A STUDY OF THE LOCATION OF FIRE EGRESS SIGNS BY YR SIMULATION

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Abstract

The purpose of this paper is to present a suggestion for the location of fire egress signs along a corridor in a building. The suggestion is made based on a virtual reality simulation of human behavior while rooms are on fire, particularly in a public Karaoka TV entertainment center (KTV). Both the rooms and smoke were modeled to simulate similar situations in which people were asked to find their routes to an egress. Case studies were made of the occurrence of two local severe fire disasters, the official investigation of damages, and related building codes. The simulation concluded that the traditional designation of egress signs at a higher location or just above the door frame may be not function appropriately in indicating the location of exit in case of fire. Since smoke is usually lighter than air and is accumulated closer to the ceiling level, either human vision or egress signs are very likely to be blocked by the darkness of smoke. Vision is additionally restricted because people are suggested to lower their body position to avoid smoke while escaping. Suggestion of alternate location of signage is also made in the research.

I. Introduction

The purpose of this paper is to present a suggestion of the location of fire egress sign along a corridor in a building. The suggestion is made based on a virtual reality simulation of human behavior while rooms are in fire, particularly in a public Karaoka TV entertainment center (KTV). Both the rooms and smoke were modeled to simulate real situation and people were asked to find path to egress. The process can help modeling design environment (Campbell 1996, Stansfield 1996) and facilitate decisionmaking in design (Campbell & Davidson 1996, Campbell & Wells 1995, Pearce & de Spiller 1995).

While building is getting larger, higher, and complicated, the consequence of fire becomes more severer and the distinguish of fire also becomes more difficult (Building and Fire Research Laboratory NIST 1996, Building Research Establishment 1996). The casualties and damage made to property and life show significant impact to public safety in public buildings in Taiwan. In order to prevent potential fire hazard, related issues have drawn public attention, such as fire prediction, detection of fire, broadcast system, evacuation, fire distinguishing, collapse prevention of structural members, and the number of fire sprinklers or hoses.

Karaoka TV entertainment center (KTV) is very popular in Taiwan. People can sing with the video and original melody from tapes. KTV usually consists of different types of design as in rooms for group of people or in stages for public access. Due to the amount of population simultaneously presented in a KTV and owner's ignorance of fire related facilities, KTV is always considered as a dangerous place and is frequently inspected by related government departments. Many studies were made to local fires occurrences. Survey concludes several factors affect human response in fire and listed all facilities related to fire egress. Official investigation tried to conclude reasons and consequently conduct modification of related building codes to prevent future disaster.

2. Two Cases

Smoke, high temperature, ambiguity of route, difficulty to rescue, and improper management of fire protection devices are among the main factors causing casualties when fire occurs. Two recent cases have drawn public attention and are discussed in terms of security design of fire protection. Investigation shows that:

- equipment which caused fire was placed on a corridor which was the main passage route during evacuation
- equipment which caused fire was placed near main exit
- interior was decorated with combustible materials
- exterior walls lacked openings for occupants to escape and smoke to ventilate naturally
- automatic systems to distinguish fire and to control smoke were not installed

In general, the problems related to fire protection are listed as follows.

- ignoring the principle of two-way corridor design
- mismanagement of passage ways and exits
- lacking the guidance of building managers, guards, or staffs
- incorrect movement or behavior of occupants
- problems in zoning and space planning
- missing clarity of exit signage in case of fire

Based on the classification of building codes, KTV and restaurant are rated as the second and third priority in building inspection (see Table 1). Significant casualties were caused in the two cases, although most of the design already met the requirements specified in building codes. Most of the casualties were caused by smoke for the reasons listed below:

- building codes do not differentiate the requirements based on the height of building and the amount of interior combustible materials
- current building codes lacks a complete regulations for smoke control and differentiation for levels of security in zoning and automatic smoke control
- current building codes do not explicitly specify the demand for the space of escape and do not differentiate situations based on floor area, density of population, amount of combustible materials, smoke control, etc.

