Cyclika: Paving A Sustainable Path Towards Empowered Biking

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Abstract
Cycling is an integral form of transportation and exercise throughout the world that has been increasing in popularity. With the sudden growth of cycling in the US, studies have shown that Americans who do not have access to protected bike lanes and similar forms of infrastructure have safety concerns about spatial awareness, accidents and surrounding motorists. Using contextual inquiry, design methods, and usability testing, we have developed Cyclika, a bike radar system that detects vehicles approaching laterally and from behind. Cyclika is comprised of two main parts: an interface mounted to the handlebars, and a radar attached under the seat of the bike. Cyclika's interface provides visual feedback to the user on the vehicles passing from behind. Users can also use the handlebar interface to provide input to the rear-mounted LED lights, nested with the radar system, which allows the user to signal their intended lateral movement.

Author Keywords
Bicycle; safety; sustainability; accessibility; behavior change; navigation; sensors; sports and exercise; transportation; health; wellbeing; user experience design; contextual inquiry; interaction design; prototyping; usability study; visual design; equity; empowerment

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

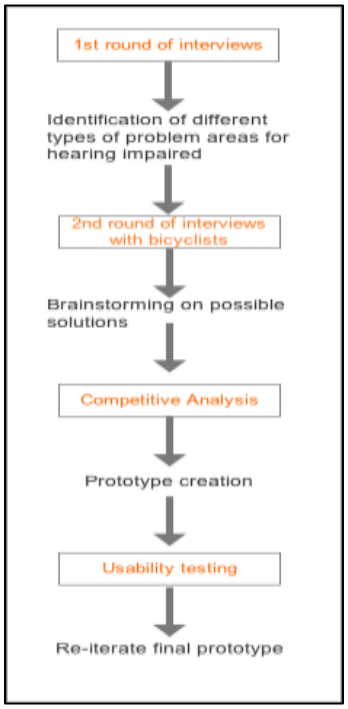

Figure 1. Our research methodology

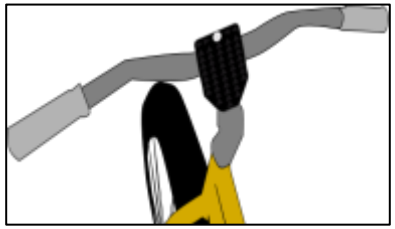

Figure 2. Handlebars with the device

Introduction

Cycling is an integral form of transportation and exercise throughout the world. As we approach an era of sustainability awareness in our communities, cycling is often regarded as an easy alternative to more environmentally destructive forms of transportation. The number of Americans who commute by bicycle has quadrupled since 2000 [9]. But despite the improved infrastructure surrounding biking, it is still not completely viable in our communities and certain groups are often excluded from the activity. A 2012 survey by the US Department of Transportation found that 83% of cyclists feel a threat is posed to their personal safety by motorists mostly because motorists drove too close to them or drove to fast [10]. Most people feel unsafe while biking because of the unknown dangers posed by motorists around them.

Another facet to this issue is that minorities, those could benefit the most from biking, are the people most concerned about bicycle safety. Women are more worried about being hit while riding bikes than men are. A survey at Ohio State University found that while 43% of women citing safety as a concern preventing them from bike riding, only 28% of men did the same [1]. And in the US, studies have found that for every 1 woman riding a bike there are 2-3 men who are doing the same, while the split is about 50/50 in some European countries [3]. Safety is also a bigger concern in minority communities where the fatality rate for bicyclists is 23% higher for Hispanic riders, and 30% higher for African-American riders, compared to white riders [12]. The Princeton Survey Research Associates reported that 26% of minorities said they would like to ride their bikes more but are worried about their safety, while only 19% of white riders said the same. Unfortunately, most cyclists feel powerless against motorists. The League of American Bicyclists advocates for five rules to follow to improve your own safety: Follow the Law, Be Predictable, Be Conspicuous, Think Ahead, and Ride Ready. These rules focus on improving your own visibility to motorists. Instead, Cyclika empowers cyclists to take their safety into their own hands.

