FallPoint: Fall Detection With 4D mmWave Radar Using PointNet and a Recurrent Neural Network

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With increasing life expectancies worldwide, falls are becoming a prevalent challenge for the elderly. Rapid detection and alert after a fall is critical to reduce the extent of damage. However, current fall detection systems rely on cameras, microphones, or wearable devices, posing concerns over privacy, comfort, and environmental resilience. mmWave radar solves these issues---the output is relatively low resolution, it does not need to be worn, and radio frequency waves can penetrate materials and see in the dark. Current radar-based approaches utilize the time-doppler, range-doppler, and range-angle heatmaps; we combine time, range, velocity, and angle with a 4D point cloud (x, y, z, velocity). We collected a large and diverse dataset on 8 individuals in 8 locations inside the home, performing 23 non-fall actions and 16 fall actions, amassing over 80,000 frames. Next, we perform preprocessing, solving the issues of noise and data sparsity with DBSCAN and a novel oversampling algorithm. Finally, we developed the FallPoint architecture with 3 components: 1) Time distributed PointNet, 2) Recurrent Neural Network based on the Gated Recurrent Unit, and 3) Multilayer perceptron. The components serve to 1) Extract the spatial features within each frame directly from the point cloud, 2) Capture the temporal relationships between frames, and 3) Perform the final binary classification. Our model achieved state-of-the-art performance with a high precision of 0.931, recall of 0.9, and F1 of 0.915, suggesting its ability to generalize well and potential for use in real-time fall detection applications within homes and healthcare environments.

Awards Won: