

STATE-OF-THE-ART IN VEHICLE-TO-PEDESTRIAN(V2P) SYSTEMS TECHNOLOGY: SURVEY AND RECOMMENDATIONS FOR EFFECTIVE DEPLOYMENTS

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Objective

- To examine the state-of-the-art on pedestrian detection and tracking, trajectory prediction and the messaging/warning components of a V2P system.
- To identify the current obstacles for widespread real world applications of V2P systems, and provide recommendations for effective deployment.

Background

Pedestrian fatalities in the United States by year	
2019	6,272
2020	6,516
2021	7,485

Fig. 1: Pedestrian fatalities.

- Advanced telecommunications, sensing technologies, connected vehicles and smartphones promise to improve the safety of Vulnerable Road Users (VRUs) [1] .
- Despite the technological advances, currently there are few viable V2P systems deployed.

Review of V2P Systems

- Any V2P system operates through detection, tracking, trajectory prediction and warnings leading to actions that avoid collision.

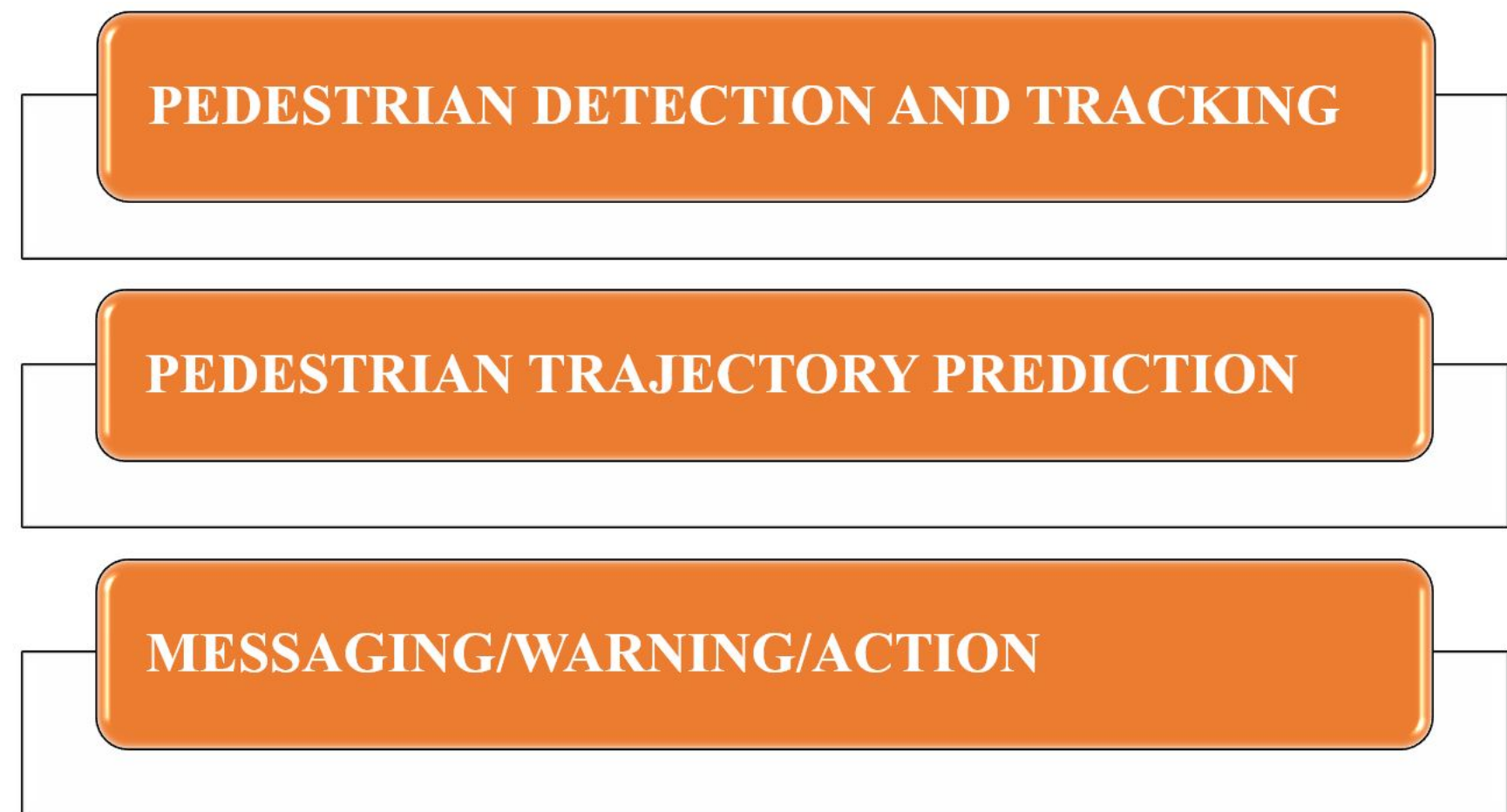


Fig. 2: Structure of the review.

Pedestrian Detection and Tracking

- Pedestrians' location can be detected using Vehicle-Based and Infrastructure-Based sensors.

