“Vection Field” for Pedestrian Traffic Control

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ABSTRACT

Visual signs and audio cues are commonly used for pedestrian control in the field of general traffic research. Because pedestrians need to first acquire and then recognize such cues, time delays invariably occur between cognition and action. To better cope with this issue of delays, wearable devices have been proposed to control pedestrians more intuitively. However, the attaching and removing of the devices can be cumbersome and impractical. In this study, we propose a new visual navigation method for pedestrians using a “Vection Field” in which the optical flow is presented on the ground. The optical flow is presented using a lenticular lens, a passive optical element that generates a visual stimulus based on a pedestrian’s movement without an electrical power supply. In this paper we present a design for the fundamental visual stimulus and evaluate the principle of our proposed method for directional navigation. Results revealed that the optical-flow of a stripe and random-dot pattern displaced pedestrian pathways significantly, and that implementation with a lenticular lens is feasible.

Categories and Subject Descriptors

H.5.2 [**INFORMATION INTERFACES AND PRESENTATION**]: User Interfaces – *User-centered design, Theory and methods*

General Terms

Design, Human Factors, Theory

Keywords

Traffic control, Vection, Lenticular lens

1. INTRODUCTION

Signage, arrows and sounds are typically used for pedestrian navigation. Portable devices such as smart phones and portable music players have also come to be used as methods of navigation [1][2]. Since such cues are provided indirectly, they require processes: the pedestrian can behave appropriately on the basis of a cue only after the cue is obtained and its meaning interpreted. Therefore, the time during which the pedestrian moves into action after receiving the cue is necessary.

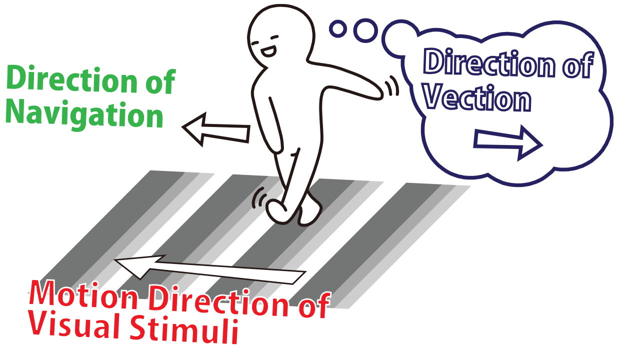

Figure 1. Concept of “Vection Field” for Pedestrian Traffic Control

Intuitive navigation methods can help reduce the time needed by pedestrians to interpret the meaning of cues. Tsukada has proposed the Active Belt, which signals the user the direction in which to go using a spatially-distributed vibrator in the belt [3]. Nakamura has used haptic sensation technology, which also signals the correct direction in which to go as an inertial force produced by a flywheel [4]. Gleeson, on the other hand, has shown that a lateral skin stretch at the fingertip can be used to indicate direction [5]. Amemiya has suggested that asymmetric acceleration produced by hand-held devices can be used to induce a pulling sensation such that the device will, in effect, “lead” the user’s hands in the desired direction [6]. Nonetheless, while these approaches do indicate the direction in which the pedestrian should to go intuitively, they do not induce the pedestrian to move directly.

In light of this disadvantage of such devices, several wearable devices which elicit pedestrian movement intuitively while providing the sensation of direction have been proposed to guide pedestrians more directly. Maeda et al. has proposed a walking navigation method that stimulates the vestibular organs electrically to affect the user’s sense of balance (vestibular sensation), using an electrode stuck on the skin behind each ear [7][8]. Kojima et al. has shown that simply pulling on the ears can influence walking direction, and has examined walking navigation using a portable ear-pulling device [9]. While these examples of intuitive navigation through body sway triggered by galvanic vestibular stimulation or tactile stimulation are of current interest, it is still necessary for pedestrians to attach and remove the stimulation devices.

Although there is no problem with using these methods for individual and personal navigation purposes, it remains difficult to

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apply them to large crowds of pedestrians, such as crowded urban centers, because they require portable devices. In other words, while such methods can be used for personal navigation, they are not well suited for the purpose of traffic control. The essence of traffic control is the control of pedestrians not as individuals but as crowds [10][11]. Therefore, it is important to consider how to maintain traffic lines at specific areas rather than how to navigate to individual destinations. Thus, here we focus on visual sensations without the use of any attached devices as an alternative method for traffic control.

