Peripheral Vision Displays: Creating an Unobtrusive LED Notification and Navigation System for Glasses

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Abstract

This project aims to develop an unobtrusive notification and navigation system using a ring of dim LEDs around the frame of glasses to shine at the user's peripheral vision when designed. The project also aims to provide an easy and cost-effective prototype solution for hobbyists while not looking strange to wear. The prototype will be tested with a range of participants to see if an effective solution compared to other existing notification and navigation approaches.

Introduction

The proposed project is to examine, implement and evaluate the benefits of using peripheral vision to help users get to a desired destination. Peripheral vision is the 'visual field beyond our current point of gaze that provides information that is essential for a vast range of tasks in everyday life' [1]. Peripheral vision allows us to see the space around us without the need to focus on it. This helps us to see movement and shapes in our field of vision. Peripheral vision is used in everyday life such as 'walking, reading, driving and sports' [2] and so taking advantage of it should be beneficial for most people.

As physical maps become more and more outdated, there is an increase in the number of people who use electronic devices to navigate around unfamiliar areas. Using GPS has become much more convenient as it comes built into most smart phones and electronic devices. In the recent years, the size of the global GPS tracking device market has had a 27.6% increase from 1.2 billion US dollars in 2020 to 1.66 billion US dollars in 2022, and a projected increase to 2.38 billion US dollars in 2025 [3].

With an increase of pedestrians using GPS navigation apps, there is a subsequent increase in the likelihood of accidents to happen because there is a lack of spatial awareness of roadside events. This is because the posture when using a mobile phone while walking decreases the view of your surroundings which can lead to accidents but also creates distractions as your focus is on the screen. This is why making a peripheral vision display where the user can still use navigation without the need to physically hold a device. It also allows for multitasking using different devices as the user can navigate to a destination with the glasses but also text on their phone at the same time without the need to pay direct attention to where they are going [4].

Background

A peripheral vision display as described in the a paper written by Nakuo Takuro and Kuzune kai, is a 'device that enables implicit and explicit interactions utilizing peripheral vision' and a their demonstration of this was to 'display patterns in the peripheral vision of the user' [5]. Their paper is an example of a very similar concept to the idea that I will be expanding on as they made a prototype to control human motion without consciousness and to alter walking speeds and motion. While their design using a grid of LEDs, I will use a single array as the user will not be asked to move at angles and at specific speeds.

One issue with the idea of using a peripheral vision display to help users with navigation is the idea of how well people will be able to adapt to the product in real life. This isn't something that I will be able to test as it may take users weeks to months of consistent use to get used to it and so further research will have to be done after the projected timeframe of this project to see if it can be a viable option or is using a phones navigation app directly, the better option. It has already been noted that people with lack of peripheral vision will not be able to use the product or gain any benefits from it but people with blurred peripheral vision may as it isn't a shape that is being produced from the LEDs but a light. It should also be noted that a normal visual field is approximately 170 degrees, with 100 degrees comprising the peripheral vision [6]. With this information, I need to make sure that the LEDs are placed somewhere between the mid and near peripheral vision otherwise the user will not be able to see the light shine. The further the placement in the field of view, the less distracting it will be but the more likely the user will miss the light.

Another paper which also designs a peripheral vision display project is one by Paul Lubos, Gerd Bruder, Oscar Ariza and Frank Steinicke. They created a display extension to The Oculus Rift DK2 by adding RGB LEDs and diffusing foil to extend the central field of view. The peripheral visual quality was not as high as the central field in the head mounted display (HMD), there was still an improvement in the users subjective sense of presence which influenced behaviour when participants navigated through a 3D virtual environment. Notes to take into consideration when they suggested changes that would make the product work better included a more realistic rendering for the LEDs in the peripheral vision as it could enhance the special awareness and presence in the virtual world [7]. As for this project the central FOV cannot be changed, there is no direct benefit for having the coloured LEDs as a basic rendering for the surroundings but, it was noted that even with the quality of the peripheral vision being low, it still helped the user sense things in the surrounding area. With this information, I am confident that using a single array of LEDs would be a better choice compared to a grid of LEDs as it is cheaper but will also make a large improvement.

