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Designing for Mutual Awareness: Early Prototyping of a Shared-Alert System for Preventing Vehicle-Cyclist Collisions

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Designing for Mutual Awareness: Early Prototyping of a Shared-Alert System for Preventing Vehicle-Cyclist Collisions

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Abstract

Collisions between cyclists and motor vehicles often result in significant emotional distress for the motorist and injuries or fatalities for the cyclist who rely mainly on passive equipment for protection. While radar-based sensing has long supported driver assistance, cyclist safety technologies have only recently begun to incorporate comparable capabilities for environmental awareness. However, most current solutions provide asymmetric safety, placing the responsibility for awareness only on one party. In this article, we present the preliminary design, implementation, and testing of a GPS-enabled, radio-based, audio-visual alert system that supports mutual awareness and reduces the likelihood of accidents by alerting both parties to each other's presence and distance. We detail our design process, report on early prototyping, and reflect on our challenges. This novel approach to mutual awareness in traffic safety hopes to inspire new research into cooperative road user technologies and help shift the safety paradigm from individual to shared responsibility.

CCS Concepts

• **Hardware → Emerging tools and methodologies**.

Keywords

Safety, RF, Transceivers, Driver Assistance, ADAS, Cycling

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1 INTRODUCTION AND MOTIVATION

As cyclists become increasingly common on roadways, accidents involving injuries and fatalities among these vulnerable road users have also increased [11, 25]. These outcomes are especially prevalent in countries where cyclists must share the road with motor vehicles due to the absence of dedicated cycling infrastructure [26, 27]. This persistent danger of serious injury may deter many would-be cyclists [2], reinforcing the need for transportation safety technologies to recognize and treat cyclists as active participants in the traffic ecosystem.

This problem is an international one. In 2022, cyclists accounted for 10% of all road fatalities in the E.U. [11]. While the absolute yearly number of cyclist deaths in Europe has remained steady (around 2000) since 2010, their proportion relative to overall traffic fatalities has increased [11, 25]. In the U.S., 1,084 cyclists were killed in crashes with motor vehicles in 2022, the highest number recorded since 1975 [23]. In both regions, a significant share of these accidents occur in urban areas [1, 25]. These trends suggest that relying solely on passive safety measures such as bicycle lanes, traffic calming road furniture, and speed limits have not been sufficient, even in cycling-friendly nations such as Denmark and the Netherlands [11]. There is an urgent need to complement passive infrastructure improvements with active safety systems that support real-time detection and awareness between drivers and cyclists.

Currently, cyclists primarily rely on hand signals and eye contact to communicate with drivers during shared-space interactions [2]. Accidents often occur when drivers fail to perceive or misinterpret these signals [15, 20]. As a result, the burden of collision avoidance falls either on the cyclist, who must make evasive maneuvers, or on the driver, who must negotiate the shared road appropriately. Advanced Driver Assistance Systems (ADAS) hold promise for preventing many of these crashes [29], but rely on clear weather [4], good road conditions [6], and quick decision-making [33]. Failures often result in harm [16, 17]. Prior work has proposed various driver- and cyclist-facing alert systems [3, 7, 13, 29, 31, 32], but these solutions often either place the onus solely on the cyclist or on the driver to avert collisions.

To address this limitation, this work-in-progress paper introduces a low-cost audio-visual alert system that uses GPS and Radio Frequency (RF)-based signaling to enable real-time, synchronized

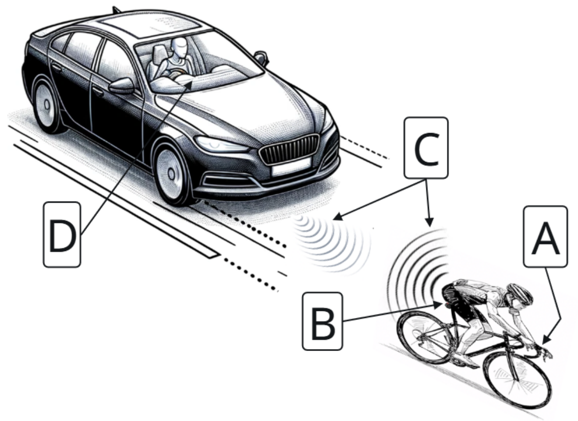

Figure 1: AI-generated illustration of a bicycle–vehicle interaction using the radio-based system. A: Cyclist's handlebar-mounted screen alerts to vehicle presence and proximity; B: Transceiver is mounted beneath the saddle of the bicycle; C: Radio signal spans bicycle and vehicle; D: Driver-facing HUD alerts the driver to the cyclist's presence and proximity.