J.J. Gibson has argued that vision is a powerful kinesthetic sense. [12]. J.R. Lishman has demonstrated, through a visual-mechanical kinesthetic conflict experiment, that vision is more dominant than somatic sensation with respect to controlling one's physical posture [13]. Therefore, in this study we focus on visually-induced self-motion perception, or "vection", which is expected to influence walking direction as a type of intuitive walking guidance that requires no attaching or removing of any devices.

2. VECTION FIELD

2.1 Concept

The concept of our proposed vection method is shown in Figure 1, in which the pedestrian is shown being led by a moving visual stimulus provided from an optical device on the ground that produces the vection [14]. It is known that vection is a perceived moving sensation based on the optical flow used to control human walking [15]. A higher intensity of vection is induced by a larger ground area of projection [16], with the optical flow originating from the ground surface rather than the sailing surface [17]. Further, vection induces postural readjustment [18]. These findings support the validity of our proposed approach, which is an example of the augmentation of human locomotion functionality, which induces unconscious behavior during walking.

We use a lenticular lens, which produces an extensive, dynamic visual effect on the ground without an electric power supply, and that is also suitable for installation in public spaces. We propose a "Vection Field", which achieves pedestrian navigation using the lenticular lens, and including the movement of a visual stimulus, as shown in Figure 1. We use the name Vection Field after "vector field" because it uses a guidance vector parallel to the moving direction of the visual stimuli and perpendicular to the walking direction.

2.2 Principle

A lenticular lens has a sheeted array of magnifying lenses, the top of which are cylindrical shaped and semicircular in cross-section. The images contained under the lens array are lenticular images, and different lenticular images are magnified and appear depending on the angle of the line of sight, which is always slightly changing. Because the lenticular lens works as a passive optical element, the produced movement of the visual stimuli corresponds exactly to the locomotion of the pedestrian without the use of an electric power supply. Accordingly, our method has the advantage of not requiring measurement of the locomotion of the pedestrian through the attaching or removing of devices.

The lenticular lens has been used for stereoscopic vision [19][20]. To obtain binocular parallax, the long axis direction of the lens is set to be parallel to the median line of an observer. However, our proposed method is different in this respect because the lenticular lens is placed in a direction perpendicular to the median line of the pedestrian.

