A Wearable Low-Cost 10.5 GHz Radar-Based Early Collision Warning System for Pedestrians With Dynamic Threshold Adjustment

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On average, every eight minutes a car hits a pedestrian, and every 70 minutes one is killed. The elderly, the hard of hearing, and those listening to music while exercising are at an increased risk, especially with the rise of silent electric cars. This work presents a novel low-cost wearable sensor that alerts pedestrians of vehicles approaching from behind to provide early warning. Conventional Doppler radars rely on stationary sensors and do not perform reliably for a moving pedestrian with rapid shaking due to the gait. To account for the complex movements of pedestrians, the sensor uses an onboard accelerometer to measure the phase of the user's gait and adjusts detection thresholds in real-time. The low-cost wearable sensor uses two custom-designed boards: a printed circuit board Doppler transceiver operating at 10.5 GHz with on-board transmission lines and a signal processing board with a microcontroller. The high-frequency board uses a branch-line coupler to generate in-phase and quadrature (90° apart) signals to differentiate approaching vehicles' blue Doppler shift from the receding environment's redshift. The signal processing board is programmed to perform Fourier analysis, peak tracking, and a vector cross-product analysis on the down-converted Doppler components to identify incoming vehicles. Field experiments demonstrate that a vehicle approaching at different speeds from behind is correctly detected in the presence of other objects and the pedestrian’s movement at average distances of 27.6 and 28.2 meters for a walking and jogging user, respectively. This provides the user sufficient time to react.

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