

# A CITY MODEL FOR STUDIES OF A CITIZEN'S WAY-FINDING BEHAVIORS

MITSUO MOROZUMI, TADASHI UCHIYAMA,RIKEN HOMMA,  
MINORU TANAE

*Department of Architecture and Civil Engineering  
Faculty of Engineering, Kumamoto University  
Kurokami 2-39-1, Kumamoto City, Japan  
moro@arch.kumamoto-u.ac.jp  
991d9339@eng3.stud.kumamoto-u.ac.jp  
homma@arch.kumamoto-u.ac.jp  
963t1521@eng3.stud.kumamoto-u.ac.jp*

**Abstract.** This paper discusses the necessary features for a QTVR (cylinder-VR) based simulation system to study a citizen's behavior of finding their way to particular points, as well as observations found in the case studies that used several prototypes developed as a step in the studies. The authors tested prototype systems developed for a downtown shopping area of Kumamoto City, and observed answers to questionnaires in which 30 students who are familiar with the site compared the three prototypes. After observing cognitive maps sketched by nine strangers to the site, and after virtual walks with one of those prototypes: prototype-III, the authors concluded that it could provide a necessary level of visual representation and system operations as a tool for simulating citizens' travel behaviors.

## 1. Background and Objective of Study

It is important for urban designers to provide an attractive environment in which both strangers and frequent visitors could be stimulated by diverse traveling activities for their pleasure. Past studies that dealt with the relationship between a citizen's behavior of way-finding or travel activities and stimulation given by their environment, suggest that they could give us various guidelines for urban design (Arthur and Passini, 1992). However, it is not so easy to collect enough data for such studies, even when one limits the type of stimulation visitors will find; observing one's behavior in a physical environment takes time and energy. It is also difficult to identify the factors which stimulate one's behavior.

As a solution to this, the authors started to develop a prototype of an interactive visual simulation system in which one can virtually experience travel

behavior in a specific urban area. VR, VRML, walk-through CG animation, linked web images, linked QTVR (cylinder VR), linked video segments, and physical models with a model scope will be some of the alternative approaches (Kaga and et. al., 1998; Maver, 1998; Strong and Woobury, 1998; Toshitomo and Okuda, 1999; Yeung and et. al., 1998). Assuming it is necessary to provide photo realistic images of an existing city to describe its environment, as well as to develop a handy system that can be operated by PCs in a normal laboratory, the authors selected an approach which uses linked web images, and linked QTVR images as a prototype system. Though Strong and Woobury (1998) pointed out that linked still images tend to lack a sense of sequential movement, the authors decided to test whether still images of a place defined at a short interval could relieve such a disadvantage.

It is the objective of this paper to discuss the necessary features of this simulation system for study as well as to establish some findings in experimenting with these developed prototypes.

## 2. Framework of Studies

The authors took a 500m x 700m central shopping district of Kumamoto City, Japan, as a case study (See *Figure 4*), and carried out the next seven steps which can be grouped into two different stages.

- 1-1) Developed three different prototype systems that applied different representation models and user interfaces.
- 1-2) Asked 30 people who know the case study area well to test the three systems and to compare their performance as a tool of virtually experiencing ramble walks, as well as their user interface for operation of the system.
- 1-3) Analyzing the answers to the questionnaire and the participants' comments, the authors summarized the necessary specifications for representation models and user interface of the system.
- 2-1) Authors selected a system that was assumed to be the best among the three.
- 2-2) Asked nine people who were not familiar with the case study area to simulate a 20-30 minute virtual walk, and to draw sketches of spatial images of the area they remember after simulation (cognitive map).
- 2-3) Asked two of them to repeat step: 2-2).
- 2-4) Observed the respective sketches as to whether they represented a major spatial feature of the area, and whether the repetition of a virtual walk could develop these elements in their cognitive maps, the authors assessed the applicability of the system for studies of citizen's way-finding behaviors.