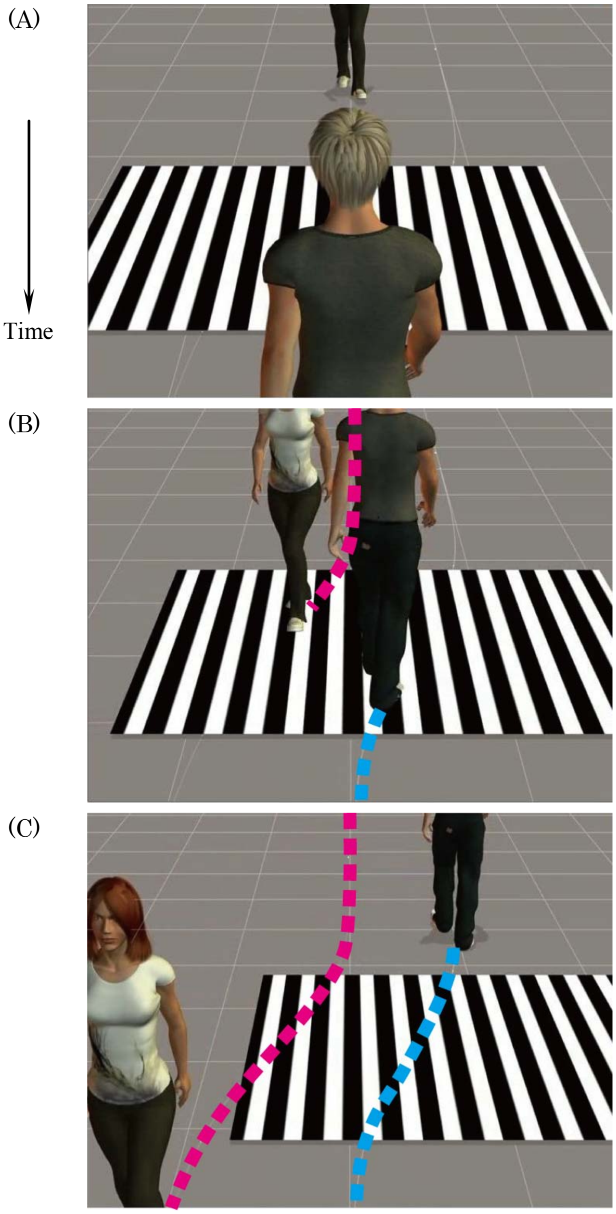

Figure 2. Traffic Control with Vection Field

The Vection Field accomplishes bidirectional traffic, which stays on either the right or left side of the road by reversing the order of the appearance of the lenticular images as necessary, as shown in Figure 2. Figure 2 (A) shows a man and woman approaching head-on, as depicted from the man's side. Frontal impact occurs if both pathways remain unchanged and neither pedestrian becomes aware of the other approaching. This is one reason why navigation is necessary.

Vection (self-motion sensation) occurs in the man, who has a field of view in which a white and black striped pattern appears as the visual stimuli produced from the lenticular lens on the ground. The angle between the line of sight and the surface of the lenticular lens changes with forward movement of the man's viewpoint as the man approaches. Occasionally the horizontal movement of the striped pattern is observed because the lenticular images appear continuously, as shown in the change from Figure 2 (A) to Figure 2 (B). When the visual stimuli moves to the right relative to the man, the man perceives the vection in the direction opposite to the shift of the visual stimuli, that is, the left direction. This perception of being swayed to the left induces a restoring force to the right to maintain posture. Consequently, a directional change in walking to the right can be expected along with this restoring force, as shown in Figure 2 (C).

It is noteworthy that the horizontal movement of the visual stimuli is observed from the viewpoint of the woman, who moves forward from the opposite side, as shown in Figure 2 (A). Moving backward, the man observes that the striped pattern moves to the "left". The direction of this backward movement is precisely equivalent to the "forward" movement of the woman, and thus the woman also observes the movement of the pattern to the "right" because the left side of the man is also the right side of the woman, as shown in Figure 2 (B) and (C).

As a consequence of this property, the Vection Field allows the bidirectional traffic to be maintained, that is, to keep to the right or left side of the road. In other words, the particular region in which the lenticular lens is installed unconsciously induces pedestrians to keep to one side. This is another reason why we refer to our proposed method as a Vection Field.

2.3 Functional Field Related Work

There are previous studies that used the vector field as a functional field. Vose realized a programmable friction field with mechanical vibration of a conveying plane using actuators having 6 degrees of freedom [21]. The friction field, which spatially defines the translational and rotational direction of the assembly parts during conveying, is similar to the Vection Field in the sense that the parts behave as if the pedestrians are guided with the Vection Field. This friction field is, however, different from the Vection Field in that the conveyed parts do not actively move, although the pedestrians walk and the navigation direction is defined only by the direction of travel.

CabBoots, on the other hand, provides a virtual rutted path with the use of a wearable solution in which the sole of the boot inclines to provide tactile experiences, which works as the vector field [22]. This method is intuitive and has the advantage of unconsciously influencing the walking direction. However, this approach was not designed for traffic control, but for personal navigation, which requires pedestrians to attach the device to their body.

Luz has described the concept of illusionary graphics realized using a tiled pattern as an interior design to influence pedestrian locomotion [23]. Although the graphics are static in this concept, the concept has yet to be adequately studied. Our proposed Vection Field, on the other hand, provides dynamic visual motion depending on the viewpoint.

We conducted an experiment of walking navigation based on the concept of Vection Field to validate the method and to better understand how to design proper visual stimuli.

3. EXPERIMENT: WALKING NAVIGATION WITH VISUAL STIMULI

3.1 Definition of Lenticular Optical Model

As shown in Figure 3, the angle φ between the y-axis and the line of sight is given by

$$\varphi = \tan^{-1}\left(\frac{x}{H}\right), \qquad (1)$$

where H denotes the height of the pedestrian's viewpoint from the lenticular lens plane, and x denotes the horizontal distance from the origin point O on the lenticular lens plane.