As a result, most of the building codes only specify the minimum requirements. The design of fire control will never reach a sufficient level of security if general codes are applied. In order to reduce casualties, the codes should be modified based on current situations, materials, and customs.

Table 1. Inspection priorities of building types

Priority	Building Types
First	hotels (five stars), department stores
Second	theaters, movie theaters, MTV, KTV, hotels
Third	large restaurants, ball rooms, clubs, sauna, entertainment centers, etc.

3. Factors affect Evacuation and Planning

Evacuation represents the movement of occupants away from hazard region when building is on fire. Evacuation behavior is related to the movement of occupants who usually have several characters, such as being oriented by light, referring to familiar routes, and blindly following crowd. There are many factors are influential when fire occurs, such as fire sources and combustibility, fire spread and smoke flow, detection and fire fighting, escape and protection of occupants, and the capability and response of fire fighting from outside.

Based on the previously mentioned characters, routes for evacuation need to be designed properly:

- simple and clear
- more than one direction should be provided for refugee
- no interruption or dead end occurs to a passage way: both ends of a passage way should lead to a safe place, looped corridor usually are safer
- behavior in emergency should be considered
- applying windows, balconies, and facilities to evacuate occupants
- include area or floor for refugee in space planning

4. Test

Since the route for evacuation and the signage of exit are important factors in fire protection. A test was conducted, recorded, and analyzed accordingly.

The test conducted in this research was based on several restrictions:

- the simulation of egress route considers a floor area as the basic region of classification
- the planning of egress route is mainly horizontal, instead of vertical
- vertical stairs is the only traffic core safe for evacuation
- elevators cannot be used in fire
- the simulation of fire egress route is the main concern, starting location of fire and burning types are not included
- smoke, which generated from burning materials and fire, covers top one third of room height
- evacuation speed is one meter per second

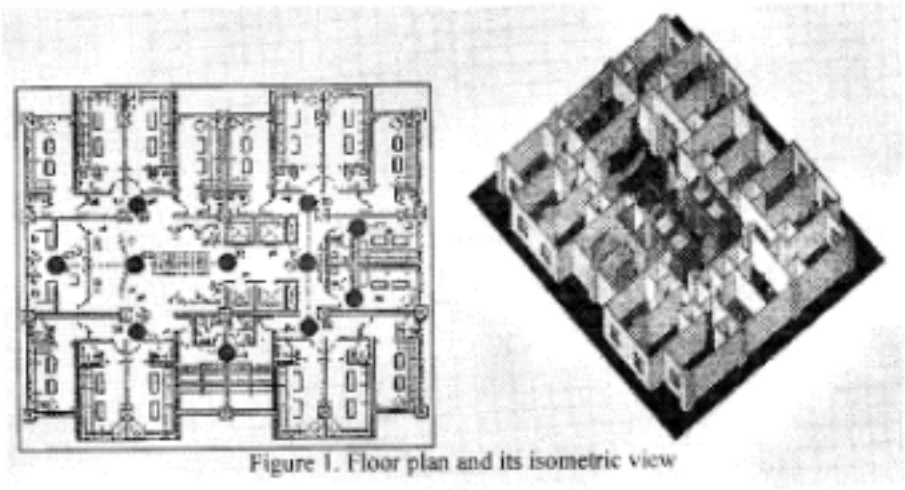

Figure 1. Floor plan and its isometric view

Figure 2. Interior views

The simulation applied QuickTime VR through which eleven scenes (see Fig. 1) were built to match the intersection points of corridors in plan (Bouman 1996). The scenes were built and rendered by ArchiCAD (see Fig. 2) and played by testees with VR Player. Each scene allows testees to view the surrounding environment in 360 degrees. A scene can be connected to the next by following the indication of an arrow. By

