RimSim Response Hospital Evacuation: Improving Situation Awareness and Insight Through Serious Games Play

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Abstract

This paper presents the results of using computer-based role-play to improve emergency responder situation awareness and insight for an existing county-wide hospital evacuation scenario developed by the King County Health Coalition. The case study exemplifies the process by which a general-purpose simulation game architecture is adapted for use by a specific segment of a first responder community looking to prepare for a somewhat likely countywide emergency event. Game play is presented in terms of affordances provided relative to other scenario exploration activities and metrics are discussed for quantifying the usefulness of serious games for situation awareness and insight generation.

CR Categories: H.1.2 [Information Systems]: Interface Design for Simulated Role-Play

Keywords: gaming experience, role-play, simulation, assessment

1 Objective

Upon completing the development of a general-purpose serious game simulator called *RimSim: Response* (RSR), the design and implementation team reached out to the local community to search out first emergency response groups that appeared to be in need of a role-play simulator with which to gain situation awareness and insight into the nature of an emergency response scenario. During the initial simulator development phase, emergency response personnel had often told the RSR project team they had difficulty in ascertaining the usefulness of visual emergency response support artifacts contained in software. As a result, the RSR team pursued the King County Health Coalition (KCHC) to gain access to an established group of first responders who would be interested in co-developing metrics that could be tested for usefulness when using software-based artifacts for improving emergency response.

Upon suggesting the possible training and planning value of using a serious role-play game to the KCHC, the project team was invited to participate in the emergency response scenario development for a hospital evacuation scenario. Together with the KCHC, a timeline was agreed upon for flushing out roles associated with a hospital evacuation scenario:

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September 2009: KCHC brainstorming session for role identification

October 2009 through February 2010: Breakout sessions for individual role development and iterative refinement

March 2010: Tabletop exercise to test out roles as documented in KCHC forms and flowcharts

April 2010: Paper-based scenario drill with back-end simulator

May 2010: Computer-based scenario drill with back-end simulator

By identifying KCHC personnel early with which to co-develop a serious game, the game development team became involved in scenario development while the KCHC became involved in exploring the RSR simulator's game potential. A vibrant social community of trust and information sharing arose which hinted at a shared culture of patience and cooperation among all participants for simultaneously developing the scenario, serious game, and metrics — each of which is presented in separate sections after the related work section.

2 Related Work

Building hospital emergency response simulations has precedent in a couple of well-documented efforts. Johnson [2006] developed a simulation for use at Glasgow Hospital in the UK while Taaffe et al. [2005] developed a model for use at Clemson University Hospital in the United States.

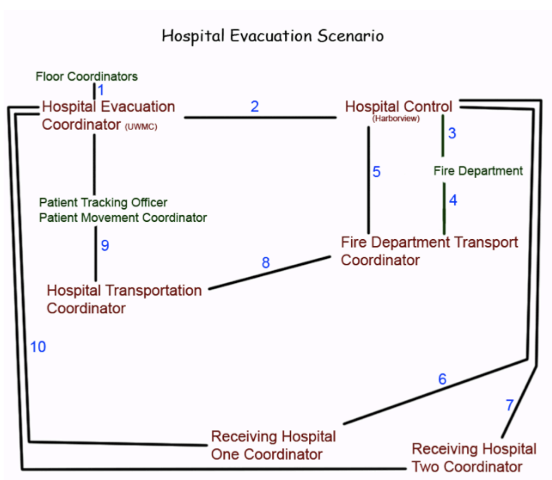
Simulation awareness and insight generation metrics have been developed and used in various well-documented cases. Accordingly, situation awareness has been shown to be a significant success factor in many complex environments. For example, Nullmeyer et al. [2005] studied situation awareness in aviation control studies, Blandford and Wong [2005] studied situation awareness in emergency response scenarios, Smart et al. [2007] studied situation awareness in military command and control operations, and Flin and O'Connor [2001] studied situation awareness in offshore oil platform management. Thomas and Cook [2004] provide a compelling case for considering insight generation in the evaluation of any visual analytics tool.

In support of hospital evacuation scenario training, Campbell [2008] developed the RimSim architecture for serious game support while Campbell et al. [2009] implemented the architecture in software in order to create the RSR general emergency response platform.