When the angle θ, shown in Figure 3, is defined as the necessary angle from which to observe one cycle of lenticular images, numbered from #1 to #N under the array of cylindrical lenses, the condition in which the arbitrary lenticular image #n appears is given by

$$\left\{\frac{(n-1)\theta}{N} \le \varphi < \frac{n\theta}{N} \;\middle|\; N \in Z, 1 \le n \le N\right\},$$

where Z denotes an arbitrary integer. This inequality expression is modified regarding n as below.

$$\left(\frac{N}{\theta}\right)\varphi < n \le \left(\frac{N}{\theta}\right)\varphi + 1 \qquad (2)$$

Hence, the lenticular image # n, which appears at the origin point O, and the point at which the pedestrian observes is given by φ. This φ, which depends on x with equations (1) and (2), is also given as follows.

$$\left(\frac{N}{\theta}\right)\tan^{-1}\left(\frac{x}{H}\right) < n \le \left(\frac{N}{\theta}\right)\tan^{-1}\left(\frac{x}{H}\right) + 1 \qquad (3)$$

3.2 Experimental Setup

Using a projector and head-position monitoring system, we conducted a simulation of the visual stimuli, which change dynamically depending on the locomotion of the pedestrian's head, as if it were produced from the lenticular lens.

Figure 4 and Figure 5 show a schematic of this experimental setup. The visual stimuli, which have an area of 3.2m x 2.3m, were projected on the first floor from the projector (LT260, NEC Corp., DMD: Single Chip Digital Micromirror Device, Resolution: 1024x768 pixels), fixed on the second-floor handrail at a height of 5.2m from the projection plane. A web camera (QCAM-200R, Logicool, 30fps, two million pixels) tracked the head movement, which was observed as the movement of the illuminated point from an electro-luminescence (EL) panel attached to a helmet worn by the participants. The CamShift Algorithm, available via

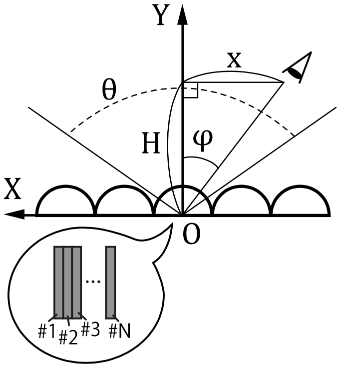

Figure 3. Lenticular Lens Model

the OpenCV API, was used to track the position of the EL panel from the video captured with the camera. The head position was tracked for rendering of the visual stimuli in real time.

The illumination intensity was 0.90 lx at the darkest area and 12.01 lx at the brightest area. The typical brightness on the projected plane is shown in Table 1.

Table 1. Represented Projected Plane Brightness [cd/m^2]

Pattern	White Area	Black Area
Striped	12.8 - 18.8	0.535 - 1.30
Random-dotted	8.38 - 16.6	0.154 - 0.356

3.3 Optical Stimuli

It follows from the previously mentioned lenticular lens model that wherever this model is implemented, a pedestrian will observe several series of lenticular lens images. Thus, the visual stimuli should have periodic patterns. Therefore, in our experiment we used two patterns, a striped (Figure 6, left), which was easily implementable as the cyclic pattern, and a random-dotted pattern (Figure 6, right), which has been commonly used in vection studies. The width of each black and white stripe was 20cm, and the random-dotted pattern had 2.5cm x 2.5cm white dots of 2% density. Both patterns moved to the pedestrian's left when he or she moved forward.

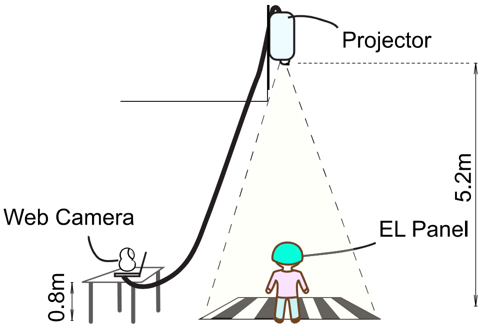

Figure 4. Schematic of Experimental Setup (Side View)

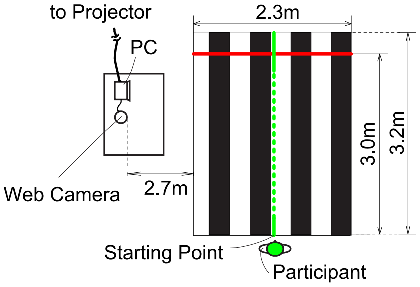

Figure 5. Schematic of Experimental Setup (Top View)

