

Location-Based Game Platform for Behavioral Data Collection in Disaster Rescue Scenarios

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Abstract

Location-based games are an emerging paradigm for training, simulation, entertainment, health and many other domains. In this paper, we consider the role of location-based games as a platform for data collection and analysis of human behavior. We also examine how human teams perform in a disaster scenario when such a scenario is mapped to a game environment conducted as a location-based augmented reality game. We use a pilot experiment to study human behavior between simulated disaster rescue teams and an integrated commander for the purpose of future research into improving exploitation of local tasks versus exploration of assigned objectives by disaster response teams. We show the results of our pilot experiment, analyze the effectiveness of TEAM-IT as a data collection platform and then investigate how additional experiments may be conducted to formalize this problem further.

Introduction

The training and simulation of human teams in mission spaces such as disaster rescue have provided significant research opportunity for interactive digital entertainment media. Many efforts have focused on mapping simulation to a 3D virtual environment for the purpose of behavioral analysis. The games are able to capture human behavior in geographical spaces but it is unclear how behavior in virtual environments maps to that in real environments (Williams 2010). We have conducted experiments that suggest the behavior of players differs meaningfully between a real world scenario and a virtual simulation.

We would like to explore location-based, alternate reality games as an alternative to 3D simulations for disaster training scenarios and other mission-critical scenarios. Location-based games are an emerging paradigm for training, simulation, entertainment, health and many other domains. In this paper, we propose a game platform capable of running scenarios that map in game objectives to real world locations, allowing for analysis of human behavior involving motion and virtual targets. We perform a disaster rescue scenario pilot experiment where real world locations are mapped as incident sites, players are equipped with tasks, a single player

is designated as a commander and a test disaster rescue endeavor is carried out. We collect and present the data having conducted multiple scenarios with the same team of rescue volunteers to aid in future improvement of disaster scenario decision support.

To aid in our investigation we use TEAM-IT, a location-based game platform that involves competition and cooperation between multiple human teams. The game is instantiated in an iOS framework which can be played in the real world. Players to be either humans or software agents. All players have locations which are tracked and shared. Human players are tracked via GPS location updates received through mobile devices - their physical location determines which virtual assets (agents or tasks) they can interact with. Proximity in the real world equates to proximity in the virtual world.

TEAM-IT supports a variety of intelligent agents. Agents can be part of a team or have their own teams. They have the ability to negotiate and trade for cards with human players, however, we will not focus on this aspect of the game in this paper. Here, we focus on TEAM-IT and its ability to serve as a platform for data collection while still being an enjoyable and extensible game platform.

In this paper, we address two main issues: (1) the use of TEAM-IT as a data collection and reporting platform in a sensitive context like disaster rescue (2) preliminary investigation of agent coordination in a disaster scenario for the purpose of improving decision support in real world instantiations of this problem. To achieve the first, we adapted the core TEAM-IT client's tonality to a disaster rescue context. To address the second, we executed various scenarios with different simulated issues like collapsed buildings, chemical fires, medical emergencies scattered around the USC campus. A volunteer was designated a commander and all volunteers were left to develop their own strategy for rescuing virtual victims around the map.

We ran our pilot experiment exploring both of these issues. The results demonstrate the capability of TEAM-IT to provide rich data while remaining a compelling game experience and the need for further investigation of how best to aid a commander in managing rescue teams in a time sensitive, stressful context.

Related Work

Location-based, mobile-powered games for displaying and recording human behavior in a disaster simulation are an emerging field. The primary reference project we studied before extending our own platform and conducting our experiments was the DEFACTO (Tambe 2006) project. We go into more detail about DEFACTO's design when we discuss the design of our own scenarios.

