Testing Guide Signs' Visibility for Pedestrians in Motion by an Immersive Visual Simulation System

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Abstract. When we visit a complex public space such as a railway station or a large shopping mall for the first time, we must rely on guide signs to find our way. In crowded situations, we are called upon to read these signs while walking so as not to disturb pedestrian flow. The present study uses an immersive visual simulation system to examine the influence of observation conditions on sign detection and recognition. The experimental variables address the spatial layout of signs as well as the presence of other pedestrians. The results indicate some quantitative relationships between the above variables and readability and suggest effective layouts for signs in spaces where crowded conditions are unavoidable.

Keywords: observation conditions, detection, recognition, guide signs, pedestrians.

1 Introduction

Urban facilities are growing increasingly larger and more complex, often leading to difficulty and stress for people seeking to navigate them. When we visit a complex railway station or a large shopping mall, we rely on guide signs to find our destination. These are not always helpful, however, since the sheer number of signs around us may distract us from picking up the necessary information. The presence of other pedestrians also adds to the difficulty by blocking our view. In crowded situations where we cannot disturb pedestrian flow, we must moreover be able to read signs while walking and paying attention to the people ahead. With the above in mind, the present study uses an immersive visual simulation system to examine the influence of observation conditions on sign detection and recognition by pedestrians in motion.

Most previous research dealing with way-finding and guide signs (e.g., Tanaka and Sugawara, 2004) do not discuss the influence of observation conditions on sign detection and recognition from a quantitative viewpoint. Although many psychophysical studies (e.g., Hara, Namba and Noguchi, 2003) have focused on the readability of individual sign attributes, for example color and type of lettering as well as background contrast, most have been conducted using static targets in laboratory settings that exclude environmental factors. Yata and Uehara (1991) tested the visibility of signs in a real setting (a railway station), but again only under static observation conditions.

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2 Method

Two experiments were performed for the present study. The first examined the readable range (readability threshold) of three types of sign lettering in motion. This served to determine conditions for the second experiment as well as to test the performance of the immersive visual simulation system known as the D-vision (see Fig. 1). The D-vision displays wide-angle images (180 degrees both vertically and horizontally) capable of filling viewers' peripheral vision; viewers may also gain stereoscopic vision through the use of polarizing glasses. The image's motion was controlled by the experimenter. The second experiment tested the influence of various observation conditions on sign detection and recognition.

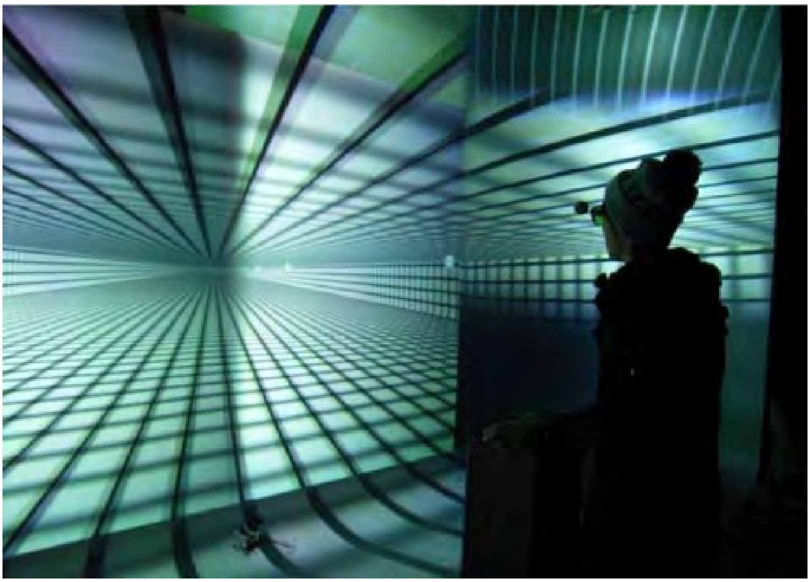


Fig. 1. The immersive visual simulation system D-vision

(This system was developed by the Sato Laboratory, Tokyo Institute of Technology)

3 Experiment 1: Threshold of Sign Readability from an Observer While Walking

3.1 Objectives and Method

To obtain the perceptual threshold (readability) of signs in motion, a series of psychophysical experiments was conducted using D-vision. Three types of stimuli were used: I) Landolt rings, II) letters of the alphabet and III) Chinese characters. Eight different figures were provided for each type (see Fig. 2). The figures were printed at 2 different heights (150 mm and 225 mm) on square boards measuring 350 x 350 mm and 450 x 450 mm, respectively. The signs were put up in a virtual corridor 10 m wide and 5 m high at 4 positions combining 2 possible horizontal alignments (immediately in front of the viewer and 10 m to the side) with 2 vertical ones (2 m and 5 m high from the floor).

