Modeling Human Modifier Diffusion in Social Networks

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ABSTRACT

This paper focuses on modeling the impact and actions of adverse events on populations, networks, groups and individuals. In the proposed approach social network evolution is analyzed for different scenarios. Therefore, this research aims at developing models to reproduce the diffusion of Human Behavior Modifiers (HBM) in social networks. This is related not only to PSYOPS in traditional operative scenarios, but also to the reproduction of the impact of terrorist actions, contaminated or defective product lots, the influence of news broadcasts as well as the diffusion of consumer fear. This research is based on the development of a dynamic simulation that combines continuous and discrete models to investigate hypotheses about the impact of several parameters and the response of different elements on the diffusion of these factors. The authors focus on fear diffusion, presenting simulator examples developed for military (i.e. PSYOPS) and civilian scenarios (i.e. food contamination) and for hybrid situations (i.e. deterrence during civil disorder). The goal is to provide interoperable stochastic models to complete statistical experimental analyses on social network behaviors to create realistic scenarios for CAX (Computer Assisted Exercises) and to support training.

ABOUT THE AUTHORS

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INTRODUCTION 1

Fear caused by terrorist attacks, pandemic fluxes, terrorist actions, natural phenomena or contamination of food and goods has a major influence on population behaviors and their demands. Even when minor problems are involved, the influence of different players (i.e. media or terrorists) and the manipulation of the event might magnify the severity of real problems and distort the perception of the event. It is very difficult to predict how people will behave. After "bad events" the population's reaction can become unstable or may even turn into behaviors that are dangerous for the community. Fear could be used to manipulate people, forcing them to be afraid of something, or to act in a different manner. In this approach the role of Social Amplification of Risk is important, Social Amplification of Risk involves the central idea that an adverse event interacts with psychological, social, institutional, and cultural processes in ways that may amplify (or attenuate) community response to the event (Kasperon). According to this theory, the effects of an accident or act of terrorism sometimes extend far beyond the direct damages to victims, property, or environment and may result in immense indirect impacts. When a mishap occurs, information flows through various formal and informal communication channels to the public and its many cultural groups. This information is interpreted largely on the basis of its interaction with the above processes. This interaction, in turn, triggers risk-related behaviour. Such behaviour, together with the influence of the media and special interest groups, generates secondary social and economic consequences that eventually call for additional institutional responses and protective actions. For these reasons, recent reports suggest that, in addition to forecasting possible economic impacts before a disaster and examining the long-term effects after a disaster, there is an urgent need for real-time modelling that estimates the potential psychosocial impacts of a disaster during the disaster while also examining and recognizing how they affect response efforts. In these cases it is critical to develop simulators that reproduce various scenarios to check system reliability and to find possible improvements. At the same time it is very important to identify a model that correlates fear with costs, and supports decisions about possible solutions for keeping the process under control and reducing risks.

Fear diffusion under these conditions could result in a very evident weakness and improvements can help to deal with adverse situations by estimating alternative reaction profiles of consumer communities.

The high number of interactions among the different phenomena suggests that simulation is probably the most effective tool to support decisions related to scenarios involving attacks on retail chains. By enabling technology to support decision-making processes, simulations can facilitate and simplify the recognition of different courses of events in order to mitigate the risks of operations in complex scenarios. Building a model that helps to explore, in advance, what can happen within a certain environment characterized by some endogenous and exogenous factors, if some conditions are met, reduces hazards, minimizes casualties and optimizes employed resources. The production of these models must take into account different dynamically linked parameters that evolve according to rules dictated by various elements and factors.

Training on how to meet these challenges and how PSYOPS might evolve is usually based on pre-estimated considerations. Today, however, these operations continue in very different frameworks where people and their behaviors evolve quickly and dynamically. So, pre-defined hypotheses as well as scripts to be included in the training are severely limited by validity ranges: in reality, interactions among the different phenomena are very significant and at the same time the natural evolution of psychological profiles becomes increasingly important due to both endogenous and exogenous factors.

The authors are currently developing a multilevel simulation that can federate different models and guarantee effective interoperation in a computer assisted exercise (CAX).

RETAIL CRISIS EXAMPLES 2

There have been numerous cases in which attacks on TV news channels have played a primary role in the flow of events and in managing the subsequent panic reactions.

In effect, it is interesting to note that some crises were caused by accidents, while others were the end result of malicious human behavior. In all cases, while the various players involved sought to take prompt action, the damage was often still quite significant.

In fact sometimes a real attack isn't necessary. It may be sufficient to spread false formation about a potential threat. So, it's evident that when modeling these scenarios, it is important to take into account the appropriate countermeasures, that we can define as "direct activities", as well as the influence on the media for the purpose of applying them among the subjects involved (indirect activities).

