
Collaborative Simulation Interface for Planning Disaster Measures

Kazue Kobayashi

NTT Comware Co.
1-6 Nakase Mihama-ku
Chiba-shi, Chiba, Japan
kobayashi.kazue@nttcom.co.jp

Atsunobu Narita

NTT Comware Co.
1-6 Nakase Mihama-ku
Chiba-shi, Chiba, Japan
a.narita@nttcom.co.jp

Mitsunori Hirano

NTT Comware Co.
1-6 Nakase Mihama-ku
Chiba-shi, Chiba, Japan
m.hirano@nttcom.co.jp

Ichiro Kase

NTT Comware Co.
1-6 Nakase Mihama-ku
Chiba-shi, Chiba, Japan
Kase.ichiro@nttcom.co.jp

Shinetsu Tsuchida

NTT Comware Co.
1-6 Nakase Mihama-ku
Chiba-shi, Chiba, Japan
s.tsuchida@nttcom.co.jp

Takaharu Omi

NTT Comware Co.
1-6 Nakase Mihama-ku
Chiba-shi, Chiba, Japan
takaharu.omi@nttcom.co.jp

Tatsuhito Kakizaki

NTT Comware Co.
1-6 Nakase Mihama-ku
Chiba-shi, Chiba, Japan
kakizaki.tatsuhito@nttcom.co.jp

Takuma Hosokawa

NTT Comware Co.
1-6 Nakase Mihama-ku
Chiba-shi, Chiba, Japan
takuma.hosokawa@nttcom.co.jp

Abstract

We introduce a disaster simulation system that supports collaborative planning of disaster measures. While several simulation tools are available for examination and evaluation of disaster prevention plans, they are limited to use on traditional computers and displays, and rarely used in collaborative planning sessions. To address this issue, we have designed and prototyped a tabletop tangible user interface for disaster simulation. This paper describes the design and implementation of our prototype and reports our preliminary user observations and their feedback. The results show that our system can effectively support collaborative emergency planning tasks by a group of users and that users can easily learn how to use our system.

Keywords

Disaster simulation, tangible user interfaces, Geographic Information Systems (GIS), collaborative design

ACM Classification Keywords

H.5.2 [Information Interfaces and Presentation]: User Interfaces.

Introduction

When planning disaster measures that minimize the damage from a hazard, simulations are useful for

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CHI 2006, April 22–27, 2006, Montréal, Québec, Canada.

ACM 1-59593-298-4/06/0004.

assessing the impact of a plan. On the other hand, in the case of an emergency, we often see crisis teams use a paper map spread out on a table and discuss what actions to take. While several simulation tools are available for examination and evaluation of disaster reduction plans [3], they are limited to use on the traditional computer and display, and hard to use in such collaborative planning sessions. To address this issue, we have designed and prototyped a tabletop interface for disaster simulation.

Tangible Disaster Simulation System

The Tangible Disaster Simulation System is a collaborative simulation tool for disaster measures based on disaster and evacuation simulations (Figure 1). A Geographic Information Systems (GIS) database is used for estimation of the damage from a hazard. On a tabletop surface, this system allows multiple users to directly input parameters such as the class and the scale of a disaster (e.g. tidal waves, earthquake, and fire), the timing of evacuation orders, locations of closed areas, capacities of a shelter, etc. Then, this system simulates and visualizes the effects of the disaster as well as the process of evacuation of people to shelters, under those conditions inputted. Users can examine how much damage a disaster will cause and possible measures for reducing that damage estimate.

Design Approach

We decided to use a Tangible User Interface (TUI) [2], with the thought that a TUI would be more suitable for collaboration than GUI in the following aspects.

First, it supports spatially multiplexed inputs [1]. The spatially multiplexed input and direct manipulation in



Figure 1: The Tangible Disaster Simulation System in use.

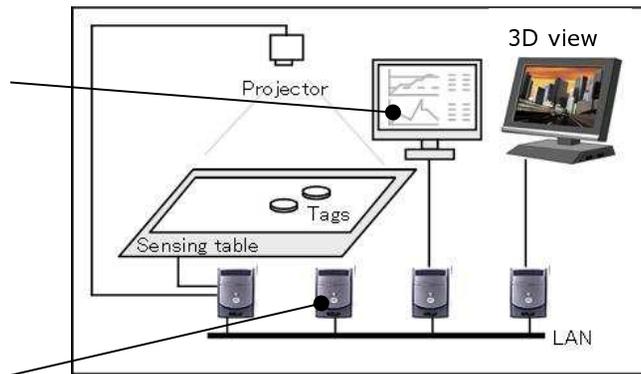
TUI speed up operations for editing plans and changing parameters. Second, physical tokens are used to control simulation parameters in graphical maps on a shared workspace. Also, simulation results are projected directly onto the token and table as an animation. These interface methods allow users to intuitively grasp and understand simulation results. Third, we expect that the physicality of the TUI model helps novices to learn how to use the system more easily and more quickly than a GUI would.