Figure 2: Illustrative handlebar-mounted display and rear-facing radar sensor on a bicycle, functioning similarly to the Garmin Varia[1] system by visualizing the proximity of approaching vehicles from behind, in this case, showing a car at 150 meters.

alerts between vehicles and cyclists to facilitate mutual awareness of presence and proximity as depicted in Figure 1. To the best of our knowledge, no existing system provides shared alerts to both drivers and cyclists in real time. Our system uses GPS-enabled microcontrollers and RF transceivers mounted on both the vehicle and cyclist, which exchange location data and alert both parties in real time to each other's presence and proximity. In early testing, our system demonstrated the ability to detect relative position and distance, while successfully communicating shared alerts using a timed transmission strategy (3.1). Unlike existing solutions that primarily place responsibility on one party, our approach distributes awareness between cyclists and drivers, which represents a novel step toward symmetric safety systems that promote cooperative road use. In this paper, we outline the early implementation decisions, challenges, opportunities for the community, and our vision for the system's integration with existing cycling technologies and ADAS of the future.

2 BACKGROUND AND RELATED WORK

In this section, we begin with a brief exploration of driver awareness and the protection of vulnerable road users (2.1). We then review related work on radar technologies supporting cyclists' safety (2.2).

2.1 Driver Awareness and Protecting Vulnerable Road Users

Vulnerable road users (VRUs), including cyclists, pedestrians, motorcyclists, and individuals with reduced mobility, face higher risks of injury or mortality on roadways compared to enclosed vehicles due to limited physical protection [2, 14, 21]. Interactions between cyclists and vehicles are especially hazardous during overtaking or lane-sharing scenarios due to limited lateral space and high speed differentials [7]. With increasing rates of crashes involving cyclists, there is a growing demand for proactive safety interventions [28].

ADAS have emerged as tools to improve driver situational awareness and reduce high risk events [4, 29]. These systems use multimodal sensors (radar, camera, LIDAR) to detect, track, and predict the behavior of surrounding road users and objects [4, 7, 30]. ADAS provide anticipatory information to improve driver gaze and extend response time [28]. While these systems are primarily designed to assist drivers, cyclists benefit indirectly through enhanced driver awareness and improved vehicle responses. However, such systems often lack mechanisms for direct, symmetric detection and notification between cyclists and drivers. Our proposed prototype moves beyond that limitation with an audio-visual shared alert system that supports mutual awareness of both cyclist and driver.

2.2 Cyclist Warning Systems and Radar-Based Hazard Detection

Radar-equipped systems have long been used in automotive safety to help vehicles detect and avoid nearby objects [29] because radars offer high accuracy in range and speed estimation, reliability in object-detection, and consistent performance in poor lighting or weather conditions [18], where other systems often fail [4]. This versatility has enabled radar technologies' more recent adaptation into rear-mounted cyclist safety systems that detect approaching vehicles and alert riders of their presence via handlebar-mounted displays as depicted in Figure 2. Commercial products like the Garmin Varia[1] and others work similarly by showing proximity of vehicles approaching from behind. Furthermore,

radars offer a cost-effective and reliable way to estimate velocity [18], which allows them to be viewed as a foundational technology in the development of robust, real-time cyclist warning systems [18, 22, 32]. Newer prototypes integrate auditory [3], tactile [24],

[1] https://www.garmin.com/en-US/p/698001/

and visual warnings [21], with studies suggesting that multimodal alerts, when deployed early, reduce corrective or evasive reaction time without significantly increasing cognitive load [28, 30].

Although the use of radar for hazard detection is robust, the systems mentioned above rely on radar purely for forward or rear detection. Our system uses GPS and RF-based signaling between vehicle- and cyclist-mounted transceivers to deliver real-time alerts to both drivers and cyclists, enabling a symmetric system that supports mutual awareness of presence and proximity. Our alert system escalates from light to sound as the vehicle nears the cyclist. To our knowledge, this is the first system to integrate mutual signaling between drivers and cyclists, marking a step toward safer interactions on the road.

