Dynamic Information Transfer and Sharing Model in Agent Based Evacuation Simulations

(Extended Abstract)

Masaru Okaya
Meijo University
Shiogamaguchi, Tempaku
Nagoya, Japan
m0930007@ccalumni.meijo-u.ac.jp

Mary Southern
University of Minnesota
Minneapolis
MN, United States
marys@cs.umn.edu

Tomoichi Takahashi
Meijo University
Shiogamaguchi, Tempaku
Nagoya, Japan
ttaka@meijo-u.ac.jp

ABSTRACT

We present a model for information transfer among people during evacuation and present results obtained in simulation with a large number of people. The results show how people behaviors affect the rate of evacuation.

Categories and Subject Descriptors

J.4 [**Social and Behavioral Sciences**]

Keywords

Evacuation simulation, Human behavior, Evacuation guidance

1. INTRODUCTION

The analysis of building evacuations has recently received increased attention, as people are keen to assess occupant safety. Evacuation drills are conducted at public facilities to egress safely and quickly from buildings, and to perform rescue operations properly during emergencies. However, it is difficult to conduct physical drills that involve many humans and real environments. Understanding and modeling human behavior enables improved social design, for purposes such as decreasing evacuation time, a composite of pre-movement time and travel time to safe places.

Reports about human behavior during emergency situations in past disasters show several types of human reactions when alarms are given (see, for instance, the National Institute of Standards and Technology report on the World Trade Center, on September 11, 2001 [1] and the cabinet office of Japan on the Great East Japan Earthquake and resulting tsunami which occurred on March 11, 2011 [2].) There are common issues in such events that are not supported in the existing systems. People know that the alarms issued by the authorities are important sources of information, but not all people evacuate immediately. Some go to find family members in remote places and try to contact them by phone.

Information, such as the layout of buildings and the safety of family members affect people's evacuation behaviors. Human behaviors characterize the efficiency of evacuations at emergencies. In this paper, we present a model for information transfer at emergencies.

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2. INFORMATION TRANSFER AND SIMULATION SYSTEM FOR EVACUATION

Information on disaster situations and personal relationships both play important role in deciding actions. Information transfer is processed through following phases.

Transfer phase: When emergencies occur, people perceive the occurrences by themselves and authorities announce alarms to people.

Sharing phase: People confirm and share the information that they get by communicating with people nearby, and people make their own decisions on how to behave.

Transfer and sharing phase: People who are unfamiliar with buildings follow guidance from authorities who are assumed to be acting according to the prescribed manuals of the buildings.

Our system consists of the following three modules.

Agents and interagents module: At each of the three phases, people hear, share information and behave in a certain manner. A Belief-Desire-Intention (BDI) model is adopted to represent such a process. For our purposes, beliefs are what people sense, for example, information about the layout of buildings and the relationships of interagents and others.

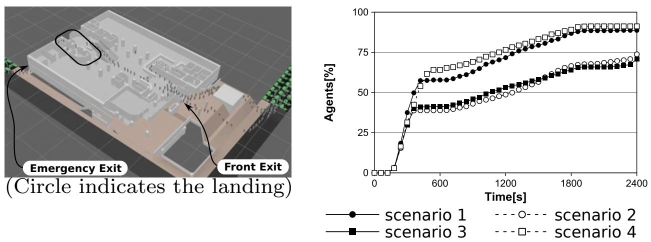
Environment module: Environments in our study are 3D models of buildings and the communications among agents. Agents communicate to others to transfer information using SAY/ BROADCAST commands which correspond to voice talk, through phones and broadcasts, respectively. HEAR/ LISTEN commands are used to get information from others.

Crowd simulation: People do not move in the same direction. Pedestrian dynamics are calculated considering physical differences such as sex and age in one sense-reason-act cycle.

3. EVACUATION SIMULATION

Figure 1(a) shows a five-story building and a snapshot simulating 1,000 people (200 people are at every floor) evacuating from the building. The building is a library of our university that has stairs between floors and two exits. One exit is the front exit, 3.7m wide, on the 2nd floor, and the other is an emergency exit on the 1st floor.