The subjects, 3 university students, participated in 6 sessions (3 types of figures x 2 sizes). For each session, subjects were asked to tap a keyboard when they detected the target figure (assigned from among the 8 figures possible) while moving through the virtual space at a walking speed (1.5 m/s). At the moment of response, the distance between the observation point and the target was recorded.

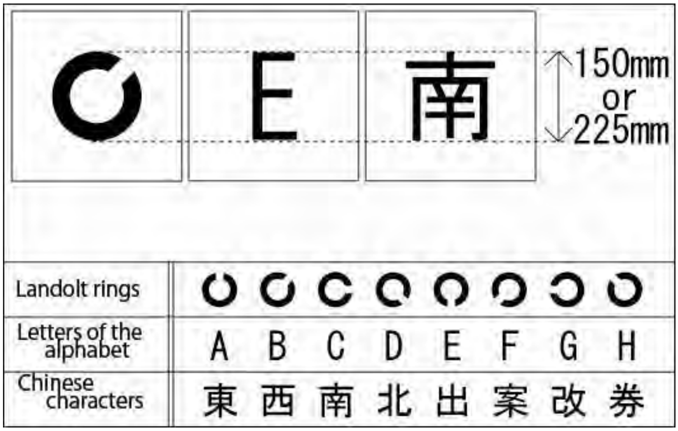
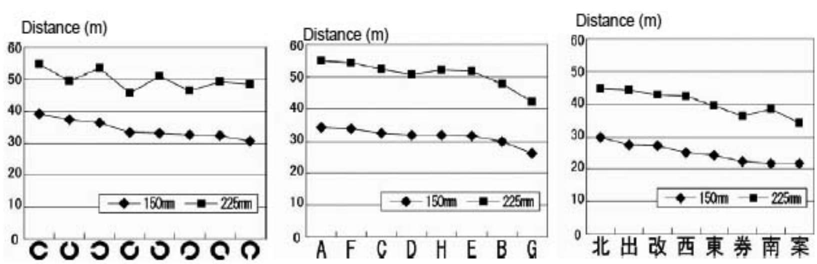


Fig. 2. Three types of targets

3.2 Results and Discussion

At each session, detection distances were recorded for all 8 figures in all 4 possible positions, resulting in a total of 32 measurements per session. Since there was no clear difference in data whether by subject or by sign position, the results were analyzed by calculating the average detection distance for each target (see Fig. 3). Although the absolute values have little meaning, given that they are based on data obtained in a virtually simulated space, they nonetheless indicate the relative readability of each figure: the farther the distance at which the target was detected, the easier it was to read. As expected, readability of figures fell along with increasing complexity. Interestingly, the readability of Landolt rings varied according to the position of the gap. Rings with a gap at the right, left, top, or the 45° positions in between tended to be detected at a farther distance, i.e., were easier to read, than those with the gap at



(a) Landolt rings (b) Letters of the alphabet (c) Chinese characters

Fig. 3. Readability thresholds
(Average distance at which each target was detected)

the bottom. While the readability of Landolt rings is supposedly the same regardless of where the gap is (the reason they are used as standardized symbols for testing vision), this does not seem to be the case for when they are in motion (see fig. 3a).

4 Experiment 2: Influence of Observation Conditions on Sign Detection and Recognition

4.1 Objectives and Method

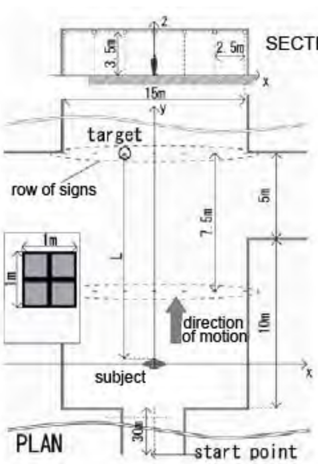
Experiment 2 examined the influence of various observation conditions on sign detection and recognition while in motion. The factors tested were sign layout and presence of other pedestrians.

