PeriMR - A Prototyping Tool for Head-mounted Peripheral Light Displays in Mixed Reality

Uwe Gruenefeld
University of Oldenburg, Germany
uwe.gruenefeld@uol.de

Wilko Heuten
OFFIS - Institute for IT
Oldenburg, Germany
wilko.heuten@offis.de

Tim Claudius Stratmann
University of Oldenburg, Germany
tim.claudius.stratmann@uol.de

Susanne Boll
University of Oldenburg, Germany
susanne.boll@uol.de

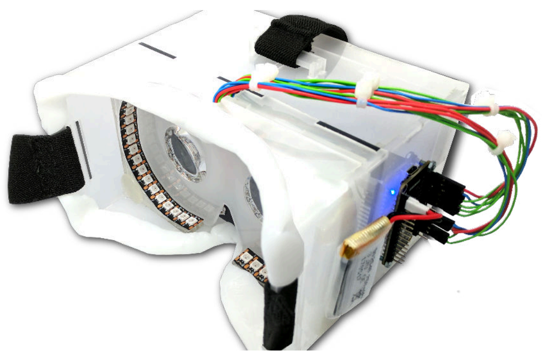


Figure 1: Prototyping tool PeriMR. *Best seen in color.*

MobileHCI '17, September 4–7, 2017, Vienna, Austria
ACM 978-1-4503-5075-4/17/09.
https://doi.org/10.1145/3098279.3125439

Abstract
Nowadays, Mixed and Virtual Reality devices suffer from a field of view that is too small compared to human visual perception. Although a larger field of view is useful (e.g., conveying peripheral information or improving situation awareness), technical limitations prevent the extension of the field-of-view. A way to overcome these limitations is to extend the field-of-view with peripheral light displays. However, there are no tools to support the design of peripheral light displays for Mixed or Virtual Reality devices. Therefore, we present our prototyping tool PeriMR that allows researchers to develop new peripheral head-mounted light displays for Mixed and Virtual Reality.

Author Keywords
Prototyping; Mixed Reality; Augmented Reality; Virtual Reality; Head-mounted; Peripheral Light Displays

ACM Classification Keywords
H.5.m. [Information Interfaces and Presentation (e.g. HCI)]: Miscellaneous

Introduction
Mixed and Virtual Reality are currently experiencing a second spring, triggered by affordable do-it-yourself solutions like Google Cardboard[1] and built upon by Virtual Reality

[1] https://vr.google.com/cardboard/

headsets like Oculus Rift[2] and HTC Vive[3]. However, compared to the human field-of-view the field-of-view currently used for these Mixed- or Virtual Reality devices is smaller. Extending the field of view is technically challenging because of more pixels to calculate, higher heat radiation and worse wearing comfort due to increased weight. Simply extending is also not useful with respect to humans perception characteristics (e.g., color appearance [1] or pattern recognition [11]). On the other hand, a small field-of-view would mean a less immersive experience and loss of space for displaying digital information. However, light displays placed in the periphery are useful in many scenarios. For example Xiao et al. showed that simulator sickness can be reduced with sparse peripheral light displays [12]. Additionally, these display can increase situational awareness. To investigate new peripheral light displays in Mixed- and Virtual Reality researchers and developers have to build a new device based on Google Cardboard or from the scratch.

In this demo, we present a low-cost prototyping tool for developing head-mounted peripheral light displays that are easy to extend. We improved the Google Cardboard platform to support generic peripheral light displays. These displays can be attached to the cardboard by sliding them into a drawer. Additionally, we added an affordable microcontroller board with Wi-Fi and a battery to allow usage in a mobile context. The prototyping tool can be built by using a laser cutter.

We propose the following research contribution:

- A low-cost and highly adjustable prototyping tool for peripheral light displays in Mixed- and Virtual Reality.

[2]https://www.oculus.com/rift/
[3]https://www.vive.com

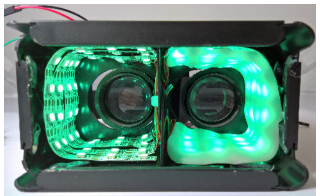
Related work

Our prototyping tool is based on the application domain of peripheral displays and prototyping tools for Mixed- and Virtual Reality.

