Using Point-Light Movement as Peripheral Visual Guidance for Scooter Navigation

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ABSTRACT
This work presents a preliminary study of utilizing point-light movement in scooter drivers' peripheral vision for turn-by-turn navigation. We examine six types of basic 1D point-light movement, and the results suggests several of them can be easily picked up and comprehended by peripheral vision in parallel with the on-going foveal vision task, and can be use to provide effective and distraction-free route-guiding experiences for scooter driving.

Author Keywords
Point-light movement, Peripheral Visualization, Wearable Display

ACM Classification Keywords
H.5.2. Information Interfaces and Presentation (e.g. HCI): User Interfaces

INTRODUCTION
Providing guidance information visually is effective to display spatial information for scooter drivers, but using tertiary displays such as smartphone displays, glass displays[1], or helmet displays[2] usually drag scooter drivers' gaze away from the road, resulting hazardous and distractive focus changes in driving [4]. Audible [3] and tactile [5] information can be acquired in parallel to visual sensory to compensate visual guidance. However, since scooter driving often suffers from noisy and bumpy environment, the scooter drivers may need to wear additional devices to amplify the signals, making the solutions less practical in use.

Visual information displayed in scooter driver's peripheral vision also can be captured and processed in parallel with the on-going foveal vision task, if the information is simple enough to be interpreted without cognitive efforts involved in a dual-task scenario [6]. Accordingly, *eye-q* [1] presented a glass display embedded LEDs in the frame to deliver blinking signals as peripheral visual hints or notifications. Although blinking point lights can be expressive and understandable if the blinking pattens are appropriately coded in time-domain, they are harder to interpret than animations or images in spatial-domain. To leverage the limitations of point light for route guidance, the dimension of the peripheral display should be extended.

[1]https://www.google.com/glass/
[2]http://www.skullysystems.com

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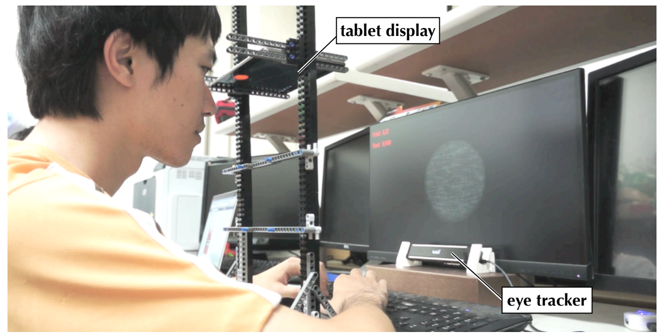

Figure 1. Experimental apparatus of the pilot studies

This work presents a preliminary investigation of utilizing scooter drivers' peripheral vision to provide point-light movement as turn-by-turn visual guidance system. To investigate the use of peripheral point-light movement, two pilot studies are conducted to understand the perceptual ability of peripheral vision and to explore the design space of peripheral visualization on a scooter helmet. A 7.7-inch Samsung Galaxy Tab[3] tablet display is used for providing visualization a configurable way. The tablet display was placed on a tablet holder with front facing down (Figure 1). A Tobii REX eye tracker[4] put in front of the participant was used to track users' gaze position.

PILOT STUDY 1: VELOCITIES OF LIGHT MOVEMENT
The first study investigates how the velocity of light movement effects users' perceptual ability of peripheral vision. Twelve participants (6 males) between the ages of 23 and 33 years with 24.92 mean age were recruited. After the participants calibrated the eye tracker, they were requested to look at the object presented on screen, and their gaze positions were tracked by the eye tracker. Users were asked to recognize whether the point light is moving to the left (Left signal) or to the right (Right signal) by using their peripheral vision, and then answer by pressing the 'F' or 'J' key eyes-freely on the keyboard using their both hands as soon as possible.

Six different velocities from $1v$ (0.146 m/s, the slowest) to $32v$ (4.656 m/s, the fastest) were tested. The velocity and type of the point light appeared in a random order, and the period between each trial were randomized in the range between 3 to 10 seconds. The answers of each trial were recorded, and the reaction times were recorded if users did not miss the signal.

[3]http://www.samsung.com/
[4]http://developer.tobii.com/rex-setup/

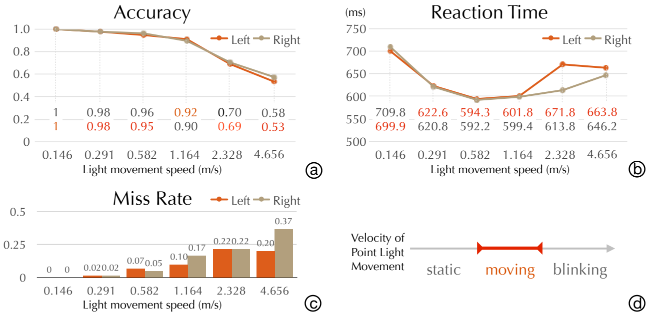

Figure 2. Pilot study results on different light movement velocities. (a) Accuracy. (b) Reaction time (c) Miss rate. (d) Results suggest that peripheral vision is able to discriminate light movement from static and blinking signals within a range of velocity.

