



Town Protection Simulation

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Abstract

In this paper, the authors propose an innovative simulator devoted to support education and training during a crisis affecting a town, with special attention to pandemics and CBRN (Chemical, Biological, Radiological and Nuclear) Threats. The proposed virtual simulator includes agents and it is devoted to provide examples, interactive scenarios and serious game experiences to operators and strategic decision makers in the field of crisis management, addressing such issues as protection of critical infrastructures and city's residents and dealing with riots, aggressive demonstrations and pandemics.

Keywords: Pandemics, MS2G, Education and Training, Modeling & Simulation, CBRN, Intelligent Agents, Demonstrations, Riots

1. Introduction

Nowadays, simulation is often used to train operational people, managers, decision makers; obviously these supports could be very effective also in education, operational planning and operation support. Hereafter, the authors present an innovative approach devoted to address CBRN (Chemical, Biological, Radiological and Nuclear) scenarios with special attention to training, education and evaluation of decision makers who deal with crises and emergency situations involving crowd and riot control; furthermore, the solution could be used also to support planning and evaluation of different strategies. In particular, TOPRO (TOWN PROtection) is devoted to support the operations related to protecting a town or a region during epidemics and contamination crisis.

Indeed, in this period the presence of covid-19 crisis makes evident the problem related to a biological

contamination and the difficulty to handle it and its impact on the population; it is evident that there is not possibility to have full success in handling a pestilence or pandemics without victims as we call it nowadays due to the dimension of the problems and the limits in available resources that cannot be prepared and maintained in advance in sustainable way; therefore, it is also clear that proper planning, valid education, effective training could help in mitigating the impact of these phenomena.

Due to these considerations, it is very important to develop models and simulations able to prepare operational people, decision makers in addressing a CBRN Crisis, if possible with solutions that could make it easy to deploy and use for multiple purposes such as education and training. In this sense the present paper proposes a solution devoted to education respect pandemics and contamination crisis over an urban area by adopting the innovative paradigm of MS2G (Modeling, interoperable Simulation and Serious



Games) in order to make it open to be integrated with other models and systems as well as to result engaging and intuitive for a large user community (Bruzzone et al. 2014a).

The authors present hereafter the model structure and approach that has been developed and used in education and training during the covid-19 crisis in spring 2020.

2. State of the art

There is a growing interest in crisis simulation, therefore there are still many aspects not completely covered by simulation models or addressed by specific solution usable for their application. For instance, in epidemics many scenarios have been investigated along years ((Dietz et al., 1985; Morris 1993; Avalle et al., 1995; Wilson et al., 1997; Allen et al., 2008; Chao et al., 2010).

In facts the use of agent based simulation introduced additional capability in mapping complex aspects of pandemics and reproduce the diffusion over the population (Avalle et al., 1999; Bossomaier et al., 2009; Mao & Brian, 2011, Bruzzone et al. 2011). Along the years the studies were addressing also specific cases such as biological warfare or impact on business and work activities of natural epidemics (Avalle et al., 1996; Carley et al., 2011; Easton et al., 2011). So simulation has been very active in modelling epidemics in recent major epidemics such as Avian Human Influenza or H1N1 (Kim et al., 010; Bossomaier et al., 2009); nowadays the data about current covid-19 crisis are still very vague and affected by high uncertainty, therefore the use of simulation models allows to investigate different hypotheses on the key parameters and to evaluate the impact of alternative decisions in terms of risk to support a more effective crisis management.

Nowadays there is evidence possibility to connect the impact of CBRN threats with other new aspects such as hybrid warfare, STRATCOM, cyber & media attacks with special attention to their impacts on human behaviors (Di Bella, 2015; Bruzzone et al., 2015, 2018a, 2019; Sathyamoorthy, 2015; Sturm et al., 2017). These aspects turn to be even more crucial in urban high density areas and require proper models even of the whole town by introducing Intelligent Agents (Bruzzone 2014a, 2015). In this context the different layers (e.g. health care, logistics, critical infrastructures) represent critical elements to model in order to study potential vulnerabilities against containment of a pandemics (Bruzzone et al., 2014b, 2017a, 2018b). Even major events such as sport games or civil disorders could have a great impact on this elements (Bruzzone & Massei, 2017b, Valentine et al. 2020).

3. Modeling Urban Protection vs. Pandemics

In case of protecting a town from epidemic diffusion, it is necessary to model this complex behavior and to address major aspects and usually the combination of M&S and AI results critical, for instance introducing Intelligent Agents able to reproduce people as well as assets operating over the terrain (Bruzzone et al., 2018a, 2018b).

