# Smart Glasses with a Peripheral Vision Display

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## Abstract
We present a demonstration of an initial peripheral vision glasses prototype. We can display patterns in the peripheral vision of the user. A simple use case is to show notifications. Up to 8 different notification types can be distinguished. We also suggest to use it to modify walking speed of users (depending on the animations people tend to speed up or slow down).

## Author Keywords
peripheral vision; smart eye wear; glasses

## ACM Classification Keywords
H.5.m [Information interfaces and presentation (e.g., HCI)]: Miscellaneous

## Introduction
Smart eye wear is an interesting new computing field. As a lot of the human senses are located on the head, it makes an interesting location for both sensing and actuation.

There are plenty of works discussing head mounted computers with displays for augmented reality applications or micro interactions. In this work however we focus on peripheral vision, as we believe there are a lot of interesting application cases for peripheral vision interaction in virtual and augmented reality. Most interestingly, it seems walking


**Figure 1:** Concept of peripheral vision and the two prototype glasses used for the experiments.

trajectories and speed can be influenced over peripheral vision [2, 3].

The contributions of this demonstration paper are as follows: (1) We show our initial prototypes [5], (2) we let the users experience 8 notifications on the display, (3) we try to alter users walking speeds using the glasses.

## Approach

As mentioned before, we want to evaluate effects related to peripheral vision for interactions in virtual and augmented reality. Complimentary to other research using peripheral vision we implement our display in an unobtrusive eye glasses design. Most of our senses including the dominant vision are on the head, making the human skull a perfect location for interaction devices. Eyeglasses are publicly accepted accessories, often worn continuously throughout the day, rendering them an ideal platform for unobtrusive information delivery. Our final goal is controlling the human motion without consciousness.

## Prototypes

We presented an initial prototype wit a single peripheral display to be utilized for unobtrusive notifications [5]. We extended this prototype with another display. It consists of a small Arduino NANO board embedded in a 3d printed glasses design and two small 8*8 dot matrix modules (OSL641501 - ARA) on the left and right side of the glasses (see Figure 1). The LED module is inclined by around 20 degrees an optimal position for the peripheral vision. The glasses design by 3DCAD software and printed by a 3D printer. See Figure 1 for details.

## Envisioned Interactions

We suggest two demonstrations that can be done in parallel by two users. The frst demonstration consists of wearing the device and getting notifications. The users can select the activity they want to do, e.g. watch a movie, walk etc. They then get an introduction to the 8 different notifications we can show on the device, perform the activity and in random intervals get a notification over the glasses. The second demonstration is the most interesting one. We can alter the movement speed slightly. Showing fast moving bars from front to back on the displays make users move relatively slower to before. The user walks first with the device a certain area(should be around 10 meters),then we start the animation on the display and the user is supposed to walk the same distance again with the same speed as before. Usually users walk slower the second time.

## Initial Notification Experiments

For details please refer to the previous publication [5]. Our initial application case focuses on explicit output: signaling to the user. We want to answer the questions "Can a user recognize patterns displayed on our glasses?", "How many different patterns can a user recognize?" and "Can the glasses be used to give the users information in an unobtrusive way while they are working or engaged in other tasks?". For these questions we designed so far 2 initial experiments. The first is explorative using a various pattern animations (we will refer to them as patterns for the rest of the paper) addressing part of the two first questions. The second looks into the last question giving the user some "distracting" tasks while randomly presenting them with patterns on the display. Each light movement was shown 0.7 seconds, and the users reactions were observed.

### *Explorative Experiments*

For the explorative experiments we designed 8 LED dot pattern animations based on information about the peripheral vision system and the limitations of the 8*8 dot matrix. The patterns used for the first experiment are depicted in Figure

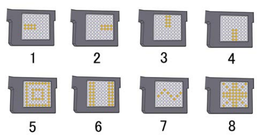


**Figure 2:** 8 different notification types to be shown on the glasses.

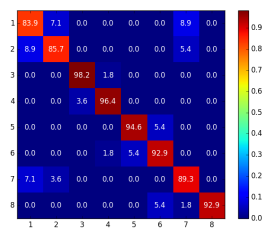

**Figure 3:** Confusion Matrix Exploration Experiment

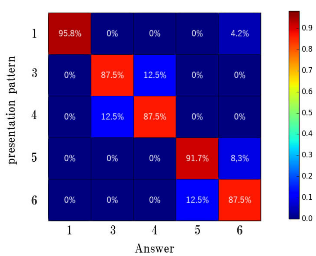


**Figure 4:** Confusion Matrix Exploration Experiment

2.