3 KCHC Hospital Evacuation Scenario

To negotiate patient allocation away from the evacuating hospital, the HC communicates with each Receiving Hospital Coordinator (RHC) to prepare the receiving hospitals for the receipt of evacuated patients and gain agreement for transfer. The flow of communications between emergency hospital evacuation scenario roles is shown in Figure 1.

Hospital evacuation is performed by defined roles identified in a variety of manuals and specifications maintained by the King County Emergency Response committee. A Hospital Evacuation Coordinator (HEC) in the evacuating hospital begins the emergency evacuation process by contacting all evacuating hospital floor coordinators who then provide a patient status report for all patients on each floor. The HEC contacts the prearranged Hospital Control (HC) contact at an external location to report on the current situation. The HC contacts the Fire Department who selects a Fire Department Transport Coordinator (FDTC) to be in charge of all physical patient removal performed by Fire Department staff. The HEC also contacts the evacuating hospital's Hospital Transportation Coordinator (HTC) who is responsible for coordinating patient transfer with the FDTC. A Patient Tracking Officer and/or Patient Movement Coordinator may be involved in the communications between the HEC and HTC.



1. Floor coordinators turn in count sheets to HEC.
2. HEC asks for assistance from Hospital Control and faxes count sheets.
3. HC asks for help from Fire Department
4. who then determines an FD Transport Coordinator.
5. FDTC and HC begin discussions
6. HC works to find a receiving hospital for evacuated patients
7. HC works to find another receiving hospital for evacuated patients
8. FDTC (movement of bodies – if fire, horizontal movement out of fire areas & fight fire – too complicated for our scenario) and HTC (release of patients with medications, accompanying staff, and oxygen) co-locate to make communications easier.
9. HTC coordinates with the HEC (potentially using a PTC and/or PMC as intermediaries)
10. Receiving Hospital Coordinators secure electronic documents from HEC.

Figure 1: Emergency Hospital Evacuation Roles and Communications.

4 Serious Game Development

Players interact with three primary shared visual artifacts while evacuating the hospital: A shared 3-D model of the evacuating hospital (seen in Figure 2), a shared 2-D floor plan for each of the evacuating floors of the evacuating hospital (seen in Figure 3), and a county-wide drill-down map (seen in Figure 4).

The HC, HEC, FDTC, and RHC roles work together to strategize and implement the overall hospital evacuation effort. As a result, four different role-play interfaces allow the roles to play individually (with simulated agents for non-playing roles), or play together through networked game play. Currently, all other roles are simulated in software-supported agents. The game role-play interfaces allow players to negotiate the state of key shared data items:

- Supplies and materials
- Transportation routes and vehicles
- Patients in the evacuating hospital
- Emergency response personnel

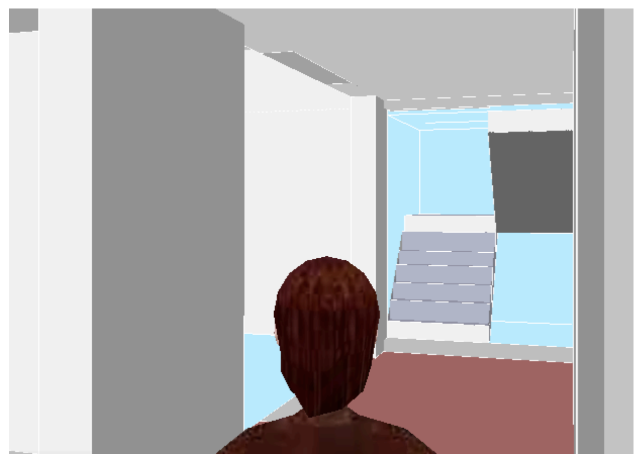


Figure 2: 3-D Model of Evacuating Hospital

The 3-D model of the evacuating hospital lets a player investigate the current state of the hospital by walking around as a digital avatar as if walking around in the physical hospital. As they move, an iconic representation of their position appears in the 2-D floor plan (see the black dot icon in Figure 3) with which they use to confirm patient release and evacuation route decisions.