3 EARLY IMPLEMENTATION DECISIONS

In this section, we outline our system's core functionality and key design decisions. As shown in Figure 3, the system includes cyclist and vehicle units that use RF transceivers to exchange real-time GPS data and trigger synchronized alerts based on proximity.

3.1 Hardware Platform and Communication Architecture

The system architecture is anchored around two Arduino microcontrollers, chosen because of their low power consumption, accessible integrated development environment, and widespread community support. Each unit, car and bicycle, continuously tracks its own location using a GPS module and sends positional data to the other via RF transceivers. This mutual exchange of positional data forms the basis for proximity detection and alert logic. Communication is separated into distinct transmit and receive channels to reduce packet collisions, a challenge that frequently caused dropped messages in earlier iterations. The RF transmission range is empirically verified to be reliable up to 250 meters with an audio-visual and context-aware alerting strategy. When the car is within 250 meters of the bicycle, both entities receive a visual alert (light), while a supplemental audio alert is triggered within 100 meters. To support environmental durability and future prototyping, both devices are housed in sturdy modifiable Lego™-like casings, with future versions envisioned as integrated elements of the vehicle's heads-up display. Recognizing the limited power supply on the bicycle, we offloaded all processing tasks, such as GPS-based distance calculation, angle computation from the bicycle, proximity threshold checks, and alert triggering, to the vehicle's microcontroller. The cyclist's unit transmits only its GPS coordinates, while the car-side system continuously computes the distance and angle between both units and determines whether alerts (visual or auditory) should be triggered. Both interfaces, as shown in Figure 3, include visual and auditory cues, appropriate for their respective noisy and attention-saturated environments.

3.2 Vector-Based Movement Modeling and Coordinate Normalization

To calculate and represent the direction of travel and relative angular motion between the bicycle and car, we reduced their interaction to three interpretable states: increasing distance, decreasing distance, or simultaneous changes in both distance and angle. This abstraction assumed both parties are moving along the same or opposite directions within a lane. Perpendicular interactions were excluded since they are typically mitigated by intersection infrastructure such as stop signs and traffic lights. Using a coordinate system where 0° is directly left, 90° ahead, and 180° right, we defined the angular field-of-risk in which both the cyclist and driver should be alerted to one another's presence to be 45°–135° based on our tests and prior research [8, 9, 14]. As vector-based logic is implemented, we redefined the car's position as the origin of a dynamic coordinate plane, continuously recalculating the cyclist's position relative to it. This approach helped mitigate GPS jitter and improved the accuracy of distance and angle calculations. We also addressed mechanical sources of signal fluctuation by fixing the RF antennas to the external casings of both modules as seen in Figure 5 to minimize angular noise from unintended antenna rotation during field testing.

3.3 Speed-Gated Computation and Distance-Based Alert Filtering

During initial testing, we observed inconsistencies in angle readings when the vehicle was stationary or moving at very low speeds. These fluctuations were caused by minor GPS drift and noise, which became impactful when there was little or no forward movement to stabilize calculations. As a result, the system occasionally reported erratic proximity estimates, even when the cyclist and vehicle were not changing position relative to each other. To address this, we introduced a minimum vehicular speed threshold of 5 kph (3.11 mph), below which the system temporarily pauses angle and distance computations to avoid false alerts and improve overall reliability during stop-and-go conditions. Alerts are also gated by vehicle motion, pausing when the car is stationary and resuming when it moves again. If the bicycle alone is in motion while the car remains stationary, no alert is issued, as the car is not considered an immediate threat. This speed and angle restriction is based on targeted moment of increased threat: when the vehicle is approaching the cyclist from behind and is moving faster than the bicycle [7, 12]. By filtering out divergent trajectories, alerts yielded more consistent and actionable outputs, as depicted in Figure 4.

