Serious Games That Improve Performance

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Abstract. Serious games can help people function more effectively in complex settings, facilitate their role as team members, and provide insight into their team's mission. In such games, coordination and cooperation among team members are foundational to the mission's success and provide a preview of what individuals and the team as a whole could choose to do in a real scenario. Serious games often model events requiring life-or-death choices, such as civilian rescue during chemical warfare. How the players communicate and what actions they take can determine the number of lives lost or saved. However, merely playing a game is not enough to realize its most practical value, which is in learning what actions and communication methods are closest to what the mission requires. Teams often play serious games in isolation, so when the game is complete, an analytical stage is needed to extract the strategies used and examine each strategy's success relative to the others chosen. Recognizing the importance of this next stage, Noblis has been developing Game Analysis, software that parses individual game play into meaningful units and generates a strategic analysis. Trainers create a custom game-specific grammar that reflects the objects and range of actions allowable in a particular game, which Game Analysis then uses to parse the data and generate a practical analysis. Trainers have then enough information to represent strategies in tools, such as Gantt and heat map charts. First-responder trainees in North Carolina have already partnered Hot-Zone and Game Analysis with great success.

1. INTRODUCTION

Multiplayer, interactive serious games can help people function more effectively in complex settings, facilitate their role as team members, and provide insight into their team's mission. In such games, coordination and cooperation among team members are foundational to the mission's success and provide a preview of what individuals and the team as a whole could choose to do in a real scenario. Serious games often model events requiring life-or-death choices, such as civilian rescue during chemical warfare. How the players communicate and what actions they take can determine the number of lives lost or saved.

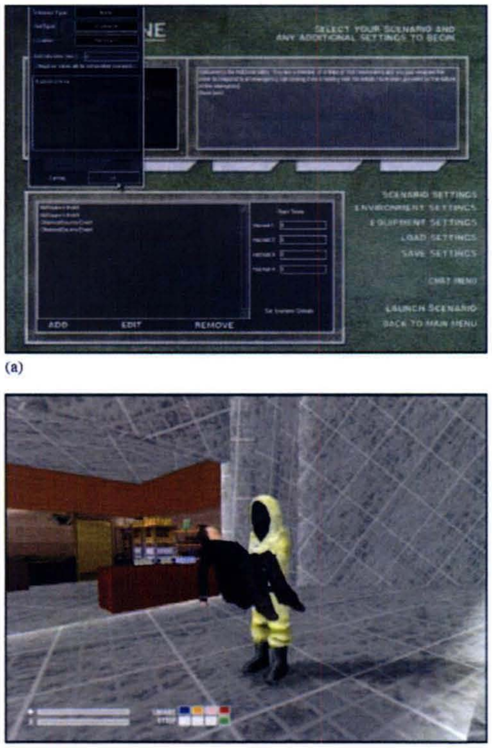
However, merely playing a game is not enough to realize its most practical value, which is in learning what actions and communication methods are closest to what the mission requires. Teams often play serious games in isolation, so when the game is complete, an analytical stage is needed to extract the strategies used and examine each strategy's success relative to the others chosen.

Recognizing the importance of this next stage, Noblis has been developing Game Analysis, software that parses individual game play into meaningful units and generates a strategic analysis. Game Analysis uses the Extensible Markup Language (XML) to import every game-play action and communication. Trainers create a custom game-specific grammar (ontology) that reflects the objects and range of actions allowable in a particular game, which Game Analysis then uses to parse the data and generate a practical analysis. Trainers have enough information to represent strategies in Gantt and heat map charts, for example.

First-responder trainees in North Carolina have already partnered Hot-Zone and Game Analysis with great success. Trainees found the game easy to play and trainers deemed Game Analysis valuable in defining what strategies worked best. Game Analysis also helped identify individuals who were particularly well-suited for certain aspects of their functional responsibilities. Trainers could see "at a glance" who was the best at communicating status or performing triage, for example. This larger view changed the training exercise from a local trainee perception to the bigger picture of the entire mission.

2. HOT-ZONE GAME PLAY

In Hot-Zone, players act as either hazardous materials (hazmat) technicians or the incident commander in responding to the release of chlorine gas in a shopping mall. With only limited equipment, they must decide how they will rescue and decontaminate as many civilians as possible in the shortest time. Their specific tasks are to neutralize the gas source; set up a security perimeter and decontamination tent; triage, tag, and evacuate people; hand over evacuated people for decontamination and decontaminate themselves.