Accuracy and scalability (Hajarnis et al. 2011) limitations present themselves when trying to put together a mixed-reality or alternate reality disaster simulation in a geospatial environment. The real world difficulties faced when organizing a disaster simulation scenario are similar to those faced during a real disaster. Though the inaccuracy of GPS data (Chang et al. 2011) can be overcome by enlarging the game space, executing trials in an ideal outdoor environment and utilizing robust wireless and cellular data networks where possible, this is not always the case in a true disaster scenario. Problems faced during experimentation with cellular networks will only be exacerbated during an actual disaster. It will be important to develop alternate channels of communication (such as radio or walkie-talkie) to augment agent knowledge during a disaster scenario. Human-agent collectives have been useful for modeling expected outcomes in scenarios such as disaster relief (Jennings, Rogers, and Moreau 2011) in the past. We particularly recognize the work of RoboCup in exploring disaster rescue policies in real life. Mixed reality games may be a powerful contribution to research by leveraging real-world environmental factors to extract more accurate behavioral models from events observed in game (Fischer et al. 2012). While certain environments like GameBots (Adobbati et al. 2001) have been created to simulate human-agent and multi-agent scenarios, in situations where actions are more important than emotional responses, the 3D environment can serve to complicate rather than complement research. Real-world environments may actually provide stronger emotional responses and suspension of disbelief in game scenarios. Other virtual environments (Ishida and Hattori 2009) seek to mimic human involvement by virtualizing data collected from real-world actors. Our approach takes the conveniences of virtualization and applies them to a real-world, spatial solution. There are other games which exist to model human behavior in real world, mixed initiative and virtual scenarios. game (Chang et al. 2011), a lightweight framework has been constructed using mobile phones and adherence to design principles which allow for efficient development on mobile platforms (Tan and Kinshuk 2009). The design principles include multi-platform adaption, minimal resource usage, minimal human/device interaction, reduced data communication bandwidth usage, and no additional hardware. Environments like Colored Trails (Grosz et al. 2004) offer great insight into human-agent interaction by providing an interface to study (van Wissen, van Diggelen, and Dignum 2009) negotiation and various behavioral models. It can be argued that robust game environments which allow accurate representation of agent interaction in real-world scenarios are still emerging. When it comes to disaster rescue, it has only been made possible in recent years by the emergence of



Figure 1: TEAM-IT iPad Map View (left) which shows player team, skills, points, time remaining, locations of various boxes and their accessibility and locations of players. (Right) Photo of real world gameplay.

mobile networks to model disaster simulations and display multimedia information through a smart phone interface.

Team It Platform

We have used our TEAM-IT framework to conduct this experiment. By extending its capabilities and altering some of the game assets we are able to rapidly change from a coordination and decision support game into a mixed-initiative disaster scenario simulation. In TEAM-IT, each player belongs to a team. The player can be human or a software agent. Each player is assigned a number of skills. In our current implementation, skills are represented by a shape-color pair. Players can move around the world and discover and complete tasks which give points to their team. Endgame scenarios can be specified to depend on point thresholds or any other rules based on the game state. In the geospatial environment, task collections or "boxes" are placed at various locations. A player can view these boxes if they are within a discovery radius of the location. This discovery radius is modifiable for each game instance. When a player is within a (typically smaller) application radius, they can open the box to see the task collection there. Each task in a task collection is associated with a set of skills that must be applied simultaneously for a given duration in order for the task to be completed. When completed, points are awarded to teams as specified by the task. In this scenario points are the number of lives saved. It is possible for a task to give points to multiple teams for completion at different values but for this instantiation of the game, we do not leverage this feature. The latter is useful to investigate environments where one would want to investigate simultaneous cooperation and competition between teams. To apply a skill to a task, a player must move to within the application radius and use the required skill. If they move away from the application radius before the required duration for the task, the task is reset to being incomplete. Often it may require skills from multiple players to complete a task. Thus, teams must coordinate to have

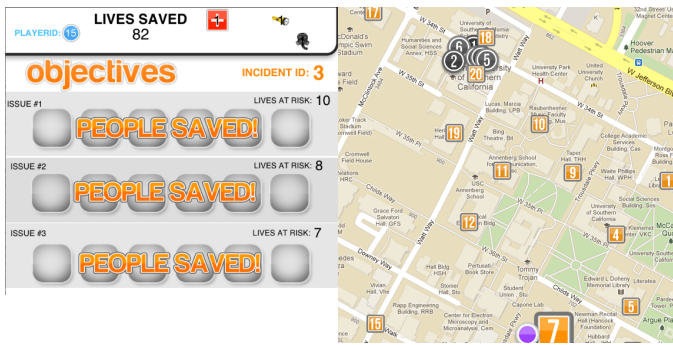


Figure 2: TEAM-IT Disaster Rescue task screen (left) showing all people saved at a location. (Right) Game map from pilot showing players collaborating north of the start location.

players in the right places at the right times to get points.