4 DEVELOPMENT CHALLENGES

Several technical challenges emerged during early development that may be instructive for others building similar mutual sensing and dual-sided alerting systems. One key issue is the potential for communication deadlocks, where both the vehicle and bicycle units continuously transmit without successfully receiving each other's messages. To address this, we implemented an alternating software-level timing mechanism which allows each device to monitor the elapsed time since its last sent message and dynamically switches into receive mode after a fixed interval. While this solution improves transmission handshakes, occasional information packet drops persist. Furthermore, the introduction of angular calculations is a critical variable since distance alone is insufficient to determine the relative spatial relationship between the car and bicycle. We know from literature that the position of the VRU relative to the car poses vastly different safety implications, perceived or otherwise [2, 8]. To address this, we incorporate directional angle calculations

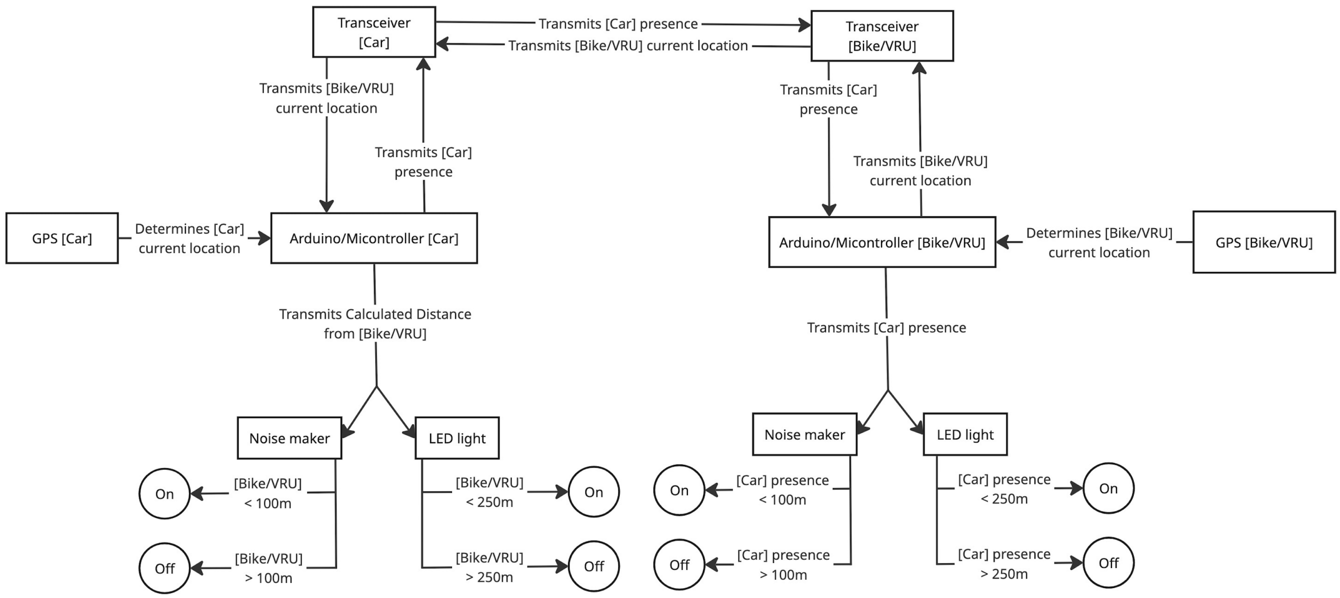

Figure 3: System flowchart showing data exchange between a vehicle and a cyclist. Each unit calculates its own GPS location, exchanges data, and triggers visual or auditory alerts based on proximity. Lights are activated within 250 m and sound within 100 m.

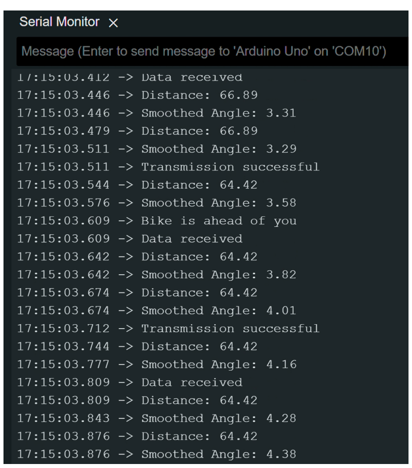

Figure 4: Serial output of early validation of proximity detection from real-world testing showing GPS-based distance (meters) and smoothed angular position (degrees) of the cyclist relative to the vehicle. Future versions will see this data streamlined on vehicle HUD.