235 patients are encoded as icons in the 2-D model. Players can change the current floor (in red) in the visualization by clicking on the floor number to the left. Icons encode ambulatory classification (walking, wheel chair, and human-assisted) on the left half of the icon and equipment classification (stable, vented, monitored, unstable) on the right half. Stairway patient counts are shown in blue by the four stairways used for evacuation. As players click to release patients, patients move toward the stairway exits following statistical velocity models.

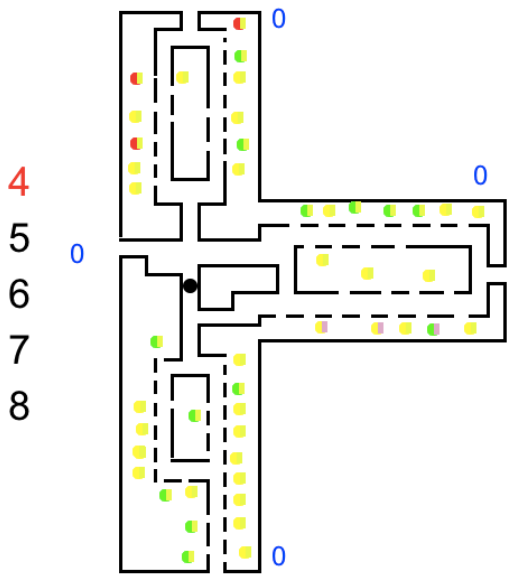


Figure 3: 2-D Model of Evacuating Hospital

Java 2D technology enables the 2-D floor plan model to be interactive and fluid in its animation. Java World Wind technology provides the drill-down interactive map in Figure 4 that shows moving vehicles that deliver patients and equipment to receiving hospitals (identified by availability icons with four quadrants that represent equipment need classifications). Each icon contains current new patient capacity, by equipment classification, at potential receiving hospitals, minus the value of any patients in transit. Vehicles in transit appear as colored icons on the map at their current simulated location. The FDTC maintains a separate view (not shown) that shows patient allocations to available vehicles in waiting or on route.

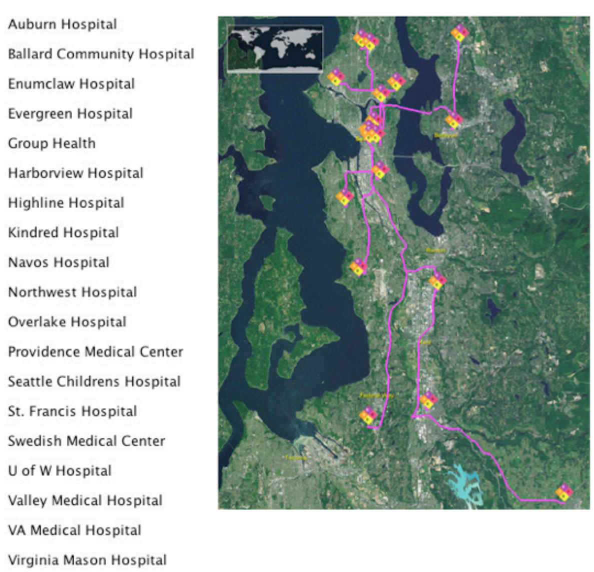
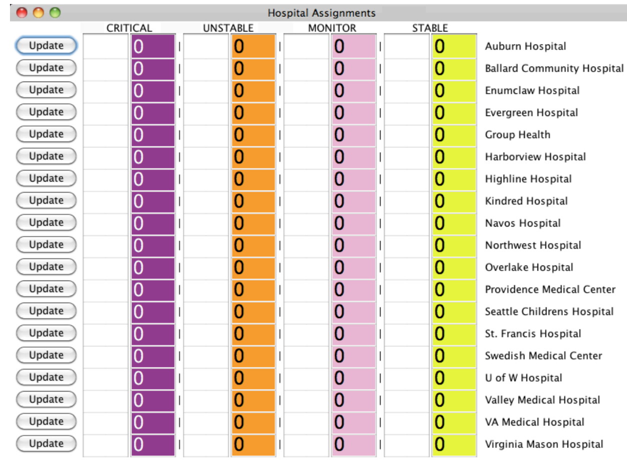