### 3. Features of Developed Systems

#### 3.1. BASIC FEATURES OF THE SYSTEM

The authors assumed the following to be the minimum features of a system that can be used on a PC.

- a) The system provides photographic images of a streetscape, seen through the eyes of pedestrians, for every point set along the streets at short intervals.
- b) User simulates a virtual walk by jumping from one photo-image to another with interactive mouse actions.
- c) The system allows the user to freely change the directions of walking at any point, and to select the direction and the course of the walk at every intersection of the streets. This means that the system allows a user to freely select a photo-image to jump to among the photo-images of the neighboring points on a street network.
- d) The system allows a user to simulate a looking-around action and a staring action, in other words to zoom in some specific points in the displayed images.

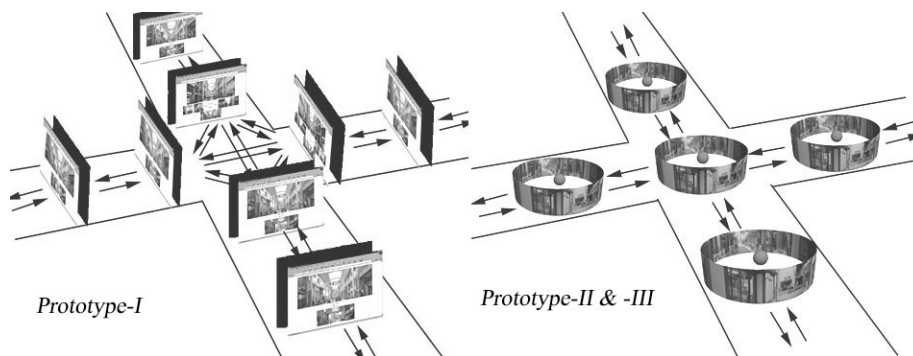
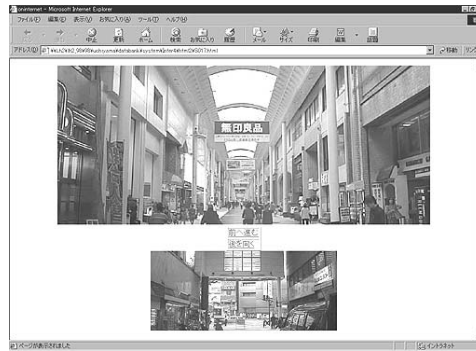


Figure 1. Conceptual Model of Prototype-I, -II and -III

The prototype-I applied a technique of establishing HTML links among the photo images, and prototype-II and -III applied a technique of linked QTVR images for system development (Figure 1).

## 3.2. FEATURES OF PROTOTYPE- I

- 1) Assuming a centerline for each street, the authors set points of representation at every intersection of the streets, and also set them along street segments between the intersections, at approximately 20m-intervals.
- 2) At points other than intersections, the prototype presents a large front view image and a small rear image (*Figure 2-a*), while, at an intersection, small view images of streets branching out from that point were presented (*Figure 2-b*).
- 3) The user selects a course of travel by touching buttons with a cursor that represent respectively, forward, turn right, turn left, or return.
- 4) A 120 degree wide view-angle photo image was used for each direction.
- 5) In prototype-I, the authors could not introduce the looking-around and staring actions as listed in d) of the previous section.



*Figure 2-a.* Window Configuration of Prototype-I  
(at points other than at an intersection)



*Figure 2-b.* Window Configuration of Prototype-I (at an intersection)

### 3.3. FEATURES OF PROTOTYPE-II AND -III

- 1) The authors have reduced the interval of representation points to 10m.
- 2) A single set of QTVR images were presented on display for each representation point (*Figure 3-a, -b*).
- 3) The user could rotate their view for 360 degrees at each point by cursor action, and even zoom in some part of an image or zoom out to a normal image by just touching a fixed key.
- 4) The user can travel forward or backward, and even turn at the intersection by just rotating the QTVR images and touching its center with the cursor, after rotating the QTVR images to the direction desired.
- 5) Prototype-II and -III applied windows of a different view angle width. Prototype-II used a window that corresponds to images of 50 degrees, while III used a window that corresponds to 130 degrees.