(a)

(b)

Figure 1*:* Playing Hot-Zone. During game play, the user must choose a strategy for evacuating and treating victims from a chemical gas explosion at a mall. (a) The interface lets the scenario manager tailor the overall difficulty of the game scenario by adjusting parameters such as the number of victims, chemical gas potency, and the decontamination tent efficiency. Such tailoring also allows for various skill levels. (b) The user's avatar is a hazardous materials technician evacuating a victim. Bars (left foreground) display the user's degree of exhaustion (cross) and pace (running man icon), while a smart-strip-like indicator (right) shows the degree of gas potency.

Figure 1 shows screen shots from Hot-Zone, which typically takes between 15 to 30 minutes to play, depending on the difficulty level the trainer chooses for that responder trainee. To accommodate variations in particular scenarios, trainers can adjust parameters such as the number of participants and victims, amount of equipment, first responder's skill level; and effectiveness of the measures taken. With this customization flexibility, trainers can conduct what-if exercises, such as examining anticipated situations or ideal responses to hypothetical events.

3. ANALYZING HOT-ZONE DATA

Given that Hot-Zone's main goal is to improve team performance, trainers need enough information to correct team behavior, which requires more insight than just numbers of lives saved and lost. Many analysis programs and game engines allow only a high level data capture, which trainers then use as a restart point, essentially a second chance for the player to face a game situation and make different choices. Such programs rarely provide enough insight for trainers to alter team behavior.

Thus, for Game Analysis, a key goal was to enable the capture and analysis of all the data generated during game play. In this way, trainers could see the entire range of a player's actions and communications, not just select blocks. Game Analysis stores these actions and communications in a database, along with relevant metadata such as beginning and end times, event triggers, and who is sending and receiving the messages.

As Figure 2 part 1 shows, the game-specific grammar expresses the game's actions and events at an atomic level and groups these atoms into composite actions and happenings, which Game Analysis uses to discover game events. By filtering the composites, it can then obtain player, team, or environmental views and can parse an event sequence into a hierarchical task-oriented description of strategy, as in Figure 2 part 2.

Figure 2 part 3 shows how Game Analysis can aggregate individual strategies to produce an overall team strategy. The game-specific grammar naturally expresses any task hierarchy, and because each task has a start and end time (time-stamping), Game Analysis can capture the task hierarchy and express it in analysis tools such as the Gantt chart in Figure 2 part 4.

Obviously, creating a game-specific grammar requires a detailed analysis of the particular game, which at present an expert must do, but at some point a software novice might be able to do through a user interface. The long term vision is to provide enough flexibility for trainers to use commercial off-the-shelf

(COTS) software to assemble a custom training program.

Another benefit of Game Analysis is that it captures the performance and style of play for individual trainees, which trainers can then relate to that trainee's professional background, skills, and training. Such factors have direct bearing on strategy development. Changing the skill mix and the way players communicate among themselves and with their incident commander can greatly influence the outcome of scenarios in game play. For example, trainees frequently delayed reporting to the incident commander that decontamination showers were ready. This communication delay often meant a longer total time to complete the evacuation successfully. Such decisions are often overlooked in games that rely almost exclusively on data about victims saved or lost.

