Integrating IoT and Wearable Technologies for Enhanced Proximity Detection and Safety in Construction Zones

Samuel Akinyede, Segun Song, Sungyop Kim

Advisor: Dr. Sejun Song, University of Missouri – Kansas City

MOTIVATION:

Bridging the gap between traditional safety measures and the pressing needs of dynamic construction environments necessitates a paradigm shift—a combination of adopting cutting-edge technology and fostering a culture of safety consciousness and technological literacy among industry stakeholders.

CURRENT PROBLEMS WITH SAFETY IN CONSTRUCTION

- Addressing the pressing issue of back-over accidents in construction zones, requiring enhanced safety measures.
- Existing safety measures often remain reactive rather than proactive, falling short of adequately addressing risks present in contemporary construction sites.
- Conventional technologies are expensive and faces significant hurdles such as device resilience, data privacy, and the need for robust communication networks.

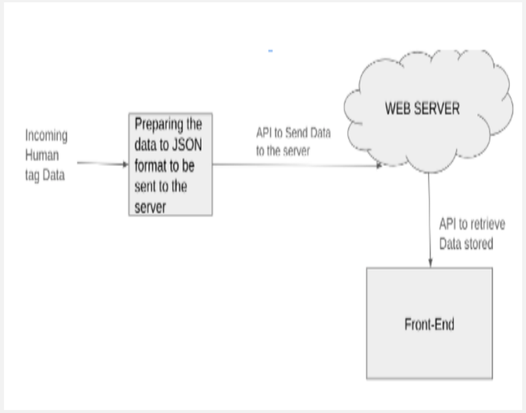
OUR SOLUTION

- We developed a bi-directional proximity detection and alert interconnected systems, harnessing the synergistic potential of IoT and wearable technologies to deliver precise real-time hazard detection and substantial safety enhancements in dynamic construction zones .

METHODOLOGY

- Beacon stuffing a technique which involves embedding additional data within the unused fields of Wi-Fi beacon frames was innovatively adapted for BLE due to its efficiency in Bluetooth data transmission represent a breakthrough in our proposed study.
- RSSI-Based Distance Estimation which employs signal strength to calculate the proximity of workers to potential hazards was utilized.
- Median and Kalman Filter Implementation help stabilize RSSI readings by filtering out anomalies and noise for more reliable distance estimates compensating for measurement within uncertainties and dynamic environments.
- IoT based sensors devices equipped with BLE 5.0 added communication within the systems.

System Architecture



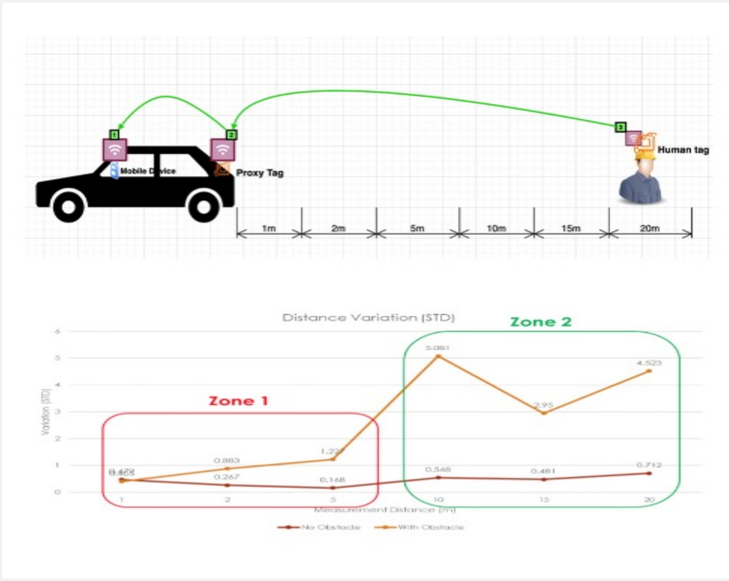
Functional Components

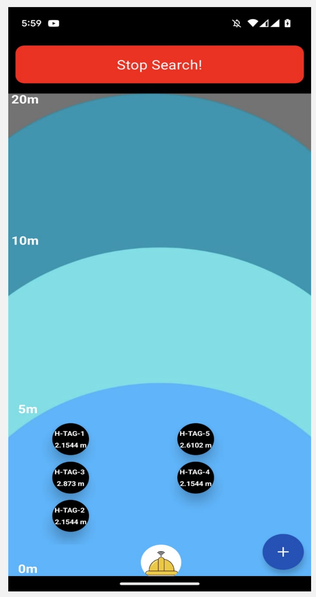
Wearable Proximity Sensors (WPS): Equip site workers with real-time proximity tracking, utilizing Bluetooth Low Energy (BLE) to communicate positional data to the system.

Vehicle Proximity Tags (VPT): Act as data relays, transmitting information from the WPS to iVPDs.

In-vehicle detection system (iVPDs): Displayed interface on a mobile device, monitors the location of workers via VPT and issues alerts when they enter designated hazard zones, enhancing site safety and response measures

RESULTS & PERFOMANCE





Zone 1: Devices falling within this zone are at a potential risk of collision. Consequently, the alert mechanisms was implemented to mitigate these risks. If a tag is classified within Zone 1, it triggers alerts to ensure the safety of individuals and assets.

Zone 2: Devices in this zone were not deemed to be at risk of collision. The variation in these devices' data did not exceed a predefined threshold, indicating a lower likelihood of potential collisions.

CONCLUSION

- This project presents a comprehensive safety solution for construction zones through an innovative system architecture that integrates IoT and wearable technologies.
- The system's use of advanced filtering techniques, such as median and Kalman filters, ensures accurate distance calculations and timely alerts.
- Empirical field tests have validated the system's efficacy in enhancing situational awareness and reducing the risk of accidents, establishing a new paradigm for proactive safety in dynamic work environments.