Scenario Design

There are several other work or paper have something to do with disaster scenario design or disaster rescuing simulator. One of them is called DEFACTO (Tambe 2006), which is a simulation tool to help train incident commanders for a large-scale urban disaster. The scenario design of DEFACTO is based on Los Angeles downtown which is under multiple fire circumstance. Another work is called Multipatient Disaster Scenario Design Using Mixed Modality Medical Simulation for the Evaluation of Civilian Prehospital Medical Response: A "Dirty Bomb" Case Study. That design includes different roles of participants with different medical kits. Also it requires selection of objective measures according to the scenario, thus a strategic response is necessary. We based our scenario design on a possible earthquake scenario on USC campus. We established a response team of six players and one commander who communicated with the players via text messages. Players must implement a strategy to rescue as many people as possible within a limited time. Different participants have different skills or tools requiring different cooperative scenarios for different locations on the map. The main game scenario contains 20 task boxes, each task box has a designated disaster scenario such as chemical fire or collapsed building. The different teams are "equipped" with various items such as medical supplies, bandages, flashlight, search dogs, shovel, dig machine, surgical tools, antibiotics, fire truck, axe, decontamination kit and gas masks. For example, in a chemical fire, it usually but not necessarily requires fire truck, gas masks and surgical tools. We designed the scenario with this abstraction keeping in mind that it would likely be teams of people responding to incident sites.

Our pilot tested 3 different 6-people scenarios with a seventh player serving the role of the commander.

Experiments

The pilot experiment was conducted over the course of approximately four (4) hours on the University of Southern

California's main campus. Seven (7) individuals participated and played the same role - with the same player label and skills - during each round. Each player was asked to provide their cellphone number so that they could text a single provided cell phone which served as the primary communication throughput for the commander. This method of communication was chosen because of the prevalence and importance of such methods in recent large scale disaster scenarios like Hurricane Katrina but most notably the Haitian Earthquake citenelson2011. Though they were given the option to change commanders after each round, the players elected to maintain a single commander across all scenarios. Each round was preceded by fifteen (15) minutes of time to analyze the scenario and plan a strategy for addressing the scenario layout. After the fifteen minutes were concluded, the teams were then given forty (40) minutes to complete as many objectives as possible, saving as many lives as they could.

In the first scenario, the players utilized most of their time devising a strategy for communicating with the commander. The players labeled certain phone numbers with their various disaster rescue labels. The commander asked that each player give reports about what they found at each disaster site. Given the layout of the scenario, the volunteers decided that it would be best to solely address the issues on the left side of the map. Figure 3, Game 1 shows the path traveled by the players during the experiment. Figure 4 shows the locations at which the players completed the tasks. All in all the players saved 51 lives in this round. During this round the players traveled a combined X kilometers with the average player traveling Y kilometers. 38 texts were exchanged between the commander and the various rescue team agents during this round. Feedback from the players was generally focused around complaints about the heat and the lack of organization and helpfulness of the commander. Observations of the teams in motion show an initial attempt to scout ahead by 2 players, and then the rest of the group catching up and grouping to complete additional tasks.

In the second scenario, the commander was cut out completely. Most of the time in the planning stage of the scenario saw the players discussing a new strategy that would not require reporting to or response from the commander. They devised a strategy which specifically delineated a path of objectives and all stuck together throughout the full duration of the scenario to complete those tasks. Only 2 texts were sent between the players and the commander to verify the amount of time left in the scenario. 107 lives were saved and the players traveled a total of X kilometers with the average distance traveled being Y kilometers. Feedback from the players after this round were also focused on the temperature outside and general elation that they had saved so many lives. Observations of the teams in motion are consistent with the trace data and initial group plan to stay together for the duration of the experiment.

In the final scenario, the players resolved to use the commander again. The stated belief was that the scenario objectives were too spread out to resolve individually, and that one individual should explore the furthest portions of the map for high-collateral areas while two teams of individu-

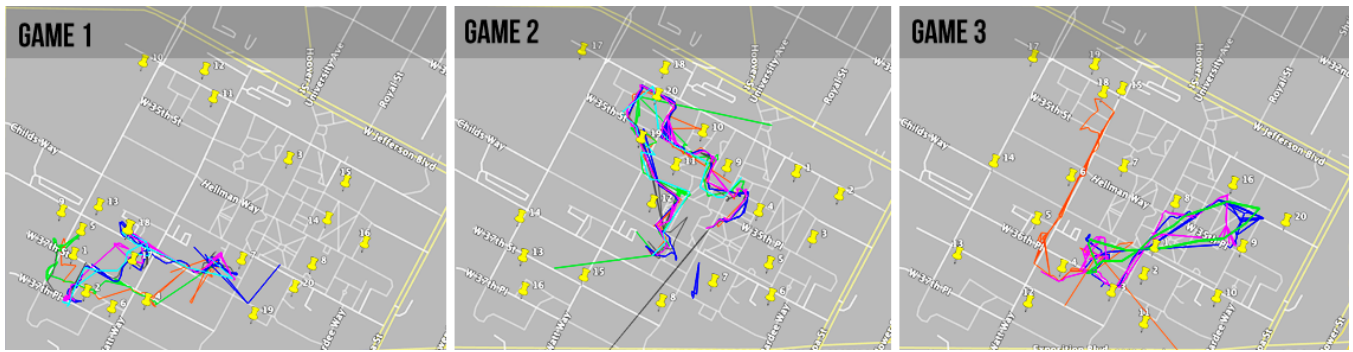


Figure 3: Game traces of player movement during the game. Different colors represent different players. The yellow pins represent the locations of objectives in each scenario.