Figure 4: Drill-down Map of Receiving Hospitals



	CRITICAL	UNSTABLE	MONITOR	STABLE	
Update	0	0	0	0	Auburn Hospital
Update	0	0	0	0	Ballard Community Hospital
Update	0	0	0	0	Enumclaw Hospital
Update	0	0	0	0	Evergreen Hospital
Update	0	0	0	0	Group Health
Update	0	0	0	0	Harborview Hospital
Update	0	0	0	0	Highline Hospital
Update	0	0	0	0	Kindred Hospital
Update	0	0	0	0	Navos Hospital
Update	0	0	0	0	Northwest Hospital
Update	0	0	0	0	Overlake Hospital
Update	0	0	0	0	Providence Medical Center
Update	0	0	0	0	Seattle Childrens Hospital
Update	0	0	0	0	St. Francis Hospital
Update	0	0	0	0	Swedish Medical Center
Update	0	0	0	0	U of W Hospital
Update	0	0	0	0	Valley Medical Hospital
Update	0	0	0	0	VA Medical Hospital
Update	0	0	0	0	Virginia Mason Hospital

Figure 5: Hospital Allocation View

Figure 5 shows the receiving hospital patient allocation view that is made available to the HTC on demand for investigation of receiving hospital patient agreements by equipment type. The HC edits the allocations through her role-play interface as she negotiates surge capacity agreements with the RTC for each hospital. The HTC cannot edit the values and attempts to abide by the agreements in order to avoid releasing excess patients to any one hospital.

5 Metrics Development

The KCHC worked closely with the serious game development team to agree upon useful metrics to evaluate whether playing the serious game was helping first responders train for a potential hospital evacuation event. Two key metrics were identified and quantified: Level of distributed situation awareness and number of insights per game play minutes.

According to the result of a KCHC consensus process, five representative quantities suggest the current level of distributed situation awareness during game play:

1. How many patients are in a significant state of discomfort currently?
2. Where are these patients located?
3. How many patients are currently in transit between the evacuating and receiving hospital?
4. How much more time will it require to fully evacuate the existing hospital given ideal circumstances?
5. How much more time will it require to fully deliver all evacuating patients to their receiving hospital given ideal circumstances?

Determinations of optimal numeric answers to the five questions were also negotiated through a consensus-building exercise. During game play, correct answers to questions one through three can be ascertained from the available visual artifacts while correct answers to questions four and five can be ascertained by running the simulation to completion and identifying the time required to do so.

The KCHC had determined the objectives of a hospital evacuation early on in the scenario development process. They agreed that emergency responders should work to successfully evacuate all patients in a timely manner, while at the same time limiting discomfort and undue economic cost. As patients are evacuated, they should be transported to a receiving hospital that can meet the needs of their proper patient care in a timely manner and without unnecessary cost.

As game players played the simulated hospital evacuation, evaluators asked them to verbalize the insights they had in regards to meeting the objectives of the evacuation scenario. Evaluators recorded all verbal statements and game interface actions and transcribed them into a format appropriate for visualizing the data in the visual analytics tool players could use to review their game play and identify insights they had experienced throughout the game play session.

Figure 6 shows the visual analytics tool used for evaluating insights. With help from the evaluators' notes taken during game play, the players listed all the insights they had that helped them make progress toward hospital evacuation objectives. Each insight provided a time stamp and score on a scale from 1 to 100 as to the significance of the insight to overall objectives attainment. Players discussed the scores at length until they reached a consensus on the value to their overall shared performance.