Implementation

This system is implemented upon a tabletop sensing surface such as the Sensetable platform [4], which can wirelessly and electromagnetically detect the physical location and orientation of tokens (or “pucks”). The table is large (80 cm x 60 cm), allowing several people

to sit around it at once. A video projector mounted on the ceiling projects a map onto the tabletop surface (Figure 2). The pucks are approximately 4 cm in diameter (Figure 3). Each puck has three LC tags inside, and the table has antenna arrays to detect a puck's location, rotation and button-press events. A computer connected to the sensing table handles the status of the pucks and sends it to the simulation engine developed in VC++. Simulation results are sent back to the computer and projected as an animation. Charts and numerical data are displayed on an LCD display next to the table. A three-dimensional view of simulation results is also available on another screen.

LCD display for charts and detailed information (e.g. earthquake center, magnitude, estimated damage, etc.).



Simulation engine.

Figure 2: System architecture.



Figure 3: Appearance of pucks.

Interface Design

By attaching video-projected components to pucks on the table, users can physically manipulate the map and input simulation parameters on the map.

Parameter settings for simulation

Before running a simulation, users can edit a map and make a simulation scenario. At the bottom center of the table is a graphical menu of the icons that can be added to the map: fire-breaking point, restricted area and additional population (Figure 4). When a user puts a puck onto one of the icons, the icon is highlighted and the user can place the icon by moving the puck to the workspace (Figure 5).

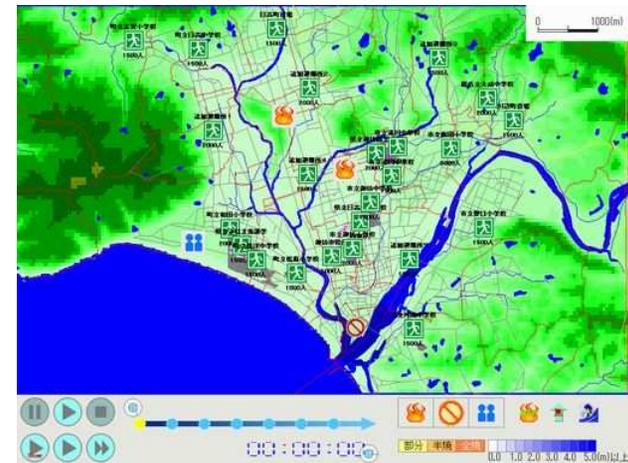
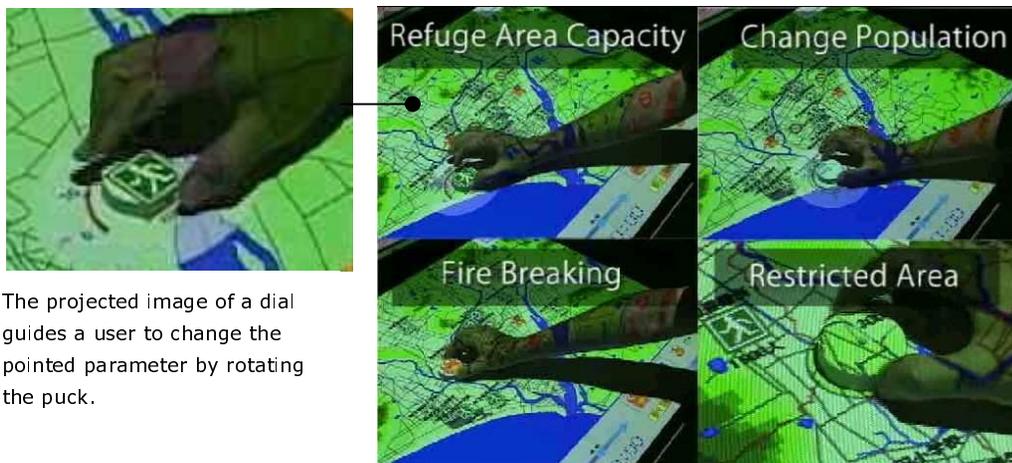


Figure 4: Screen image on the tabletop surface. Upper part is a workspace (a regional digital map). At the bottom of the table are simulation control buttons, a simulation clock and a menu of icons that can be added to the map.



Figure 5: Interaction sequence to add a restricted area to the map.



The projected image of a dial guides a user to change the pointed parameter by rotating the puck.

Figure 6: Changing simulation parameters using pucks.