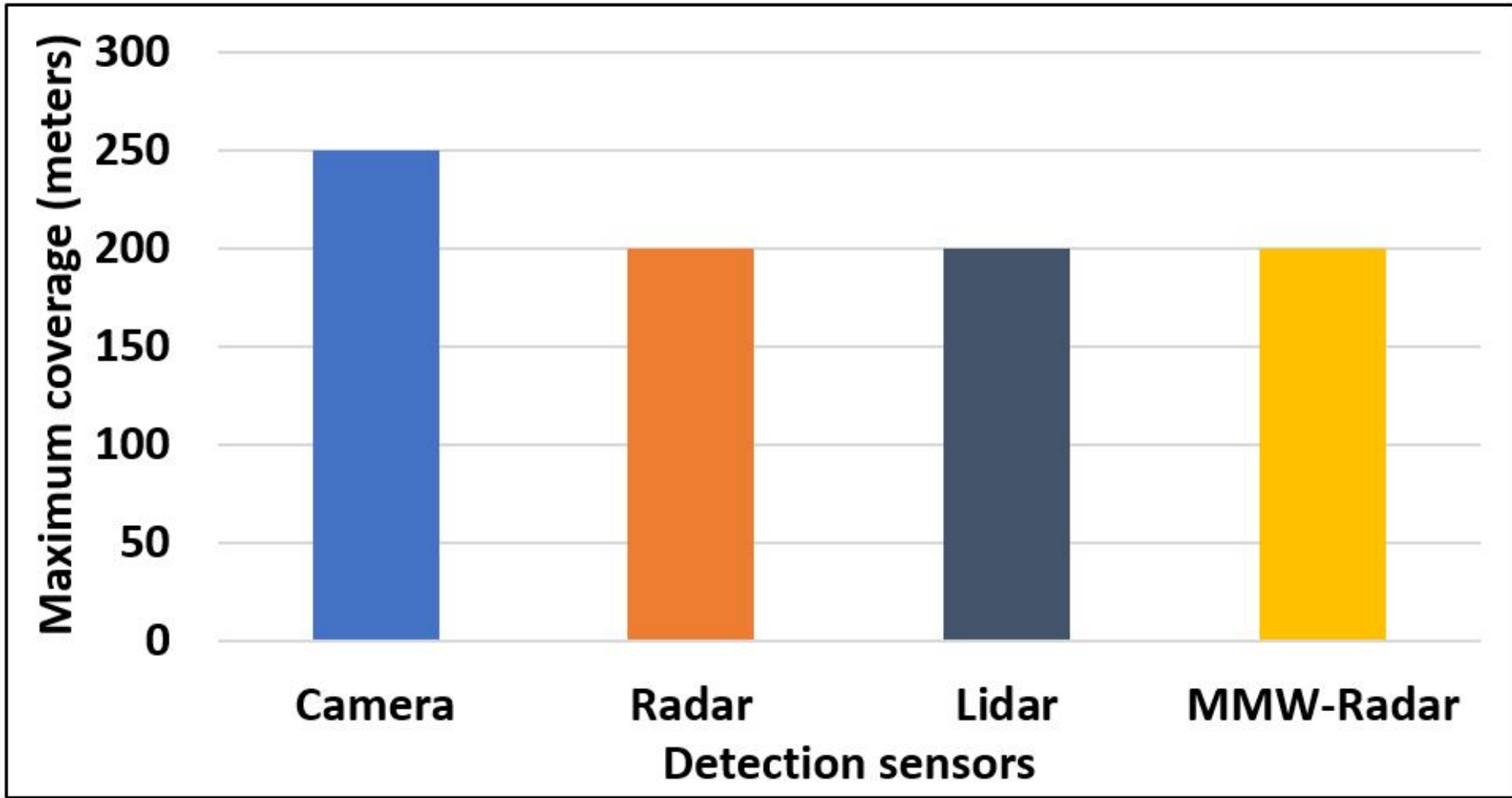


Fig. 3: Comparison of sensors' coverage.

- Smartphone sensors have also been used to obtain pedestrian's position.
- Data from a smartphone's accelerometer, magnetometer and gyroscope have been used in pedestrian detection [2].
- Though GPS presents the highest accuracy, it is energy consuming and cannot be active constantly.
- WiFi Direct system is a promising alternative to the GPS system.

Pedestrian trajectory Prediction

- The techniques are based on various input variables including the pedestrian's previous trajectory, environmental attributes, pedestrians' characteristics like their coordinates, heading, and velocity, among others.
- Physics-based models generate future human motion considering a hand-crafted, explicit dynamical model f based on Newton's laws of motion.
- Data-driven approaches have an advantage over the physics-based approach due to their ability to learn complex walking patterns that are difficult to present mathematically.
- Combination of Physics based and DL algorithms seems to improve accuracy of predictions.
- Factors like pedestrians' thoughts that influence accurate trajectory predictions have not been accounted for by the existing methods.
- The level of accuracy and precision of pedestrian trajectory prediction while having a lower communication delay plays an important role in effective V2P systems.

Messaging/Warning/Communication

- Upon the detection of a possible collision, V2P systems give alerts to either the vehicle or pedestrian or both [3].
- smartphones provide a communication platform to warn pedestrians of impending collision.
- Systems that are able to detect pedestrians have been released with the automotive industry being at the forefront of research.