Network Modeling 1

The network is the tool through which different entities can interact and exchange any kind of information. Different rules can be applied to how, where and when a bit of information has to be passed by one entity to another one. It can be decided to adopt a topology, a protocol or a methodology to transfer the information and it can also be decided which rules are limiting an entity and which ones instead are empowering a different one. Once the information has been passed by 1 to 2 then it must be taken into account what 2 does before passing it to 3 or 4 or if there are any restrictions and it must be passed to 5 beforehand. Defining the path could help to understand the sort of modifications the information must go through and allow us to predict its end state networks are networks which can be ruled though peer-to-peer interactions. Within this context the entities are people from different countries, religions, backgrounds, education, etc. Today social networks are particularly popular thanks to the existing World-wide-based solutions. Therefore, in order to model social networks, it is critical to tackle the following issues:

- What are the endogenous and exogenous factors in a network?
- What are the rules of propagation?
- Do common practices have an impact on general behavior?
- If the network is a grid of entities and each entity is well defined and well modeled in terms of behaviors, is the interaction a subset of the previously mentioned behaviors?

Crisis Modeling 2

To study interconnections between fear and other factors, such as security measures, processes and media influence, the authors developed a multilevel dynamic simulation. Such an approach is presented in this paper.

In the event of a disaster, people's anxiety and perceptions of risk influence the amount of response efforts required to mitigate the threat. Their behaviors may accumulate and become collective social anxiety. Without a doubt, a disaster can cause tremendous damage to both physical entities (e.g., buildings, roads, factories) and humans (e.g., sickness, death). Disaster-induced negative psychological outcomes may take time to develop, whereas psychosocial effects start immediately when a disaster occurs. A typical phenomenon observed during a disaster is fear and collective anxiety, which represent common responses to imminent threats and actual disaster events. Such collective anxiety also can involve somatic reactions.

Because human behaviour is not only determined by a person's own internal decisions but also influenced by others during a disaster, people affected to various degrees tend to intertwine over time. It is necessary to examine first, how people perceive risk and quantify their behavioural reactions when facing a threat, and then model macro-level collective anxiety in the targeted population to analyze its effects on levels of social productivity. Psychosocial effects reduce social productivity and compromise response efforts. Moreover, these impacts can cause social disruption if no intervention occurs during the course of the disaster.

The relationship between emotion and risk perception may affect behaviours that managers and policy makers care about.

For example, after the attacks on September 11, the public's desire to avoid airline travel not only contributed to the huge loses suffered by the industry, but that behaviour resulted in an estimated 1,595 additional highway deaths. Travelers' willingness to travel to a destination depended on their estimate of terrorism risk and their degree of worry. The role of emotion may have a prominent influence on how communities respond to threats of the future. Emotional states have been demonstrated to affect cognitive evaluations, which in turn can affect emotional states. This reciprocal and self-reinforcing relationship affords the potential for fear to greatly intensify at the individual and societal levels, suggesting that effective policy must seek to mitigate both the real risks as well as irrational fears. This latter point appears especially appropriate with respect to a number of dire threats including pandemic flu.

Hypothetical damage scenarios have found that acts of terrorism had unusually large effects on perceptions of risk relative to comparable non-terrorist events. The mechanism involved (infectious disease vs. explosions) also mattered. They incorporated their findings into a system dynamics simulation model to show how fear might rapidly diffuse in a community following a terrorist attack. While panic is rarely seen, intense and prolonged fear in a community not only has implications for quality of life but may cause large ripple effects through the national economy.

Human modifiers could be modeled by operating on different layers and guaranteeing their dynamic interaction to combine the behaviors of individuals and societies.

In a general sense we have integrated macro models, micro models and meso models that guarantee the man-in-the-loop with the overall infrastructure

System theory provides a set of concepts and methods for modeling the dynamic behavior of complex systems by breaking them down into simpler interconnected components (coupled models). This recursive modeling stops when simple blocks can be defined (atomic models). These concepts and methods are very appropriate for representing the behavior of humans in groups and organizations through macro models. A macro model of humans in groups considers interactions between macro-level variables, such as unemployment, crime, education, poverty, etc.

In this paper the authors focus mainly on fear diffusion, but it's evident that by changing specific characteristics related to the phenomena it might be possible to reproduce other types of diffusion based on psychological factors.

With regard to fear there are different phenomena that can be summarized as follows:

- Fear Evolution & Cycle for individuals (i.e. hysteria, saturation, relaxation)
- Diffusion due to direct perception (i.e. impact of participating in the fear experience)
- Diffusion due to *relata referto* (i.e. social interactions)
- Diffusion by Media (i.e. communication techniques)
- Effect of psychological modifiers (i.e. stress)
- Effect of cultural modifiers (i.e. education)
- Effect of social modifiers (i.e. experience)
- Fear & Social Networks at Entity Level (i.e. mimic of current leader's actions)
- Fear & Social Networks at Population Level (i.e. sharing responsibilities)

For instance, fear models are affected by negative information provided by the media. It is essential to model an equivalent "bad media" level based on the value of equivalent time dedicated to the amount of time each broadcaster dedicates to the fear that triggered the crisis. This is the result of time functions that combine the shape and magnitude of the events and of the media representations. Bad media simulates different types of fear, such as spike panic, long tail fear, moderate apprehension or slow rising fear.