The degree of influence of a factor was determined by analyzing the detection distance for a comparison stimulus versus for a standard stimulus. Fig. 4 shows the virtual setting displayed by the D-vision for the standard stimulus. The main experimental space, made to resemble a concourse in a common large railway station, was 15 m wide and 3.5 m high with byways 5 m wide extending every 15 m on both sides. The subject entered this space from a corridor 30 m long and 5 m wide shown at the bottom. The subjects were 9 (4 male and 5 female) university students. The procedure for the experiment was the same as in experiment 1.

Two indicators of degree of influence were calculated from the data as follows:

(1) Variation ratio (V)
V = detection distance for comparison stimulus / detection distance for standard stimulus

(2) Detection ratio (D)
D = number of targets detected / number of targets displayed



(a) Experimental setting

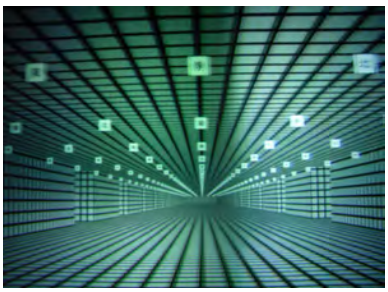
(b) Standard stimulus:

- Seven Chinese-character signs displayed per every row placed 7.5 m apart in depth.
- Five occurrences of the target (selected from the 8 characters in Figure 3c) randomly placed among 210 signs.

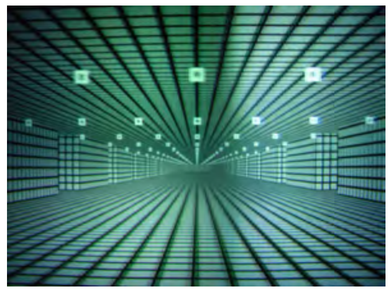
Fig. 4. Experimental setting for the standard stimulus

4.2 Influence of Signs' Layout

Density of Signs. Two comparison stimuli were used for this test: lower density (7 signs per row, rows placed 10 m apart) and higher density (7 signs per row, rows placed 5 m apart). As shown in Fig. 5, a significant difference ($P < 0.01$) in variation ratio was observed between the standard and higher-density stimuli, while the lower-density stimulus did not result in significant change ($P = 0.068$). The findings suggest that because the signs moved toward subjects at constant speed, the amount of visual information required to process grew as the density of signs increased, resulting in information overload and lowered performance after a certain level.

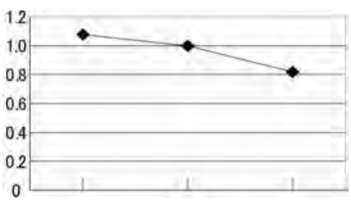


a) Comparison stimulus
(lower density: 7 signs/10 m)



(b) Comparison stimulus
(higher density: 7 signs/5 m)

Variation ratio



Lower Standard Higher

Detection ratio = 0.98 (lower density)
= 0.93 (higher density)

Fig. 5. Influence of density of signs

Aggregation. In this comparison stimulus, 2 sign boards were paired above and below and placed at the same position as in the standard stimulus. To make the number of signs (i.e. the amount of information) per distance equal to that in the standard stimulus, the distance between rows was made twice as long (15 m). Two tests were conducted using signs of different sizes (150 mm and 225 mm). As shown in Fig. 6, the results obtained were inconsistent. With the smaller signs (150 mm), aggregation had a significantly negative effect on readability ($P = 0.023$), while for the larger signs the effect appeared positive, although the significance level was low ($P = 0.053$). These phenomena may be interpreted as follows. Since in the aggregated stimulus subjects were faced with 14 signs at once, it took them more time to complete searching for the target than with the standard stimulus, thus lowering performance. This effect was more remarked for the smaller signs because the distance at which subjects grew able to read the lettering was shorter and the movement of the signs away from view (optic flow) was therefore faster. As for the inconsistent effect seen for the larger signs, it may be that doubling the signs made them more noticeable, allowing subjects to know further in advance where they would need to look before the lettering actually became readable.