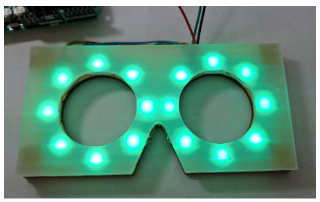
Peripheral displays

In the beginning of this century, researchers have started to explore the presentation of information and notifications in the periphery [3, 5]. These systems allow monitoring information sources while focusing on a primary task. However, with the trend towards head-mounted devices users can use such technologies in a mobile context. Poppinga et al. showed a simple setup consisting of 12 LEDs placed on the frame of safety glasses [10]. In their conducted user study participants were able to locate the correct LED with 71 percent accuracy. Beak et al. showed that even low-resolution displays are usable in a head-mounted device by adding two small LCD's on its sides [2]. More technically advanced optical-see-through devices are proposed in different works [8, 9]. Most of them are based on a more complicated technical setup to achieve displaying digital information in the periphery.

A more recent approach was suggested by Xiao et al. [12]. They investigated low-resolution LED arrays surrounding a central high-resolution display in a virtual and an augmented environment. In a user study they showed that sparse peripheral displays are useful in conveying peripheral information and that they improve situational awareness. Further, Luyten et al. investigated visual elements for near-eye out-of-focus displays [7]. Their findings show that limiting the possible shapes and clever usage of orientation and motion makes information visualization in the periphery more usable.



(a) Behind lenses.



(b) In front of lenses.

(c) Sidebars.

Figure 2: Prototypes for testing the design space. *Best seen in color.*

Prototyping

PapAR from Lauber et al. transfers the well-known method of paper-prototyping to AR [6]. Two layers are used. One is a normal sheet of paper on which the environment is drawn on. Another is a transparent foil that shows the overlaying digital information. However, since peripheral displays need to consider the human perception characteristics, this approach is not viable for research on information presentation in the periphery. A similar problem arises from other prototyping approaches that focus on interface elements (e.g., [4]). To our knowledge there is no research that addresses prototyping for head-mounted peripheral light displays for Mixed or Virtual Reality.

Requirements for VR- and MR prototyping

We identified three characteristics that have to be fulfilled by our prototyping tool.

Extendability

Our prototyping tool should support head-mounted Virtual and video-see-through Augmented Reality devices. Further, it should support the use different lens sizes. The tool should allow LED placement on various positions.

Flexibility

The prototyping tool should be reconfigurable to support different design pattern. Reconfiguration should be possible within an user study.

Low-cost

The prototyping tool should be cheap and publicly available.

Concept of PeriMR

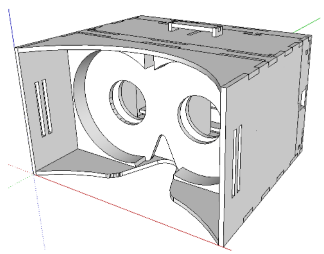
As a first step we investigated the design space for peripheral LEDs on head-mounted Mixed and Virtual Reality devices. We tested three positions: between lenses and smartphone display (behind lenses), between eyes and lenses (in front of lenses) and attached to the frame (sidebars). Additionally to the position we investigated different kinds of diffusors: Gorilla Plastic [4], milky plexiglass and without diffusors. The prototypes are shown in Figure 2.

The outcome of the pre-testing with the developed prototypes was that in front of lenses and sidebars are the best fitting positions for LEDs. For the sidebar no diffusor was needed and in front of lenses semi-transparent plexiglass worked best. Behind lenses also worked to some extent but due to reflections in the lenses only low resolution LED arrays make sense here. Since the testing of behind lenses needed further exploration we left this position out of the scope of our design space for this version.