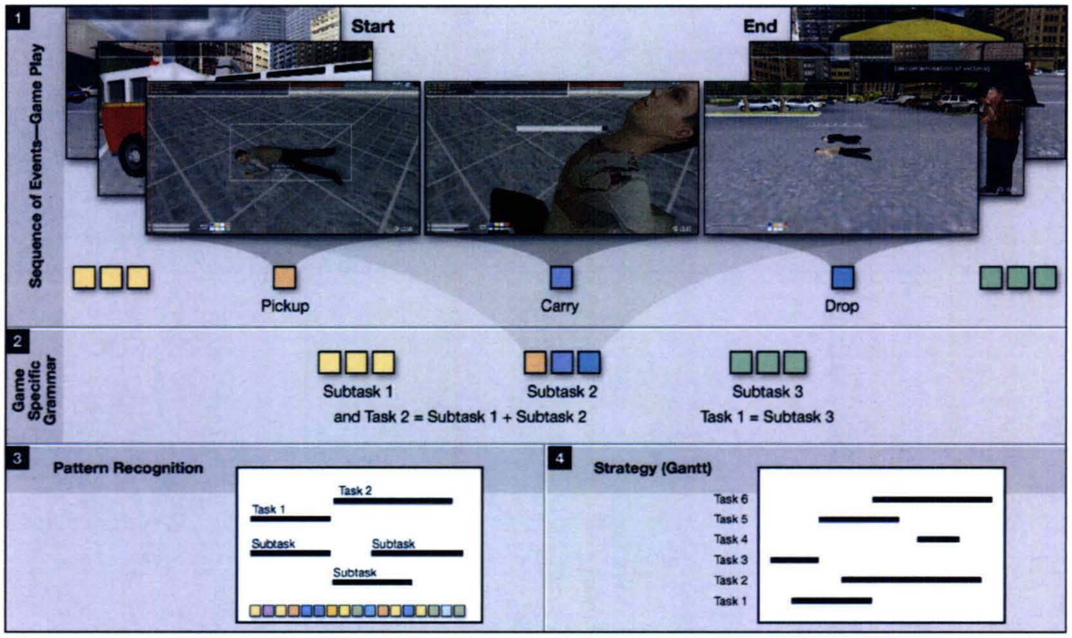


Figure 2: Using a game-specific grammar to parse atomic events into subtasks. (1) The row of colored squares represents atomic events that make sense in a particular game essentially all actions taken. (2) Applying the game-specific grammar, Game Analysis can sort these actions into specific subtasks. For example, in Hot-Zone, Subtask 2 could be defined as consisting of the sequence pick up victim (orange square), carry victim (purple square), and drop victim (blue square). (3) Game Analysis provides pattern recognition by breaking subtasks into their start and end times and can then generate useful analysis tools, such as (4) a Gantt chart to show the tasks performed and how long it took to perform them.

4. APPLICATION RESULTS

In July 2007, Noblis tested the partnership of Hot-Zone and Game Analysis on trainees at Wake Technical Community College (WTCC) in Raleigh, North Carolina, which trains more than a thousand law enforcement and first responders yearly. The tests took place for one week at 15 fire stations in the Raleigh area, typically two play sessions daily. The first responders did not operate Game Analysis but were shown the analysis results at the end of the second game. Overall 25 different teams played the game.

Overall, first responders were enthusiastic about playing Hot-Zone. In about 15 minutes, all players in all departments—no matter how old or young or even injured, which is common among first responders—could master game play using the keyboard and mouse controls, in part because even the older players had some experience with gaming for entertainment. Only one team member had difficulty, which he attributed to limited computing experience. Players were very professional during game play, and their professionalism intensified as the scenarios became more challenging. Figure 3 shows a typical level of concentration and interest. At the end of the game, each player saw a quick team performance summary, and a week later, many viewed the results of analyzing their games with Game Analysis (some players had corrupt data sets that could not be analyzed).

Figure 3: First responder trainees from Wake Technical Community College intently playing Hot-Zone. WTCC trains more than a thousand law enforcement and first responders yearly.

Each of the 25 teams had the same four scenarios in the same order. Beginner: introduces teams to game controls and communication mechanisms. Easy: mall scenario with only a few people and so only a few victims need rescuing. Medium: same as Easy but with a population more representative of an actual mall. Hard: Same setting as Medium but with a secondary explosion and a heavy dose of chlorine.

Figure 4 shows the results of two WTCC teams. Both teams were experienced first responders, yet Team A had five fatalities and Team B had none. In addition, Team A took 33 percent longer than Team B to complete all the essential tasks (40 minutes vs. 30 minutes).

The charts in the figure reveal some interesting insights into why Team B's performance was superior. Team A took the seemingly natural step of starting to evacuate as soon as possible. In contrast, Team B's initial focus was on finding and neutralizing the source of the chlorine gas. Team A also deferred decontaminating team members until the end, while Team B opted to perform at least some team decontamination in parallel with decontaminating the evacuees.

These differences have important implications for strategy. The more successful strategy was to recognize and attend to the most significant obstacle to overall success—in this case, the source of the chlorine gas—rather than to rush immediately to improve a score, such as evacuating victims right away in the mistaken notion that this will save more lives.