Considering the complexity of this framework it is evident that there is a big potential to reuse and readapt models used for other purposes such as city planning (Bruzzone et al. 2018a) that is a great driver supporting the idea to adopt solutions based on MS2G paradigm that makes its use even more effective and simple especially over large number of trainees for education and training (Bruzzone et al. 2014a, 2018c).

In the past, several models were developed in similar way to address crises; for example, the IDRASS project addressed handling of emergencies caused by leakage of hazardous materials from Chemical Facilities and Nuclear Plants and allowed to educate and train personnel to interact with new assets based on autonomous and remotely controlled vehicles to reduce vulnerabilities and improve safety (Bruzzone et al. 2017b). In similar way the ongoing ALACRES2 project deals with emergency management in ports even considering covid-19 as a boundary condition adding complexity to the scenario; indeed, ALACRES2 aims to develop a virtual laboratory capable to support decision makers, education, training and development respect new emergency procedures and innovative solutions (Bruzzone et al. 2019b).

In current cases it was created a new system, named TOPRO (Town Protection) that get benefits of previous development and quickly readapt it respect a pandemics crisis; indeed the system was activated within one week during early phase of the covid-19 crisis and further developed along the months thanks to the synergy among different Simulation Team members. It is evident that in this context the human behaviors represent a major aspect, while new technologies could provide additional aids such as autonomous vehicles and IoT (Internet of Things) and they require to be mapped in new simulation solutions.. In similar way it is crucial to model the first responders as well as activities related to protection, cordoning of urbanized areas, planning of decontaminations and treatments and resource allocation. In TOPRO the current assets include among the others: police, military units, first responders, social networks and sensors. Additionally, TOPRO simulate the epidemics spreading as well as the movement of infected people and the phenomena related in order to introduce various possibilities of evolution of crisis.

4. Proposed Scenario

Definition of interesting, feature-rich, but realistic scenario is one of most important aspects of development of many simulation systems especially during a crisis. Indeed, in order to guarantee effectiveness of the training and evaluation, it is critical not only to provide high level of interaction and immersive environment to satisfy the user, but to reproduce realistically situation and instruments available to the player; these considerations are pillars of MS2G paradigm (Modelling and interoperable Simulation for Serious Games) and have been extensively used in the case of TOPRO, even due to the limited time available to train users to interact with the simulator (Bruzzzone et al. 2014a). For these reasons, the authors chosen to develop a specific initial scenario that is presented hereafter; indeed, TOPRO scenario is based on a combination of several actual situations and crises.

In particular, the situation includes following elements:

- Proximity to a country border, which causes cat-and-mouse game between persons (legal and not immigrants, criminals, commuters etc.) and border patrols. In some cases, tentative to surpass the border could result in demonstrations, riots and violence.
- Presence of critical infrastructures (e.g. a power plant) in the area requiring people to access and leave as well as to introduce a potential asset to be protected. In such case the game requires additional attention to guarantee its security, while in some cases border-crossing persons could be hidden guided by someone who aims such critical infrastructure.
- A medium size town, characterized by presence of population with different ethnics and cultural backgrounds, living their own life cycles.
- Specific public services (police, healthcare, firefighters etc.), additional armed forces caused by presence of the critical infrastructure and/or assigned to decontamination activities and health care extra support
- Non-homogeneous terrain, which includes rivers, mountains and swamps which from one side limits possible movements of persons, from the other one obstruct its detection.
- Presence of an external factors or their combination, which shake previously stable situation and causes necessity of immediate intervention for its remediation. For instance, it could be presence of refugees, virus, spill of dangerous substance in the zone of interest as well as tentative of violent intervention masked initially by apparently peaceful crowd.

Hence, the major threat to the territory is represented by potential antagonists (e.g. terrorist groups), which are trying to penetrate the border with different objectives, and by distinct means. For example, they could move by walk, use bicycle, bike or a car, which means their interception harder, while increasing also uncertainty in definition of their location in time considering possibly elevated movement speed.