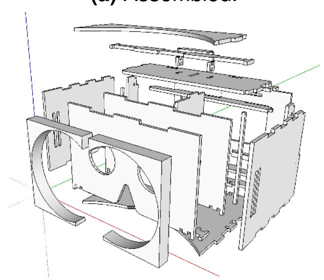
As mentioned already, our prototyping tool is developed based on the official Google Cardboard template. We modified the template using SketchUp [5]. During two iterations we changed the following points to fit the template to our needs.

1. We changed the proportions and increased the space before the lenses to allow more LEDs and displays to be applied in this space. Further, it allows participant to wear glasses along with PeriMR.
2. We made the plane including the lenses detachable by adding a drawer with a slide-in. The plane can be changed, thereby allowing support for different LEDs and display patterns. Furthermore, different sizes of lenses can be used by this approach. An example is described in the next section.

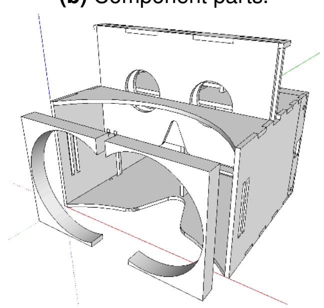
[4]http://www.gorilla-plastic.com
[5]http://www.sketchup.com



(a) Assembled.



(b) Component parts.



(c) Replaceable parts.

Figure 3: Different views on the 3D model of PeriMR.

3. Additonally, we created two easy-to-attach sidebars, one for each side. These can be used for testing with LED strips on them.

After cuttting all parts we assembled the prototyping tool and added a NodeMCU developer board[6] with a low-cost Wi-Fi bord attached and one Li-Po battery. These components are lightweight, affordable and allow mobile usage of the prototyping tool.

The resulting 3D model is shown in Figure 3: Subfigure 3a) shows the assembled PeriMR, Subfigure 3b) shows the component parts and Subfigure 3c) shows the replaceable parts.

Prototyping with PeriMR

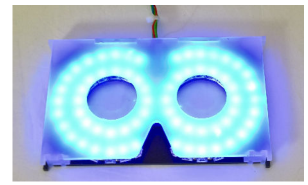
Key to our prototyping tool is the drawer for replaceable slide-ins. To demonstrate, we created an example slide-in shown in Figure 4. This example uses a radial projection of LEDs in two rows around the center. We used a semi-transparent plexiglass as diffusor. To create new slide-ins is one way to build prototypes with PeriMR. Another way is to add new dettachable sidebars (see Figure 3c). Both ways can be used by altering the template[7] that comes with PeriMR.

Limitations

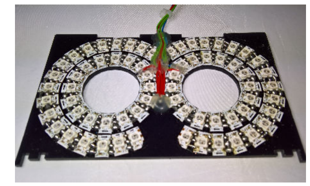
For our prototyping tool we see four main limitations:

1. It builds on Google Cardboard and uses a smartphone for the Virtual and Augmented Reality experience. Therefore, the graphic power for the main experience is rather limited but acceptable since the peripheral light displays are in focus of the investigation.

[6]https://en.wikipedia.org/wiki/NodeMCU
[7]https://github.com/UweGruenefeld/PeriMR



(a) Completed version.



(b) Circuits.

Figure 4: Example for a PeriMR slide-in. *Best seen in color.*

2. We recommend that a laser cutter is used to build the prototype. Building it with other tools may take longer and is not as accurate.

3. The attachment of the sidebars is not perfect yet. One has to glue them to the frame to fix them for usage in studies. This means they can not be replaced during studies. In a new iteration, the sidebars should also be detachable like the slide-ins.

4. Our prototyping tool does not support the use of curved light displays, which would be hard to achieve due to the limitations of the tool.

Conclusion and Future work

In this demo we presented an affordable and simple to build prototyping tool for peripheral light displays. The tool is built upon Google Cardboard and adds an easy to use mechanism to test different setups. However, in future work we want to evaluate how feasible the prototyping tool is for user-studies.

Acknowledgments

We thank the Ministry of Science and Culture of Lower Saxony for supporting us with the graduate school *Safe Automation of Maritime Systems (SAMS)*.

