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Visualizing Pedestrian Safety Testing of Vehicle Hood Tops: A Novel Web-Based Tool for Regulatory Analysis

Introduction:

Newly developed vehicles must undergo and pass a series of safety testing procedures to comply with Federal Motor Vehicle Safety Standards (FMVSS). The National Highway Traffic Safety Administration (NHTSA) is responsible for verifying results and approving vehicles to ensure public safety. To improve this process, NHTSA is developing WebSAT — a web app platform for efficient visualization and analysis of vehicle safety testing data.

FMVSS 228, titled “Pedestrian Head Protection,” was proposed by NHTSA on September 19, 2024, with the aim of reducing risk of head injuries in pedestrian crashes by setting requirements for vehicle hood design for any passenger cars, light trucks, or busses with gross vehicle weight rating (GVWR) of 10,000 lbs. or less. FMVSS 228 includes setting Head Injury Criterion (HIC) limits during head-to-hood impact tests using instrumented headforms, test area definitions based on likely head impact locations for each vehicle, as well as compatibility with other standards such as FMVSS 127 (Automatic Emergency Braking and Pedestrian AEB) and Global Technical Regulation 9 on pedestrian safety.

This project contributed to WebSAT by building a "Pedestrian Hood Visualizer” component into the website specifically designed for analyzing FMVSS 228 compliance. This component generates and displays diagrams of vehicle hood test regions, along with overlays of landmarks, impact locations, and Head Injury Criterion (HIC) thresholds. By providing a fast, intuitive, and centralized interface for FMVSS 228 testing data, this project makes critical safety information more accessible and verifiable, ultimately improving safety for all pedestrians and road users.

Materials and Methods:

WebSAT used a containerized architecture with four key tools. Vue.js was used for front end user interactions and real-time updates. Django REST Framework was employed as the backend structure for API endpoints, data management, and signal processing. Plotly.js was used for interactive charts, graphs, and diagrams. Finally, Docker was used to containerize all components for consistent dependency management and simplified deployment across environments. The Pedestrian Hood Visualizer included full stack integration across all these layers, creating an efficient pipeline for dynamically generating labeled diagrams of hood test areas, landmarks, impact points, and HIC threshold labels for vehicles regulated by FMVSS 228. This pipeline was then tested using JSON data from 6 vehicles of varying GVWR: 2024 Honda Accord, 2024 Ford Mustang, 2024 Volkswagen ID.4, 2023 Jeep Gladiator, 2025 Ram Pro Master, and 2021 Ford F250. All input data followed NHTSA database formatting conventions. Output was then assessed for code errors, diagram rendering time, and diagram consistency with FMVSS 228 documentation.

Results:

The system demonstrated real-time generation of vehicle hood diagrams showing test areas, landmarks, impact points, and HIC threshold labels. Testing confirmed successful diagram generation and rendering across all vehicle models. Diagram generation time in all models was less than 0.1 sec.

Conclusions:

The Pedestrian Hood Visualizer was successfully developed and integrated into the WebSAT platform, providing an effective solution for visualizing pedestrian safety testing data. This work demonstrates the role engineering can play in bridging the gap from technical data complexity to practical regulatory applications, ultimately advancing public health through improved safety assessment tools.

Discussions:

This project addresses the need for accessible safety data visualization in regulatory environments. However, certain factors should be considered when interpreting its results. Firstly, the Pedestrian Hood Visualizer tool relies on data precisely formatted to NHTSA conventions, meaning diagrams may not generate correctly if vehicle data provided deviates from the expected conventional format. Secondly, while the system allows for rapid visualization of current metrics, future changes in regulation and testing procedures may require different diagrams, thus requiring updates to the code. Finally, it does not account for edge cases such as pop-up headlights, which—according to FMVSS 228—must be tested in both open and closed positions if they fall within the test region.

Future enhancements to the tool could expand functionality to include 3D hood surface representations, add additional safety metrics beyond HIC thresholds and build in greater flexibility on input formats. As vehicle design continues to advance, these may comprise safety technology like automatic emergency braking, crash prediction, and autonomous driving features. Such expansion would benefit from the scalability provided by WebSAT's containerized architecture and further contribute towards user-centered design in regulatory technology, a place where intuitive interfaces can significantly impact the efficiency of safety assessments.

References:

Media, NHTSA. "NHTSA Proposes New Vehicle Safety Standard to Better Protect Pedestrians." NHTSA, 9 Sept. 2024, https://www.nhtsa.gov/press-releases/nhtsa-proposes-new-vehicle-safety-standard-protect-pedestrians.