People at the 1st and 2nd floors are guided to evacuate from the exits that are connected to the floor: the front exit and the emergency exit, respectively. For people at the other floors, different evacuation plans are prepared to evacuate smoothly (Table 1). Plan A is designed to ease congestion at staircase landings where people coming from upstairs meet people coming to the stair from the floor. Plan B leads people in proportion to the widths of exits.



(Circle indicates the landing)

(a) snapshot of evacuation (b) rate of evacuation

Figure 1: Evacuation from building

Table 1: Routes guided in phased evacuation.

building		plan A		plan B		comment
F	exit	Em.	Fr.	Em.	Fr.	
5		✓			✓	security office
4			✓		✓	
3		✓		✓		
2	front		✓		✓	width is 3.7m.
1	emer.	✓		✓		width is 1.3m.

Evacuation guidance scenarios.

Four scenarios are simulated. Scenario 1 and 2 are plan A and B, in which the evacuation guidance is announced once at the starting step. Scenario 3 and 4 are modifications of plan B. At scenario 3, in addition to the initial announcement, five security department staff members go to the landing spaces of the stairs at each floor. And they guide by giving SAY command people who stay there hear the same initial announcement again. In scenario 4, the guidance of the staff at 3F is that people should go out of the building from the front exit (not the emergency exit).

Figure 1(b) shows the percentage of evacuated people. We expected scenario 2 to be better than scenario 1 and that the local evacuation guidance of scenario 3 would work well, because the width of the front exit is wider than the emergency exit. What we found in simulations is that the scenario 1 was better than scenario 2. In scenario 2, the path of the agents heading to the emergency exit and the path of the agents heading to front exit collide. These movements caused congestion and prevented a smooth evacuation at the landing of 3F. In scenario 3, the guidance given from the staffs at the landings did not produce any results. In scenario 4, the changed guidance eased the congestion, and made for a better evacuation rate, compared with scenario 1.

Family evacuation.

We placed 500 parent-children pairs in the library. When the evacuation guidance was given, the pairs were randomly located in the library. The parent and child in 22% of pairs are together on the same floor, and the parent and child of the rest pairs are on different floors. As for the distribution of by floor, 23%, 19%, 18% and 18% pairs were located at1, 2, 3, and 4, respectively (Table 2).

The child agents cannot go to the exits by themselves. Examples of typical communications that are exchanged between parents and their child before their egress (the left column is types of Agent Communication Language (ACL)) are as follows:

Query-Ref	Where are you?
Inform	I am at location X.
Request	Stay there.
Agree	I will stay here.
Query-If	Is it safe to use the main exit?

Table 2 shows the time from the announcement to when the parents go to their child. When the parents are at a lower level, they go to their child at an upper floor, and their movements are counter to the major flow of people who are trying go down the stairs to the exit. Most of the pairs in which the parent was at a lower level than their child did not evacuate.

Table 2: Family movement time to get to child.

diff. of floor	parent agent is at A or B their child			
	A: above floor		B: below floor	
4	7/48	831 ± 696	1/44	2178
3	7/36	2171 ± 87	0/54	-
2	4/34	2211 ± 10	0/59	-
1	5/58	1775 ± 496	3/57	2264 ± 87
0: at the same floor as their child, 13/110 516 ± 680.				

2nd and 4th column are the number of evacuated pairs and initial assigned pairs, respectively.

4. DISCUSSION AND SUMMARY

We propose an information transfer and sharing model, which enables announcement of evacuation to people or information sharing during evacuation. In conjunction with the BDI model and our information transfer using ACL based communication, our simulation system 1) enables the simulation of evacuation behaviors at various scenarios, 2) demonstrates places where congestions may occur, and 3) eases congestion by proper guidance.

The simulation results demonstrate that ways of guidance can improve evacuation time, and they reveal phenomena in agent behaviors that have not been simulated by other methods. The results show some possibilities for evaluating prevention plans including the ways of administering evacuation guidance.

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