A study by Martin Pielot, Benjamin Poppinga, Wilko Heuten and Susanne Boll, reports a field study on using different feedback methods in pedestrian navigation systems [8]. They found that tactical feedback reduces distractions whilst multimodal feedback improves navigation. It suggests adjusting tactile feedback to avoid unnecessary cognitive load. The study also found that using a single actuator for directional cues is effective in aiding navigation, although there were no significant differences observed. Participants showed a slight decrease in navigation performance with tactical cues, likely because they were more used to visual systems. With this information, it is likely that users will find a benefit in this projects prototype as there are no tactical cues and instead are visual cues to signal the user to turn.

Using LEDs instead of other information channels was mainly influenced by the surrounding area in which the user would use the system. Sound would be a very poor way to send information to the user as when walking in public, there is likely to be very loud sounds from cars and other people. This will lead to the user having to pay attention to the sound and make sure they do not miss any of the cues which will be less intuitive. Vibration is also a bad choice as for the same reason, the user is likely to miss cues. It should also be noted that both sound and vibrations are very limited information channels more so than using LEDs in the view of this project. LEDs will also allow for multidirectional cues whereas the other options can only change intensity and fast they are played.

The proposed project

Aims and objectives

The aim of this project is to implement and test the usability of peripheral vision to improve the user experience of navigating to a desired destination with being less obtrusive than carrying a mobile phone to check directions. This project will accomplish these objectives:

a. Creating a functional LED display – A functional LED display is necessary for giving the user the ability to view information from their phone without directly using the phone.
b. Making an unobtrusive LED display – The aim of the project is to make sure that the LEDs are unobtrusive and out of central vision and to make sure they are dim enough to be visible but not too bright that it's distracting. The LEDs must not be placed in the focal field of view.
c. Creating a connection between an android phone and an embedded system – The system must have a way of communicating between the external system and the phone and using a Bluetooth connection would be the most ideal way of doing this as it allows for the embedded system to be separate to the phone and WIFI would be a bad choice because the system wouldn't work if there isn't a consistent signal.
d. Develop an application software – The application software is necessary for sending a notification signal to the embedded system when the user needs to turn during the navigation or for other notifications, which in return will flash the LED to the user.
e. Making the system compact, lightweight, and easy to use – After prototyping the display and system, presenting the system in its final form which will be the design that hobbyists would use is important. this is because people would not like to go out in public wearing large, heavy glasses.
f. Evaluate in comparison to existing approaches – With the research taken place, I have gathered information on the limitations of other similar products. I will take advantage of this information and evaluate my prototype based on the existing approaches to see if the product would influence users beneficially and better than the other options.
g. Have cheap and have easily accessible resources – Do a cost and resource check to make sure that I am not using resources that are hard to order for a hobbyist. I also need to make sure that the cost of building the physical system is cheap as this is a prototype and not a final product ready for consumers.

Methodology

This project will involve me using a mixture of the waterfall and agile methodologies. This is because this is an individual project, but I would also need to develop multiple parts of the system at the same time to be able to test new code works. When creating the backend system, this process will use the waterfall methodology as it will allow me to make sure that I keep on track and remember exact progress being made. When creating the physical connection between the microcontroller and the LEDs, this will be an agile process as it will happen while I am coding the system so I can test it while its being developed. These are two examples of stages listed and described in the "Programme of work" section that use the two different methodologies.

Iterative development / prototyping would be very beneficial to the refinement of the product but due to time constraints and the goal of the project being a test to see if it would benefit users, there is no need to make cosmetic changes, only changes to benefit functionality. To make sure the end prototype works correctly, refinement will be done after participant testing through evaluation with the users to see areas of functionality that can be improved. If participants find the product to be too heavy, this is an area that needs to be fixed but the look of the product doesn't need changing as it isn't the final product.