In addition, the decrease in fear is regulated by a "calm down" function that corresponds to a decay in the perception of fear (i.e. habituation, self-relaxation) and by the effect of positive actions and the diffusion of corresponding information,

The assumption is that fear should decrease, even without a remedy, but slowly, and with different profiles, until it reaches a steady-state condition.

Fear decrease also considers how people directly experience the threat, both in positive and negative terms, and how it spreads naturally in the community.

The media-related model simulates the effect of the four different media being considered: Internet, Radio, Television and Press. Each media had a different cost and a different effectiveness over time, caused by the different nature of each type of media. It's possible to decide how much to spend in each media campaign and how much delay time is needed before starting the campaign. The cumulative effect of a media campaign affects the calm down function, which in turn has an influence on the fear reduction factor.

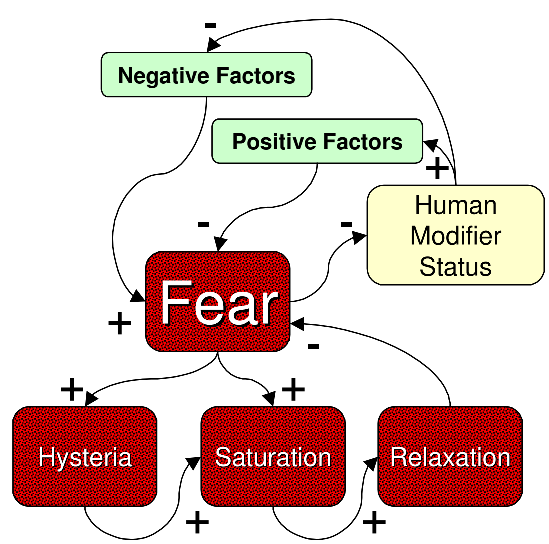


Figure 1. Extract of fear model Life Cycle

Obviously, these behaviors correspond to single aspects while the advantage in developing the simulation model is that each single event and factor introduces additional stimuli affecting the different models and algorithms while generating self reactions.

By tweaking parameters and factors it's possible to simulate many different fear diffusion scenarios and remedy campaigns.

The general architecture for the process is proposed in the following figure

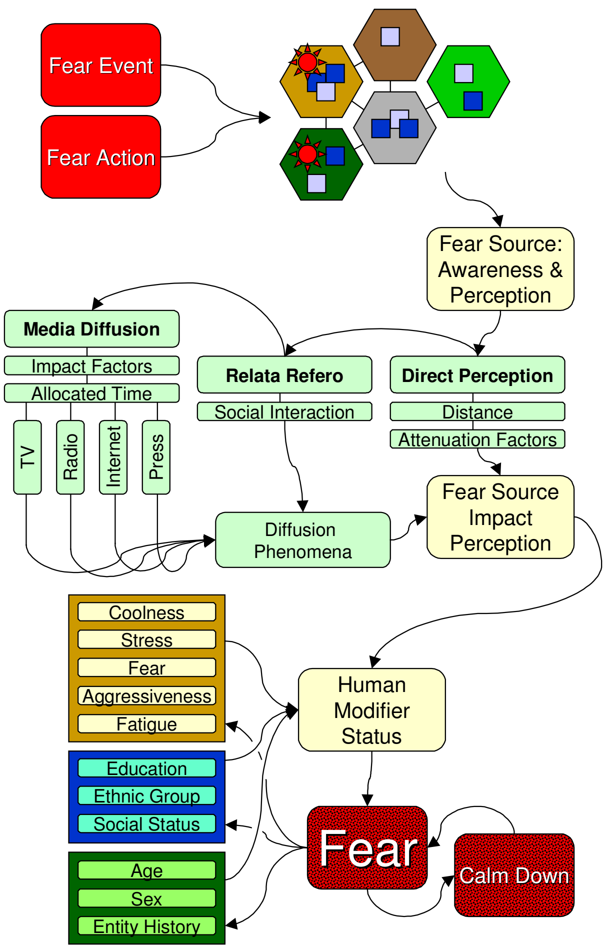


Figure 2. General scheme for fear diffusion Proposed Model 3

Some fear diffusion models were first implemented using StellaTM 9.1.0, in a joint effort with Dartmouth College, to develop I-ThinkTM models. DIPTEM (University of Genoa), Institute for Security Technology Studies (Dartmouth College), Liophant Simulation and MAST also collaborated during this phase. Models can be rapidly developed in this phase by writing some code, experimenting with different types of models instead of focusing on model implementation and code debugging.