Figure 3-a Window Configuration of Prototype-II



Figure 3-b. Window Configuration of Prototype-III

#### 4. Procedure for Producing Image Data

##### 4.1. PROTOTYPE-I

The authors took three photo images with a digital camera<sup>i</sup> set at man's eye level, facing the same direction for each point of observation. They were synthesized to produce wide view angle images. 38.5MB JPEG image data was produced for 29 points set along sections of a 520m street in the study area (surrounded by dash lines in *Figure 4*).

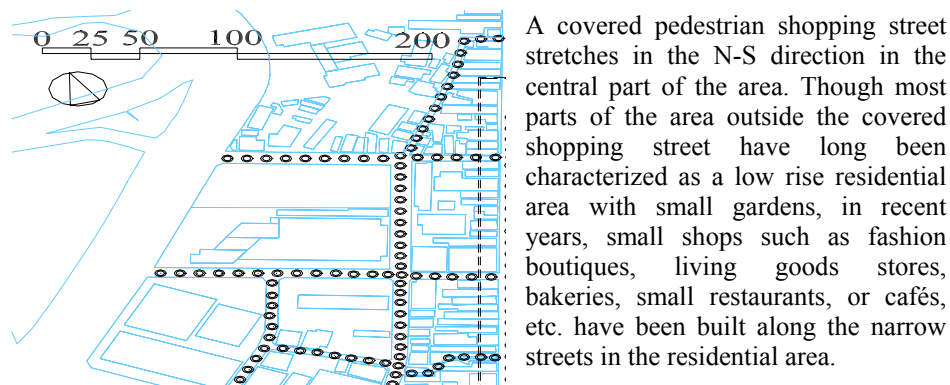


Figure 4. Case Study Area and the Locations of Observation Points

##### 4.2. PROTOTYPE-II & -III

At each point, the authors took 12 photo images with a digital camera, rotating 30 degrees along the vertical axis on a tripod of 1.3m height. *QTVR Authoring Studio* was used to synthesize these images to a 360 degrees-QTVR image, as well as to assign links among those QTVR images. The width of the view angle for a QTVR window was adjusted at the time of simulation by just changing the parameter of QTVR viewer. The authors added streets for prototype-II and -III to carry out simulation of virtual walks in addition to testing the viewing ability of the system. 207MB QTVR image data was produced for 320 points defined along each section of the 2900m street in the study area (*Figure 4*)

## 5. Comparison of the Prototypes

### 5.1. METHOD AND CONTENTS OF QUESTIONNAIRE

The authors asked 30 students<sup>ii</sup> in the Architecture department of Kumamoto University, to simulate virtual walks of visiting the predetermined points on the city map, using the three prototypes<sup>iii</sup>. After the simulations, the authors asked them to answer a questionnaire based on whether they could produce an image sequence of spaces in the case study area. To avoid the effect of order in a system test, 30 students were subdivided into 6 groups that would test the prototypes in different orders.

There were three sets of seven questions asking pair-wise comparisons of the three systems, as well as comment space to describe the reasons for their evaluations<sup>iv</sup>:

- Q1)\* The impression of the interface of system operation.
- Q2) The effect of the horizontal view angle in observing various scenes of the streets<sup>v</sup>.
- Q3)\* The legibility of street scenes in terms of the window configurations: one or multiple window.
- Q4) The impression of the sense of travel movement along the streets.
- Q5) The recognizability of the location of the intersections.
- Q6) Their overall impression on the sense of atmosphere pervading in different sections of the streets.
- Q7) Their over all impression on the sense of direction of walking and the location of the standing point while traveling.