Some icons have a single changeable parameter, modifiable by a rotating operation (e.g., the capacity of a shelter or the radius of a restricted area). When the user starts rotating the puck linked with such an icon, a scale appears around the puck to guide users to increase or decrease the value by that rotation (Figure 6). This system can handle multiple and simultaneous changes of parameters.

Simulation Result Feedback

During simulation, this system visualizes locations of people moving into shelters or refuge areas.

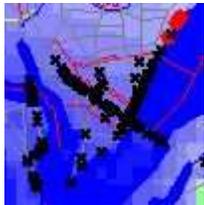
Red dots show the current locations of people (Figure 7). Evacuation routes are searched dynamically according to simulated disaster state and road conditions. For example, if a road is closed during simulation, evacuees near or on the road will seek an alternate route. As the simulation progresses, how high and how far tidal waves have come can be also shown with gradation of blue color. The color of a shelter icon is green at a normal status, and changes to red if the number of people in it is over capacity.

A couple of pucks are color-coded and assigned to monitor the status of a specific point. When a user places a colored puck onto a shelter, a chart indicating the number of people who have arrived at that shelter appears in the puck color on the chart display (Figure 8). In a same way, the immersion level of a tidal wave can be monitored by putting one of these pucks onto any point onto the map. (Figure 9)

After the simulation completes, numerical data of estimated damage is displayed on the chart screen for further detailed analysis. This data includes human damage (i.e., estimated number of dead and injured), building losses, and evacuation-related data (e.g. average time for evacuation, etc.).



Red dots moves according to estimated locations of people evacuating to shelters.



Information of injuries is shown as x mark.



Figure 7: Screenshots of animation on the table during simulation (top: 50 sec after earthquake, below: 33 min 50 sec after earthquake).

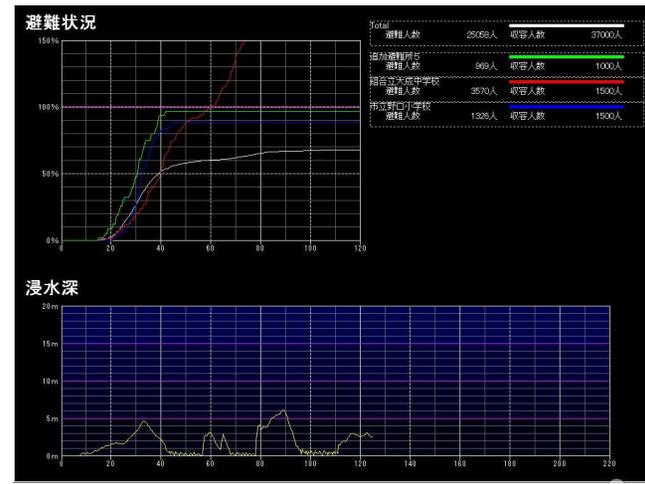


Figure 8: Screenshot of the chart display: the number of people at each shelter (top) and water immersion levels (below). Line plots are drawn in a color of corresponding puck.



Figure 9: Putting color-coded pucks onto the icons to be monitored.

Preliminary Evaluation

After installing our prototype in a showroom at NTT Comware Co. in Japan, we demonstrated this system to more than 100 visitors, including professionals in the disaster control domain. We have informally observed their use of this system in order to preliminarily assess if our interface achieves the aims listed in the Design Approach section above.

First, we have seen that most user groups enjoy and make full use of the capabilities of spatially multiplexed and direct inputs. For example, a user designated a restricted area as he and other persons were monitoring the water levels nearby. Another group was interested in investigating a combination of shelter capacities by using two pucks simultaneously. Second, users commented that they could easily recognize hazardous areas and evacuation plan flaws because the system visually represented simulation results on the map. Third, we also saw visitors understand how to use this system very quickly and easily after a short demonstration session.

Quite a few people noted that this interface could be very effective as a collaborative learning tool for citizens as well. Recently, to raise awareness of potential dangers and to develop citizens' preparedness, communities have been starting to provide hazard maps and to host training sessions. This system has a great potential to make such learning processes more enjoyable for participants because of its interactivity.

Conclusion and Future Work

We present the Tangible Disaster Simulation System, a tabletop tangible interface for collaborative simulation of disasters and countermeasures. Preliminary observation of and feedback from visitors who interacted with our prototype show that our approach can effectively support collaborative planning tasks. Our future work includes: conducting user experiments to evaluate this system with potential users (e.g., disaster control professionals), and enhancing the simulator and UI to deal with other kinds of disasters and measures. We would also like to further study this system in a collaborative learning context.

Acknowledgements

We thank our colleagues at NTT Comware and Professor Hiroshi Ishii and members of Tangible Media Group at MIT Media Lab for their valuable feedback.

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