Interactive Simulation Technology for Crisis Management and Training: The INDIGO Project

Alexandre Ahmad
Olivier Balet
Jesse Himmelstein
DIGINEXT[1]

Arjen Boin
Maaike Schaap
CRISIS PLAN[2]

Paolo Brivio
Fabio Ganovelli
ISTI-CNR[3]

Enrico Gobbetti
Giovanni Pintore
CRS4[4]

Jean-Baptiste de la Rivière
IMMERSION[5]

ABSTRACT

To face the urgent need to train strategic and operational managers in dealing with complex crises, we are researching and developing an innovative decision support system to be used for crisis management and interactive crisis training. This paper provides an overview of current decision-support systems, simulation software and other technologies specifically designed to serve crisis managers. These findings inform the design of a new interactive simulation technology system, where a 3D Common Operational Picture (COP) is shared between tactile digital whiteboard in the command center and mobile devices in the field.

Keywords

Crisis management; crisis simulation; Augmented Reality; visualization systems and software; image-based rendering

INTRODUCTION

As crisis managers at all levels of government confront new types of crises (Boin, 2009), there is an urgent need to train strategic and operational managers in the tasks, complexities, patterns and pitfalls of crisis management. Moreover, given the increasingly complex nature of crisis management, there is a growing need for decision support systems. This paper presents a new interactive approach that can be used for both crisis simulations and for decision support. It aims to fill a void in practice. A study of the literature, described prototypes, and existing software – together with extensive end-user consultations – informed this project. We begin by reporting the findings of the underlying study. We then describe the various elements of the INDIGO system and conclude by discussing the added value of this system in light of practitioner demands, shortcomings of existing tools and early validation results.

STATE OF THE ART

This section reviews core technologies that are available to crisis and emergency managers. We performed a desktop study, studying selected journal articles using keywords (published after the year 2000).[6] In addition,

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[1] alexandre.ahmad@diginext.fr, olivier.balet@diginext.fr, jesse.himmelstein@diginext.fr

[2] boin@crisisplan.nl, schaap@crisisplan.nl

[3] paolo.brivio@isti.cnr.it, fabio.ganovelli@isti.cnr.it

[4] gobbetti@crs4.it, gianni@crs4.it

[5] jb.delariviere@immersion.fr

[6] Journals accessed: *Communications of the ACM; Journal of Contingencies and Crisis Management; Simulation and Gaming; Journal of Management Information Systems; International Journal of Information Technology and Decision making; International Community on Information Systems for Crisis Response and Management; Decision Support Systems; Cognition, Technology and Work; Human Computer Interaction 2009; Journal of Crisis and Contingencies.*

we searched the Internet for relevant product descriptions, using the same keywords and following up on names/products mentioned in the literature. We organized our findings and observations into two categories: crisis simulation software and Decision Support Systems (DSS).

We found that the literature reports primarily on design specifications, ideas and "prototypes"– very little can be found on assessments/evaluations of software-in-use. As one pair of experts noted: "Even the most advanced information technologies did not seem to notably contribute to the faster relief of affected populations" (Van de Walle and Turoff, 2007:29; cf. Mendonca et al, 2007). In addition, the research makes painfully clear that IT/software engineers and crisis scholars do not communicate, i.e. they are clearly unfamiliar with each other's work and key findings of that work. This leads to IT products that crisis managers do not need; it also means that crisis managers are not familiar with the technological possibilities available to them.

Simulation tools

In general, we can state that the crisis literature pays little attention to the use of IT-based simulation tools (for a general overview, see Dugdale et al, 2010). In our search for simulation tools, we distinguished between three types of audiences: individual responders, response networks, and leaders/executive teams. There is a large number of simulation games that individual responders can use to enhance their skills (see de Brake et al, 2006). The developments in this product category are spectacular. Below we briefly describe a few examples of simulation software we found. The CRIMSON system developed with the support of the European Commission combines Simulation and Virtual Reality technologies for the simulation of complex crisis and contingency scenarios that would be difficult to recreate and validate in real conditions (Balet et al, 2008).

The CRIMSON technology has been adopted by industrials and military forces. The Virtual Terrorism Response Academy, created by Dartmouth's Interactive Media Laboratory (discussed by Losh, 2007) is a reusable advanced distance learning environment that supports the development and dissemination of terrorism response courseware. This academy offers fire, EMS and law-enforcement personnel more than 16 hours of practical training about chemical, biological, radiological, nuclear, and explosive threats. "Ops-Plus" features multiple videogame-style simulations that put the player in tactical terrorism-response scenarios[7].