REFERENCES

1. Israel Abramov, James Gordon, and Hoover Chan. 1991. Color appearance in the peripheral retina: effects of stimulus size. *J. Opt. Soc. Am. A* 8, 2 (Feb 1991), 404–414. DOI: http://dx.doi.org/10.1364/JOSAA.8.000404
2. Jin-uk Baek, Jaehoon Jung, and Gerard J. Kim. 2005. Head Mounted Display with Peripheral Vision. In *Proceedings of the 2005 International Conference on Augmented Tele-existence (ICAT '05)*. ACM, New York, NY, USA, 282–282. DOI: http://dx.doi.org/10.1145/1152399.1152472
3. Edward S. De Guzman, Margaret Yau, Anthony Gagliano, Austin Park, and Anind K. Dey. 2004. Exploring the Design and Use of Peripheral Displays of Awareness Information. In *CHI '04 Extended Abstracts on Human Factors in Computing Systems (CHI EA '04)*. ACM, New York, NY, USA, 1247–1250. DOI: http://dx.doi.org/10.1145/985921.986035
4. Marco de Sá and Elizabeth Churchill. 2012. Mobile Augmented Reality: Exploring Design and Prototyping Techniques. In *Proceedings of the 14th International Conference on Human-computer Interaction with Mobile Devices and Services (MobileHCI '12)*. ACM, New York, NY, USA, 221–230. DOI: http://dx.doi.org/10.1145/2371574.2371608
5. Frank L. Kooi and Marcel Mosch. 2006. Peripheral Motion Displays: Tapping the Potential of the Visual Periphery. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting* 50, 16 (2006), 1604–1608. DOI: http://dx.doi.org/10.1177/154193120605001619
6. Felix Lauber, Claudius Böttcher, and Andreas Butz. 2014. PapAR: Paper Prototyping for Augmented Reality. In *Adjunct Proceedings of the 6th International Conference on Automotive User Interfaces and Interactive Vehicular Applications (AutomotiveUI '14)*. ACM, New York, NY, USA, 1–6. DOI: http://dx.doi.org/10.1145/2667239.2667271
7. Kris Luyten, Donald Degraen, Gustavo Rovelo Ruiz, Sven Coppers, and Davy Vanacken. 2016. Hidden in Plain Sight: An Exploration of a Visual Language for Near-Eye Out-of-Focus Displays in the Peripheral View. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems (CHI '16)*. ACM, New York, NY, USA, 487–497. DOI: http://dx.doi.org/10.1145/2858036.2858339
8. A. Maimone and H. Fuchs. 2013. Computational augmented reality eyeglasses. In *2013 IEEE International Symposium on Mixed and Augmented Reality (ISMAR)*. 29–38. DOI: http://dx.doi.org/10.1109/ISMAR.2013.6671761
9. Andrew Maimone, Douglas Lanman, Kishore Rathinavel, Kurtis Keller, David Luebke, and Henry Fuchs. 2014. Pinlight Displays: Wide Field of View Augmented Reality Eyeglasses Using Defocused Point Light Sources. In *ACM SIGGRAPH 2014 Emerging Technologies (SIGGRAPH '14)*. ACM, New York, NY, USA, Article 20, 1 pages. DOI: http://dx.doi.org/10.1145/2614066.2614080

10. Benjamin Poppinga, Niels Henze, Jutta Fortmann, Wilko Heuten, and Susanne Boll. 2012. AmbiGlasses-Information in the Periphery of the Visual Field.. In *Mensch & Computer*. 153–162.
11. Hans Strasburger, Ingo Rentschler, and Martin Jüttner. 2011. Peripheral vision and pattern recognition: A review. *Journal of Vision* 11, 5 (2011), 13. DOI: http://dx.doi.org/10.1167/11.5.13
12. Robert Xiao and Hrvoje Benko. 2016. Augmenting the Field-of-View of Head-Mounted Displays with Sparse Peripheral Displays. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems (CHI '16)*. ACM, New York, NY, USA, 1221–1232. DOI: http://dx.doi.org/10.1145/2858036.2858212