ISSN: 2767-2972

Research Article

International Journal of Forensic Research

From Post-Mortem to Prevention: Redefining "Invisible" Pedestrians Through ISO 26262 and Multi-Modal AI

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Submitted: 2026, Mar 09; **Accepted**: 2026, Mar 30; **Published**: 2026, Apr 14

Citation: Barua, N. (2026). From Post-Mortem to Prevention: Redefining "Invisible" Pedestrians Through Iso 26262 and Multi-Modal AI. *In J Fore Res, 7*(1), 01- 02.

Abstract

*Pedestrians in non-upright postures—those who have fallen due to medical emergencies, intoxication, or primary collisions—represent a significant yet underserved demographic in automotive safety research. Despite the proliferation of Advanced Driver-Assistance Systems (ADAS), forensic data suggests that "low-profile" humans remain largely invisible to standard monocular and LiDAR-based detection systems. This opinion piece argues for a paradigm shift in vehicle safety, moving from post-mortem forensic analysis to proactive prevention through the integration of **ISO 26262** functional safety standards and multi-modal AI architectures. By leveraging the **Advanced Falling Object Detection System (AFODS),** which utilises YOLOv7-Tiny for spatial detection and MFCC-based audio classification for verification, detection accuracy for prone individuals can be significantly improved. Furthermore, the piece addresses the ethical implications of these systems, positing that the protection of the most vulnerable road users is a deontological necessity that transcends traditional "Trolley Problem" utilitarianism.*

1. Introduction: The Forensic Imperative

In forensic pathology, the reconstruction of pedestrian-vehicle collisions often reveals a critical disparity: while modern vehicles are adept at avoiding "standard" road users, they remain remarkably blind to individuals in compromised postures. Nationwide database studies in Japan indicate that pedestrians lying on the road account for approximately **7.8% of all traffic fatalities [1].**

From a biomechanical perspective, a fallen human presents a radically different cross-section that monocular camera systems often misinterpret as road irregularities. This "classification gap" is a silent contributor to secondary impact fatalities, particularly in low-light conditions, where standard systems yield a 21.4% True Positive Rate (TPR) [2]. The forensic community must therefore advocate for a transition from observing the aftermath to engineering active prevention.

2. Functional Safety and ISO 26262: A Forensic Requirement

The detection of fallen pedestrians is no longer just a luxury feature; it is a critical safety goal under the **ISO 26262** international standard for functional safety.

- **ASIL and Risk Assessment:** ISO 26262 mandates a rigorous approach to **Automotive Safety Integrity Levels (ASIL).** Our research suggests that the "fallen pedestrian" should be considered a high-severity hazard in Hazard Analysis and Risk Assessment (HARA).
- **Multi-Modal Redundancy:** To comply with ISO 26262's demand for fail-operational behaviour, we advocate for a "sensory envelope" combining **Long-Wave Infrared (LWIR), Near-Infrared (NIR),** and **Ultrasonic sensors.** LWIR is essential because it captures the biological thermal signature (36.5–37.5°C), which remains constant regardless of posture or lighting [2].

3. Deep Technical Integration: YOLOv7-Tiny and RNNs

Our **Advanced Falling Object Detection System (AFODS)** addresses the detection gap through a custom AI pipeline designed to handle the unique visual signatures identified in forensic case studies:

• **Detection:** Utilising a **YOLOv7-Tiny** architecture optimised for edge computing, the system identifies prone individuals with high precision [2].

• **Prediction and Acoustic Verification:** By integrating **Recurrent Neural Networks (RNNs),** the system analyses the kinematics of a stagger to predict a fall *before* it occurs. This is supplemented by audio classification using **Mel-Frequency Cepstral Coefficients (MFCC)** to identify the acoustic signature of a fall, providing a secondary layer of confirmation [3].

4. Ethical Implications: AFODS and the "Trolley Problem"

The "Trolley Problem"—a moral dilemma where an AI must choose between two harms—is often criticised as an unrealistic "edge case." However, in the context of AFODS, it becomes a tangible engineering challenge [4,5].

• **Prioritising the Vulnerable:** Our research moves beyond utilitarianism toward **deontological ethics,** which emphasises the inherent duty to protect the most vulnerable road users. A fallen pedestrian is inherently more vulnerable as they lack the mobility to self-evacuate.

• **Deterministic vs. Probabilistic Ethics:** AFODS shifts the focus from "who to hit" to "how to avoid." By achieving a 98.2% detection rate, the system reduces the statistical likelihood of entering a "Trolley" scenario in the first place [2].

• **Transparency:** As mandated by the EU Expert Group on Ethics of Connected and Automated Vehicles, safety systems must be explainable. AFODS's use of multi-modal confirmation provides a clear "forensic audit trail" for why a braking decision was made [6].

5. Conclusion

The future of forensic science is not merely the study of death, but the engineering of survival. By demanding that automotive manufacturers align their AI training with forensic biomechanical data and ISO 26262 standards, we can eliminate the "invisible" status of fallen road users. The transition from forensic observation to proactive, AI-driven intervention is the most significant leap traffic medicine has taken in decades [7].

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