Development of International USAR Coordination Exercises Simulator Based on INSARAG Methodology

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Abstract

Earthquake is a sudden, devastating natural disaster which causes casualty and catastrophic losses to human society and economy. If USAR (Urban search and rescue) operations are well coordinated, more opportunities will be presented for more teams to rescue more. The INSARAG Guidelines is recognized by the UN General Assembly Resolution 57/150 as "a flexible and helpful reference tool for disaster preparedness and response efforts." In order to master the INSARAG coordination methodology more effectively and efficiency, USAR teams must be trained properly. One strategy for enhancing the immersive training experience is using virtual reality technology to build Virtual-reality exercises simulation system. The article reports on the experience of virtual reality technology for increasing levels and quality of training for USAR team management. The interactive virtual simulator-"International USAR coordination simulation system" has been created by using unity3d and 3Ds Max programs in China National Training Base for Urban Search and Rescue. This article presents a study on how International USAR coordination simulation system is used to design and conduct operation coordination exercises. It also details the system architecture and realistic simulation of operation coordination activities such as establishing Reception/Departure Centre（RDC）, USAR Coordination Centre（UCC）and Base of Operation（BoO） and so on. After application in CISAR training, results indicate that participants can immerse themselves in computer-centred exercises and imagine what it is like to actually be handling that emergency. Authors found these exercises to be effective in developing participants' abilities to operate in disaster coordination management, especially suitable for application in preparing for INSARAG External Classification.

Keywords: INSARAG, Coordination Methodology, Simulation, Exercises Simulator

Introduction

Earthquake is a sudden, devastating natural disaster which causes casualty and catastrophic losses to human society and economy. As the tragedy of Wenchuan in 2008 so graphically illustrated, we cannot stop earthquakes. We cannot even accurately predict them. We have no choice but simply to be as prepared as we can to respond rapidly to the particular kind of devastation they provoke. Earthquake rescue is a necessary means to decrease the loss. USAR team is a rescue organization that supply with searching and rescuing victims in cities

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after disasters occurred. If USAR operations are well coordinated, more opportunities will be presented for more teams to rescue more.
The INSARAG Guidelines, prepared by USAR responders and representatives of INSARAG members countries, is recognized by the UN General Assembly Resolution 57/150 as "a flexible and helpful reference tool for disaster preparedness and response efforts." It is living document, being improved with the lessons learned from major international USAR operations. It is also the reference document for capacity building at all levels. The Guidelines represent best practices, and all affected and assisting countries are encouraged to actively implement and practice these internationally accepted procedures and to contribute to its development.
Disaster training is crucial to the mitigation of casualty associated with disasters. Conducting exercises regularly is also crucial to avoiding a disaster or preventing mass causalities. In order to master the INSARAG coordination methodology more effectively and efficiency, USAR teams must be trained properly. Virtual reality simulation is a teaching methodology that has the potential to be a powerful educational tool. Virtual simulation may be a low-resource solution to teach principles of INSARAG methodology. One strategy for enhancing the immersive training experience is using virtual reality technology to build Virtual-reality exercises simulation system.
Research carried out in recent years has put forward virtual reality simulation frameworks as a possible solution to increase the efficiency of training. During the interactive operation, with the generation of a novel idea of design in the virtual space by the user, his/her brain activation state alters accordingly. Researchers worldwide are conducting research on Virtual-reality exercises simulation system. Computer hardware and software have been applied to emergency exercises conducted in developed countries, such as emergency management software exercises, record database exercises and scenario simulations. Advanced disaster management simulation created by ETC offers challenging true-to-life virtual environments for training teams in command and disaster management on all levels. Trainees gain the confidence, practical experience and decision-making skills needed to solve real-life incidents. The multilevel ADMS-Command training suite includes an on-scene command room with a 180-degree immersive theater screen, four field unit positions and an emergency operation center. The VSTEP Company developed RescueSim, a virtual training platform that realistically replicates over 20 different 3D environments used to training different emergency services and other instances. These studies are primarily on-site emergency command, decision-making and rescue strategy exercises mostly for on-site emergency management rather than international urban search and rescue team. Referencing the experience of other countries, we created the interactive virtual simulator - "International USAR coordination simulation system".