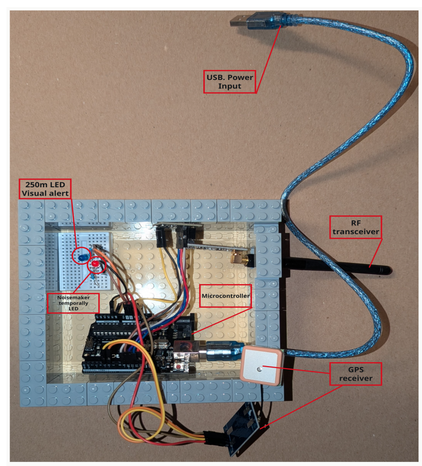

Figure 5: Annotated prototype of one of the units showing key components: GPS receiver, RF transceiver, microcontroller, USB power input, 250-meter LED visual alert, and a placeholder LED for the noisemaker.

as discussed in Section 3.2. Early angle logic models attempts resulted in erratic outputs when either vehicle changed direction, even minimally. Iterative geometric analysis corrected these fluctuations, including thresholding computations based on vehicle movement and speed. However, angle measurements, though sufficiently accurate to inform our alert system and support meaningful testing as shown in Figure 4, still requires further work. To improve stability, we plan to combine GPS data with information from an accelerometer to smooth and filter out erratic changes.

5 CONCLUSION AND FUTURE WORK

This work-in-progress paper presented a novel radio-based hazard detection system that shifts bicycle-vehicle collision avoidance from a one-sided notification model to a shared, symmetric, real-time awareness framework. By equipping both cyclists and drivers with GPS-enabled microcontrollers and RF transceivers capable of exchanging real-time location data over a 250-meter range, the system provides mutual awareness and early audio-visual notifications that extend beyond simple confirmation, which increases reaction time for both users. Field testing with a single vehicle-bicycle pair successfully showed the system's feasibility, though challenges remain.

Several areas continue to present opportunities for future development to enhance system reliability, integration, and user trust. Upcoming efforts will focus on improving its stability, refining angle detection capabilities, and conducting iterative rounds of user testing involving multiple bicycles and cars in varied environments. We envision the system being natively integrated into vehicle dashboards, akin to existing blind spot detection or lane-keeping systems. This work contributes to ongoing discussions around equitable safety technologies [5], trust in assistive systems [10], and designing for shared environments [3]. Our prototype illustrates how relatively low-cost sensing and feedback systems can meaningfully support mutual safety when designed with real-time communication, interpretability, and cooperative dynamics in mind. It also raises technical challenges such as multimodal sensing reliability, spatial positioning accuracy, and user's ability to understand and respond to the system feedback under real-world conditions.

Planned enhancements include a driver-facing HUD that conveys cyclist proximity using visual metaphors (e.g., green/yellow/red zones), dynamically updated in real time. To further improve signal reliability and directionality, we also plan to optimize antenna design by fixing, encasing, and upgrading to higher-gain antennas to ensure consistent signal orientation. Longitudinal investigation of HUD visual metaphors will also examine how drivers interpret cyclist proximity feedback and how that interpretation influences behavior. More broadly, future work should examine multi-cyclist scenarios and explore communication protocol enhancements in diverse weather, traffic, and urban/rural areas.

We hope our prototype opens a pathway for rethinking how driver assistance systems account for vulnerable road users such as cyclists. By shifting the responsibility for safety to both the driver and the cyclist, our approach introduces the possibility of more symmetric, cooperative safety systems that reduce the cognitive and technological burden on either party. In doing so, we challenge traditional paradigms that assume VRUs must adapt to motor vehicle dominance, which aligns with growing efforts to reimagine more equitable road-sharing futures [5, 19]. Continued iteration and refinement of the foundation we have built can contribute to the emergence of a transportation network redefined by the seamless data exchange and awareness between vehicles and VRUs. As vehicle systems become increasingly intelligent and networked, this work serves as an example of how human-centered, symmetric safety systems can be embedded into everyday mobility experiences. We encourage the AutomotiveUI community to explore how such safety systems might become a ubiquitous driver-assist feature in the near-future.

