A VR-BASED PREFERENCE STUDY ON THE SELECTION OF EGRESS ROUTE IN EVACUATION

NAAI-JUNG SHIH and CHIH-HSIANG YANG
Department of Architecture
National Taiwan University of Science and Technology
43, Section 4, Keelung Rd.
Taipei, Taiwan, China

Abstract. This preliminary study tried to characterize an occupant’s preference in egress route selection, with/out signage and smoke. In a VR simulation conducted in a public space, six types of egress routes were categorized and exemplified based upon the width of the corridor, fillet corner, or the intersection of two corridors.

1. Introduction

The word “evacuation” mentioned in this paper is related to the movement of occupants away from danger without assistance, when a building is on fire. An occupant’s behavior cannot be observed, recorded, and analyzed from a real fire situation. In most of the studies on behavior investigators have either visited a real site afterward to collect evidence (Lin, 1997; Yang, 1998) or conducted psychological analysis with a theoretical model in an artificial environment (Canter, 1990; Ebihara, Notake & Yashiro, 1997). Surveys or interviews of original occupants have also proved to be useful in collecting first hand data (Fahy & Proulx, 1997).

Formal studies concluded that an occupant’s behavior exhibits several characteristics (Architecture Department of Residence Bureau, 1997; Canter, 1990):
1. select original route as the first choice in evacuation;
2. follow original route to evacuate;
3. evacuate from entrance;
4. illustrate linear route preference;
5. follow signage;
6. illustrate left turn preference in darkness;
7. oriented toward open area (hall, for example);
8. follow blindly;
9. cross zone evacuation;
10. follow the shortest distance.

While many former studies have emphasized an occupant’s behavior based on rooms or zones, investigation into the preference of routes at an intersection
needs special attention for its strong relation to architectural design in terms of circulation.

Since fire usually demolishes the original building, rebuilding the site scene becomes a standard procedure before concluding reasons for the causes of the fire. Site scene, in a three-dimensional model, is not only useful for inspection purposes, but it also helps the designer to analyze the potential dangers of the plan layout in the schematic design stage. As a result, this study tried to apply virtual reality (VR) technologies to build a virtual environment (VE) and to conduct tests regarding an occupant’s behavior in terms of preference in selecting egress routes.

This study selected a local public entertainment facility, Karaoka Center (also called KTV) (see Figs. 1,2,5), to conduct a preliminary test regarding the assumptions and potential blind points in the evaluation of time required for evacuation. This KTV was re-constructed in a virtual environment. This test consisted of four scenarios regarding the presence of signage and smoke: 1) both signage and smoke were presented, 2) only signage was presented, 3) only smoke was presented, and 4) neither signage nor smoke was presented. During
the test of each scenario, each subject was led to a room by a tester and then requested to evacuate as if a real fire had just started. The tester recorded route types, traveled distance, and behavior of each subject. During this test, the kitchen was where the fire began. Because this KTV did not have fire extinguishing facilities installed at the entrance, the entrance was not included as an exit. Evacuation generally includes horizontal and vertical directions (see Fig. 3). Since this KTV was located in a basement and was only one floor, only horizontal evacuation was simulated.

Several assumptions were made in advance.
1. The fire would start in the kitchen.
2. Subjects would be not particularly informed about the presence of escape signage.
3. The height of the viewpoint would be set at 1.4 meters.
4. Smoke would be colored a light gray.
5. The range of visibility would be between 2 and 4 meters.
6. All subjects would be first time customers at the KTV and they have never seen building plans before.
7. No person would guide the subject in finding an egress route.
8. Delay time due to the effective width of an exit would not be considered.

![Egress routes in KTV](image)

**Figure 3.** Egress routes in KTV

### 2. Preference in the selection of egress routes

VR simulation was applied to study an occupant’s behavior in selecting an
The recorded paths of the subjects were used to classify preference in terms of a corridor’s spatial characteristics. In general, the most obvious behavior would be to use the most familiar route, like the route entered before, to evacuate. Another obvious behavior is to evacuate toward an open area.

