Emergency Decision Support Using an Agent-based Modeling Approach

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***Abstract*— A key activity in emergency management is preparation for natural and man-made disasters. If the right precautions are implemented beforehand, the harmful effects of a disaster can be significantly mitigated. However, evaluation and selection of effective precautions is difficult due to the numerous scenarios that exist in most emergency environments coupled with the high associated cost of testing such scenarios. This paper presents a prototype of a computer simulation system that uses agent-based modeling to simulate an emergency environment with crowd evacuation and provides for testing of multiple disaster scenarios at virtually no cost.**

Keywords-Modeling and Simulation; Agent-based System; Emergency Management; Disaster Mitigation

I. INTRODUCTION

Of paramount importance to emergency managers is the question of how to prepare for as yet unseen disasters. Agent-based systems use a computational model of autonomous agents that move and interact with each other and their environment [1]. This paper presents a prototype of an Agent-based Emergency Management System (ABEM) for the simulation of fire/bomb disasters in enclosed environments. The goal of the system is to simulate a concert-event setting such as a stadium or auditorium and allow for multiple scenario testing and measurement of casualties during an emergency situation. The system is unique in the current literature as it aims to simulate a concert-event environment rather than an urban roadways or building/floor evacuation setting [2].

II. ABEM SIMULATION SYSTEM

The prototype ABEM system is designed to simulate a two-dimensional enclosed area that includes seats, aisle and path ways, stages/playing fields, exits, and people. It allows for the specification of multiple fire/bombs with dynamics of fire spreading and smoke production included. The ABEM system is designed to be highly configurable and allows for the specification of any setup of seats or bleachers, aisle and path ways, stages or playing fields, exits, and people.

A user can specify multiple fires with associated rates of fire spreading and smoke production. In the simulation environment agents representing people can be hurt either by being burned by fire or from accumulated smoke. People in the environment have one goal: to quickly move to an exit while avoiding fire. The algorithm governing person movement consists of three components: selection of an exit, movement from the seating area to a path way, and movement along a path way toward the selected exit. These three components are all influenced by a fourth component governing fire avoidance.

People in seating areas move along aisles toward the nearest path. People on a pathway move toward their desired exit while staying on the path. The environment is made up of many square shaped "patches" some of which represent pathways. Each path patch stores four directions representing north, south, east, and west. During environment setup, the system calculates allowed directions for each path patch by making a short distance scan from the center of the patch in each direction in search of other non-path patches. If a scan yields a non-path patch, then that direction is disallowed. Thus, a person is moved along a path by selecting a valid direction from his/her current patch.

Although people on a pathway may only move in one of four directions, fine-grained movement can be achieved by decreasing the size of the patches (and thereby increasing the total number of patches in the environment). A person chooses from the available valid directions by calculating the absolute angular difference between each valid direction and the direction directly facing the desired exit. The valid patch direction with the minimum angular difference is then selected.

As fires spread during a simulation run, exits that were originally unblocked by fire may become blocked. At each simulation step a person in the seating area or on a pathway rechecks his/her desired exit and current heading and, if either are blocked by fire, chooses a different exit and/or heading. In this way a person attempts to avoid fire while moving toward an unblocked exit in a changing environment.

A simulation demo that replicates an actual auditorium at a mid-sized university under a fire emergency can be viewed at http://youtu.be/tDc1l5Vt43Q.

III. CONCLUSION AND FUTURE WORK

This paper presents a prototype of the ABEM system for the simulation of fire/bomb disasters in concert-event environments. Future work includes the setup and execution for simulations of several real-world concert venues.

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