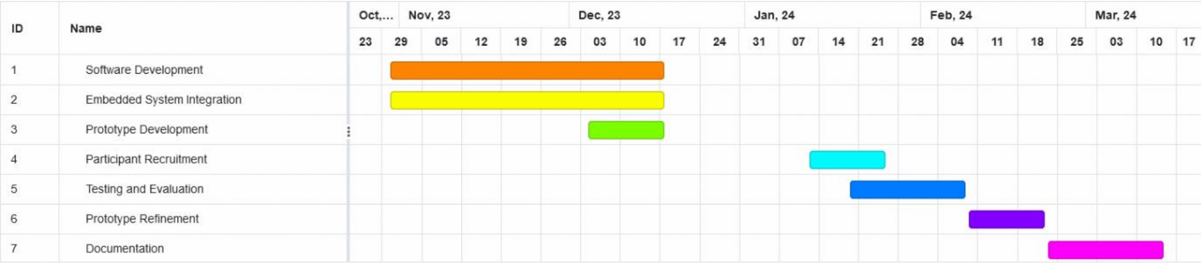
Programme of work

The project will start from October 2023 to March 2024 and will be divided and focused on these distinct stages:

1. Software Development:
   - This will involve the development of software to send a simple signal to the microcontroller when the navigation application needs the user to turn or to keep on going straight. The software will be on an android phone and will use Bluetooth to connect to the microcontroller. This stage is planned to take the most time to develop being around 7 weeks.
2. Embedded System Integration:
   - This will involve adding a microcontroller (Raspberry Pi Pico W) that will connect to the android device and receive signals from the software which will then be processed, and signals will then be sent to the LEDs. The microcontroller will require a power supply which both will have to be designed to be placed on the user either with the glasses or in a separate compartment. This stage is planned to be developed while developing the software so will also take around 7 weeks to complete.
3. Prototype Development:
   - This will involve designing and building a functional prototype of the peripheral vision display system, which includes the LEDs integrated into the frame of glasses. The prototype must meet the aims of the project. This stage is planned to take around 2 weeks.
4. Participant Recruitment:
   - When the full prototype is created, participants will be needed to test the system to make sure that it works correctly, easy to use and is easy to understand for a range of people based on eyesight and technological knowledge. The participants are required to fill out consent forms before any testing can begin. This process is planned to happen after the first term will take 1-2 weeks.
5. Testing and Evaluation:
   - This will involve testing and evaluating the prototype with participants that were recruited. The testing will involve the participants wearing the glasses and connect themselves to the navigation app with a specified destination. The participant will then follow the directions given to them from the prototype and hopefully reach the destination will positively feedback. This stage is planned to take 2-3
6. Prototype Refinement:
   - This will involve taking the previous prototype and create theoretical changes to the design based on the user testing. This stage will take more consideration into the functionality of the product instead of the cosmetic choices. This stage is planned to take 1-2
7. Documentation:
   - This will involve documentation of the prototype's design, components and software to show a clear record of how it was c7onstructed and how it works. I will include resources used, the cost and the time it took to complete the whole project. I will also document the software with comments on the code and creating a simple guide on how to make the product. This stage is planned to take 2-3 weeks

Gantt chart

Figure 1: Project Gantt chart for October 2023 – March 2024



Resources required

The resources required include:

- Two android mobile devices to make sure that the application and device can work on different environments. The application will be tested on participants devices when performing research on how easy the system can be used for a range of people. Using two phones before testing the system on participants will allow me to reduce the number of errors that the final product will have. The android phones used require Bluetooth to be inbuilt on the system and will be provided by myself.
- A Raspberry Pi Pico W to connect the mobile phone to the LEDs on the glasses. The microcontroller will connect to the phone using Bluetooth and will connect to the LEDs using wires.
- 0805 LEDs that will be used to shine at the users' peripheral vision to notify them of any actions they must perform to get to a destination and for other notifications. These LEDs require to have a very small form factor otherwise it will be a hinderance to the user. They also need to be dim as they could be too distracting for the user. Resistors will also be needed to dim the light output of the LEDs.
- Glasses that will be used for testing the LED configuration. I will need multiple cheap glasses or sunglasses as it is likely I will need to change the way the LEDs are running which may break the glasses after continuous wear. When testing the system using participants, it would be better if there was a way, I could attach the system to their glasses quickly and nearly, but this wouldn't be possible for time purposes. To make it as fair as possible, using sunglasses or glasses without prescription lenses for the final prototype would be the most ideal.
- Battery that will power the microcontroller and the LEDs. The battery doesn't need to be very powerful but to will be better if it was able to last a long time as users would need it to last them a whole day of travelling. It is unlikely that I would be able to place the battery on the glasses so it will be designed to be placed elsewhere, likely with the microcontroller as well, also allowing for a bigger battery size.

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