Methodology

Initially, we targeted hearing-impaired users to understand their concerns and how we as students could level up the play field for them. The initial set of interviews brought out the concern of safety on roads. Our second set of user interviews were conducted with (a) bicyclists to understand their safety concerns and frustrations, and (b) with hearing-impaired to understand their frustrations with using a personal vehicle. The biggest safety concern, which even prevented such users from biking, was to know the vehicles approaching from behind. Hence our solution will not just assist hearing-impaired cyclists but can also be used by other bike enthusiasts for safety purposes, thus making our design universal and inclusive. (Figure 1)

Solution Overview

Our solution consists of the following components:

1. A sensor to detect vehicles approaching from behind and sideways
2. A visual display to convey the presence and proximity of a vehicle
3. Another visual display that acts as a turn signal to notify the vehicles behind

The handlebars of the bike will contain a display made of LEDs (Figure 2). The seven LED strips convey information about obstacles not only behind the rider but as well as on the side lanes. As soon as the vehicle is within 350 feet range of the rider, the LEDs start lighting up accordingly to depict relative distance of the vehicle from the rider (Figure 3). At the back of the seat, a combination of turn signals and radar sensor is mounted. The turn signal is a grid of LEDs that light up as a left turn signal as well as a right turn signal (Figure 4). The turn signals are activated by two buttons located by two buttons located on either side of the

Figure 3. LED on the display depicting an approaching vehicle

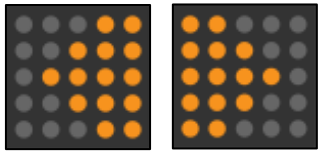

Figure 4. Turn signals for following riders

handlebar. The LED buttons on the handlebar and on the rear section of the bicycle light up if the corresponding turn signal is activated. The sensor employs radar technology to get the information about vehicles that are behind.

Based on our interviews and personal experiences, bicyclists' main concern is towards their safety from other vehicles. Our solution is to a universal and inclusive safe biking experience.

The prototype focuses on the following design elements:

1) Presence of an object:
   a) The prototype detects the approaching vehicles from behind and informs the rider through flashing of led bulbs. As the vehicle approaches nearer to the vehicle, the blinking lights change their color from orange to red. (Figure 5)
   b) The detection is not just limited to the rear view. Our interviewees have had instances where they were surprised by an obstacle coming from the side. Riders rely on their hearing ability to detect approaching obstacles, however for hearing impaired it is difficult to "hear" these obstacles. Hence our solution also considers edge-cases of sideways obstacles. (Figure 6)
   c) The minimal use of different types of colors is to keep the cognitive load at the minimum.

2) Proximity:
   Riders often must turn around to check whether there is any vehicle behind or overtaking them. The possibility of the bike wobbling a bit away from the straight path due to head turning is dangerous, especially on a crowded road. Hence to provide a safer experience, the lights reflect 5 lanes with the rider's presence in the central lane. The rider doesn't have to turn around to check whether there is an approaching car in the next lane. (Figure 7)

3) Feedback for the rider:
   The rider is aware of what is happening behind them, but the drivers around the rider may not be aware that the person is hearing-impaired or not aware of the approaching traffic. Hence whenever the rider decides to move to the right or left, they will give the signal by turning on the appropriate signal. This signal appears on the back for the other drivers and in the handle bars for the rider. Just like car drivers get an audio and visual signal to imply that the signal is on, the cyclist will also be given the same visual signal on the display. (Figure 4)

Design Decisions

1) Handle bar v/s mobile application
   The design decision to use the handle bar and not a mobile application to communicate this information is based on the user research that cyclists prefer to save their phone battery for emergency situations and would not be comfortable using it up for a ride which can last from 10 minutes to 40 minutes. Handle bars are the most accessible and visible part of the cycle to the rider. Once the rider gets a notification that a vehicle nearby is approaching they can be aware of what is happening behind them.

2) Radar v/s Lidar and ultrasonic
   To keep this device affordable and usable, our selection criteria were range, detection ability during day and night and cost. Based on these factors, Radar is the most suitable sensing technology. (Figure 8, 9, 10)