Methodology

We developed the "International USAR coordination simulation system" by using unity3d and 3Ds Max programs in China National Training Base for Urban Search and Rescue. We implement the simulator that can undertake international USAR coordination activities exercises. These exercises provide relatively realistic earthquake disaster scenarios and a vivid international rescue background. The coordination simulator is an interactive virtual reality simulation system for training international urban and rescue team. The system is structured in five modules aligned to its key functions, Scenarios editor, Implement module, Evaluation module, Record module and Simulation platform.

The system architecture and work-flow are shown in Fig.1.Virtual earthquake disaster scenario editor is used by exercise controllers, to design urban 3D scenes, earthquake disaster and secondary disasters events. The editor visually designs virtual 3D city buildings and coordination mission background environment. The teachers prepare scenarios. Virtual disaster exercise scenario editor is used by exercise controllers that usually acted by instructors of urban search and rescue training base to design urban 3D scenes, disaster and secondary disasters events. The editor visually designs virtual 3D cities and emergency events, including disaster scale, the location and extent of secondary disasters, the number of victims, rescue missions. The instructors prepare scenarios. Exercises consist of virtual 3D environments, including airport, residential section and a central business district where dynamic safety and security incidents are created. The controllers select and customize scenarios from a library. The Director Module controls and runs exercises by the controllers. The controller inputs disaster event information. Exercise participants analyze event information through the virtual environment and propose solutions or make decisions using Implement Module. Observer oversee exercises and score participant performance by the evaluation module.

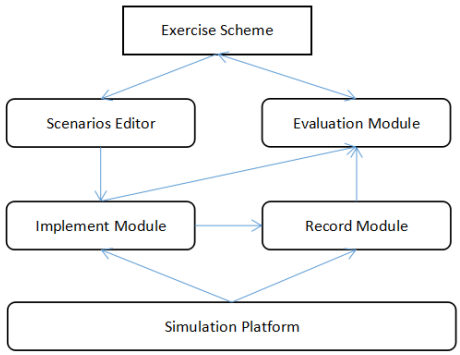

Figure 1. The system architecture and work-flow

Based on actual disaster response needs and INSARAG, the aims and goals of an exercise first must be defined. That is, who will take part, what problems are to be solved and what the desired effects should be achieved in the exercise. The central criteria for defining aims and goals are the presumed roles and tasks that participants may take in future rescue mission. Aims and goals must be clear and specific, defining who, what, where, when, why, and how. These are the starting points for planning and preparing the exercise. Exercise controller design the overall plan of the exercise according to different exercise aims and goals.

With basic aims and goals defined, the next step is to develop a 3D city and surrounding areas, editing disaster scenarios to be used during the exercise. Disaster scenarios are based on the area's geographical location, topography, population, buildings, potential risks, hospitals, and the resources of the earthquake region simulated. Disaster scenarios include disaster scale, casualties, building collapse, secondary disasters, evacuation needs, the degree to which adversely affected areas are isolated, and persons affected, goods distribution, disaster prediction and development. The hypothesis of the disaster also should learn from the historical earthquake response. Inject Scripts should be designed based on the operation recycle, response process, trainee knowledge background and experience learned from practical disaster response. The exercise controller edit scenario according to Injection Scripts and set event triggered mechanism.

The establishment of the overall plan of the exercise, on the one hand, is to guide the process of the exercise. On the other hand, it is also the basis for evaluating the exercise effect of the trainees. The overall plan of the exercises is converted into specific requirements that are used as the input parameters of the Scenario module and the Evaluation module. According to the requirements, the Exercise controllers simulate virtual reality disaster environment and missions through scenarios editor module. Trainees immerse themselves in the virtual disaster environment that are simulated by through Implement Module and interact with the virtual environment in real time to complete the exercise subject under specific missions. On the one hand, the results of the exercise will be saved in real time by the exercise recorder module for playback during the review stage. On the other hand, the results of the exercise are given to exercise evaluation module.
Our empirical study is based mainly on three virtual reality tabletop training that is crucial to prepare for international external classification exercise. Participants were team members in China international USAR. Exercise participants collect information, analyze situations, estimate casualties, handle emergency events, make decisions and propose solutions. Exercise participants used emergency management techniques during the exercise to analyze computer recordings of exercises, written opinions from participants and observation by teachers during exercises.