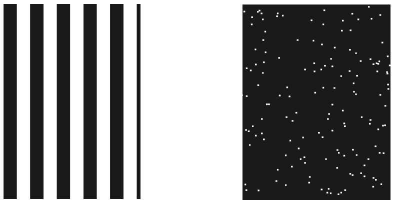

Figure 6. Striped Pattern and Random-dotted Pattern as Visual Stimuli

The experiment was conducted by setting $N = 15$, $\theta = 30$ degrees and $H = 160$ cm on the assumption that a typical lenticular lens is used to implement the visual stimuli. The horizontal head position, measured as previously described, was substituted for x. The tracking resolution was approximately 200pixels/m with captured VGA images(640x480). The translation displacement 0.40m (with the width of one white stripe and one black stripe being 0.20m each) as one spatial cycle of visual stimuli required the participant's forward movement of 0.875m. This displacement was obtained by doubling x_{half} which is defined by equation (4) transformed by equation (1), with φ =30 degrees (due to the value of $\theta = 30$ degrees) and $H = 160$ cm, as stated above.

$$x_{half} = H \tan\left(\frac{\varphi}{2}\right) \tag{4}$$

To reveal the effectiveness of the "movement" of the visual cue for inducing body sway, we used two conditions: a "dynamic" condition with movement of the visual stimuli, and a "static" condition without it. Therefore, four versions of the experiment were conducted, that is, 2x2 conditions of the two movement conditions and the two visual pattern conditions.

3.4 Experimental Sequence

The participant, wearing a helmet attached with the EL panel, was instructed to stand at the starting point so that the green center line on the projected plane was at the center of the participant, as shown in Figure 5. The participant was instructed to walk while gazing at the red line, which was at a distance of 3m from the standing point, and to stop walking upon reaching the red line. The green center line vanished while the participant was walking. The participant was directed to relax, and to walk at a normal pace.

After the participant reached the red line and stopped, the experimenter redisplayed the green center line and measured the displacement from the center line to the point where the participant stopped. The positive axis of the displacement points the left of the participant. The experimenter instructed the participant to begin walking, and then measured the walk time with a stopwatch.

The experiment was conducted in 14 total trials for each participant, with 5 trials each of the striped pattern and random-dotted pattern in translational motion, and 2 trials with both static patterns. The conditions were generated randomly. Figure 7 shows an image of the experiment being conducted.

The result of the preliminary experiment showed that the six of nine participants were able to perceive vection. Thus, in this main experiment, these six well-conditioned individuals (three males and three females), that is, who had been able to perceive vection were chosen to participate. The average age was 24 years old (Standard Deviation ± 2), and the average height was 165 cm (S.D.± 11).

3.5 Results

The average walking speed was 0.70 m/s (S.D. ± 0.10). All participants navigated their walking in the translational direction of the visual stimulus. The results are shown in Figure 8. The vertical axis indicates the displacement from the center line to the point where the participant stopped, and the error bars indicate the standard deviations. Figure 8 also shows that displacement was observed in both of the dynamic conditions, while little displacement was observed in both of the static conditions. The difference between the dynamic striped pattern condition and the static striped pattern condition was significant (t-test; $p<0.01$). The difference between the dynamic random-dotted pattern condition and the static random-dotted pattern was also significant (t-test; $p<0.01$). The difference between the striped pattern and the random-dotted pattern, however, was not significant.

3.6 DISCUSSION

The results of the experiment indicate that movement of the visual stimulus influenced the walking direction of the participants if we assume that the movement induced the body sway of the participants through vection.

There was also anecdotal evidence obtained from the participants. For example, one participant noted: "I felt the navigating force to the left with the flow of the pattern, but it was such a small force that I moved against it." Thus, it seems that the force the participant perceived with the translational movement of the visual stimuli was not strong enough to cause the participant to forcibly change their walking direction, while it was sufficient to help the participant navigate.