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References

[1] 2025. Fatality Facts 2022: Bicyclists. https://www.iihs.org/topics/fatality-statistics/detail/bicyclists
[2] Ammar Al-Taie, Frank Pollick, and Stephen Brewster. 2022. Tour de Interaction: Understanding Cyclist-Driver Interaction with Self-Reported Cyclist Behaviour. In *Adjunct Proceedings of the 14th International Conference on Automotive User Interfaces and Interactive Vehicular Applications (AutomotiveUI '22)*. Association for Computing Machinery, New York, NY, USA, 127–131. doi:10.1145/3544999.3552531
[3] Ammar Al-Taie, Graham Wilson, Thomas Goodge, Frank Pollick, and Stephen Anthony Brewster. 2024. Bike to the Future: Designing Holistic Autonomous Vehicle-Cyclist Interfaces. In *Proceedings of the 16th International Conference on Automotive User Interfaces and Interactive Vehicular Applications*. ACM, Stanford CA USA, 194–203. doi:10.1145/3640792.3675727
[4] Jackie Ayoub, Zifei Wang, Meitang Li, Huizhong Guo, Rini Sherony, Shan Bao, and Feng Zhou. 2022. Cause-and-Effect Analysis of ADAS: A Comparison Study between Literature Review and Complaint Data. In *Proceedings of the 14th International Conference on Automotive User Interfaces and Interactive Vehicular Applications*. ACM, Seoul Republic of Korea, 139–149. doi:10.1145/3543174.3547117
[5] Siri Hegna Berge, Marjan Hagenzieker, Haneen Farah, and Joost de Winter. 2022. Do cyclists need HMIs in future automated traffic? An interview study. *Transportation Research Part F: Traffic Psychology and Behaviour* 84 (Jan. 2022), 33–52. doi:10.1016/j.trf.2021.11.013
[6] Gaetano Bosurgi, Orazio Pellegrino, Alessia Ruggeri, and Giuseppe Sollazzo. 2023. The Role of ADAS While Driving in Complex Road Contexts: Support or Overload for Drivers? *Sustainability* 15, 2 (Jan. 2023), 1334. doi:10.3390/su15021334
[7] Tom Brijs, Filomena Mauriello, Alfonso Montella, Francesco Galante, Kris Brijs, and Veerle Ross. 2022. Studying the effects of an advanced driver-assistance system to improve safety of cyclists overtaking. *Accident Analysis & Prevention* 174 (Sept. 2022), 106763. doi:10.1016/j.aap.2022.106763
[8] François Char, Serre , Thierry, Compigne , Sabine, , and Pablo Puente Guillen. 2022. Car-to-cyclist forward collision warning effectiveness evaluation: a parametric analysis on reconstructed real accident cases. *International Journal of Crashworthiness* 27, 1 (Jan. 2022), 34–43. doi:10.1080/13588265.2020.1773740 Publisher: Taylor & Francis _eprint: https://doi.org/10.1080/13588265.2020.1773740.
[9] François Char and Thierry Serre. 2020. Analysis of pre-crash characteristics of passenger car to cyclist accidents for the development of advanced drivers assistance systems. *Accident Analysis & Prevention* 136 (March 2020), 105408. doi:10.1016/j.aap.2019.105408
[10] Mark Colley, Christian Bräuner, Mirjam Lanzer, Marcel Walch, Martin Baumann, and Enrico Rukzio. 2020. Effect of Visualization of Pedestrian Intention Recognition on Trust and Cognitive Load. In *12th International Conference on Automotive User Interfaces and Interactive Vehicular Applications (AutomotiveUI '20)*. Association for Computing Machinery, New York, NY, USA, 181–191. doi:10.1145/3409120.3410648
[11] European Commission. 2024. *Facts and Figures Cyclists.* Technical Report. European Commission, Directorate General for Transport, Brussels. https://ec.europa.eu/transport/road_safety/specialist/statistics_en
[12] Nicole Fritz, Fanny Kobiela, Dietrich Manstetten, Andreas Korthauer, and Klaus Bengler. 2020. Designing the Interaction of Highly Automated Vehicles with Cyclists in Urban Longitudinal Traffic: Relevant Use Cases and Methodical Considerations. In *12th International Conference on Automotive User Interfaces and Interactive Vehicular Applications*. ACM, Virtual Event DC USA, 8–11. doi:10.1145/3409251.3411710
[13] Garmin. 2025. Bike Computers | Bike Radars & Bike Light | Power Meters | Garmin. https://www.garmin.com/en-US/c/sports-fitness/cycling-bike-computers-bike-radar-power-meter-headlights/?series=BRAND10561#shopallcycling
[14] Fábio Gonçalves, Bruno Ribeiro, João Santos, Oscar Gama, Francisco Castro, João Fernandes, António Costa, Bruno Dias, Maria João Nicolau, Joaquim Macedo, and Alexandre Santos. 2022. Enhancing VRUs Safety with V2P communications: an experiment with hidden pedestrians on a crosswalk. In *2022 14th International Congress on Ultra Modern Telecommunications and Control Systems and Workshops (ICUMT)*. 96–103. doi:10.1109/ICUMT57764.2022.9943508 ISSN: 2157-023X.
[15] Alan Latham and Michael Nattrass. 2019. Autonomous vehicles, car-dominated environments, and cycling: Using an ethnography of infrastructure to reflect on the prospects of a new transportation technology. *Journal of Transport Geography* 81 (Dec. 2019), 102539. doi:10.1016/j.jtrangeo.2019.102539
[16] Sam Levin. 2018. Tesla fatal crash: 'autopilot' mode sped up car before driver killed, report finds. *The Guardian* (June 2018). https://www.theguardian.com/technology/2018/jun/07/tesla-fatal-crash-silicon-valley-autopilot-mode-report