Conducting Exercises

Originally delivered in 2013 with the ability to train emergency management personnel in dealing with earthquake disasters, Emergency Decision Making Simulator has now been upgraded with the ability to train USAR personnel in coordinating rescue operation at all-scale disaster on-site. The scenario, designed by instructors with simulation curriculum developers, is a dynamic simulation of large scale destroyed city. The exercise system uses interactive game-like function that allows user operates directly with the mouse, as if the user will fully play in the space. The scenario presents a number of local citizen and emergency management personnel, international actors and relief items, victim. USAR must react appropriately and mitigate the developing situation to best avoid and minimize casualties. The action and results depend entirely on the choices made by USAR during the exercise.
The instructors have the ability to customize exercises to allow for different types of situations, including varying the number of victims and number of casualties. The virtual airport authority personnel and citizens can be controlled by instructors or entirely by the simulator's artificial intelligence engine in response to the trainee's efforts. At any time, instructors can make injects like second disaster, such as fire, explosion. This scenario is useful for management component of USAR teams in decision making under stressful conditions while working within International USAR operation procedures.
We designed several scenarios that International USAR Teams need to coordinate. These coordinated activities include coordination at arrival airport and coordination in the field.
The exercise based on computer simulates a disastrous earthquake in republic of Yepal, a fictitious country in south Asia. The epicenter is in the Town of Daman. Daman has suffered dreadful destruction in the earthquake，with more than 2000 houses totally collapsed. A variety of scenarios can be exercised, including RDC establishment, BoO site selection and planning, SAR coordination, work-site triage.

RDC Establishment Scenario

A large-scale disaster generally results in a sudden influx of assistance from the international community to the affected country. Response teams and relief supplies will converge in the country at one or more points of entry, seeking access to the disaster area. The RDC often serves as the first coordination stop for international response teams. All incoming international resources will need to navigate key processes, such as immigration and customs. Considering the airport is the most common entry point, we built the three-dimensional airport internal environment scenes include facilities about immigration and customs.

The exercise is based on the assumption–That no Reception Departure Centre (RDC) is in place, meaning that the first arriving INSARAG classified team will need to establish one. RDC staff should become familiar with the basic immigration practices of the local authorities as quickly as possible in order to work in collaboration with the country immigration authorities to facilitate the efficient clearance of arriving international response teams. DC staff should aim to quickly learn the basics of the requirements on the specific customs regulations of the affected country, especially those relating to ICT equipment, canines and medicine which may have specific and more stringent regulations.

The exercise participants, usually USAR management responsible for USAR coordination, experience how to Facilitate immigration and customs procedures for incoming teams, Register arriving/departing teams, Deliver situational and operational briefings. The trainees can be trained to negotiate a venue for the RDC that is visible and easily accessible but not too exposed to public traffic. The trainees immense in virtual reality airport and select the location of the RDC. They can borrow the resources such as boards, desks, chairs at the airport and utilize RDC equipment to establish functional work areas. The trainees can drag the 3d model partition into three-dimensional scene and divide the space into three distinct functional work areas include Public displays, “Team only” displays, “RDC Staff only” displays, in order to provide an effective use of space and to ensure different levels of information are communicated to the right audiences. DC staffs deliver the briefing using the visual wall displays and the RDC Briefing Handout Form that includes information about the current situation, location of the BoO, location of coordination cells and team logistics requirements.

Figure 2. RDC Establishment Scenario

BoO establishment scenario

The BoO serves as the USAR teams‘site for headquarters, communications hub, sleeping/resting/eating/health areas, equipment stock set-up and refuge from the elements while operational in a disaster-affected country.

The participants can walk around in three-dimensional digital city to identify potential BoO locations. They should consider the following factors when selecting a BoO site: Suitably

sized areas, Locations should be as safe and secure as the environment allows, Safety and security, Environmental considerations (hard surfaced, good drainage, etc.) and so on.
Classification and management of 3D models of equipment are implemented. Generally speaking, a standard BoO includes 11 functional areas: command, communication, living, medical, treatment, equipment, logistic, canine, sanitation and disinfection, garbage disposal, parking and team assembling area. The participants can drag 3D model from library into virtual environment and adjust the position in order to establish BoO. The trainees can focus in planning layout of the BoO more than build functional areas. In practical operation on-site, USAR management map the layout of the BoO and mark the construction sequence. The team leader can command his soldiers to build functional areas according to the map. USAR management should consider the needs, the requirements, or demands for Base of operation. For an example, medical treatment area, garbage disposal area and toilets should be located on the leeward side of BoO. If there is any flowing water nearby, the above-mentioned areas should be located downstream.