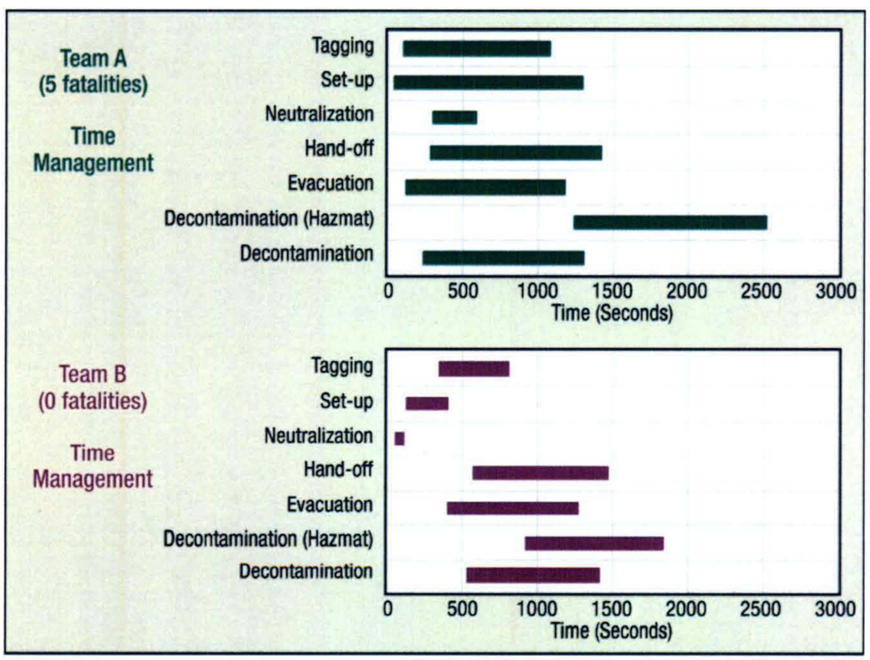


Figure 4: Gantt charts from Hot-Zone game play. Given the same initial situation, Teams A and B chose different strategies, leading to different outcomes. Examining game outcomes in terms of choices made leads to better performance, since the focus is on mission success, not on a particular score.

5. TOWARD A GAMING PLATFORM

Numerous commercially available systems engineering tools provide disciplined approaches to examining user and system requirements and operational and system performance. These systems engineering tools can combine with a serious game and Game Analysis to form an integrated framework. A framework, such as that in Figure 5, makes it possible to develop and test operational concepts and system designs.

The serious game play stage of the framework is the game environment, which consists of the game to be played, a game scenario editor that the trainer operates, and a quick reporting service that displays limited results after each game play session. The reporting service generates XML logs that can serve as input to Game Analysis. The pattern recognition algorithm in Game Analysis then analyzes the raw data and generates a strategy hierarchy, as described earlier. The strategy hierarchy becomes the basis for generating visualizations of the captured strategy and an XML representation of the strategy that is compatible with the chosen systems engineering tool.

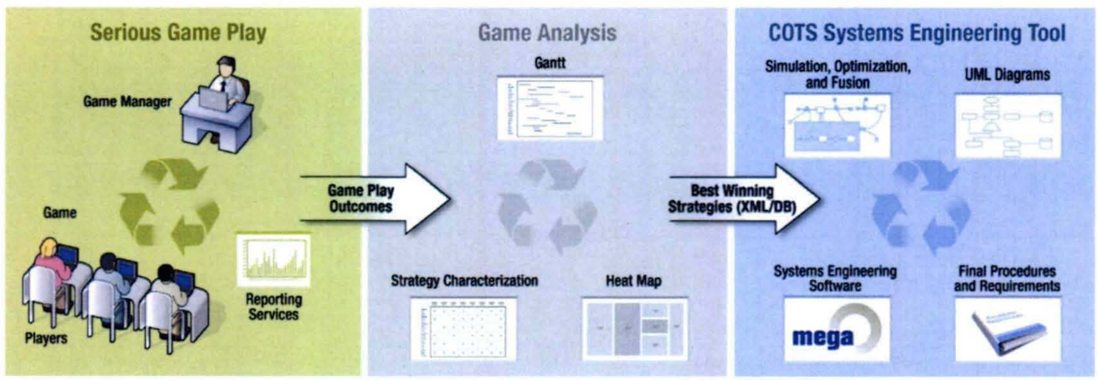


Figure 5: An integrated framework for playing serious games and analyzing results. The framework consists of the game play environment, Game Analysis for characterizing strategies, and any XML-compatible system engineering tool. The best strategies identified in Game Analysis become the basis for recommended processes, which are straightforward to represent in systems engineering tools.

Noblis has already used the framework with Hot-Zone and Mega International's Mega modeling suite systems engineering tool (www.mega.com). Using Mega Designer, Noblis analysts generated a swim-lane representation of how the team operated. In this representation, each first responder has his own "lane" with the time axis going from the top of the page to the bottom. Individual lanes show the actions that a particular player takes and the time they were taken. The swim-lane representation also shows the communications among players as well as the actions that several players took jointly.

When supplemented with strategy extraction and an analysis capability, serious games are an effective way to improve operational performance, providing feedback on strategies chosen and empirically finding what works best.

The use of serious games for training individuals and teams will continue to grow, as more organizations realize their value in letting trainees experiment with different strategies and visualize their results. By working through a variety of scenarios, players begin to develop a feel for what will work and for how to act more strategically in emergency situations. Ultimately, they will begin to view a mission more systematically and adapt strategies that lead to the overall successful resolution of an emergency.

A more advanced and practical use of the game analysis framework is in the design of a dynamic and adaptive operation management tool. By collecting and analyzing hundreds of plays and scenarios from many first responder teams, it might be possible to generate an artificial-intelligence-like algorithm that could provide recommendations on resource allocations and task priority to an incident commander. The incident commander could then use the tool by plugging in the current state of an ongoing operation and receive actionable recommendations to optimize its current strategy. This application could lead to more immediate correct actions in a crisis.