Hazmat: Hotzone is developed by Public Health Games at University of Illinois at Chicago (Losh, 2007). It is a networked, multiplayer simulation that uses videogame technology to train first responders for chemical and hazardous materials emergencies. For the first responder trainees, the primary objective of the simulation is communication, observation, and critical decision making. The instructor creates a hazardous scenario with such factors as the location of the hazard, its effects, the weather conditions, and the placement and symptoms of the victims involved. Students assumes the role of the incident commander and establishes a decontamination zone. The others students communicate over radios and respond to the situation accordingly[8].

The Civil Protection Application School of Valabre (ECASC, France) has developed software that confronts, through virtual reality, first responders with situations close to those they will experience on the terrain. The aim of the simulation tool, based on a 3D map system, is to enable each trainee to experience his own operational situation, according to his position and actions he/she conducts. The full range of forest firefighting equipment is integrated as well as fire hydrants and water tanks.

The simulation and management tool the ENSOSP is dedicated to chemical risk training. The aim is to provide a commandment and decision-making training in an emergency context, by closely recreating the operational context through a realistic visualization of the events, while staying in contact with authorities, victims and responders. It is a virtual reality simulator integrating virtual 3D mock-ups, physicochemical mathematical models, operational models describing the actions, condition and evolution of the resources, and pedagogical models for evaluating the knowledge of the trainees.

We note that these systems focus solely on training purposes and not created as a DSS. Additionally, we did not find (articles on) software that is made specifically to train crisis response networks, nor executive leadership teams. The INDIGO project aims to develop a tool that can bridge this gap to train crisis response networks and executive leadership teams simultaneously, as well as serve as a DSS during real crisis management.

Decision Support Systems for Crisis Management

The literature describes a long history of trying to design DSS for crisis and disaster managers. The development of an effective DSS for crisis management is something of a Holy Grail – everybody seems to

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[7] VTRA (2011) website: http://iml.dartmouth.edu/education/pcpt/vtra/ops-plus/1.0/

[8] HH (2011) website: http://www.etc.cmu.edu/projects/hazmat_2005/screenshots.php?page=0

agree that an effective DSS could have revolutionary impact on the practice of crisis management. The assessment that emerges from reading the literature is somewhat pessimistic, however. We found many ideas, design premises, and even prototypes – but very few descriptions of working systems. The working systems typically organize communication flows; they do little in terms of decision support. The most accurate premises can be found in Turoff et al (2004; cf. French and Turoff, 2007; see also Hale, 1997; Carver and Turoff, 2007; and Kim et al., 2007). Even though this is a much-cited piece, it has not been translated into working software (personal correspondence with Prof. Turoff). In addition, the latest development mentioned in the literature is the use of user-generated content (Palen et al, 2007; Lafranchi and Ireson, 2009). People on location, from first responders to citizens, report in *real time* on the situation through such means as Twitter, Facebook, wikis, etc. This leads to an additional design principle: an effective DSS should be able to "mine" these data sources to help create an accurate picture of the situation.

The INDIGO system's conception is inspired by the first 8 premises cited in (Turoff, 2004):

1. Premise 1: The system is a decision support tool. By "plugin" an optional trainer, it is enhanced by a trainer's directives. Only one tool is designed for the trainer, and has a connection to all others;
2. Premise 2, 3, 5, 7,8: Information is created, shared, and visualized in real time. COP information is organized by type and can be filtered, e.g. localization information is visualized on maps;
3. Premise 4, 5, 7: Even though one must be able to see any information shared, the way to visualize the information differs. For example, in a crisis center many people are gathered around a table. Thus, a specific digital white board was designed for this use. An mobile tool that can be carried easily and able and still be connected was designed for operational commanders on the field.
4. Premise 3, 6: Crisis managers in crisis centers are often away from the crisis location and do not see images of the disaster. Having a clear picture of the problem is part of the decision support. A novel technology has been developed for creating and exploring 3D environments thanks to real-time photos streamed. Moreover, the INDIGO symbology takes information validity into account by displaying planned and unsure information with different line styles in the frame shape and colors.

2D/3D COMMON OPERATIONAL PICTURE SHARING

As a collaborative tool, each shared information is time stamped, recorded, geolocalised if possible, and linked to its creator. In addition, items can be filtered by the creator's hierarchical belongings. One can show or hide information originating from other groups to respectively fetch data or focus only on their current concern.