Comparison stimulus (Aggregated 150 mm signs)

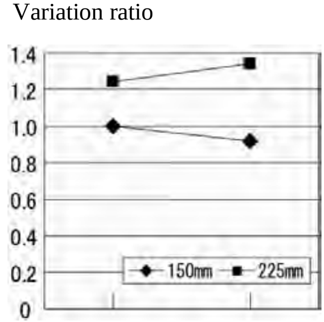


Fig. 6. Influence of aggregation of signs

Alignment. In this comparison stimulus, the sign boards were placed irregularly, i.e. they were shifted randomly from their original positions to the right and left and front and back within a range of 1.2 m as well as up and down within a range of 1.0 m. As shown in. 7. A significant difference ($p < 0.01$) in variation ratio was observed between standard and irregularly placed stimuli.

This may be because the lack of smoothness in eye movement caused by the irregular layout cost subjects more time while searching for the target.

Comparison stimulus (irregular placement)

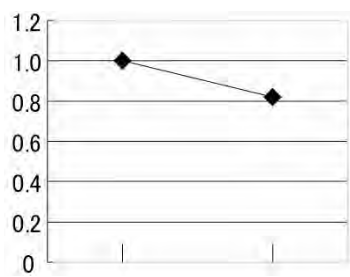


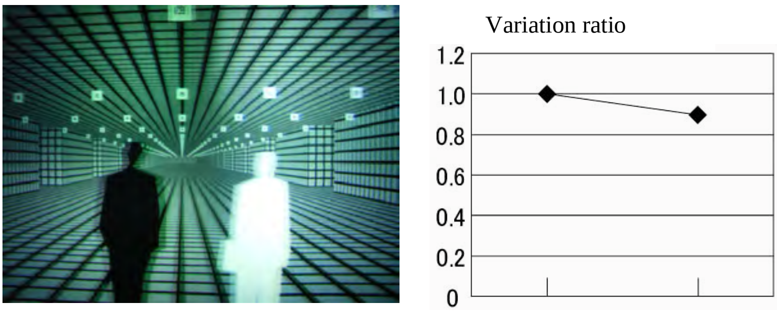
Fig. 7. Influence of alignment of signs

4.3 Presence of Other Pedestrians

In a real setting such as a railway station, other people are usually also present and may affect readability of signs in at least 2 ways: as distracters of attention and as visual barriers.

Pedestrians Ahead. In this comparison stimulus, silhouettes of pedestrians ahead (see fig. 8) were added to the standard stimulus. Subjects were asked to use a handheld controller (see fig. 9) to change motion along with the silhouettes, which moved at uneven speeds. The hypothesis that pedestrians ahead would disturb detection of the target was supported by the drop in the variation ratio (P = 0.047) and the detection ratio (0.82).

This result may be explained by the allocation of subjects' limited resources of attention away from the task of searching for the target to keeping pace with others near them.



Comparison stimulus
(Silhouettes of pedestrians ahead)

None With

Detection ratio = 0.82

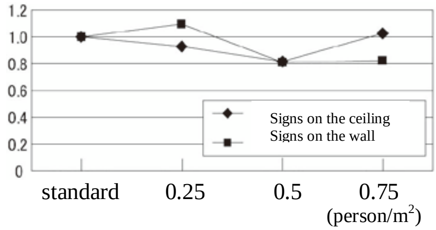
Fig. 8. Influence of other pedestrians ahead

Fig. 9. The controller

Density of Surrounding Crowd. In this comparison stimulus, silhouettes of a surrounding crowd (see Fig. 10) were added to the standard stimulus at 3 levels of density. Signs were also placed on the side walls in addition to the ones on the ceiling. The signs on the wall were hidden by the crowd from time to time, while the ones on the ceiling stayed always visible. The influence of crowd density on the readability of signs was not clearly evident from the variation ratio. However, the detection ratio of the signs on the ceiling dropped to 0.53 in highly crowded settings, while that of the signs on the wall remained at 0.97. It is interesting that the subjects tended to fail to detect the always visible signs on the ceiling while almost completely detecting the occasionally hidden signs on the wall. This result may also be related to allocation of attention.