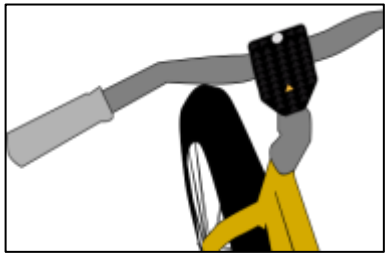

Figure 5. Presence of an object approaching from behind

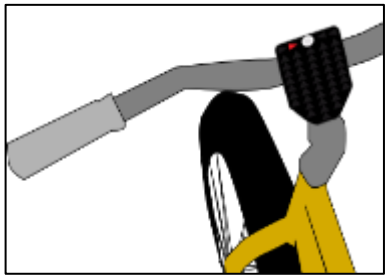

Figure 6. Presence of an object approaching from sideways

Figure 7. A user testing our product

Competitive Analysis

Biking radar systems is a market that has not been fully explored by many companies. In fact, only one company is involved with this market. Garmin is the main and direct competitor to our problem statement and has produced the world's first bike radar system called Varia in 2015 [8]. In conjunction with the Garmin edge products, users can add on a bike radar system that allows for alerts when an incoming car or large object is behind them in within vicinity. The Varia directly solves our problem in regards to locating and sensing what is behind the user, however the Garmin edge must be used to alert the cyclist. The cost is high and involves multiple devices to solve our problem statement. Although Garmin is a brand that has high reputation where its products are involved with bicycling enthusiasts of all levels, the cost for the radar system is $300 [5]. The additional accessories such as the tail and headlights that can alert others of an oncoming cyclist cost an additional $300. The solution to our problem involves many products of which are not affordable to some. An additional $400 can be spent if the user desires a hands-free option called Varia Vision [6]. Currently, the benefits of the solution that Garmin Varia offers is in its reputation and that the product is in production. It can be easily bought, manufacturing durability and given to the user with the promise of high customer service given for the cost. Garmin Varia solves one of our goals which is creating a solution to help alerting those who have trouble hearing of surrounding objects. We understand that having less requirements, space usage and costs will help benefit our solution and future users.

Two indirect competitors allowed us to understand that potential users hold aesthetics and visual cues highly. Hammerhead is a smart tool that allows for GPS alerts while biking. Cyclists can navigate hands-free to destinations with the help of route directions and mapping of a device that can be easily unmounted from the bike. The product costs a tenth of Garmin's cost by being $130, however a smartphone with Bluetooth technology is required to function properly [7]. Hammerhead partially solves our solution by creating a hands-free notification system. We understand that visual feedback, specifically LED lights are successful in notifying users of important messages, varying in color. To understand where and how a user needs to turn, Hammerhead uses an alert system that demonstrates direction [7]. Hammerhead, however, does not provide any solution to an alert system to what is surrounding the user. The notification system that Hammerhead uses focuses on the future actions that the user will take. The feedback is not about the present movement of the user nor his or her surroundings. Like Hammerhead in goal and price, SmartHalo provides a permanent navigational assistance for bicyclists without the distraction of a phone interface. Likewise, the SmartHalo requires use of a smartphone and downloading their app [11]. Although it is on pre-order, the SmartHalo is gaining attraction and interested bicyclists for its simplicity and beauty which was emphasized in their Kickstarter pitch [4]. From understanding the limitations to these indirect competitors, creating a simple, standalone and aesthetically-pleasing solution is ideal.

Conclusions: limitations and future work

Cyclika's future iterations can accommodate more symbols to represent the obstacles approaching the rider sideways which can be done by condensing the symbols to not make the display bulky. During usability tests, we had found that our users expected the same range of sideways obstacle detection as from behind. Our rationale, however, to have less number of symbols sideways was that vehicles approaching from the sides shall be partially visible to the user. Through this prototype proposal, we are leveling the play field by addressing the safety concerns of biking and enabling users, who were previously unable to harness

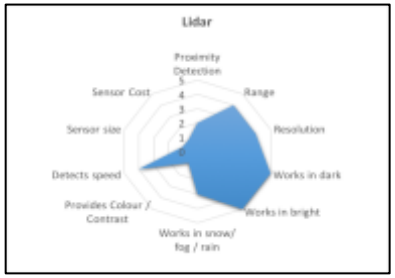

Figure 8: Lidar [2]

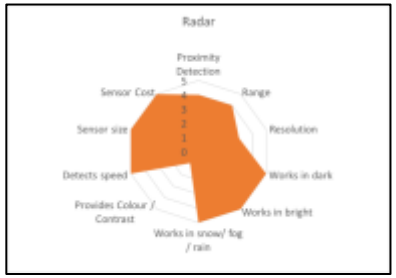

Figure 9: Radar [2]

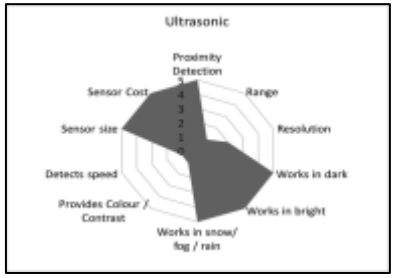

Figure 10: Ultrasonic [2]

the health benefits of this exercise due to fear of injury or lack of awareness of surroundings, to bike. Our prototype is a perfect example of inclusive design which targets users with and without hearing-impairment since the uncertainty of vehicles approaching from behind is experienced by everyone. Cyclika will also have a positive impact on users who biked before but had to quit it due to developing a hearing-impairment at a later stage of their lives. One of Cyclika's key differentiators is its cost which is way less than its competitors. By doing so, not only are we allowing Cyclika to reach the masses but also inspiring future innovators to come up with an even cheaper solution for safe biking.

Acknowledgement

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