[17] Sam Levin and Julia Carrie Wong. 2018. Self-driving Uber kills Arizona woman in first fatal crash involving pedestrian. *The Guardian* (March 2018). https://www.theguardian.com/technology/2018/mar/19/uber-self-driving-car-kills-woman-arizona-tempe

[18] David Lindström, Victor Malmsten Lundgren, Jonas Andersson, Thanh Bui, Azra Habibovic, Henrik Clasen, and Hugo Drakeskär. 2019. Designing HMIs for an active safety system on bicycles. In *Proceedings of the 11th International Conference on Automotive User Interfaces and Interactive Vehicular Applications: Adjunct Proceedings*. ACM, Utrecht Netherlands, 125–129. doi:10.1145/3349263.3351495

[19] Karthik Mahadevan, Sowmya Somanath, and Ehud Sharlin. 2018. Communicating Awareness and Intent in Autonomous Vehicle-Pedestrian Interaction. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems (CHI '18)*. Association for Computing Machinery, New York, NY, USA, 1–12. doi:10.1145/3173574.3174003

[20] G. Markkula, Madigan , R., Nathanael , D., Portouli , E., Lee , Y. M., Dietrich , A., Billington , J., Schieben , A., , and N. Merat. 2020. Defining interactions: a conceptual framework for understanding interactive behaviour in human and automated road traffic. *Theoretical Issues in Ergonomics Science* 21, 6 (Nov. 2020), 728–752. doi:10.1080/1463922X.2020.1736686 Publisher: Taylor & Francis _eprint: https://doi.org/10.1080/1463922X.2020.1736686.

[21] Andrii Matviienko, Swamy Ananthanarayan, Shadan Sadeghian Borojeni, Yannick Feld, Wilko Heuten, and Susanne Boll. 2018. Augmenting bicycles and helmets with multimodal warnings for children. In *Proceedings of the 20th International Conference on Human-Computer Interaction with Mobile Devices and Services (MobileHCI '18)*. Association for Computing Machinery, New York, NY, USA, 1–13. doi:10.1145/3229434.3229479

[22] Andrii Matviienko, Mario Boot, Andreas Löcken, Bastian Pfleging, Markus Löchtefeld, Tamara Von Sawitzky, Gian-Luca Savino, Miriam Sturdee, Josh Andres, Kristy Elizabeth Boyer, Stephen Anthony Brewster, and Florian 'Floyd' Mueller. 2024. Learning from Cycling: Discovering Lessons Learned from CyclingHCI. In *Extended Abstracts of the CHI Conference on Human Factors in Computing Systems (CHI EA '24)*. Association for Computing Machinery, New York, NY, USA, 1–5. doi:10.1145/3613905.3636291