Messages, Problems, Stats, Checklist, Story, Maps

We have designed several distinct information workspaces: Problems – A list of current problems to be dealt with. Statistics – Important numbers; Checklists – Tasks or important actions; Decisions – A log of decisions made. To help actors converge on a maps, we have created a 2D and 3D digital map component that allows natural annotation that can be shared with, and modified by, all other users of the system. Based on VirtualGeo3[9], 2D and 3D visualization can help crisis responders understand complex terrain or urban environments, especially when coupled with simulation services. In a larger sense, 3D can help one visualize what the situation appears like to those on the ground. For the purposes of training, we use 3D to add a level of realism thanks to Virtual Reality.

Symbols

To encourage communication across organizational boundaries, we have developed an European symbol set dedicated to crisis management. Unlike the FGDC[10] set, the goal is to gather the smallest set covering most emergency needs. Including incidents, resources/activities, and infrastructures, these symbols can be rapidly placed onto the map, and annotated with extra information, such as the number of vehicles, or the number of free hospital beds. In the cases for which this symbology proves insufficient, maps can also be annotated in a free-form fashion with lines, polygons, and text, or even with one's specific symbols.

9 http://www.virtual-geo.com/

10 http://www.fgdc.gov/HSWG/index.html

Mobile

For operational actors, the use of the mobile tool is twofold: to receive situational information from the trainer, that is simulated data, and to report to their hierarchy. Situational information may take a variety of forms. For example, an operational actor may receive a text message about a feeling of heat or an image of an approaching fire even more explicit. Reporting to their command is done both transparently, through automatic transmission of their position thanks to GPS as well as explicitly through audio, video, and text messages, which can be preformatted. The interface has been designed to reduce the time and difficulty of reporting in order not to distract from the pressing work at hand.

Whiteboard

Whiteboards have always been a device of choice to share ideas, display data and draw content that can be viewed by many people gathered in a room. The interactivity and flexibility of computers also bring many advantages, which makes video-projection a must-have in today meeting rooms. Some solutions, like Smarttech's Smartboard[12] have tried to bring the two practices together and offer ways to display video content while interacting in a natural manner. Crisis management could benefit from such interactive whiteboards and other collaborative devices, as shown by the ESponder[13] project. In the scope of INDIGO, we are trying to integrate all the relevant interaction hardware and visualization software technologies within one single system. The goal of such a device is to display the COP and associated information to the group gathered in the crisis center. The equipment is flexible enough to be easily transported, while still adequate to be comfortably seen from anywhere in the room. Interactions are simple enough that little to no training is required to use the device, while standard interaction tools that are currently used, e.g. like a pen on a whiteboard, are supported.

Photo World

We strive to improve navigation/location awareness in complex environments through the exploitation of 3D or near-3D data. The 3DNSITE module enhances the COP by adding a detailed 3D navigation in a specific operational site. The tool allows browsing of large collection of photographs aligned, as well as to enrich the collection by adding new photographs of the same environment. Exploring a collection of thousands or more images of the crisis environment poses a challenge by itself. The 3DNSITE tool includes an advanced compact image-browser and a multi-resolution 3D model renderer, integrated with iconic visualization of the images in the 3D space and on-the-fly projection of the selected image on the 3D scene. Navigation is driven in both the 2D and the 3D spaces, with smooth transitions between them in an integrated seamless fashion.

Training

The trainer tool provides a way to create a scenario. A scenario includes a list of actors involved, groups and prerecorded multimedia messages. The trainer can define (multimedia) press events, that can be displayed on a dedicated device to emulate press coverage and to retransmit interviews performed during the exercise.

CONCLUSION AND FUTURE WORK

A first version of the INDIGO system has been evaluated by an industrial natural gas storage site in France in collaboration with local firefighters. The scenario was mainly concerned by natural disasters. The feedback of the participants and evaluators is currently being used to further improve the system. The next version will be tested during an exercise is Stockholm, were the scenario will focus on human panic and organization. Initial

[12] Smarttech (2011) website: http://smarttech.com/

[13] http://www.e-sponder.com/

feedback of our end-user group suggests that INDIGO facilitates the effective organization of large-scale exercises. Moreover, this system makes it easier to establish a COP, which should enhance crisis management capacities at the strategic level.

In future work, we envision the system to provide more automatic 3D scenario editing, allowing for complex branching scenarios coupled with interoperability with third-party fire, smoke, and other simulation services. Moreover, we plan on moving beyond message-based situational awareness and into using the mobile device as a "window" into the virtual world of the simulated crisis. This will relieve the trainer of the significant task of preparing a large number of messages to be sent.

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