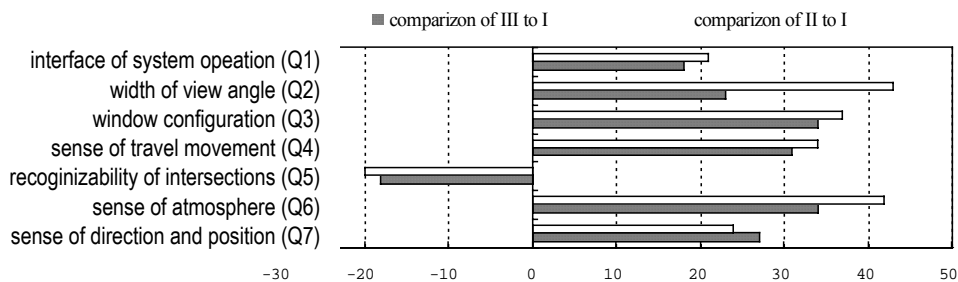


Figure 5. Comparison of the Performance of Prototypes

(Prototype-III and -II against -I)

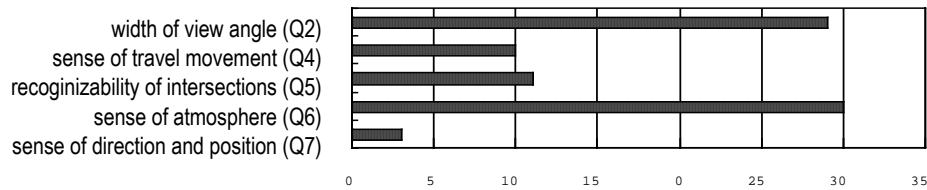


Figure 6. Comparison of the Performance of Prototypes -III against -II

## 5.2. OBSERVATIONS OF THE RESULTS

In the pair wise comparison, the authors used a five-ranked Semantic Differential Scale. Assuming that the prototypes with a larger code number have better features, the authors gave the following scores to the answers and simply summed them up to assess their evaluation for each pair-wise question. +2: A is clearly better than B, +1: A is slightly better than A,  $\pm 0$ : almost equal, -1: A is slightly worse than B, -2: A is clearly worse than B.

### 5.2.1. Interface of System Operation (Q1)

Comparing the score for the other questions, prototype-II and -III gained only lower scores, but *Figure 5* still suggests that more than two thirds of the users answered was both have a slightly better interface than prototype-I. It is obvious that QTVR asks the user for many operations such as movements, rotation of view, and zoom, while prototype-I asks users to just touch one of the two or three buttons. An impression that prototype-I does not provide enough visual information seemed to make them answer that prototype-II and -III are slightly better than -I.

### 5.2.2. Width of Horizontal View Angle (Q2)

Though prototype-I displayed images of a larger view angle than that of prototype-II, the latter clearly gained higher scores<sup>vi</sup>. A utility of QTVR to rotate view directions while traveling seems to have given more information on the street scenes than the wider views of prototype-I. *Figure 5* and *Figure 6* suggests that all users answered to the superiority of -III against the two others.

### 5.2.3. Window Configuration and Utility of Looking Around(Q3)

The score for Q3 in *Figure 5* suggests that the users felt natural and preferred to observe street scenes through a single window with the looking around utility of QTVR. There were several comments that support such an assumption.