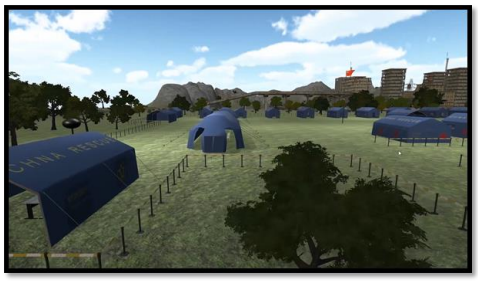

Figure 3. BoO establishment scenario

UCC establishment scenario

The first arriving classified team should also expect to engage in initial USAR coordination to ensure operations are coordinated from the onset. The first arriving team should make contact with the LEMA to obtain information about the disaster response and with the next arriving teams to ensure coordination. As this is done the team should also establish the UCC. The UCC is a cell within the OSOCC but is established prior to the arrival of the rest of the OSOCC personnel. The UCC functions is a stand-alone entity until absorbed into the full OSOCC structure and the personnel who begin the coordination process should remain in the UCC throughout the disaster to ensure continuity.
The participants can be trained how to select the location for UCC. For an example, the UCC must be established in close proximity but outside the boundaries of the international Boo. The UCC location should be clearly identified using the UN - UCC flag. The trainees can drag the 3d model partition into three-dimensional scene and divide the space into three distinct functional work areas include "Public" area, “Working” area, “UCC Staff" area, in order to provide an effective use of space and to ensure different levels of information are communicated to the right audiences. The UCC should be Include suitable facilities, Sufficient wall space for display of information, an area for electronic projection of vital incident information, Include an area of sufficient size for UCC internal meetings and briefings with USAR Team.

"Public" area should be located between the UCC functional workspace and the rest of the OSOCC and can be accessed by anyone passing by the UCC.UCC staff must ensure that there is a clear border between the public area and working area of the UCC and consider using barrier tape. "Working" Area is a private area accessed only by UCC staff and Team Managers. "UCC Staff" Area should be a closed area accessible only to UCC staff members. This should be separate from the Working area and should not be accessed by USAR team members. If possible, this area will include an office desk and a number of walls displays used by the UCC Manager for the administrative functions of the UCC. In the virtual reality environment, USAR teams can be trained and become proficient in the use of the Standardized information display forms and delivering briefings to ensure effective coordination. UCC deliver briefings to USAR teams' members.

Figure 4. UCC establishment scenario

Work-site triage scenario

Proper planning is a vital component of any response management practice. The planning process facilitates the adequate and safe use of resources through proper selection of strategies and tactics. These planning principles do not differ during large-scale incidents requiring international assistance. In the INSARAG coordination methodology there are Assessment, Search and Rescue (ASR) Levels that define the different types of activity carried out at a major USAR incident and these can be used to help the planning process.

The simulator provides a three-dimensional digital Daman city, a fictitious large-scale damaged city. The details of every building on every block might be observed by walk through or fly through operation just like by walk, vehicle, helicopter. The participants can experience the planning process about Assessment, Search and Rescue (ASR) level in Game-like interactive operation. Firstly, they begin with a thorough assessment of the situation that provides information needed to make initial USAR coordination decisions by using the principles defined in ASR Level 1: Wide Area Assessment. Secondly, they coordinate the USAR teams to deploy and then carry out ASR Level 2: Sector Assessment, which primarily gathers details of the potential live rescue locations (work-sites) so a more detailed action plan can be formulated and teams deployed to maximize life-saving opportunities. They use The Work-sites Triage form to gather the essential information at this stage. Information from the local population and local res-ponders is often valuable and should be sought during the assessment.

A key element of the INSARAG coordination methodology is a means of clearly identifying and defining every level, or type of work, normally needed during a major USAR incident. Having a clear definition of all the possible operational levels allows the coordination actors to be specific about the planning, tasking, specific USAR operations needed and the progress made.

Figure 5. Work-site triage scenario

Results

After exercises, questionnaires were sent to participants, observers and evaluators. Observations during the simulated USAR coordination exercise and the questionnaire evaluating phase indicate using virtual reality exercises had the following results:

• Participants immerses themselves in exercises and imagined what an actual scene might be like based on simulated scenarios of disaster situations displayed on the computer screen.

• Participants understood exercise scenarios better and made better decisions through disaster information based on computer injection the same way as for an actual emergency response.

• Through electronic map plotting, participants presented the dynamic decision process, zooming in and out of electronic maps in detail, recording in database and exporting pictures for future discussion.