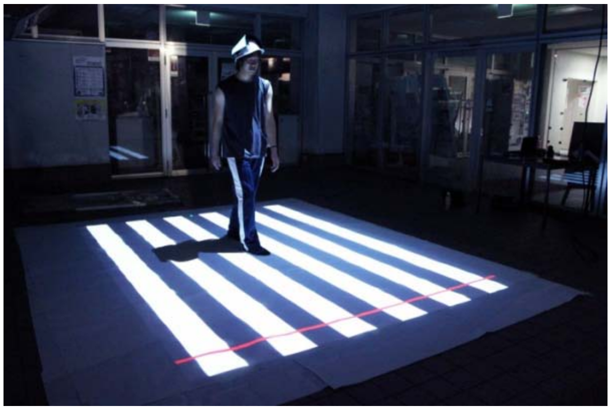

Figure 7. Experimental Environment

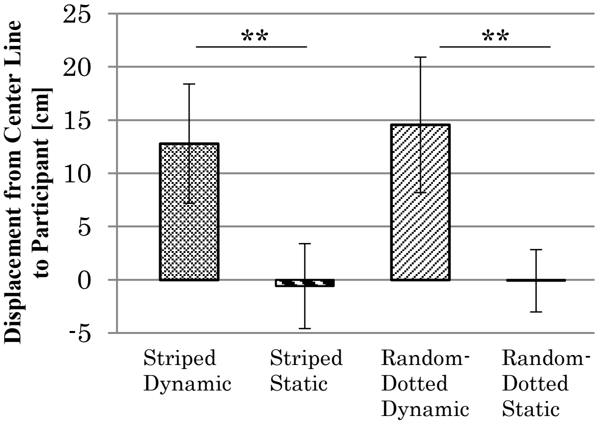

Figure 8. Displacement Induced by Visual Stimulus

Another participant made the following statement: "I felt like I was getting carsick with the random-dotted pattern". A possible explanation for this result is that the set of lenticular images for this simulation was discontinuous due to a large shift when the lenticular images changed from #N to #1, although they are continuous from #1 to #N.

Other participants reported as follows: "The more I approached the red line, which I watched, the stronger I was guided," and "I was guided more strongly when my legs came into sight". These comments suggest that stronger vection is induced near the goal because the proportion of the visual stimuli to the total field of view increases when the participant gets closer to the red line gazing target. These findings correspond with findings that visual sensations wield a dominant influence on the control of posture compared to somatic sensations, as mentioned before [13].

It is interesting to note that the optical flow provided from the simulated lenticular lens on the ground induced this navigation despite the presence of additional optical flow observed from the sailing surface and the walls. In other words, two contradictory types of optical flow were available as cues that the participants can use to maintain their posture during walking: a fixed optical flow, connected to world coordinates, and a non-fixed flow, which is translated depending on the participant's viewpoint. The results of our experiment, which suggest that visual cues from the ground are ascendant compared to those from the sailing surface or walls, are supported by the findings of Sato [17].

Regarding the inconsistencies previously described between the kinesthetic and vestibular senses, Lepecq has reported that galvanic vestibular stimulation modifies vection paths [24]. The possibility therefore exists that our experiment actually tested translational visual stimuli on the ground with participants instructed to walk, while Lepecq's experiment tested translational visual stimuli on side walls with subjects instructed to sit.

4. Implementation of Vection Field

4.1 Optical Design Matters

The optical properties of the simplified lenticular model mentioned above were ignored for the purposes of our experiment. However, such properties must be considered when in the creation of a real prototype Vection Field with a lenticular lens to be used as an actual optical element. The first matter to be addressed is spherical aberration [25], which is a quality of all cylindrical lenses. Spherical aberration blurs visual stimuli patterns due to variations in light-gathering points in the direction of the optical axis, because the light path must travel a certain distance from the spherical lens to the optical axis. However, the visual stimuli of our simulated experiment had sharply-represented boundary lines.

The second matter to be addressed is the fact that the spatial density of the cylindrical lens array and the lenticular images are ignored in the current experimental setup. The spatial density of the cylindrical lens, which is defined in terms of lines per inch (LPI), regulates the density of the lenticular images to be contained under the lens. A higher lens spatial density requires a higher lenticular image spatial density. A lower number N of lenticular images for one period is necessary, because the spatial density has a practical limitation of suppressing the blur of spherical aberration. However, lower angular resolution in the production of translational movement occurs with a lower number of lenticular images. For our purposes, this means that lower angular resolution, which yields lower spatial resolution for translational movement, impairs the smooth translational movement of visual stimuli.

The third matter to be addressed is the angular speed between arrayed lenses and the fact that light rays are not constant, because they depend on the position from which they originate. The angular speed is highest beneath the viewpoint of the pedestrian and decreases the shallower the angle becomes. Therefore, the pedestrian observes not the visual cue with the spatially constant translational speed, as was used in the main experiment, but a cue with a spatially distributed speed. Further, the shallower angle used to observe the visual stimuli also blurs the observed patterns, because of spherical aberration [25].

The purpose of our prototype is, therefore, to reveal the feasibility of our proposed method despite this trade-off. The black and white striped pattern was chosen because although the cyclic pattern is easy to realize, its spatial cue is resistant to being impaired by the blur induced by spherical aberration, and the striped pattern rarely causes unpleasant feelings among observers.