Each pattern ashes exactly 0.7 sec, this is approximately double of the mean time an average human can recognize movement using his peripheral vision. Pattern 1 and 2 are horizontal movements (left to right, right to left respectively). Pattern 3 and 4 are vertical (up to down, down to up). Pattern 5 is a "ripple" movement originating in the middle of the LED matrix (4x4 LEDs) towards the outside. Pattern 6 is a movement from both sides to the center. Pattern 7 is similar to Pattern 1, yet includes waves (not straight lines). Pattern 8 is a radial movement. For the rst experimental design we recruited 7 participants (age average 24, 1 female). The participants sit still and at random intervals they see a random stimulus 7 for each pattern, 56 per user, 392 in total. The participants need to say out loud in case they recognize a pattern and have to say which pattern they recognize.

*Distraction Experiments*

For the second experimental setup we wondered if the information display will work also if the user is occupied by another task. We selected "watching a video" as task, the users watch a youtube video 1. From experiences from the first experiment we limited the stimuli to patterns 1, 3, 4, 5 and 6. The rest of the experimental setup is the same as above: the same user participated and the same random occurrences of the patterns and animation duration.

## DISCUSSION AND RESULTS

Figure 4 summarizes the results of the first experiments, downwards you see the number of patterns and towards the right are the stimuli the users reported. This shows the usefulness of our smart glasses. The vertical movements seem to perform best (pattern 3 and 4). One possible explanation is that most of our visual stimulation we receive from peripheral vision is horizontal. Therefore, vertical movements might be more noticeable as they don't occur so often in ordinary life. The Exploration Experiment showed that our glasses can present information to the users and gave some evidence about selected presentation patterns. The Distraction Experiment demonstrate the presentation ability of the glasses in situations with a more dynamic stimuli. As for the first experiment, the results are depicted in Figure 5. The vertical axis shows the randomly presented movement of light, and the horizontal axis shows the answer of the subjects. There are slight confusions between up and down movements and the two full screen animations (5 and 6 ripple and moving to the middle).

### Potential Applications

The most straight forward application cases are notifications. The current prototype system can already be used for this, as least 5 different states can be communicated to the user with sufficient recognition accuracy (at least for "casual" notifications). The display LEDs are not so bright so the notification might not be seen by somebody else (e.g. the person you are talking to). Yet, this still has to be evaluated.

However, more interesting is to use the device for movement related illusions (as some of the related work already explored for VR applications [3]). Therefore interesting application cases are for us also in sports or in other movement related activities.

### Application Scenarios

The most straight forward application cases are notifications. The current prototype system can already be used for this, as least 5 different states can be communicated to the user with sufficient recognition accuracy (at least for "casual" notifications). The display LEDs are not so bright so

**Figure 5:** User Walking with the glasses.

the notifications cannot be seen by somebody else (e.g. the person you are talking to). Yet, this still has to be evaluated.

However, more interesting is to use the device for movement related illusions. Users can try out the display to change their movement speed (e.g. let them walk slower or faster depending on the animation shown on the glasses). Also we can alter their trajectory slightly. However this does not work for all users so far.

## Related Work

Closest to our approach seems a patent from Andes et al. They also describe a peripheral display to convey information unobtrusively. However, as other approaches they focus on a single LED ring on top or below they eye [1]. Also close to our apporach, Poppinga et al. use peripheral vision on ambient glasses for navigation tasks [4]. However, they use single LEDs on different positions on the glasses frame and no motion animations.

Okano induces the illusion of motion by stimulating the users peripheral vision with still images and animations [3].

There are a couple of notification systems on glasses. Most of them use single LEDs and don't present movement/motion. [1,2]

To our knowledge, this is the first evaluation of a larger low resolution display for peripheral vision interactions.

## Conclusion

We present an initial prototype for peripheral vision glasses. The demonstration entails notifications for implicit interactions as well as a pattern to alter the walking speed of users. The later does not work for all users yet. We are currently redesigning the glasses so the there is a larger display area.

[1] http://www.weonglasses.com
[2] http://fun-iki.com

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