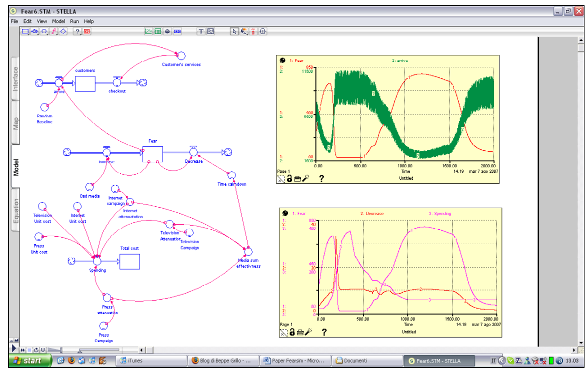
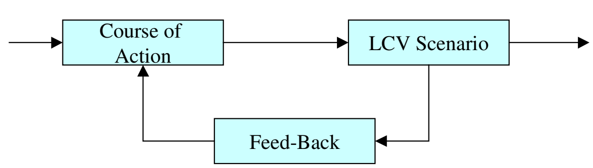


Figure 3. Demonstrator Developed To Analyze Fear of Food Contamination in Extensive Communities

Once basic models were successfully established a new demonstrator integrating the various aspects tested in the previous phase was started. This new demonstrator was implemented using multipurpose application implementation languages to facilitate manipulation of the results and to elaborate parameter definitions and settings. This approach ensured interoperability with other systems and offers multiple options for interacting with previously developed models and historical data tools. In the demonstrator it's possible to set the magnitude of a "bad event" and to choose any of four fear-over-time profiles: Panic spike, Long tail fear, Slow raising fear and constant moderate apprehension.

The model requests to set the magnitude of the Internet, Television and Press stabilization campaign, including the cost of each single action on the media. The simulator manipulates historical data based on a predefined stochastic distribution in order to quickly generate complex scenarios that are ready to be injected into a CAX and to be submitted for testing to trainees. One way to employ such a model is as a constructive model that evolves contextually with the entire simulation where virtual or even live assets interact with each other. The model could modify the run-time scenario by taking into account the way the players are modifying the environment through their actions and reactions. In other words, it could be considered a loop-back connection that "injects" the output of the entire scenario into the model (as shown in the figure).



Obviously, at this stage, their interconnection, in relation to interactions among different factors, is just based on hypothetical reactions.
However, based on their experience the authors suggest relying on the know-how of experts from the world of science (i.e. psychology, sociology) and users (i.e. planners, experts). In fact, even if the details of each correlation are unknown, there is usually some understanding of relations, which means that general scenario configurations can be verified and validated.
During this phase the simulator can be used to carry out experiments to continue the reverse identification process to best fit these parameters on previous cases or on subject matter experts estimations. This last aspect is particularly critical as it requires the use of ad-hoc numerical strategies to minimize the spurious effects related to the aforementioned feed-backs. Besides, an accurate distinction among model uncertainty, data errors and numerical approximations must be taken into account to perform a correct model identification. In fact, when simplified models are employed, the residuals (that is the difference of the experimental data to the values predicted by the approximate model) do not belong to a well-defined distribution function. Thus, the usual regression methods, such as those relying upon the maximum likelihood, can sometimes lead to seriously biased estimates. In this context, we refer the reader to the paper of Dovì et al., where a regression technique for avoiding either under- or overestimation due to compensation or cumulation of experimental errors and model deviations is discussed and efficient algorithmic schemes are proposed
Each reference variable is regulated by a differential of flows, which depends on various factors. Obviously, it takes time to properly tune these parameters before finalizing their values in the definitive model.

CONCLUSIONS 3

This paper represents the first step in developing models for analyzing the diffusion of Human Behavior Modifiers (HBM) in social networks with special attention focused on fear and other emotional reactions related to major crises or to PSYOPS.
Developing models for evaluating different strategies and solutions to tackle these problems and to identify the best reaction policy is a very critical sector. In addition, new technologies, enabling additional controls and checks, must be evaluated in terms of their impact on the entire framework.
From this point of view the simulation turns out to be the critical solution. If the model was properly designed, in a CAX (Computer Assisted Exercises) application it will have already been tuned to that scenario and to the possible related cases. As a result, it will soon be possible to introduce these phenomena and, in particular, to include an interactive and dynamic simulation affected by all the other actions and events.

The authors are currently finalizing the demonstrator over a set of scenarios in order to obtain increasingly better results in this new field of research.
This is possible by taking full advantage of the positive results already generated by previous studies, which are more closely linked the civil environment, since they focused on supply chain attacks and food contamination.

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