3rd-Eye: A Novel Embedded System for Driver Attentiveness Monitoring Using Machine Learning (Year 3)

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Many studies estimate that over 150,000 police-reported accidents are caused by drowsy, distracted, or drunk driving, resulting in over 400,000 injuries and over 4,000 deaths annually. An embedded Driver Monitoring Suite (DMS) under $80 was developed to detect and respond to driver inattention in real-time by monitoring physiological and behavioral indicators. The physiological signal processing pipeline utilizes chest displacement readings captured from a non-invasive mmWave radar to generate a heart waveform that can be analyzed for pulse rate variability (PRV). This enables the proactive detection of drowsiness by analyzing changes in key statistical parameters (RMSSD, LF/HF ratio, etc.) in both the frequency and time domains. Behavioral features such as gaze, head pose, and eye movements are monitored using a camera and analyzed using a vision-processing pipeline to detect drowsiness, distraction, and intoxication. At the core is a HOG algorithm to localize facial features, a custom Convolutional Neural Network (modified EfficientNet B0) to detect the various states of distracted driving (texting, eating, etc.), and a logistic regression model to classify drunk driving. An Inertial Measurement Unit was utilized for sensor calibration and detecting anomalies in a driver's acceleration and steering behavior associated with unsafe driving to supplement the other methods of detecting driver inattention. A custom PCB integrates all components (microprocessor, camera, radar, etc.) within the rear-view mirror. The DMS, tested across file-based, lab-based, and simulator settings, had an accuracy of 90% for drowsiness, 94% for distraction, and 92% for drunk driving detection. Solely using PRV analysis, an 86% accuracy rate in predictive drowsiness detection was achieved.