- A major challenge facing V2P systems the distraction caused by the alerting messages which in turn reduces the response time to the possible collision.

Conclusions

- It is a challenge to develop sensor technology to gauge the traffic conditions consistently and accurately, and pedestrians' movement initiation in real time.
- Due to long coverage, camera can be one component of the sensor fusion for effective pedestrian detection.
- There is lack of a standard reference for evaluation of the existing detection and prediction methods .
- ML along with Physics based methods can provide the best accuracy for trajectory prediction.
- Visual vehicle-based warnings are found to cause more distraction to drivers and increase their reaction time to collision warnings.

Recommendations

- Real world tests with Wi-Fi direct system could be carried out.
- Defining the cap value for performance measures to gauge the quality of the existing and future pedestrian detection and prediction methods.
- ML along with Physics based methods for trajectory prediction should be examined to a greater extent.
- There is need to understand the general population's background on transport mode choice, their frequency, and personal experiences on the road to effectively convey safety messages to pedestrians via smartphones.
- Examination of systems that alert for both drivers and pedestrians.

References

- [1] Parag Sewalkar and Jochen Seitz. In: (2019). DOI: <https://doi.org/10.3390/s19020358>.
[2] Ioannis Vourgidis et al. In: (2020). DOI: <https://doi.org/10.3390/s20040997>.
[3] Florian Seeliger et al. In: IEEE. 2014. DOI: 10.1109/IVS.2014.6856479.