the Algerian mountain. The case analysis shows us some impact of the stress: (I) Imposing a decision without measuring the impact and the consequences. (II) Repetition of expressions and words. (III) Silence, missing decision and actions. (IV) Simplification of the situation and inadequate means and actions.

Generate Situations From the Case Studied by Using "NOE"

For our study, we apply the generator "NOE" to the scenario cited upper. We observe how some data like victims, place, and assailants using the linguistic modifiers can change. These help the manager to have the best understanding of the situation and to take the best decision in managing the crisis situation. Applied the fuzzy generator on the same example, we can also note that for the same state and for the same action, communication (silence), the fuzzy generator can generate three situations (**Erreur ! Source du renvoi introuvable.**). Otherwise, for the same state we can use other actions and with the fuzzy generator, we can generate a considerable number of states.

CONCLUSIONS

The present study suggests a crisis situation predicts, which generate a number of states of crisis. This is based on the stress impact representation by using experience feedback during a crisis. An experience is presented and modeled as specialization of existing crisis management ontologies. Based on that, we answer the main question. A representation is illustrated in a real case study in order to verify its applicability. The predict system is based on the Fuzzy theory that helps to deal with uncertainty and dynamicity of situations. So, for the same state and for the same action, the predict-system can generate a variety of situations. The natural progression of this study is to implement "NOE" generator in a learning system. This can help the crisis manager to explore different situations of the crisis and discover stress consequences to deal with.

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