#### 5.2.4. Sense of Travel Movements (Q4)

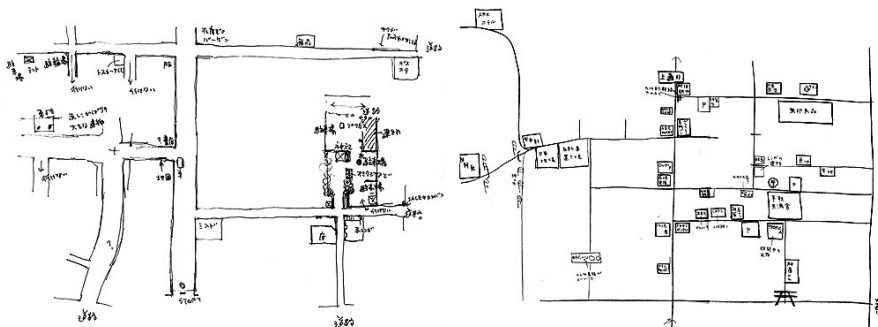
Though the authors did not test prototype-I which changes the interval of representation points, the scores for question four in *Figure 5* and *Figure 6* suggests that the reduction of their intervals from 20m to 10m could clearly improve the sense of travel. Several test users commented that “displaying an image at 10m intervals would improve the sense of distance”, or “the impression of jump has been reduced very much”. But there were still some who commented “Prototype-III still lacks an impression of continuous movement”. Comparison of prototype-II and -III also suggested that widening the horizontal view angle could further improve the sense of travel movement (*Figure 6*).

#### 5.2.5. Recognizability of Intersections (Q5)

Prototype-I gained higher scores in this feature. This is because prototype-I indicates the location of intersections by displaying side view images (*Figure 2-b*), while prototype-II and -III require them to identify their locations only through QTVR images. Though the wide view image of prototype-III improved the conditions in which the users could identify building elements that would indicate a corner of an intersection, they still seem to have difficulty in recognizing their location during travel. Once users start moving straight, by clicking the central part of the QTVR window, they tend to repeat the same action without rotating the view directions. This tendency seems to create a difficulty for the users to find their location.

#### 5.2.6. Sense of Atmosphere (Q6), Direction and Location (Q7)

*Figure 5*, and *Figure 6* clearly indicate that prototype-II and -III have a better environment for experiencing the atmosphere of street spaces. The score of Q7 was not so high when comparing it to other questions, but it still indicates that most testers agree that prototype-III is slightly better or clearly better than prototype-I.



*Figure 7.* Examples of Cognitive Maps Sketched After Virtual Walks

### 5.3. OBSERVATIONS ON THE VIRTUAL WALK WITH PROTOTYPE-III

The observation of the cognitive maps which were sketched by nine people after a 20 to 30 minute virtual walk with prototype III are as the follows:

- 1) All could draw the network configuration of the streets for about 60% of the area with little errors. Three of them identified a difference in the street width.
- 2) They indicated many shops that they found interesting, though some of them were misunderstood concerning location. Some people described spatial impressions of some segment of the streets quite in detail.
- 3) When two people repeated the virtual walks twice or three times, the area of their cognitive maps were extended and the number of roadside elements were increased as they repeated the virtual walks. The location of shops which were misunderstood at first were corrected after the consequent walks.

## 6. Conclusion

Considering the observations found in the answers to the questionnaire and the cognitive maps sketched after the virtual walks, it is possible to regard that prototype-III could provide the necessary level of visual representations and the system operations as a tool for simulating citizens' travel behaviors.

Themes for further improvement of prototype-III are as follows:

- 1) Some special indicator should be displayed when the user enters an intersection, so that the user would not overlook it even when he or she does not rotate the view direction frequently.
- 2) When one moves from one scene to the next, the view axis had moved slightly in the prototype systems. Such a motion gave a strange impressions to those who wanted to move straightforward along some street. It is recommended to take photo images targeting the same object in one segment of the street.
- 3) Authors plan to add sound effects to represent the atmosphere of each street in the future system.

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<sup>i</sup> Sony, Cybershot DSC-F3. 640x480 pixels/shot

<sup>ii</sup> 19 male and 11 female students, between 20 to 24 years old.

<sup>iii</sup> Hardware used: Dell Dimension XPS T550, OS: windows NT, CPU: Pentium III 600MHz Memory: 768MB Display: 21inch 1600 x 1200

<sup>iv</sup> Questions with \* were not asked in comparing II and III.

<sup>v</sup> This will relate only to the amount of information user receives, because images were presented through a display monitor.

<sup>vi</sup> Score of over 15 means more than two thirds of users admitted superiority of II to I.