4.2 Optical Design and Prototyping

The prototype was built strip-shaped owing to the difficulty of doing a single casting to construct a large area equivalent to the experimental conditions described above. The total visual field, which consisted of 10 sheets lined up side-by-side, was 2000mm in width and 3000mm in length (each stripe was 2000mm in width and 300mm in length). 5000 dpi silver-salt photographic paper was used to contain the lenticular images. As for the lenticular lens, we used cylindrical lenses made of polyethylene terephthalate and having a density of 20LPI (lines per inch). In total, the lenses and photographic paper were 2.4mm thick. The width of each of the black and white stripes was 20cm, which was equivalent to the simulation conditions. The two values of N = 6 and 8 were used to prevent blur from impairing the sharpness of the visual stimuli.

Figure 9 shows the 10 prototyped strip lenses lined up side-by-side. The translational movement of the striped pattern, which depends on the forwarding movement of the pedestrian, is observed from this prototype. This prototype also has the expected functionality in which the inversed direction of walking also produces the inversed direction of translational movement of the visual stimuli, as shown in Figure 2.

In the prototype, the striped pattern is not observed as a distinct image, but as a blurred one, despite the fact that the high-contrast black and white striped pattern is used. This is presumably due to the following factors: because of the abovementioned spherical aberration, the angle between the line of sight and the lenticular lens depends on the position of the arrayed lenses. As a result, the brightness distribution, which is an intrinsically-square wave formed as shown in Figure 6, is observed as the sinusoidal wave shown in Figure 9. This result probably does not influence the functionality of the prototype, because this brightness distribution modified by the sin-wave has the potential to induce vection [18]. Further, the Café Wall illusion [26] is recognized in Figure 9, and the movement of the visual stimuli is sufficiently distinct compared to the illusion. In addition, the distributed sections of the prototype are recognized in the horizontal direction of Figure 9, which suggests the realization of the translational movement of the stripe, which is ideally smooth with the use of a smaller number of lenticular images. The discontinuous pattern in the front-back direction results from the initial phases of the spatial brightness distribution of the 10 sheets of lens being incongruous.

Figure 9. Implementation of Vection Field (N=6) with Lenticular Lenses

4.3 Evaluation

Because the above results indicate that the basic functionality of the proposed model was realized, we next attempted to estimate whether the prototype had quantitative specifications that were equally efficacious in the treatment of the experimental conditions of our simulation. We evaluated (i) the reproducibility of the visual stimuli depending on the changing observed angle, and (ii) the coefficient required to convert the distance of forward movement to the distance of translational movement of the striped pattern. The latter calculation was done to compare the prototype with the simulation.

The N=8 prototype condition was selected for evaluation owing to its smoother results compared to the N=6 condition. In the evaluation (i), the boundary angle of the black and white pattern was obtained during rotation of the prototyped lens on a protractor. The experimenter's line of sight was kept perpendicular to the axis of revolution of the lens at a constant height, while the brightness change was observed from an arbitrary angle varying from 0 to 180 degree at the side of the lens. The distance between the revolution axis of the lens and the observed point was approximately 15cm. The measurement was continued at each position on the x-axis, defined as the horizontal direction in Figure 9. The x positions are spaced according to each distributed section, 400mm in width, of one spatial period of the striped pattern for each N (See the x axis shown in Figure 10). First, a measurement of 180-degree revolution was completed at the constant height of the observer's eye, and then the observer's height was changed, and the previous angular measurements were repeated. This measurement was conducted once from the perspective of the observer's eye for each condition. The results are shown in Figure 10 (A).

The vertical axis in Figure 10 illustrates the revolution angle, and the horizontal axis illustrates the observed x-position, as described above. The filled circle depicts the angle where the brightness of the observed point changes from white to black, and the open circle depicts the angle where the brightness changes from black to white. The four lines are drawn with first-order approximation. The observed images at the point of 90 degrees, that is, directly above the lenticular lens, are described in Figure 10. The