Each trial was considered invalid only if users did not gaze at the target on the front display for more than 0.2 seconds, which is the lower bound of the typical eye movement time [2]. If an invalid task was performed, participant need to retry until successful. In total, 2 (signals) $\times$ 6 (speeds) $\times$ 10(trials) $\times$ 12 (participants) = 1440 successful trials were collected.

Results and Discussions

Figure 2 shows that, when the speed of light movement is slower than $4v$ (0.582 m/s), participants were capable of distinguishing light directions with more than 95% accuracy using their peripheral vision, and they react faster when the light move faster. On the contrary, when the speed of light movement is faster than $4v$, participants became less certain to recognize the signal, causing the miss rate and reaction time increased. According to the results, we learned that using peripheral vision can recognize light movement when the point light moves in a moderate speed. Otherwise, it would be seen as a static blob, a blinking signal, or even nothing.

PILOT STUDY 2: TYPES OF LIGHT MOVEMENT

The second study investigates how different types of light movement effects users' perceptual ability of using peripheral vision. Twelve participants (2 females) between the ages of 20 and 29 years old with 23.54 mean age were recruited. After participants calibrated the eye tracker, they were requested to answer the type of signal in their peripheral vision.

Six types of basic light movement: Left, Right, Merge, Split, Dilate and Erode are tested in this study (Figure 3). According to study 1, we set the velocity of signal in $4v$ (0.582 m/s). After seeing the visual signal, the participant answers the type of light movement by pressing the corresponding icon using a mouse cursor. Differ from study 1, each time participants need to answer the question after each light signal displayed, thus no miss would occur, and the reaction time does not count. The type of the point light movement appears in random order, and the period between each trial were randomized in the range between 3 to 10 seconds. Each trial was considered invalid only if users did not gaze at the target on the front display for more than 0.2 seconds, and need to retry the task until successful. In total, 6 (signals) x 5 (trials) x 4 (blocks) x 12 (participants) = 1440 successful trials were collected.

	Initial State	Movement	Left	Right	Split	Merge	Dilate	Erode	Accuracy
Left			239	1					.996
Right			1	239					.996
Split				1	239				.996
Merge			1	3	1	233		2	.971
Dilate			3	2	2	2	217	14	.904
Erode					1	1	6	232	.967

Figure 3. Pilot study results in confusion matrix on the accuracy of the six types of point-light movement.

Results and Discussions

Figure 3 shows all types of the signals can be recognized in more than 90% accuracy, which suggests that participants were generally able to distinguish and recognize them. Dilate and Erode are prone to be misinterpreted, since the movement is less salient for peripheral vision. Merge sometimes were misinterpreted as Left or Right, since peripheral vision failed to perceive the initial state. According to the results, we learned the tested signals are generally perceivable and interpretable in peripheral vision. Using more salient movement and/or less ambiguous initial states are more effective.

CONCLUSION AND FUTURE WORK

We have presented a preliminary study of utilizing point-light movement for distraction-free communication in peripheral vision. Results identify a suitable range of light transition speeds and a set of visual signals, which can be provided by a LED strip[5] module attaching to the front edge of the scooter helmet. Future research can further investigate the human factors on other possible effective factors, such as light colors, light accelerations, or absolute directional cues to expand the applications of the peripheral visualization technique.

REFERENCES

1. Costanza, E., Inverso, S. A., Pavlov, E., Allen, R., and Maes, P. Eye-q: Eyeglass peripheral display for subtle intimate notifications. In *Proc. MobileHCI '06* (2006), 211–218.

2. Gross, H., Singer, W., Totzeck, M., Blechinger, F., Achtner, B., Dörband, B., and Müller, H. *Handbook of Optical Systems*, vol. 4. Wiley Online Library, 2008.

3. Komninos, A., Barrie, P., Stefanis, V., and Plessas, A. Urban exploration using audio scents. In *Proc. MobileHCI '12* (2012), 349–358.

4. Kun, A. L., Paek, T., Medenica, v., Memarović, N., and Palinko, O. Glancing at personal navigation devices can affect driving: Experimental results and design implications. In *Proc. AutomotiveUI '09* (2009), 129–136.

5. Prasad, M., Taele, P., Goldberg, D., and Hammond, T. A. Haptimoto: Turn-by-turn haptic route guidance interface for motorcyclists. In *Proc. CHI '14* (2014), 3597–3606.

6. Somervell, J., McCrickard, D. S., North, C., and Shukla, M. An evaluation of information visualization in attention-limited environments. In *Proc. VISSYM '02* (2002), 211–216.

[5]http://www.adafruit.com/product/1506