The subjects’ selections of various egress routes in the KTV are listed in Fig. 4. These selection were based on the characteristics of the subjects’ behavior concluded from the formal studies. Several characteristics were discovered when subjects face the selection of routes at an intersection (see Fig. 5-7):

Figure 4. Percentage of egress routes chosen in KTV.

Figure 5. Route selection preference
1. Preference 1: Subjects tend to keep to the original moving direction, if the width of a branch is small at an intersection.

2. Preference 2: Subjects tend to change moving direction, if the width of a branch is larger at an intersection.

3. Preference 3: Subjects tend to change moving direction, if a fillet corner occurs at an intersection where all branches have equal width.

4. Preference 4: Subjects tend to change moving direction along a fillet corner, if both right and left branches have equal width at a T-junction.

5. Preference 5: Subjects tend to change moving direction to a wider branch, if the width of the right and left branches is different at a T-junction.

6. Preference 6: Subjects tend to change moving direction to a wider branch, if the branch width in the original direction is narrower and the other direction is equal to or wider than the original one.

Although the findings are illustrated in terms of plans corresponding to a real case, line drawings are merely used as a simplified representation. The tests were conducted in a virtual environment which was modeled to meet the original setup in texture and scale of objects. The subject’s behavior using four scenarios was characterized by route types based on final results. More cases are needed before concluding a thorough spatial description which would include height, visibility, or psychological factors.
return to where the subject entered this KTV

special behavior characteristics

follow zoning plan and signage

follow signage

move to open area

follow blindly

the shortest path

Figure 7. Tests with both signage and smoke presented
While relating the preferences mentioned above to plan layout, conflicts exist in egress route design in terms of width, orientation, access, and the location of exits. The width of a corridor usually indicates its importance and tolerable capacity in conveying occupants. Circulation, from entrance to the most closed area, usually reflects the width-and-importance fact. The width of an egress route may conflict with psychological preference which is more likely oriented toward an open area. Unless the evacuation direction in a plan is purposely designed toward a hall in order to reach safe places, the corridor may lead occupants to exits which are hidden or not obvious. As simulated in this test, a cut corner also influences a subject’s preference. An architectural designer should notice this difference and simulate possible choices in 3D from the inner most location within plans to all exits, instead of merely reviewing 2D drawings.

The entrance and exit along with approaching corridors in this test illustrated the following conflicts:
1. Wide-narrow conflict: The corridor leading to an exit was smaller than the ones leading to the entrance.
2. Important-insignificant conflict: The plan layout is entrance-emphasized, that is, it seems all decorations imply a room’s spatial relation to the entrance, and vise versa. The relationship between exits and other parts of this plan relies on the indication of signage.
3. Familiar-unfamiliar conflict: Most of the customers may not be as familiar with the routes to exits as they are with the route to the entrance. When smoke was presented, great difficulty was encountered in the search for exits.
4. Priority conflict: Exits are usually hidden or not as obvious, since they are less important compared with the main entrance. Entrance and exits are allocated in a priority manner creating not only a spatial but functional conflict.

No plan layout is “exit-oriented” in order to facilitate evacuation in a dangerous situation. As a result, designers may enhance the interrelationship between entrances, circulation, and exits by considering the findings of this research:
1. locate exits in correspondence to the main circulation system;
2. combine the functions of entrance and exit at the same place;
3. apply cut corners to imply preferred moving direction.

3. Conclusion

This paper presents a preliminary investigation of the preference of routes at an intersection for its strong relation to architectural design. Several types were identified. Conflicts were also indicated and exemplified in the tested plan. In order to facilitate evacuation of occupants, designers should enhance the
interrelationship between entrances, circulation, and exits by preventing design conflicts, and simulate possible choices of 3D routes from the inner most location within plans to all exits, instead of merely reviewing 2D drawings.

References


Lin, C.W.:1997, Course Pact of Building Material and Fire Security, Ch. 10, Department of Architecture, National Taiwan University of Science and Technology.