[23] Alexander G. Mirnig, Philipp Wintersberger, Alexander Meschtscherjakov, Andreas Riener, and Susanne Boll. 2018. Workshop on Communication between Automated Vehicles and Vulnerable Road Users. In *Adjunct Proceedings of the 10th International Conference on Automotive User Interfaces and Interactive Vehicular Applications (AutomotiveUI '18)*. Association for Computing Machinery, New York, NY, USA, 65–71. doi:10.1145/3239092.3239100

[24] Marie-Christin H. Oczko, Lukas Stratmann, Mario Franke, Julian Heinovski, Dominik S. Buse, Florian Klingler, and Falko Dressler. 2020. Integrating Haptic Signals with V2X-based Safety Systems for Vulnerable Road Users. In *2020 International Conference on Computing, Networking and Communications (ICNC)*. 692–697. doi:10.1109/ICNC47757.2020.9049723 ISSN: 2325-2626.

[25] European Transport Safety Council. 2020. How safe is walking and cycling in Europe? (PIN Flash 38). https://etsc.eu/how-safe-is-walking-and-cycling-in-europe-pin-flash-38/

[26] Paul M. Salmon, Mitch Naughton, Adam Hulme, and Scott McLean. 2022. Bicycle crash contributory factors: A systematic review. *Safety Science* 145 (Jan. 2022), 105511. doi:10.1016/j.ssci.2021.105511

[27] Antonella Scarano, Massimo Aria, Filomena Mauriello, Maria Rella Riccardi, and Alfonso Montella. 2023. Systematic literature review of 10 years of cyclist safety research. *Accident Analysis & Prevention* 184 (May 2023), 106996. doi:10.1016/j.aap.2023.106996

[28] Sabine Springer-Teumer, Isabel Kreißig, and Josef F. Krems. 2023. Anticipatory information makes the difference: Behavioral effects and user assessments of a cyclist warning system to enhance cyclists' situation awareness. *Journal of Safety Research* 87 (Dec. 2023), 266–284. doi:10.1016/j.jsr.2023.09.022

[29] Sergio A. Useche, Mireia Faus, and Francisco Alonso. 2024. "Cyclist at 12 o'clock!": a systematic review of in-vehicle advanced driver assistance systems (ADAS) for preventing car-rider crashes. *Frontiers in Public Health* 12 (Feb. 2024). doi:10.3389/fpubh.2024.1335209 Publisher: Frontiers.

[30] Tamara von Sawitzky, Chantal Himmels, Andreas Löcken, Thomas Grauschopf, and Andreas Riener. 2023. Investigating Hazard Notifications for Cyclists in Mixed Reality: A Comparative Analysis with a Test Track Study. In *Proceedings of the 15th International Conference on Automotive User Interfaces and Interactive Vehicular Applications (AutomotiveUI '23)*. Association for Computing Machinery, New York, NY, USA, 202–212. doi:10.1145/3580585.3606282

[31] Minjuan Wang, Sus Lundgren Lyckvi, and Fang Chen. 2016. Same, Same but Different: How Design Requirements for an Auditory Advisory Traffic Information System Differ Between Sweden and China. In *Proceedings of the 8th International Conference on Automotive User Interfaces and Interactive Vehicular Applications*. ACM, Ann Arbor MI USA, 75–82. doi:10.1145/3003715.3005450

[32] Yu Wang, Sonja Dorfbauer, Linda Van Der Spaa, Alexander G. Mirnig, Florian Michahelles, and Philipp Wintersberger. 2024. Development and Evaluation of Advanced Cyclist Assistance Systems on a Bicycle Simulator. In *Proceedings of the 16th International Conference on Automotive User Interfaces and Interactive Vehicular Applications*. ACM, Stanford CA USA, 283–293. doi:10.1145/3640792.3675721

[33] Fei Yan, Shyukryan Karaosmanoglu, Aslihan Demir, and Martin Baumann. 2019. Spatial visualization of sensor information for automated vehicles. In *Proceedings of the 11th International Conference on Automotive User Interfaces and Interactive Vehicular Applications: Adjunct Proceedings (AutomotiveUI '19)*. Association for Computing Machinery, New York, NY, USA, 265–270. doi:10.1145/3349263.3351311