• Virtual simulation may be a low-resource solution to teach principles of triage.

After the exercise, observer and participant feedback indicated that using the virtual reality exercises had useful effects and participants had developed their abilities to respond to international search and rescue coordination situations in a limited exercise time better than they had before taking part in exercises. The USAR team will be able to develop coordination abilities from the hands-on experiences they are exposed to within the simulation, and allow them to bridge the gap between what they have learned in the theory and what they will experience in their practical disaster on-site. SAR coordination simulator enable USAR team members to train their coordination skills in an efficient, cost-effective and sustainable way. Together, the trainees can work towards a safer world through the use of cutting-edge simulation. The mode of the virtual reality exercise was thus valuable to other provincial exercises. “This type of simulation can be adapted and applied to many other coordination scenarios and International USAR Teams around the world. "said Rajasingham, the OCHA Director of Coordination.

Conclusion

Results show that the virtual reality exercise was one of the most effective and efficiency exercises. This suggests that an approach utilizing virtual reality coordination simulator as the basis for planning and conducting exercises was successful. It also made the evaluation and organization of exercises easy and convenient. Using the virtual reality coordination

exercise had meaningful effects on the operation mode, scenario presentation. Conducting a coordination exercise was successful in helping participants improve their disaster response and coordination capacity, enhancing participant understanding of the INSARAG Methodology based on comprehensive, 3D disaster information provided by exercises. Using electronic technologies on virtual reality technology, 3D modeling and the Web-based system to build realistic disaster environment that directly shows disaster scenes helps participants feel enthusiasm in exercises and develop their abilities to coordinate urban search and rescue mission. Processes of exercises were recorded in a database for further review and easy evaluation.

Some 3D events in the preset exercise process did not have to be changed with participants' responses. For exercise evaluations, assessment results should consist of statistics and intuitive charts reflecting exercise effects based on aims and goals. Future exercises should be non-scripted, meaning that there are no predetermined outcomes, and what happens in the system should be based only on participants' decisions. 3D disaster scenes have physics-based simulation in which fire, smoke, gas clouds, leaks, etc., spread as they would in a real situation, reacting to influences such as wind direction and speed. All disaster features are based on real-world timing, such as how a person's injuries progress if not treated. Exercises should produce high-level immersion in which trainees feel like they are acting in an actual situation and feel the stress they would feel at such a time. Exercises should score trainees automatically on defined objectives and let instructors completely replay and view an exercise from any angle. A detailed, time-stamped action list presented after an exercise should describe scenario events and actions taken by trainees. We will progress our system's functionality to include training more capability of USAR coordination, which has been at the forefront of concerns about International USAR mission. We're looking forward to cooperation with experts around the world to further develop scenarios in the search and rescue domain.

References

[1] R. W. Perry and M. K. Lindell, Emergency planning, John Wiley & Sons, 2007.

[2] D. D. Deaner, ETC Simulation receives new ADMS contract from Netherlands Institute for Safety, Reuters, 2008.

[3] VSTEP, RescueSim brochure, The Netherlands, 2010.

[4] C. Zhonghui and X. Yongzhi, Research and implementation of earthquake rescue virtual scenario editor, Microcomputer, Information, Vol.2, pp. 298-301, 2006.

[5] J. Qunlin and Z. Bojia, The application of earthquake rescue training simulation, World Press, 2009.

[6] Lu.Zhang ,Lian Shuan.Shi, The Use of 3d Design Tools With Game-Like Functionality and Physiological Information in Urban Planning and Architectural, computer science, 2020.

[7] Z.Qinping, DVENET distributed virtual reality application systemo peration platform and development tool, Science Press, 2005.

[8] W. Broll, Distributed virtual reality for everyone – A framework for networked VR on the internet, Proc. of VRAIS' 97, pp. 121-128, 1997.

[9] KC, U., Garg, S., Hilton, J., An Efficient Framework for Ensemble of Natural Disaster Simulations as a Service, Geoscience Frontiers,2020.

[10] W. Dongming, Research on earthquake disaster scenario and rescue simulation, Recent Developments in World Seismology,Vol.2010, Issue 1, pp. 31-33, 2010.

[11]Design Sato. Reika and Guo Weimin, The Use of 3d Design Tools With Game-Like Functionality and Physiological Information in Urban Planning and Architectural Design, environment science.

[12] Information on http://www.insarag.org