Hindsight: An End-to-End Ultra-Low-Cost Wearable Safety Radar for Pedestrians With Edge-Executed Machine Learning

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On average, every 3 seconds a car hits a pedestrian, and every minute one is killed. Hindsight is a low-cost wearable sensor that alerts pedestrian users of vehicles approaching from behind to help avoid potential collisions. It uses a custom-designed in-phase and quadrature (IQ) Doppler radar board operating at 10.5 GHz, on low-cost FR4 substrate, to detect incoming vehicles and differentiate the approaching objects' positive Doppler shift from the receding environment's negative Doppler shift. A second signal processing board with a microcontroller and accelerometer, also on FR4, performs Fourier analysis on the I and Q components to prepare the signal for the neural network. An edge-executed, multi-layer 2D convolutional neural network has been developed and runs entirely on the low-cost, low-power microcontroller to detect vehicles approaching from behind. It uses multiple discrete Fourier transform frames of the amplified baseband Doppler signal data received from the custom IQ Doppler radar to compute the probability of an approaching car's presence. To train and test the model, more than 170,000 frames of data were collected and labeled by the finalist across parking lots, city streets, and roads with diverse ranges of clutter, vehicle types, and pedestrian motion. The system generates an alert for the pedestrian an average of 6.9 seconds before collision, demonstrating a robust and reliable machine-learning-based pedestrian threat detection model executed entirely on the wearable radar. This end-to-end wearable sensor, designed from scratch, not only demonstrates the feasibility of wearable early-warning systems for pedestrians but goes beyond a simple prototype to provide an accessible and commercially viable solution for pedestrian safety.

Awards Won:

Second Award of $2,400

Qorvo: Qorvo Innovator Award - 1st Place

Association of Old Crows Educational Foundation: 1st Place