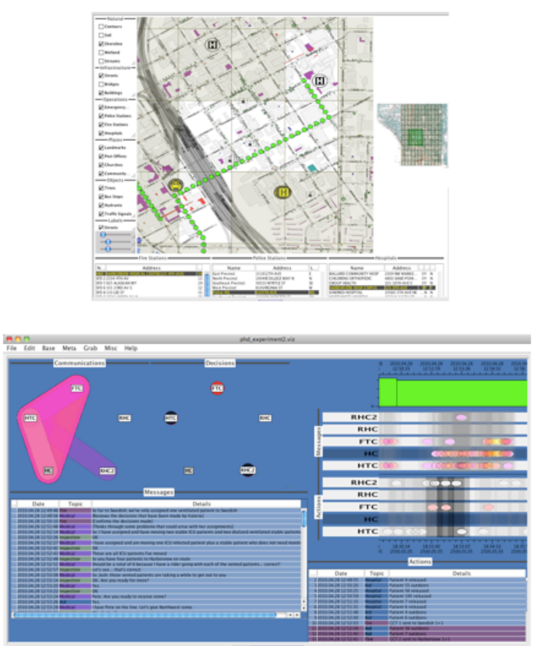


Figure 6: Visual Analytics Tool Used in Evaluation

6 Results

When comparing the level of distributed situation awareness accuracy between the game play sessions with and without the full-fledged computer-game interface, a paired-t statistic comparing situation awareness accuracy (awareness compared to actual) for the paper-based and computer-based trials showed significant improvement for the computer-based game play interface. Figure 7 shows the actual statistical results for all five situation awareness questions which were asked at ten random times for both trials.

Question	Paired-t statistic	p value
How many patients are in a significant state of discomfort currently?	4.347	.0002
Where are these patients located?	2.610	.0142
How many patients are currently in transit between the evacuating and receiving hospital?	3.537	.0014
How much more time will it require to fully evacuate the existing hospital given ideal circumstances?	5.558	< .0001
How much more time will it require to fully deliver all evacuating patients to their receiving hospital given ideal circumstances?	2.055	.0490

Figure 7: Distributed Situation Awareness Improvement with Game Interface

When comparing insight generation scores between the paper-based interface and the computer-based game interface, evaluators found that the insight generation score increased from 1,889 to 2,487 as seen in Figure 8.

Trial	Number of insights	Total Score
Paper only	52	1889
Computer game-interface	94	2487

Figure 8: Insight Generation Results

Evaluators found it interesting that the computer game-based interface generated 49 insights that were scored at less than ten points by the players versus only 17 insights scored less than ten during the paper-based trial. As a result, it appears that the computer-based interface lets players consider the evacuation at a higher level of resolution than their usual paper-based interface.

Because both game play periods were exactly two hours in duration, the insights metric on a per minutes played basis can be calculated by dividing the Figure 8 values by 120 minutes. The insights generation metric appears to be highly dependent on the range of activities that took place before the game was played by role-players would have chosen to use in the absence of an available computer-based interface.

7 Conclusions

In turn, first responders can co-develop tools that help train them better and train their colleagues. We believe a RSR game is a potentially alienating approach to force on a first responder or group of first responders who don't want to spend the time to engage in the process of developing a better tool for themselves from which to train. As many developers saw first-hand when working with the groupware industry in the early 1990s, computer-mediated solutions to support human behavior either succeed or fail through many complex variables that contribute to motivation and organizational support. Perhaps even those variables can begin to be explored via simulation.

Since training teams can find it difficult to schedule professional emergency response personnel, serious game developers who wish to work in the first response training and simulation realm need to be patient and communicative with potential clients. As younger people retire after having lived a career in emergency response during the digital and information ages, we see our work becoming more feasible to more groups of people without having to interrupt emergency responders during their day-to-day responsibilities.

Like any new process being attempted by human beings, there is potential to improve RimSim implementations through repetition and modification by expanded exposure of the process to a wider range of scenarios. Creating interfaces for human beings is not an exact science and one person's ideal interface might not be able to become another person's ideal interface. By starting from a defined architecture, we can provide the opportunity to plug-in different components to adapt to different environmental conditions and personal preferences. We can distribute the job of improving the whole simulation process across people who each take a piece of the architecture and implement solutions that improve that piece as part of the whole.

8 Future Work

Based on the results obtained with the hospital evacuation scenario, the game development team looks to make the *RimSim: Response* iterative development process available to support a wide range of first response communities who wish to apply a simulation approach for better insight into potential community-wide crises of concern in their communities. Applying the RimSim architecture as a basis for game development has potential for training individual first responders in a scenario and in helping a team of first responders train in the collaborative aspects of first response activities. Evaluators feel that first responders who engage in a RimSim-supported process can improve training potential.

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