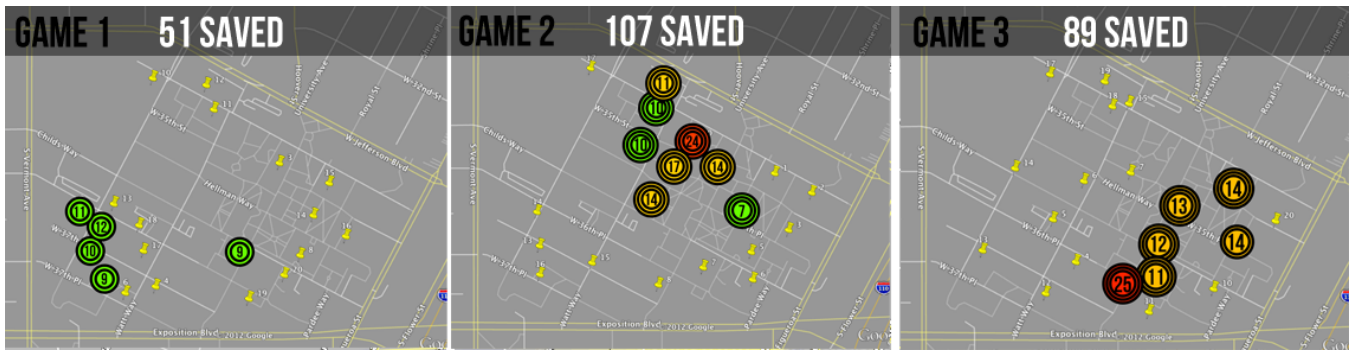


Figure 4: Locations and point values of tasks completed by teams in the three scenarios. The start location is at map center.

als would address issues to the east and west of the center starting location. Early on the players deviated from that plan though they would later split into 2 teams of 4 and 2 players. 53 texts were sent between the commander and the players. In this scenario, the players accessed a total of 16 locations, the most of any scenario; this is attributable to the scout player as can be noted in the trace in Figure 3. 89 lives were saved, the players traveled a total of X kilometers and an average of Y kilometers each. 2 players elected to give up and stop playing the scenario 10 minutes early due to fatigue despite having intelligence that there were 50 more individuals available to save if they traveled north in those last minutes.

Conclusion

These experiments demonstrate the ability of TEAM-IT to provide meaningful data and visualizations in a disaster scenario as well as its ability to quickly map to any geospatially-situated problem domain. We observe that players can exhibit a wide, unpredictable range of actions during a scenario that can make it difficult for commanders in such a scenario to effectively marshal their resources. We also observe the effect the real environment has on the results of the experiments; a 3D simulation of a disaster scenario with the exact same citenewnan2012aiide mapping citespraragen2012cosmopolis yields meaningfully variable human behavioral data, especially with respect to fatigue. We ob-

serve the need to collect even more information about player movements and interactions and store these histories for the purpose of generating volunteer models that might affect the interactions between volunteer agent and commander agent, as well as the construction of a commander-facing decision support agent.

Future Work

After arriving at these conclusions we have determined that more research must be done into the realm of task allocation in real time in physical domains. As such we have already sourced one author's research from our own university citegerkey2001. Gerkey's work in multi-robot task allocation seems to map appropriately to the challenges faced in actual geospatial situations. The uncertainty present in our experiments - that is, the lack of knowledge given to the commander - must be replaced with some dynamic probabilistic information formatted similarly to how real world disaster teams (coordinators citation?) gather crowdsourced data (which service was this? in haiti??) during a disaster rescue. We will likely modify our scenarios to allow for some probabilistic sampling of task information that will be provided to the commander during the experiment.

As for modifying our scenarios and data collected, we hope to increase the parallelism with true disaster response by providing an extended training session for commanders given past observations (coordinators cite) showing how sea-

soned commanders do a much better job organizing volunteers even if the volunteers are themselves untrained. The next step would then be to take a random sampling of trained commanders and run similar experiments with a decision support agent lending aid to some commanders while deploying others on their own. We intend to maintain a history of individual volunteer agents and certain heuristics such as their willingness to follow orders, responsiveness at following orders, responsiveness to communication channels and measured fatigue in order to generate some measure of personality to allow for better coordination on behalf of the commander in a disaster scenario.

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