Comparison stimulus
(Silhouettes of other pedestrians)

Variation ratio



Detection ratio

position	density (person/m^2)		
	0.25	0.5	0.75
ceiling	**0.81**	**0.86**	**0.53**
wall	1	0.97	0.97

Fig. 10. Influence of other pedestrians

5 Conclusions

The above experiments conducted revealed that the readability of figures viewed in motion may differ when they are viewed under static conditions. The following factors were found to be relevant to sign detection and recognition while in motion: I) density of signs (amount of visual information), II) smoothness of eye movement from one sign to another, and III) allocation of visual attention. Although the results were obtained in a virtual setting and the absolute numerical values have limited meaning, the results nonetheless clarify empirically some of the mechanisms involved in the detection and recognition of guide signs by pedestrians.

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Preface

In the last few years, the use of computers to study and solve urban planning and design problems has become widespread. More recently, and also thanks to the advances of computer technology, the focus has shifted toward integrative approaches that attempt to look at urban systems at multiple scales, both in terms of space and time. However, such approaches also imply being connected to a growing number of fields, and it can be hard to keep track of the connections and – more importantly – of the connection points. Thus, many solutions computer and information science might have to offer are simply not recognized.

This book is thematically positioned at the intersections of urban design, architecture, civil engineering and computer science, and it aims to provide specialists coming from respective fields with a multi-angle overview of state-of-the-art work currently being carried out. It addresses both newcomers who wish to obtain more knowledge about this growing area of interest, as well as established researchers and practitioners who want to keep up to date. In terms of organization, the volume starts out with chapters looking at the domain from a wide angle and then moves focus toward technical viewpoints and approaches.

We wish to thank all authors – without them, this volume could not have been realized. Particular thanks go to Gerhard Schmitt, Chair of Information Architecture and Director of the Singapore-ETH Centre, who supported this work from the very beginning and provided valuable input throughout. Finally, we would like to thank Leonie Kunz and Stefan Göller of Springer for the excellent assistance during the editing process.

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Table of Contents

Part I: Introduction

A Planning Environment for the Design of Future Cities 3
Gerhard Schmitt

Calculating Cities 17
Bharat Dave

The City as a Socio-technical System: A Spatial Reformulation in the Light of the Levels Problem and the Parallel Problem 24
Bill Hillier

Technology-Augmented Changes in the Design and Delivery of the Built Environment 49
Martin Riese

Part II: Parametric Models and Information Modeling

City Induction: A Model for Formulating, Generating, and Evaluating Urban Designs 73
José P. Duarte, José N. Beirão, Nuno Montenegro, and Jorge Gil

Sortal Grammars for Urban Design: A *Sortal* Approach to Urban Data Modeling and Generation 99
Rudi Stouffs, José N. Beirão, and José P. Duarte

Sort Machines 117
Thomas Grasl and Athanassios Economou

Modeling Water Use for Sustainable Urban Design 138
Ramesh Krishnamurti, Tajin Biswas, and Tsung-Hsien Wang

Part III: Behavior Modeling and Simulation

Simulation Heuristics for Urban Design 159
Christian Derix, Åsmund Gamlesæter, Pablo Miranda, Lucy Helme, and Karl Kropf

Running Urban Microsimulations Consistently with Real-World Data ... 181
Gunnar Flötteröd and Michel Bierlaire

Urban Energy Flow Modelling: A Data-Aware Approach ... 200
Diane Perez and Darren Robinson

Interactive Large-Scale Crowd Simulation ... 221
Dinesh Manocha and Ming C. Lin

An Information Theoretical Approach to Crowd Simulation ... 236
Cagatay Turkay, Emre Koc, and Selim Balcisoy

Integrating Urban Simulation and Visualization ... 262
Daniel G. Aliaga

Part IV: Visualization, Collaboration and Interaction

Visualization and Decision Support Tools in Urban Planning ... 279
Antje Kunze, Remo Burkhard, Serge Gebhardt, and Bige Tuncer

Spatiotemporal Visualisation: A Survey and Outlook ... 299
Chen Zhong, Tao Wang, Wei Zeng, and Stefan Müller Arisona

Multi-touch Wall Displays for Informational and Interactive Collaborative Space ... 318
Ian Vince McLoughlin, Li Ming Ang, and Wooi Boon Goh

Testing Guide Signs' Visibility for Pedestrians in Motion by an Immersive Visual Simulation System ... 339
Ryuzo Ohno and Yohei Wada

Author Index ... 347