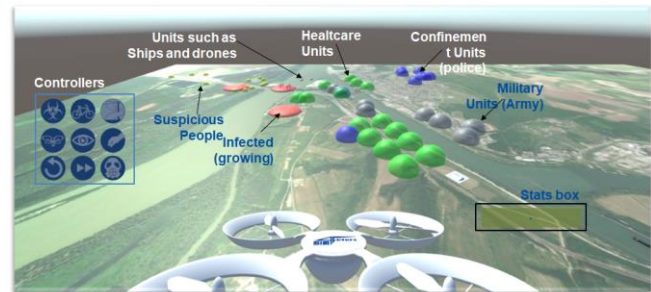


Figure 1 TOPRO interactive presentation

Considering these aspects, TOPRO proposes itself as a serious game devoted to educate people in containment of a crisis and in responding to critical conditions during protection of a town from epidemic diffusion. In these case, the main goal of the players is to handle the waves of people potentially infected trying to enter into the area due to their tentative to leave dangerous places or other reasons. So checkpoints and testing facilities are set on the border between the safe area and the infected one and impact of demonstrations and other actions are reproduced dynamically during the scenario evolution by TOPRO simulation.

From the other side, the player is put in command of the forces composed of:

- Police, which has limited capability to hold incoming flows of people, but is relatively fast in the city and can be deployed rapidly; indeed, police units are equipped with cars and motor bikes, which grant them high mobility. These units are available starting from the first moments of the game.
- Military forces, units with higher capacity to handle adversary, each one specially focused on protection or decontamination missions. However, they are transported by trucks, which lowers their speed on the road and require additional time for deployment into the area with exception to few units already into the area. These units are available only after some time after the start of the scenario.
- Autonomous Assets to be used in order to conduct surveillance and search in urban areas and bordering rural zone
- Containment forces - troops specialized on dealing with riots and insurgents. Their operation is

similar to the military forces and related to military police and/or specific units.

5. The Simulator Interface

In order to facilitate familiarization of the user with the simulator, interactions are implemented in a way similar to the Real Time Strategies (RTS).

Indeed, this type of interaction is known to most of the users and allows adapting training by gaming approach. In particular, the user can select assets, check their information (type and affiliation, status, type of vehicles, number of units etc.) and give relocation command, which is done by means of drag and drop of units on the map as proposed in figure 1.

The unit transfer includes initial delay caused by loading and preparation of vehicles, while their movements are limited to the ground surface and performed taking into account maximum speed and external conditions (traffic, weather). At the beginning, the user can choose one of previously mentioned threats and set initial location of troops, infected people and incoming crowds.

During the game, the players assign commands to controlled assets: for instance to move around in the virtual world and check people, acquire data. The simulation could be played at different time speed (e.g. real time, fast time) depending on the purpose of the game: e.g. education vs. training). A specific metrics is defined to evaluate the performance of the players; indeed, the simulator calculates scores, which is used for efficiency evaluation of the player in terms of his success rate (e.g. capability to block epidemic outbreak), responsiveness (e.g. time to succeed) and efficiency (e.g. number of units and costs of operations).

The simulator includes several running modes:

- Cinematic. TOPRO shows a predefined scenario and moves automatically all assets which otherwise would be controlled by the user. This mode looks like a virtual cinema, where the player can move around the world to better observe the actions and understand the dynamics of events.
- Free Play. Familiarization scenario, in which player is enabled to move freely units in order to become more familiar with moving speeds and delays as well as with other aspects of operation of units; in this scenario the user creates different initial conditions from where to run the classical scenario of crowd pressure over the checkpoints to enter into the town.
- Competition. In this mode, the player starts from a given situation and tries to contain the threats by using controlled units.
- Analysis, which allows to the simulator to calculate efficiency of actions conducted by the player

respect some infected people penetrating the area. In particular, it evaluates time required to identify, track and block these infection agents as well as the percentage of successful containment obtained, quantity of involved assets and cost of the entire operation.

As mentioned, immersive property is one of the key requirements for efficient training on gaming. Indeed, the authors used the Unity 3D for implementation, which allows easy integration of the program with different devices. For example, it is possible to integrate Virtual Reality headsets (e.g. Oculus Rift) as well as Augmented Reality smart glasses (e.g. Microsoft HoloLens). Indeed, based on experience of the authors, current Mixed Reality (MR) solutions could be very effective in training (Bruzzone et al. 2018c, 2019).

6. Conclusions

TOPRO has been used for education and training and it is currently subjected to further developments respect new applications and scenarios. Indeed, based on tests already conducted we obtained several proposal from Subject Matter Experts (SME) to apply for different training and educational programs devoted to address different audiences.

TOPRO is promising in terms of results and it could be even considered to evolve in order to support operational planning as well as other actual issues, such as riots and violent manifestations in addition to covid-19 pandemics.

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