clicking the arrow, a testee will be moved to the center of next scene, which simulates the escape from a node (an intersection of two corridors or a hallway) to another. Testees can choose directions in a scene to determine which one is the appropriate way to escape, without clear indication of egress signs. Each testee was demonstrated with the manipulation of cursor which corresponds to the movement in a scene first. In the beginning, each testee was led by a waiter from entrance (the eleventh scene) to a room which represents the seventh scene where the simulation starts by informing her/him of the fire. Once fire condition is given, testee tried to escape though the manipulation of cursor. In the mean time, tester recorded the number of scene and the period of time that each testee had traveled before reaching exit. Escaping route was drawn and shown to each testee. Whole manipulation process of each testee was recorded by camcorder.
This test was an interactive manipulation which is different from traditional animation with defined route. However, the connection between scenes was conducted by quick transfer from one to another, instead of continuous movement. Due to the limits of computational capacity of computer and the demand for more memory, only eleven scenes were installed, instead of one scene at each interval. Not many escaping routes could be selected. Additional location of fire, which has significant influence to the judgment of routes, was not taken into consideration.
Future tests would include the improvement of the construction of computer models and manipulation process. Tests would allow continuous movement between any two locations on plan, demonstrate the influence of the speed of smoke spread, specify the height of signage in various design, compare the difference between the existence of sign, and add more scenes in representing real environment.

4.5 FINDINGS

The test process was recorded and evaluated based on traveled distance and required period of time (see Fig. 3). Distance is checked by the sequence of scenes that a testee has traveled in order to calculate the number of path segments. The total period of time is measured in order to check if a certain limit is exceeded, by comparing to a human's escaping speed as one meter per second. Recorded data show that testees tended to escape by taking the route that they came from. The number of traveled scenes varies from three, which is exactly the shortest path to the entrance, to nine. In general, time is proportional to the distance traveled.
The simulation concluded that traditional designation of egress sign at higher location or just above the door frame may be not functioned appropriately in indicating the location of exit in fire. Since smoke is usually lighter than air and is accumulated closer to ceiling level (1/3 of room height), either human vision or egress sign is very likely to be blocked by the darkness of smoke color. Vision is additionally restricted because people are suggested to lower their body position while escape for the presence of smoke. The design of egress indication should be integrated with corridor design or the building components within the passage way, in contrast to exit indication only. The indication should provide egress direction at the first place when occupants are in

corridors. The building components can be skirts, wall finishes, floor finishes, or any additional signage which have clear indication. Detailed suggestion of the location and the shape of signage is yet to be tested in future research and confirmed in real situation to prove its feasibility.

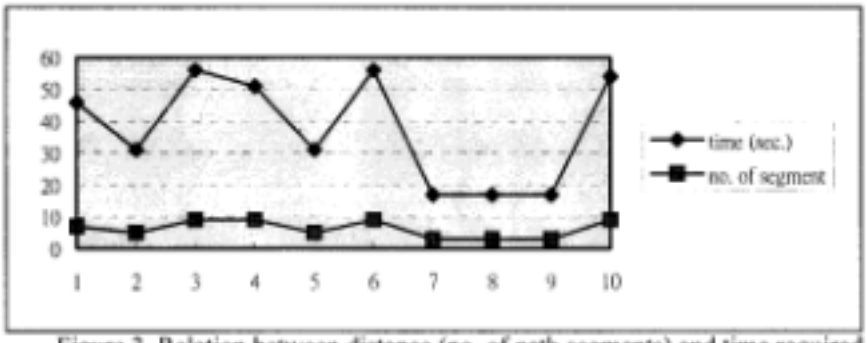

Figure 3. Relation between distance (no. of path segments) and time required

5. Conclusion

A simulation was conducted to confirm the influence of location of fire egress sign along a corridor in a building, through an image-based virtual reality simulation. Based on the findings of simulated result, the test concluded that traditional designation of egress sign at higher location or just above the door frame may be not functioned appropriately in indicating the location of exit in fire. Detailed suggestion of the location and the shape of signage is yet to be tested in future research and confirmed in real situation to prove its feasibility.

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