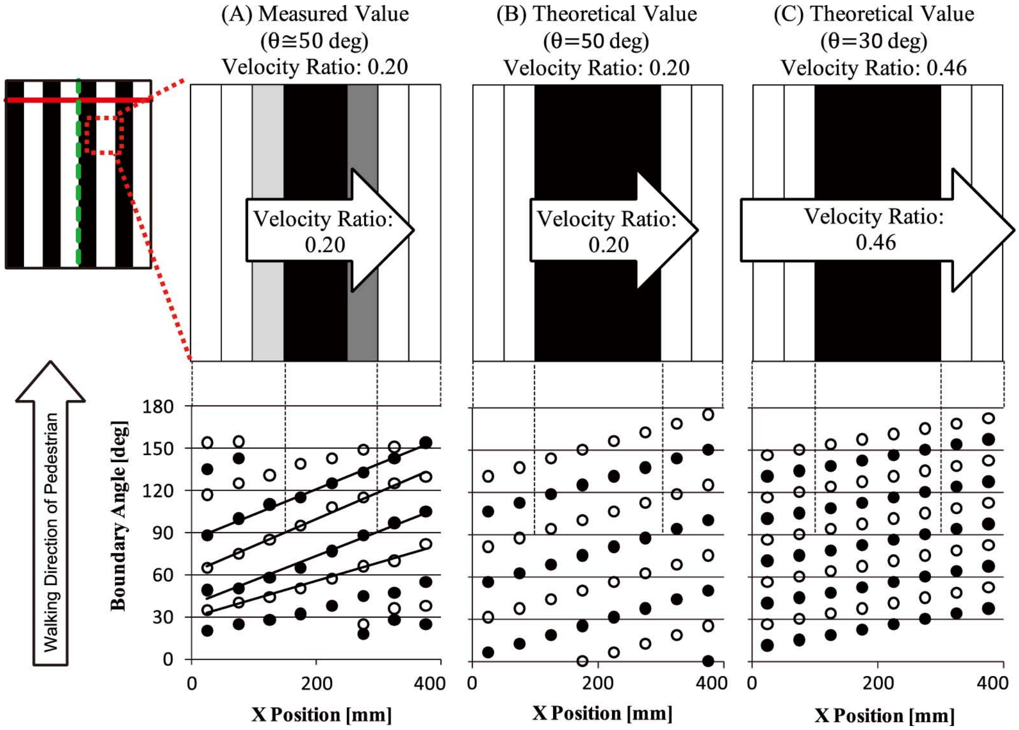

Figure 10. Angular Measurement of Lenticular Lens Prototype (N=8)

translational movement of the visual stimuli in the direction of the x-axis can be understood from Figure 10 (A) with the revolution of the lenticular lens. However, the measured angle, $\theta = 50$ degrees, corresponding to one cycle of the lenticular images, was found to be different from the angle used in the simulation, $\theta = 30$ degrees. Then, the theoretical change, which is shown in Figure 10 (B), $\theta = 50$, and Figure 10 (C), $\theta = 30$, was calculated using equation (3).

The coefficients used to convert the distance of forward movement into the distance of translational movement of the striped pattern were calculated with equation (4). The coefficient 0.20, shown in Figure 10 (A), was obtained by doubling x_{half} of equation (4), with $\varphi = 50$ degrees. The prototype converts the forward movement of 1.49m obtained with equation (4) to the translational movement of 0.30m shown in Figure 10 (A), while the simulated condition mentioned above converts the forward movement of 0.875m obtained with equation (4) and $\varphi = 30$ degrees to the translational movement of 0.40m, equivalent to the conditions of the simulation. The coefficients of this conversion are 0.20 (=0.30m / 1.49m) and 0.46 (=0.4m / 0.875m). Therefore, the translational speed of the visual stimuli produced by the prototyped lenticular lens was found to be less than half the speed produced by the simulated condition. Although this lower speed produced by the prototyped lenticular lens will result in lower displacement of walking induced by the translational movement of the visual stimuli compared to the simulation, it seems that the dynamic movement dependent on walking provoked the navigating effect. Therefore, this implementation with the lenticular lens and design of the visual stimuli as described above proved feasible.

5. CONCLUSION

In this study we proposed the Vection Field, which induces vection and the directional shift of walking. The results of our simulation suggest that the dynamic movement of visual stimuli induces the directional shift of walking, and therefore we can conclude that the fundamental principle of our method is feasible. The results of our implementation with the lenticular lens produced the expected optical-flow of striped patterns, thereby provoking directional navigation in the participants. Therefore we conclude that the proposed Vection Field can be useful for pedestrian traffic control.

We will continue to evaluate the feasibility of the Vection Field with the implemented lenticular lens. Further, we will consider additional experimental conditions in which we adjust the width of the patterns and change the brightness of the stimuli to reveal possibly more effective conditions.

6. ACKNOWLEDGEMENTS

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